ÖkoRess III

Pilot Screening of Environmental Hazard Potentials of Mine Sites

Factsheet:

Kiruna

Swedish State, Sweden

ID: 21

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

Kiruna

Iron ore

General information

Indicator or criteria	Description and values
Name of mine	Kiruna
Description of mining area	In 2019, the largest underground iron ore mine in the world is over four kilometers long, between 80 and 120 metres wide and the main level is at 1365 m depth, for 2019. Depth of mineralization is unknown (LKAB 2019a). Mine is located of the northern part of the Scandinavian mountains, with Kiruna as the northernmost province in Sweden. The ore body of Kiruna (Kiirunavaara) was formed 1,600 million years ago by the precipitation of iron-rich solutions on a syenite porphyry base. The ore bed was covered by other volcanic deposits (quartz porphyry) and sedimentary rocks before being deposited on the current inclination of 50 - 60° has been adjusted (Mining Technology n.d.)
Surface extension	45.51km^2 45.51 km2 (Image date: 25.07.2019; Viewing height: 13.01 km) (Google Earth)
In operation since	1899 1899
Operator	LKAB
Owner	Swedish State
Closest town	Kiruna
Province	Norrbotten
Country	Sweden
Longitude	20.195639°
Latitude	67.851472°

Altitude	600 m a.s.l. 500 to 600 m a.s.l. (Google Earth)
Main product and by-products	Main product: iron ore pellets; by-products: none
On-site processing stages	The ore of LKAB is transported from the mines and processing plants to the ports in Narvik and Luleå along the ore railway. Two thirds of the ocean freight depart from Narvik and one third depart from Luleå (LKAB 2019b).
Annual production	27.4 Mt crude ore, 14.8 Mt of iron ore products (LKAB 2019a)
Proven Reserves	Total: 624 Mt (44.1 % Fe) (LKAB 2019a)
Probable Reserves	Total: about 62 Mt (40.5 % Fe) (LKAB 2019a)

Geology

Indicator or criteria	Description and values	Explanation	Assessment result	Data quality
Preconditions for acid mine drainage (AMD)	Iron ores are usually present in oxidic minerals, whereby the respective general association (including accompanying minerals) can often also contain sulfides. In these cases, a medium rating is recommended.	Sulfidic rock types are present but not predominant, also Iron is a siderophil element, therefore AMD poses a medium Environmental hazard potential (EHP).	Medium	B2 = medium, classified according to measurement instructions
Paragenesis with heavy metals	No indication of paragenesis with heavy metals could be determined.	As there is no direct information on the paragenesis with heavy metals available. In this case the measurement instructions indicate that oxidic iron ores can be associated with heavy metals such as lead, zinc, copper, chrome, and arsenic. Accordingly, heavy metals and arsenic may have a	Medium	B2 = medium, classified according to measurement instructions

		limited relevance in the extraction of oxidic iron ores, leading to a medium EHP.		
Paragenesis with radioactive components	No indication of paragenesis with thorium and uranium.	In accordance with the measurement instructions, iron ore deposits are evaluated with a medium EHP, if no other information is available.	Medium	B2 = medium, classified according to measurement instructions
Deposit size	According to UBA, 940 Mt of ore were extracted till 2004 (Umweltbundesamt 2004). 15 years of production from 2004 to 2019, with an approximation of 20 Mt crude ore per year, sums up to 300 Mt. This means that roughly 1,240 Mt of crude ore has been mined at Kiruna. With a given reserve of 624 Mt, this equals a total of 1,864 Mt crude ore. With a grade of 60%, this results in 1,118.4 Mt Fe content.	The deposit can therefore be classified as large. Large deposits are assessed with a high EHP.	High	B1 = medium, can be estimated on the basis of available information
Ore grade	Approx. 60 % Fe (Mining Technology n.d.)	Compared to other globally mined iron ores, the mine has a high grade. Highest grades range round 66 %. The measurement instructions categorizes iron ore with grades higher than 60 % as high grade. Accordingly, the environmental hazard potential caused by the ore grade is low.	Low	A = high, can be derived directly from available data

Technology

Indicator or criteria	Description and values	Explanation	Evaluation result	Data quality
Mine type	Underground mining, sub-level caving (see "Use of auxiliary substances"). The current main haulage level of the Kiruna mine is at a depth of 1,365 metres (LKAB 2019b). Due to the mining southeast of the Kiirunavaara, faults already appear in the surface today. These cracks form because rock masses slip into the cavities when the iron ore is mined underground. The deeper the mining of iron ore progresses, the closer the risk of crack formation comes to Kiruna (town) (ecosistema urbano n.d.). These cavities eventually collapse and fill with surrounding rocks, which over time cause surface deformations. The processes are getting closer towards the city center of Kiruna at a rate of about 40 meters a year. Since 2014 there has been a plan for the relocation of the town Kiruna five kilometers to the east, which should last until 2030/2035 (Kiruna Kommun n.d.)	The extraction method used in mining gives an indication of the interventions at the earth's surface necessary for the extraction of the raw material. These are naturally lowest in underground mining. Accordingly, the EHP resulting from the mining method is low. The situation at Kiruna clearly shows that negative impacts from mining cannot be rules out by the ÖkoRess evaluation. The result solely refers to the likelihood of an (potential) impact, which has been realized in this case nevertheless.	Low	A = high, can be derived directly from available data
Use of auxiliary substances	Sub-level caving is based on creating cavities in the ore body through drilling and blasting. Excavating tunnels within the ore and then through drilling and blasting in the tunnel ceiling make the ore and the rock above the	Ore separation can include the application of reagents. Beside, only physical separation methods are applied. Accordingly, processing poses a lowEHP.	Medium	B2 = medium, classified according to measurement instructions

	ore collapse because of its weight into the tunnel from where it can be excavated. This will make the ground above the orebody sink and destabilising the ground in the mines vicinity. Sub-level caving is a mining method allows extraction from steep ore bodies. Kiruna operations use dry magnetic separation, followed by wet magnetic separation for sinter feed production afterwards (LKAB n.d.).			
Mining waste	At the Kiruna site, overburden rock is transported by trucks to the deposition areas. Loaders push the waste rock to form a starting layer 15 m high (at base level) followed by raises with a height of less than 30 m. Between each new level, a horizontal distance of at least 10 metres is provided (Garbarino et al. 2018) The Kiruna tailings dam is located close to the iron ore mine. The dam is about 4 kilometers in length and consists of a central core of compacted, low permeability material surrounded by sandy filters and supporting rock fill (Mainali et al. n.d.). During 2002, a major investigation of a mine tailings dam was conducted. Tailing ponds are located in Kiruna and Svappavaara, the slurries have a low solids content (3-15 %). The dams are off-valley site type with a total dam area of 6.5 km^2 including a volume of 9 Mm^3 tailings. The highest point of the three tailing dams is up to 17 m (Svemin n.d.). Two	Despite the concepts of a safe disposal in deposits, large-scale or large settling tanks and/or mud ponds lead to a higher risk. As a result, there is a high EHP.	High	B1 = medium, can be estimated on the basis of available information

	existing tailing ponds have a volume of 4.5 Mm^3 (Umweltbundesamt 2004).			
Remediation measures	In July 2018, the LKAB applied to the Land and Environment Court for a new authorization for the operations in Kiruna. The application includes the extraction of 37 Mt of crushed ore, the production of 18 Mt of pellets, 5 Mt of other end-products and the storage of the necessary quantities of waste rock and tailings (LKAB 2018b). According to LKAB, the company has a total of five active mining and pit operations in Sweden, each of them with closure/remediation plans in accordance with environmental permits. LKAB has allocated a total of SEK 1,346 million (€ 125 million) for remediation measures at the mining operations in Sweden. LKAB is currently working on guidelines for environmentally friendly remediation to increase natural values such as biodiversity and reindeer husbandry (LKAB 2019c).	There are site rehabilitation and restoration plans for mine closure in place. Accordingly, the EHP -due to balance sheet provision and remediation measures- is low.	Low	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). Metrics are directly taken from the given risk assessment. The indicator total is determined by the highest hazard level of the sub-indicators.	For the Kiruna mine is located in the very north of Sweden and within the Arctic region defined by the Arctic Monitoring and Assessment Programme (see measurement instructions). The EHP in this case is medium.	Medium	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 water stress for the mining area is low and it is not situated in a desert area, which results in a low EHP.	Low	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 p. 20).	The Kiruna mine is situated in a protected area which determines a medium EHP.	Medium	A = high, can be derived directly from available data

State Governance

Indicators

WGI 1 -Voice and Accountability	99.51 °°°
WGI 2 -Political Stability and Absence of Violence/ Terrorism	81.43 °°°

WGI 3 - Government Effectiveness	96.15 °°°
WGI 4 -Regulatory Quality	95.67 °°°
WGI 5 - Rule of Law	99.04 °°°
WGI 6 -Control of Corruption	98.08 °°°
EPI (Environmental Performance Index)	80.51
EITI membership	°°°
International Agreements	
ILO 176	Ratification in 1997
Others	None
Legal framework	

Areas of Law: Environment	The Swedish Minerals Act from 1991 is the main legislation applicable to the mining industry. The Minerals Act regulates the exploration, exploitation and designation of land and covers valuable mineral substances, known as concession minerals. Environmental permits for mining activities are issued in the first instance by the Land and Environment Court. An application must include an environmental impact assessment, a waste management plan and a closure plan to carry out the rehabilitation after the completing the mining. An environmental permit specifies the conditions that apply both to the operation of the mine and to the rehabilitation of the site. The environmental permit also includes provisions for the granting of financial guarantees to ensure that adequate resources are available for remediation if the company does not have the financial capacity to remediate the site as planned. During the operation of the mine, a supervisory authority shall verify that the conditions laid down in the permit are met by the operator. Agencies and the general public will be involved in the consultation (Swedish Ministry of Enterprise, Energy and Communications 2013).
Areas of Law: Occupational Health and Safety (OHS)	The Ministry of Employment is responsible for issues relating to work environment, the organisation of work and labour legislation. The Swedish Work Environment Authority (SWEA) is the administrative authority for issues relating to the working environment and carries out inspections at workplaces. The SWEA is an independent authority of the Ministry of Labour (International Labour Organization 2011) The Work Environment Act (1977) builds the foundations on occupational safety and health and defines the outer framework of work environment regulation in Sweden. The Act contains rules on the state of the work environment, the responsibility for the working environment, the power of the Work Environment Authority to operate and act concerning the working environment, health and safety issues, penalties and the right of appeal against decisions. The Work Environment Authority supervises the observance

	of the Work Environment Act and of the Provisions issued pursuant to the same. The Work Environment Authority ensures that laws and regulations are followed by inspecting, and by communicating injunctions and prohibitions. The Authority is also responsible for official statistics, providing information, responding to inquiries, and to follow developments in the area of occupational safety and health. The employer has the main responsibility for the work environment, and must take all measures needed to prevent the exposure of employees to the risk on health or accidents at work. The Act requires the employer to systematically execute and also control activities that the operation will meet the requirements of work environment legislation (International Labour Organization 2014).

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
Towards Sustainable Mining (TSM) Is the mine owning company a member of the Mining Association of Canada (MAC)?	No No
Towards Sustainable Mining (TSM) outside Canada: Are TSM standards implemented*?	No No

Initiative for Responsible Mining Assurance (IRMA): Is the mine owning company a member?	No No
Initiative for Responsible Mining Assurance (IRMA): Is the mine certified?	No No
Responsible Copper (RC): Is the mine owning company a member of RC?	Not applicable Not applicable
Responsible Copper (RC): Is the mine certified?	Not applicable Not applicable
Responsible Mining Index (RMI): Has the mine been rated?	No No
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?	No No
Responsible Steel (RS): Is the mine certified?	No No
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

CSR-directive 2014/95/EU: Does the mine owning company have its headquarters in an EU country?	Yes Yes
OECD Guidelines: Does the company have its headquarters in a signatory state?	Yes Yes
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.

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A Glossary

Table 1 Legend

Environmental hazard potential

low

medium

high

Data quality

low

- 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.

medium

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

high

- 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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