SPECIAL REPORT
Glaciers and Mining Series

Xstrata Copper San Juan

Impacts to Rock Glaciers and Periglacial Environments by El Pachón (Xstrata)

San Juan, Argentina

May 2011

SPECIAL REPORT: GLACIERS AND MINING SERIES

Versión: May 23, 2011
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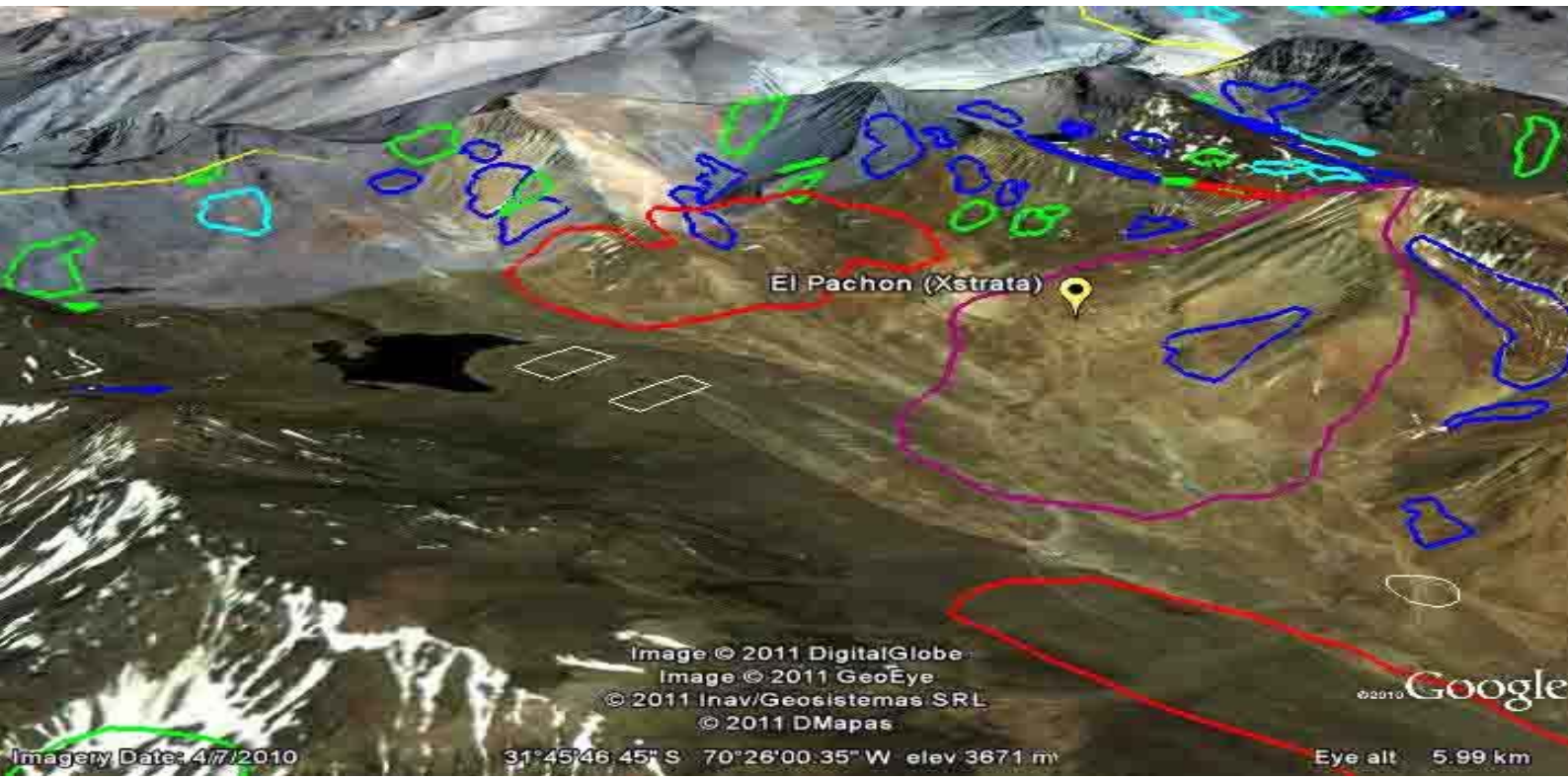
Impacts to Rock Glaciers and Periglacial Environments by El Pachón (Xstrata)

Project: El Pachón
Company: Xstrata Copper (Swiss/UK/Australian mining company)
Location: San Juan, Argentina
GPS Site: 31 45 5.26 S, 70 26 2.61 W (cut&paste in Google Earth)
Glaciers Affected: 220 +
Periglacial Environment Affected: at least 20% of total project area



Satellite image of El Pachón mining project revealing a rock glacier inside the pit area (purple polygon) and at one waste dump site (in red)

By Jorge Daniel Taillant
Coordinator Mining, Environment and Human Rights Program
Center for Human Rights and Environment (CEDHA)

with Scientific Contributions by:
Alexander Brenning, University of Waterloo, Canada
Mateo Martini, National University of Córdoba, Argentina

About CEDHA

The Center for Human Rights and Environment (CEDHA) is a non-profit organization based in Córdoba Argentina working to create a more harmonious relationship between people and the environment. CEDHA works to protect human rights, strengthen judicial and normative frameworks on social and environmental protection, and encourage the compliance and enforcement of environmental law by State and corporate actors. CEDHA has programs focusing on climate change, deforestation, right to water and sanitation, international finance corporations, corporate accountability, and mining and human rights, among others.

With support from the Wallace Global Fund, CEDHA participated actively in the promotion and eventual promulgation by the Argentine Congress of the world's first National Glacier Protection Act[1] in October of 2010. Argentina's glacier law could not come at a more timely moment. Climate change is bringing unparalleled impacts to our global environment. Glaciers are an indicator of this change. They are melting faster than ever recorded. Just weeks before the publication of this report, even the Vatican through its' Pontifical Academy of Science issued it's Fate of Mountain Glaciers in the Anthropocene, calling attention to anthropogenic impacts on one of the world's most delicate and important natural resources, glaciers.

Argentina is bearing much of the brunt of global glacier melt, with some 25% of the world's freshwater reserves packed in the ice of the high Andes mountains. Glaciers are clearly in retreat. This climate devolution however, is accelerated by human impact on the ground, particularly from mining operations, which have flocked to the region encouraged by a favorable legal and investment incentives. Miners are crisscrossing the Andes in search of precious metals, sometimes indiscriminately cutting through terrain without regard of the surroundings. The problem of this model is further aggravated due to the region's governance systems' lack of capacity and political will power to ensure that mining operations are fully complying with the law. The Argentine Glacier Protection Act will hopefully help ensure that the sector is more respectful of such delicate natural resources, so important to environmental systems, to environmental services, and to local populations.

In parallel to what will be the first Argentine official glacier inventory, CEDHA is carrying out its own inventory, to check and ensure the effective implementation of Argentina's National Glacier Act. This and other activities related to glacier and mining are part of CEDHA's efforts to "democratize" glaciers which includes the wide dissemination of information about glaciers, their water provision value to local communities and their importance as key and strategic natural resources as well as encouraging and empowering stakeholders and communities to actively engage in debate about the protection of glaciers and glacier environments.

We've also initiated a satellite imagery analysis and inventory of key mining investments and projects underway in Argentina and in the region, correlating these to communities and key environmental resources such as lakes, rivers, glaciers and other strategic natural resources. The content of this report is the product of the work of all of CEDHA's team, and particularly its Mining, Environment and Human Rights program staff, which collaborated in this effort with the help of specialized scientists from Argentina and Canada.

[1] See: http://www.cedha.org.ar/documents/Argentine%20National%20Glacier%20Act%20-%20Final%20Document.pdf

Acknowledgements

This work is dedicated to the people and communities of the Province of San Juan.

We would like to especially thank Alexander Brenning, of the Geography Department of the University of Waterloo, for his patience in reviewing and revising our work and our glacier impact analysis for this and other works we are engaged in, to help protect and democratize the issue of glaciology and bring attention to the impacts on glaciers in the region by the mining industry and other large public works.

Also special thanks go to Mateo Martini, geologist of the National University at Córdoba, a Conicet fellow and member of the Center for Science and Research of the Earth (CICTERRA). Mateo provided invaluable assistance in the review and analysis of this report and in our rock glacier inventory of the Pachón project vicinity.

To Cedomir Marangunic (Geo Estudios of Chile), Juan Carlos Leiva (IANIGLA) and Benjamín Morales Arnao (Patronato de las Montañas Andinas, Perú), who were our trainers at the United Nation's Environmental Program's Glaciology Course. Cedomir, Juan Carlos and Benjamin were extremely patient in answering our many questions on the characteristics and techniques for identifying rock glaciers, and periglacial environments. We also would like to thank Isabel Martinez of UNEP who gave an NGO that had little previous experience on glaciology, the opportunity to learn about glaciers and glacier recognition opening a door for us into a network of glacier specialists that has changed our perspective on the planet we live on. Without their help, this report would not have been possible.

To Richard Mott and the Wallace Global Fund, which finances our Mining, Environment and Human Rights Program to carry out our glacier research and mining advocacy. The Wallace Global Fund has been a key player in the financing of initiatives defending the environment and human rights around the world.

And finally, to Romina Picolotti, who as Environment Secretary of Argentina (2006-2008) helped introduce and fight to get our National Glacier Act through Congress and who has inspired this and many other social and environmental causes.

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Report Summary

(We recommend this report be read with Google Earth open on your computer)

Set to begin production in 2012, Xstrata's El Pachón project in the southwestern region of San Juan Province of Argentina impacts or potentially impacts over 200 glaciers including many active rock glaciers in arid mountainous regions of the Andes, all at or within a very short distance of the project site. El Pachón also directly impacts or places at risk extensive periglacial environments which makes up approximately 20% of the project's stipulated area. Easily accessible satellite imagery (as publicly available through Google Earth) shows that as many as 60 rock glaciers in the El Pachón vicinity appear to have been left off of the geomorphological survey found in Xstrata's 2008 Environmental Impact Assessment (EIA). According to this report at least a dozen rock glaciers are at severe risk from the El Pachón project, while the remaining 200+ are close enough to merit in-depth study to gauge El Pachón's impact and whether El Pachón is complying with provincial[2] and national laws protecting rock glaciers and periglacial environments.

The two projected open pit sites (according to El Pachón's 2008 EIA) will completely destroy several rock glaciers and approximately 80 hectares of periglacial environments located inside the pit location. The sites reserved for tailing wastes will also affect or destroy rock glaciers and/or periglacial environments. Both impacts to rock glaciers and to periglacial environments are prohibited by the National Argentine Glacier Protection Act promulgated in October of 2010.[3]

By law, Xstrata Copper should have presented an additional glacier impact study in April 2011, which up to the publishing of this report, it has failed to do. The project is scheduled to initiate operations in 2012. As it stands, El Pachón's serious violation of both Argentina's national and provincial laws, with regards to glacier and periglacial environment impact and protection, would indefinitely stall the project until these impacts can be assessed, mitigated and avoided (should the project continue forward). This may involve considerable redesigning and/or the introduction of extensive glacier repair and protection contingency plans for the El Pachón project.

Glaciers (white glaciers and rock glaciers) and periglacial environment are critical to San Juan Province's local water supply for small farming, local industries and populations. Rock glaciers in the Pachón project area feed local rivers and tributaries, including the Pachon, Mondaca, Carniceria, Sta Cruz, Blanco and Rio de los Patos rivers, which in turn feed the San Juan river, the province's most important waterway. We are currently working on volumetric measurements to determine the amount of San Juan's waterways fed by glaciers affected by the El Pachón project. That study will be available in the near future.

El Pachon's impacts to rock glaciers and periglacial environments are primarily caused (or will be caused) by roads and infrastructure both during the project's exploratory phase as well as in the implementation phase. The choice of pit sites as well as the choice of tailing waste deposits sites and their resulting acid drainage, will be at sites that include rock glaciers or periglacial environments, all of which have negative impacts on rock glaciers and periglacial environments.

Exploratory roads were introduced by Xstrata since the company became owner in 2006, while some roads predate Xstrata's purchase, however, these roads and their impacts to the environment and to rock glaciers and periglacial environment in particular, are part of the environmental impact of the project, for which Xstrata must now answer. Furthermore, in the case of rock glaciers impacted prior to Xstrata's purchase of El Pachón, road upkeep and use by Xstrata, also causes impacts to rock glaciers and periglacial environments, so it is presumed that past damage to rock glaciers and periglacial environments continue today and will continue indefinitely if not addressed.

[2] See: http://www.cedha.org.ar/contenidos/glaciares%20-%20docs%20-%20ley%20glaciares%20-%20san%20juan.doc
[3] See: http://www.cedha.org.ar/documents/Argentine%20National%20Glacier%20Act%20-%20Final%20Document.pdf

El Pachón will also impact rock glaciers and periglacial environments during the implementation of the project by the removal of earth, rocks, and ice in the mineral extraction phase at the two projected project pits. Additionally, tailing waste, rocks, earth, and ice will be disposed on adjacent land, also causing serious impact to the land area that receives this disposed material. These lands also contain rock glaciers and if found to have permafrost, that resource would also be affected.

Xstrata's Environmental Impact Assessment references the existence of rock glaciers and periglacial environments in the project vicinity, but suggests that impacts will be " localized, with a high probability of occurrence, [but] will be moderate with certain prevention and mitigation needs. Amongst these needs, particular attention will be given to avoid affects to cryoforms or related geoforms, and to minimize the erosive processes of removing mass." (p.68, 2008 EIA)

The EIA's geomorphological survey map, (by URS for Xstrata in 2008), show the existence of some 205 rock glaciers and extensive periglacial environment areas around the project comprising some 20% of the project area. Our analysis of satellite imagery shows that Xstrata has failed to identify some 60 or more rock glaciers from its inventory. Many of the rock glaciers in the El Pachón project area are at risk or may be totally destroyed by El Pachón. This is illegal under Argentine law.

In the preparation of this report, we have reviewed documentation for El Pachón which has only recently become available, including a *2008 Environmental Impact Assessment: Pachón's Exploratory Area*. Numerous requests over several months to obtain all of El Pachón's Environmental Impact Assessments to the Province of San Juan and to Xstrata, went largely unanswered until the last few weeks before the publication of this report.

This report as well as our inventory of rock glaciers has been prepared by CEDHA staff with the scientific contribution of Dr. Alexander Brenning, Department of Geography and Environmental Management University of Waterloo, Canada and Mateo Martini, Geologist and PhD Candidate of the Geology Department of the National University of Córdoba, Argentina. We would like to thank Dr. Brenning and Martini for their scientific contributions to this report, for their assistance in reviewing our glacier inventory, and for contributing to the analysis on the risks posed by El Pachón to glaciers in the project vicinity. We would like to stress that all of the opinions in this report belong primarily to CEDHA, as well as any errors in the present analysis and conclusions.

We call on the Federal and Provincial environmental and mining authorities to:

- **Suspend** Xstrata's El Pachón project as established by Argentine national[4] and provincial law[5], until a proper *glacier impact assessment* can be carried out to determine if El Pachón will indeed destroy, move, or impact the more than 200 glaciers in its vicinity and related periglacial environment areas.
- **Ensure no more harm is done to rock glaciers or periglacial environments** in the area by this or other largescale industrial projects, particularly large mining projects, whether they are in exploratory or implementation phases;
- **Ensure full compliance** with National and Provincial glacier protection laws;

Our demands to Xstrata are:

- **Suspend** all activity until a proper glacier impact assessment clarifies what past, present and future impacts to rock glaciers and periglacial environments have been or will be;
- **Repair** damage to rock glaciers and periglacial environments and avoid future impacts;
- **Contribute** to the creation of a Protocol on Mining Operations in Glacier Areas;
- **Ensure fluid and transparent communication** with stakeholders and society;
- **Guarantee public participation** in future discussions about glaciers as is mandated by the Argentine National Glacier Act;

[4] See: http://www.cedha.org.ar/documents/Argentine%20National%20Glacier%20Act%20-%20Final%20Document.pdf
[5] See: http://www.cedha.org.ar/contenidos/glaciares%20-%20docs%20-%20ley%20glaciares%20-%20san%20juan.doc

What are Rock Glaciers?

This report is about impacts to rock glaciers by the El Pachón copper mining project by Xstrata Copper in the South Western corner of San Juan Province, in Argentina, in the high, dry and arid Andes mountains. The first issue we will review before proceeding to examine El Pachón's impact to rock glaciers and to periglacial environments is precisely *what is a rock glacier*, its properties, and how it differs from what are normally recognized by most, simply as *glaciers*.

Rock glaciers are essentially frozen groundwater bodies, or bodies of ice and debris (rock fragments) which move down a slope or valley floor as a consequence of their own weight as well as the angle and slipperiness of the surface on which they rest. Rock glaciers have a distinct landform, with characteristic steep frontal and lateral slopes, and furrows and ridges on their surface as an expression of their deformation. Rock glaciers are very hard to spot for the untrained eye because ice is normally not visible (as distinct from common white glaciers). The ice within rock glaciers is conserved under what may be several meters of rock and debris, providing key melt-water storage at lower elevations where common white glaciers could not survive.

Below is a picture of a typical active rock glacier called *Zenta*, in Jujuy Province in northern Argentina, similar to the ones that are found in the El Pachón project area. While the formations in the picture to the untrained eye would seem to be merely rocks on a mountainside, in fact, these rocks are covering large amounts of sensitive and environmentally critical ice. You can visit the Zenta glacier in Jujuy by going to the following Google Earth address: by copying and pasting the following coordinate address in Google Earth's search box: [23 12 11.33 S, 65 3 43.18 W]. The following image is what you will see appear. Immediately below the Google Earth image is an actual recent photograph of the area marked by the yellow circle (photo: courtesy of Universidad Nacional de Córdoba).

Typical Rock Glacier (black arrow points to glacier top and frontal edge)

In some cases, the ice structure of rock glaciers can be several meters underneath the surface. Below is a photograph of a cross section of a rock glacier, showing fine rock matter above ice.

Debris-covered Glacier showing ice beneath rock (source: Geostudios)

Why are Rock Glaciers Important?

"Glaciers and rock glaciers in the semiarid Andes constitute natural sources of water that control the runoff of mountain rivers, especially in the dry summer months. They are responsible for the water supply to the agglomerations of Santiago, Chile (5.3 million inhabitants), and Mendoza, Argentina (1.1 million inhabitants), and the irrigated land in the surrounding lowlands". (Brenning 2008). Rock glaciers are also key sources of freshwater in other arid regions such as San Juan Province.

Rock glaciers and mountain permafrost are extremely important to the natural environment and to ecological systems. Snowfall on the rock glaciers and in their upslope contributing area and resulting meltwater, can be captured permanently or temporarily in the rock-ice structure and within the overlying active layer, where it may be stored for future water needs. The rock cover protects much of the ice from quickly melting off. Rock glaciers can be found at elevations significantly lower than ordinary white glaciers, where exposed ice would melt off quickly due to higher ambient

temperatures. That means that thanks to rock glaciers, we have more ice volume than would otherwise be possible. This is a fantastic adaptation mother nature has developed *to conserve more ice for longer periods of time, so that streams and rivers get water from ice melt for many more months than just the first snowmelt months in the spring*.

This stored ice in rock glaciers, hence, becomes available during the warm season and in particular during extremely hot summers, or dry years when water demand is greatest. In the long term (decades to centuries), as the climate warms and glaciers around the world begin to melt, rock glaciers may also become inactive and finally start to thaw as a consequence of climate change, in which case thawing rock glaciers and permafrost contribute as nonrenewable resource to the water supplies.

As mentioned earlier in this report, Arenson, Pastore, Trombotto et.al., recognized geologists and glacier experts, and in relation to the El Pachón project, make the critical observation that "the ground ice in these latter permafrost zones is often the only source of multi-year ice in the absence of substantial surface snow and ice areas." (p.1501) They also establish that "most likely the majority of the rock glaciers in the El Pachón area are still active, i.e. they contain renewable ice-rich zones that are creeping downslope. (p. 1502)

The following images of the nearby Central Andes Region of Chile, in the Laguna Negra Basin, shows water appearing amidst rocks in a rock glacier area. This is most likely directly due to glacier melt from the rock glacier.

Water gushing forth from rocks below a rock glacier
in the Central Chilean Andes region (Laguna Negra Basin); by Pablo Irribarren

Mining Risks to Glaciers, Rock Glaciers and Periglacial Environments

Because of company ignorance and/or disregard for existing white glaciers, rock glaciers, and permafrost, as well as total failure of State authorities to control glacier impacts, mining operations in the high Andes mountains have caused *and continue to cause* enormous impacts to glaciers, rock glaciers and periglacial environments. Satellite imagery of the high Central Andes region along the Argentine/Chilean border offer dozens and dozens of images of mining exploratory work crisscrossing near, into and across glaciers, rock glaciers and permafrost. The problem is so extensive, that Argentina chose recently to enact legislation to protect this critical water reserve resource.

With over 200 new largescale mining projects in the pipeline for the Central Andes region, the cumulative impacts to glaciers, rock glaciers and permafrost could be devastating if it is not controlled. San Juan, the province of focus of this report has over 150 projects in preparation according to the Minister of Mining of the Province, [6] most of these in glacier territory.

Mining impacts to glaciers come from many aspects of mining operations, including:[7]

- Modifications to mountain sides whose particular shape and environmental conditions lead to the accumulation of snow and ice, the transport and accumulation of rock fragments, and the existence of the thermal condition of permafrost, which in turn allow for the formation of ice-rich permafrost and ultimately rock glaciers;
- Disturbance of the delicate steady-state creep of the rock-ice mixture, which may lead to the collapse of the structure and ultimately the destruction of the rock glacier;
- Explosions which may alter and collapse ice structures or destroy necessary glacier containment valleys;
- Introduction of roads onto, adjacent to, or near rock glaciers, which can lead to modifications in meltwater flow into the rock glacier, possibly reducing or inhibiting temporary and permanent water storage in the rock glacier, and modifying the surface heat flux which may possibly affect any underlying ice structure;
- Deposit of residues, waste rock, and other solids on the rock glacier surface which can lead to an acceleration of the rock glacier's flow and eventually to its collapse;
- Contamination of the rock glacier's surface, leading to color changes and material cover change, and subsequent temperature absorption changes, which could in turn lead to ice melt and eventual collapse;
- Contamination from the deposits made on the surface of the rock glaciers, leading to acidic chemical and heavy metal drainage (acid rock drainage, ARD) into the ice and water of the rock glacier, and possible permafrost degradation related to the heat created by these geochemical processes.

We now turn specifically to look at Xstrata's El Pachón project and the impacts we have been able to document to rock glaciers and periglacial environments (permafrost) in the project vicinity.

[6] See Entrevista con Felipe Saavedra, ministro de Minería provincial: San Juan: Avanza la Construcción de Tres Megaproyectos Metalíferos por $36,000 Millones. El Inversor Energético y Minero. Año 5 Nro.55 Abril 2011. p. 17.
[7] compare Brenning, 2008; Kronenberg, 2009; Brenning & Azócar, 2010

El Pachón Project Description

According to Xstrata's website, "El Pachón is a bi-national project located 3,600 meters above sea level[8] in Argentina's San Juan Province, five kilometers from the Chilean border. Our analysis shows that project activity has occurred up to the actual border. The project falls under the Mining Integration Treaty signed in 1997 by Argentina and Chile and its Specific Protocol, which will enable concentrates to be shipped via the Pacific Ocean. In December 2010 Xstrata Copper published a 30% increase to Mineral Resources at El Pachón, which now total 1.79 billion tones at a copper grade of 0.51%, using a 0.2% cut off grade."[9]

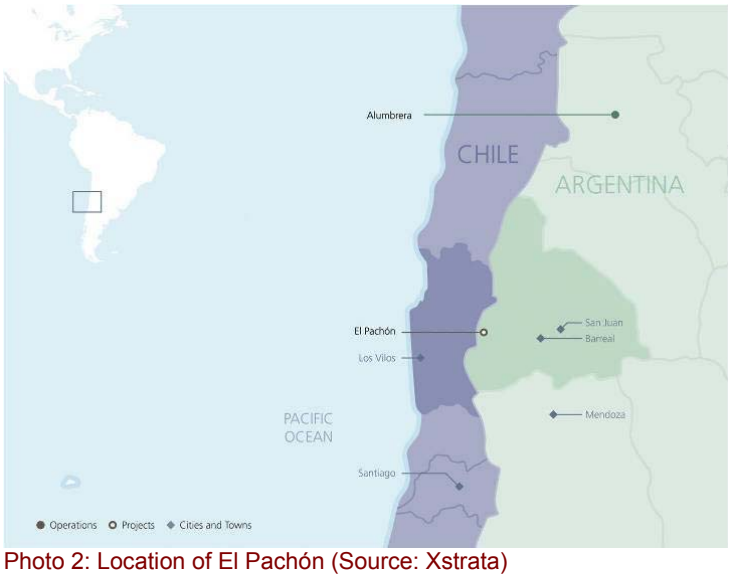


Photo 2: Location of El Pachón (Source: Xstrata)

The open pit copper mine project site is some 400 hectares in size (4.3 km2). The altitude range is between 3100m and 4500m above sea level, and covers the *Pachón*, *Mondaca*, *Carnicería*, and *Arroyo Mondaquita* river basins as well as part of the *Santa Cruz River*. These rivers then feed into the *Rio Blanco* and subsequently into the *Rio de los Patos*, and finalize their course in San Juan's largest and most important river, *the San Juan River*. The nearest Argentine town to the mine site is the agricultural and important tourist location, *Barreal,* which has some 3200 inhabitants. There are also small human settlements at: *Estancia Rio Blanco*, *Las Hornillas*, *Casa Amarilla*, and *Alvarez Condarco*. Other populated cities include: *Calingasta*, *Tamberias*, and *Pituil*. The greater Calingasta area has some 10,000 inhabitants. All of these communities are downstream from the El Pachón projects at about 100km in a straight line from the project site. More will be said about these localities in subsequent sections.

Xstrata purchased the El Pachón Project from Falconbridge in 2006. The mine is set to produce some 200,000 tons of copper per year, and will have a useful life of approximately 20 years.

[8] Xstrata's 2007 Sustainability report indicates that elevations of El Pachón range between 3,100 and 4,500 meters above sea level.
[9] See: http://www.xstratacopper.com/EN/Operations/Pages/ElPachón.aspx

Glaciers and Periglacial Environments in the Vicinity of El Pachón

The El Pachón valley as well as surrounding valleys and mountains, are a very dry and arid, but they are also fortunately rich in glacial activity and periglacial environments (including permafrost), critical to feed San Juan's limited water supply, year round.

Arenson, Pastore, Trombotto et.al., recognized geologists and glacier experts, referring to the El Pachón area, make the observation that "the ground ice in these latter permafrost zones is often the only source of multi-year ice in the absence of substantial surface snow and ice areas." (p.1501) They also establish that "most likely the majority of the rock glaciers in the El Pachón area are still active, i.e. they contain ice-rich zones and are creeping downslope. (p. 1502)

Despite many requests to the company and to the government of San Juan, we could not obtain access to Environmental Impact Assessment prior to 2008, nor to the more recent 2011 Exploration Addendum which is announced on San Juan Province's mining website but not available.

Xstrata's 2008 EIA Addendum, which only became available a few weeks before the publication of this report, and only because CEDHA repeatedly requested information about the project to the company and to the provincial government of San Juan, includes a geomorphological survey of the El Pachón project area, which identifies rock glaciers and periglacial environments, other glacial activity and other glacier-related geomorphological characteristics of the region. The reader can view this map by downloading a *[.jpg]* image on CEDHA's website.[10]

Xstrata's map identifies some 200 rock glaciers in the project vicinity. Our analysis of available satellite imagery suggests that as many as 60 or more rock glaciers have been left off of the EIA Geomorphological Survey showing that the glacier inventory process carried out by Xstrata for the 2008 report is either outdated, incomplete and/or insufficient upon which to draw conclusions on glacier and periglacial environment impacts of the project. An updated rock glacier and periglacial environment inventory is urgently needed.

We should note that as a consequence of the limited resolution and quality of the available imagery, our inventory is also likely to be incomplete or may fail to identify small rock glaciers (approximately <0.01 km2). Field mapping is required to obtain a complete inventory of these rock glaciers. However, we estimate that this error will result in the *addition* of glaciers and not the downgrading of ones that we have inventoried, likely bringing the total number significantly higher. This may also be true for inactive rock glaciers, which sometimes lack the characteristic morphological features such as a steep front slope and flow-related surface structures with which to determine their existence.

While most of the mapped rock glaciers are based on evidence collected by CEDHA through image interpretation, *some* (marked in red in the excel spreadsheet at the end of this report and represented as light blue polygons in the Google Earth file we offer) were included *only* because they had been presented as such in the geomorphological survey offered by Xstrata in its 2008 Environmental Impact Assessment addendum. We presume that such inclusion was done based on field evidence not available to CEDHA for the preparation of this report. We could not determine, *as did Xstrata*, that these were indeed rock glaciers.

Official Inventories of rock glaciers in the vicinity of El Pachón are currently underway, both by the Province of San Juan Argentina, as well as by the IANIGLA and Conicet, Argentine national scientific centers which have been mandated by the recently enacted and regulated Argentine

[10] See: http://www.cedha.org.ar/contenidos/MAPA%202.6.1-AM-GEOMORFOLOGIA.jpg

National Glacier Act[11] to carry out an official glacier inventory for the entire country. However, in the case of San Juan Province's inventory, the El Pachón project area has inexplicably been entirely left out of the maps recently published in the Provincial Glacier Inventory (December 2010).[12] This provincial inventory for the moment also fails to include rock glaciers, despite the fact that we have information indicating that at least a partial inventory may exist for rock glaciers of the province, including for the El Pachón region.

Further limiting the access to official information about Argentina's glaciers is that the national inventories may take upwards of 5 or more years to carry out, long after El Pachón is set to initiate operations (2012). For this reason, the Center for Human Rights and Environment (CEDHA) decided to carry out *it's own glacier inventory* for San Juan focusing on areas where mining operations are active. We received training in glacier inventorying and satellite image analysis, and have already inventoried more than 1000 glaciers (many rock glaciers), in San Juan as well as in Catamarca, Tucuman, La Rioja, Mendoza, Jujuy and Salta provinces.

CEDHA's ultimate objective is to help ensure full implementation of the national and provincial glacier laws, and guarantee above all, the protection of all of Argentina's glaciers. The technical team participating in this report included two trained professionals (Dr. Alexander Brenning of the University of Waterloo, and Mateo Martini, Geologist and PhD Candidate of the University of Cordoba, which both contributed to the content of this report.

In its *Glaciers and Mining Series*, CEDHA recently published a report on impacts from mining to glaciers in Catamarca Province, where we inventoried more than 150 rock glaciers in the Sierra del Aconquija which forms the natural border of Catamarca and Tucumán provinces.[13] *That* report focuses on impacts to rock glaciers by two mining projects, *Agua Rica* which belongs to the Canadian mining company Yamana Gold and *Filo Colorado* which is a project owned by Xstrata. Having found serious impacts to glaciers in the Filo Colorado project area and concerns over Yamana's Agua Rica project, we have proceeded to examine other mining operations in glacier zones.

In addition to El Pachón, we are presently reviewing impacts to the Los Azules (TNR / Minera Andes) and have subsequently programmed glacier impact reviews of the following projects: Pascua Lama and Veladero (Barrick); El Altar (Perigrine); Amos Andres (Cerro Vanguardia); Batidero, Vicuña and Las Flechas (Suramina); Northern Properties (TNR); Vanessa (Anglo American), among others.

For this report and inventory, CEDHA has mapped out over 220 rock glaciers in the El Pachón project area, which include both the rock glaciers presented in Xstrata's 2008 EIA as well as other glaciers not reported by the company. We have generated a .[*kmz*] *file* with corresponding rock glacier locations and polygons, with longitudinal and latitudinal coordinates which can be entered and viewed by the reader on Google Earth. To view this file, download it from our website and open it in Google Earth[14]. We also provide at the end of this report, a glacier combined (CEDHA/Xstrata) inventory in an excel spreadsheet with longitudinal and latitudinal coordinates and elevation.

Most of the rock glaciers found at the El Pachón mining site are located in south-facing mountain sides and valleys ranging from [31 37 S to 31 49 S] and from [70 13 W to 70 31 W]. In the southern hemisphere, south-facing mountain sides at high elevations (above 3500 meters in San Juan's latitudes) offer ideal cool shady temperatures for the development and preservation of rock glaciers

[11] For regulatory decree of National Glacier Act see: http://www.cedha.org.ar/contenidos/Reglamentacion%20de%20la%20ley%20de%20glaciares.pdf; for regulatory guidelines of National Glacier Act see: http://www.cedha.org.ar/contenidos/CronogramaInventarioGlaciaresIANIGLA.pdf

[12] See: http://www.cedha.org.ar/contenidos/Relevamiento_Inicial_de_los_Glaciares_de_SJ_Dic_2010.pdf (this is a large document an may take a while to download)

[13] See: http://www.cedha.org.ar/contenidos/Informe%20Glaciares%20de%20Aconquija%20-%20Impactos%20de%20Mineria%20Agua%20Rica%20y%20Xstrata%20-%20Final%20-%20feb%2018%202011.pdf

[14] See: www.cedha.org.ar/contenidos/Glaciar-Inventory-Pachon.kmz

and permafrost. While we cannot identify permafrost regions directly using satellite imagery, Xstata's 2008 EIA's geomorphological survey shows extensive permafrost in the project's area comprising some 20% of the project's total site.

Rock glaciers can also be used as indicators of the presence of mountain permafrost (Barsch, 1996), and consequently indicate its widespread presence in the El Pachón area. Xstrata's own geomorphological survey shows that some 20% of the total project area is in fact nationally protected periglacial environment. The periglacial environment area begins at approximately 3500 meters above sea level, although we have identified a few rock glaciers that suggest the periglacial environment region in some of El Pachón's valleys may be a few hundred meters below this line.[15] This needs to be confirmed however, by site inspection.

In the nearby Chilean Andes at the same latitude, Azócar & Brenning (2010) found the lower limit for rock glaciers to be located at approximately 3400 m above sea level, active rock glaciers being more widespread above 3700 m above sea level, which would coincide with findings at nearby El Pachón. Xstrata reports the periglacial environment limit to be approximately 3800 meters, (pp.12-13 of the 2008 Environmental Impact Assessment Addendum).

Much of the existing exploratory work in the El Pachón project is located on these largely south-facing mountain sides and valleys, thus placing these rock glaciers and periglacial environments at risk. From our satellite imagery analysis, we have been able to pinpoint specific sites where impacts to rock glaciers and periglacial environments from exploratory mining roads of the El Pachón copper project are evident. From Xstrata's documents, we can also ascertain that if project pit sites and tailing deposit sites are maintained as planned, there will be further impacts to rock glaciers and periglacial environments resulting in a violation of provincial and national laws.

Barriers of Access to Xstrata's Environmental Assessment Reports

For this report, we've reviewed El Pachón's Sustainability Report 2006, 2007, 2008, and 2009. For our initial research we could not gain access to the Environmental Impact Assessments for El Pachón, despite many requests to both the company and to the provincial government of San Juan, and thus had to limit ourselves to third party information we could find about rock glaciers in the vicinity, and from our own analysis of satellite imagery of the site, available through Google Earth as well as from aerial photographs we were able to obtain from the area.

Approximately one month prior to the publication of this report, and because of CEDHA's repeated requests, the Mining Ministry of San Juan finally published the 2008 EIA Addendum on their website (approximately end March or early April of 2011) more than three years after they had it available. Ironically, a few days later, CEDHA received via courier mail, a disk copy of the report, sent and signed by the Mining Minister (which he had posted just days before), stressing that we could have downloaded it from their website.

Public access to all of El Pachón's assessment documents is critical to ensure transparency and for interested stakeholders to be able to evaluate the project's impacts to stakeholder interests. Article 7 of the National Glacier Protection Act states that "All activities planned on glaciers and in the periglacial environment, that are not prohibited, shall be subject to environmental impact evaluations and environmental strategic evaluations, depending on the scale of intervention, in which public citizen participation must be guaranteed".

[15] See for example: Glacier R 3145-7019: 31 45 51.34 S, 70 19 26.08 W; 3220-3470 meters

However, except for the 2008 EIA addendum, El Pachón's impact assessment documents are not available online. The province of San Juan, despite rhetoric suggesting otherwise, does not make the full array of available project documents easily, completely and readily available to the public. While it can be presumed that all documentation exists in electronic copy, in order to access documents, one must travel to San Juan personally and physically visit the mining office, and only in the short morning hours during which the office is open, request and pay for photocopies of each page one needs. Considering that EIAs are generally hundreds, even thousands of pages long, this *modus operandi* for information access makes *true access* to documentation, materially and financially impossible for stakeholders.

Xstrata does not publish the project's EIA on its website (*it should*), suggesting that stakeholders should contact the Province of San Juan or their local offices for documents, while the province suggests that they make all documents available to the public. This is a typical and characteristic vicious circle of access information *(which ultimately is inaccessible)*, of the mining sector in Argentina.

The following are the dates and targets of the requests we made to the company and to the State for the EIA information.

February 22:	vía email to Xstrata's Public Relations Office in Chile
March 4th:	In person request to Xstrata's Public Relations office in San Juan
March 4th:	In person and formal request to the provincial government of San Juan
March 29	vía email to Xstrata's Public Relations Office in Chile
April 7th:	vía email to Xstrata's Public Relations Office in San Juan
May 4th	vía email to Xstrata's Sustainable Development Chief for Argentina

Lastly, and worthy of mention, is that in the last few days before the publication of this report, Xstrata contacted our office and extended an offer to meet in person. CEDHA immediately accepted the offer and the author of this report met on May 12, 2011 in Buenos Aires, with Xstrata's Head of Sustainable Development of the El Pachón Project in Argentina. During that meeting, Xstrata indicated that they were willing to engage in discussions about our findings concerning the El Pachón project. CEDHA hopes that an engagement will ensue after this report is published and that we can collaborate constructively to ensure the fullest protection possible of rock glaciers and periglacial environments of the Andes affected by Xstrata's operations. We also extend this request to project operations that have taken place in the Filo Colorado project in Catamarca Province, which has also been the subject of a recent report on glacier impacts by Xstrata that we published.

Glacier References in Pachón's Reports

Sustainability Reports

Xstata's Sustainability Reports for El Pachón (2006, 2007, 2008, 2009) make no mention that there are rock glaciers or periglacial environments in the project area. This oversight, in the company's documents that are typically read by the general population, is at the very least troublesome, considering that the El Pachón project area is rich in rock glaciers and periglacial environment, and particularly given the recent widespread social and political concern over glacier impacts from mining in Argentina since late 2008.

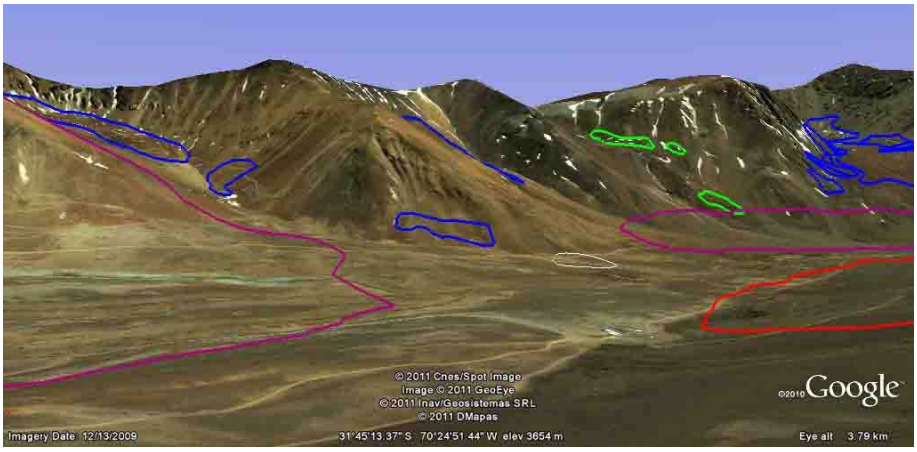
Ironically, several pictures in these reports show rock glaciers. For instance, page 28 of the 2006 report, shows several rock glaciers in the background. These are practically invisible to the untrained eye (appearing to most as rock since rock glaciers need not display visible snow or ice at their surface). Yet it is clearly evident that there are rock glaciers in these images when we examine

satellite imagery for landform geometry and surface flow structures, it is clear that *there are rock glaciers* and very likely periglacial environments in the report images.

Below is a photograph from Xstrata's Sustainability Report 2006 for El Pachón.

Photo: Xstrata's El Pachón Project (source Xstrata: Susainability Report 2006, p.28)

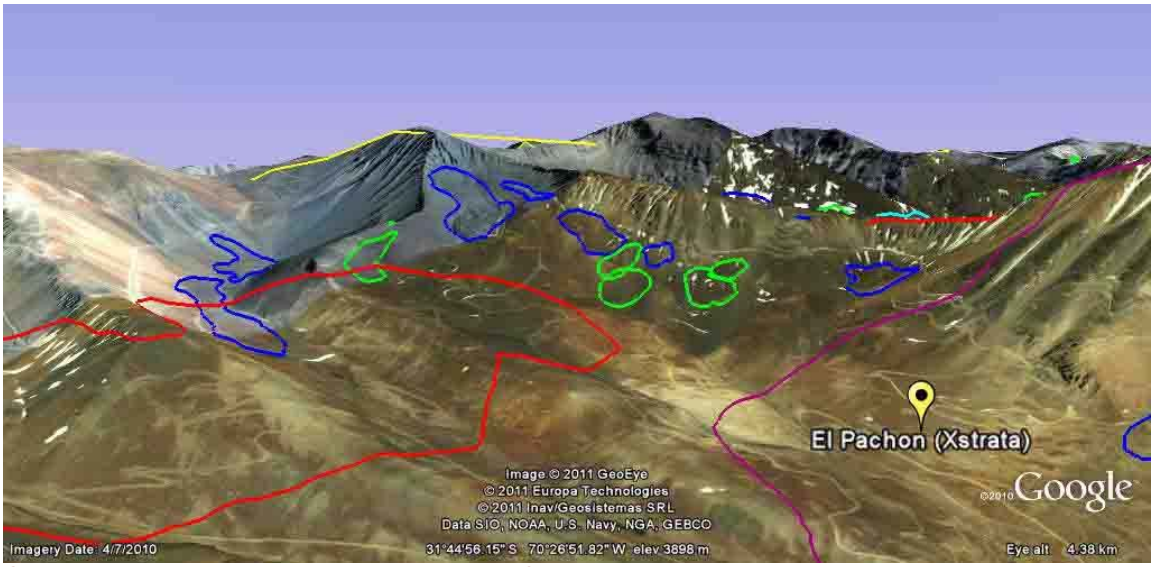
We can find the same site showed in the image, using Google Earth at:
[31°45'05.87" S 70°24'46.41" W], polygons in blue and green added to the image show multiple locations of rock glaciers at this specific site. The purple polygons are El Pachón's pit sites, while the red polygon is a tailing waste dumping site. The project campground shown in the first picture is visible in the Google Earth image as a small flat white mark near the bottom of the image, and off to the right of center.



A birds eye aerial view of the same site, more clearly shows the presence of more than 70 rock glaciers (in blue, light blue and green) in the general area of the photo. Purple polygon areas are destined for pit excavation, red for waste dumping, white for infrastructure.

In Xstrata's 2007 Sustainability Report, once again we find photographs that include numerous rock glaciers. The following is a picture on page 21 of the 2007 Sustainability Report from El Pachón.

The same image can be found using Google Earth, angling the compass bearing to NNW at: [31°45'07.34" S 70°26'44.66" W]. Tilting the image into 3D position we get the following satellite image (without the majestic condor) in which we've marked rock glaciers in blue and green contour, some 15 or more rock glaciers are present at this photo site. We also see the project pit site (purple polygon) as well as a waste deposit site (red polygon).



Google Earth Image (equivalent to Xstrata's 2007 Sustainability Report) reveals numerous glaciers

Environmental Impact Assessments

Despite our many requests spanning over several months, to Xstrata and to the Provincial Government of San Juan, requesting information about project impact reports, and particularly about information relative to rock glaciers and periglacial environments, for most of our work, we were unable to obtain the several documents that make up El Pachón's Environmental Impact Assessments. We eventually obtained *only* the 2008 EIA Addendum[16], and this just weeks before completing our research. We should note that the EIA Addendum was key to our analysis for this report, which goes to show how important it is for mining companies and State agencies to publish and make available all environmental study information for public consultation.

The 2008 EIA document makes some general observations about the existence of glacier areas in the El Pachón project impact area. A second document posted the same date, (*called Propiedades e Instalaciones*[17]) offers a geomorphological survey of the project zone, which includes mapping of rock glaciers and periglacial environment zones, as well as other glacier activity in the area. This map has been very useful to our report preparation, as it shows some *200 rock glaciers* inside the project's area, as well as extensive periglacial environment zones covering approximately 20% of the total project area. These zones are now protected by Argentina's National Glacier Act (promulgated in 2010) and by the provincial glacier law of the same year; they were not in 2008, the year the report was published.

The EIA document mentions glacial activity in the project area in Sections 3 and 5 of the report. Review of the information in the 2008 EIA Addendum and maps provide critical insight into El Pachón's impact on rock glaciers and periglacial environment regions. The company however, minimizes the projects impacts to rock glaciers and/or periglacial environment zones, even though several glaciers will be entirely destroyed and others severally damaged by project implementation. Some rock glaciers and periglacial environment zones have already been impacted by exploratory phases of the project. We detail these further down in this report.

[16] This document can be found at: http://www.mineria.sanjuan.gov.ar/pachon/PACHON_%202011_ADENDUM_EXPLORAC/URS-IIA%20Exploracion-Adendum-PACHON%20230109%20REV%2001%20CdV.pdf

[17] See: http://www.mineria.sanjuan.gov.ar/pachon/PACHON_%202011_ADENDUM_EXPLORAC/propiedades_e_instalaciones_XPSA.zip

In Section 3.3 (pp.11-12) of the EIA Addendum we find the first mention of *past* glacier activity in the El Pachón zone, but this phrase does not mention that rock glaciers exist presently. (We have provided our own translation of the original documents published in Spanish):

> "The present scenery is the result of a combination of endogenous processes, generating (tectonic and volcanic) formations and exogenous processes, both erosive and aggradations, produced principally by glacial, periglacial, fluvial and mass removal activity".

Shortly afterward (pp. 12-13) we find the following reference clearly establishing the presence of rock glaciers in the El Pachón area:

> "In regards to the cryogenic [ice] conditions of the area, the Carnicería, Pachón and Mondaca valleys are located in geo- and para-cryogenic zones (Corte, 1990) with the following characteristics:
>
> - Cryogenic Zones (periglacial environment zones): on south-facing mountain-sides these are found at approximately 3,800 meters [above sea level]. Presence of active rock glaciers and asymmetrical transversal profiles of the valleys;
> - Para-Cryogenic Zones: These extend below the previous and can reach as low as 2,400 meters [above sea level]."

In Section 5 of the EIA (beginning on page 59), environmental impacts are described. Subsection 5.3.6 (page 68) offers a brief description of impacts to geomorphologic elements.

> "The activities associated to potential geomorphologic impacts, correspond principally to the introduction and maintenance of roads, construction of platforms, pits and mini-pits." (p.68)
>
> … "These impacts will be localized, with a high probability of occurring, which will result in moderate impacts with certain prevention and mitigation needs. Amongst these needs, particular attention will be given to avoid affects to cryogenic forms or related geomorphological forms, and to minimize the erosive processes of mass removal. (p.68)

In sum, Xstrata recognizes:

a) that there are rock glaciers and periglacial environments in the El Pachón project area;
b) that there will be impacts to these rock glaciers and periglacial environment zones;
c) that measure will need to be implemented to minimize these impacts;

The legal implications of these statements regarding rock glacier and periglacial environment presence and impact, are critical, since from them we derive that Xstrata now needs to inform the National and Provincial governments of its rock glacier and periglacial environment impacts and that the corresponding State authorities must decide whether the project may move forward, whether it should repair damage, whether design should be modified, or whether the project should be terminated.

We find indications already in the 2008 EIA Addendum that Xstrata knows it needs more information about rock glaciers and periglacial environment impacts. Section 4.3.2.4 (page 48) of the 2008 EIA addendum indicates that Xstrata will "continue to study de avalanche of cryogenic forms at the mine and at the location of mine infrastructure". It is unclear whether this is due to the company's concern of terrain collapse and subsequent damage to their installations and works or because of the company's concern over the preservation of existing rock glaciers. Xstrata's

previous actions (for example at Filo Colorado) would suggest that the company has not taken measures or has any plans to preserve the ice forms.

On page 50, Section 4.3.2.8 states that Xstrata has "installed 6 meteorological stations which collect data to study cryogenic forms, avalanches and hydrology". Until our meeting just a few days ago with Xstrata, however, we could not presume that a full glacier and periglacial environment impact study was underway. Our only indication that a study was underway (and this seemed to be only an update of the 2008 EIA Addendum—which is already mandatory for the company), was an indication received from one of Xstrata's Public Relations officers in the region which communicated to us that Xstrata is,

> "in the process of completing an Environmental and Social Impact Study for the project and this will include a detailed analysis of the project area's periglacial environment and potential impacts on water resources. However, until we have completed these studies, there are no conclusions that we can share with you at this point."

Under the 2010 Argentine National Glacier Protection Act, the El Pachón project should have prepared a glacier impact report by April of 2011 in order for public authorities to adequately gauge rock glacier and periglacial environment impacts and make a determination if the project can go forward, whether it should make design changes, and/or if it should repair damages.

The National Glacier Protection Act mandates that any project in glacier, rock glacier or periglacial environment regions existing at the time of the adoption of the law (October of 2010), has 180 days to carry out impact studies in order to determine reparation activity, or if need be, to suspend or definitely cease operations. That study, as stipulated in Article 15, must be shared publicly and must take comments from interested stakeholders. The study for the El Pachón project should have been completed by end April 2011 and a public commentary period opened up at that point, the approximate timing of the publication of this report. To our knowledge, Xstrata has not invited the public to comment on its rock glacier and periglacial environment impact and risk and company assessments regarding these impacts and risks matter.

The meeting with the Xstrata official on May 12th 2011 revealed *informally* that indeed a glacier study is apparently underway or at least that the 2011 EIA Addendum update would include a review of rock glacier and periglacial environment impacts. That information, however, is not available anywhere in the public domain nor have we seen *terms of references* for the study. We are also concerned that the level of attention to specific issues in the 2008 version would not suffice to review rock glacier and periglacial environment impacts. A specific study on cryogenic impact is needed. The responsible State authority, which is the Mining Ministry of the Province of San Juan, has not released any document suggesting that it is presently requiring the company to produce a *specific report related to glacier impact* as mandated by national and provincial law.

We are greatly concerned by the lack of controls the Provincial Government and other provincial authorities have shown regarding glacier impacts. Statements by the authorities and their actions suggest that the province is not pushing to protect glacier resources, but rather, is covering up mining impacts, leaving glacial resources at great risk.

A recent legal complaint attacking the National Glacier Protection Act filed by the company Barrick Gold (a company which has caused extensive damage to glaciers in the Veladero and Pascua Lama projects), for example, has been supported by the Provincial Government of San Juan which has now joined the lawsuit as plaintiff.

We are surprised for example, that the Province assigns as coordinator of the glacier inventory, Mr. Silvio Peralta – Director of Geology of the Exact Sciences at the National University of San Juan, but which has no previous manifest experience in glaciology. We should note that the most recognized glacier expert of the province, and one of the most knowledgeable Argentine

glaciologists resigned from the inventory team due to his displeasure over the official handling of the inventory. Peralta states publicly in a most simplistic and unprofessional way,

> "We have not seen glaciers affected by mining activity, nor by any other industrial activity" [he was alluding to controversy over provincial road work that has been shown to impact glaciers], "we've seen that the glaciers are *'over there', nearby,* but mining activity doesn't reach them and doesn't affect them". [18]

Milana's resignation from the glacier inventory, which he authored came after incidents such as the government's decision to leave off entire sections of San Juan's territory off of the inventory maps and to not indicate the precise location of glaciers. Coincidently, the portions not reported on contain many of San Juan's large mining projects. The area encompassing the El Pachón project, for example, does not appear on any of the glacier inventory maps. [19]

Peralta has also made recent declarations in the press suggesting that mining projects are not located in glacier areas. He stated in a local daily,

> "Mining, according to its present development, at least in the Province of San Juan, does not destroy glaciers since the mining activity underway, both those at high altitudes such as Veladero and Pascua Lama and Pachón, as the others are not at altitudes above 3,500 to 4,000 meters. Considering that the preservation of glaciers is between 4,600 to 4,800 meters in the winter and 5,000 meters in the summer, this is evidence that there is no relation between zones of industrial activity such as mining and the glaciological zones where glaciers develop". [20]

It is clear that San Juan's highest official voice on glacier conservation is misleading the public. First of all, glaciers elevation persistence does not vary from season to season. Glaciers persist, form, evolve, move, and are dynamic year round, they are perennial. Snow may accumulate at different elevations according to the season in the vicinity of a glacier, but the glacier itself will not incorporate that snow at varying elevations. In fact, glaciers incorporate snow at very precise locations on their mass. It is impossible to have glaciers appearing and disappearing at 4,600 to 4,800 meters in the winter time and at 5,000 meters in the summer time, as Peralta's comment would suggest.

Further, CEDHA's work on glacier inventory *has* found mining impacts to glaciers in northern San Juan, including extensive mining exploratory roads crisscrossing mountainsides in the vicinity of the Potro Glacier. We also know of white glacier impacts by projects like Veladero in high altitude regions. We have also seen further information suggesting that Pascua Lama may also be affecting glaciers in the project vicinity in San Juan Province.

However, the Province's Official Inventory left glaciers in the most northern 15 kilometer strip of the province, off of the inventory. Coincidently, that's where many of the mining projects are tearing into mountainsides looking for minerals. This omission and many others evident in the December 2010 provincial glacier inventory is in part the reason Milana resigned as head of the inventory, and Peralta took over.

The province is playing with a nuanced difference between white glaciers and rock glaciers, suggesting that the essential discussion (which is the protection of cryoforms) does not include rock glaciers, which by both provincial and national law, is simply not the case.

Peralta does suggest that

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[18] Diario del Cuyo. December 30th, 2010. See: http://mineroargentino.com.ar/?p=274
[19] For San Juan's Official Glacier Inventory (work in progress) see: http://www.cedha.org.ar/contenidos/Relevamiento_Inicial_de_los_Glaciares_de_SJ_Dic_2010.pdf
[20] http://www.diariodecuyo.com.ar/home/new_noticia.php?noticia_id=458732

> "Mining is generally located in areas which have rock glaciers". But then he makes another simplistic and unfounded comments indicating "I have seen that the glaciers near Veladero, are placed around the mining operation, but in no way is the mining operation placed on any type of rock glacier".

We are extremely concerned by the way the Province has downgraded its glacier inventory team, placing at its head a person who is clearly not trained in glaciology, and that has already made several statements showing his ignorance or worse, his willful deceit in regards to mining impacts to glaciers, rock glaciers and periglacial environments.

There *is* one other publicly available document indicating that the Province of San Juan realizes that further information about glacier impacts of El Pachón are urgently needed.

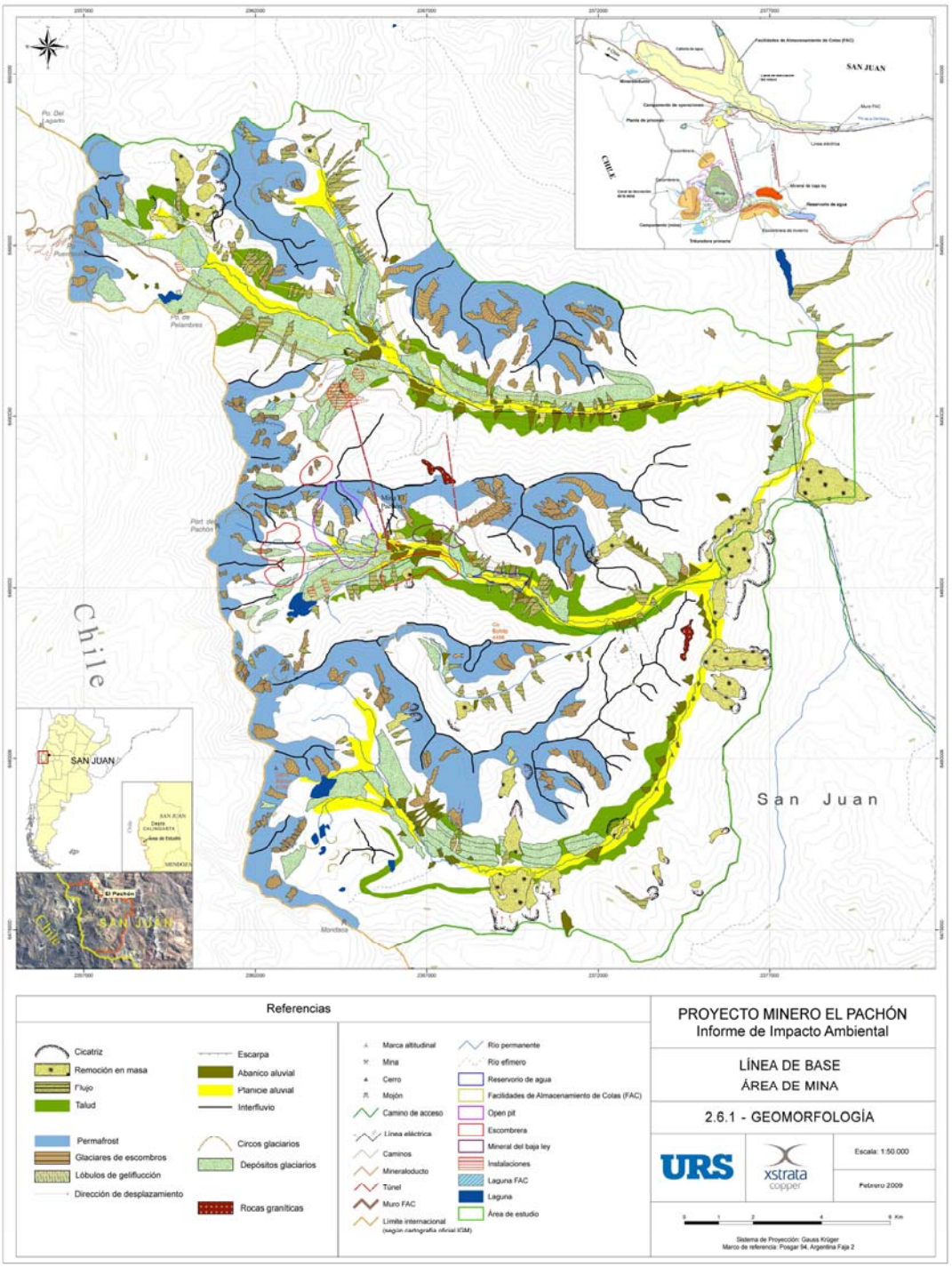
Appearing alongside the 2008 EIA Addendum report a few weeks ago, the provincial mining website posted Resolution 046 DIA Pachón, dated 23 February 2009 (two years old) of the Mining Secretariat of the Province of San Juan. Article 3, point (8) of the resolves of this resolution, states the following which would indicate that a general request has been made to the company, among a series of other points of clarification—however this would not necessarily provide the information needed according to the National Glacier Act (we translate the original Spanish text):

> "8. the company must expand and present before this authority, glacier studies in the Pachón project's area of exploration". … "

Article 4 of the resolution establishes that Xstrata must "present in a maximum period of two years a report containing the results of the environmental protection actions taken, as well as new issues that might have occurred." The two year period expired February 23rd, 2011. Xstrata is already more than two months late with this report. We do not know, however, of any publicly available report offering the information mandated from Xstrata by this resolution. We also are unclear if the report mentioned by the public relations officer is this report or not.

Glacier Mapping in the 2008 EIA Addendum

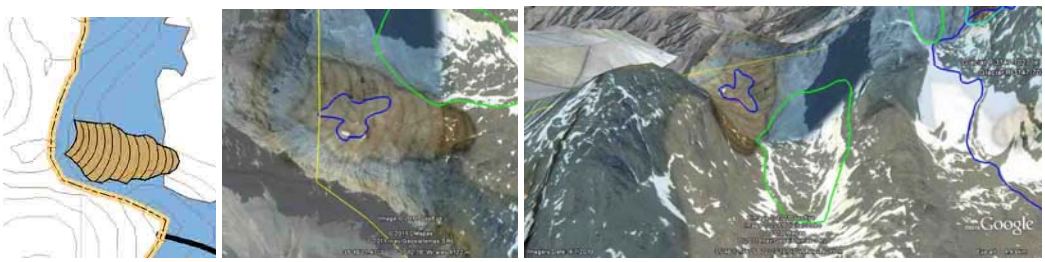
The following geomorphological map in the 2008 addendum offers information about Pachón's impacts to rock glaciers and periglacial environmenst. It can be downloaded from our website:[21]



[21] http://www.cedha.org.ar/contenidos/MAPA%202.6.1-AM-GEOMORFOLOGIA.jpg

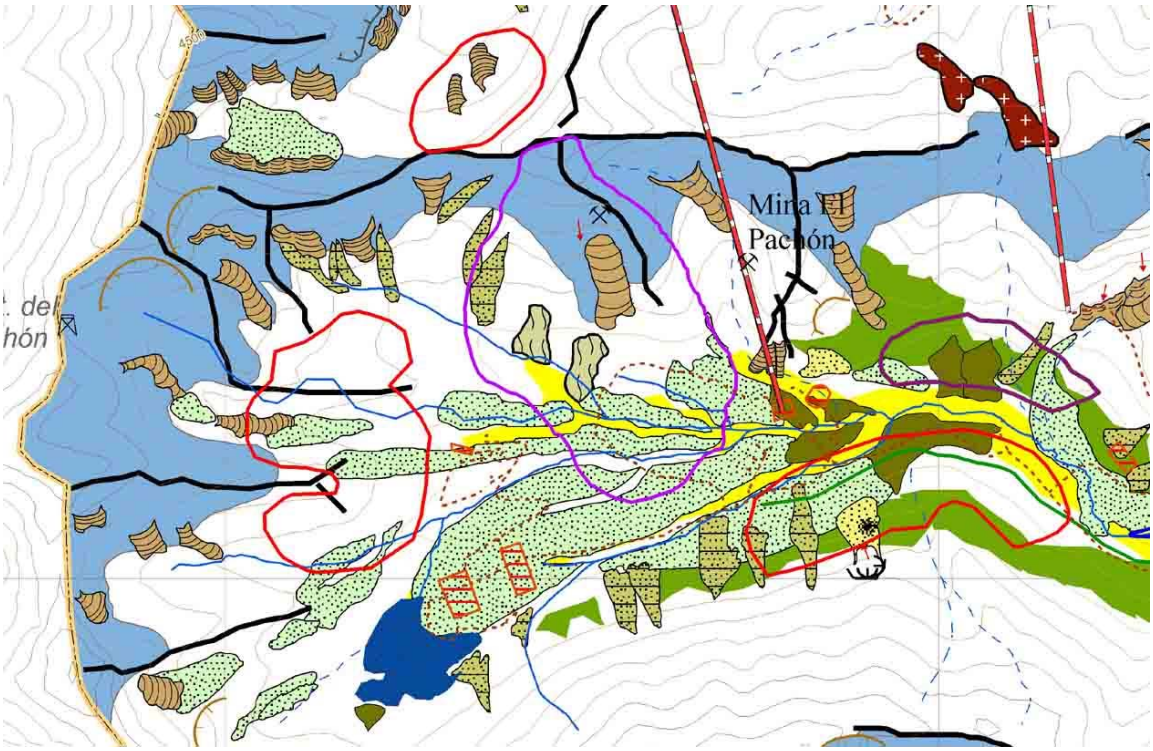
A few key elements in the mapping to note.

Light blue regions are permafrost. Rock glaciers are represented as brown rock-like shapes with striped black lines showing flow direction. In the following example, the picture on the far left is from Xstrata's Geomorphological Survey Map. We see a rock glacier flowing downhill inside a periglacial environment zone (in the blue area). The actual image of this glacier (taken from Google Earth) is shown immediately to the right (the center image), with the Survey Map image superimposed in transparency. In our own survey we differ in the interpretation of the location and structure of this glacier (our inventory shows the glacier to have a slightly different form than that reported by Xstrata (see the blue polygon). We have identified another rock glacier above the geomorphological survey mapped rock glacier (the green polygon), not included by Xstrata in its inventory. We've provided a third image (far right) showing an up-close visual of the two rock glaciers we have inventoried. The reader can visit this site using Google Earth at: [31°48'19.62" S 70°27'15.18" W]



In the following section of the map there are several other elements worth noting:

- The projected mining pit areas are outlined in PURPLE.
- The mineral tailing waste accumulation sites are outlined in RED.



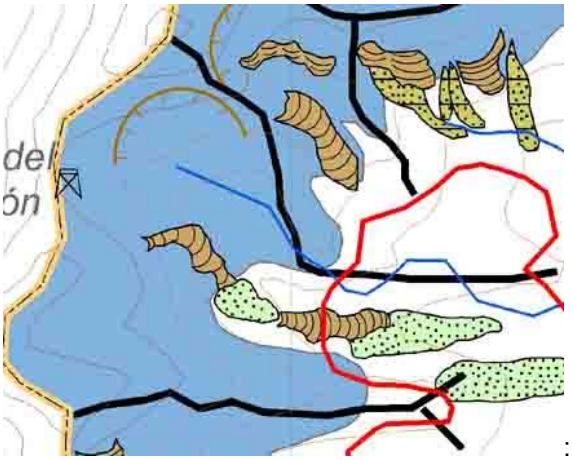
Note that inside the main pit area, according to Xstrata's own map, there is a prominent rock glacier. This glacier will be entirely destroyed by the excavation. This site can be viewed at: [31°44'58.73" S 70°25'41.96" W]

Further, in the mineral tailing waste deposit areas, the images show three rock glaciers. Any additional weight placed on rock glaciers can greatly alter ice structure balances, which can lead to the eventual collapse of the glacier. Acid drainage from the waste also contaminates the ice and water that melts from the glaciers. This drainage, if fed into the nearby streams, could end up in San Juan's river system contaminating agricultural lands and drinking water.

Mapping rock glaciers from satellite imagery with accuracy depends on precision imagery. Periglacial environment areas meanwhile, are not possible to map from satellite imagery alone. Our review and comparison of this map with our own inventory, reveals that more than 60 rock glaciers are missing from Xstrata's inventory, which would also suggest that periglacial environments may have also been missed.

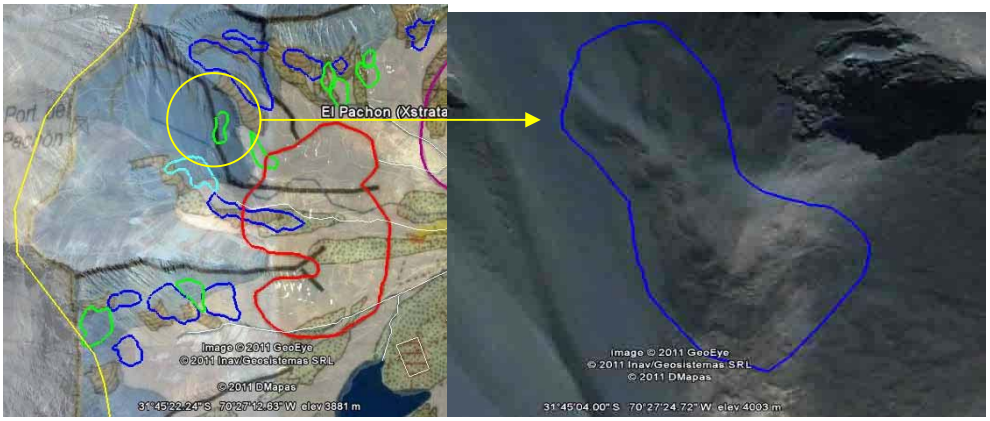
For example:

In the following portion of the geomorphological map we see 6 rock glaciers, one of which is inside one of the tailing deposit sites.



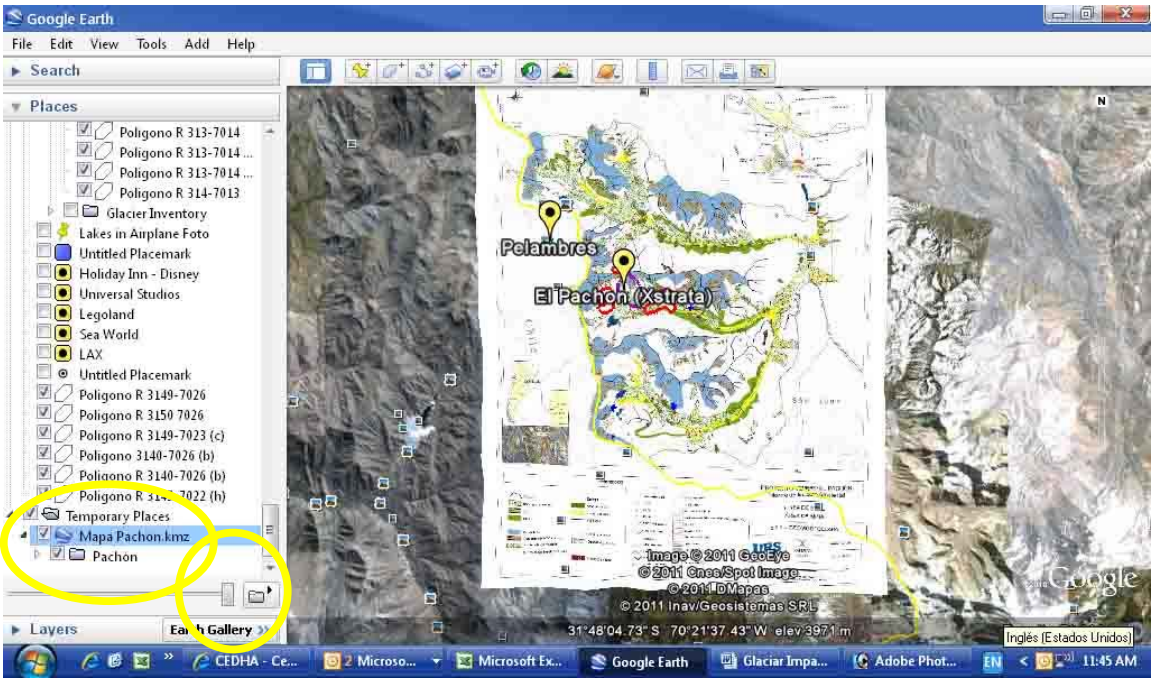
:

In the next image, our review of the same area with the geomorphological map as a transparency [31°45'09.86" S 70°26'59.92" W] reveals at least 15 rock glaciers (blue and green polygons); at least 8 of which (in green) have been left out in the 2008 EIA. To the right of the image, we've amplified the image to show one of the missing glaciers. (view at: [31°45'04.00" S 70°27'24.72" W])


El Pachon (Xstrata
Image © 2011 GeoEye
© 2011 Inav/Geosistemas SRL
© 2011 DMapas
31°45'22.24" S 70°27'12.63" W elev 3881 m
Image © 2011 GeoEye
© 2011 Inav/Geosistemas SRL
© 2011 DMapas
31°45'04.00" S 70°27'24.72" W elev 4003 m

We have converted Xstrata's geomorphological survey map into a [.kmz] file which can be opened and viewed in Google Earth, to compare the company's glacier inventory, mining pit, waste deposit sites, and other infrastructure with our own glacier inventory. The reader can locate and download this file from our website (It's large at 4MB, so be patient!).[22]

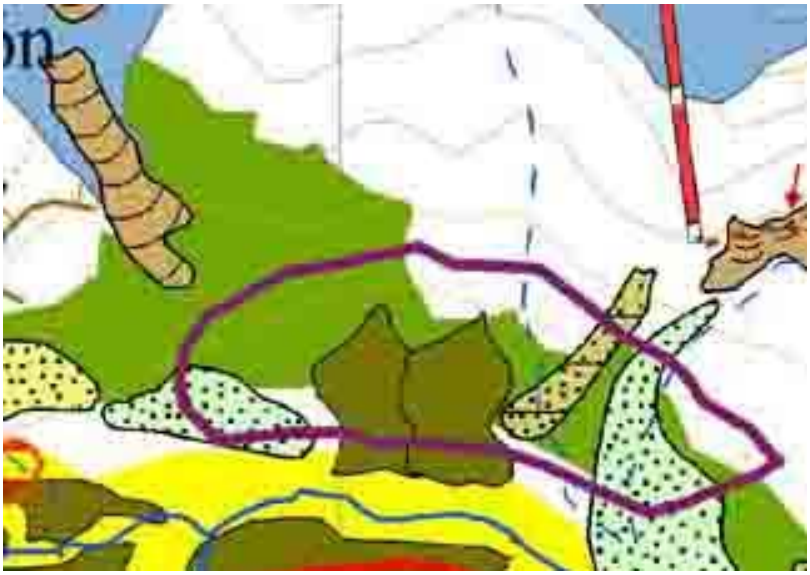
When you open this document in Google Earth, you will see the following appear:



Note the appearance of the file at the lower left as "Mapa Pachón.kmz" (marked in the image inside the yellow oval). If it doesn't appear, you may have to tick off the box next to the file name to have the map appear or disappear at will. Also note the transparency adjustment tool (marked in the image inside the yellow circle). By adjusting the transparency level (by moving the lever left or right), you can juxtapose the map and the Google Earth image, and any other markers you may choose to add to *your* Google Earth, and compare the company's glacier inventory and various project infrastructure to the actual terrain and to your markings. This tool is convenient to properly analyze project related infrastructure mapping provided by the company to the actual environment. Below, in the following image, we provide a sample image showing the geomorphological survey map superimposed with the Google Earth image and our own inventory.

[22] See: http://www.cedha.org.ar/contenidos/Mapa%20Pachon.kmz

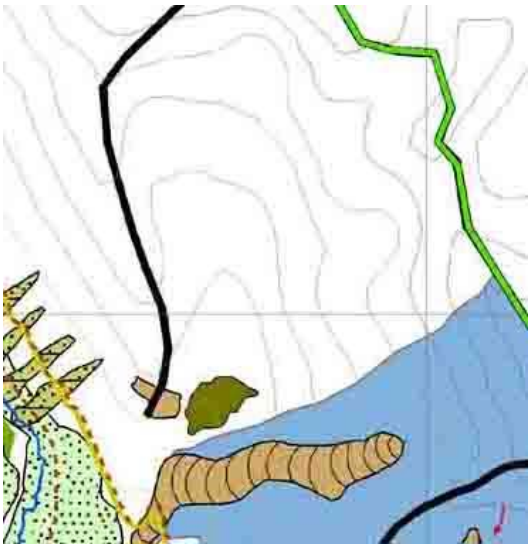
Returning now to Xstrata's reporting of glaciers, in another example of *glacier under-reporting* of the 2008 EIA Addendum map, in the following segment, showing the area at, and above, the second pit site of the mine (outlined in purple), the reader will notice that in the center and above the pit area of the equivalent Google Earth image at: [31°45'11.46" S 70°23'59.95" W] there are three additional glaciers NOT mapped in the Xstrata inventory. (we've circled these in yellow).



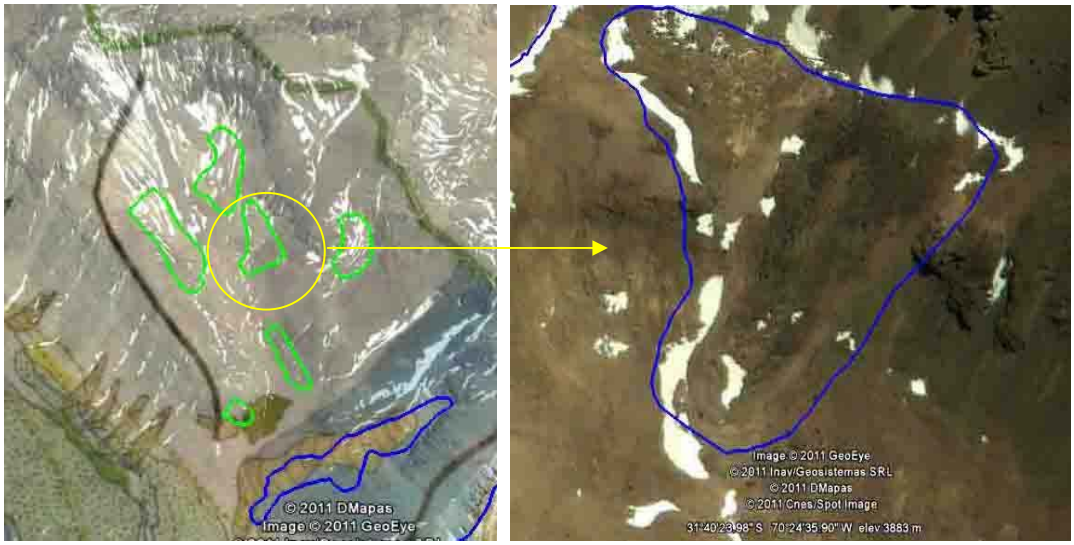
The next image shows a 3D Google Earth image at: [31°45'05.89" S 70°23'56.78" W] of the rock glacier located on the edge of the pit that was missed by Xstrata's inventory.

Finally, a last example of glacier under-reporting follows**.** These can all be found in the last pages of this report, in the El Pachón Glacier Inventory. The rock glaciers in GREEN type (which correspond to the green polygons in our maps and *kmz file*) have been left out by Xstrata.

In the following image excerpt from the 2008 EIA Addendum, we see one large rock glacier and a very small rock glacier slightly above and on the left end this larger glacier.



The image below on the left is the equivalent Google Earth image [31°40'28.02" S 70°24'31.61" W] revealing at least 5 additional rock glaciers that have not been reported. The image on the right amplifies one of the unreported rock glaciers in 3D format [at: 31°40'23.98" S 70°24'35.90" W]. We can presume that this area also includes periglacial environment not mapped by Xstrata.



Publications Confirm El Pachón Impacts Rock Glaciers

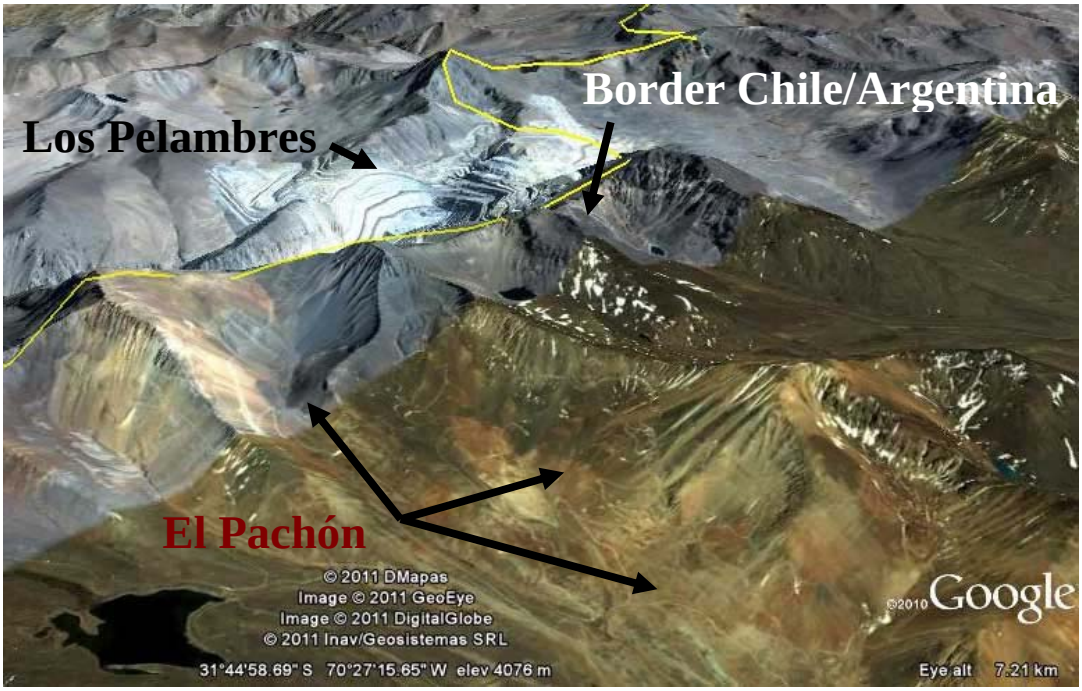
There have already been several rock glacier experts that have alluded to the impacts of Xstrata's mining project to glaciers in the El Pachón project vicinity. Brenning (technical contributor to this report) and Azócar 2010, who have looked closely at satellite images and aerial photographs revealing the rock glacier impacts of the Los Pelambres copper mine just over the mountain crest from El Pachón (and across the border into Chile), mention mining impacts to rock glaciers in Argentina (translated from Spanish):

> "We can already observe minor impacts to rock glaciers due to the construction of roads in the projects, El Pachón, Los Azules and probably El Altar".[23]

Below is an image taken from Google Earth which shows the close relationship between El Pachón (Argentina) and Pelambres (Chile)—the two projects are immediately adjacent to one another. (see this image at: [31°43'26.42" S 70°27'11.56" W]). The yellow line in the image is the international border formed by the highest points along the Andes combined with watersheds. Los Pelambres, which shows a pit in operation, is already in full implementation. The copper deposit of both projects belongs clearly to the same mountain; they are each on opposite sides of the same range. Numerous rock glaciers have also been severely impacted in the Chilean Pelambres project. (Azócar & Brenning, 2008).

[23] See: Brenning & Azócar, 2010 p.154

A 3D view of the same area follows:



Arenson, et.al (2010) in a recent publication closely examine the presence of rock glaciers in the El Pachón valley of San Juan. According to the informal information we have received from multiple sources, these authors are carrying out, under contract with Xstrata, a glacier inventory and impact analysis, however, we have not seen any formal confirmation of this report or more importantly, the *terms of reference* to determine if it will shed light on the concerns raised in our report, for example, if the study will make recommendations about impact and reparations.

Impacts to Rock Glaciers and Periglacial Environments by El Pachón

Review of the limited available documentation from Xstrata as well as satellite imagery, indicate that the El Pachón project zone is rich in rock glaciers and periglacial environment. Project areas extensively intervene periglacial environments and penetrate, are adjacent to, or are extremely near enough to rock glaciers and periglacial environments to warrant an in-depth study of past or potential future impact from mining activity.

The present Argentine National Glacier Protection Act (October 2010) prohibits much of the activity that has taken place and that is planned for implementation of the El Pachón project. Simply stated, as is, the El Pachón project does not comply with national or provincial glacier protection laws.

Exploratory and Access Roads

Earlier aerial imagery dating to 1996 shows that several exploratory roads are recent suggesting that they have been introduced by Xstrata, while in a few cases, impacts to the rock glaciers predate the Xstrata purchase of El Pachón. In either case, Xstrata is responsible for addressing any past environmental impact as well as any present impacts they have caused to these rock glaciers and to periglacial environments. It should be noted that the maintenance of existing access roads can cause ongoing impacts to glacier preservation and sustainability, since companies generally try to avoid water flow from entering road areas. Glaciers, by contrast, need that water for their own sustainability.

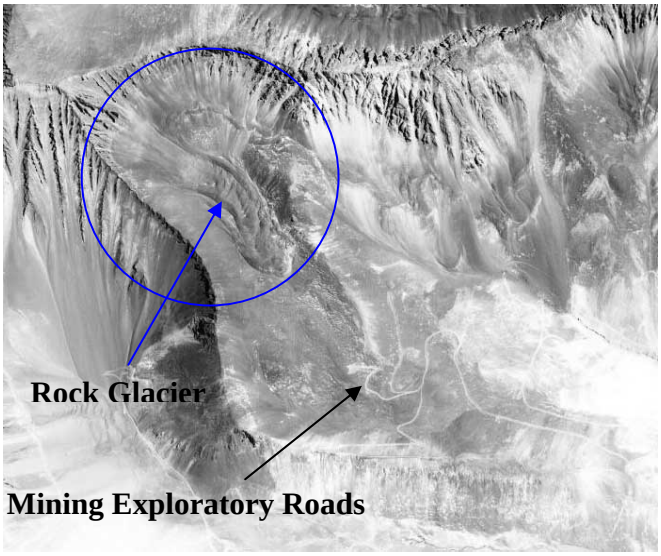
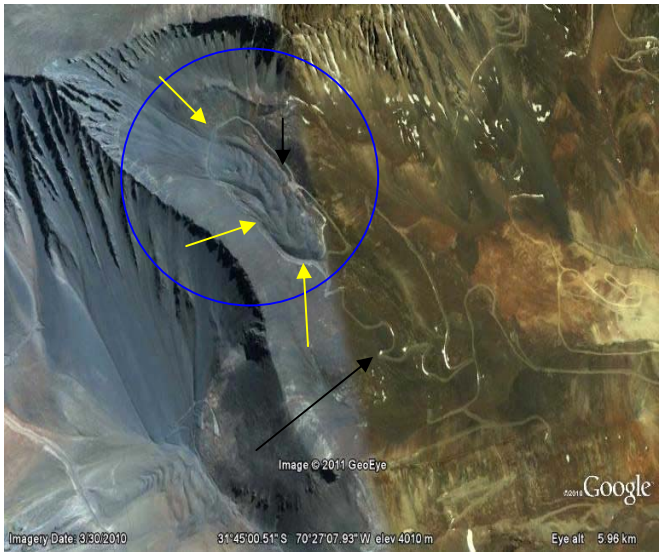


Photo: Aerial Photograph 1996 (before Xstrata Intervention)
Black arrows show exploratory roads



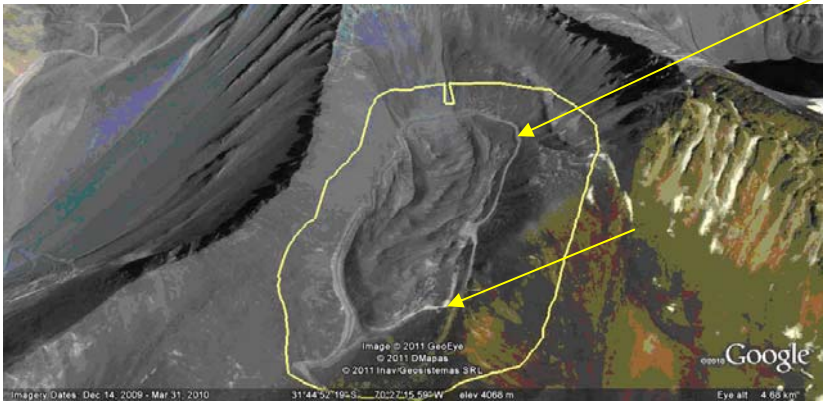
Google Image: March 2010 (after Xstrata Intervention)
Black arrow show past, yellow-new exploratory roads

In the above photos taken in 1996 (aerial photo from flyover; source: Servicio Aerofotogramétrico, Chile) before Xstrata became involved with El Pachón, compared to the Google Earth image taken in March of 2010, well after El Pachón became property of Xstrata, we notice how exploratory roads introduced in the El Pachón project in subsequent years (see yellow arrows) were expanded into a rock glacier (indicated by the blue circle) nested in the mountain valley. The road surrounds and actually crosses the rock glacier at it's' source, which for a rock glacier can mean that it will be eventually strangled and dried up. These roads need to be eliminated and the glacier surfaces restored as much as possible to their pre-intervention state.

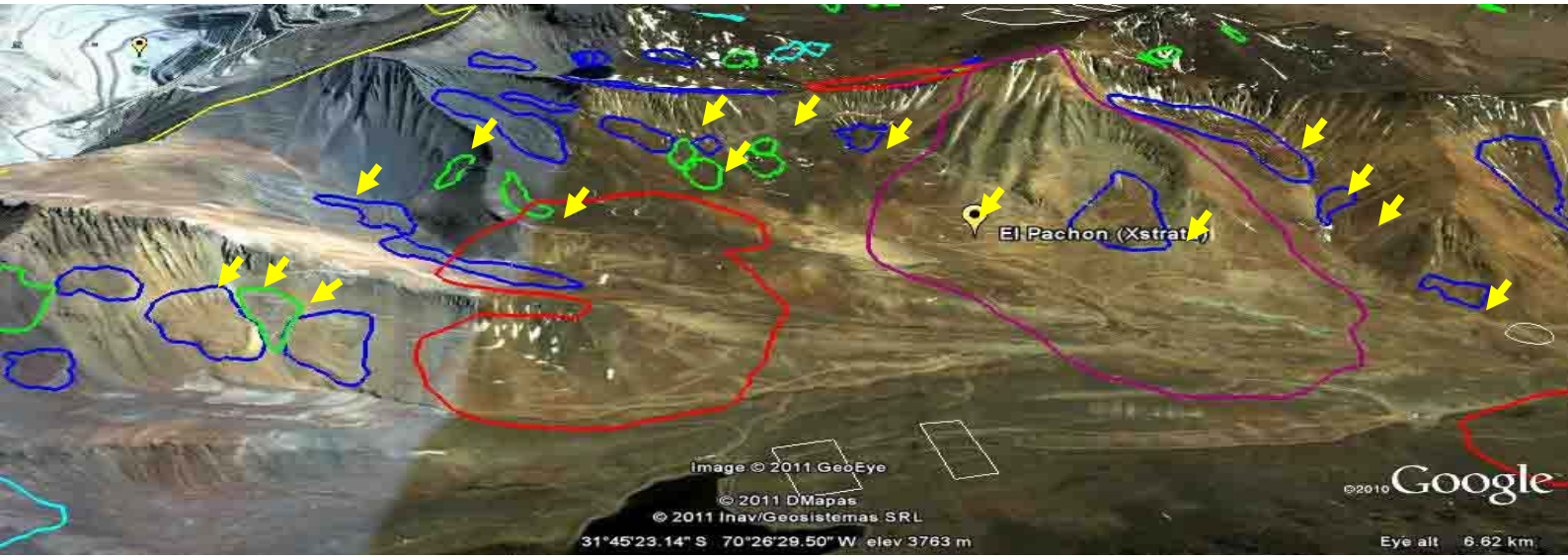
To see this site for yourself, visit in Google Earth: [31°45'00.51" S 70°27'07.93" W]

We can see a 3-Dimensional image of the impact by Xstrata to the above mentioned rock glacier by tilting the image in Google Earth at this site. To do this, once you are at the glacier site by going to [31°45'00.51" S 70°27'07.93" W] click on the upper arrow of the cardinal reference circle in the upper right hand corner of the Google Earth screen. Then use the up/down/left/right arrows of your keyboard to position the image as you prefer to see it in 3 D format.

After tilting the image properly, you can see a full 3-D view (see below) of the rock glacier impacted by El Pachón. As clearly visible by satellite imagery, the exploratory road introduced by Xstrata completely encircles the glacier, and crosses the rock glacier's so-called *rooting zone*, which is the area where rock fragments and snow accumulation feed the rock glacier.



Several satellite images available from the immediate El Pachón site indicate that numerous exploratory roads have had extensive impacts to rock glaciers in the El Pachón valley and surroundings. The following image shows at least a dozen other rock glaciers affected by El Pachón's exploratory roads. We can clearly see the zigzagging roads go up and down the mountain sides, in some cases penetrating rock glaciers indiscriminately. In other cases, the roads are adjacent to the rock glaciers, some of these in their rooting zone, i.e. the area in which the deposition of rock fragments and snow 'feed' the rock glacier.



Rock glaciers affected by El Pachon's exploratory roads.

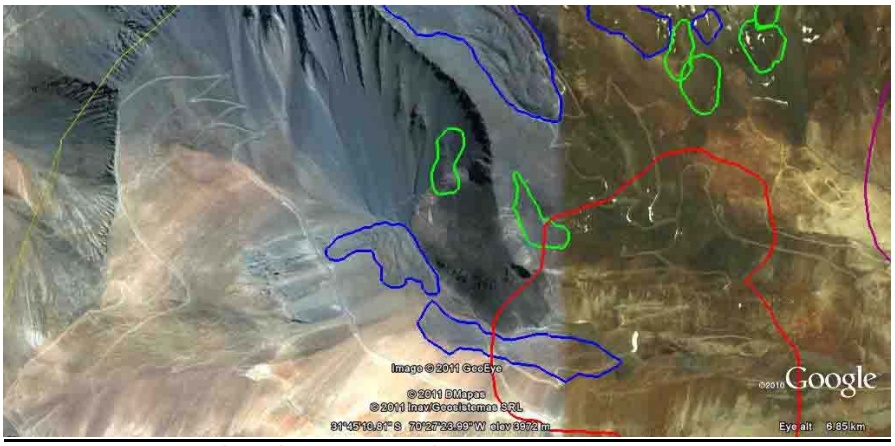
In the next image, once again, exploratory roads for El Pachón, directly impact rock glaciers. (See image at: [31°45'54.10" S 70°27'24.33" W])

Photo: Exploratory Roads zigzag through, adjacent to, or near 3 Rock Glaciers

No exploratory roads are visible in the 1996 aerial photograph of this same site (image source: Servicio Aerofotogramétrico de la Fuerza Aérea de Chile, SAF, GEOTEC flight):

In the next example, the following image from Google Earth, which you can visit at: [31°45'16.79" S 70°27'42.57" W] shows once again, exploratory roads for El Pachón crossing or pushing up against rock glaciers, although in this case, the 1996 photograph would indicate that the roads predate Xstrata's ownership of the project. As already mentioned, this does not preclude in any way that Xstrata is exempt from the responsibility of environmental harm caused by El Pachón to these rock glaciers, particularly as any maintenance or usage of these roads continues to impact these glaciers. Even leaving these roads as they are impacts these rock glaciers. Xstrata should in this case, assume responsibility for past and present environmental harm, correcting this harm and avoiding any further impact to these glaciers.

(See Image at: [31°45'11.28" S 70°27'39.61" W])

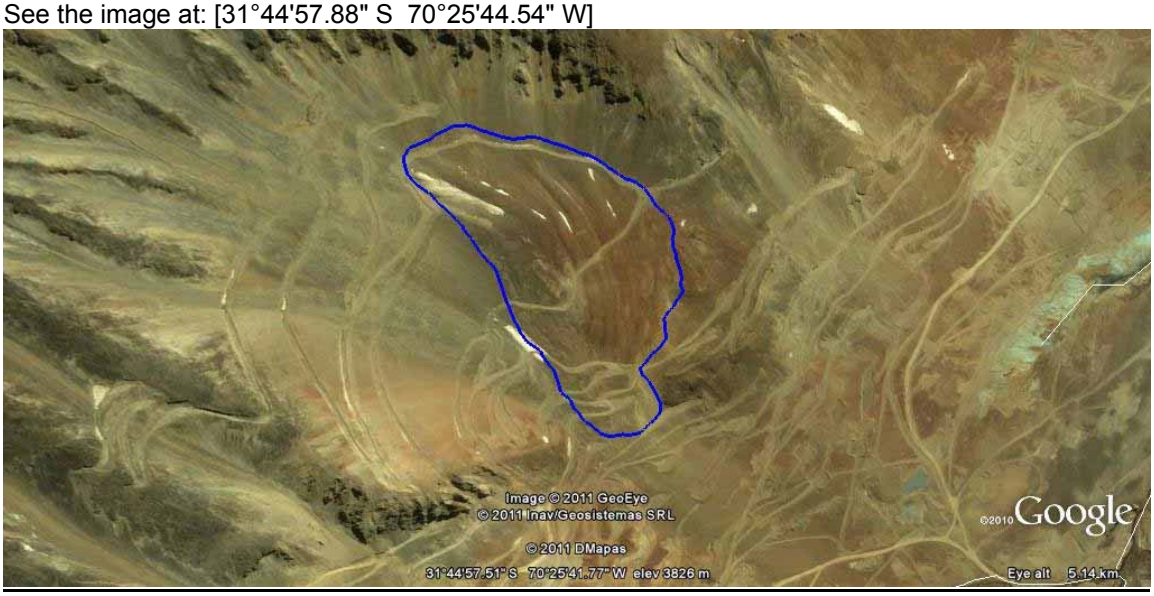


Recent Image taken from Google Earth of the 1996 Photograph (below)

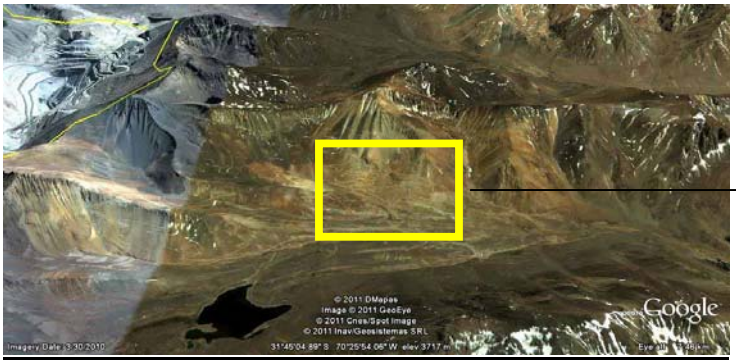
1996 Photo shows in this case, preexisting impacts to rock glaciers.

In the following picture, we see a rather large rock glacier with multiple cuts from exploratory roads of Xstrata's El Pachón project. This rock glacier is located in the middle of where El Pachón will introduce its pit. If the pit is to remain at this location, this rock glacier will be entirely destroyed. That would be illegal under provincial and national glacier protection laws.

See the image at: [31°44'57.88" S 70°25'44.54" W]



Glacier to be destroyed by El Pachón's main Pit Excavation

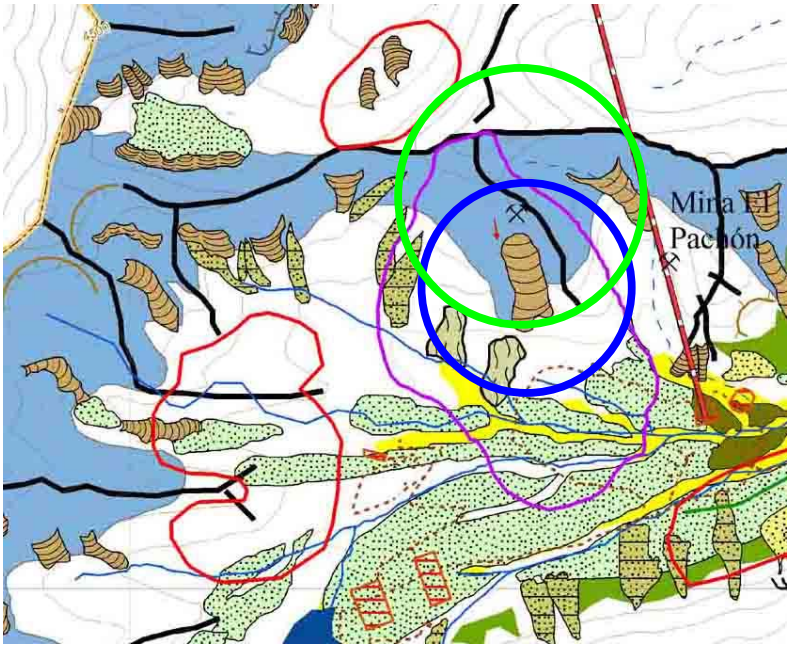


Enlarged Area

Pit Excavation

El Pachón contains two pit areas, both of which contain rock glaciers which will be partially or entirely destroyed by project implementation.

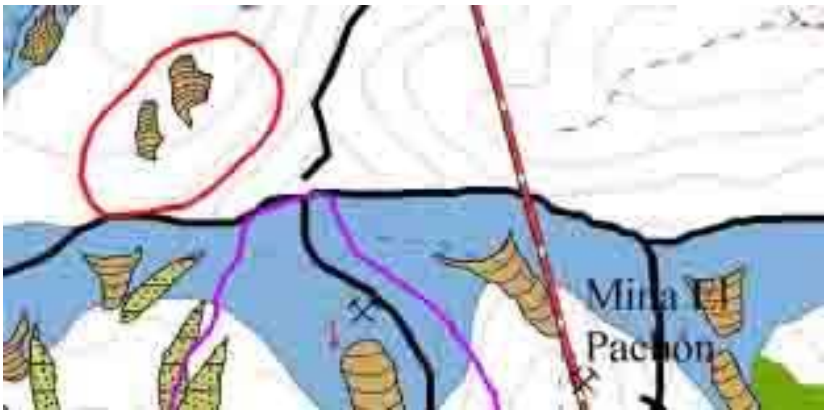
In the first and most serious case, the following map image from the 2008 EIA Addendum shows a large sized rock glacier in the middle of the pit (pit area in purple, blue circle shows glacier). This glacier will be entirely destroyed by mineral extraction. The reader can see the section below on the nearby similar Los Pelambres copper project to see *before and after* pictures of how rock glaciers are destroyed when they are located in open pits.



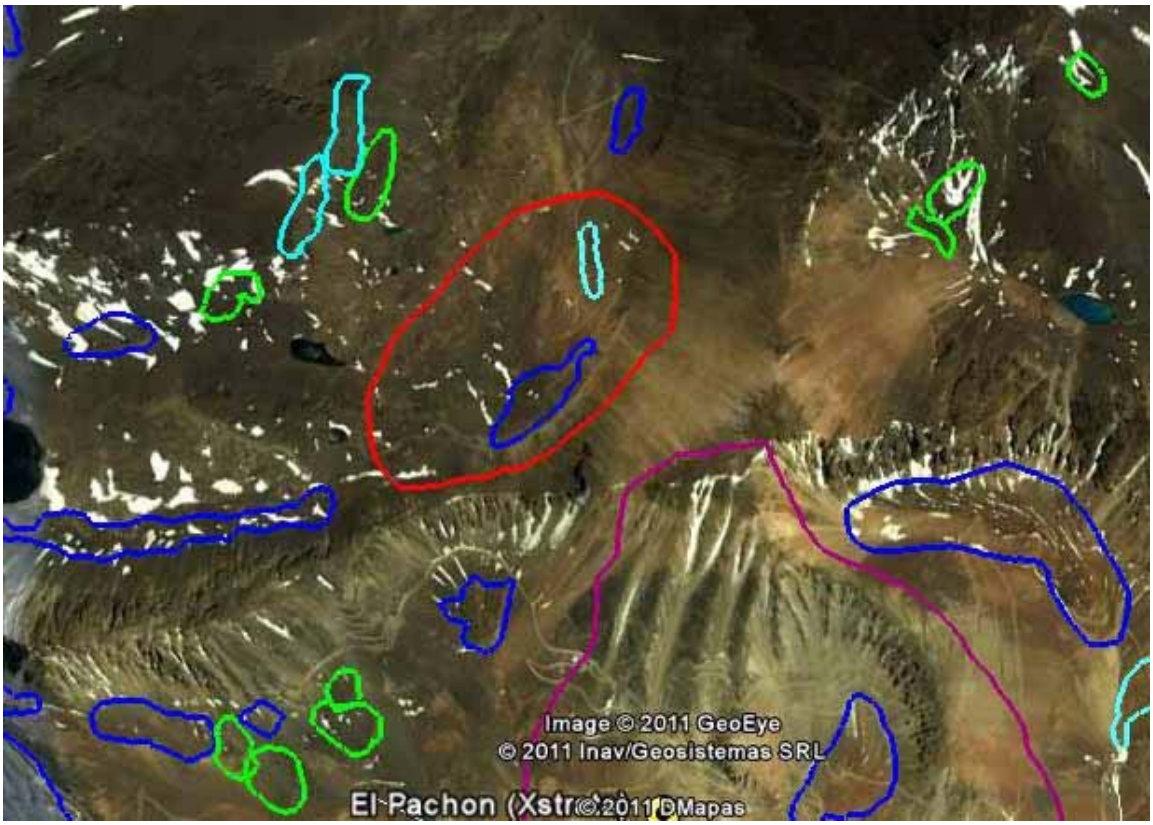
We also see that the pit area includes nearly 30% periglacial environment (see the blue colored areas inside the green circle we've added to show the spot), which will also be destroyed by excavation of the pit. Clear from the image we showed above in the section on Glacier Mapping, the second pit borders rock glaciers. Those rock glaciers are at enormous risk of suffering partial or complete destruction from mineral excavation.

Mineral Tailing Waste Deposits and Acid Drainage

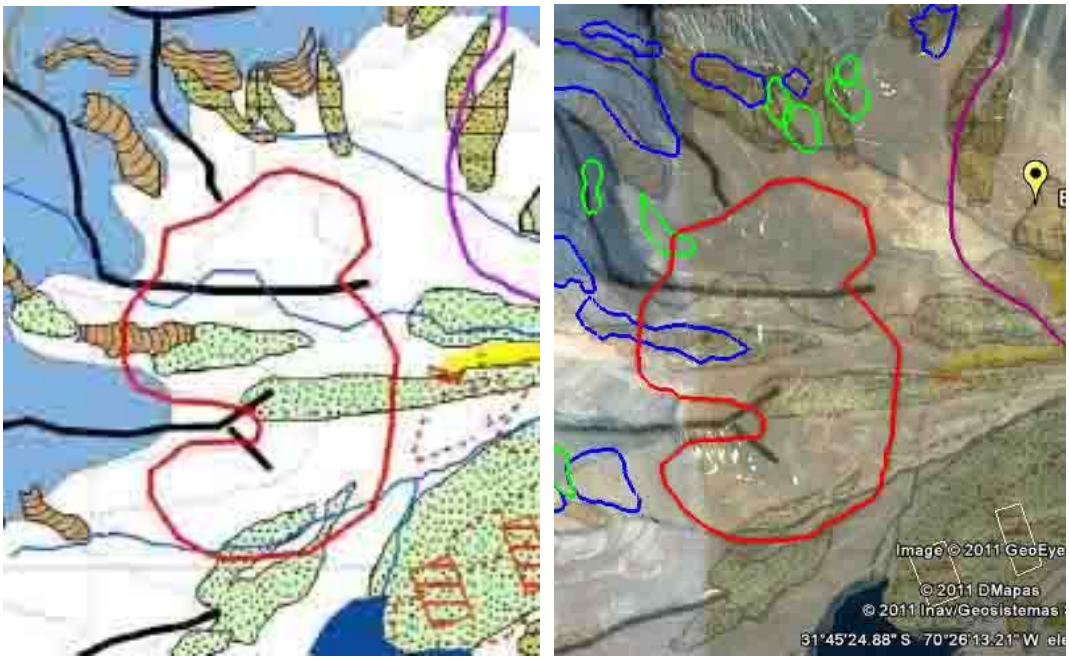
We can also see on the 2008 geomorphological survey map that sites destined for mineral tailing waste deposit contain glaciers. The mineral tailing waste deposit site (shown below encircled in red) has two prominent rock glaciers inside the projected site.



A Google Earth Image [31°44'15.79" S 70°26'09.58" W] reveals that Xstrata has also under-reported glaciers at or near this site, and probably periglacial environments as well. The image below shows at least 5 rock glaciers near the mineral tailing waste deposit site. Two unreported rock glaciers are near the pit, close enough for potential risk. The rock glaciers we've mapped (in blue) which correspond to the two by Xstata are slightly further SE from the site indicated in the Geomorphological Survey Map.



The other mineral waste deposit site is marked in red in the following image taken from the 2008 geomorphological survey. A Google Earth image is offered to the right with transparency of the map as well as our glacier inventory added.



In this image we see one rock glacier entering the mineral waste deposit area from the middle left. The reader can visit this site on Google Earth at: [31°45'29.47" S 70°26'38.88" W] We show that an additional rock glacier (in green) not mapped by Xstrata in the upper left portion is also partially inside the waste dump site.

Glaciers and rock glaciers are geo-mechanically dynamic features that are sensitive to mechanical interventions due to, for example, the deposition of material on their surface. The creation of an overload on a rock glacier's surface will increase its deformation velocity and may possibly lead to instability or even collapse of the structure. This has been extensively observed and documented at two mine sites in Chile, where rock glacier velocities increased from around 1 meter per year to 20-30 meters per year after the deposition of waste rock, causing instabilities and affecting the mine's operation in at least one instance (Contreras & Illanes, 1992; Apablaza et al., 2001; Valenzuela, 2004; Brenning, 2008; Brenning & Azócar, 2010).

In terms of environmental harm, this impact is further amplified by acid drainage from the contaminated minerals deposited on the rock glacier, which seep through the ice and contaminate ice and water, and which may also heat the ice, possibly affecting the permafrost and slope stability. (Brenning & Azócar, 2010)

Rivers and Streams in the El Pachón Project Area

The Argentine National Glacier Protection Act[24] specifies that (unofficial translation):

> "we understand by the periglacial environment of high mountains the area with frozen ground acting as regulator of the freshwater resource. In middle and low mountain areas, it is the area that functions **as regulator of freshwater resources** with ice-saturated ground." (bold added)

Rivers, especially in arid regions of provinces like San Juan, depend on seasonal snowfall, and remaining ice in periglacial environments, rock glaciers, and where present, uncovered "white" glaciers, to provide water year round.

This report section focuses on the importance of rivers in the Pachón project area as "regulators of freshwater resources". Our objective is to convey to the reader what this means, and stress the significance of these rivers to San Juan's water supply and furthermore, to show tangibly what these rivers look like, how and where they flow, the relationship of the rivers to rock glaciers affected by El Pachón, and to visually show how communities, despite sometimes being many kilometers away, depend on the waters provided by these rivers year round.

While clearly the rock glaciers in the Pachón area provide but a portion of the flow volume of these rivers further downstream from the project area, the decisions made on glacier protection at El Pachón will greatly influence how the State and how companies address glacier and rock glacier impacts in future projects, and particularly to rock glaciers that have gone largely ignored by mining exploration cutting into mountainsides in search of minerals. The Minister of Mining of the Province indicated in a recent interview that more than 150 projects are in the project pipeline. With such a large volume of mining activity coming to San Juan in the near future, in the context of statements made by the province's highest authority on glacier protection who negates mining relevance to glaciers, the cumulative impact of mining operations to streams and rivers, both in terms of reductions of water volume as well as contamination, could be devastating.

Our objective here is to visually show to the reader the relationship between rock glaciers to streams, rivers and communities.

As concerns El Pachón, three principal rivers emerge from the project area. From north to south these are *the Carnicería*, *the Pachón*, and *the Mondaca* rivers. Additionally one significantly-sized stream just south of the Pachón River, *the Mondaquita*, is a significant tributary to the Pachón River. These rivers in turn are tributaries of the *Santa Cruz River,* which is part of the San Juan River Basin.[25]

[24] See: http://www.cedha.org.ar/documents/Argentine%20National%20Glacier%20Act%20-%20Final%20Document.pdf
[25] For an analysis of the San Juan River Basin see: http://www.hidricosargentina.gov.ar/54_nueva.pdf

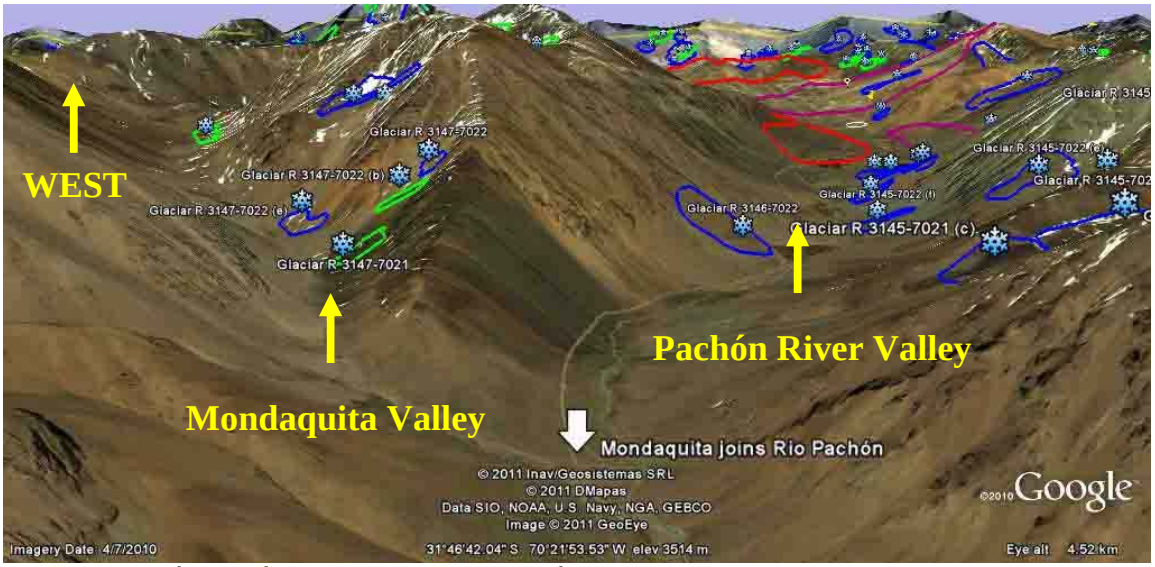


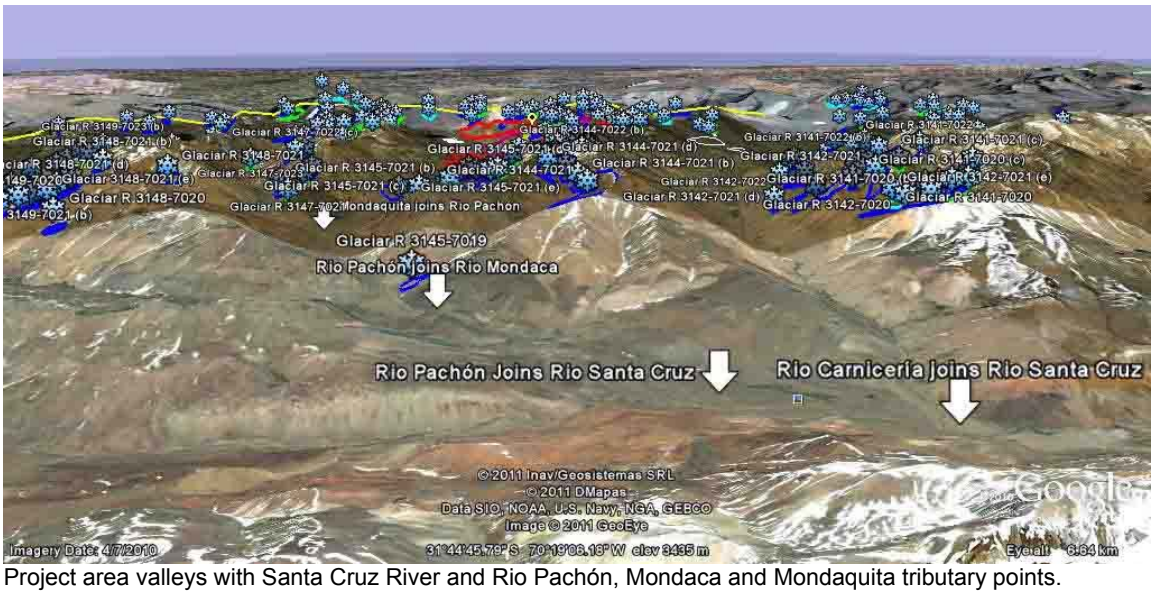
Image shows Río Pachón amidst glaciers in Pachón project valleys, at joining with Mondaquita Stream

The Pachón river, running west to east, (top to bottom in the above image) originating just east of the Chilean border (which is at the top edge of the image), flows nearly 20km running through the central project area. The image above shows the Chilean border in the far background (which is faintly visible as a yellow line in the west end of the image), and shows two of El Pachón project's valleys formed by the Mondaquita stream (on the left) and the Pachon River valley (on the right). Over 60 rock glaciers and extensive periglacial environment feed the Pachón River before it joins the Mondaquita. These are visible as blue and green polygons. The purple and red polygons located in the Pachón river valley are the mining project pits and waste dump sites, respectively.

As is clear from the image, the pits and waste dump sites coincide with the course of the Pachón River. Several streams feed into the Pachón river in this valley, which are also located in the main project area. These are: the Agua Buena, the Sur, Medio, Norte, and Azul (these are not identifiable in this image).

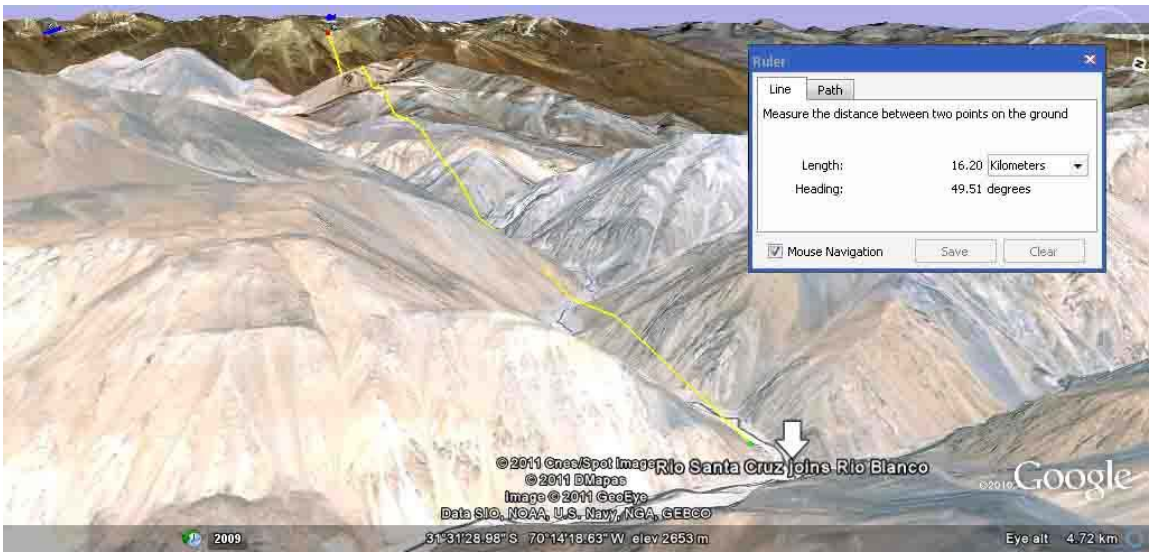
The Pachón river is a key tributary to other rivers that run through San Juan's arid terrain. At its easternmost point the Pachón feeds into the larger Santa Cruz river at: [31°44'11.75" S 70°17'16.58" W] which takes in the Carnicería river (also from the Pachón project area) about 2 km north of the Pachón River and Mondaquita junction at [31°43'04.55" S 70°16'56.50" W]. Some 60 rock glaciers and periglacial environments feed the Carnicería river in the project area. Over 100 rock glaciers and periglacial environments in El Pachón's project area, contribute to the Carniceria and the Pachón river systems. This does not include other rock glaciers and periglacial environments in the other stream and river tributaries (such as from the Mondaca), which comprise the more than 200 rock glaciers and periglacial environments that we have inventoried.

The following image shows the Santa Cruz river and its tributaries from the El Pachón project site, *the Pachón*, *Mondaca* and *Carnicería* rivers. We can get a sense of the majestic breadth of these valleys and the many rock glaciers and periglacial environments that provide a year-round, critical water supply to the Santa Cruz river which in turn feeds communities and agricultural lands further downstream. Also visible in the image are: the international border with Chile (in yellow), the project pit and waste dump areas (polygons in purple and red), as well as numerous rock glaciers (blue and green polygons).



Project area valleys with Santa Cruz River and Rio Pachón, Mondaca and Mondaquita tributary points.

From the project area, the Santa Cruz River runs more than 20 km in a northern and slightly eastern direction before eventually joining the Río Blanco at: [31°31'16.26" S 70°14'07.92" W]. The project area is in the image's upper left corner– two rock glacier polygons are visible in the area.



Xstrata's EIA Addendum from 2008 downplays the impact that the El Pachón project will have on the rivers and downstream communities, which Xstrata considers are too far away to face any impact. The company states in the 2008 EIA that the Pachón River Basin covers some 207km2, and also indicates that water quality of the Pachón river as well as that of the Mondaca, Carnicería and Santa Cruz rivers is poor. Not so, says the company for the Mondaquita stream, which according to the EIA is of excellent quality (p. 23). The EIA also points out that the rivers' flow volume grows as it joins the Mondaquita, Mondaca, Carnicería and Santa Cruz, improving its quality as it progresses downstream (EIA 2008, p.24). In the section on environmental impacts Xstrata states that road works, rock removal, and water extraction impact, and impact to aquifers will be "not significant" to "none" on the rivers (2008 EIA Addendum, pp. 64-65).

While limited data exists on river flow volume, we know that average flows are poor indicators of volume flow during critical dry warmer months. There are tremendous seasonal variations in river discharge, with discharges normally lowest in the winter and highest in the spring (due to snow and ice melt). We would expect rock glaciers and the active layer of permafrost to contribute most in the late summer (see eg. Burger et.al. 1999). Further, when an extremely dry year occurs in these arid dry mountains, ice forms such as rock glaciers and permafrost provide higher percentages of a river's flow volume and become critical to maintain delicate ecosystems balances.

From the limited information available, the approximate average river discharges are as follows.

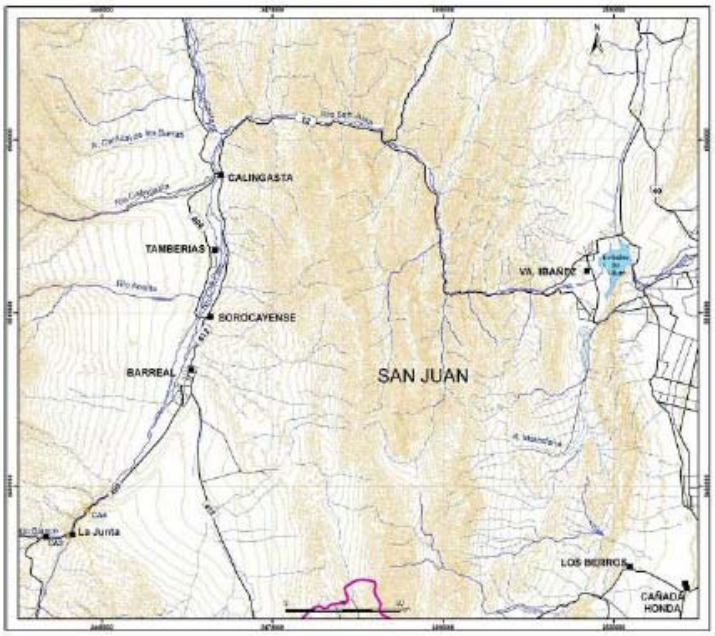
Rio Pachón	Not Available
Rio Carniceria	Not Available
Rio Mondaca	Not Available
Mondaquita Stream	Not Available
Rio Santa Cruz	Not Available
Rio Blanco	5-20m3/sec[26,27,28]
Rio de los Patos	49m3/sec[29,30]
Rio San Juan	53-56m3/sec[31,32]

[26] Ver: http://www.paseandoenargentina.com.ar/geografia__san_juan.htm
[27] Ver: http://www.mineria.gov.ar/estudios/irn/snjuan/g-41a.asp
[28] Ver: http://es.wikipedia.org/wiki/R%C3%ADo_Blanco_(Calingasta)
[29] Ver: http://www.paseandoenargentina.com.ar/geografia__san_juan.htm
[30] Ver: http://es.wikipedia.org/wiki/R%C3%ADo_de_los_Patos
[31] Ver: http://www.paseandoenargentina.com.ar/geografia__san_juan.htm
[32] Ver: http://es.wikipedia.org/wiki/R%C3%ADo_San_Juan_(Argentina)

At that point the river turns south-southeast, running through mountainous terrain for 65km (measured in straight line), then joining the Río de los Patos at: [31°53'39.96" S 69°41'39.18" W], (see image below) arriving at the first important residential and agricultural locations of Villa Pituil, Barreal, Tamberías and Calingasta.

Finally, from the point of junction of the Rio Blanco and the Rio de los Patos, we can take in the full view of the Calingasta Valley, home to some 10,000 inhabitants, irrigated by the accumulated waters of the Pachón, Mondaca, Carniceria, Santa Cruz, Rio Blanco and the Rio de los Patos rivers. Along the riverside running up and down the image just right of center we see the localities of Barreal, Villa Pituil, Tamberias, La Isla and Calingasta.

Xstrata's mapping of the same area found in the 2008 EIA Addendum follows.


CALINGASTA
TAMBERIAS
BOROCAYENSE
BARREAL
SAN JUAN
VA. IBANEZ
La Junta
LOS BERROS
CAÑADA HONDA

Below are several images of the various rivers in the project area.

Lagoon on Rio Santa Cruz: 31°41'33.95" S 70°17'25.58" W

Rio Blanco (by Richi Bruner): 31°53'40.28" S 69°49'44.66" W

Rio de los Patos (near Barreal): 31°49'23.94" S 69°36'00.81" W

Rio de los Patos (by Nan-CBA) at: 31°35'41.75" S 69°28'21.68" W

Rio de los Patos (by J.Carosio) 31°39'19.93" S 69°29'09.11" W

Rio San Juan (Near Calingasta) at: 31°16'47.42" S 69°24'22.95" W

Despite Xstrata's minimization of the impacts El Pachón will have on the local water ways, it is known that rivers of the highland Andes mountain region provide critical water supply to the entire population of San Juan Province, even though the key population centers may reside many kilometers away. It is precisely for this reason that the recent National and Provincial Glacier Protection laws protect rock glaciers and periglacial environments.

While it is difficult to determine the exact amount of water that a given rock glacier, permafrost area or periglacial environment provides to its related streams and aquifers, we know that these

contributions taken in cumulative form can be significant, and they become even more significant when faced with an unusually dry and warm season.

As clarified by Brenning in his reply to Arenson and Jakob (2010), in relation to the significance of rock glaciers in the dry Andes,

> "The volumetric ice content of rock glaciers is known to vary strongly within a rock glacier and between individual rock glaciers … For regional-scale estimation as in Azócar and Brenning (2010), however, only the average ice content of an entire rock glacier population can be of relevance. The average volumetric ice content of rock glaciers is widely accepted to vary between approximately 40 per cent and 70 per cent, as assumed by Azócar and Brenning (2010) in their discussion of uncertainties (Barsch, 1996: 40–60%; Burger et al., 1999: 50–70%). This is consistent with field data from different climatic regions worldwide (Haeberli et al., 2006; see also Croce and Milana, 2002; Milana and Guell, 2008). If these local measurements are summarised by calculating the median values of the lower and upper bounds of published ice contents in a preliminary meta-analysis, a median lower bound of ice contents of 47 per cent and a median upper bound of 70 per cent are obtained. This suggests that the assumption of an average 50 per cent ice content and of a 40–70 per cent range in the analysis of uncertainties made by Azócar and Brenning (2010) is reasonable and possibly even conservative."

With the arrival of dozens and even hundreds of largescale mining projects to San Juan's highlands, proper water and glacial management is key to ensure that permafrost and rock glacier environments are not impacted or destroyed. This highly delicate water resource is at grave risk by El Pachón's ongoing and future activity if the project is to assume operations as programmed for 2012.

Cities and Towns Near the El Pachón Project Area

An aerial view of the principal project area (see image below) shows the relative location of the towns near to the El Pachón's project site. Our concern over glacier impacts by El Pachón and other programmed future mining projects in the area are related to how water volume of river flow may be reduced thereby affecting irrigation water for small agriculture and human consumption.

Xstrata cites the following key population centers (parenthesis show population):

The majority of towns cited form part of the Department of Calingasta with approximately 10,000 people living in the area living largely from tourism and agriculture (fruits, legumes, etc.).

Town	Population	Distance from Project (straight line)
Barreal	(3202)	86 km
Tamberías	(860)	95 km
Villa Calingasta	(2039)	102 km
La Isla	(< 400)	100 km
Villa Pituil	(820)	85 km
Las Hornillas	(N/A)	62 km
Hilario	(< 400)	95 km
La Alumbrera	(N/A)	70 km
San Juan	(421,640)	175 km

Foto: Department of Calingasta

Barreal [31°37′60″S 69°28′00″W] is the first important human settlement downstream from the project site. At less than 90 km distance (measured as the crow would fly), with a population of 3202, is a agricultural and tourist driven locality. The town is located in the center of the Calingasta Department. The Rio de los Patos runs through the middle of the town area. In one European tourist guidebook it was cited as one of the most beautiful places in all of Argentina. With abundant water deriving from glacier melt, tourists visit Barreal for water sports such as Rafting and Kayaking.

Barreal at the foot of the Andes

*Villa Pituil [*31°38′60″S 69°28′00″W], a small town near Barreal, has approximately 820 inhabitants. It's located about 90km as the crow flies from El Pachón.

Tamberías [31°27′29″S 69°25′20″W], population 860 is a town at the head of the Calingasta Department 95 kms from El Pachón. Tamberías is experiencing a significant population increase over recent years, largely driven by toursim. It is an agricultural center of the Calingasta valley. It has a significant number of small hotels/hostels.

Calingasta [31°20′07″S 69°25′14″W] population 2039 is on the Río de los Patos, and near the birth of the Río San Juan and at just over 100km from El Pachón, is an agricultural hub for the region, and caters strongly to tourism.

La Isla, Colón, and Hilario are small settlements of less than 400 inhabitants each located in the general vicinity along the rivers or near the above listed towns.

Single family homes are found at Estancia del Río Blanco, Las Hornillas, Casa Amarilla and Alvarez Condarco.

We offer below some images of the various settlements in the project vicinity.

Vineyards at Barreal (by Ascalise)

Agricultural Lands in Calingasta Valley (by Ilfocall)

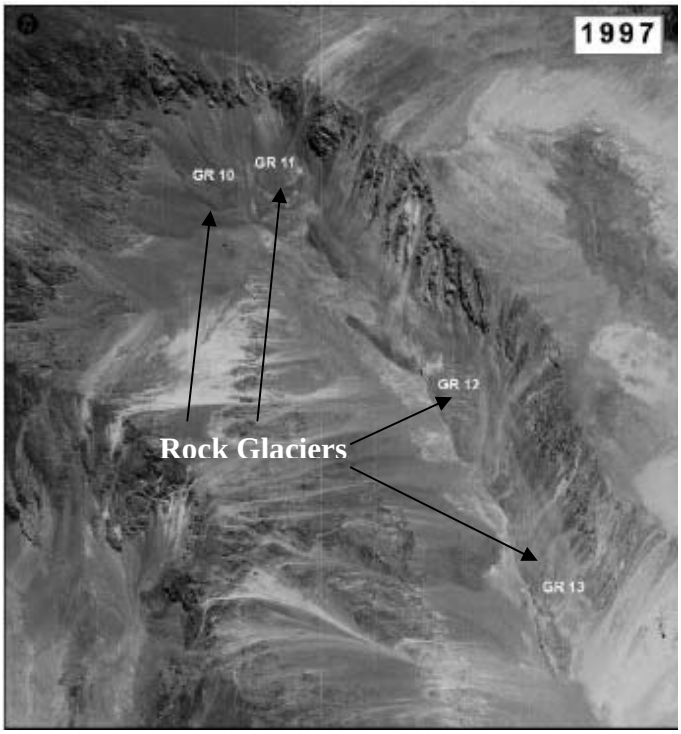
Agro Lands in Tamberías (Finca Nevada) By i.e.

City of Calingasta. By Omar Gobbi 31°20'08.20" S 69°25'08.72" W

Agricultural at Barreal with glaciers in background. (By Dario Cimino

Impacts to Glaciers at Nearby Los Pelambres Project

As an example of what might happen to rock glaciers at the El Pachón mining project site, we can look just across the border at a very similar project, Los Pelambres, which is located in the same mountain range, literally just over the top edge of the border mountain. Azócar and Brenning (2008) studied Los Pelambres examining rock glacier impacts of mining operations. The authors published the following 1997 image of a portion of the mine site adjacent to the border. We can compare this image to the image available from Google Earth today, showing extensive mining intervention to the rock glaciers.



Azocar and Brenning (2010) enumerate many types of impacts caused by mining to rock glaciers, and point to projects such as Barrick's Pascua Lama which will "bury a rock glacier under a waste rock pile" at the Barrick project site. Other cases have been documented, such as in *Los Bronces* and *División Andina* where glaciers are accelerating due to waste deposited on their surface. One of the key issues pointed out by the authors are the waste deposits generated by Los Pelambres, many of which are on rock glaciers. The added weight (in the billions of tons) exerts enormous pressure on the rock glacier structure, which may ultimately lead to its acceleration and even collapse. El Pachón has similar sterile waste piles which will have the same impacts on rock glaciers as in the Los Pelambres project.

Environmental impact studies in the Los Pelambres project do not mention the presence of rock glaciers, nor is there any information about potential impacts of mining activity on this ice. (Azócar & Brenning, 2008, p. 5)

Further, as in the El Pachón case, the second risk posed to the rock glaciers mentioned by the authors is the modification of the terrain in order to introduce access roads to the mine site (p.5).

This modifies the glaciers' drainage system through the introduction of water deviation in order to better maintain the roads.

A recent article by Ahumada, Palacios and Paez, draws attention to the impacts to rock glaciers in Salta and Jujuy provinces of Argentina, from road introduction and road maintenance work.[33]

Azócar and Brenning alert of the near total disappearance of at least 4 rock glaciers due to waste deposits on these glaciers. These glaciers are very similar in characteristics to the rock glaciers found in the El Pachón project area.

Azocar & Brenning (2008) estimate that the volumetric content of ice at 40-60% and an ice-rich permafrost content of approximately 20m, with an ice density of 0.9 g cm3.[34] While in most cases extrapolating such data from one ice formation to another in a different region would be highly questionable, in this case, the association is quite logical to make, since the Los Pelambres site and the El Pachón site are on opposite sides of the same mountain, virtually in the same place with practically identical environmental ecosystem characteristics.

In the case of the Chilean Los Pelambres Project, the authors cite that the project owners failed to mention the presence of glaciers and later even denied their existence, although they clearly knew of their presence, since the mine owners contracted out studies from glacier specialists. However, the information stemming from these studies was not informed to the permitting authority in Chile, and as such, there is no approval for the project in regards to glacier impacts. This failure to inform or minimize glacier relevance at mining sites is typical of mining projects in the area, and very systematic of projects in the Andean regions of San Juan.

We know in the case of Xstata's Filo Colorado project in Catamarca, the same situation holds. Xstrata makes no mention of glaciers in the Environmental Impact Assessments of Filo Colorado, and subsequently there is mention or treatment of these in the permitting process. Nor do we know of any protocols or mitigating actions by the company to repair damages to rock glaciers or periglacial environments at Filo Colorado.

[33] See: http://www.cedha.org.ar/contenidos/ahumada-palacios-paez-caminos%20-%20punena.pdf
[34] See: Azócar & Brenning, p.7

What the Law Says About Mining Impacts to Rock Glaciers and to Periglacial Environments

The recently enacted National Argentine Glacier Protection Act[35] clearly states in Article 6 that that mining as well as exploration activities for mining **is prohibited** where there are glaciers, rock glaciers or periglacial environments.

> **Art. 6º –** Prohibited Activities
> All activities that could affect the natural condition or the functions listed in Article 1, that could imply their destruction or dislocation or interfere with their advance, are prohibited on glaciers, in particular the following: *(unofficial translation)*
>
> a) The release, dispersion or deposition of contaminating substances or elements, chemical products or residues of any nature or volume. Included in these restrictions are those that occur in the periglacial environment;
> b) The construction of works or infrastructure with the exception of those necessary for scientific research and to prevent risks;
> **c) Mining and hydrocarbon exploration and exploitation. Included in this restriction are those that take place in the periglacial environment; [bold added]**
> d) The installation of industries or the building of works or industrial activity.

Xstrata's decision to extract minerals at a pit site with glaciers or periglacial environments in the site is illegal. So is the deposit of waste tailings onto glaciers as is presently projected.

Further, the law states in Article 15 (giving retroactive applicability to the law) that:

> The activities described in Article 6, in progress at the moment of the sanctioning of the present law, must, in a period of no more than 180 days from the promulgation of this law, submit to an environmental audit in which potential and actual environmental impacts to glaciers are identified and quantified. In the case of verification of negative impacts to glaciers or the periglacial environment, contemplated in Article 2, the authorities shall order the pertinent measures so that the present law is complied with, and could order the ceasing or relocation of the activity and protective measures, cleaning and restoration as appropriate.

Xstrata is already at fault with article 15.

Even San Juan's provincial glacier protection law prohibits activities at the El Pachón site if it is deemed to destroy glaciers, rock glaciers or periglacial environment environments. The provincial law says:

> **Article 6º.-**Prohibition. All activity that implies the destruction or movement of glaciers in the provincial inventory or that interferes in its advancement, affecting its functions cited in Article 1, all of which shall be determined by the corresponding environmental evaluation as mentioned in Article 7, is hereby prohibited. *(unofficial translation)*

Hence, both pit areas as well as tailing deposit sites of El Pachón are illegal according to San Juan's provincial glacier protection law.

[35] See: http://www.cedha.org.ar/documents/Argentine%20National%20Glacier%20Act%20-%20Final%20Document.pdf

What to do about Xstrata's Glacier Impacts at El Pachón

First and foremost, *all activity of El Pachón, including exploratory work, project preparation, or any other activity* ***should immediately cease*** *until past, present and future impacts to rock glaciers and periglacial environments of any mining activity at the El Pachón site can be determined.*

Second, Xstrata must immediately produce a Glacier Impact Assessment, of past, present and future activity, as mandated by Argentine federal law as well as San Juan's provincial law.

Third, all past impacts to rock glaciers and to periglacial environments caused by El Pachón mining project should be repaired (including existing roads affecting rock glaciers or periglacial environments), and the glacier eco-systems (glaciosystems[36]) restored as best possible to their original state, prior to any mining or other anthropogenic intervention.

Fourth, Xstrata should establish and clarify what procedures it will use in any future mining activity at El Pachón or other sites where glaciers, rock glaciers, or periglacial environments exist near operations and where any of its mining activities might potentially impact any type of glaciers, white glaciers, rock glaciers, periglacial environment, etc. This would include reconsideration of pit location excavation, relocation of mineral tailings waste deposit sites, infrastructure or other elements related to the project, as well as any other modifications to glacial formations and glaciosystems which might impact existing glaciers or periglacial environments.

Fifth, Xstrata should be absolutely transparent and share all information about its mining operations taking place in glacier territory, and any past, present or future studies on glacier impacts, including relative to operations anywhere in Argentina (San Juan, Catamarca, or other provinces), Chile and any other countries where it may have operations in areas with the presence of glaciers and rock glaciers or in periglacial environments. Delegating communication dissemination to a government authority that restricts public access to information, as in the case of San Juan, does not suffice.

Sixth, we encourage Xstrata to consider participating, drafting or authoring (with the collaboration of other actors) a Protocol for Mining Activities in Glacier Territory.

[36] For a definition of "glaciosystems" see: http://www.cedha.org.ar/contenidos/glaciares-docs-AnexoIV-Definicion%20de%20Glaciosistema.pdf

About the Authors

Jorge Daniel Taillant has over 15 years of experience in issues related to International Development Finance, Human Rights, Environment and Corporate Accountability. He founded CEDHA in 1999 to promote greater environmental and human rights protection, including efforts to achieve greater corporate responsibility and compliance of social and environmental norms. In 2007, CEDHA received the *Earth Care Award*, the Sierra Club's most distinguished international advocacy award for the promotion of Corporate Accountability and Human Rights. In 2006-2007 Taillant served as the Chief Strategic Advisor to the Secretary of Environment of Argentina, assisting in the design and launch of a strong push to bring contaminating industries into compliance with local and international norms, which included the creation and training of a new enforcement team at the national level, reviewing corporate and multi-jurisdictional state responsibilities in the protection of the environment. In 2008, the Argentine Congress unanimously passed a National Glacier Protection Act. That law was vetoed by the Argentine President in response to strong lobby from the mining sector. Taillant engaged directly with the Congress in 2009-2010 to help bring back the glacier law, which was reinstated in 2010, with even stricter protective measures for glaciers, including a ban on mining in glacier areas. Taillant now leads CEDHA's Mining, Environment and Human Rights Program, and is now carrying out a glacier and mining inventory and mapping with a view to draw attention to mining impacts on glaciers, rock glaciers and periglacial environments. This report is the second in a series on "mining and glaciers" in Argentina.

Alejandro Vera. A native of San Juan Province, is Assistant Coordinator of CEDHA's Mining, Environment and Human Rights Program. He is a legal degree candidate of the National University of Córdoba's Law School. His work at CEDHA includes participation in CEDHA's Human Rights and Environment Legal Clinic. He has been active in forestry protection coordinating activities of the commission created to channel civil society's input into the recently regulated provincial adoption of the national forestry law. Alejandro is one of CEDHA's principle liaisons with the National Congress and with provincial legislatures, and was key in communications with Congress on the reintroduction, debate and vote of the recently enacted National Glacier Protection Act.

Scientific Contributors

Dr. Alexander Brenning has been conducting research on rock glaciers in the Andes since 2002, first as part of his doctoral research at Humboldt-Universität zu Berlin, which he finished in 2005, and since 2007 as an Assistant Professor at the Department of Geography and Environmental Management of the University of Waterloo, Ontario. Canada. Dr. Brenning has directed several publicly funded research projects and research collaborations related to rock glaciers, mountain permafrost, and mass movements, using remote sensing data, field instruments for monitoring, and spatial distribution models. He directed most recently a project on rock glacier dynamics, which was funded by the Dirección General de Aguas of Chile and hosted by Pontificia Universidad Católica de Chile, where Dr. Brenning is a Visiting Professor.

Mateo Martini
Mateo Martini is a Geologist and fellow of the National Council of Scientific and Technical Research (CONICET) in Argentina. He is a member of the *Centro de Investigaciones en Ciencias de la Tierra* (CICTERRA) at the National University of Córdoba, where he is studying his Ph.D. His Doctoral Thesis focuses on glaciations in the northern arid regions of Argentina, during the Quaternary Period including the study of periglacial environments and rock glaciers. He has also conducted research of periglacial environments and rock glaciers in the Antarctic region.

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ANNEX:

Glacier Inventory at Xstrata's El Pachón Project

The reader can download a KMZ file viewable in Google Earth which shows each of these rock glaciers in polygon form. The file can be downloaded at:

www.cedha.org.ar/contenidos/Glaciar-Inventory-Pachon.kmz

Total Rock Glaciers in Combined CEDHA/Xstrata Inventory: 223 Glaciers

Color Coding

BLUE: Our inventory closely matches Xstrata's 126 Glaciers
GREEN: Xstrata Omitted these Glaciers from its inventory 62 Glaciers
RED: While Xstrata Suggests these are Glaciers we cannot be certain 35 Glaciers

No.	Glacier Reference Name	Coordinates	Altitude (mts)
1	Glaciar R 3139-7025 (b)	31 39 7.87 S, 70 25 41.66 W	3840-3980
2	Glaciar R 3139-7026 (d)	31 39 44.82 S, 70 26 41.43 W	3870-3975
3	Glaciar R 3139-7026 (e)	31 39 54.54 S, 70 26 57.86 W	3830-4030
4	Glaciar R 3139-7026 (f)	31 39 42.85 S, 70 26 52.22 W	3890-4040
5	Glaciar R 3139-7026 (g)	31 39 54.03 S, 70 26 50.44 W	3790-3900
6	Glaciar R 3139-7026 (i)	31 39 41.49 S, 70 26 32.94 W	3760-3900
7	Glaciar R 3139-7027	31 39 20.14 S, 70 27 24.79 W	4040-4140
8	Glaciar R 3139-7027 (b)	31 39 55.17 S, 70 27 24.44 W	3990-4130
9	Glaciar R 3139-7027 (c)	31 39 12.42 S, 70 27 22.62 W	4015-4070
10	Glaciar R 3139-7028	31 39 37.26 S, 70 28 15.44 W	3750-3895
11	Glaciar R 3139-7028 (b)	31 39 35.07 S, 70 28 15.22 W	3750-3900
12	Glaciar R 3139-7028 (c)	31 39 29.52 S, 70 28 6.74 W	3875-3960
13	Glaciar R 3139-7029	31 39 45.09 S, 70 29 56.00 W	3830-4025
14	Glaciar R 3139-7029 (b)	31 39 4.24 S, 70 29 26.01 W	3900-3970
15	Glaciar R 3139-7029 (c)	31 39 46.48 S, 70 29 44.87 W	3825-3895
16	Glaciar R 3139-7029 (d)	31 39 59.77 S, 70 29 45.65 W	3775-3829
17	Glaciar R 3139-7030	31 39 52.38 S, 70 30 27.52 W	3945-4000
18	Glaciar R 3140-7024	31 40 23.15 S, 70 24 35.09 W	3840-3950
19	Glaciar R 3140-7024 (b)	31 40 43.32 S, 70 24 36.74 W	3765-3830
20	Glaciar R 3140-7024 (c)	31 40 18.00 S, 70 24 52.15 W	3870-4040
21	Glaciar R 3140-7024 (d)	31 40 27.89 S, 70 24 17.29 W	4025-4140
22	Glaciar R 3140-7024 (e)	31 40 9.41 S, 70 24 37.23 W	3960-4080
23	Glaciar R 3140-7024 (f)	31 40 50.68 S, 70 24 50.14 W	3705-3775
24	Glaciar R 3140-7026	31 40 40.59 S, 70 26 31.26 W	3970-4080
25	Glaciar R 3140-7026 (b)	31 40 53.13 S, 70 26 46.75 W	3890-3910
26	Glaciar R 3140-7029	31 40 1.76 S, 70 29 56.41 W	3800-3880
27	Glaciar R 3140-7030 (c)	31 40 7.50 S, 70 30 27.56 W	3830-3935
28	Glaciar R 3140-7030 (d)	31 40 1.52 S, 70 30 16.65 W	3780-3970
29	Glaciar R 3140-7030 (e)	31 40 18.77 S, 70 30 20.75 W	3770-3875
30	Glaciar R 3140-7030 (g)	31 40 0.43 S, 70 30 9.65 W	3830-3915
31	Glaciar R 3140-7030 (h)	31 40 7.88 S, 70 30 18.72 W	3775-3840
32	Glaciar R 3141-7020	31 41 35.17 S, 70 20 55.92 W	3890-4110

33	Glaciar R 3141-7020 (b)	31 41 55.77 S, 70 20 47.11 W	3800-3890
34	Glaciar R 3141-7020 (c)	31 41 43.38 S, 70 20 55.12 W	3960-3990
35	Glaciar R 3141-7021	31 41 57.88 S, 70 21 33.38 W	4110-4210
36	Glaciar R 3141-7021 (b)	31 41 51.85 S, 70 21 7.92 W	3780-3890
37	Glaciar R 3141-7021 (c)	31 41 25.41 S, 70 21 19.51 W	4170-4260
38	Glaciar R 3141-7021 (d)	31 41 29.55 S, 70 21 12.26 W	4100-4185
39	Glaciar R 3141-7021 (e)	31 41 40.78 S, 70 21 17.14 W	3910-3960
40	Glaciar R 3141-7022	31 41 49.70 S, 70 22 28.67 W	3760-4100
41	Glaciar R 3141-7022 (b)	31 41 44.50 S, 70 22 56.02 W	3810-4150
42	Glaciar R 3141-7022 (c)	31 41 26.32 S, 70 22 39.97 W	4060-4220
43	Glaciar R 3141-7023	31 41 45.51 S, 70 23 53.48 W	3760-3930
44	Glaciar R 3141-7023 (b)	31 41 47.44 S, 70 23 7.61 W	3955-4055
45	Glaciar R 3141-7024	31 41 0.57 S, 70 24 20.07 W	3580-4070
46	Glaciar R 3141-7024 (b)	31 41 34.05 S, 70 24 4.82 W	3750-4080
47	Glaciar R 3141-7026 (c)	31 41 6.52 S, 70 26 58.47 W	3530-3895
48	Glaciar R 3142-7020	31 42 5.80 S, 70 20 53.24 W	3590-3790
49	Glaciar R 3142-7021	31 42 11.83 S, 70 21 25.70 W	3890-4090
50	Glaciar R 3142-7021 (b)	31 42 23.12 S, 70 21 25.50 W	3860-3910
51	Glaciar R 3142-7021 (c)	31 42 42.30 S, 70 21 22.66 W	3590-3940
52	Glaciar R 3142-7021 (d)	31 42 59.37 S, 70 21 39.92 W	3480-3670
53	Glaciar R 3142-7021 (e)	31 42 9.06 S, 70 21 0.19 W	3745-3900
54	Glaciar 3142-7022	31 42 42.24 S, 70 22 52.13 W	3565-3620
55	Glaciar 3142-7022 (b)	31 42 33.05 S, 70 22 28.90 W	3690-3740
56	Glaciar 3142-7022 (d)	31 42 52.28 S, 70 22 12.47 W	3540-3640
57	Glaciar 3142-7022 (e)	31 42 2.07 S, 70 22 42.55 W	3770-3910
58	Glaciar 3142-7022 (f)	31 42 0.60 S, 70 22 14.91 W	3760-4010
59	Glaciar R 3142-7023	31 42 0.49 S. 70 23 50.90 W	3720-3915
60	Glaciar R 3142-7023 (b)	31 42 30.55 S, 70 23 44.17 W	3570-3580
61	Glaciar R 3142-7023 (d)	31 42 29.56 S, 70 23 14.42 W	3710-3820
62	Glaciar R 3142-7023 (e)	31 42 4.31 S, 70 23 20.82 W	3890-4095
63	Glaciar R 3142-7026 (f)	31 42 58.81 S, 70 26 34.14 W	3715-3815
64	Glaciar R 3142-7026 (g)	31 42 53.92 S, 70 26 21.83 W	3730-3835
65	Glaciar R 3142-7026 (h)	31 42 48.59 S, 70 26 41.69 W	3850-4015
66	Glaciar R 3143-7025	31 43 51.06 S, 70 25 10.31 W	4090-4160
67	Glaciar R 3143-7026 (b)	31 43 49.66 S, 70 26 1.45 W	3865-3890
68	Glaciar R 3143-7026 (c)	31 43 55.15 S, 70 26 31.44 W	3900-3940
69	Glaciar R 3143-7026 (e)	31 43 50.11 S, 70 26 33.38 W	3930-3980
70	Glaciar R 3143-7026 (f)	31 43 58.48 S, 70 26 37.19 W	3970-4080
71	Glaciar R 3143-7027	31 43 10.52 S, 70 27 37.57 W	3860-4060
72	Glaciar R 3143-7027 (b)	31 43 39.71 S, 70 27 12.01 W	4040-4080
73	Glaciar R 3143-7027 (c)	31 43 21.97 S, 70 27 12.47 W	3845-3950
74	Glaciar R 3143-7027 (e)	31 43 31.04 S, 70 27 23.72 W	4000-4120
75	Glaciar R 3144-7021	31 44 36.97 S, 70 21 7.26 W	3760-4120
76	Glaciar R 3144-7021 (b)	31 44 41.05 S, 70 21 24.25 W	3935-4035
77	Glaciar R 3144-7021 (c)	31 44 46.77 S. 70 21 38.83 W	3935-4053
78	Glaciar R 3144-7021 (d)	31 44 55.69 S, 70 21 54.67 W	4060-4190
79	Glaciar R 3144-7022	31 44 31.90 S, 70 22 57.51 W	3970-4090
80	Glaciar R 3144-7022 (b)	31 44 35.87 S, 70 22 52.42 W	3950-4025
81	Glaciar R 3144-7022 (c)	31 44 43.84 S, 70 22 47.08 W	3945-4110
82	Glaciar R 3144-7022 (d)	31 44 54.32 S, 70 22 52.35 W	3910-3970
83	Glaciar R 3144-7022 (e)	31 44 36.22 S, 70 22 58.99 W	3960-4080

84	Glaciar R 3144-7022 (f)	31 44 30.33 S, 70 22 53.38 W	3990-4100
85	Glaciar R 3144-7023	31 44 44.67 S, 70 23 50.36 W	3890-3950
86	Glaciar R 3144-7023 (b)	31 44 48.84 S, 70 23 48.20 W	3860-3910
87	Glaciar R 3144-7023 (c)	31 44 31.93 S, 70 23 8.22 W	4050-4100
88	Glaciar R 3144-7023 (d)	31 44 50.86 S, 70 23 9.34 W	3875-4025
89	Glaciar R 3144-7023 (e)	31 44 50.49 S, 70 23 3.85 W	3895-3940
90	Glaciar R 3144-7023 (f)	31 44 56.65 S, 70 23 17.73 W	3825-3875
91	Glaciar R 3144-7023 (g)	31 44 41.15 S, 70 23 0.31 W	3930-4070
92	Glaciar R 3144-7024	31 44 42.58 S, 70 24 33.55 W	3760-3960
93	Glaciar R 3144-7025	31 44 37.93 S, 70 25 11.06 W	3820-4080
94	Glaciar R 3144-7025 (b)	31 44 56.06 S, 70 25 38.99 W	3750-3880
95	Glaciar R 3144-7025 (c)	31 44 51.45 S, 70 25 5.75 W	3720-3780
96	Glaciar R 3144-7025 (d)	31 44 4.48 S, 70 25 27.21 W	4035-4090
97	Glaciar R 3144-7025 (e)	31 44 1.85 S, 70 25 25.18 W	4050-4100
98	Glaciar R 3144-7026	31 44 48.19 S, 70 26 55.31 W	3820-4100
99	Glaciar R 3144-7026 (b)	31 44 50.65 S, 70 26 36.82 W	3850-3930
100	Glaciar R 3144-7026 (c)	31 44 38.16 S, 70 26 20.93 W	3890-3960
101	Glaciar R 3144-7026 (d)	31 44 55.12 S, 70 26 45.74 W	3850-3920
102	Glaciar R 3144-7026 (e)	31 44 44.60 S, 70 26 37.69 W	3860-3980
103	Glaciar R 3144-7026 (f)	31 44 49.65 S, 70 26 50.39 W	3900-4050
104	Glaciar R 3144-7026 (g)	31 44 9.84 S, 70 26 59.04 W	4040-4100
105	Glaciar R 3144-7026 (h)	31 44 7.63 S, 70 26 48.16 W	4020-4030
106	Glaciar R 3144-7026 (i)	31 44 6.18 S, 70 26 6.33 W	3920-3980
107	Glaciar R 3144-7026 (j)	31 44 47.03 S, 70 26 47.69 W	3950-4010
108	Glaciar R 3144-7026 (k)	31 44 17.00 S, 70 26 14.25 W	4000-4060
109	Glaciar R 3144-7027	31 44 51.05 S, 70 27 14.47 W	4023-4250
110	Glaciar R 3144-7027 (b)	31 44 25.08 S, 70 27 28.90 W	4130-4260
111	Glaciar R 3144-7027 (c)	31 44 40.63 S, 70 27 17.94 W	4140-4180
112	Glaciar R 3144-7027 (d)	31 44 15.80 S, 70 27 14.31 W	4095-4150
113	Glaciar R 3144-7027 (f)	31 44 25.46 S, 70 27 15.57 W	4040-4100
114	Glaciar R 3144-7027 (g)	31 44 15.88 S, 70 27 15.93 W	4100-4150
115	Glaciar R 3144-7027 (h)	31 44 16.02 S, 70 27 16.72 W	4100-4150
116	Glaciar R 3144-7027 (i)	31 44 15.22 S, 70 27 13.00 W	4100-4150
117	Glaciar R 3145-7019	31 45 51.34 S, 70 19 26.08 W	3220-3470
118	Glaciar R 3145-7021	31 45 26.35 S, 70 21 42.12 W	3905-4035
119	Glaciar R 3145-7021 (b)	31 45 44.95 S, 70 21 34.46 W	3780-3980
120	Glaciar R 3145-7021 (c)	31 45 60.00 S, 70 21 30.45 W	3690-3850
121	Glaciar R 3145-7021 (d)	31 45 20.72 S, 70 21 32.62 W	3990-4050
122	Glaciar R 3145-7021 (e)	31 45 24.66 S, 70 21 37.96 W	3945-3990
123	Glaciar R 3145-7022	31 45 0.17 S, 70 22 59.89 W	3890-3940
124	Glaciar R 3145-7022 (b)	31 45 39.80 S, 70 22 58.76 W	3640-3715
125	Glaciar R 3145-7022 (c)	31 45 40.21 S, 70 22 55.23 W	3675-3725
126	Glaciar R 3145-7022 (d)	31 45 33.05 S, 70 22 3.47 W	3770-3940
127	Glaciar R 3145-7022 (e)	31 45 33.94 S, 70 22 22.03 W	3700-3880
128	Glaciar R 3145-7022 (f)	31 45 52.55 S, 70 22 37.51 W	3470-3550
129	Glaciar R 3145-7022 (g)	31 45 14.59 S, 70 22 12.03 W	4030-4110
130	Glaciar R 3145-7022 (h)	31 45 48.59 S, 70 22 56.18 W	3495-3610
131	Glaciar R 3145-7023	31 45 1.97 S, 70 23 26.44 W	3760-3860
132	Glaciar R 3145-7023 (b)	31 45 4.51 S, 70 23 57.81 W	3630-3720
133	Glaciar R 3145-7023 (c)	31 45 42.11 S, 70 23 17.19 W	3550-3590
134	Glaciar R 3145-7023 (d)	31 45 8.66 S, 70 23 39.57 W	3700-3780

135	Glaciar R 3145-7023 (e)	31 45 3.24 S, 70 23 29.74 W	3760-3790
136	Glaciar R 3145-7023 (f)	31 45 4.69 S, 70 23 3.34 W	3895-3920
137	Glaciar R 3145-7023 (g)	31 45 40.86 S, 70 23 10.99 W	3540-3620
138	Glaciar R 3145-7023 (h)	31 45 0.57 S, 70 23 9.58 W	3670-3955
139	Glaciar R 3145-7024	31 45 13.86 S, 70 24 52.97 W	3610-3685
140	Glaciar R 3145-7027	31 45 14.23 S, 70 27 32.60 W	3900-4000
141	Glaciar R 3145-7027 (b)	31 45 50.66 S, 70 27 35.72 W	3860-4050
142	Glaciar R 3145-7027 (c)	31 45 53.61 S, 70 27 21.25 W	3780-3880
143	Glaciar R 3145-7027 (d)	31 45 24.23 S, 70 27 23.23 W	3780-3900
144	Glaciar R 3145-7027 (e)	31 45 9.48 S, 70 27 12.82 W	3980-4030
145	Glaciar R 3145-7027 (f)	31 45 47.31 S, 70 27 52.25 W	4080-4130
146	Glaciar R 3145-7027 (g)	31 45 54.19 S, 70 27 59.92 W	4080-4120
147	Glaciar R 3145-7027 (h)	31 45 5.08 S, 70 27 24.42 W	3950-4060
148	Glaciar R 3145-7027 (i)	31 45 46.81 S, 70 27 31.48 W	3870-4030
149	Glaciar R 3146-7022	31 46 16.60 S, 70 22 23.53 W	3460-3730
150	Glaciar R 3146-7024	31 46 46.98 S. 70 24 31.15 W	4170-4220
151	Glaciar R 3146-7026	31 46 50.38 S, 70 26 27.16 W	3850-3900
152	Glaciar R 3146-7026 (b)	31 46 57.02 S, 70 26 30.13 W	3890-3900
153	Glaciar R 3146-7027	31 46 0.14 S, 70 27 52.86 W	3950-4040
154	Glaciar R 3146-7027 (b)	31 46 52.98 S, 70 27 26.09 W	3910-4070
155	Glaciar R 3146-7027 (c)	31 46 57.30 S, 70 27 9.98 W	3880-3975
156	Glaciar R 3146-7027 (d)	31 46 29.13 S, 70 27 50.77 W	4150-4230
157	Glaciar R 3146-7027 (e)	31 46 28.25 S, 70 27 40.05 W	3900-4060
159	Glaciar R 3147-7021	31 47 10.92 S, 70 21 58.32 W	3570-3660
160	Glaciar R 3147-7022	31 47 1.88 S, 70 22 19.47 W	3850-3920
161	Glaciar R 3147-7022 (b)	31 47 5.19 S, 70 22 11.85 W	3715-3810
162	Glaciar R 3147-7022 (c)	31 47 17.15 S, 70 22 53.84 W	4000-4170
163	Glaciar R 3147-7022 (d)	31 47 11.96 S, 70 22 53.76 W	4035-4220
164	Glaciar R 3147-7022 (e)	31 47 19.34 S, 70 22 16.75 W	3610-3660
165	Glaciar R 3147-7023	31 47 46.41 S, 70 23 10.11 W	3800-3860
166	Glaciar R 3147-7023 (b)	31 47 10.36 S, 70 23 38.94 W	3990-4170
167	Glaciar R 3147-7024	31 47 13.76 S, 70 24 3.11 W	3940-4020
168	Glaciar R 3147-7024 (b)	31 47 2.15 S, 70 24 4.61 W	3910-4040
169	Glaciar R 3147-7024 (c)	31 47 4.32 S, 70 24 25.24 W	4110-4350
170	Glaciar R 3147-7024 (d)	31 47 44.78 S, 70 24 58.27 W	3860-3995
171	Glaciar R 3147-7025 (b)	31 47 27.34 S, 70 25 55.05 W	3870-3950
172	Glaciar R 3147-7025 (c)	31 47 29.05 S, 70 25 43.93 W	3840-3940
173	Glaciar R 3147-7025 (d)	31 47 27.48 S, 70 25 1.26 W	3660-4265
174	Glaciar R 3147-7025 (e)	31 47 14.81 S, 70 25 36.74 W	3970-4120
175	Glaciar R 3147-7025 (f)	31 47 46.21 S, 70 25 19.51 W	3790-3880
176	Glaciar R 3147-7025 (g)	31 47 41.12 S, 70 25 22.86 W	3845-3870
177	Glaciar R 3147-7026	31 47 37.22 S, 70 26 34.80 W	3940-4150
178	Glaciar R 3147-7026 (b)	31 47 7.68 S, 70 26 41.02 W	3925-4160
179	Glaciar R 3147-7026 (c)	31 47 36.87 S, 70 26 26.92 W	3935-4035
180	Glaciar R 3147-7026 (d)	31 47 42.07 S, 70 26 57.44 W	4010-4500
181	Glaciar R 3147-7026 (e)	31 47 11.08 S, 70 26 27.83 W	3940-4060
182	Glaciar R 3147-7027	31 47 15.84 S, 70 27 23.84 W	3960-4108
183	Glaciar R 3147-7027 (b)	31 47 2.44 S, 70 27 32.03 W	3950-4075
184	Glaciar R 3147-7027 (c)	31 47 14.81 S, 70 27 35.04 W	4035-4110
185	Glaciar R 3147-7027 (e)	31 47 5.66 S, 70 27 37.78 W	4055-4110
186	Glaciar R 3147-7027 (f)	31 47 3.55 S, 70 27 35.90 W	4015-4120

187	Glaciar R 3147-7027 (g)	31 47 3.55 S, 70 27 19.48 W	3895-3935
188	Glaciar R 3147-7027 (h)	31 47 31.63 S, 70 27 17.75 W	4430-4610
189	Glaciar R 3147-7027 (i)	31 47 23.99 S, 70 27 37.27 W	4130-4360
190	Glaciar R 3148-7020	31 48 36.24 S, 70 20 31.10 W	3670-3770
191	Glaciar R 3148-7021	31 48 3.67 S, 70 21 33.59 W	4020-4080
192	Glaciar R 3148-7021 (b)	31 48 40.67 S, 70 21 49.53 W	4070-4180
193	Glaciar R 3148-7021 (c)	31 48 49.59 S, 70 21 30.24 W	3905-4000
194	Glaciar R 3148-7021 (d)	31 48 53.90 S, 70 21 21.93 W	3830-3960
195	Glaciar R 3148-7021 (e)	31 48 56.09 S, 70 21 15.23 W	3775-3940
196	Glaciar R 3148-7024	31 48 48.87 S, 70 24 10.83 W	3830-4000
197	Glaciar R 3148-7025	31 48 51.91 S, 70 25 55.27 W	3680-3815
198	Glaciar R 3148-7026	31 48 10.26 S, 70 26 55.57 W	3890-4030
199	Glaciar R 3148-7026 (b)	31 48 50.20 S, 70 26 10.95 W	3690-3970
200	Glaciar R 3148-7026 (c)	31 48 54.79 S, 70 26 39.76 W	3770-3900
201	Glaciar R 3148-7027	31 48 18.39 S, 70 27 21.58 W	4060-4220
202	Glaciar R 3149-7020	31 49 12.33 S, 70 20 58.62 W	3675-3750
203	Glaciar R 3149-7021	31 49 1.83 S, 70 21 10.52 W	3740-3850
204	Glaciar R 3149-7021 (b)	31 49 6.25 S, 70 21 6.75 W	3695-3820
205	Glaciar R 3149-7021 (c)	31 49 14.12 S, 70 21 1.91 W	3650-3775
206	Glaciar R 3149-7021 (d)	31 49 17.56 S, 70 21 26.75 W	3710-3980
207	Glaciar R 3149-7021 (e)	31 49 6.36 S, 70 21 55.40 W	3960-4110
208	Glaciar R 3149-7021 (f)	31 49 17.57 S, 70 21 52.13 W	3965-3980
209	Glaciar R 3149-7022	31 49 2.36 S, 70 22 30.00 W	3975-4100
210	Glaciar R 3149-7022 (b)	31 49 44.41 S, 70 22 1.96 W	3770-3840
211	Glaciar R 3149-7023	31 49 29.57 S, 70 23 28.77 W	3770-3930
212	Glaciar R 3149-7023 (b)	31 49 11.02 S, 70 23 15.83 W	4050-4100
213	Glaciar R 3149-7023 (c)	31 49 43.88 S, 70 23 44.10 W	3670-3805
214	Glaciar R 3149-7026	31 49 47.65 S, 70 26 32.46 W	3780-3865
215	Glaciar R 3149-7027	31 49 43.70 S, 70 27 8.89 W	3980-4090
216	Glaciar R 3149-7027 (b)	31 49 11.32 S, 70 27 8.00 W	3840-3935
217	Glaciar R 3150-7026	31 50 54.42 S, 70 26 34.41 W	3960-4010
218	Glaciar R 3150-7026 (b)	31 50 0.97 S, 70 26 40.67 W	3810-3840
219	Glaciar R 3150-7026 (c)	31 50 6.93 S, 70 26 45.30 W	3820-3850
220	Glaciar R 3150-7026 (d)	31 50 10.50 S, 70 26 50.94 W	3840-3860
221	Glaciar R 3150-7026 (e)	31 50 13.20 S, 70 26 57.74 W	3840-3860
222	Glaciar R 3150-7027	31 50 15.56 S, 70 27 7.76 W	3870-4000
223	Glaciar R 3150-7027 (b)	31 50 13.50 S, 70 27 3.46 W	3860-3900