Environmental Research of the
Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Project number: 3715 32 3100

Report number: FB000275/ANH,5,7,ENG

OekoRess II: Country Case Study IX

Turkey - Borate (Kırka Mine)

By

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On behalf of the German Environment Agency

Completion date October 2018

Abstract

The project "Further development of policy options for an ecological raw materials policy" (OekoRess II) builds on the results of two preceding research projects, UmSoRess and OekoRess I. It links experiences gained in the analysis of environmental and social standards with the assessment of environmental risks in the mineral resources sector. The project team conducts 10 case studies to evaluate and refine the method to assess site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. The focus is on improving the indicator for environmental sector governance, by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the questions whether existing governance indices and indicators are able to adequately reflect the capacity of governments, companies and civil society to manage potential environmental hazards and avoid or reduce environmental impacts of mining.

This case study analyses the environmental hazard potentials and the reported environmental impacts of the Kırka boron mine in Turkey. The main environmental impacts are land cover disturbance as well as water and soil contamination. Studies showed elevated levels of harmful substances in the region, but conclusive evidence on the impact on human health is lacking. The site-related environmental hazard potentials identified by the OekoRess methodology generally mirror the findings of the environmental impact analysis. Although the study pointed to possible environmental and health impacts from elevated levels of radioactivity in the mining sector, the environmental hazard potential for radioactivity was assessed as low. The elevated levels of radioactivity, however, do not stem from the boron-bearing sediments itself, but from the magmatic host rock of the area.

Existing governance indicators reflect the capacity of Turkish authorities, companies and civil society to manage potential environmental hazards well. Turkey scores rather low on all indicators included in this study. In particular, the Environmental Performance Index (EPI) and the Fraser Policy Perception Index (PPI) captured Turkeys weak (with a tendency to average) mining sector governance very well.

Kurzbeschreibung

Das Vorhaben „Weiterentwicklung von Handlungsoptionen einer ökologischen Rohstoffpolitik" (ÖkoRess II), welches auf den Ergebnissen zweier vorangegangener Forschungsprojekte (UmSoRess und ÖkoRess I) aufbaut, verbindet Erfahrungen aus der Analyse von Umwelt- und Sozialstandards mit der Bewertung von Umweltrisiken im Rohstoffsektor. Das Projektteam führt 10 Fallstudien durch, um die im Rahmen des ÖkoRess-I-Projekts entwickelte Methode zur Bewertung standortspezifischer Umweltgefährdungspotenziale im Bergbau zu evaluieren und weiterzuentwickeln. Der Fokus liegt auf der Verbesserung des Indikators für Umwelt-Governance, indem die bewerteten Umweltgefährdungspotenziale, die tatsächlichen Umweltauswirkungen und die Governance-Analyse mit vorhandenen Governance-Indikatoren verglichen werden. Ziel ist es, die Frage zu beantworten, ob die Governance-Indikatoren in der Lage sind widerzuspiegeln, inwiefern relevante Akteure (Regierungen, Unternehmen und Zivilgesellschaft) potentielle Umweltgefährdungen bewältigen und Umweltauswirkungen des Bergbaus vermeiden oder reduzieren können.

Diese Fallstudie analysiert das Umweltgefährdungspotenzial und die tatsächlichen Umweltauswirkungen des Borbergbaus Kırka in der Türkei. Die wichtigsten Umweltauswirkungen sind Schädigung des Oberbodens sowie Wasser- und Bodenverunreinigungen. Studien zeigten einen erhöhten Schadstoffgehalt in Wasser und Boden, es fehlen jedoch Belege für negative Auswirkungen auf die menschliche Gesundheit. Die von der ÖkoRess-Methodik identifizierten standortbezogenen Umweltgefährdungspotenziale spiegeln die Ergebnisse der Analyse der tatsächlichen Umweltauswirkungen generell gut wider. Obwohl die Studie mögliche Umwelt- und Gesundheitsauswirkungen durch erhöhte Radioaktivität

im Bergbau identifizierte, wurde das Umweltgefährdungspotential für Radioaktivität als gering eingeschätzt. Die erhöhten Radioaktivitätswerte stammen jedoch nicht von den Bor enthaltenden Sedimenten selbst, sondern aus dem magmatischen Gestein des Gebietes.

Die Governance-Indikatoren für die Türkei spiegeln die Fähigkeit der relevanten Akteure (Behörden, Unternehmen und Zivilgesellschaft), potenzielle Umweltgefahren zu bewältigen, gut wider. Die Türkei schneidet bei allen in dieser Studie berücksichtigten Indikatoren eher schlecht ab. Insbesondere der Environmental Performance Index (EPI) und der Fraser Policy Perception Index (PPI) erfassten die schwache (bis durchschnittliche) Bergbau-Governance sehr gut.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AMD	Acid Mine Drainage
ANFO	Ammonium Nitrate Fuel Oil
AZE	Alliance for Zero Extinction
CPI	Corruption Perception Index
DPSIR	Driving forces, Pressures, States, Impacts and Responses
EAV	Eskisehir-Afyon Volcanic Area
EIA	Environmental Impact Assessment
EPI	Environmental Performance Index
Eti Maden	ETI Mine Works General Directorate
EU	European Union
GDMA	General Directorate of Mining Affairs
GDP	Gross Domestic Product
GTAI	Germany Trade and Invest
ha	Hectare (equal to 10,000 square meters)
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
MENR	Turkish Ministry of Energy and Natural Resources
MoE	Turkish Ministry of Environment and Urban Planning
Mt	Megatons (equal to million metric tons)
NMA	National Mining Association
OekoRess	Research Project "Discussion of ecological limits of raw materials production and development of a method to evaluate the ecological availability of raw materials with the aim of further developing the criticality concept"
ppb	Parts per billion
TMMOB	Turkish Association of Chambers of Engineers and Architects
TUIK	Turkish Statistical Institute
UmSoRess	Research Project "Approaches to reducing negative environmental and social impacts in the production of metal raw materials"
U.S. (USA)	United States (United States of America)
USD	US Dollar
WGI	Worldwide Governance Indicators

WHO	World Health Organization
WSI	Water Stress Index

1 Focus of the study and relevance

The following is the ninth of ten case studies that are being prepared as part of the project "Further development of policy options for an ecological raw materials policy" (OekoRess II), commissioned by the German Federal Environment Agency. The case studies build on the results of two research projects, the UmSoRess project and the OekoRess I project. In UmSoRess, the impacts of raw material production on the environment, society and the economy were analysed in 13 case studies. The goal of the case studies was to gain a better understanding of the connections between the environmental and social impacts of mining in the context of various countries with different problems and governance contexts. In OekoRess I, a method to evaluate the ecological availability of raw materials and the site-related environmental hazard potentials posed by mining operations was developed, with the aim to further develop the criticality concept.

As part of the follow-up project OekoRess II, 10 additional case studies will be conducted, combining the analytical approaches of UmSoRess and OekoRess I in order to evaluate and further develop the method to assess the site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. This effort will particularly focus on improving the indicator for environmental sector governance used in the methodology by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the questions if existing governance indices and indicators are able to adequately reflect the capability of governments, companies and civil society to manage environmental hazards and avoid or reduce environmental impacts of mining. The results of the 10 case studies will be compared and a set of governance indicators will be identified that can be used to improve the raw-material-related assessment approach developed as part of the OekoRess I project.

This case study analyses the environmental hazard potentials and the environmental impacts of the Kırka boron mine in Turkey. The mine has one of the largest boron deposits in the world. Boron is a valuable additive for ceramics, detergents, fibre glasses, high quality optical glasses and other industrial materials (Önal and Burat 2008). Although boron is in small amounts important for all plants and living beings, it can be toxic at elevated concentrations. Higher than normal amounts of boron have been found in the soils and waters surrounding the Kırka mine. However, no accounts of protests or conflicts around this mine and its impacts could be found.

The case study is divided into four parts: First, the structure of the mining sector of Turkey and its contribution to the national economy are analysed (chapter 2). Second, a brief overview of the Kırka mine is given. The geographic and geologic context is analysed followed by an overview of the applied mining and processing methods (chapter 3). Third, the environmental hazard potentials posed by the mining operation are discussed using the OekoRess I methodology and selected environmental impacts and reactions to these are described using the DPSIR framework that was also used in the UmSoRess case studies (chapter 4). Fourth, the governance of Turkey's mining sector is analysed (chapter 5) and last, the findings of the assessment of the environmental hazard potentials and environmental impacts and the governance analysis are compared to existing governance indicators and indices and first conclusions for the methodology development are drawn (chapter 6).

2 Structure and macroeconomic relevance of the Turkish mining sector

Since the beginning of the millennium, Turkey experienced an unprecedented economic growth. The GDP has almost quintupled from 200 billion USD in 2001 to its peak value of 950 billion USD in 2013. For more than one decade, the average growth rate was 5 per cent and in some years, it exceeded 10 per cent (World Bank 2017a). With its geostrategic position as a turnstile between Europe, Asia and Africa, the country has built a considerable industrial sector with a considerable export orientation. However, since 2013 Turkey has been shaken by political conflicts; the GDP decreased by 100 billion to 850 billion USD. Nevertheless, in terms of GDP, Turkey is still listed among the 20 largest economies in the world (World Bank 2017a; 2017b).

Mining has only minor importance for the Turkish economy. It generates, around 0.6 – 1.5 per cent of the GDP (Hastorun 2014; E&MJ, 2014; GTAI 2015). Together with quarrying and mineral processing industries, the sector accounts for 3.3 percent of GDP (Hastorun 2014). Minerals, including non-metals, account for 2 percent of the total export volume (Ministry of Economy 2017; World Bank 2017a).

The mining sector in Turkey is very divers. In the past decades, the Turkish mining industry was transformed from a sector dominated by public actors to a sector that is in most parts privatised. Today, a high number of small private companies run most of the over 13,000 mines and quarries in Turkey (GTAI 2015; Anaç and Tamzok 2007), with over 85% of mining companies in Turkey being private companies (E&MJ 2014). Only three large state-owned companies remain in Turkey's extractives sector: two large coal producers, TKI and TTK, and the mine operator of the Kırka boron mine Eti Maden (GTAI 2015; Eti Maden n.d.).

Alongside the high number of small mines being in operation in Turkey, the minerals produced are very diverse: No single extractive resource dominates the Turkish mining sector (Anaç and Tamzok 2007). However, the most important resources are natural stones and coal (hard coal and lignite). Natural stones are mostly quarried by small private companies and contribute for half of all mineral exports. In contrast, fuel production (coal and oil) in Turkey is driven by state owned companies and mainly used for domestic power production (Ministry of Economy 2017).

The mining sector (including non-metallic resources) employs 190,000 people in total, one third of them are working in marble quarries (GTAI 2015). The degree of mechanization is low (Hartlieb et al. 2016). For comparison, over 5 million people work in agriculture (Turkish Statistical Institute 2016).

Borate[1] production

Boron is a valuable additive for ceramics, detergents, fibre glasses, high quality optical glasses and other industrial materials (Önal and Burat 2008). For some years now, Turkey has a singular position in the global boron market. According to the USGS (2017), approximately 60 per cent of all known borate reserves are in Turkey. GTAI (2015) estimates an even higher share of 72 per cent. The boron deposits in Turkey are distributed over four mining sites: Bigadiç, Kestelek, Emet and Kırka. The latter one was the first boron mine in Turkey, operating since 1962 (Nasuf et al. 2011). Since 2014, Turkey has evolved to the most important borate supplier for global markets (see Figure 2-1; USGS 1996 – 2017).

In association to the borate exploitation in Kırka, the mine operator Eti Maden runs processing plants and produces for the world market (Eti Maden n.d.; MENR n.d.). Most of the boron is therefore processed and not sold as a raw mineral.

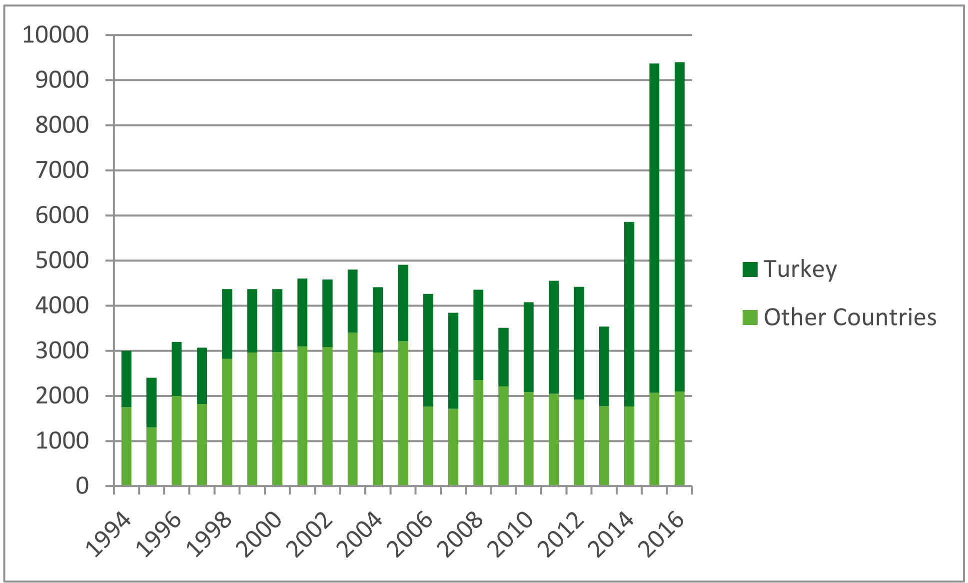
[1] Borates are deviates (salts and ester) of boric acids and, thus, contain the element boron. Industrial minerals containing borates are, e.g., colemanite, borax (tincal) and ulexite.

Table 2-1: Turkish Mineral Production 2015

Mineral [*= critical according to EC, 2017]	Production 2015		
	Volume [t] (unless otherwise noted)	% of ∑ World	Global Production [t]
Antimony*	1,917	1.34	143,000
Baryte*	310,000	3.92	7,900,000
Boron* (USGS, 2017)	7,300,000	77.91†	9,370,000[2]
Chromium	6,600,000	18.70	35,300,000
Diatomite	86,656	3.65	2,374,000
Feldspar	7,960,844	30.44	26,150,000
Gypsum	8,638,715	3.22	268,200,000
Kaolin	2,032,103	8.03	25,300,000
Lead	75,902	1.52	5,000,000
Nickel	8,637	0.41	2,092,000
Salt	10,994,822	3.80	289,600,000
Sodium Carbonate	1,854,290	15.85	11,700,000
Zinc	173,589	1.32	13,200,000

Source: BGS (2017); USGS (2017).

Figure 2-1: Global Boron Production in 1000 t



Source: USGS (1996-2017).

[2] Excludes U.S. production as they do not publish any Boron production data.

3 Overview of the geology and the mining operation in Kırka

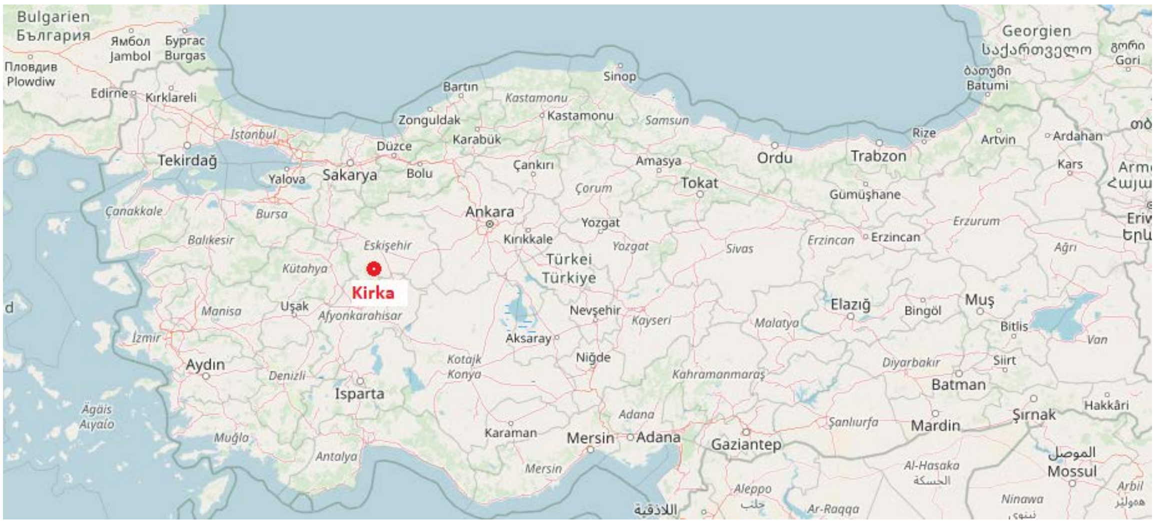
The Kırka boron deposit is located in Central Anatolia (Turkey), south of the city of Eskişehir and is Turkey´s second largest borate deposit (Eti Maden 2017). Borate operations in Turkey are managed by Eti Maden (ETI Mine Works General Directorate), a government-owned company (according to the Turkish law titled as #2840). This also includes all boron deposit fields (Kırka/Eskişehir, Bigadic/Balıkesir, Kestelek/Bursa, and Emet/Kütahya). The most common boron-bearing minerals mined in Turkey are colemanite, borax (tincal) and ulexite. The Kırka boron deposit is mainly composed of borax (tincal) ($Na_2O.2B_2O_3.10H_2O$) and the borax (tincal) mineral deposit amount to around 827,496,297 tons, which is the second largest deposit after Emet (colemanite and ulexite, 1,818,264,009 tons) located ca. 100 km west of Kırka (Eti Maden 2017). The refined boron products from Kırka are tincal, concentrated tincal, and tincalconite (pentahydrate). According to the operating company, approximately 3 million tons of borax (tincal) are produced in Kırka every year (Eti Maden 2017).

3.1 Geography

The Kırka open-pit mine and its production site are located approximately 60 km south of Eskişehir (Figure 3-1). The Kırka mine is located in the eastern part of the Kırka town which belongs to the Eskişehir province and is situated in the Seyitgazi district. The geographic coordinates of the Kırka mine are 39° 17’ 24’’N/30° 29’ 12’’E. The open-pit mine covers around 9.9 km^2 including around 3.31 km^2 of tailings and waste water facility (Figure 3-2).

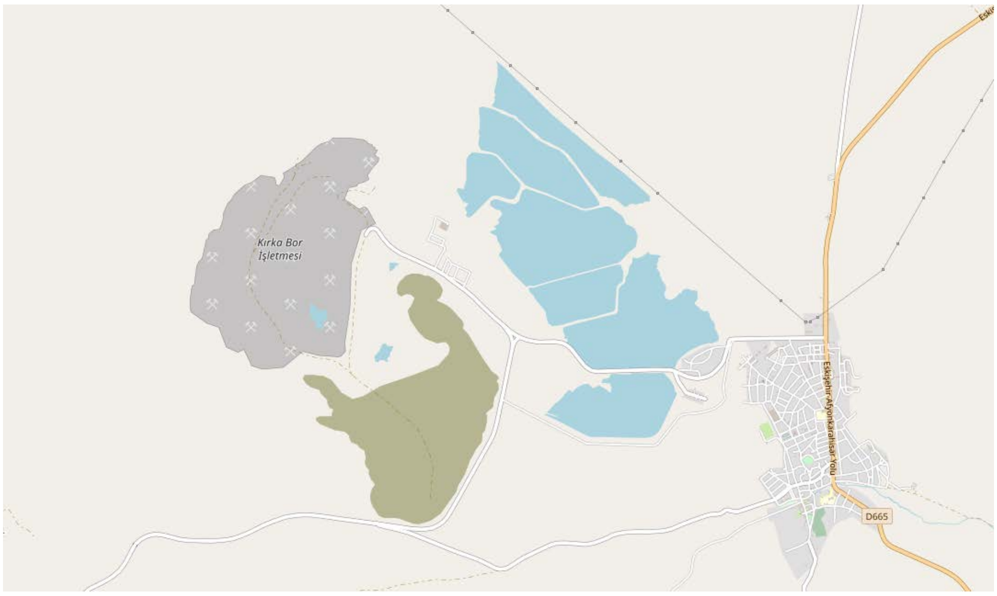
On the western side of the Kırka open-pit, the mine borders the highest elevation of the Kırka region which is around 1,180 m. The production site is situated at an altitude between 1,060-1,140 m. Moreover, the main waste-water treatment facility of the Kırka boron deposit is around 1,020-1,040 m above sea-level.

Figure 3-1: Location of the Kırka mine in Turkey



Source: Open Street Map (n.d.)

Figure 3-2: Aerial view of the Kırka mine facility



Source: Open Street Map (n.d.)

The Kırka boron deposit is situated in the Kırka basin, which is known as the southwestern part of the Seyitgazi Basin. The Kırka Basin is fed by two main rivers - Akın and Lepcek - from north to south. The Akın River feeds the Kunduzlar reservoir in the northeast of the Kırka mine site; the Lepcek River feeds the Catoren reservoir in the East.

The winters in the Eskişehir province are cold with average day temperature between 1°C and 3°C and a maximum rainfall of 50mm in December. The summer seasons are dry and hot with average maximum temperatures around 28°C (Climate data n.d.). The annual average rainfall amounts to 393 mm (Climate data n.d.).

The overall population of the Eskişehir province is 860,620 (total area of the Eskişehir province is 13,925km^2 (TUIK 2017). Kırka is located within the Seyitgazi district whose population is around 13,000. The Kırka village has 3,160 inhabitants according to TUIK (2017) statistics. Most of the inhabitants (ca. 2000) are working in the Eti Maden and only 5-10% of the inhabitants are dependent on agriculture and farming (TUIK 2012). The population density in Kırka village varies depending on the seasonal job opportunities around Eskişehir; however, the population is increasing around 2-3% per year in average (ibid.). The seasonal workers are mostly from the eastern part of Turkey. In recent years, also more and more Syrian seasonal workers are working in agriculture in the area.

The Kırka mine site is located in the 2nd grade earthquake zone. Turkey is divided into 5 seismic risk zones from 1 (high earthquake risk) to 5 (no risk) (Adanur et al. 2013). Along the Porsuk river site, some places -such as the Sarıcakaya and the Mihalıççık district- are considered as flood risk areas during the heavy rain season. However, the Kırka area is further south of these districts and there is no recorded flood risk for the Kırka Mine site.

The mine is surrounded by forest that is subjected to special permission (General Forest Law number 6381, line 17) for any purpose of use and agricultural fields used for forage production. In the literature, there are no references to natural or cultural assets in the surrounding area of the Kırka Mine. (TUIK 2012; Çevre ve Şehircilik Bakanlığı 2016; Turkish Republic Ministry of Culture and Tourism Eskişehir 2018).

3.2 Geological context and ore deposit formation

Most of the borate-deposits in western Anatolia are connected to active-extension regimes. Economically important deposits in this region, such as Kırka and Bigadic, have formed as a result of Neogene (Early Miocene) volcanism and terrestrial sedimentation.

Against this backdrop, the Kırka borate deposit is located in a distinct N-S-trend graben system in the northernmost part of the Miocene Eskişehir-Afyon volcanic area (EAV) and limited by faults to the east and west. More precisely, the mine is situated in the early Miocene Kırka-Phrigan Caldera, which is related to late-stage hydrothermal activity (see Figure 3-3). The caldera exhibits post-collapse sedimentation and volcanism (Seghedi and Helvaci 2016; Dilek and Altunkaynak 2010). From north to south (Kırka to Isparta), the volcanic rocks become gradually younger from 19 Ma to 4 Ma (Early Miocene to Pliocene; Ersoy and Palmer 2013).

Helvaci (2005) writes that here are more than 150 minerals that contain boron, which form under different geological conditions and are thus found in various geological formations. Three groups can be distinguished: 1. skarn group (magmatic origin) 2. magnesium oxide group (marine evaporitic origin) and 3. Sodium -and calcium-borate hydrates group (originate from volcanic activity in lacustrine environment).

According to Helvaci and Orti (2004), the Kırka borate deposits belong to the group 3, as they were formed by chemical precipitation (see Figure 3-3) in a lacustrine environment, i.e. the borate sequences accumulated as chemical and clastic borax layers under shallow water conditions (beach to lake). The rocks cropping out around the mine consist of late Miocene limestone and quaternary alluvium. According to Helvaci (2005), following conditions were mandatory for the formation of the deposit:

"*1. formation of playa-lake environment;*

2. concentration of boron in the playa lake, sourced from andesitic to rhyolitic volcanics, direct ash fall into the basin, or hydrothermal solutions along graben faults;

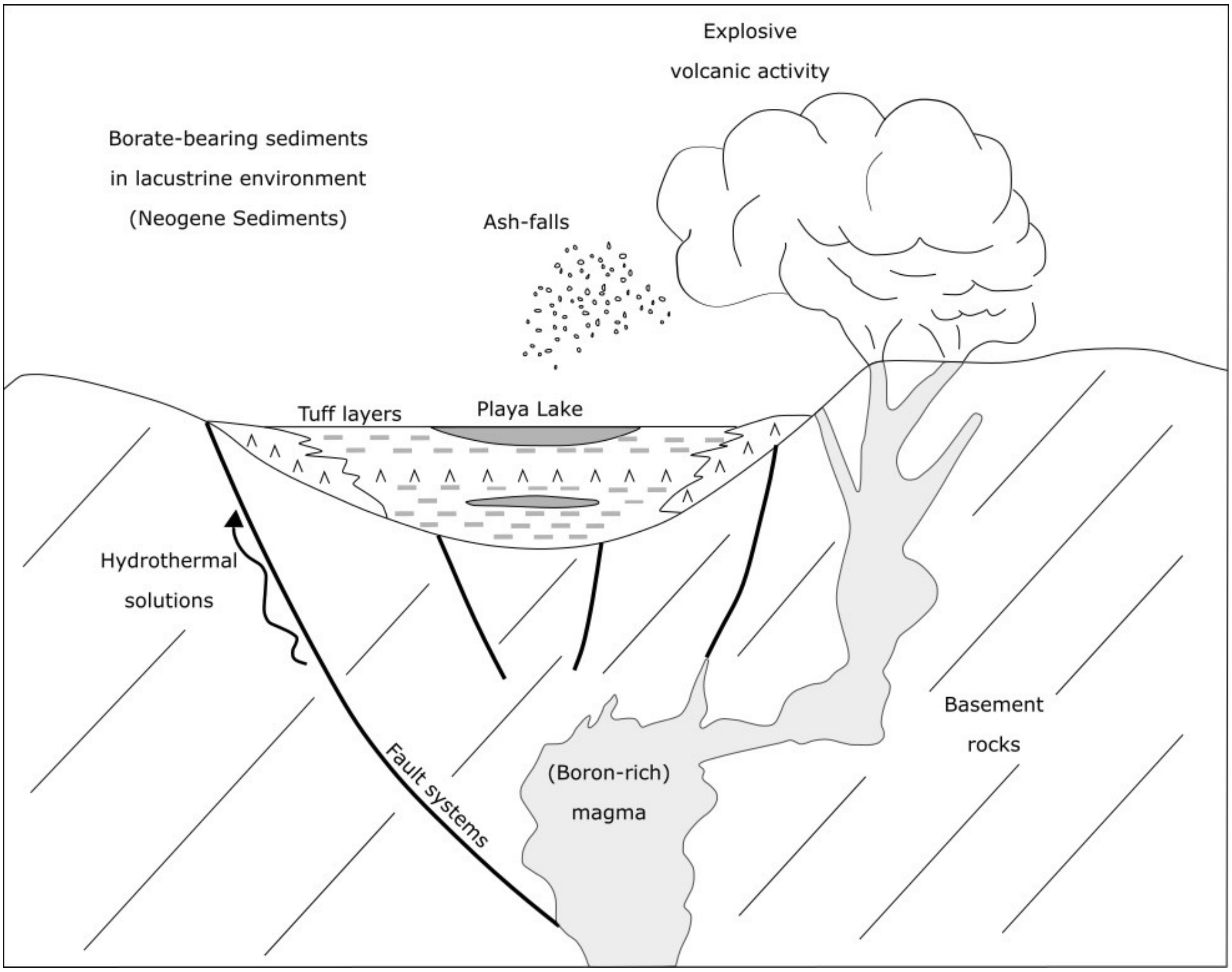
3. thermal springs near the area of volcanism;

4. arid to semi-arid climatic conditions; and

5. lake water with a pH of between 8.5 and 11."

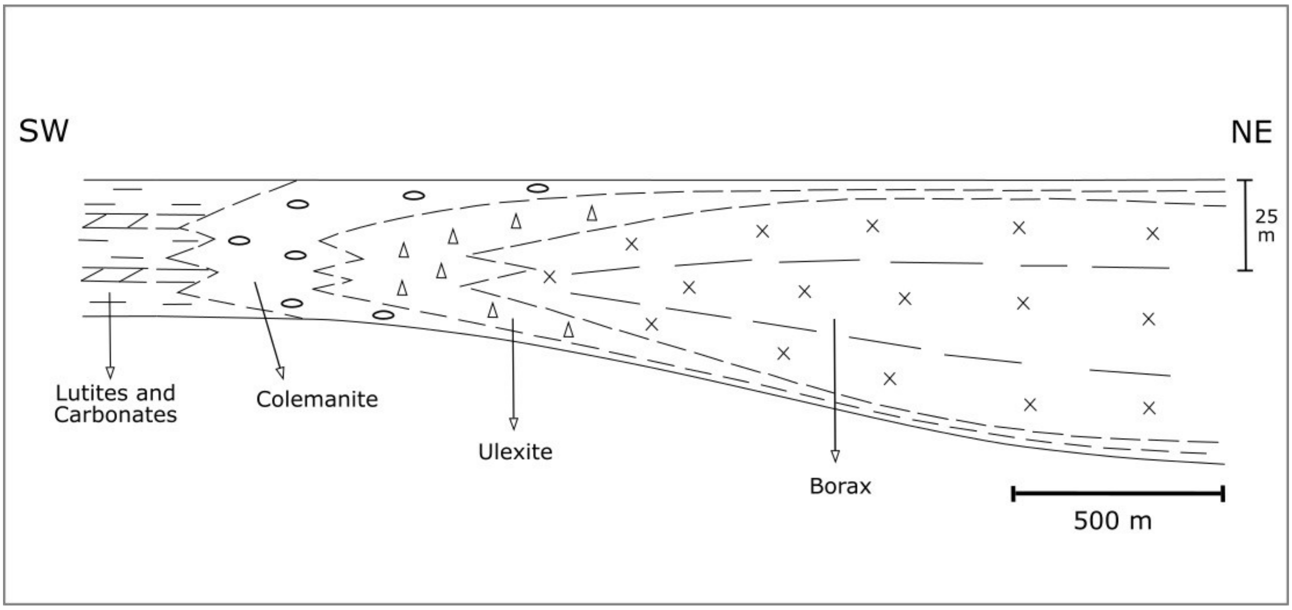
The borate unit is up to 145 m thick and interlayered with claystones and tuffs (Seghedi and Helvaci 2016). The main mined boron mineral is borax, a sodium (Na) borate that was formerly also called tincal. The mineral in the Kırka Mine can be classified as lithophile due to its magmatic origin.

Figure 3-3: Generalized deposition model of the Neogene Borate-Deposits



Source: Own graphic based on Helvaci (2014).

Figure 3-4: Generalized cross-section of the Kırka Borate formation



Source: Own graphic based on Helvaci and Orti (2004)

In the Kırka open-pit mine, three mineral-ore zones are observed (see Figure 3-4, Helvaci 2014):

i) Na Borate zone, in the centre with borax as primary mineral and a thickness of 2 to130 m;
ii) Na-Ca Borate zone that surrounds the Na Borates in the centre and consists mostly of ulexite with a thickness of 5 to 20 m. It is separated into a lower and an upper part. Between these two parts exists the
iii) Ca Borate zone, which mainly consists of the boron bearing minerals colemanite, padermite and lunelite.

In the Kırka open-pit facility, three main boron ores are commonly produced, these are: i) borax, ii) concentrated borax, and iii) pentahydrate (or tincalconit). Gang minerals related to secondary chemical weathering processes are observed, such as clay minerals, calcite, gypsum and chlorite.

The Eti Maden drilling observations in the Kırka facility in 2008 have shown that the reserve at Kırka amounts to 269,710,630 tons. The ore grade varies in the boron basin with a mean calculated value of 26.54% (Ozgun and Sensoy 2009). In the southern part of the Kırka Boron Facility, boron ore occurs with grades >30% and in the northern parts of the site it varies around 20-25% B_2O_3 (Eti Maden 2017).

3.3 Mining and Processing

The Kırka-Borate site is an open-pit mine producing mainly borax. It has6 tailing ponds and plans exist to build further ones in the Kırka Boron Facility within the next 5 years.

The open-pit mine has almost 40 m of cover, which is being removed using explosives by subcontractor companies of Eti Maden (Ozgun and Sensoy 2009).

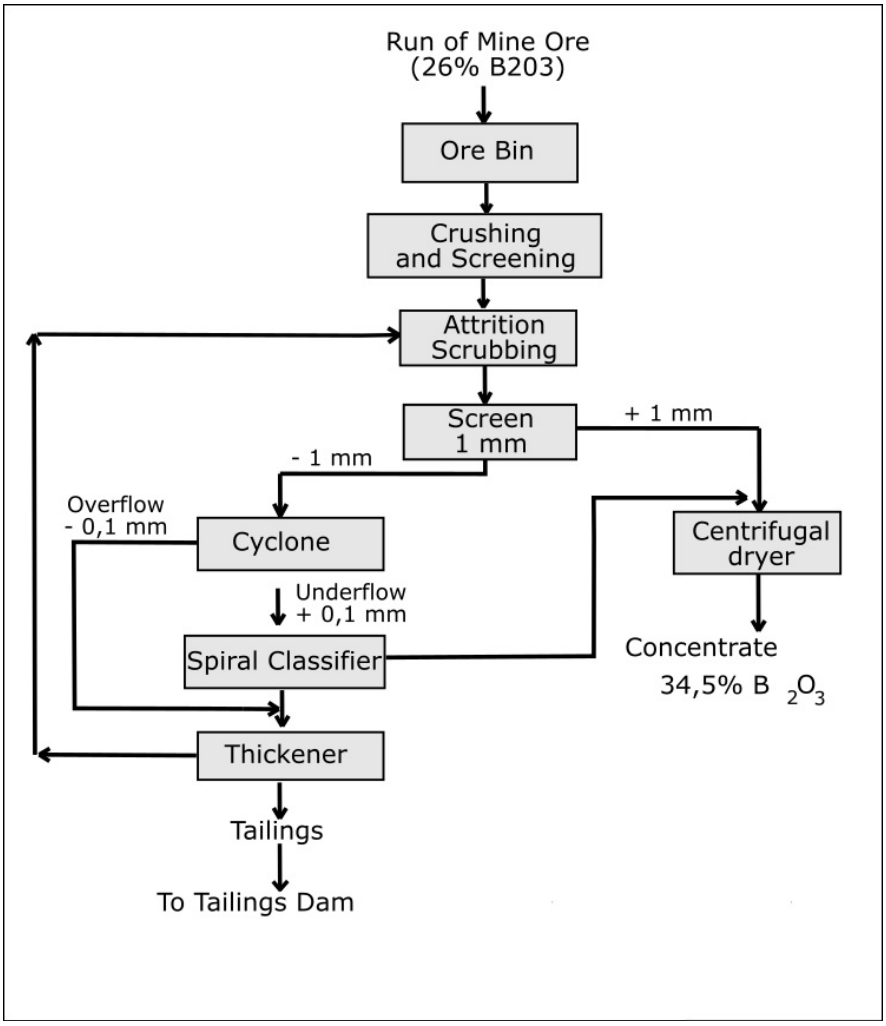
Drill and blast is the main technique in the open-pit site of the Kırka mine to remove the ore and the cover material. Dynamites, ammonium nitrate fuel oil (ANFO)[3], electrical capsules and magnetos are used as explosives (Ozgun and Sensoy 2009).

During the wintertime, clay zones in the mine result in a slowdown of the production process due to the heavy mud conditions of water-saturated clays. During the summer time, Eti Maden hydrates the related field, reducing the significant formation of dust on-site so that the performance is barely affected.

Since 1994, the first borax derivative facility (the Kırka Boron Facility) operated by Eti Maden produces Borax Pentahydrate (160,000 ton/yr), dehydrated borax (60,000 ton/yr) and borax decahydrate (17,000 ton/yr) (Ozgun and Sensoy 2009).

[3] ANFO is a widely used bulk industrial explosive.

Figure 3-5: The processing procedure of the Kırka borax concentration process



Source: Own graphic based on Önal and Burat (2018).

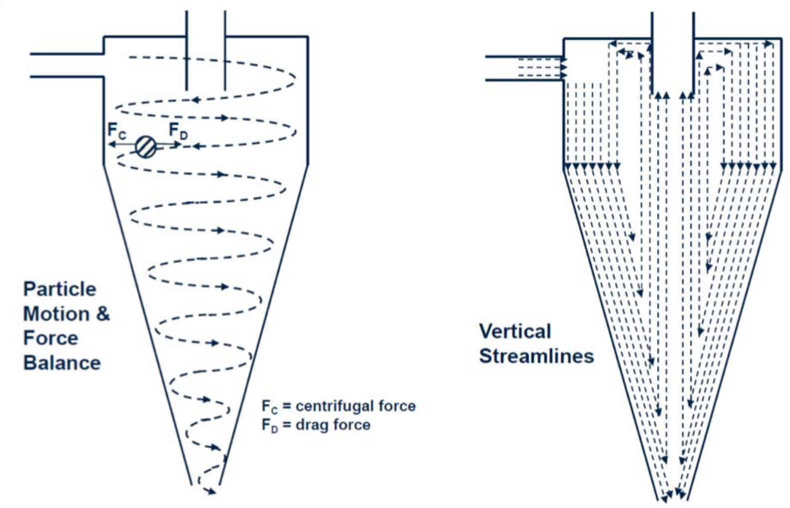
A concentrate of water-soluble Na-Borate with a fraction 0.1 to 6 mm is obtained a series of processing steps. This includes:

1. A three stage crushing and screening process (Figure 3-5) followed by
2. Attrition and scrubbing (Figure 3-5) and
3. A further screening step.

The fraction larger 1mm is subsequently sent to the centrifugal dryer. In this production step, the boron saturated slurry is concentrated to 34.5% B_2O_3. This ore concentration is the highest on the market (Ozgun and Sensoy 2009).

The fraction > 1mm is going through a cycle including a cyclone (Figure 3-6) and a spiral classifier and thickener. In the following, the material is either fed back into the process at the stage of attrition and scrubbing or stored as tailings (Onal and Burat 2008).

Figure 3-6: Cyclone scheme



Source: Millops (n.d.).

4 Overview of environmental hazard potentials and impacts

4.1 Environmental hazard potentials

As part of the OekoRess I research project an evaluation scheme for assessing the environmental hazard potentials (EHPs) of the extraction of primary abiotic raw materials was developed. This evaluation scheme is based on indicators, which are assigned to three levels of consideration. These levels are geology, technology and site surroundings. The level "Geology" comprises five indicators, which include environmental factors inherent to the geology on site. These key influencing factors are "precondition for acid mine drainage (AMD)", "paragenesis with heavy metals", "paragenesis with radioactive components", "deposit size" and "specific ore grade". The second level is "Technology" and includes the indicators "mine type", "use of auxiliary substances", "mine waste management" and "remediation measures". The third level "Site (surroundings)" comprises the indicators "natural accident hazard due to floods, earthquakes, storms, landslides", "Water Stress Index (WSI) and desert areas", and "protected areas and Alliance for Zero Extinction (AZE) sites". Furthermore, the indicator "conflict potential with local population" focusses on the social context. The latter indicator is further developed by analysing ten case studies of which the present case study is one.

The environmental hazard potential for each indicator can be rated as low (green), medium (yellow) or high (red) (for detailed information on the method see Dehoust et al. 2017b). Table 4 1 shows the evaluation of the EHPs of the Kırka mining site, which are described in detail below.

The assessment of the EHPs of the Kırka mining site is followed by an analysis of the actual situation and impacts of the mining activities on the environment as well as the responses from the mine site operator, the responsible authorities as well as the local communities, using the DPSIR framework (Chapter 4.2).

Table 4-1: Site-related OekoRess assessment

Thematic Cluster	Indicator	Environmental hazard potential		
		low	medium	high
Geology	Preconditions for acid mine drainage (AMD)	X		
	Paragenesis with heavy metals		X	
	Paragenesis with radioactive components	X		
	Deposit size			X
	Specific ore grade	X		
Technology	Mine type			X
	Use of auxiliary substances		X	
	Mining waste management			X
	Remediation measures	X		
Site (surroundings)	Natural accident hazard due to floods, earthquakes, storms, landslides			X

Thematic Cluster	Indicator	Environmental hazard potential		
		low	medium	high
	Water Stress Index (WSI) and desert areas		X	
	Protected areas and Alliance for Zero Extinction (AZE) sites	X		
	Conflict potential with local population			X

4.1.1 Geology

Preconditions for acid mine drainage (AMD)

The boron in Kırka is obtained from borax, a litophilic mineral, which occurs in oxidic deposits not prone to AMD. Therefore the potential for acid mine drainage is low (*low environmental hazard potential*).

Paragenesis with heavy metals

Water samples around Kırka showed increased heavy metal concentrations (As, Pb, Fe), especially the arsenic levels are increased in the area of the tailing dumps (Basaran 2015). In general, sedimentary boron deposits are not associated with heavy metals and the concentration of lead and iron may originate from the geogenic background. However, arsenic is associated with colemanite – a boron bearing mineral that is present and mined at Kırka – even though borax mineral is dominant in the deposit. Therefore, the hazard potential is classified as medium (*medium environmental hazard potential*).

Paragenesis with radioactive components

Elevated radioactivity levels close to Eskisehir city are related to the magmatic host rock of the area (Yuce et al. 2009) and are thus caused by the geogene background and not influenced by the sedimentary deposit and the mining. In consequence, the environmental hazard potential for the indicator radioactivity is low (*low environmental hazard potential*).

Deposit size

The deposit in Kırka has a size of over 827 million tonnes with an average ore grade of 26.54%. This makes Kırka one of the world's largest boron deposits. In accordance with the OekoRess assessment scheme, the environmental hazard potential is assessed as high (*high environmental hazard potential*).

Specific ore grade

With an ore grade of 26.54% that is refined to an ore grade of 35, the Kırka deposit is a high-grade deposit in comparison to other economically important boron mines (Helvaci 2015). In consequence, a low environmental hazard potential is deducted for this indicator (*low environmental hazard potential*).

4.1.2 Technology

Mine type

Kırka is a sedimentary deposit and boron is extracted via open-pit mining. The land surface disturbance due to open-pit mining activities in unconsolidated sedimentary deposits is comparatively high. In accordance with the measurement intructions, Kırka deposit is assessed with a high environmental hazard potential due to the extensive open-pit operations in unconsolidated rock (*high environmental hazard potential*).

Use of auxiliary substances

In Kırka, mechanical processing without any toxic or other additives is performed. Nevertheless, drilling and blasting is the main method to remove the cover material of the ore. Thus, the environmental hazard potential of the indicator Processing is determined to be medium *(medium environmental hazard potential).*

Mining waste management

The waste from open-pit mining is stored in several large tailing dumps next to the mine site (a total area of over 3 km^2). The structural height of the ponds is unknown. However, the potential of environmental damage can be classified as high here due to the large-volume tailing dumps (*high environmental hazard potential*).

Remediation measures

Currently there is no information on Kırka mine closure plans and possible recultivation activities. However, according to the OekoRess evaluation system, it can be assumed that large, formalised mining projects must comply with international standards for responsible mining practice (e.g. ICMM). Therefore, the potential is classified as being low (*low environmental hazard potential*).

4.1.3 Site (surroundings)

Natural accident hazard due to floods, earthquakes, storms, landslides

The total natural disaster risk is assessed by analyzing four individual sub-indicators. All sub-indicators (earthquakes, floods, tropical storms, landslides) show a low environmental hazard potential. The evaluation is carried out in accordance with the measurement instructions, which suggest to use georeferenced data from publicly available risk maps. The results are taken directly from the given risk assessment. The indicator total is derived by the highest hazard potential of the sub-indicators. According to the Global Assessment Report on Disaster Risk Reduction 2013, Kırka is located in a region that poses a medium risk for landslides. As mentioned before, the risk for earthquakes is high since Kırka is located in a seismically active area (GSHAP world MAP), leading to a high environmental hazard potential *(high environmental hazard potential).*

Water Stress Index (WSI) and desert areas

The WSI by Pfister et al. (2009) provides characterization factors on the relative water availability at watershed level. The indicator combines this information with an evaluation whether the site is located in a desert area. Mining operations often need large amounts of water for the operation. Depending on the hydrological situation, a competition for water between the different users can occur. The evaluation was carried out in accordance with the procedure described in the measurement instructions (Dehoust et al. 2017a). The province of Eskişehir is located in a region of moderate water stress (WSI 0.15-0.5). The EHP for this indicator is consequently evaluated as medium *(medium environmental hazard potential).*

Protected Areas and Alliance for Zero Extinction (AZE) sites

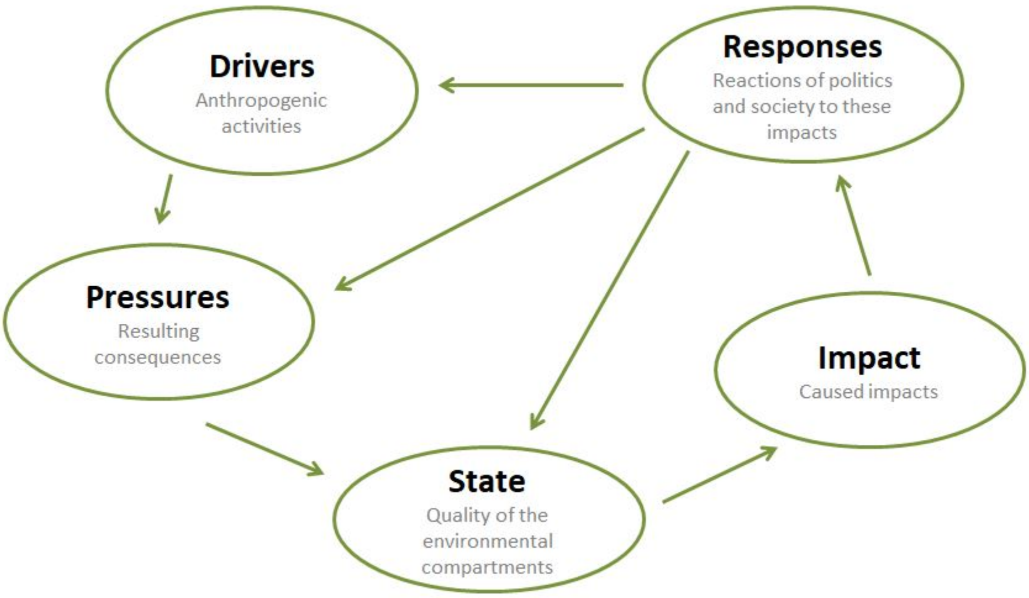
Georeferenced data for designated protected areas are used to assess hazards posed by mining extraction. The metric to evaluate EHPs corresponds to the method first described in the draft standard of the Initiative for Responsible Mining Assurance (IRMA 2014). There are no protected areas as defined in the measurement instructions in the near and far surroundings of the Kırka mine and its processing facilities. Therefore, the environmental hazard potential is low *(low environmental hazard potential)*.

Conflict potential with local population

The governance indicators "control of corruption" and "voice and accountability" indicate a percentile rank of 50.48% and 29.56%, respectively (World Bank 2017a). Consequently, the environmental hazard potential associated with weak governance can be classified as high (*high environmental hazard potential*).

4.2 Environmental impacts

Figure 4-1: DPSIR Framework



Source: Own preparation, based on Kristensen (2004).

The DPSIR framework is a systemic analytical approach to better understand the interaction of humans and their environment in order to derive adequate policy measures. It comprehensively accounts for and visualizes the causal connections between human activities, the resulting consequences for the environment and the responses of humans. The model consists of driving forces, pressures, state, impacts and responses.[4]

This chapter focuses on environmental impacts of mining activities in the area of the Kırka mine and the adjacent refinery. The focus lies mainly on land cover disturbance, water and soil contamination and impacts on health. No information on further pressures on the environment in the surroundings of the Kırka mine or boron mines in general could be found as the availability of literature on the topic was rather low.

4.2.1 Pressure

Environmental impacts at Kırka have been existent since the opening of the mine and are likely to persist as the remaining deposit is big enough to last for operations over many more decades and global

[4] For further information on the DPSIR framework and its elements see Kristensen (2004).

demand is improbable to decline. Covering 10.5 km^2 and being an open-pit mine, the size of the mine site is relatively large and the concomitant impact on the environment considerable. In addition the impacts and sizes of both the tailing dumps near the mine site covering over 3 km^2 and the refinery, located only about 0.5 km from the mine have to be taken into account. Apart from the land use, the toxicity of boron constitutes a problem for the mine tailings' potential for contamination of water resources.

4.2.2 State and Impacts

Pressures | State | Impact | Responses

Surface disturbance and biodiversity

Not only is the land surface of the mine site relatively large, the mining area is also constantly going deeper below the surface. Whereas production started at a height of 1,290 m a.s.l. in 1962, the working level was already as low as 1050 m by 2011 (Nasuf et al. 2011). The increasing depth has caused stability problems because of a too high pit slope, the structure of rock mass formations and water conditions. Slope failures and erosion have been one consequence (*ibid.*). This is illustrative of the impact the mining operation is having on the local ecosystem.

A study of the plant varieties on and near the Kırka mine site has shown that the species diversity declines with increasing proximity to the boron mine. In the zone with the lowest B concentrations (0.1–2 mg/kg), 84 species were counted, in the intermediate zone (10 mg/kg) 28 species, and in zone with the highest concentrations just two plant taxa could be found that are resistant to the high elevations of boron (Türe and Bell 2004).

Water use

There is little information available on the level of water consumption of the mine apart from the fact that water is used by Eti Maden to hydrate mined areas in summer times in order to minimise dust formation (see above) and in the processing of borax-kernite ores, which are dissolved in hot water and recycled borate liquor (Kistler and Helvaci 1994).

Contamination of water bodies and soils

The land in the Eskişehir region, where Kırka is located, is used intensively for agriculture and about 60% of it is irrigated. Groundwater pollution is therefore detrimental to the livelihoods and health of many people in the region.

The Turkish boron industry is estimated to produce 400,000 tonnes of borax waste per year, of which boron compounds can seep into soil and groundwater (Özdemir and Kıpçak 2010). In the Western Anatolian region, in which Turkish boron deposits are concentrated, about 45,000 km^2 of the ecosystem are affected by the mining activities and likely to exceed natural boron levels. Numbers from the end of the 1990s show that the Kırka mine itself produced an annual amount of 120,000 tons of clay wastes, which were discharged to the mine site area and contain about 8–22% B_2O_3, which is "a quite high concentration" (Özdemir and Öztürk 2003: p. 1659).

There were no tailing ponds at Kırka mine until 1989; today, there are two big tailing ponds that collect the leachates from the ore-deposits and solid waste is also dumped near surface water in the tailing area (Yuce and Yasin 2012). Due to the easy solubility of boron in water, the waste dissolves due to rainfalls and, especially in wet seasons, gets into stream water near the mine site and into surface water that recharges nearby dams. This water is then used for irrigation in the region. In addition, boron is also contaminating groundwater resources. Due to the groundwater flow direction being from Kırka to the Seyitgazi Plain, environmental pollution from the Kırka province also impacts the quality of groundwater resources in the latter region – there, recent measurements have shown boron contents in groundwater three to four times higher than shown by initial measurements from 1989. Although natural leaching is one responsible factor for the high boron concentrations in the catchment area, the mining activities seem more significant (Yuce and Yasin 2012).

A study (Simsek et al. 2003) that was financed by a subsidiary of Eti Maden found the boron content of drinking water for Kırka town to be only between 0.36 and 1.4 mg/l and thus considerably lower than in some places near the Bigadic mine (boron concentrations up to 29 mg/l); however, this is still above the regulatory limits defined by the WHO and the EU[5]. The same study also explained higher boron contents in food produced in Turkey with the higher boron concentration in Turkish soils and found those levels to be unproblematic and stressed the results of other studies that did not find adverse impacts on human reproduction in the area of bore deposits.

While no other data on the level of boron concentration in the Kırka region could be found, water samples from e.g. the Hisarcık area have shown levels ranging from 2.05 to 29.00 mg/l (Çöl and Çöl 2003). Another study from 1985 analysing the boron pollution of the Simav river (about 170 km west of Kırka), demonstrated that the river had a concentration of 0-0.5 mg/l before entering the mining area and of 4-7 mg/l after receiving the discharge waters from the mines with higher values showing during the irrigation season. Again, all these values exceed the threshold values or safe drinking water of numerous renowned organisations.

Furthermore, the contamination with heavy metals and the elevated radioactivity can be expected to bring about environmental and health impacts (see sections on biodiversity and health). Basaran (2015) examined soil and water samples from ten observation wells around the Kırka Boron Facility. The study reveals that soils are enriched with heavy metals, namely: As, Pb, Fe. These are related to secondary hydrothermal processes. Especially the samples from the tailings and waste water facility display elevated heavy metal concentrations. In these samples, arsenic (As) values are 2,189 ppb and 139 ppb (moderately high), respectively. Values for lead (Pb) are low in these areas with 5.59 ppb and 1.89, respectively. Iron (Fe) values are around 157 and 232 ppb, respectively (Basaran 2015).

No elevated radioactive levels were found around the Kırka Boron Facility. However, the radioactivity levels based on the water radiometric measurements in 18 locations around Eskişehir city exceeded the limits of the WHO from 1993 (gross alpha = 0.1 Bq/l; gross beta = 1 Bq/l). These elevated radioactivity levels are caused by the strong influence from the magmatic host rock of the area (Yuce et al. 2009). The trace element composition in the magmatic rocks controls the radiometric values and affects the values in the aquifer. Around the Kırka Boron Facility, uranium values (10-43 ppb) are slightly increased in comparison to the other wells around the Eskişehir city (Basaran 2015). Elevated radioactive levels related to the seasonal aquifer changes around Kırka are to be expected as a consequence. PH-values around the waste treatment pools indicate neutral to alkaline values.

Health

Some health problems such as pulmonary emphysema, asthma and bronchitis were identified among the population of Kırka Province where the level of boron was found to be equal or higher than 0.6 mg/l (Yuce and Yasin 2012).

In addition, high concentrations of arsenic and other heavy metals in groundwater, as found around Kırka (see above), can cause serious and long-term health problems (Yuce and Yasin 2012). However, no further scientific publications investigating health impacts of the Kırka mine in particular could be found.

[5] The WHO recommends a maximum level of boron content of 0.5 mg/l for potable water; the EU recommends an exposure limit twice as high (Özdemir and Kıpçak, 2010). Unpolluted, natural waters in the U.S. mostly have a boron concentration of only 0.01-0.02 mg/l; however, this natural level varies depending on the geographic location and further environmental conditions (Hasenmueller and Criss 2013). Groundwater in Europe ranges from 0.1 to 1.5 mg/l (Yuce and Yasin 2012). Typically, elevated concentrations are found in industrial and urban areas (Hasenmueller and Criss 2013).

4.2.3 Responses

Pressures | State | Impact | **Response**

Very few information could be found regarding responses to the environmental impacts of the mining operations at Kırka. In a promotional video of the mine, Eti Maden speaks of an afforestation program. However, no further information could be found. Several studies gauging the feasibility of boron removal e.g. by the use of constructed wetlands exist, but it is unclear whether Eti Maden is making use of any or is investigating this further. However, some studies, such as Özdemir and Öztürk (2003), have mentioned investigation on a re-use of the tailings, pointing out the economic value of such an operation given the high boron content that seems to remain in the tailings.

5 Governance

5.1 Sector governance, regulation and effectiveness of national institutions

Institutional and administrative framework

The major governmental authority regarding mining is the Ministry of Energy and Natural Resources (MENR). It is in charge of making policies relevant to natural resources and their trade and production. It supervises and regulates mining activities through the General Directorate of Mining Affairs (GDMA). The GDMA is responsible for the issuance of mining licenses and permits (which nonetheless must be approved by the Prime Ministry) and also conducts both research and exploration activities (Budak 2016; Tunç and Altunyuva 2017).

Another important actor is the Ministry of Environment and Urban Planning (MoE)[6], as mining activities also need to comply with environmental legislation. This ministry grants environmental licenses and permits and also has the authority to decide the approval of Environmental Impact Assessments (Budak 2016; Tunç and Altunyuva 2017).

Legal and Regulatory Framework

Turkey's mining sector is mainly regulated by the Mining Law No. 3213 of 1985, applicable to "all minerals found naturally on the earth or under water" (Budak 2016). It sets out "the general principles and procedures applicable to the exploration and exploitation of minerals, the permission and licensing frameworks, and other general issues regarding mines and mining activities" (Budak 2016); the recent Mining Regulation of September 2017, which covers the implementation of the Mining Law; the Regulation on Mining Activity Permits of 2005; and the Regulation on the Tender of Mining Fields of 2017 (Budak 2016; Tunç and Altunyuva 2017).

Ownerships over land (surface rights) and the mineral resources it contains are separated in Turkey. All mineral resources belong to the state, whereas land can be owned also by private individuals. The state grants mining rights for exploration and exploitation through mining licenses. In the cases where the holder of the mining right and the land owner do not come to an agreement, the land owner may be expropriated by the MENR (Budak 2016).

Licenses can be issued to Turkish citizens, Turkish legal entities (which, however can also be an entirely foreign-owned subsidiary) and public authorities. There are exploration and operation licenses, both establishing minimum financial capabilities, which must be proven by the license candidate and differ according to the mineral. The mining of all minerals but those grouped within categories[7] I, II(a) and II(c) need an exploration license. It can generally be attained through a tender. However, for some minerals (group II(b) and IV in which boron is included) exploration licenses are issued on a first-come-first-serve basis (USGS 2015). In addition, a mining project also requires an operation permit. This permit is only given when a number of other authorisations and permits have been obtained; including, amongst others, a certificate attesting either a positive Environmental Impact Assessment (EIA) or that no EIA is needed (Tunç and Altunyuva 2017).

Several payments need to be made by mining operators. Apart from license fees, annual royalties of 1-4% need to be paid (for most minerals it is 4%) and an additional 30% if the mine is located on land that belongs to the state or is under the state's disposition. For a few selected metals, royalties are calculated as proportions of their sales revenues. Of the royalties the national treasury receives, it keeps one half and distributes a quarter each to the special provincial administration of the province and to

[6] Sometimes also translated as Ministry of Environment and Urbanisation

[7] The Mining Law 3213 groups minerals into five different categories, some splitting into subgroups. "Minerals" means "all kinds of substances, except for petroleum, natural gas, geothermal and water sources that are naturally found on earth and in springs and that have economical and commercial value" (Laws Turkey 2018).

the Village Service Providing Unions. In addition, 1% of the extracted ore's value must be paid to the finder of the resources' location (Budak 2016; Tunç and Altunyuva 2017).

Several financial incentives are provided for mining companies. The national government aims to increase domestic production in order to retain a larger profit of the mineral exploitation in the country. It therefore cuts royalties by up to 50% when the mined minerals are processed domestically (Budak 2016). In addition, the government introduced more customs duty exemptions, tax reductions for some projects, and more streamlined entry requirements for potential miners. This is to attract more foreign investment and falls in line with the overall process of liberalisation of the mining sector (BMI Research 2017).

Apart from regulating the financial aspects of mining operations, the Mining Law only barely mentions environmental concerns, only stating the necessity for EIAs and environmental permits.

Environmental legislation

In Turkey, legal protection of the environment only began with the 1982 constitution. Earlier, all environmental protection and reclamation measures were voluntary and hence largely deficient (Arol 2002). The main piece of environmental legislation is the Environment Law No. 2872, which came into effect in 1983. It introduced the polluter-pays-principle and represented a starting point for many following regulations but did not itself explicitly refer to the mining sector. With a view to acceding to the European Union in the future, Turkish environmental legislation was increasingly harmonised with the acquis communautaire and international standards. Furthermore, the enforcement became steadily stricter (Mavioglu et al. 2017; BRGM 2012). A first Environmental Impact Assessment Regulation was enacted in 1993 making EIAs mandatory for most mining operations (Arol 2002). It was updated several times, most recently in November 2017 (Tunç and Altunyuva 2017).

Mining projects require environmental licenses and/or permits, given their potentially adverse impact on the environment. The specific laws and regulations applied and the licenses and permits needed all depend on the respective circumstances of each project. Permits may relate to air emissions, noise control, chemical use, wastewater discharge and/or deep sea discharge, as well as to the respective surroundings of the mines such as forests, wildlife protection zones or pasture lands; however, information on the specific threshold values for contamination could not be found. An EIA, to be submitted for approval to the MoE, is generally necessary before starting a mining operation. Whereas the Mining Law sets a time limit of three months for state authorities to decide upon an EIA application, in practice this deadline is rarely met; yet, the law does not include any sanctions for the non-compliant authorities (Budak 2016; Tunç and Altunyuva 2017). Additionally, a restructuring plan, providing for a sufficient recovery and restoration of the mined land, must be prepared during the environmental assessment process as a consequence of the publication of the Regulation on Reclamation of Lands Disturbed by Mining Activities in 2007, amended in 2010 (Toprak n.d.). Generally, abandoned mine sites are restored by afforestation (Kuter 2013).

A Regulation on Mining Waste was published in the official Gazette in July 2015. It distinguishes between "hazardous" and "non-hazardous" or inert waste. While the former cannot be disposed at sea, the latter can (Moroğlu et al. 2015). This way of waste disposal received international critique and Turkey and Norway were the only of 53 countries who voted against an international ban on dumping mining waste at sea at an international conservation summit in 2016 (Sutterud and Ulven 2016).

In practice, implementation of environmental legislation is mixed and lacking oversight. While there has been progress, especially in relation to the first negotiations over Turkey's EU accession, the situation has worsened again since prospects of an agreement stagnated (Cheung 2010). With regards to the mining sector, concomitant to the liberal reforms and aiming at quickening the permitting process, some projects have been explicitly exempted from environmental regulations (BMI Research 2017)[8].

[8] The source does not mention what projects are exempted.

In the same vein, the Turkish government announced in 2013 to allow big projects to commence on the basis of a preliminary EIA while the final approval would be issued already after the start (Hürriyet Daily News 2013).[9]

Health and Safety

Health and safety regulations for mining operations exist and are extensive; including the Law on Occupational Health and Safety No. 6331, the Regulation on Health and Safety at Mining Facilities, the Regulation on Protection of Employees from Risks related to Explosive Areas, the Regulation on Protection of Employees from Risks related to Noise and other relevant labour laws (Tunç and Altunyuva 2017). Yet, the reality is that many accidents still occur: In 2011, 15.4 per hundred thousand workers died in accidents at their workplace, many of which were miners,[10] compared to a rate of 2.6 in EU countries (HRW 2015).

In the mining sector, 600 workers died between 1983 and 2014 (The Economist 2014). Others speak of 1,500 deaths between 2000 and 2015, and of 13,000 miners who were involved in accidents in 2013 alone (Guguen 2015). Most salient, however, was the accident at the Soma coal mine that occurred in May 2014 and caused the deaths of 301 miners because of carbon monoxide poisoning and injuries to at least 162 workers as the ventilation system failed following an explosion (HRW 2015). Investigators found the mine company guilty of having ignored clear warning signs of the looming catastrophe and avoided evacuation (Guguen 2015). Moreover, health and safety standards previous to the accident, as well as controls and inspections, were described by the miners as very poor.[11] Only two months before the Soma disaster, a four-day governmental inspection found "no flaw". Mine workers have also reported that in previous events of fire, many gas masks were dysfunctional as they were never inspected (HRW 2015). Safety readings allegedly were "routinely fabricated" (Guguen 2015). Moreover, miners have also complained over lacking financial compensation for workplace accidents (HRW 2015). Following the Soma disaster, political pressure mounted and regulatory changes, such as the establishment of a permanent supervision system, were announced (Hürriyet Daily News 2015). How effective these changes have been is unclear. In another report, the Turkish association of chambers of engineers and architects (TMMOB) identified another cause: "The reason for the carnage (at Soma) is privatization, marketization and the outsourcing policies over the past 12 years in the mining sector and also in the area of health and safety" (as cited in Guguen 2015).

Illegal Mining and Corruption

No information on illegal mining of minerals could be found for Turkey, except for coal. Illegal coal mines are mostly found in the province of Zonguldak and are typically small-scale mines with three to four workers, which are often hidden in backyards. These mines also employ women and children aged 15 or 16 and generally feature particularly poor health and safety conditions (Hürriyet Daily News 2014).

Corruption is perceived by Turkish society as one of the most pressing issues (USA International Business Publications 2012). The country has numerous anti-corruption laws and further strengthened them in recent years by aligning them with international standards. Corruption mainly is a problem on the local level. In the Corruption Perception Index of Transparency International, Turkey fell from rank 54 out of 174 countries in 2015 to 81 out of 180 in 2017 (BMI Research 2017; Transparency International 2018).

[9] No German or English sources providing information on whether an EIA was conducted for the Kırka Mine could be found.

[10] Official statistics claim that 10.4 per cent of all work accidents in Turkey relate to the mining industry, which is relatively high in international comparison (Ritter 2014).

[11] Illustrative to the public approach to safety is the statement of then Prime Minister Recep Tayyip Erdogan in 2010 that death in mining were a "profession's fate" (Tait 2014).

5.2 Social context of mining and conflicts

Protests and discontent in Turkey have mounted over a variety of mining-related issues. Disasters, on the one hand, have induced the rallying of people demanding safer working conditions and voicing their discontent over faulty public oversight. The most notable example for this was the Soma disaster, which was followed by strikes and demonstrations as well as the creation of an investigative commission and several legislative changes due to the great public pressure (Akacara 2016; Al Jazeera 2014).

On the other hand, the negative environmental consequences of mining have stirred public grievances, especially of those living in the vicinity of the mining areas and particularly in the case of gold mining. Opposition to mining projects has been predominant in the cases of gold mines, most notably in the Artvin-Cerratepe area near the Georgian border and the Ovacik mine in Bergama near the Aegean Sea.

For example, the movement against the mine construction in Artvin-Cerratepe has been going on for over twenty years and culminated in the biggest environmental legal case in Turkish history. Despite repeated court orders to stop the mine project, the company managed to obtain new EIAs and operation licenses on multiple occasions (Gonenc 2016). Protests have been incessant and took the form of petitions and demonstrations in which almost the entire population of Artvin participated, as well as the form of barricades and bonfires in an attempt to block construction works. Protests were increasingly met with violence from the side of the state, especially in the context of the state of emergency implemented in summer 2017 (AFP 2016; MacDonald 2017). Similarly in Bergama, locals have protested against cyanide-based gold mining since the early 1990s and managed to raise nation-wide awareness (Özen and Özen 2018). Protests have also been constantly ongoing. However, despite a court decision, which ordered a production stop at the mine, operations continued due to incoherent state and judicial decisions (Mavioglu et al. 2017).

Both the Cerratepe and the Bergama case were increasingly politicised. The environmental protesters are more and more portrayed as threats against the state and lumped together with illegal militant groups. One pro-government newspaper said the environmentalists were linked to the Kurdish PKK while another denounced the protesters as "fake" and under the control of Germany (MacDonald 2017; Özen and Özen 2018). President Erdogan himself referred to the Cerratepe movement as a "junior Gezi" and police interventions became increasingly harsh (MacDonald 2017).

There were no German or English sources found, which provided information on past or ongoing conflicts around the Kırka mine.

6 Conclusion and comparison of the analysis with existing governance indices

In this final chapter, the findings of chapter 4 (environmental hazard potential and environmental impacts) and chapter 5 (governance analysis) are analysed to answer the following research questions:

- Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?
- Are existing governance indices and indicators able to adequately reflect the governance capability to cope with the challenges arising around the environmental hazard potentials and environmental impacts of mining? In other words, are the identified governance gaps reflected in existing governance indices and indicators?

In order to answer the second question, a number of indices and indicators (see Table 6-1) were chosen based on a screening of a wide range of existing governance, environmental governance, and peace and conflict indices.

The results of this case study will be compared with the results of nine additional case studies that are conducted as part of this project as well as the case studies conducted in UmSoRess and OekoRess I. By comparing the findings of the case studies, a set of governance indicators will be identified that can be used to improve the assessment approach to analyse the potential for environmental hazard potential of the OekoRess I project.

Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?

Only limited information could be found on environmental impacts of the mining operations at the Kırka mine. The main environmental impacts identified were the high land use and the contamination of soils and water bodies. The results of the site-related OekoRess assessment for the Kırka mine generally mirror the findings of the environmental impact analysis.

The Kırka mine is an open pit mine that affects large areas of land surface. Given the large reserves that remain to be exploited, the land use impact is likely to increase in the future. This is reflected by the indicator "deposit size", indicating a high environmental hazard potential.

The indicator "waste material management" poses a high environmental hazard potential, corresponding to the contamination of surface and groundwater partially caused by solid waste, which is dumped near surface water.

Equally, the medium environmental hazard potential of the indicator "paragenesis with heavy metals" is mirrored by the impact analysis showing high concentrations of arsenic and other heavy metals in groundwater, which can cause serious health impacts.

Corresponding to the indicator "conflict potential with local population", pointing out a high environmental hazard potential, the governance analysis revealed a lack of implementation, common corruption and the overruling of court decisions in the mining sector.

Furthermore, the high environmental hazard potential indicated by the "mine type" indicator is somewhat reflected in the category of surface disturbance and biodiversity, namely slope failures and erosion caused by the too high pit slopes.

Lastly, while the environmental hazard potential for the indicator "paragenesis with radioactive components" is assessed as low, the study showed possible environmental and health impacts from elevated levels of radioactivity in water in the mining area. However, this elevated levels of radioactivity do not stem from the boron-bearing sediments itself, but from the magmatic host rock of the area thus reflecting the OekoRess assessment.

Main findings of the governance analysis

The analysis of the Turkish mining governance shows a sound framework of regulations and strategies. Environmental legislation, not directly included in the Mining Code, has become increasingly strict with the perspective of joining the EU. Yet, as accession negotiations have been stalled, so did the progress on environmental legal protections. Furthermore, the sector is being increasingly liberalized and exceptions have been made for some projects, demonstrating an inconsistent application of the law. Particularly blatant is the practice regarding health and safety standards, which are poorly applied. In addition, corruption is perceived to be very pronounced and some companies have managed to repeatedly attain new environmental licenses from public authorities despite judicial decisions stopping the extraction. Protests over mines in Turkey have generally evolved around poor working conditions as well as negative environmental impacts, especially in the case of several gold mines. Against the backdrop of increased state repression under president Erdoğan, protests have been put down harshly.

Do existing governance indicators reflect Turkey's governance gaps and challenges?

Turkey's overall poor to average sector governance is well reflected in the set of Worldwide Governance Indicators (WGI), however, the rank varies between the different underlying indicators. Turkey has by far its lowest value for the WGI "Political Stability and Absence of Violence/Terrorism" with a percentile rank of only 5.71. The state has indeed increasingly shown the use of force and violence when responding to protests and demonstrations particularly since the state of emergency was declared in mid-2017. However, no information of protest or violence concerning the mining site could be found. "Voice and Accountability" represents the country's second lowest WGI value with a percentile rank of 29.56. This reflects a weak governance situation, e.g. limited freedom of expression and freedom of association. The best-rated WGI is the indicator on "Regulatory Quality" with a value of 61.06, mirroring the situation in Turkey well. This ranking reflects the average to high degree of policy formulation, although the government remains weak in implementing such policies as health, safety and environmental standards. The remaining three WGI indicators range around the 50th percentile, making it an average result: WGI "Government Effectiveness" (54.81), "Rule of Law" (48.56) and "Control of Corruption" (50.48). However, the value for "Rule of Law" could be expected to be even lower considering incoherent state and judicial decisions in the mining sector. The WGI "Control of Corruption" value seems slightly too high given the urgency of the matter and thus does not fully reflect the governance situation.

An index that aims at specifically capturing Turkey's performance of the protection of human health and ecosystems is the Environment Performance Index (EPI). Turkey ranks 108 out of 180, scoring 52.96 out of 100. This outcome corresponds very well to the mixed picture of environmental legislation and its implementation.

Turkey's sector governance and its associated problems are very well reflected in the Fraser Policy Perception Index (PPI) surveyed yearly by the Fraser Institute. Turkey ranks only 72th of 91 countries in the world in terms of attractiveness of its policy environments (52.74 /100 points). The index depicts a fall of almost 20% from 2015 to 2017, which is most likely influenced by the various restrictions and economic as well as political uncertainties that followed the coup d'état attempt in 2016.

The Corruption Perception Index (CPI) rates countries on how corrupt their public sector is perceived by experts. Turkey ranks 81 out of 180 countries assessed, which reflects the results of the governance analysis well. Even though Turkey has legislation against corruption in place, corruption is still a pressing issue.

Conclusion

Overall, the assessment of the environmental hazard potentials adequately pointed to the identified environmental impacts, which were in particular the high land use and the contamination of soils and water bodies.

Furthermore, Turkey's overall weak (with a tendency to average) sector governance and its mining governance is well reflected by the selected indices and indicators such as the WGI. However, the "Rule of Law" and the "Control of Corruption" WGI do not completely reflect the current situation. In contrast, the lower value of the CPI corresponds better to the results of the analysis.

Both, the EPI and the PPI reflect Turkey's sector governance very well.

The case study shows a mixed picture regarding the governance of the mining sector in Turkey and recent trends point towards a negative development. Liberal reforms and the acceleration of the permitting process have weakened the implementation of environmental regulations. Shortcomings regarding the state of corruption and rule of law have further hampered former governance progresses, which Turkey had achieved.

Table 6-1: Governance indicators

Indicator	Turkey	Year	Indicator measures…	Applicability
Voice and Accountability (WGI)	-0.63 (estimate between -2.5 and 2.5) 29.56 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Voice and Accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	Reflects well the low governance performance in this specific area in Turkey. +
Political Stability and Absence of Violence (WGI)	-2.00 (estimate between -2.5 and 2.5) 5.71 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Reflects well the overall governance and Turkey's political stability. The study found no evidence for violence or terrorism in at the mining site. +
Government Effectiveness (WGI)	0.05 (estimate between -2.5 and 2.5) 54.81 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Reflects well the average governance with well-developed policies but poor implementation in the mining sector. +
Regulatory Quality (WGI)	0.20 (estimate between -2.5 and 2.5) 61.06 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	Reflects well the average policy formulation and the government's weaknesses regarding the implementation of policies such as health and safety and environmental standards. +

Rule of Law (WGI)	-0.16 (estimate between -2.5 and 2.5) 48.56 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	Reflects the overall average governance performance well. However, the value could even be expected to be lower considering incoherent state and judicial decisions in the mining sector +
Control of Corruption (WGI)	-0.20 (estimate between -2.5 and 2.5) 50.48 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	Reflects somewhat the average governance in this area despite numerous anti-corruption laws. However, the value could even be expected to be lower. -
Environmental Performance Index (EPI)	Rank 108 of 180, Score 52.96 (out of 100)	2018	The protection of human health and protection of ecosystems.	Reflects well the overall average governance in the environmental sector. ++
Fraser Policy Perception Index	Rank 72 of 91, Score 52.74 (out of 100)	2017	The index measures the overall policy attractiveness and the country's government policy on attitudes towards exploration investment.	Reflects well the mining sector's average governance and policy attractiveness.
	Rank 45 of 109, Score 71.46 (out of 100)	2015		It shows a decrease of almost 20% from 2015 to 2017 which is most likely influenced by the various restrictions and economic as well as political uncertainties that followed the coup d'etat attempt in 2016. ++

Corruption Perception Index (CPI)	40 (rank 81/180; scale 0 -100)	2017	Describes the perception of the corruption in the public sector by experts	Reflects well the weak to average governance in this area and the problem of corruption. +

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