

ÖkoRess III

Pilot Screening of Environmental Hazard Potentials of Mine Sites

Factsheet:

Chuquicamata Copper Mine

Codelco, Chile

ID: 45

Note

The qualitative assessment of Environmental Hazard Potentials (EHPs) in this factsheet was conducted according to the method developed in the precursor project ÖkoRess I “Discussion of the environmental limits of primary raw material extraction and development of a method for assessing the environmental availability of raw materials to further develop the criticality concept”¹ (Dehoust et al. 2017a). The measurement instructions applied here are described in Dehoust et al. 2017b. The method is tested and further developed within this project (ÖkoRess III).

The information in this factsheet refers exclusively to publicly available, designated sources that have been classified as serious by the authors. It is specifically pointed out that no statement is made about the implementation and quality of agreements or standards that are applied. The implementation of agreements through memberships, certifications, etc. is the responsibility of the companies.


The surface extension of each mine area has been estimated based on publically accessible satellite images as official land-use plans from the public authorities or mine operators are not consistently available. It therefore only corresponds to the apparent area where mining, processing facilities, heaps, etc. and related infrastructure are clearly identifiable.

The fact sheets make no claim to completeness of all relevant voluntary standards. Mentioning a membership in one of the listed voluntary standards does not imply an assessment of the suitability of the standard in itself, nor does it make any statement about the member's success in implementation.

¹TEXTE 87/2017 <https://www.umweltbundesamt.de/publikationen/discussion-of-the-environmental-limits-of-primary>

Chuquicamata Copper Mine

Copper

General information 	
Indicator or criteria	Description and values
Name of mine	Chuquicamata Copper Mine
Description of mining area	<p>The Chuquicamata complex consists out of the Chuquicamata pit (sulphide ores), the Mina Sur pit (oxide ores) and processing plants. Both open-pits are in the process of closure due to a transformation of the operation (Codelco 2019b; Flores / Catalan 2019; Portal Minero 2011). The complex is located in a sparsely populated part of the Atacama desert, approximately 15 km north of Calama in the province of El Loa. The region is extremely dry with less precipitation than the Sahara desert. The large copper deposit extends over 14 km and includes besides the Chuquicamata operations other mining sites such as Radomiro Tomic and Mesa Mina and (Rüttinger et al. 2014). The deposit is mainly composed of the Chuqui Porphyry orebody which is a medium/coarse grained granodiorite and monzogranite. Concentric bornite-chalcopyrite, chalcopyrite-pyrite and pyrite-chalcopyrite are characteristic for the hypogene mineralisation in this region (Porter Geoconsultancy 1998).</p> <p>By the end of the decade the Chuquicamata pit reaches its profitable limit. Investigations and preparatory planning of an underground mine have been underway since 2002. In 2019 the underground mine started operation and in the next years the open pit operation will come to an end. The underground mine is designed for an operational life of 40 years (Flores / Catalan 2019; Moore 2019).</p>
Surface extension	243.85km ² 243.85 km ² (Image date: 21.02.2020; Viewing height: 16.56 km) (Google Earth)
In operation since	1915 1915 (Codelco 2019a p. 20)
Operator	Codelco
Owner	Codelco
Closest town	Calama (15 km north)

Province	El Loa, Región de Antofagasta
Country	Chile
Longitude	-68.90194°
Latitude	-22.30472°
Altitude	2870 m a.s.l. 2.870 m a.s.l. (Codelco 2019c)
Main product and by-products	Main product: copper; by-products: molybdenum, gold, silver, acid (Codelco 2019a p. 28)
On-site processing stages	Open pit: drilling, blasting, truck and shovel. Underground mine: macroblock as a variant of block caving. Further processing stages also on site: flotation, smelting and refinery facilities (Flores / Catalan 2019; Rüttinger et al. 2014). Tailings are transported to Salar de Talabre which is only 10 km southwest of the mine site(Consejo Minero 2019).
Annual production	2018: 321 kt of copper, 12 kt of molybdenum, 1.4 t of gold, 262 t of silver (Codelco 2019a p. 28)
Proven Reserves	679 Mt copper ore (Codelco 2019a p. 101)
Probable Reserves	624 Mt copper ore(Codelco 2019a p. 101)

Geology



Indicator or criteria	Description and values	Explanation	Assessment result	Data quality
Preconditions for acid mine drainage (AMD)	At División Chuquicamata, the copper was obtained from sulphides (Chuquicamata pit) and oxides (Mina Sur pit) (Porter Geoconsultancy 1998; Schwerin et al. 2009). Today, the Chuquicamata complex undergoes an expensive transition phase from open pit mining to complete underground operation	Due to the large investment and anticipated production capacity of the underground mine, it is assumed that sulfide ore extraction is the main activity at Chuquicamata complex. The extraction of sulphidic minerals has a	High	B1 = medium, can be estimated on the basis of available information

	(US\$ 5.000 millones investment, anticipated production of 140 ktpd copper ore) (Codelco 2019b; Flores / Catalan 2019). According to local press the production of oxide ores from Mina Sur has been stopped in 2014 (Portal Minero 2011).	high environmental hazard potential with regard to AMD.		
Paragenesis with heavy metals	No indication of paragenesis with heavy metals could be determined.	Since copper itself is considered to be a harmful metal to the ecosystem and human health, the measure instructions suggests a high EHP.	High	B2 = medium, classified according to measurement instructions
Paragenesis with radioactive components	No indication of paragenesis with thorium (Th) and uranium (U) could be determined.	In accordance with the measurement instructions, copper ore deposits are evaluated with a medium EHP, if no other information is available.	Low	B2 = medium, classified according to measurement instructions
Deposit size	Codelco announced total reserves of 1,303 Mt copper ore with an average copper grade of 0.73 % in its annual report (Codelco 2019a p. 101).	The announced total reserves would account for approx. 9.5 Mt of copper. According to Rüttinger et al. (2014) Chuquicamata has a historical production of approx. 3,300 Mt of copper ore (since 1915) with an average copper grade of 1.53 %. This would account to 50.5 Mt of copper. By considering the reserves and historical production of the mine, an estimated total deposit size of 60 Mt of copper is assumed. The deposit is classified as very large and, hence, is evaluated with a high EHP.	High	B1 = medium, can be estimated on the basis of available information

Ore grade	In 2018: 0.73 % average copper grade in reserves (Codelco 2019a p. 101)	With a copper ore grade of 0.73 %, the deposit of Chuquicamata is classified as an average grade deposit.	Medium	A = high, can be derived directly from available data
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Technology



Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Mine type	Chuquicamata is one of the oldest and biggest open pit mines in hard rock. However, the open pit operations are coming to an end in the following years and the mine will be transformed into an underground operation (Flores / Catalan 2019).	The case of Chuquicamata is special and unique. It is the first mine of this size to transform from full open pit operation to full underground operation. Even though in the future the deposit will be exploited solely in an underground operation, the mine is rated as an open pit mine. The indicator describes an environmental hazard potential that points towards a possible impact on landscape and environment. The history of Chuquicamata as a large open-pit mine needs to be taken into account. The EHP resulting from the open pit mining on hard rock is medium.	Medium	A = high, can be derived directly from available data
Use of auxiliary substances	Open-pit: Drilling, blasting, truck and shovel. Underground: The ore will be extracted by macro block caving The extracted ore is first crushed, milled and then processed on site in a flotation circuit to produce copper concentrates. The	The processing of the ore at División Chuquicamata covers the whole processing process of the ore to the final copper product (anode copper). The process involves a flotation process where reagents are added,	High	B1 = medium, can be estimated on the basis of available information

	<p>concentrates are further treated in a pyrometallurgical plant and finally refined via electrolysis to anode copper of 99.9 % Cu (MDO 2019; Rüttinger et al. 2014). The excavated oxide ore from the Mina Sur pit followed after crushing and milling a leaching process. No recent data on production from the specific pit could be found. National press indicates that the operation has already stopped (e.g. (Portal Minero 2011)). Furthermore the emphasis of Codelco is put on the underground operation which will exploit sulfides.</p>	<p>pyrometallurgical treatment and refinery. Accordingly the environmental hazard potential caused by the processing method is high. The evaluation is focused on the processing of sulfide ores which will have the highest share of production in future.</p>		
Mining waste	<p>Since 1985 the active tailing of División Chuquicamata is Salar de Talabre which is located 10 km southwest of the mine site. Talabre has the permission for operation until 2025. It's maximum capacity is 2,059 Mt of tailing material. This will cover an area of 6,000 ha. The actual hight of the dam varies between 21 and 59 m (Consejo Minero 2019). Icold Chile (2019) estimates a maximum capacity of 1.2 km³ of the TSF.</p>	<p>The actual hight of the dam with 59 m results into the large dam category (> 16 m) according to the definition of ICOLD (2018). Large TSF's are evaluated with a high EHP.</p>	High	A = high, can be derived directly from available data
Remediation measures	<p>Codelco states it is in compliance with the transitional provisions of Law No. 20.551 and has eight current closure plans duly approved by the authority, corresponding to each of its eight operating divisions. The plans were updated in 2018 with the objective of bringing them from the transitional rules of the law to full regularization for 2020. Additionally, Codelco has bank guarantees constituted for 27,058,918 Unidades de Fomento (UF) in favor</p>	<p>Closure plans are under approval by authorities and funds have been provisioned. Nevertheless, accompanying renaturation or recultivation can not be observed and change in landscape might be irreparable in desert region with little vegetation. Accordingly, a medium EHP is assigned.</p>	Medium	A = high, can be derived directly from available data

	of the Chilean state, to ensure full compliance of with future facility closures (Codelco 2019a p. 62).			
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Framework conditions natural environment



Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Accident hazard due to floods, earthquake, storms, landslides	The rating system for the 4 sub-indicators uses georeferenced data from publicly available risk maps (see measurement instructions (Dehoust et al. 2017b)). Metrics are directly taken from the given risk assessment. The indicator total is determined by the highest hazard level of the sub-indicators.	The Chuquicamata mine has a high EHP for earthquakes and floods which determine the evaluation result. Additionally, the mine has a medium EHP for landslides. The other sub-indicators have a low EHP.	High	A = high, can be derived directly from available data
Water Stress Index (WSI) und desert areas	The WSI by Pfister et al. (2009) provides characterization factors on the relative water availability at watershed level. Absolute water shortages in dry areas is supplemented by desert areas. The highest hazard level of the sub-indicators determines the total result.	The EHP for water stress is high and the mine is situated in a desert area. Both results alone already determine the high EHP result.	High	A = high, can be derived directly from available data
Protected areas and AZE sites	Georeferenced data for designated protected areas are used to assess hazards posed by mining extraction. The metric to evaluate EHPs corresponds to the method first described in the draft standard of the	The mining area is not situated in designated protected areas and AZE sites, which results in a low EHP.	Low	A = high, can be derived directly from available data

	Initiative for Responsible Mining Assurance (IRMA 2014)			
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State Governance

Indicators	
WGI 1 -Voice and Accountability	79.31 ^{ooo}
WGI 2 -Political Stability and Absence of Violence/ Terrorism	60.95 ^{ooo}
WGI 3 - Government Effectiveness	77.88 ^{ooo}
WGI 4 -Regulatory Quality	88.94 ^{ooo}
WGI 5 - Rule of Law	81.73 ^{ooo}
WGI 6 -Control of Corruption	82.21 ^{ooo}
EPI (Environmental Performance Index)	57.49
EITI membership	n.d.
International Agreements	

ILO 176	No
Others	Ratification of the Minamata Convention on Mercury 27.08.2018 (UNEP 2019) Signature of the Paris Agreement on Climate Change (which entered into force on 12.03.2017) (UNFCCC 2016).
Legal framework	
Areas of Law: Environment	<p>The Chilean state is obliged to guarantee a pollution-free environment through environmental legislation. The Environmental Law 19.300 includes the statutory environmental framework and defines that Environmental Impact Assessments (EIA) are mandatory to obtain an environmental license for projects in the mining sector. To these belong, e.g., projects for minerals, oil, gas and coal at different stages of the mine life cycle (exploration to mine closure), (EI SourceBook 2016).</p> <p>The design of the EIAs differ, depending on the potential hazards to a number of social or environmental circumstances. Previous consent of indigenous communities need to be obtained, if these communities are directly affected by a mining project (Minehutte 2019).</p> <p>Three main institutions -with different and defined roles- enforce the environmental regulations: The Ministry of Environment, the Environmental Assessment Service and the Environmental Superintendence. Moreover, according to Law No. 20.600, Environmental Courts have the power to resolve environmental disputes. EIS are presented to the responsible Regional Commission on the Environment or the Executive Directorate of the National Commission on the environment if several regions are affected (Minehutte 2019).</p>

<p>Areas of Law: Occupational Health and Safety (OHS)</p>	<p>Chile ratified the ILO Convention N° 161 Occupational Health Services Convention since 1999 (MDNP 2018). The Supreme Decree No. 132/2004 of the Ministry of Mining regulates occupational health and safety (OHS) measures in the mining sector with the objective to protect the life and physical integrity of all humans that work in or are related to the mining industry. It, furthermore, aims to protect facilities and infrastructure that allow mining operations and their continuance (MDNP 2018)(National Library of Congress 2017). In this framework, companies with more than 100 workers are required to have a Risk Prevention Department in place. This department is headed by an expert qualified by the National Geology and Mining Service (SERNAGEOMIN). The development of plans and programs for the prevention of accidents and occupational diseases is mandatory (MDNP 2018). In general, employers are obliged to ensure the safety of employees, machines and buildings (through training, protective clothing, maintenance of machines). At the same time, employees must ensure that occupational safety and safety rules are observed and controlled (ICLG 2018).</p>
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Corporate Social Responsibility (CSR)

Voluntary Standards	
Aluminium Stewardship Initiative (ASI): Is the mine owning company a member?	Not applicable Not applicable
Aluminium Stewardship Initiative (ASI): Is the mine certified?	Not applicable Not applicable

International Council of Mining & Metals (ICMM): Is the mine owning company a member?	Yes Yes (ICMM 2019)
Towards Sustainable Mining (TSM) Is the mine owning company a member of the Mining Association of Canada (MAC)?	No No (MAC 2019)
Towards Sustainable Mining (TSM) outside Canada: Are TSM standards implemented*?	No information available No information available.
Initiative for Responsible Mining Assurance (IRMA): Is the mine owning company a member?	No No (IRMA 2018)
Initiative for Responsible Mining Assurance (IRMA): Is the mine certified?	No No (IRMA 2018)
Responsible Copper (RC): Is the mine owning company a member of RC?	No The BMW Group and the Chilean copper mining company Codelco have signed an agreement to cooperate on a sustainable and transparent supply of copper (BMW Group 2018).
Responsible Copper (RC): Is the mine certified?	No information available No information
Responsible Mining Index (RMI): Has the mine been rated?	0.67 / 6.00 Yes, 0.67 / 6.00 (RMI 2018a)
Responsible Mining Index Company indicator „Working conditions“	0.664 0.664 / 1.000 (RMI 2018b)
Responsible Mining Index Company indicator „Environmental sustainability“	0.326 0.326 / 1.000 (RMI 2018b)
Responsible Steel (RS): Is the mine owner a member of the RS?	Not applicable Not applicable
Responsible Steel (RS): Is the mine certified?	Not applicable Not applicable

Australian Steel Stewardship Forum (ASSF): Is the owner a member of the ASSF?	Not applicable Not applicable
Australian Steel Stewardship Forum: Is the mine certified?	Not applicable Not applicable
ISO and CSR reporting	
ISO 14001 (ISO 14004): Is the mine ISO 14001 certified?	Yes Yes (Codelco 2011)
CSR-directive 2014/95/EU: Does the mine owning company have its headquarters in an EU country?	No No (Codelco 2019a)
OECD Guidelines: Does the company have its headquarters in a signatory state?	Yes Yes (Codelco 2019a)
ISO 26000: Does the mine implement ISO 26000?*	No information obtained No information available
Banking Standards	
WB Standards / IFC Performance Standards: Is the mine financed to a major extend by the world bank?	No information obtained No indication of current investment (The World Bank 2019).
Equator Principles (EP): Is the mine financed to a major extend by a bank adherent to the EP?	No information obtained No information available

*by companies own account.

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A Glossary

Table 1 Legend

Environmental hazard potential



low



medium



high

Data quality



low



medium



high

- No concrete information, no general specifications of the measurement instructions, expert estimation.
- Assessment not possible due to lack of data at the site, as there is also no evidence for an assessment and there are no generalized assessment rules.

- Assessable on the basis of available information.
- Generalized classification according to measurement instructions.

- Can be derived directly from available data.

B Abbreviations

EHP	Environmental hazard potential
FY	Financial year
kt	Kilo tonnes
m a.s.l.	Meters above sea level
Mt	Million tonnes
OHS	Occupational Health and Safety
t	tonnes
TSF	Tailing Storage Facility
WGI	World Governance Indicators
WHS	Work Health and Safety

C Imprint

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