

ÖkoRess III

Pilot Screening of Environmental Hazard Potentials of Mine Sites

Factsheet:

Candelaria Copper Mining Complex

Lundin Mining, Chile

ID: 58

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>

Candelaria Copper Mining Complex

Copper

General information 	
Indicator or criteria	Description and values
Name of mine	Candelaria Copper Mining Complex
Description of mining area	The Candelaria Copper Mining Complex consists of two mining operations that produce copper concentrates from an open pit (Minera Candelaria) and two underground mines (Minera Ojos del Salado) in the Atacama Region in northern Chile (Lundin Mining 2019a). It is located in a desert environment with warm climate and minimal vegetation cover. The sulphide deposit of Candelaria is part of the polymetallic district of Punta del Cobre, which lies within the volcanic Punta del Cobre formation. Mineralization comprises chalcopyrite, magnetite, pyrite, pyrrhotite and sphalerite at Candelaria open pit. At the Santos and Alcaparrosa underground mines in the north of the complex, exploitable deposits of gold and other minerals as occur (Cole et al. 2018 pp. vi, 24–25).
Surface extension	34.62km ² 34.62 km ² (Image date: 10.8.2019; Viewing height: 9 km) (Google Earth)
In operation since	1995 1995 (Cole et al. 2018 p. vi)
Operator	Lundin Mining
Owner	Lundin Mining
Closest town	Copiapó, 20 km north of the mine (Google Maps)
Province	Región de Atacama (Google Maps)
Country	Chile
Longitude	-70.28892°
Latitude	-27.51388°

Altitude	650 m a.s.l. 650 m a.s.l. (Lundin Mining 2019a)
Main product and by-products	Main product: copper; by-products: gold, silver (Lundin Mining 2019a)
On-site processing stages	Crushing, two parallel lines of grinding and flotation with final concentrate filtration and shipping of bulk copper concentrates (Cole et al. 2018 p. 108)
Annual production	134,578 t of copper; 78,000 ounces of gold; 1.2 million ounces of silver (concentrate) in 2018 (Lundin Mining 2019b p. 1)
Proven Reserves	584.7 Mt, 0.5% Cu ; 477.8 Mt (excluding stockpiles) (Lundin Mining 2019c)
Probable Reserves	113 Mt, 0.5% Cu (Lundin Mining 2019c)

Geology



Indicator or criteria	Description and values	Explanation	Assessment result	Data quality
Preconditions for acid mine drainage (AMD)	The Candelaria deposit is such a sulphidic deposit and therefore, particularly prone to AMD (Cole et al. 2018 p. vii).	The extraction of sulphidic minerals has a high environmental hazard potential with regard to AMD.	High	B1 = medium, can be estimated on the basis of available information
Paragenesis with heavy metals	Copper is a heavy metal itself and moreover often associated with zinc, lead, nickel and arsenic (Dehoust et al. 2017b p. 22). Copper at Candelaria provide very low content of lead and arsenic. The range of the zinc content varies strongly within the concentrates of Candelaria (0.1 % to 3.75 %)(Cole et al. 2018 p. xiv).	Copper is a heavy metal itself. The extraction of copper is consequently always evaluated with a high environmental hazard potential (EHP). Furthermore, the zinc values underline the assessment result.	High	B2 = medium, classified according to measurement instructions

Paragenesis with radioactive components	No indication of paragenesis with thorium (Th) and uranium (U) could be found.	In accordance with the measuring 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	663.7 Mt total reserve with an average copper grade of 0.54 % leads to a total copper content of 3.58 Mt (Lundin Mining 2019d)	Calculating with an annual production of roughly 123,900 t of copper, ca. 2.8 Mt of copper have been mined since the mine was commissioned (1995). Combined with the current metal content of the reserve, the deposit size is approximately 6.4 Mt. The deposit is classified as large sized and, hence, is evaluated with a high EHP.	High	B2 = medium, classified according to measurement instructions
Ore grade	0.54 % Cu (Lundin Mining 2019d)	With a copper content of 0.54 %, Candelaria deposit is assessed as an average grade deposit.	Medium	A = high, can be derived directly from available data

Technology



Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Mine type	Hard-rock open pit mining and underground mining (Cole et al. 2018 p. iii).	Conventional solid rock open pit mining is evaluated with a medium EHP. During open pit mining in solid rocks, the mining activities are restricted to the	Medium	A = high, can be derived directly from available data

		horizontal and vertical extension of the ore body/mineralized zone. The impact is higher than in underground mining but less pronounced than in mining of alluvial or unconsolidated sediments. The overall result of the evaluation always depends on the highest EHP determined at the site.		
Use of auxiliary substances	The Candelaria processing plant consists of two parallel lines for grinding and flotation, process water treatment and final filtration of the copper concentrate. The flotation circuit is thickening copper concentrate with gold and silver by-products and stores it on site. The PAC processing plant (Santos underground mine) comprises crushing, grinding and multi-stage flotation units as well as filtration processing (Cole et al. 2018 pp. xii-xiii).	Solvent-extraction is often conducted with the help of toxic additives such as chemical solvents, leading to a high EHP in the evaluation result.	High	A = high, can be derived directly from available data
Mining waste	Tailings from the Candelaria open pit are disposed of in a rockfill embankment tailings facility. Tailings from the PAC processing plant are stored in the Candelaria tailings storage facility. It is located at an altitude of 800 m a.s.l. and covers an area of 456 ha with a maximum capacity of 331 mm ³ . The first construction phase of the new Los Diques tailings storage facility was completed in 2018. It consists of three retaining walls made of rolled material (sterile material): Main, North and South, which will reach a height of 156 m, 87 m and 112 m respectively, to finally reach a height of 873 m a.s.l. It is located southwest of the mine site and will have an estimated	The treatment of polymetallic and fine ores by flotation, leads to a high quantitative proportion of fine waste which are stored in large tailing ponds. The disposal of waste in high-volume ponds or dams are evaluated with a high EHP.	High	B2 = medium, classified according to measurement instructions

	capacity of ca. 600 Mt. (Consejo Minero 2019). Flotation tailings will be thickened and then pumped to Los Diques through a pipeline which will be installed in 2019 (Cole et al. 2018 pp. xii–xiii).			
Remediation measures	All mines of the Candelaria Complex have closure plans compliant with the Chilean mining law and corporate standards of Lundin. An environmental monitoring program has been installed in 1993 to assess environmental changes. It includes parameter as groundwater quality, dust, noise and vibration. Results are supervised by the Chilean authorities (Cole et al. 2018 pp. 130–131). Up to 2018, no disturbed area has been recultivated during the mining process (Lundin Mining 2018).	The EHP is determined as medium medium due to existing closing plans and ongoing environmental monitoring. However, there was no recultivation of disturbed areas or compensatory measures concomitantly to the mining activity.	Medium	B1 = medium, can be estimated on the basis of available information

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. 2017)). Metrics are directly taken from the given risk assessment. The indicator total is	The Candelaria complex has a high EHP for floods and earthquakes which determines the evaluation result. The other sub-indicators have a low EHP.	High	A = high, can be derived directly from available data

	determined by the highest hazard level of the sub-indicators.			
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 although La Candelaria is not situated in a desert area. This result 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 Initiative for Responsible Mining Assurance (IRMA 2014).	The mine 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

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 °°°
WGI 6 -Control of Corruption	82.21 °°°
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	

<p>Areas of Law: Environment</p>	<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</p>

	<p>(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?	No No (ICMM 2019)
Towards Sustainable Mining (TSM) Is the mine owning company a member of the Mining Association of Canada (MAC)?	Yes Yes (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 information available No information available
Responsible Copper (RC): Is the mine certified?	No information available No information available
Responsible Mining Index (RMI): Has the mine been rated?	No No (RMI 2018)
Responsible Mining Index Company indicator „Working conditions“	Not applicable Not applicable
Responsible Mining Index Company indicator „Environmental sustainability“	Not applicable Not applicable
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 (Cole et al. 2018 p. 131)

CSR-directive 2014/95/EU: Does the mine owning company have its headquarters in an EU country?	No No (Canada) (Lundin Mining 2019e)
OECD Guidelines: Does the company have its headquarters in a signatory state?	Yes Yes (OECD 2019)
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?	Yes Yes (MIGA 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 (EP n.d.)

*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

Publisher:

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Project period: 03/2018 –02/2021

The research project has been commissioned by the German Environment Agency as part of the Environmental Research Plan of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and funded by the Federal Government (FKZ: 3717 35 306 0).

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