ÖkoRess III

Pilot Screening of Environmental Hazard Potentials of Mine Sites

Factsheet:

Centinela (Esperanza)

Antofagasta, Chile

ID: 55

German Environment Agency

Umwelt Bundesamt

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.

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

Centinela (Esperanza)

Copper

General information

Indicator or criteria	Description and values
Name of mine	Centinela (Esperanza)
Description of mining area	The Centinela mining district is located in Northern Chile (Region II) in a very dry, desert-like and sparsely populated region. Centinela was formed in 2014 from the merger of the Esperanza and El Tesoro mining companies. In 2015, Antofagasta plc and Marubeni merged Minera Centinela with its fully-owned subsidiary CCM Encuentro to start exploitation of an oxide/sulphide deposit in the same mining district (Yourmetalnews Sep 03, 2015). As of 2016, Centinela is operating four (4) production pits: Esperanza, Tesoro Central, Tesoro Noreste and Mirador (Antofagasta plc 2019). Mineralisation in these porphyry copper-type deposits mainly chalcopyrite and bornite, minor chalcocite and molybdenite, associated with gold. (PorterGeo, 2016). The mining district has an expected lifespan of 49 years. (Antofagasta plc Annual Report 2018)
Surface extension	76.56km^2 76.56 km^2 (Image date: 04.06.2019; Viewing height: 12.88 km) (Google Earth)
In operation since	2001 El Tesoro (2001), Esperanza (2011) (Antofagasta plc 2019)
Operator	Minera Centinela
Owner	Antofagasta
Closest town	Sierra Gorda, about 25 km from El Tesoro open pit (GoogleEarth 2018)
Province	Antofagasta (Region II)
Country	Chile
Longitude	-69.05928°

Latitude	-22.9734°
Altitude	2350 m a.s.l. 2,200 m – 2,350 m a.s.l. (GoogleEarth 2018)
Main product and by-products	Main product: Copper (Cu) with by-products gold (Au), silver (AG) and molybdenum (Mo) (Antofagasta plc 2019).
On-site processing stages	Centinela produces copper concentrate (containing gold and silver) through a milling and flotation process, and, as of 2018, molybdenum concentrate. It also produces copper in cathodes, using the solvent extraction and electro-winning (SX-EW) process (Antofagasta plc 2019). Mined sulphide ore is milled then sent to flotation cells where it is upgraded to a concentrate containing some 25-35 % copper. This concentrate is then shipped to a smelter operated by a third party and converted to copper metal. (Antofagasta plc 2018) Mined oxide ore, sometimes combined with leachable sulphide ore, is crushed, piled into heaps and then leached with sulphuric acid, producing a copper solution. This solution is then put through a solvent extraction and electrowinning (SX-EW) plant to produce copper cathodes, which are sold to fabricators around the world. (Antofagasta plc 2018) Starting 2019, Encuentro is expected to produce an average of approximately 43,000 t/a of copper cathode over an eight-year period, using the existing capacity at Centinela's SX-EW plant (IM-Mining n.y.).
Annual production	Centinela 2018: 248,000 t annual copper production, including 155,500 t from concentrates and 92,500 t from copper cathodes. Gold production was 146,900 ounces and the new molybdenum plant started operation during 2018 producing 300 t of molybdenum in concentrates with a design capacity of 2,400 t/a (Antofagasta plc Annual Report 2018). The expected mine life of the Centinela district is 49 years. (Antofagasta plc Annual Report 2018)
Proven Reserves	Centinela as at December 31, 2018 (Antofagasta plc Annual Report 2918): Sulphides: 565.9 Mt @ Cu 0.48 %, , Mo 0.012 %, Au 0.19 g/t Oxides: 134.3 Mt @ Cu 0.52 %
Probable Reserves	Centinela as at December 31, 2018 (Antofagasta plc Annual Report 2918): Sulphides: 1,279.2 Mt @ Cu 0.40 %, Mo 0.012 %, Au 0.12 g/t Oxides: 191.8 Mt @ Cu 0.32 %

Geology

Indicator or criteria	Description and values	Explanation	Assessment result	Data quality
Preconditions for acid mine drainage (AMD)	Esperanza: Sulphide mineralisation associated with gold, mainly chalcopyrite and bornite, minor chalcocite, molybdenite (PorterGeo, 2016) Tesoro: Exotic copper oxide deposit with mainly paratacamite, atacamite, minor chrysocolla, wad (PorterGeo, 2016)	The mined ore is mainly sulphidic, moreover copper is a chalcophile element. Overall preconditions for generating acid mine drainage are given. Accordingly, the Environmental Hazard Potential (EHP) resulting from AMD potential is high.	High	A = high, can be derived directly from available data
Paragenesis with heavy metals	Mineralization is associated with heavy metal copper (Cu) (PorterGeo, 2016)	Since copper itself is considered to be a harmful metal to the ecosystem and human health, the measurement instructions suggest a high EHP.	High	A = high, can be derived directly from available data
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	Proven & probable reserves: 2,171.2 Mt @ 0.42 % Cu (Antofagasta plc Annual Report 2918) = 9.119 Mt Cu (own calculation)	The Centinela complex consisting of four major orebodies with 9.119 Mt of contained copper is classified as a large copper deposit (3-10 Mt Cu), even without calculating the extracted ore to date. According to measurement	High	A = high, can be derived directly from available data

		instructions based on Petrow (2008), this results in a high EHP.		
Ore grade	0.42 % Cu (Antofagasta plc Annual Report 2918)	The medium range grade of the Centinela orebodies (Cu 0.5-3.0 %) indicates a high EHP according to measurement instructions based on Priester et al. (2019).	Medium	A = high, can be derived directly from available data

Technology

Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Mine type	Convential solid rock open pit mining with shovels/loaders and trucks (Antofagasta plc 2019).	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 horizontal and vertical extension of the ore body/mineralized zone. The impact is higher than in underground mining but less pronounced then in mining of alluvial or unconsolidated sediments.	Medium	A = high, can be derived directly from available data
Use of auxiliary substances	Mining: Drill & blast, loading and truck hauling to Mill. Processing: a) Copper concentrate (containing gold and silver) through a milling and flotation process; b) Copper cathodes using a solvent extraction	Both processes applied at Centinela commonly use toxic chemicals, therefore a high EHP is indicated.	High	A = high, can be derived directly from available data

	and electrowinning process SX-EW. (Antofagasta plc Centinela)			
Mining waste	Chile has very strict regulations governing TSF construction requiring safety measures. emergency plans and continuous stability analysis. Centinela TSF includes a physical and chemical stability monitoring system providing real-time information to mine, communities and authorities. (Antofagasta Annual Rport 2018) Centinela operations generate sterile material (below cut-off, placed in waste dumps), spent ore (from cathodes) and mill tailings. (Anto-fagasta Sustainability Report 2017) Antofagasts is a member of ICMM's committee responsible for finding sustainable and innovative solutions to mining waste management. (Anto-fagasta Sustainability Report 2017)	Large-scale open-pit mining of low grade material within the Centinela district creates large waste dumps and mill tailings as visible on GoogleEarth. Mine location is in mostly uninhabitated and barren territory, however, due to the very large footprint of the operation, which according to Antofagasta PLC's expansion plans is expected to double in the coming years, the EHP is indicated as high, however, good management principles and best practices based on ICMM guidelines would indicate a medium EHP.	Medium	A = high, can be derived directly from available data
Remediation measures	First thermo-solar plant of industrial scale in the mining industry 100% use of sea water without desalination in the concentrator Large scale thickened tailings operation (Centinela presentation to shareholders, Dec 2016)	Innovative environmental protection measures to reduce freshwater and fossil fuel consumption are in place. No other information on remediation measures was available, therefore a medium EHP is indicated.	Medium	A = high, can be derived directly from available data

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 mine is located in a seismic active area (Andean Region) with a high EHP for earthquakes and floods which determines the evaluation result. 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 availablility 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 Initiative for Responsible Mining Assurance (IRMA 2014).	The mine site 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 °°°
WGI 2 -Political Stability and Absence of Violence/ Terrorism	60.95 °°°
WGI 3 - Government Effectiveness	77.88 °°°
WGI 4 -Regulatory Quality	88.94 °°°
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	
Areas of Law: Environment	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). 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). 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).

Areas of Law: Occupational Health and Safety (OHS)	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).

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 Yes, Antofagasta plc joined ICMM in 2014.
Towards Sustainable Mining (TSM) Is the mine owning company a member of the Mining Association of Canada (MAC)?	No No (MAC n.y)
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?	0.50 / 6.00 0.50 / 6.00 (RMI n.y.)
Responsible Mining Index Company indicator „Working conditions“	0.553 Antofagasta plc 0.553 / 1.000 (RMI n.y.)
Responsible Mining Index Company indicator „Environmental sustainability“	0.469 Antofagasta plc 0.469 / 1.000 (RMI n.y.)
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?	No information obtained No information available
CSR-directive 2014/95/EU: Does the mine owning company have its headquarters in an EU country?	Yes Antofagasta plc is registered in London, UK.
OECD Guidelines: Does the company have its headquarters in a signatory state?	No The UK is an OECD member state since 1961.
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 information available
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.

Sources

ooo

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:

German Environment Agency

Section III 2.2

PO Box 14 06

06813 Dessau-Rosslau, Germany

Tel: +49 340-2103-0

info@umweltbundesamt.de

www.umweltbundesamt.de

Contact:

Jan Kosmol – jan.kosmol@uba.de

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).

Contractor:

Projekt-Consult GmbH

Eulenkrugstrasse 82

22359 Hamburg, Germany

T +49 (40) 60306-740

F +49 (40) 60306-199

www.projekt-consult.de

Contact:

Dr. Aissa Rechlin – aissa.rechlin@projekt-consult.de

Christopher Demel – christopher.demel@projekt-consult.de

Project Partners:

- ifeu – Institut für Energie-und Umweltforschung Heidelberg gGmbH (Institute for Energy and Environmental Research)
- Öko-Institut e.V. (Institute for Applied Ecology)