

ÖkoRess III

Pilot Screening of Environmental Hazard Potentials of Mine Sites

Factsheet:

Morenci Copper (SX-EW) Mine

Freeport-McMoRan , USA

ID: 48

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>

Morenci Copper (SX-EW) Mine

Copper

General information	
Indicator or criteria	Description and values
Name of mine	Morenci Copper (SX-EW) Mine
Description of mining area	Morenci is a copper ore mining complex located within the desert in Greenlee county, Arizona (FCX 2018a). The mining complex is composed of three pits, the Metcalf, the NWX and the Coronado (Verdict Media Limited 2019). Morenci copper mine was mined in underground operation first, but since 1939 it was converted to an open-pit mine. The main types of ore found at Morenci are chrysocolla (oxide copper mineral) chalcocite (secondary copper sulfide) and chalcopyrite (primary copper sulfide) (FCX 2019a). According to (Verdict Media Limited 2019), molybdenite, galena and sphalerite are also present.
Surface extension	103.85km ² 103.85 km ² (Image date: 05.05.2019; Viewing height: 18.49 km) (Google Earth)
In operation since	1872 Open-pit mining since 1939, before underground mining (FCX 2019a), mining started in 1872 by Detroit Copper Company (Verdict Media Limited 2019).
Operator	Freeport Minerals Corp
Owner	Freeport-McMoRan
Closest town	80 km northeast of Safford (FCX 2019a)
Province	Arizona
Country	USA
Longitude	-109.36525°
Latitude	33.10131°
Altitude	1447 m a.s.l. Approx. 1,447 m a.s.l. (Verdict Media Limited 2019)




Main product and by-products	Main product: copper. By-product: molybdenum (FCX 2018a).
On-site processing stages	On-site processing consists of milling with two concentrators (115,000 m ³ of ore per day) in order to obtain copper and molybdenum concentrate, a crushed-ore leach pad and stacking system, a low-grade run-of-mine (ROM) leaching system, 4 solvent extraction plants and 3 electro-winning tank houses that produce copper cathodes (FCX 2018a). According to (MDO 2019), flotation also belongs to the processing technologies of Morenci.
Annual production	The annual report 2018 of FCX contains only aggregated production data for the North American copper mines (FCX 2019b, p. 23). The entire joint ventures production was 454 kt of copper and 4 kt of molybdenite in 2018. FCX has a 49% share in the mine.
Proven Reserves	Estimated recoverable proven and probable mineral reserves in 2018: 4,619 Mt copper ore (FCX 2019b)
Probable Reserves	No differentiation between proven and probable reserves.

Geology



Indicator or criteria	Description and values	Explanation	Assessment result	Data quality
Preconditions for acid mine drainage (AMD)	According to the Goldschmidt classification, copper (and thus also copper ore) is a chalcophile element. Chalcophile elements do have acid mine drainage potential due to the fact that they are often obtained from sulfidic deposits. With respect to neutralization potential and acidic base account, no indication of considerable neutralization potential or acidic base account at the site could be found.	The environmental hazard potential (EHP) for AMD is high because mining at Morenci mine is associated with sulfidic mineral extraction that is prone to AMD.	High	B2 = medium, classified according to measuring instructions
Paragenesis with heavy metals	Water contamination in 1996 of - among others - heavy metals such as cadmium, has	The measurement instructions indicate that copper ore can be	High	B1 = medium, can be estimated on the

	been reported by the U.S. Protection Environmental Agency (U.S. Environmental Protection Agency 1997). For 7 parameters, the sample results exceeded maximum contaminant levels.	associated with zinc, lead, arsenic, selenium, nickel and mercury. Furthermore, copper itself is considered to be a harmful metal to the ecosystem and human health. Measurements revealed increased contaminant levels of cadmium which justifies the assignment of a high EHP.		basis of available information
Paragenesis with radioactive components	No indication of paragenesis with radioactive components 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	According to (FCX 2019b), the proven and probable reserves are 4,619 Mt copper ore (0.24 % copper), which results in a total of 11.08 Mt copper.	By considering historic statistical data, a total production of 16,09 Mt copper between 1939 and 2018 was estimated (own calculation based on (FCX 2018a; MDO 2019; Phelps Dodge Corporation 1993, 1999, 2004; Verdict Media Limited 2019)). Adding the current reserves of 2018 to the cumulated mined copper, it results in a total deposit size of 27.17 Mt copper. 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	0.24 % copper (FCX 2019b)	The ore grade < 0.5 % is classified as a low ore grade. Therefore, a high EHP has been assigned.	High	A = high, can be derived directly from available data

Technology 				
Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Mine type	Mining at Morenci started in 1872 (Verdict Media Limited 2019) with underground mining until 1937. Since then, the mine type is an open-pit mine (FCX 2019a).	Given the fact that superficial removal of the overburden leads to a high surface consumption of the mining operation and that copper ore mining is referred to hard-rock open-pit mining, the EHP is considered medium.	Medium	A = high, can be derived directly from available data
Use of auxiliary substances	The entire process of extraction and processing ranges from truck and shovel (FCX 2018a), leaching with bacterial assistance (Verdict Media Limited 2019) up to solvent extraction (SX) and flotation (MDO 2019).	The EHP is high with respect to the measurement instructions, especially solvent extraction (SX) methods usually require toxic solvents for the extraction process.	High	A = high, can be derived directly from available data
Mining waste	At Morenci, an active management system for tailing dust prevention has been developed and implemented (FCX 2017). New TSF's at Morenci have been built, whereby earthquakes, rainfall, soil conditions as well as production conditions have been taken into account (FCX 2019c). The current tailings storage impoundment volume of all active TSF's of Morenci is 583.27 Mio m ³ (FCX 2019d).	According to the definition of (ICOLD 2018), the TSF volume of 583,27 Mio m ³ is considered to be large (> 3 Mio m ³). Large TSF's are evaluated with a high EHP.	High	A = high, can be derived directly from available data
Remediation measures	Information about remediation measures are hardly available. Freeport McMoRan states that land reclamation is a part of mine	On the one hand, no official closure plan for the active sites could be found, but on the other hand reclamation has in	Low	C = low, no concrete information, no

	<p>operation in Arizona. With respect to Morenci, Freeport-McMoRan developed a new reclamation technology, where large-size waste rock is used as an alternate cover material at Morenci's open-pit mine. This technology has been implemented in 2012 and subsequently evaluated. In addition, efforts for bat and big horn sheep conservation have been undertaken (FCX 2014).</p>	<p>taken place in 2012 and efforts for species resettlement have been undertaken. In addition, Article 3 Aquifer Protection Permits 49-252 Closure notification and approval regulates that the owner or operator of a mining area shall submit a closure plan within 90 days after closure notification (Justia 2019). In accordance with the measurement instructions, the mine is evaluated with low EHP as the mine is owned and operated by a large and international mining company and situated in a country with high governance performance.</p>		<p>general specifications in the measuring instructions, (expert) estimate</p>
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Framework conditions natural environment



Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
<p>Accident hazard due to floods, earthquake, storms, landslides</p>	<p>The rating system for the 4 sub-indicators uses georeferenced data from publicly available risk maps (see measurement instructions). Metrics are directly taken from the given risk assessment. The indicator total is determined by the highest hazard level of the sub-indicators.</p>	<p>The Morenci mine has a high EHP for floods which determines the evaluation result. The other sub-indicators have a low EHP.</p>	<p>High</p>	<p>A = high, can be derived directly from available data</p>

<p>Water Stress Index (WSI) und desert areas</p>	<p>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.</p>	<p>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.</p>	<p>High</p>	<p>A = high, can be derived directly from available data</p>
<p>Protected areas and AZE sites</p>	<p>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).</p>	<p>The mining area is not situated in designated protected areas and AZE sites, which results in a low EHP.</p>	<p>Low</p>	<p>A = high, can be derived directly from available data</p>

State Governance

Indicators	
WGI 1 -Voice and Accountability	82.27 ^{ooo}
WGI 2 -Political Stability and Absence of Violence/ Terrorism	59.05 ^{ooo}
WGI 3 - Government Effectiveness	92.79 ^{ooo}
WGI 4 -Regulatory Quality	92.79 ^{ooo}
WGI 5 - Rule of Law	91.83 ^{ooo}

WGI 6 -Control of Corruption	88.94 ^{ooo}
EPI (Environmental Performance Index)	71.19
EITI membership	No (EITI 2019), the US joined the EITI in 2014 and withdrew from the EITI in 2017
International Agreements	
ILO 176	Yes, ratified in 2001
Others	OECD member
Legal framework	

<p>Areas of Law: Environment</p>	<p>The National Environmental Policy Act (NEPA) is the principal environmental law implicated by mining on federal lands. It requires federal agencies to take a “hard look” at the environmental consequences of its projects before action is taken. An agency must prepare an Environmental Impact Statement (EIS) for all major federal actions significantly affecting the quality of the human environment. The analysis generally requires consideration of other substantive environmental statutes and regulations, including the Clean Air Act, the Clean Water Act and the Endangered Species Act. State laws may also require environmental analysis. Third parties may sue the federal agency completing the review to ensure that the agency considered all relevant factors and had a rational basis for the decisions made based on the facts found. Prosecuting the litigation would extend the project approval time, and if the agency loses, additional time would be required for the agency to redo its flawed NEPA analysis (Kahalley 2018). The Clean Air Act is administered by the Environmental Protection Agency (EPA) and states with delegated authority. The Clean Water Act is administered by the EPA, the US Army Corps of Engineers, and states with delegated authority. The US Fish and Wildlife Service and National Marine Fisheries Service administer the Endangered Species Act. States also have a wide range of environmental laws that govern permitting and reclamation on mining projects. A variety of federal and state laws govern the storage of tailings and other waste products on mining operations and for the closure of mines. In general, a mine plan must provide a detailed description of how the mine operations will comply with such requirements (Kahalley 2018). The Federal Land Policy and Management Act (FLPMA) requires the US Bureau of Land Management (BLM) and the US Forest Service (USFS) to prevent unnecessary or undue degradation of public lands. BLM and USFS reclamation standards include saving topsoil for reshaping disturbed areas, erosion and water control measures, toxic materials measures, reshaping and re-vegetation where reasonably practicable, and rehabilitation of fish and wildlife habitat. State laws may also include closure and reclamation</p>
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	<p>requirements. Federal and state laws generally require financial guarantees prior to commencing operations to cover closure and reclamation costs (Kahalley 2018).</p>
<p>Areas of Law: Occupational Health and Safety (OHS)</p>	<p>The Federal Mine Safety and Health Act requires the Mine Safety and Health Administration (MSHA) to inspect all mines each year to ensure safe and healthy work environments. MSHA is prohibited from giving advance notice of an inspection, and may enter mine property without a warrant. MSHA regulations set out detailed safety and health standards for preventing hazardous and unhealthy conditions, including measures addressing fire prevention, air quality, explosives and others. MSHA regulations also establish requirements for: testing, evaluating, and approving mining products; miner and rescue team training programmes; and notification of accidents, injuries, and illnesses at the mine. Owners, employers, managers and employees all have obligations under the laws described in question (Kahalley 2018).</p>

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 Not specifically mentioned
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 obtained
Responsible Copper (RC): Is the mine certified?	No information available No information obtained
Responsible Mining Index (RMI): Has the mine been rated?	No No (RMI 2018)
Responsible Mining Index Company indicator „Working conditions“	0.617 0.617 (RMI 2018)

Responsible Mining Index Company indicator „Environmental sustainability“	0.405 0.405 (RMI 2018)
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 (FCX 2018b)
CSR-directive 2014/95/EU: Does the mine owning company have its headquarters in an EU country?	No No, USA (FCX 2018c)
OECD Guidelines: Does the company have its headquarters in a signatory state?	Yes Yes (World Population Review 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?	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

Dehoust, G.; Manhart, A.; Möck, A.; Kießling, L.; Vogt, R.; Kämper, C.; Giegrich, J.; Auberger, A.; Priester, M.; Rechlin, A.; Dolega, P. (2017a): Erörterung ökologischer Grenzen der Primärrohstoffgewinnung und Entwicklung einer Methode zur Bewertung der ökologischen Rohstoffverfügbarkeit zur Weiterentwicklung des Kritikalitätskonzeptes (ökoRess I) - Konzeptband. Umweltbundesamt, Dessau-Roßlau.

Dehoust, G.; Manhart, A.; Möck, A.; Kießling, L.; Vogt, R.; Kämper, C.; Giegrich, J.; Auberger, A.; Priester, M.; Rechlin, A.; Dolega, P. (2017b): Erörterung ökologischer Grenzen der Primärrohstoffgewinnung und Entwicklung einer Methode zur Bewertung der ökologischen Rohstoffverfügbarkeit zur Weiterentwicklung des Kritikalitätskonzeptes (ökoRess I) - Methode für einen standortbezogenen Ansatz. Umweltbundesamt, Dessau-Roßlau.

EITI (2018): United States of America | Extractive Industries Transparency Initiative. <https://eiti.org/united-states-of-america>. (20.08.2019).

EITI (2019): EITI Countries. In: Extractive Industries Transparency Initiative. <https://eiti.org/countries>. (16.04.2019).

FCX (2014): MINING RECLAMATION IN NORTH AMERICA. Supporting A Sustainable Future. Freeport-McMoRan (FCX). https://fcx.com/sites/fcx/files/documents/sustainability/mining_red_na_2014.pdf (16.08.2019).

FCX (2017): Morenci Facts from FCX. Tailings Dust Management at Morenci. Freeport-McMoRan. https://fcx.com/sites/fcx/files/documents/fast_facts/morenci_tailings_dust_mgmt.pdf (16.08.2019).

FCX (2018a): FORM 10-K. United States Securities and Exchange Commission. https://www.miningnewsfeed.com/reports/annual/Freeport-McMoRan_10_k2018.pdf (16.08.2019).

FCX (2018b): Environment. In: Freeport-McMoran (FCX). <https://www.fcx.com/sustainability/environment>. (23.07.2019).

FCX (2018c): CONTACT Freeport-McMoRan | Freeport-McMoRan. In: Freeport-McMoRan (FCX). <https://www.fcx.com/contact>. (20.08.2019).

FCX (2019a): NORTH AMERICA | Freeport-McMoRan. In: Freeport-McMoRan (FCX). https://fcx.com/operations/north-america#morenci_link. (20.08.2019).

FCX (2019b): 2018 Annual Report. Freeport-McMoRan (FCX). https://s22.q4cdn.com/529358580/files/doc_financials/annual/FCX_AR_2018.pdf (13.09.2019).

FCX (2019c): Tailings Management and Stewardship Summary. Freeport-McMoRan (FCX).
https://www.fcx.com/sites/fcx/files/documents/sustainability/FCX_Tailings_Stewardship_Program.pdf (16.08.2019).

FCX (2019d): Overview of Tailings Management and Stewardship Program.
https://www.fcx.com/sites/fcx/files/documents/sustainability/supporting_data.pdf (23.01.2020).

ICMM (2019): Member companies. In: International Council on Mining and Metals (ICMM). <https://www.icmm.com/en-gb/members/member-companies>. (16.04.2019).

ILO (2017): Ratifications of C176 - Safety and Health in Mines Convention, 1995 (No. 176). In: International Labour Organization (ILO).
http://www.ilo.org/dyn/normlex/en/f?p=1000:11300:0::NO:11300:P11300_INSTRUMENT_ID:312321. (12.04.2018).

IRMA (2018): Responsible Mining Map. In: Initiative for Responsible Mining Assurance (IRMA). <https://map.responsiblemining.net/>. (16.04.2019).

Justia (2019): Clause 49-252 Closure notification and approval :: 2016 Arizona Revised Statutes :: US Codes and Statutes :: US Law :: Justia.
<https://law.justia.com/codes/arizona/2016/title-49/section-49-252/>. (24.10.2019).

Kahalley, K. (2018): USA: Mining Law 2019. In: Mining Law 2019 | Laws and Regulations | USA | ICLG. Text, <https://iclg.com/practice-areas/mining-laws-and-regulations/usa>. (11.06.2019).

MAC (2019): Our Members. In: The Mining Association of Canada (MAC). <http://mining.ca/members-partners/our-members>. (16.04.2019).

MDO (2019): Major Mines & Projects - Morenci Mine. In: Mining Data Online (MDO). <https://miningdataonline.com/property/84/Morenci-Mine.aspx>. (20.08.2019).

Pfister, S.; Koehler, A.; Hellweg, S. (2009): Assessing the Environmental Impacts of Freshwater Consumption in LCA. In: Environmental science & technology. Vol. 43, No.11, S. 4098–4104.

Phelps Dodge Corporation (1993): 1993 Annual Report on Form 10-K Part I. <http://getfilings.com/o0000950147-94-000024.html> (06.02.2020).

Phelps Dodge Corporation (1999): 1999 Annual Report.
<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwjtuq-jz7znAhUGaFAKHScJDYgQFjAAegQIBRAB&url=http%3A%2F%2Fwww.tomfrey.com%2Fuploads%2F1%2F0%2F6%2F5%2F10651530%2Fpd99ar.pdf&usg=AOvVaw3cfDiUAykr-9d8aXGwCCJL> (02.06.2020).

Phelps Dodge Corporation (2004): Annual Report on Form 10-K For the Year Ended December 31, 2004.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwj18-eA07znAhWLJlAKHXPwBqAQFjABegQIBBAB&url=https%3A%2F%2Fwww.nrc.gov%2Fdocs%2FML0513%2FML051310321.pdf&usg=AOvVaw05b8ZRurf_tmVUnlun4w5s (02.06.2020).

RMI (2018): Companies. In: Responsible Mining Index (RMI). </en/companies/29>. (16.04.2019).

U.S. Environmental Protection Agency (1997): Damage Cases and Environmental Releases from Mines and Mineral Processing Sites. S. 231.

<https://nepis.epa.gov/Exe/ZyPDF.cgi/P1000J98.PDF?Dockey=P1000J98.PDF> (06.08.2019).

Verdict Media Limited (2019): Morenci Copper Mine, Arizona - Mining Technology | Mining News and Views Updated Daily. <https://www.mining-technology.com/projects/morenci/>. (20.08.2019).

Wendling, Z. A.; Emerson, J. W.; de Sherbinin, A.; Esty, D. C. (2020): 2020 Environmental Performance Index. Yale Center for Environmental Law & Policy, New Haven, CT. <https://epi.yale.edu/epi-results/2020/component/epi> (11.08.2020).

WGI (2019): The Worldwide Governance Indicators (WGI). The World Bank. <http://info.worldbank.org/governance/WGI/#home>. (10.12.2018).

World Population Review (2019): Oecd Countries 2019. <http://worldpopulationreview.com/countries/oecd-countries/>. (20.08.2019).

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
Eulenkruogstrasse 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)