



IPMS 2024

22-24 MAY 2024 ZONGULDAK

INTERNATIONAL POST-MINING SYMPOSIUM

FULL TEXTS

MAYEM

ZONGULDAK BÜLENT ECEVİT ÜNİVERSİTESİ 1924

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Dr. Mehmet BİLEN

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About the International Post-Mining Symposium

Mining is an activity that provides great economic benefits but can also lead to environmental and social problems in the long term. During the extraction of natural resources, ecosystems can be damaged, water resources can be polluted and the quality of life of local communities can be negatively affected. Therefore, when mining activities cease, it is crucial that mining areas are restored to the environment and society.

The rehabilitation process aims not only to reduce environmental impacts, but also to achieve economically and socially sustainable development. Preventing soil erosion, revitalizing nature and economically supporting residents are key components of this process. Natural balance is restored by replanting plants, improving the soil, cleaning water sources and returning animals to their habitats.

Furthermore, rehabilitation should take into account not only the physical environment, but also the needs and expectations of local people. Approaches such as training programs, creating new job opportunities and engaging communities in decision-making play an important role as part of community development. Effective implementation of this process leads to positive outcomes, both environmentally and socially.

In the International Post Mining Symposium held in Zonguldak on May 22-24, 2024 in cooperation with our university and the Association for the Development of Mining Engineers, post-mining rehabilitation processes were examined, examples from around the world were presented and the best methods applied in this field were shared. The aim of this symposium is to contribute to sustainable and responsible mining practices by providing a comprehensive resource for academics, environmentalists, policy makers and mining industry professionals.

Together, we will explore ways to leave a livable world for future generations while using natural resources responsibly, and we will increase our knowledge in this field, which will ensure the reduction and recovery of environmental damage. This endeavor will enlighten us all as an indicator of our respect for nature and society.

Prof. Dr. İsmail Hakkı ÖZÖLÇER
Zonguldak Bülent Ecevit University
Rector

Post-Mining

After mining in our country; It is mostly done through works such as landscaping, afforestation, creating vineyards, and planting lavender and olive trees. Like TKI, archaeological excavations and industrial heritage practices like TTK are also rare examples. There are also rumors of preparations to use the open pit steps, whose reserves are exhausted, for solar energy production.

Our mining and environmental legislation focuses on these post-mining activities. “Regulation on the Restoration of Lands Degraded by Mining Activities to Nature” and “Mining Law (Article 32)” regulate the activities in this regard. It is observed that the regulations are made only on the rehabilitation of the landscape and environment. Another environmentally important aspect of Post-Mining Activities is waste management. Closing and monitoring waste dams, afforesting waste/strip piles and reintroducing them to nature, and preventing negative effects on the environment.

As we all know, negative reactions to mining activities are primarily due to environmental impacts. The appearance of the quarry, which is called visual pollution, the appearance of waste dams or stockpiles and their possible negative effects on the environment are the first phenomena that catch the eye.

Although negative examples are more noticeable; It is a fact that the good practices in our country cannot be explained to the public. It is thought that it would be useful to persuade the opponents of mining, to announce olive groves, vineyards, afforestation, lavender fields and landscaping, to raise awareness among the opponents of mining, and to draw their attention to good practices during and after mining. In addition, it is aimed to reach a wide audience by revealing their contributions to studies in the field of archeology and presenting mining together with culture and art.

By post-activity in most countries, rehabilitation and land reclamation issues have been resolved; It is seen that the focus is on the evaluation of industrial heritage, architecture and infrastructure, socio-economic activities and psychosocial support.

We will meet in another province for the IPMS 2026- Post-Mining Activities Symposium.

Halim DEMIRKAN
Mining Engineer, MSc.
Chairman
MAYEM

From Editor

IPMS 2024, International Post Mining Activities Symposium, the first of which was organized in collaboration with the Association for Professional Development of Mining Engineers and Zonguldak Bülent Ecevit University is planned to be organized every two years.

In this symposium, where the post-mining period was discussed for the first time as an event in Turkey, the studies on rehabilitation and land reclamation, industrial heritage, architectural and infrastructural evaluation, socio-economic activities during and after mining in our country, as in developed countries, were compiled and presented by experts, scientists and sector representatives from different disciplines.

I believe that explaining mining, which is mostly on the agenda with its environmental impacts and negativities, to the public with post-mining activities and explaining the perception formed against mining with examples of post-mining activities (olive groves, vineyards, afforestation, lavender fields, landscaping arrangements) will be extremely beneficial in terms of making our country's mining sustainable. From this point of view, within the scope of the International Symposium on Post-Mining Activities (IPMS 2024), which we organized for the first time, in addition to the studies carried out in our country, it is aimed that the experiences described through speakers from abroad will serve as an example for post-mining activities in our country, the symposium will be a platform where suggestions for the relevant legislation are compiled, knowledge will be shared and the public will be enlightened in this context. The IPMS 2024 symposium was successfully held in Zonguldak, our distinguished city where the best practices of industrial heritage can be observed with the participation of 10 speakers from 7 different countries, hosted by Zonguldak Bülent Ecevit University on 22-24 May 2024, with 30 papers and panel discussions, and guided the mining and post-mining activities of our country.

The IPMS 2024 symposium also addressed studies in the field of archaeology, emphasized the social aspect of mining and tried to ensure that it is evaluated together with culture and art, and aimed to reach a wide audience through media and social media platforms.

As a participant in the COST action on post-mining activities, we are proud to organize a symposium on post-mining activities and to host a platform where examples and suggestions are presented to make the necessary improvements in this sense before it is too late in our country. I would also like to express my gratitude to the Association of Professional Development of Mining Engineers, of which I am proud to be a member, for their institutional efforts in organizing this symposium and for the individual efforts of the members of the board of directors and the chairman of the board of directors, Mr. Halim Demirkan, in this context.

Dr. Mehmet BİLEN

INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Industry and Identity Relationship

***Şenol Hakan Kutoğlu*[1]**

ABSTRACT

Zonguldak is a city shaped by coal mining and heavy industry, which has created a unique culture within the city. The economy and culture of Zonguldak have developed intertwined with mining, leading to other sectors being overshadowed. The city experienced an industrial revolution during which significant industrial structures were built. However, over time, many of these structures were demolished, damaging the city's cultural heritage. In recent years, various steps have been taken to preserve Zonguldak's cultural heritage, including the restoration of some old mining facilities. The city's industrial past is still being kept alive through expressions of social identity, such as "We are the grandchildren of miners."

Although Zonguldak's industrial heritage is an important part of the city's identity, many industrial structures have been destroyed due to a culture of unconscious consumption. These demolitions have damaged the city's history and collective memory, leading to a loss of identity in the community. However, in recent years, there has been a growing awareness of cultural heritage preservation, and some restoration projects have been undertaken under the leadership of the Zonguldak Governor's Office. As a city that hosted Turkey's industrial revolution, Zonguldak is making efforts to preserve this heritage and pass it on to future generations.

Keywords: Industrial Heritage, Hardcoal Mining, Zonguldak, Turkiye

Introduction

In discussions on economic, social, and cultural development, the phrase "Geography is destiny," often attributed to Ibn Khaldun, a 14th-century historian, sociologist, and thinker, is frequently referenced. Although there is no direct evidence that Ibn Khaldun explicitly used this expression, he deeply examined the impact of geography on societies in his works. In his seminal work, " Muqaddimah," Ibn Khaldun discusses in detail the effects of geography—particularly climate and soil—on the development of societies [1].

In dictionaries, the concept of "destiny" is defined as experiences that are impossible to change [2]. Ap-

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proached from this perspective, the word "destiny" often creates a negative connotation for people. Perhaps for this reason, knowingly or unknowingly, this phrase is used to create a sense of acceptance of their situation among societies. It also provides a convenient excuse for those who tend to justify their circumstances. However, destiny is a path of life. The situations encountered throughout life (like geography) are choices made along this path. Choices determine your destiny. You either choose to struggle or to accept your situation. Those who choose to struggle grow and strengthen, using their geographical conditions to develop tools, equipment, technology, and ultimately, a culture.

Geography and Culture

Geography, in its literal sense, is defined as a discipline that examines the relationships between the Earth's surface and the interactions between humans and their environment. Your location on Earth, topography, geology, climate, and vegetation all interact with one another. Societies living in deserts and steppes have engaged in animal husbandry, those in plains with wetlands have focused on agriculture, and those in forested areas have practiced forestry. In places rich in underground resources, mining has been a primary occupation. People living in rocky areas have used stone, in forested areas wood, in clayey soils mud, and in deserts and steppes, they have lived in tents. They adapt their diet, clothing, architecture, and art to their geography and occupations, gaining knowledge and skills accordingly. These experiences and accumulated knowledge are passed down from generation to generation, eventually forming the societal culture.

FIGURE 1. Geographical Conditions and lifestyle

As explained above, mining has created a unique societal culture in the regions where it has been practiced, passed down from generation to generation. In cities with mining-based economies, industries closely related to coal have developed, often at the expense of other sectors. Specifically speaking of Zonguldak, despite the city's natural beauty, industries like ecotourism, maritime, and other service sectors have remained in the background. Naturally, as a city rooted in mining, the local culture has evolved quite differently compared to an agricultural town.

At this point, I cannot overlook mentioning the significant work by Daren Acemoğlu and James A. Robinson, *Why Nations Fail*. In this book, the authors argue that the key factor determining a nation's development is not geography but rather institutions and policies. In my opinion, the primary reason they fall into this misconception is that they consider geography in a narrow sense, focusing only on location rather than the broader definition I mentioned earlier. The institutions and policies developed by societies are a reflection of their culture, and culture is shaped by geography. Even migrations are a product of geography; when lands that once supported large populations lose their productivity for one reason or another, people migrate to new geographies. The societies that come together through migration must develop new institutions and policies to live in harmony.

Returning to our main topic, culture defines the identity of a society and the individuals within it. For example, the phrase "We are the descendants of miners" is a widely known and frequently used expression of social identity in Zonguldak.

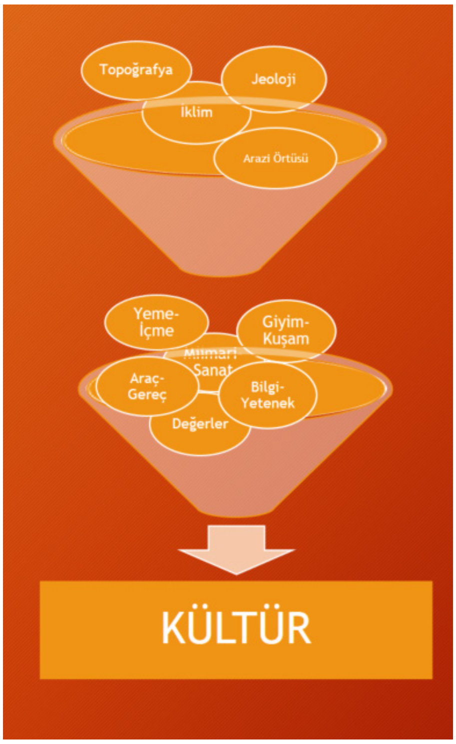

FIGURE 2. THE RELATIONSHIP BETWEEN GEOGRAPHICAL FEATURES AND CULTURE

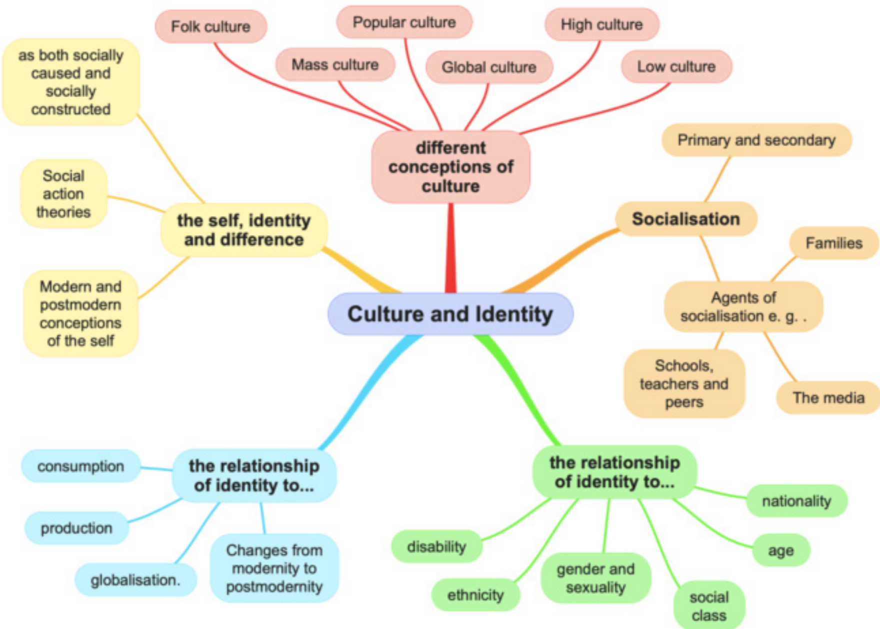

FIGURE 3. CULTURE AND IDENTİTY [5]

Industrial Heritage

The technological revolutions that began with the First Industrial Revolution in the 18th century and have continued at an increasing pace to the present day have had significant impacts on human life. The waves of migration from rural areas to cities have led to substantial changes in the fabric of urban life, resulting in cultural crises and, consequently, the emergence of social identity crises.

In order to prevent social identity crises, a movement to preserve cultural heritage began in Europe, which also led to the development of the concept of Industrial Heritage as a subcategory of cultural heritage. According to the definition by James Douet (2016) [6], industrial heritage "refers to the physical remnants of the history of technology and industry, such as production and mining sites, as well as energy and transportation infrastructure." Another definition broadens this scope to include places used for social activities related to industry, such as housing, museums, educational or religious sites, and structures that possess values from various disciplines, highlighting the interdisciplinary character of industrial heritage.

To protect industrial heritage, the International Committee for the Conservation of the Industrial Heritage (TICCIH) was established in 1973. Since 2000, TICCIH has served as an expert advisor to the International Council on Monuments and Sites (ICOMOS). The Nizhny Tagil Charter for the Industrial Heritage, published by TICCIH in 2003, serves as an international guidance document for industrial heritage [7]. Additionally, in 2011, the ICOMOS-TICCIH Dublin Principles for the Conservation of Industrial Heritage Sites, Structures, Areas, and Landscapes were published [8]. Furthermore, the European Route of Industrial Heritage (ERIH) has been established as a tourism network for industrial heritage [9].

Industrıal Heritage In Zonguldak

According to official records, coal mining in Zonguldak began in 1848. Coal production was initially conducted under British control and later under French hegemony. After the proclamation of the Republic, it was nationalized [10]. The coal production in Zonguldak also led to the establishment of heavy industry facilities in the region due to logistical convenience. One of the foremost of these facilities is the Işıkveren Thermal Power Plant, also known as ÇATES A, which was commissioned in 1948. This power plant is notable as it marks the beginning of Turkey's interconnected electrification system, and it is the only power plant from the Republican era mentioned in the report titled "A Brief History of the Development of Electrical Energy in Turkey and General Production Information," prepared by the Chamber of Electrical Engineers [11]. The steel industry's two leading plants, KARDEMİR and ERDEMİR, were also established here. In addition, many of the first heavy industry representatives in Turkey were founded in this region. In short, although Turkey missed the Industrial Revolution on a global scale, the country experienced its own industrial revolution in Zonguldak. For this reason, foreign state dignitaries visiting Turkey were brought to Zonguldak to showcase the country's industrial power. Due to being the city most visited by kings, apart from Ankara and Istanbul, Zonguldak was sometimes referred to as the "City of Kings."

FIGURE 4. VISITS OF THE SHAH OF IRAN, AND THE KINGS OF IRAQ AND AFGHANISTAN TO ZONGULDAK

Certainly, due to its rich industrial history, the city has produced many industrial and artistic structures that depict the lifestyle of that era. Unfortunately, many of these works have fallen victim to the culture of an unconscious consumer society. Some of their past and present conditions can be seen below.

FIGURE 4. THE OLD PORT AUTHORITY BUILDING IS NO LONGER THERE

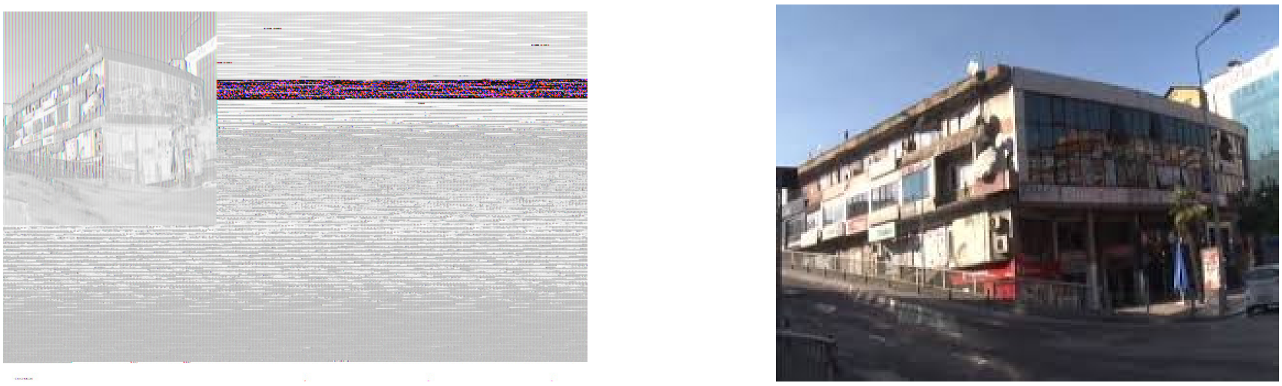

FIGURE 5. THE OLD BATHHOUSE AND THE NEW MARKET BUILT IN ITS PLACE

FIGURE 6. THE OLD AND NEW STATES OF THE SEE CLUB

FIGURE 7. AN EXAMPLE OF MIXED CONCRETE AND WOODEN ARCHITECTURE: NAMIK KEMAL SCHOOL (LEFT)

WAS DEMOLISHED AND REPLACED WITH A NEW BUILDING (RIGHT)

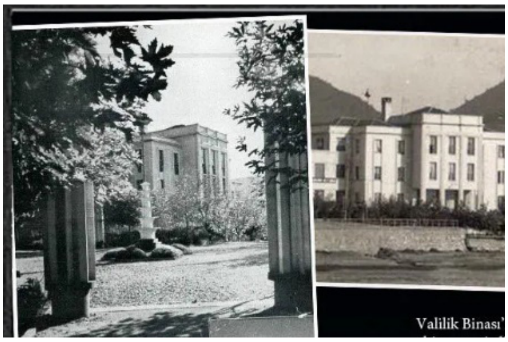

FIGURE 8. THE RESTAURANT BUILT IN PLACE OF THE WORKERS' DİRECTORATE

FIGURE 9. THE OLD GOVERNOR'S OFFİCE BUILDING AND THE NEW ONE

FIGURE 10. THE OLD AND NEW STATES OF BAHÇELIEVLER NEIGHBORHOOD

Certainly, what is lost with the demolition of these buildings is not just the structures themselves but also the lived experiences and memories of a city—our ancestors' memories. The demolished buildings were symbols of a culture of production, while those erected in their place are products of an ugly, degraded consumer culture devoid of aesthetic value. When the works reflecting a city's past are destroyed, it is not merely the buildings that are lost but the cultural heritage of the community. The result is a society without identity, leading to individuals without identity. A city that has been severed from its past cannot establish a healthy future with an identity-less society.

Result

In civilized societies, it is essential to preserve cultural, artistic, and industrial works as heritage, as they narrate the construction, development, and cultural accumulation of a nation from past to present. This ensures that the story of a nation can be passed down from generation to generation, preserving its culture. Zonguldak, a city where Turkey's industrial history was written and which served as the capital of the country's industrial revolution, is one such place. However, as mentioned earlier, many industrial works have unfortunately been destroyed. If the few remaining ones are also damaged, it will be impossible to convince even the inhabitants that this city once hosted an industrial revolution and a mining industry.

Fortunately, thanks to the preservation impulse that has grown and developed over the past 10 years through the efforts of a small group of people, the Zonguldak Coal Geopark Directorate was established under the leadership of the Zonguldak Governorship. The city has been included in the national geopark list, and an application has been made to UNESCO Geoparks. As part of this initiative, a group of old mining facilities has been restored (Figure 11).

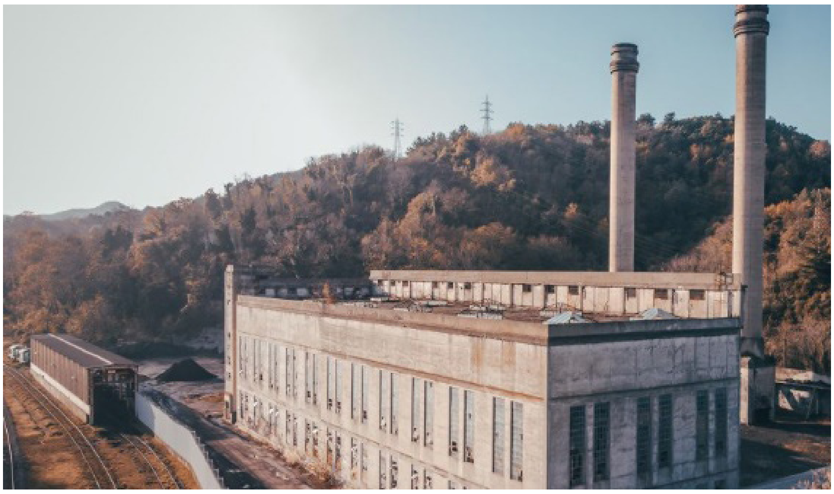

FIGURE 11. MINING FACILITY RESTORED UNDER THE NAME UZULMEZ CULTURE VALLEY

THANKS TO THE EFFORTS OF THE CITY COUNCIL, THE IŞIKVEREN THERMAL POWER PLANT, A MONUMENTAL WORK OF OUR INDUSTRIAL HISTORY, HAS BEEN PLACED UNDER PROTECTION BY THE MONUMENTS COUNCIL. HOWEVER, IT STILL REMAINS IN A STATE OF NEGLECT, AWAITING RESTORATION

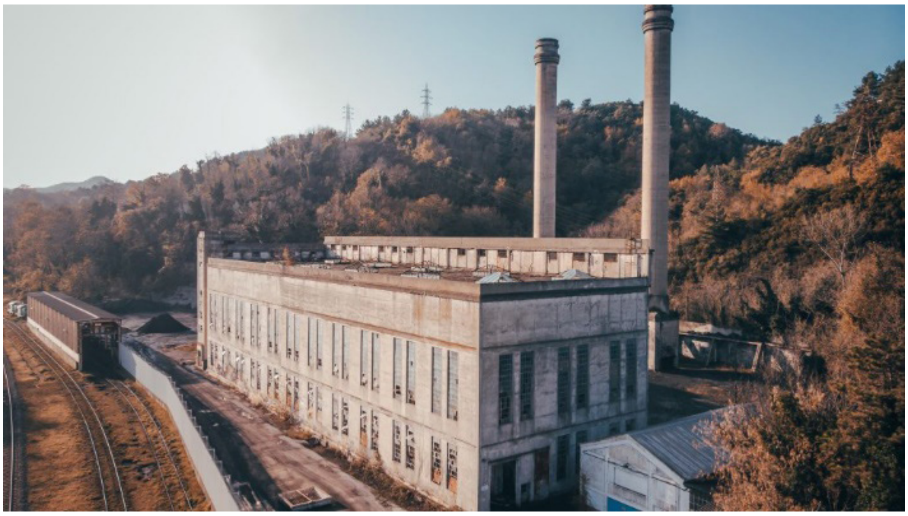

FIGURE 12. IŞIKVEREN (ÇATES A) THERMAL POWER PLANT

In Zonguldak, the phrase “We are the descendants of miners!” has become a slogan. It is often invoked in response to a situation or challenge. However, when witnessing the destruction of so many historical works, one can’t help but think, “If you were truly the descendants of miners, then why did you allow your forefathers’ works to be destroyed?”

When comparing Zonguldak’s current state with its illustrious past, one feels compelled to adapt Necmettin Halil Onan’s famous poem “Stop, Traveler” to Zonguldak:

> Stop, traveler! The ground you tread unknowingly
> Is the city where Turkey’s industrial revolution took place.
> The building you see at the end of this desolate, shadowless road
> Was once Işıkveren, the first and largest power plant of the Republic,
> Illuminating the entire country from Istanbul to Ankara.

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He may be contacted at shakan.kutoglu@beun.edu.tr *or* kutogluh@hotmail.com

Ergani Copper – Saving the World Heritage

Sabri Karahan

ABSTRACT

This study addresses the historical, cultural, and industrial significance of the Ergani Copper Mine in Turkey, a site with a legacy of copper production dating back to 7000 BC. Known as the cradle of copper metallurgy, Ergani Copper contributed to civilizations, including the Hittites, Assyrians, and Ottomans. However, recent developments, including the dismantling of its smelter and environmental negligence, have threatened its legacy. This paper presents a detailed review of the mine's historical contributions, current degradation, and the socioeconomic and environmental impacts of modern mining activities. Recommendations for preserving this world heritage site are provided, emphasizing the importance of sustainable development principles.

Keywords: Ergani Copper, cultural heritage, environmental impact, copper metallurgy, sustainable development, historical mining sites, Turkey.

Introduction

It is a sad moment for me to present to such distinguished guests the demise of Ergani Copper out of history of Mankind.

I was raised in this town of MADEN, went to middle-school, and was inspired by the activities going on at the mine and the smelter, amazed at the age of 15 with how rocks turned into metallic copper, and motivated at an early age to be a mining engineer.

My father was a worker at the open pit, whom I used to visit frequently at the mine site. Each moment of visit filled me with pride that he was part of the copper production, at the head of the line. This drive stays with me even now after 55 years of my engineering courier.

History and archeology tell us that this land offered copper to Human Civilizations starting from 2000 BC (some even dating it back to 7000 BC) until this date without interruption. It has seen Hurrians, Mitanni, Hittites, Assyrians, Persians, Macedonians, Romans, Byzantiniums, and Ottomans reining the land who extracted native metallic copper initially, then developed the art of producing copper from mineralized rocks. Ergani Copper (MADEN) has the evidence of slag remnants on the top of the hills around the open pit and numerous holes (adits) dug into the rich orebody, reminding us of the old history of the mining millenniums before the modern mines and smelters built and put into operation.

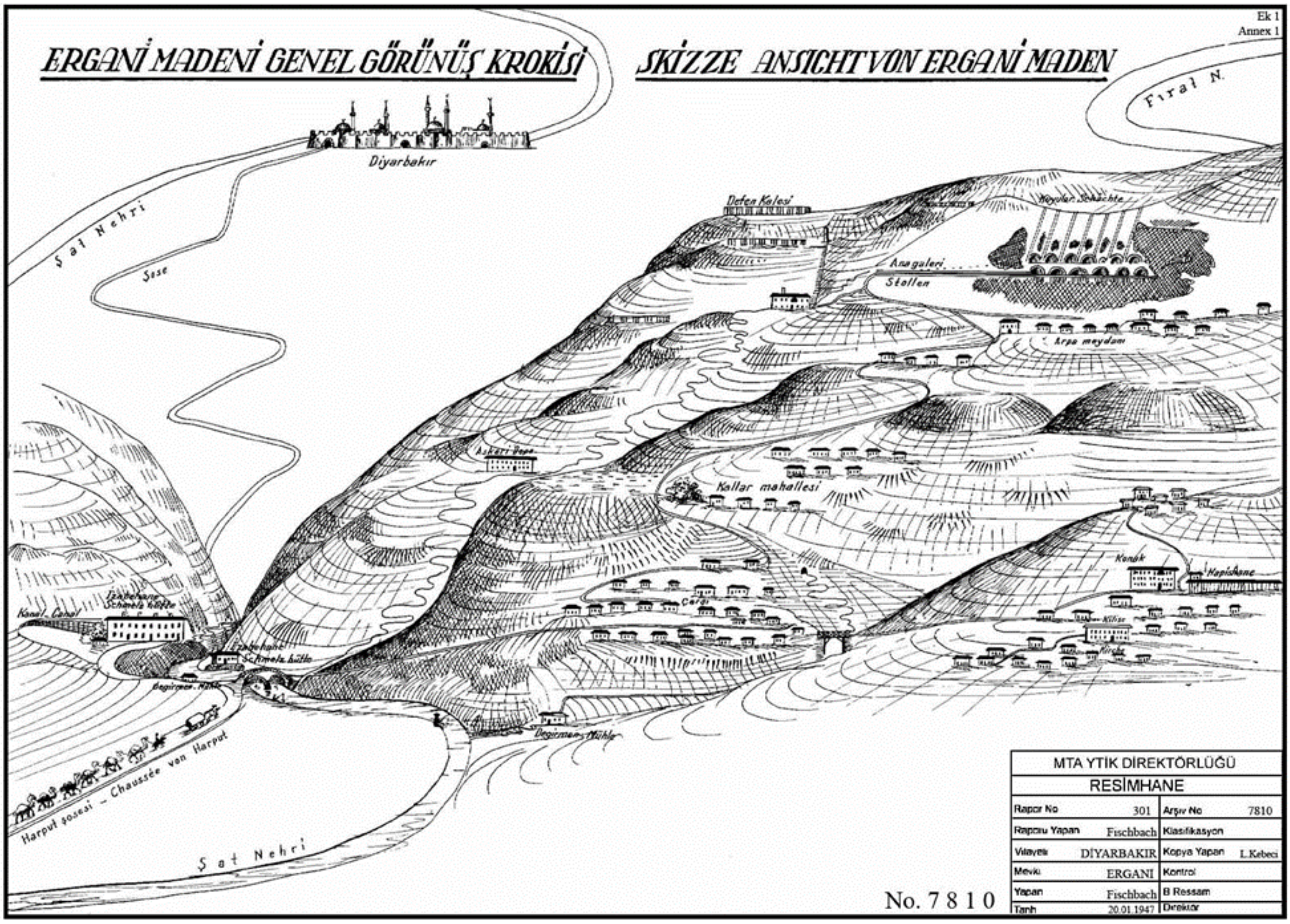

Figure 1: Sketch of the Region (Fishbach,1900: Barrowed from MTA Report 301)

The land attracted those skilled people from every race being Jews, Armenians, Greeks, Arabs, Turks and other historical races now extinct, who dwelled in harmony and made a living. Many Kings, E the mperors and Presidents visited the mine, the last one being M.K. Ataturk who visited the site, in 1937, to expedite the construction of the smelter. The copper produced from this land had been shipped by Hittites to Pharaohs in Egypt and Byzantium Constantinople of the time to decorate monuments, build armaments and ornaments.

During the 4th quarter of 19th century, the Ottoman Engineer Ethem Pasa built a relatively modern smelter (caller KALHANE) on the banks of river TIGREESS and engineered the underground mine for mining and transporting ore from hill side tunnels. Remnants of the smelter were still solid on the banks of the TIGRES river until 1960's.

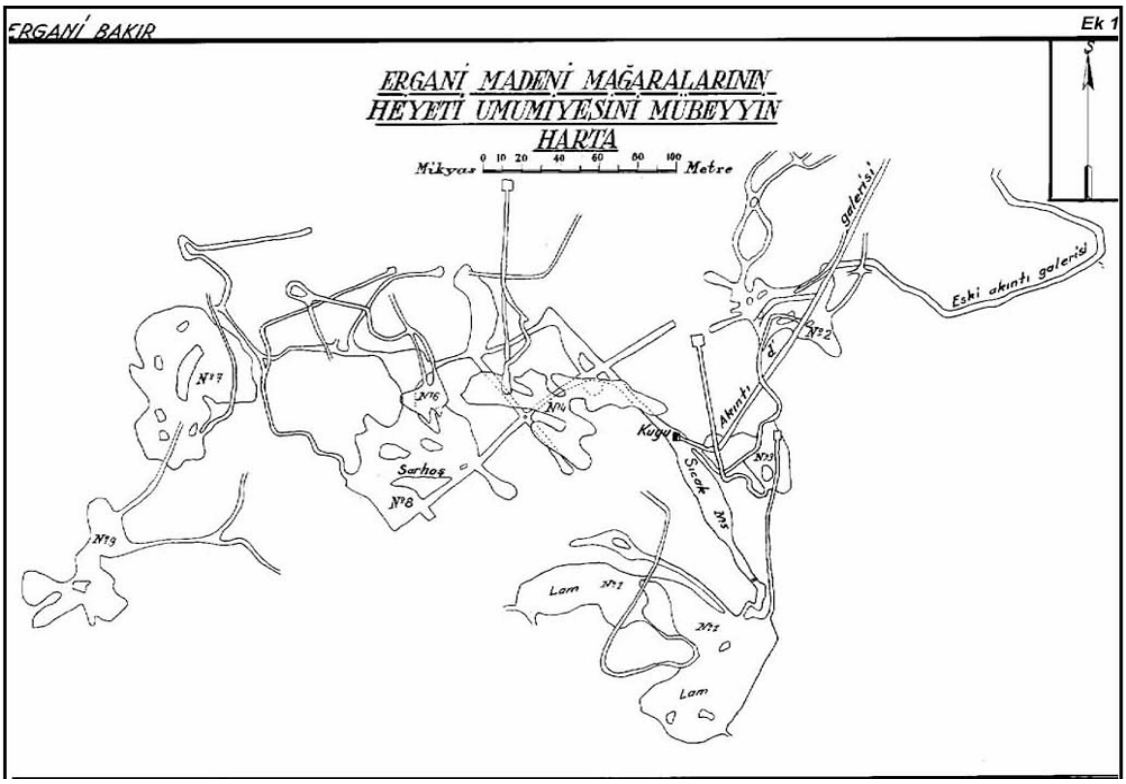

Figure 2: Historical Underground Operations Map

Figure 3: The Smelter On The Riverbank-Water Channel, Water-Wheel, Below And Smelter

After the First world war, the thirst for copper brought French, German and British investors to MADEN who invested into building a large open pit mine and a smelter with 10,000 tons of blister copper capacity, to be paid back in copper. In recent times, from1939 till 1994 blister copper from Ergani Copper was shipped to refineries in Europe.

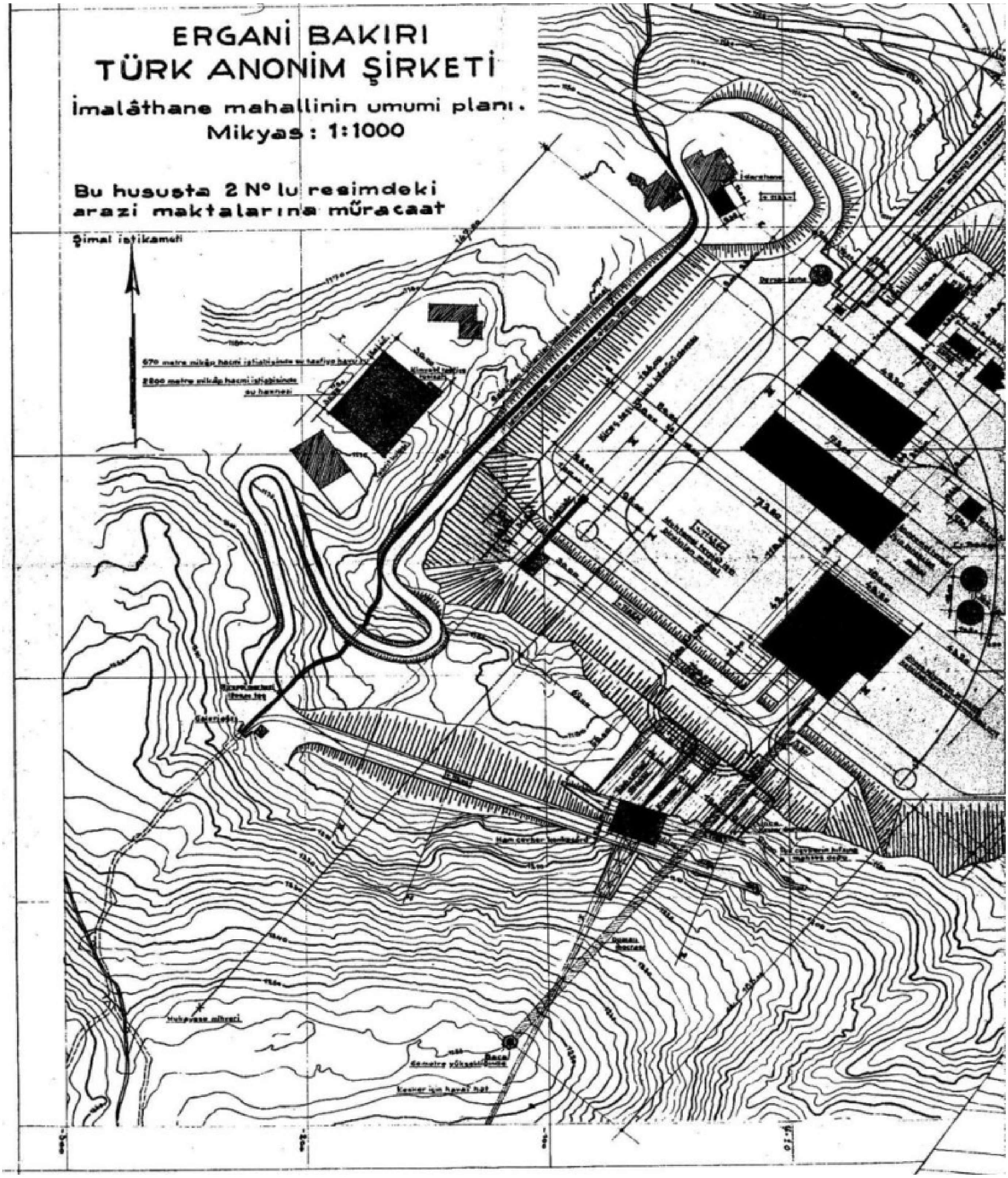

Figure 4: Modern smelter plans in 1931(barrowed from CCA Archive)

Figure 5: Panaromic view of the mine

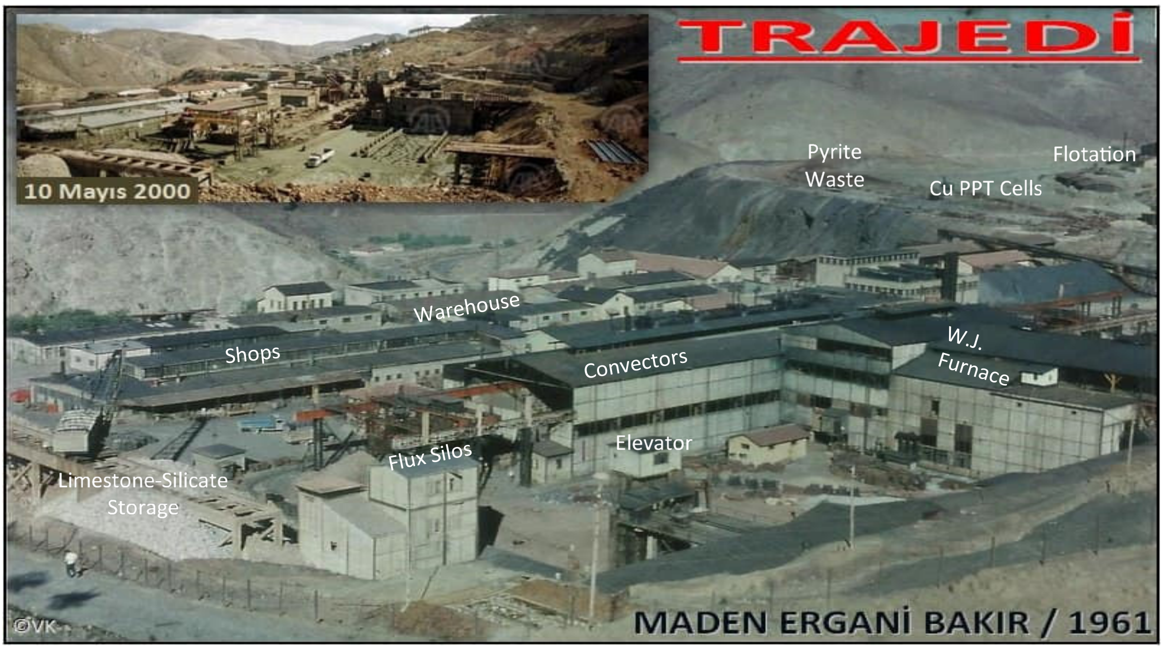

Figure 6: Below-Ergani Smelter in 1961 and Above- in 2000 (Local artist)

What happened to Ergani Copper and why it happened to her, the mother of civilization that mankind developed? Why couldn't we save her from this end? Is it the end of ERGANI COPPER, the end of HISTORTY?

Ergani Copper, Credle of Bronz age, one of the cornerstones of humanity of the day? Is it going to be forgotten, buried under the rubles, or is there a chance to make this HARITAGE survive, to remind our children that this MINE was part of the development of our existing civilization?

The destruction of the smelter area, a site that embraced the technological advancements in copper smelting and environmental safeguards from 1938 to 2010 took place quietly, without any consultation with locals.

Who had the audacity to permit dismantling and selling off the entire plant, smelters, refiners, and countless supplementary facilities to mere scraps for a few dollars. Who permitted the only flat land at MADEN, which could be utilized for developing an industrial base to keep the Haritage growing and attractive, to be filled with waste material from the mine that is destined to be exhausted?

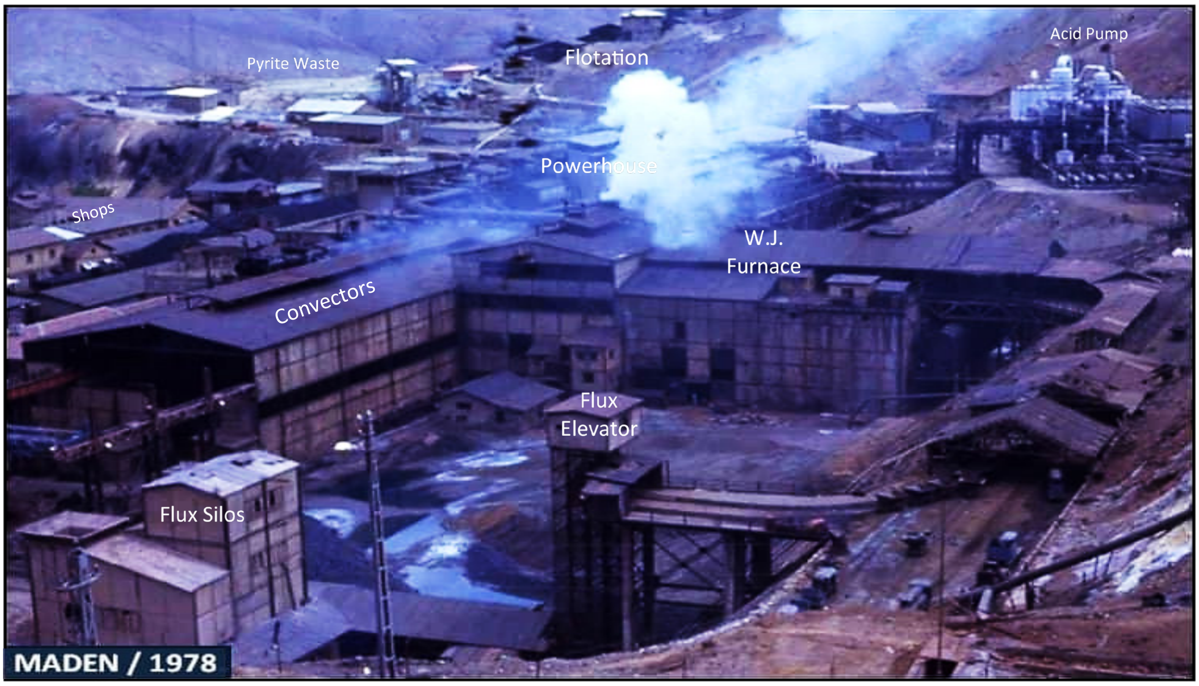

Figure 7: Ergani Copper smelter in full development

Figure 8: Ergani Copper smelter site after destruction

Why no authority is listening to the cries of inhabitants of the town, whose houses are crumbling under the load of waste from the mine put on the flat land, which once filled by life giving smelter technological artifacts such as smelters, refiners, scrubbers, ateliers serving the facilities and buildings? Is this a negligence or a demonstration of incompetence on the part of locals, operators and authorities jointly, who lacked the imagination and appreciation to preserve the remains of a distinguished culture, a world heritage, into socially, economically and environmentally sustainable everlasting site?

The inhabitants of the home of civilization MADEN, numbers of times refused to un-inhabite the village, to move to supposedly a better residential area. Those people did not want their past buried in the dust, live without memories of the forefathers and let 7000 yrs of history to be forgotten. These days they are still fighting vandalism trying to destroy their history. Their history is so rich that it can not be compared with mining towns ones flourished and then destroyed after the ore was mined out.

The author of this text recently made a presentation at The International Post Mining (IMPC) symposium on Post Mining Rehabilitation held in city of Zonguldak, thanks to International Post Mining Organization-Turkey, member of the international organization. There were number of presentations from mainly Europa, which put us to shame the way they preserved their mining heritage and turned into showcases of revenue making cultural sites. Especially what was done in Ruhr area, where they turned the Collery surface facilities and Underground openings into museums and recreation areas. Frankly, despite its beauty well exposed, none of the rehabilitated sites compared to Ergani Copper's great past in history and now destroyed smelter which was offering 11 technological developments.

Figure 9: Closed Ruhr Collery near ESSEN in GERMANY is now a UNESCO World Heritage Site
(Thanks to Mss. Meltem Kucukyilmaz, museum Director, for granting permission)

Brief developments that took place in the last 200 years are accounted below for those who may be interested in cultural history of mining.

•It is not over-estimation to argue that mining history developed around BC 7000 in Ergani copper area. The evidence are slags at the tops of mountains, demonstrating the old smelting techniques employed during Assyrian period of Anatolia.

•The documented history of Ergani Copper starts with HITITES, who are known to have dispatched copper from Anatolia to the Pharaohs in Egypt, probably the first copper technology transfer between cultures.

•Ottomans documented that the production of copper from Ergani Copper was kept going through Jewish and Greek entrepreneurs who delivered their copper on caravans to the State in Istanbul via Trabzon Sea Port.

•The first modern mining and smelting operation started in Ergani Copper around 4th quarter of 19th century by an Ottoman Engineer, Ethem Pasa. The hand crushed ore was mined from underground and transported via adits, shafts and tunnels to the level of Tigris River, where the smelter was. The underground mine plans are professional by today's standards. Water wheels, powered by water from creeks running down from mountains, were used to operate bellows supplying pressurized air to two (2) chimney type smelters. Oak wood from the forest around Maden was used as fuel, limestone and silicate from around Maden were used as fuel and flux. The operation continued until the modern smelter was put into operation in 1939. The remnant of this operation survived until 1970s at the riverbank.

•The Modern smelter started operating in 1939 after 9 years of construction period. It was designed and built by a consortium between Turkish Republic, German and Fench investors established in 1929. The railway planned to be constructed between Malatya- Diyarbakir, passing Ergani Copper, needed to transport the large equipment such as excavators, power generators, smelters and refiners required to mine and produce blister copper, arrived Maden in 1938. Then the supply of large equipment, coking coal and fuel started to arrive in large quantities. The construction of the smelter was completed in 1939 and the first copper bar was produced in October. The day was always celebrated by the mine management and the locals by organizing a Ball. It is a duty to note that the railway part between Elazig-Maden had to pass numbers of tunnels which were dug mostly by hand using picks and hammers since blasting powder was scarcely available.

· The Ergani Copper mine, the smelter and the railway extended from Cetinkaya via Malatya to Diyarbakir were the most prestigious investments of the time for the new Republic. The operation was not just a mine or smelter, but also acted to start a change in local social life by providing electricity to the town, building and supporting hospital, health clinics, schools, modern housings, guest hotel, social facilities for workers, supporting facilities for tennis, basketball and swimming. The village of Maden was turned into the modern town of the republic that set the standards for other communities to ketch-up with.

· Copper production steadily continued at 10,000 t/year blister copper production until 1985 under Etibank Ergani Copper operation.

•Starting from 1990s the decline in production started. An exploration program financed by Etibank and run by MTA did not produce any tangible minable ore deposits. Finally, Etibank pulled out of the area and left the mine and flotation plant to contractors to operate. The irony is that, recently a large copper deposit was discovered by MTA, 7km to the NE of Maden, which location is almost adjacent to the old small open pit mined in the past by Etibank Ergani Copper and previously explored by MTA. A successful campaign was carried between 1984 and 1985 to operate the smelter at full capacity by buying concentrate from local resources was stopped for reasons not known to us.

Scavengers and Vandals in Operation

The details of the agreement between Etibank G. Management and the contractors is not known to us, what we know is that the Contractors will mine the remaining ore at the open pit in compliance with the Country mining law and regulations. Neither local population was aware whether destroying the smelter was part of the deal?

The Contractors:

•Mined out the remaining ore from the main open pit as well as from satellite deposits around,

•Modern slags from Water Jacket Smelter were subjected to flotation,

•Historic slags from around the smelter were also floated,

•Then, the Ergani Copper guest house which was originally built on the historical slags (known to have been built in 1930s to house the engineers supervising the smelter construction),

•Workers social and sleeping quarters, the housings for bachelor and married engineers, technicians, schools and supporting facilities were demolished down for removing slags,

•Finally historic slags under an area holding quarter of town population was demolished and slags were sent to flotation for floating copper concentrate.

In total roughly, one square km of inhabited area holding millions of tons of old slags were mined over the years, but no attempt was made to rehabilitate any of the barren parts.

The worst to follow; first, the smelter was scavenged for valuable small items, then the whole heavy and light equipment were cut to pieces (hard to believe the Pierce-Smith smelter and converters be cut to pieces to sell as scrubs), then all the smelter building were demolished. Almost nothing was left at the smelter site. In order to hide the site where the crime was committed, the whole smelter area is filled with millions of tons of waste.

Since the company was providing jobs to a few dozens of the people and workers, the villagers were subdued under the threat that the local workers would be fired if they raised their voice.

Few years later when the land under the heap of waste crumbled and creeped, creating an unsafe situation for numbers of buildings below, the voices were heard from the villagers, and the company called in so-called experts who reported that the waste is acting as the supporting berm holding the mountain behind, on which 2 of the large smelter stacks located. The villagers tried to take the case before the Governor's office and court but were refused based on the so called 'Expert report'.

The waste material, dumped on the demolished smelter area, is the loose material from an open pit called serpentinite, which could not hold itself and broke down into the pit as land slide. This weathered, slippery material has the lowest friction angle to hold itself in its original place, let alone holding a mountain in its place. Contrary to the claim, it acts as a load to create small internal movements within the formation it is sitting on. Already, a historical bridge, number of State buildings and local houses damaged. The was the waste material 's placed, it is blocking the galleries and tunnels used to drain the open pit area.

Accumulated water in the open pit is expected to be absorbed into the local faults rendering them slippery, therefore making them amenable to slide. The waste is loaded directly on the historical fault mapped by geologists before the smelter was constructed. This fault was drained by a gallery, drained water contained economical amount copper sulfate from which metallic copper used to be produced from cementation cells.

What are the country Laws regulating?

Mining is regulated under the MINING LAW & REGULATIONS as well as under the ENVIRONMENTAL LAW & REGULATIONS. (See Appendix 1).

Here we will concentrate on 2 general provisions that we believe were totally undermined.

Sustainable environment: The process of improving, protecting, and developing all environmental values that make up the environment of both todays and future generations in all areas (social, economic, physical, etc.) without jeopardizing the existence and quality of resources that future generations will need,

Sustainable development: Development and progress based on the principle of balancing environmental, economic, and social goals that guarantee the living of today's and future generations in a healthy environment,

The social and economic damage done:
a) By destroying the smelter, the social goals were undermined, allowing no room for local people to turn the facilities into a museum which used to hold about 11 industrial developments to be seen by public, universities and students. It was going to be a source of probably 200 jobs for guides, shopkeepers, artisans, rock sample gatherers.

b) Depriving the community from the only flat piece of land on which sport facilities, school, even a technical high academy could be established.

c) The waste piled up in the area blocking mine drainage, creating a hazardous stuatin by triggering land slide in the short and long period. Already, there are indications that sliding may occuer if the waste load is not removed from where it is.

d) The company destroyed number of residential areas to mine historically accumulated slags, including Guest House (Alman House), worker sleeping and social buildings without consulting the locals, which buildings could have been turned into community gathering places, art schools, shops, restaurants, etc.

e) The act of breaching all ammendmens of Mining and Environmental laws and regulations deprived the MADEN village from employing about 200 people, therefore sustaining about population of 1000.

Actions Required:

Urgent-

- Call in experts (Environmentalists, Mining, Geologist, Geotechnical, Hydrologist) for the assessment of HAZARDS inflicted and economic, social and environmental damage, and recommendations for remediations.

- Remove the waste dump material from the land, which should have never been used for such an action, before the whole area crumble under the load,

Long Term-

- Start restoration and rehabilitation of the land that been left barren.

- Built a model replica museum of the smelter on the same land.

- Develop underground edits, galleries and Tunnels for tourism.

- Prevent further demolishing of river bank and houses to open areas for mining slags.

What was done to Ergani Copper is a CRIME, to destroy the culture built over millenniums. By restoring what is left behind, may history forgive us partly.

This is the last chance, either the State comes to the aid of saving and restoring what remains of the world Heritage or all will be lost for good? We hope that the distinguished guests gathered here today, who have influence in Turkey and Europe will take interest in this Human experience and help to salvage what remains.

Sabri KARAHAN

Mining-Mineral Processing and Hydro-Metallurgy Engineer (MSc)

Sabri Karahan was born in 1942 in Elazığ, Turkey. He graduated with both bachelor's and master's degrees from Istanbul Technical University's Faculty of Mining and later completed a master's degree in Copper Hydro-Metallurgy at the University of Birmingham. Karahan began his career in 1968 at ETİBANK, where he held key positions such as Chief Engineer at the Ergani Copper Facility, Operations Manager at the Uludağ Tungsten Mine, Head of the Phosphate Group, Chairman of the Board at the Çayeli Copper Mine, and Head of Operations at ETİBANK. Between 1988 and 1998, he served as the General Manager of Cominco Mining. Subsequently, he played a pioneering role in the commissioning of Turkey's first gold mine, the Bergama Ovacık Gold Mine, while working with Normandy Mining and Newmont. In 2005, he established DAMA Engineering, offering engineering and consultancy services at international standards. Collaborating with over 300 clients, he carried out JORC and NI43-101 compliant resource estimations, feasibility studies, and turnkey projects. Karahan contributed to the development of Turkey's first modern chrome processing plant and numerous gold mines. He is married, has two children, and three grandchildren. He has dedicated his life to bringing innovative solutions to the mining industry.

Ruhr Area National Geopark – A Case Study of a Geopark in a Post-Mining Area in Germany

Volker Wrede[1], Till Kasielke[2]

ABSTRACT

The aims of the National Geoparks in Germany are: (1) conservation of the geoheritage of the area in co-operation with the relevant authorities, (2) to elucidate the local geosites and to inform the public about geoscientific topics, (3) stimulation of local development by geotourism. The development of the Ruhr area as an industrial region with more than 5 million people was based on the use of mineral resources. Hard coal and various other resources were mined in great style. Aiming to preserve the awareness for the roots of the area's development, the Ruhr Area GeoPark was founded in 2004. Its geology comprises Palaeozoic rocks of the Devonian and Carboniferous, sediments of the Cretaceous and Tertiary and widespread remains of the Quaternary ice ages. The geoheritage of the area mainly consists of primary geosites (i.e. rock outcrops) and collections in museums (secondary geosites). The industrial heritage is promoted by a separate organisation. The Geopark established a network of geotrails both for walking and biking and several information centers connected to museums and show caves. Many geosites have been equipped with information panels. Further, the Geopark addresses the public by publications on different levels from children´s books to scientific publications, guided field trips and lectures.

Keywords: National Geopark, geoheritage, conservation, geotourism

ADMINISTRATIVE BACKGROUND

The Ruhr Area GeoPark in Germany was founded in May 2004 by the Ruhr Regional Council (RVR) and the State Geological Survey of North Rhine-Westphalia (GD NRW). Formal backgrounds were the "Guidelines for the certification of National GeoParks in Germany", which had been established by the German Federal Board of Geosciences ("Bund-Länder-Ausschuss-Geowissenschaften") in 2002. The conditions for the certification as "National Geopark" are similar to those of the UNESCO Global GeoPark Network: The area

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of the geopark must be clearly defined and, of course, comprise features of outstanding geoscientific value. A unique characteristic should be defined, distinguishing the geopark from others. Further, there must be an organization responsible for the organization and future development of the geopark. In case of the Ruhr Area Geopark a non-profit incorporated association "GeoPark Ruhrgebiet e.V." was set up in 2004 as the operating institution. Membership in this association is open to all natural persons or legal entities supporting the statutory aims of the Geopark. These aims in general are:

• protection and conservation of the geological heritage of the area,

• informing the public about geoscientific topics,

• stimulation of geotourism.

Beside RVR (as representative body of the region) and GD NRW (as scientific backbone) the network includes local authorities (town and district administrations), universities and museums, representatives of the extraction and mining industry, environmental and conservation organisations, mining heritage groups, scientific societies and touristic enterprises, as well as personal members. In 2024 the GeoPark Ruhrgebiet e.V. numbers 230 members, about 50% of them individuals and institutions, respectively. The members generally act autonomously, but the Geopark coordinates their activities and creates synergy.

The advantage of the National Geopark system in Germany, operating parallel to the UNESCO Network, is that the certification process is quicker, and more areas may be awarded the status of an officially recognized geopark. Today 20 National Geoparks exist in Germany; 8 of them additionally are members of the UNESCO Global Geopark Network.

The Ruhr Area Geopark was evaluated and certified as a "National GeoPark" in 2006. Thereafter, every five years the Geopark was successfully re-evaluated and its status as a German National Geopark confirmed.

The basic concept and motto of the Geopark is "Geospotting: Man and Mineral Resources – from exploitation to responsible use". This coincides with the claim of the Operational Guidelines for UNESCO Global Geoparks "Geoparks use geological heritage…to enhance awareness and understanding of key issues facing society in the context of the dynamic planet we all live on". The motto combines two main features:

Geospotting: Due to the very versatile geology of the area and an unusual wealth in geosites, the Ruhr Area GeoPark is an ideal region to study all aspects of geology.

"Man and Mineral Resources – from exploitation to responsible use" defines a unique feature for the Geopark and reflects the fact that the area is extremely rich in resources (at least 17 different materials have been mined economically). The mining and excavation industry is not only a historic activity, responsible for the origin and development of the Ruhr metropolis, but it still is an important factor of the region's economy. Security of supply with raw materials for a growing world population, with respect to the limitations given by nature and the environment, and in responsibility for future generations doubtlessly is one of the key issues for mankind today and in future.

GEOGRAPHIC SETTING

The Ruhr Area GeoPark is located in the State of North Rhine-Westphalia in the north-western part of Germany. The Geopark comprises the area of the Ruhr Regional Council (RVR), a legal entity representing the communities and districts of the Ruhr area (Ruhrgebiet).

The GeoPark covers an area of some 4450 km². The area is defined mainly by the extension of the Ruhr coal mining district, which – based on the natural resources – stimulated the economic, social and cultural development of the present-day urban agglomeration with about 5 million inhabitants [1].

In terms of physical geography, the Ruhr area is not a uniform region. Its structure is generally determined by the valleys of the river Rhine, which flows through its western part, and its eastern tributaries Ruhr, Emscher and Lippe. The southern part of the area, including the valley of the river Ruhr, belongs to the Rhenish Mountains, while the northern and western sections are part of the German Lowlands – the Münsterland Basin (Westphalian Lowland) and the Lower Rhine Plain [2] (Figure 1).

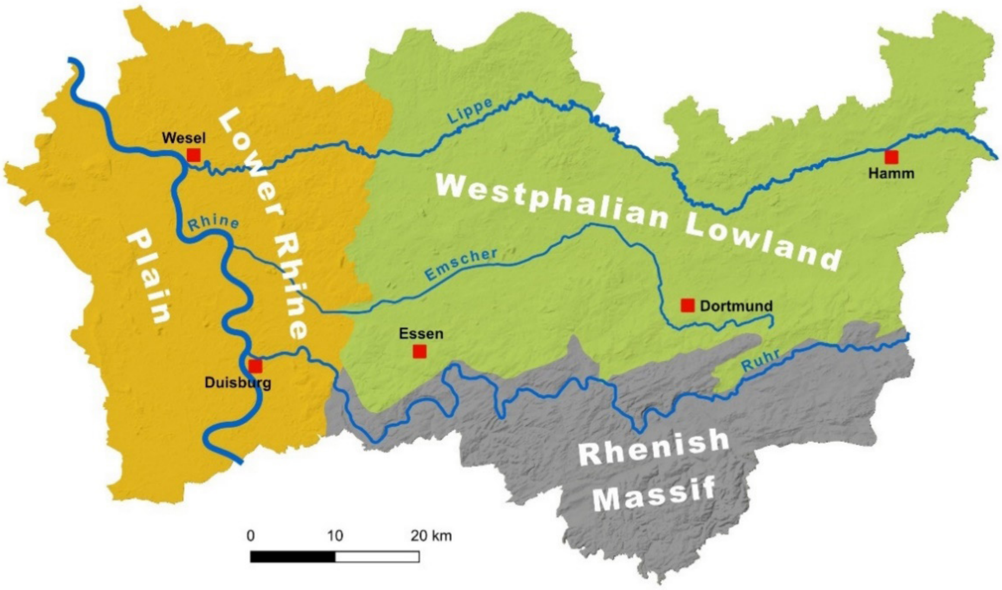

FIGURE 1. NATURAL REGIONS OF THE RUHR AREA GEOPARK

The southern part is characterized by moderate mountain ranges with the highest elevation of 441 m a.s.l. and deeply incised valleys. If not covered by settlements, most of the area is forested or in agricultural use.

The central part, the Emscher Valley Zone, forms a densely populated metropolitan area with limited stretches of open landscape. Nevertheless, in the view of the Geopark, this central area has great significance as it houses a good part of the industrial and mining heritage, as well as museums, universities and other institutions, which act as “secondary geosites”.

Towards the north this agglomeration leads over to the “Münsterland”, a hilly, predominantly rural area with dispersed settlements in a patched landscape of forests, fields and pastures. Its southern part is drained by the river Lippe, which flows into the river Rhine near the town of Wesel.

In the western part of the Geopark, the river Rhine flows through the broad Lower Rhine Plain. This plain is interrupted by a north-south directed chain of hills which are the remains of the terminal moraine of the Saale glaciation. These hills reach elevations of 80 m a.s.l., while within the Rhine Valley the lowest point of the Geopark is found at an elevation of just 13 m a.s.l. Despite the general impression of the Ruhr area as being an urban agglomeration, today only 34% of the area is occupied by settlements and industrial complexes, but 38 % of its area is in agricultural use, and nearly 19 % are forests.

Historically seen, the townscape of the Ruhr area is very young; 200 years ago, neither the term ‘Ruhrgebiet’ nor the structure existed. A few old, but small, towns were situated in the Ruhr Valley, using hydropower for mills and small-scale industries. The cities of Bochum, Essen and Dortmund grew up along an old trade route, called the “Hellweg”, leading from the Rhine eastwards to central Germany. Other than these urban developments, most of the area was remote – a rural, sparsely inhabited, agricultural landscape. The term ‘Ruhrgebiet’ itself came into use only in the 1930s.

The development of the Ruhr area in terms of industrialisation and population growth only started in the 19th century. Within a few decades, the rural area had developed into one of the largest urban agglomerations in Europe. In 1852 the Ruhr area was inhabited by some 375,000 people; in 1925 the number of inhabitants exceeded 3.8 million, and today the Ruhr area is home to some 5 million inhabitants. This development was initiated by the increasing use of coal, outcropping at surface in the Ruhr Valley. The discovery of iron and other metal ores then stimulated steel mills and metal works. Limestone and dolomite became important resources for metallurgical processes. Clays and mudstones, used to produce bricks, along with sandstones and other building materials found in the region, enabled the erection of housing areas and infrastructure. The use of salt springs and salt mining is another example of mineral production in the area, with a long history dating back to prehistoric times.

Therefore, the development and identity of the region are based on the occurrence and use of its natural resources. Few other landscapes in Europe demonstrate the connection between natural resources and the economic, socio-cultural development of humankind as clearly as the Ruhr area. Occurrences and distribution of mineral resources reflect the versatile geology of the area. The economic and environmental impacts of the mining industry today and in future are a main issue for the Geopark.

GEOLOGY

The Ruhr Area GeoPark represents nearly 400 million years of earth history. The three geographic units of the Ruhr area partly reflect three regions of different geological structure (Figure 2). However, they are linked by the existence of coal-bearing Carboniferous strata, which led to a similar economic and cultural development in all three parts of the area.

The southern part, belonging to the Rhenish Mountains, is built up by uppermost Early Devonian to Late Carboniferous (Pennsylvanian) strata. The succession begins with terrestrial and near-coast sediments of late Emsian and early Eifelian age, followed by fully marine deposits of Middle and Late Devonian age. The transgression of the Rhenohercynian Ocean can be traced by the evolution of reef complexes. Beginning with near-coastal only decimetres thick patch-reefs in the lower Givetian, the development ends with massive reef limestones of up to 1000 m in thickness, which are of high importance both economically and for the natural scenery.

Within the GeoPark one of the Auxiliary Global Stratotype Sections (GSS) for the boundary between the Devonian and the Carboniferous was defined, the Hasselbach section near Hagen. During the Dinantian a sea-level high stand led to the sedimentation of clastics in Kulm-facies within the Rhenohercynian Basin in the eastern part of the area. In the western part at that time a carbonate platform existed. During the Namurian a marine regression started, which in combination with the northward prograding Variscan Orogen finally led to a mostly paralic environment during the latest Mississippian and the Pennsylvanian. The "Subvariscan Basin" in the foreland of the orogen showed a strong subsidence; up to 3000 m of Namurian and 3500 m of Westfalian sediments were deposited, containing some 150 coal seams. They origin from forest swamps growing on a widespread, flat plain between the Variscan Orogen in the south and the open sea in the north. At the end of the Carboniferous the complete sedimentary sequence has been affected by the Variscan Orogeny. The folded and thrusted Carboniferous rocks locally are unconformably overlain by Early Permian conglomerates ("Menden Conglomerate", Figure 3).

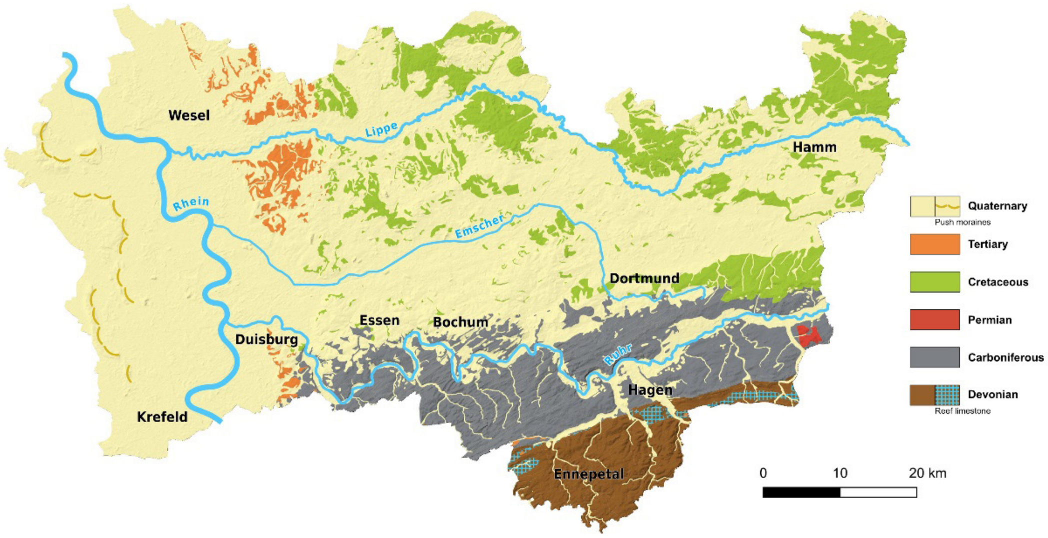

Figure 2. Geological map of the Ruhr Area GeoPark.

In the western part of the Geopark strata of Late Permian (Zechstein) age, including a mineable deposit of rock salt, to Early Cretaceous age are only known from underground exposures and boreholes, but not exposed on the surface. However, due to the intense mining and drilling activities, samples and fossils of all these strata have been collected and are on display in different museums and exhibitions. This western part of the Geopark is part of the Mid European Central Graben System. Thick unconsolidated sediments of Tertiary, Pleistocene, and Holocene age determine the regional geology on surface. The terminal moraines of the Saalian glaciers form a clear-cut ridge of hills. Sand and gravel deposits of the Rhine terraces are widespread and extracted on a large scale (Figure 4).

Figure 3. Early Permian conglomerate ("Menden Conglomerate")

In the north-eastern section of the Geopark, i.e. the southern part of the Münsterland Basin, a thick sequence of marine Late Cretaceous strata directly covers the Palaeozoic (Pennsylvanian) basement, beginning with the Cenomanian transgression. These cretaceous sediments, for their part, are widely concealed by glacial sediments of the Pleistocene.

Including the Triassic and lower Mesozoic strata, which are only known from underground exposures, a nearly complete sequence from the Devonian to the Holocene can be displayed in the Ruhr Area GeoPark. Surface geology covers the Palaeozoic from Early Devonian to Early Permian and most of the Late Cretaceous, Tertiary and Quaternary.

Nearly all types of sedimentary rocks are existent, many of them rich in fossil content. A few exposures additionally show volcanics of Devonian age. Volcanic ashes ("Tonsteins") have been observed in the Late Carboniferous strata. Tectonic structures such as folds, thrusts and faults are excellently exposed, as well as the unconformity between the folded Palaeozoic basement and the nearly flat lying post-Variscan strata. Coal-mining activities extended over most of the area, reaching depths of more than 1.500 m and are documented in great detail. Therefore, the geological structure is well known, enabling to create a 3-D-model of the folded basement.

Figure 4. Gravel extraction in the Lower Rhine Plain formed numerous artificial lakes

GEOSITES

Including the Triassic and lower Mesozoic strata, which are only known from underground exposures, a nearly complete sequence from the Devonian to the Holocene can be displayed in the Ruhr Area GeoPark. Surface geology covers the Palaeozoic from Early Devonian to Early Permian and most of the Late Cretaceous, Tertiary and Quaternary.

According to the Geotope Inventory of GD NRW, there are 438 registered geotopes within the Ruhr Area GeoPark. All of them have at least some scientific or documental relevance. Additionally, far more than hundred caves (of all sizes) are documented within in the Cave Inventory of North Rhine-Westphalia's Cavers Association, three of them open to the public as show caves.

Among the listed geosites, several are of outstanding national, European or global value. Five of the geosites have been officially honoured as "National Geotopes" by the German Academy of Geosciences: The "Felsenmeer" in Hemer, the "Vorhalle Quarry" in Hagen, the "Muttental" in Witten, the "Geological Garden" in Bochum, and the Klutert Cave in Ennepetal.

The "Felsenmeer" ("rock sea") is a unique combination of karst phenomena and historic mining relicts. Within a loess covered peneplain the surface of the mid-Devonian reef limestones was exhumated over an area of 10 hectares. The limestone was strongly affected by karstification during the warm periods of the Tertiary. It resulted in a remarkable cone karst landscape near the surface and extended cave systems underground, stretching over several kilometres of galleries. "Heinrichshöhle", one of the show-caves of the Geopark, is part of these systems. This cave is well known for the findings of thousands of relicts of Pleistocene mammals, mainly of cave bears. Portions of the limestone and the clayey cave-fillings have been mineralised by iron ores in minable concentrations. Mining activities can be proved from the 10th century until the year 1871. The early miners used the natural cavities in the limestone as shafts and transport routes, thus creating a bizarre system of irregular galleries. The Felsenmeer is an important touristic site and in 2010 it was incorporated in the concept of the State Gardening Fair, which took place in a neighbouring area. This provided an opportunity to install new paths and a pedestrian bridge now spans the canyon-like depression of the Felsenmeer, providing excellent views (Figure 5).

Figure 5. The "Felsenmeer" in Hemer

The "Vorhalle Quarry" near Hagen exposes strata of Namurian B age (Carboniferous, lower part of the Silesian). The clays (originally used for brick production) and sandstone layers have been deposited in a marine environment, probably in a river estuary very close to the coast. Thus, marine fossils (e.g., Goniatites) and terrestric fossils (e.g., plants) can be found in the same beds. Findings of arthropods, mainly insects, make the quarry unique in the world. Several hundred specimens, belonging to more than 20 species have been excavated here – many of them excellently preserved. The winged species found here are among the oldest examples worldwide. They show remarkable sizes with wingspans up to 30 cm. Palaeontological excavations were carried out mainly by the Westphalian Museum of Natural History in Münster. However, some representative findings are on display in the nearby Werdringen Castle Museum.

Besides their outstanding value for palaeontology, the intensively folded rocks in the "Vorhalle Quarry" are also important for tectonics. Fold and thrust structures visible here give insight into the mechanics of orogenic processes to scientists, but they are also impressive to the layman.

In the "Muttental" ("Mutten-Valley") near Witten coal seams crop out on surface. Thus, it is estimated to be one of the cradles of coal mining in the Ruhr area. Today, this valley, a southern tributary to the Ruhr, is part of a larger recreation area. It is difficult to imagine that this sylvan, hilly area, with its clear flowing streams and wide scenic views over the Ruhr Valley, only a few decades ago, was a busy industrial region. However, dozens of original or reconstructed mining heritage relicts, explained by information panels, can be found along a 9-km heritage trail and are witnesses of some 450 years of mining history. The "Dünkelberg Quarry", formerly used to extract clay stones for brick production, excellently exposes the coal-bearing strata and visualizes the different environments of the Carboniferous coastal plain (Figure 6). The Nightingale Mine, dating back to the 18th century, is an important object of industrial heritage. Today it is part of the Westphalian Museum of Industry, but also houses one of the Geopark´s information centres. Authentic underground workings of the coal-mine are open to the public. The kilns of the "Dünkelberg brickworks", which were operated until the 1950s, and an abandoned sandstone quarry on the same site demonstrate the diversity of resources found within the area. Muttental and Nightingale Mine are regional touristic hot spots. They are crossed by hiking trails (among them the "GeoRoute Ruhr" [3]) and the supra-regional bike route "Ruhrtalradweg". They are also easily accessible by excursion boats on the river Ruhr and by the Ruhr Valley heritage railway line.

Figure 6. The "Dünkelberg Quarry" in the "Muttental" exposes coal-bearing Carboniferous strata

The "Geological Garden" in Bochum is probably one of the best exposures of the Variscan unconformity in Europe. It is a textbook example of nearly horizontally bedded strata of the Createaceous (Cenomanium, Essen Grünsand member) overlaying a tilted sequence of Carboniferous rocks (Figure 7), including coal seams, a layer of black band iron ore, and a marine horizon. The Geological Garden, originally a quarry, is one of the first examples of a legally protected geosite in Germany. Today, the outcrops form part of a public park and are maintained by the Bochum town administration. A free guidebook is available.

The Klutert Cave in Ennepetal is Germany´s largest show cave (Figure 8). Its nearly 6 km of galleries are developed in reef limestone within the Honsel Beds of Middle Devonian (Givetian) age. At that time, isolated patch reefs grew on the sea floor. Some of them are well exposed in and around the town of Ennepetal. The near-by geosite "Zuckerberg Quarry" displays a complete section of a patch reef, but also documents early quarrying activities. Per archaeological evidence they date back to the 13th century. The reef limestones, rather limited in extension and surrounded by more or less permeable clastics, are intensively affected by karstification. A great number of caves make Ennepetal the "Cave Capital of Germany". However, what makes the Klutert Cave unique is the exposure of reef organisms in the walls of the cave galleries. Stromatopores, corals and other inhabitants of the reef, many of them still in situ, cover large areas throughout the cave [4]. Since the rock faces have been cleaned in the last years, the visitor literally gets the impression of walking through a Devonian biotope. Klutert Cave probably displays one of the best-preserved Palaeozoic reefs in Europe. Thus, the cave is not only important for the public under touristic aspects, but also for (palaeo-)biological information and scientific research. It has been recognised as one of the first National Nature Monuments in Germany according to the Federal Nature Protection Law.

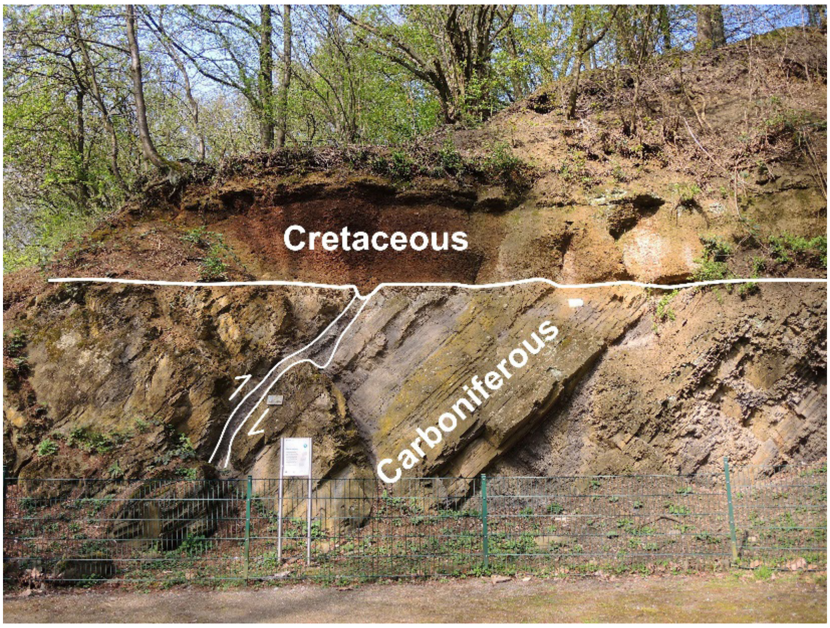

Figure 7. "Geological Garden" in Bochum: Unconformity between Carboniferous and Cretaceous with a thrust fault within the Carboniferous strata

Figure 8. The Klutert Cave in Ennepetal formed in Devonian reef limestone

An abandoned small quarry in Bochum-Stiepel exposes the "Finefrau-Sandstone", a fluviatile sandstone of lower Westfalian A age. In 2012, using a field-guide published by the Geopark, a family discovered structures on a bedding plane, resembling a tetrapod track, unknown at the time. They reported their discovery to the Geopark, which organized a scientific investigation. This resulted in the identification of several footprints of a tetrapod animal, left in the muddy sediments of the fossil riverbank. Only three tetrapod tracks were known from the Ruhr Carboniferous up until then, all in younger parts of the sequence. In fact, with its Lower Westfalian A age, the Bochum track finally proved to be one of the oldest in Europe.

Geological exposures in unconsolidated rocks rise a general problem of geoconservation. When the rock face itself is not the focus, but rather e.g., paleontological or mineralogical features, it may be that the better long-term solution is their recovery, conservation and display in a museum. Some of the sand and gravel layers of the Emscher Valley in the central part of the Geopark are well known for their rich content of relicts of Pleistocene mammals. Literally thousands of them were detected during construction works in the Rhine-Herne-Canal between 1956 and 1975 and were systematically collected in the "Museum für Ur- und Orts-geschichte Quadrat" (Museum for pre-history and local history) in Bottrop. The most spectacular findings are on display in a special pavilion at the museum.

Marine sands and clays of Tertiary age are exposed in several pits near Schermbeck and Kirchhellen. Some of these pits provided fossils, among them skeletons of manatees, today kept in the Bottrop Museum of Pre-historic and Local History.

A long chain of hills within the far-spread flat area of the Rhine Lowlands marks the western border of the Geopark. These hills were formed as glacitectonic push moraines when the glaciers during the Saale period of the Pleistocene reached their furthest extension ca. 150.000 years ago. This chain of hills is an important geomorphic landmark, determining the maximum extent of glaciation within Central Europe. To the west of these hills, meltwater sediments of the sandur are extracted in several pits. Other gravel and clay pits within the moraine expose its forged internal structure but are imperilled by erosion and weathering. Eastwards of the hills, tills and erratic blocs are relicts of the ground moraine deposited below the glacier. Near the village of Sonsbeck a heritage trail and a collection of erratic blocs explain the landforms of the hills of "Sonsbeck Switzerland" to visitors (Figure 9). Another collection of erratic blocs, collected over years in a near-by gravel pit, is on display near a popular restaurant destination on the terminal moraine "Hüls Hill" near Krefeld, where the GeoPark established a geotrail in 2023.

Figure 9. The hills of this terminal moraine in "Sonsbeck Switzerland" tower 50 m above the Lower Rhine Plain

Mining Activities and Heritage

The geological sequence of the Ruhr area contains numerous raw materials of economic value. Carboniferous hard coal was by far the most important, but not the only, valuable natural resource which gave rise to economic development. Probably hard coal was already used in Roman times, but the first documented mining activities date from the 14th century. With the closing of the Prosper-Haniel Mine in Bottrop in 2018 the history of hard coal mining in Germany came to an end. Within the last 200 years of industrial coal mining some 9 billion tons of coal have been exploited.

The use of iron ore is archaeologically documented since the 3rd century AD. Rich reserves of sedimentary iron ores and non-ferrous metal ores, mainly found in veins in the Palaeozoic rocks, during the times of industrialisation played a significant role until the 1950s. The north-eastern part of the Ruhr area and the adjacent part of the Münsterland are the only places in the world, where the mineral strontianite has been mined economically, used in a sugar refining process exercised in the past. One of the biggest salt mines in Germany is in the Ruhr area, exploiting Late Permian rock salt in the Lower Rhine area. Starting in prehistoric times, saline brines were used in salt works in the north-eastern part of the Geopark. There are large valuable reserves of limestone and dolomite, of great importance for supply to the building industry and the iron works of the area. Devonian and Carboniferous sandstones are quarried along the Ruhr Valley (Figure 10).

Figure 10. This former sandstone quarry in the Ruhr Valley is an important geosite to demonstrate the geology of the coal-bearing Carboniferous ("Wartenberg Quarry", Witten)

Other raw materials, for example Tertiary clay used to produce bricks, play an important role in the development of housing areas and infrastructure. Sand and gravel are found and used in huge quantities in the Rhine Lowlands. Moreover, ground-water plays an important role in the supply for people and industry, and natural gas is extracted from the coal-bearing strata. All together nearly twenty different raw materials have been used economically in the area of the Geopark over time. This richness in different mineral resources with a well-documented mining history and a wealth of authentic mining locations is the unique feature of the Geopark.

It's highly versatile geology, the large number of excellent exposures, and the intense mining activities underground and on the surface over centuries, has made the Ruhr area one of the geologically best surveyed areas in Germany and Europe. Even today, some 30 enterprises still use the raw materials of the area demonstrating their unbroken importance for the regional economy. Therefore, the slogan "Geospotting: Man and Mineral Resources from exploitation to responsible use" exactly describes the situation of the Geopark.

Numerous relicts of mining heritage are to be found in the southern part of the Geopark. Some of them, namely the UNESCO World Heritage Site "Zeche Zollverein" in Essen (Figure 11), or the Zollern-Mine in Dortmund are of outstanding architectonic value. Others may be regarded as being of less importance. Collectively, however, they give evidence of one of the largest historic coal mining districts in the world. Moreover, these sites have a great importance for the local people and their identification with mining heritage and the Geopark.

Figure 11. UNESCO World Heritage „Zeche Zollverein" in Essen

Three visitor´s mines are open to the public:

“Graf Wittekind-Mine” near Dortmund is a historic mine, operated between the 16th and the end of the 19th century. Its mine galleries have been excavated and restored by a group of volunteers during the last decade.

“Nightingale Mine” near Witten is part of a historic industrial complex including a 19th century mine, brick works from the first half of the 20th century and old sandstone quarries.

“Stock- und Scherenberger Erbstollen” in Sprockhövel is part of a drainage tunnel system, already laid out in the 18th century for the dewatering of neighbouring coalmines.

The German Mining Museum in Bochum is operating a show-mine, while the Ruhr-Museum in Essen or the Nature Museum in Dortmund exhibit large geological collections.

Geopark Activities

The working programme of the Geopark includes geotope conversation and the installation of information panels on geosites. Several geotrails have been marked in the field, among them the long-distance trails “Georoute Ruhr” and “Georoute Lippe” designed for hikers or cyclists. The numerous publications of the Geopark aim at a wide range of readers: From children´s books to scientific papers. The Geopark regularly organises field trips, public lectures, and scientific congresses. It cooperates with schools, universities and museums. Twice a year the Geopark publishes a magazine for its members and friends.

Classic tourism does not play a primary role in the Ruhr area, but there is a great demand for local recreation facilities. The large number of inhabitants, many of them with family roots in the mining industry, form a large target group for geo-educational programs. A public poll in 2023 proved a great interest in topics like mining history, fossils, show caves or mine visits [5]. In the Ruhr area they can easily combined with outdoor activities like hiking, cycling, or canoeing on the River Ruhr. Likewise, it is possible to combine these activities with all the facilities offered by the vibrant metropolitan area.

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INTERNATIONAL POST-MINING SYMPOSIUM
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Corporate Social Responsibility and Social Closure in Mining Operations: The Case of Çayeli Copper Mines

Dr. Melik Zafer YILDIZ Osman Zeki Yazıcı

Introduction

One of the fundamental components of sustainable mining activities is comprehensive closure planning, which is implemented when the mine reaches the end of its operational life. This planning encompasses not only physical and environmental dimensions but also the social dimension, which aims to manage the potential negative impacts of the cessation of mining activities on the region's socio-economy (Van Zyl, D. 2006).

Located in the village of Madenli in the Çayeli district of Rize-Türkiye and owned by First Quantum, Çayeli Copper Operations (CBI) is already implementing corporate social responsibility (CSR) approaches for the social closure process during its ongoing production activities. Having started operations as an underground mine in 1994, producing copper and zinc concentrates, and ranking among Turkey's top 100 companies in terms of tax payments for many years, CBI's strategies for managing the social dimension of closure form the focus of this study.

Methodology and Social Management Structure

CBI's social closure strategy is based on social development projects implemented throughout its operational period, aiming for sustainability even after the cessation of mining activities. A multi-stakeholder approach has been adopted in managing this process. These include:

1- Social Funds Committee (SFC)

The Social Funds Committee (SFC) was established to identify and support social projects. This committee consists of nine members who make decisions by majority vote. The committee members include representatives from Çayeli Copper Mine, the district governor's office, Madenli Municipality, local NGOs, village heads, women's and youth organizations, as well as representatives from educational institutions. ÇBİ supports the committee's activities with financial and in-kind support.

2- Community Advisory Board (CAB)

A Community Advisory Board (CAB) has been serving SFC since 2010. The CAB encompasses a broader range of stakeholders than the SFC, comprising university representatives, the district governor's office, the municipality, village heads, employees, businesspeople operating in the region, NGOs, and representatives from educational and healthcare institutions. The functionality of SFC and CAB has been ensured by the legitimacy of multi-stakeholder governance structures, as advocated by Freeman (1984). A system consistent with Hilson's (2016) view, which emphasizes the importance of local community participation in decision-making processes in the mining sector and transparency in governance, also exists in CBI.

3- Social Closure-Focused Social Development Projects

The foundation of the company's social closure plan consists of projects focused on the regional economy, employment, and the development of local community skills. These are:

3.1. Local Employment and Professional Development

Within the framework of CBI's social policies, priority is given to local employment. Under the Basic Mining Training program, 193 people have been awarded Vocational Competence Certificates to date, following the launch of training programs in 2010. Forty-seven percent of those who completed these training programs have been directly employed by CBI.

As mentioned above, the Community Advisory Board was established in 2010 to promote sustainable mining practices, thereby fostering the development of relationships with stakeholders through effective communication and collaboration. The Basic Mining Training Program (BMT), developed at the suggestion of a committee comprising external stakeholders of the mine, has evolved into a project aimed at increasing local employment and developing local professional capacity by establishing links between CBI and other partners. This program, which offers theoretical and practical training opportunities to the regional workforce, has enhanced the professional qualifications of the local workforce and facilitated the development of competencies in various fields of work beyond mining.

The BMT program has provided its participants with extensive job opportunities and a competitive edge in the labor market, with a focus on the mining sector. The training covers various topics, including underground mining, the use of heavy machinery (mixer and drilling machine), platform operation, safety procedures, and first aid. Excluding the disruptions experienced during the pandemic in 2020 and 2021, the program returned to its previous active status in 2023 with 26 participants. To date, 193 participants have successfully completed the program, and a total of 704 training certificates have been issued in various subjects.

The essence of the program is to integrate unskilled/semi-skilled labor into the workforce by providing them with professional skills through a structured training process tailored to their abilities. To this end, the eight-month program, comprising theoretical and practical training, aims to enhance the employability of the young population and reduce the need for specialized workers in hazardous industries. During this process, participants have the opportunity to reinforce their theoretical knowledge with practical experience by taking advantage of hands-on training opportunities in real working environments at the CBI site. All participants are insured during the training process and receive regular wages (for most of them, this is their first time earning a salary). This financial support provided during the training encourages participants in their career development process.

At the end of the training, participants who successfully pass the exams administered by the Community Education Center can obtain certificates approved by the Vocational Competency Authority, thereby documenting their professional competence. The program not only provided participants with the opportunity to develop their technical skills, but also helped them gain insights that would enhance their job interview performance by developing their social skills through resume (CV) preparation and interview technique workshops.

The BMT program has made a significant contribution to strengthening local employment by creating job opportunities not only in the mining sector but also in various other sectors, thereby substantially supporting the socio-economic development of the local community. As of 2024, the employment status of participants who completed the program is being tracked. Of the 193 participants, 47% have started working in the mining sector, 18% in different mining sites, and 23% in other sectors. The remaining 12% continue to seek employment in the job market as skilled workers.

3.2. Sustainable Livelihoods

Beekeeping Project: Launched in 2014, the project continues its activities with increased capacity thanks to the cooperative established in 2017. From the program's inception until 2022, ÇBİ provided $237,000 in support to the project. Starting in 2023, ÇBİ will no longer provide cash support to the project.

The Beekeeping Development Project (BDP) is one of the essential development investments supported by the CBI since 2014, aiming to contribute to local sustainable economic development. This project began in 2014 with an investigation into complaints from the local community in the mine's area of influence regarding bee deaths. During the study, it was understood that bee deaths were caused by producers' incorrect agricultural practices. Subsequently, the project decision was made to revive the region's long-standing beekeeping tradition using correct production techniques. Before the project, honey production was the preferred option in the region. However, with the project, the production of products such as propolis and bee cake, which are labor-intensive but have high added value, has also become widespread.

In the early years of the project, the hives were provided by the cooperative. Under the guidance of a full-time beekeeping expert employed by CBI, the cooperative's continuity was ensured, and production efficiency was increased by adopting sustainable production methods in place of outdated practices.

Revitalization efforts were initiated under the leadership of the beekeeping expert, thereby increasing the efficiency of beekeeping activities. In the first phase, 90 beekeepers were provided with 650 Caucasian bee colonies, specifically adapted to the region, and wooden hives. By the end of the first season, bee colony losses were reduced from 51% to 2%.

Since the project's inception, the total support provided by the CBI has been $237,000; this amount has been gradually reduced due to the project's positive outcomes. In 2022, with only $1,000 in support, beekeepers generated $112,000 in revenue. In 2023, US$83,000 in revenue was generated without the need for any financial support. A similar trend continues in 2024. For the past three years, the project has been sustained without any financial contribution from the CBI, thanks to the extraordinary ownership of the participants.

Expert support is critical for the professionalization and continuity of the cooperative's activities. Additionally, various forms of support are provided, including propolis production and the distribution of bee cakes. A co-financing contribution of 36,000 euros has also been provided from the Agricultural and Rural Development Support Agency projects.

Honey production, which initially stood at approximately 2.5 tons, has now exceeded 8 tons. The cooperative's product offerings have expanded annually, enhancing its effectiveness and helping to meet the region's growing demand for beekeeping products. Before the project, the region only produced honey, but thanks to the support and training provided, the cooperative now also produces queen bees, bee cakes, pollen, propolis, and beeswax. This diversity has increased the economic value of beekeeping, creating additional sources of income for producers and ensuring the project's sustainability.

Beekeeping, which is easy to implement and represents an ancient culture, is a widespread agricultural activity in the region. However, the production of labor-intensive products such as propolis and bee cakes remains limited. In collaboration with the Büyükdere Valley Agricultural Development Cooperative, Madenli Municipality, and Public Education Centers, 296 beekeepers participated in training provided by a CBİ beekeeping expert and earned a Public Education Center-approved beekeeping certificate. With support and guidance, including the provision of bee cakes, cooperative members are continuing their beekeeping activities in a more professional manner. The cooperative has had positive effects, including reducing bee mortality rates and lowering input costs.

The Women Empowerment Project was launched with a similar approach. Starting in 2016, Workshops in Glass Processing, Copper Processing, Sewing, and Rize Cloth Work were established, benefiting 1,000 women to date.

The Beekeeping and Women's Empowerment projects are becoming autonomous structures that support the economic sustainability of the region. This situation coincides with the explanation of Porter and Kramer (2006), who argue that CSR is not only philanthropy but also a means of creating competitive advantage and shared value.

3. Land Use and Diversification

Under Post-Mining Land Use, the mining land is planned to be utilized for tourism and agriculture following the closure process. According to this plan, an underground hotel, a recreation area, a botanical garden, and orchards featuring citrus, walnut, and chestnut trees are planned to be established. This situation parallels Jenkins' (2004) approach, which emphasizes the importance of post-mining economic diversification projects addressing CSR practices in the mining sector.

Discussion and Conclusion

CBI's social closure approach represents a proactive CSR model designed to minimize the social risks of mine closure and maximize development opportunities. The company's focus on local needs through its multi-stakeholder committees (SFC and CAB) and its phased withdrawal of financial support by supporting self-sufficient economic cooperatives, as in the Beekeeping Project, demonstrates a strong commitment to the sustainability of the projects. This model presents a valuable case study for other actors in the mining industry, illustrating that social closure is not only a requirement but also an investment opportunity that contributes to long-term local development.

CBİ's Post-Closure Sustainability process draws its scientific inspiration from Laurance's (2015) approach, which focuses on post-mining land rehabilitation and the integration of post-closure economic activities, supporting land use plans (Tourism/Agriculture).

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YENİKÖY KEMERKÖY ENERGY "A BREATH FOR THE FUTURE" FORMER MINE SITE CLOSURE AND REHABILITATION WORKS

Burak Işık,
Deputy General Manager of Yeniköy Kemerköy Inc.

The establishment purpose of the Yeniköy Lignite Enterprise (YLİ), which is a branch of the General Directorate of the Turkish Coal Enterprises (TKI), is the production of low-calorific lignite reserves located around the villages of Sekköy, İkizköy, Karaağaç, and Hüsamlar, to be burned for energy generation at the Yeniköy and Kemerköy Thermal Power Plants, and to supply the heating coal required by the local region. The Yeniköy Thermal Power Plant, with a capacity of 2x210 MW, became operational on September 24, 1986, and the Kemerköy Power Plant, with a capacity of 3x210 MW, began operation in 1993. The YLİ (Yeniköy Lignite Enterprise), established on January 1, 1984, to meet the fuel needs of these power plants and the surrounding region, operated under the South Aegean Lignite Enterprises (GELİ) until December 31, 1993. Starting from January 1, 1994, it was connected to the TKI General Directorate as the Yeniköy Lignite Enterprise Directorate. The Enterprise was then converted into the Yeniköy Enterprise Regional Directorate on September 1, 1995. Since April 1, 2004, it continued its operations as an Enterprise Directorate affiliated with the GELİ Directorate, and in 2014, it was transferred to the private sector with the 5th largest privatization in the history of the Republic.

The Yeniköy Kemerköy Power Plants have a total capacity of 1,095 MW. They provide 15 percent of the domestic base-load power and meet an average of 2.58 percent of Turkey's electricity needs. Furthermore, they cover approximately 64 percent of the electricity used in the Southern Aegean region.

The concept of rehabilitating the lignite mining areas—from which the lignite coal used for energy generation for many years is extracted—under the management of Yeniköy Kemerköy Electricity Generation and Trade Inc., located in Milas/Ören, is seen as an extremely rational approach in terms of forestry ecology and policy.

A NATURE RESTORATION STORY: HÜSAMLAR YENİDEN

Mining is an indispensable field for the advancement and development of humankind. However, the environmental effects of these activities have been debated for many years, sometimes criticized, and occasionally stigmatized by false perceptions. Today, as Yeniköy Kemerköy Energy, I would like to talk to you about a project that aims to break down these perceptions and repay our debt to nature:

"Hüsamlar Yeniden – Former Mine Site Rehabilitation"

We are Repaying Our Debt to Nature

During mining activities, we temporarily borrow a part of nature. However, it is possible to restore this borrowed area to nature with the right approach. With this understanding, we have embarked on a massive transformation project across a 511-hectare area in the village of Hüsamlar, which was expropriated for coal mining 40 years ago. That is an area the size of exactly 715 football fields. Hüsamlar Yeniden is one of the largest nature restoration projects, not only for Yeniköy Kemerköy Energy but also in the history of the Republic.

When initiating the project, we placed great importance on collaboration. With the scientific guidance of Assoc. Prof. Dr. Sultan Gündüz, we examined every detail, from the region's soil structure to its climatic features. The pilot application we started in November 2023 was only the beginning. In this 65-hectare area, we brought approximately 145,000 plants and trees together with the soil. Before commencing the work in 2023, we planned the process considering factors such as soil characteristics, plant sociology, and the precipitation regime. By the end of the first year, while our planting success rate across all areas reached a high average of **80 percent**, in some regions, it went up to **96 percent**. These results were made possible by controlling every stage of the process through accurate planning. The tree planting season is as short as three months. It is essential to utilize this period in the most effective way. This is why we believe that the success of nature restoration works is rooted in correct planning.

Transparency has been an indispensable principle for us throughout the nature restoration process. By collaborating with the Turkish Nature Protection Society (TTKD), we ensured that our rehabilitation process was independently monitored and that the findings were reported to the public. This collaboration not only provided public trust but also offered us the opportunity to continuously improve our process. With a new agreement signed on November 11, 2024, we extended this monitoring and reporting process for another year.

What we have achieved in Hüsamlar shows that responsible mining is not just a slogan. This project is a symbol of our commitment to the environment, the community, and our future. However, we must not stop here. The success we have achieved in Hüsamlar will also serve as a model for similar projects. Environmental awareness should not just be a company policy, but a priority for all of us.

Rehabilitation is Not Just Afforestation

"Hüsamlar Yeniden" is much more than a simple afforestation project. Our goal is to create an ecosystem in Hüsamlar. Within the scope of the project, in addition to trees, plants, and ponds, we will also construct social facilities such as an amphitheater, walking paths, and picnic areas. Furthermore, we will give the project symbolic meaning by planting a **600-year-old monumental olive tree**, a symbol of Milas, at the center of the rehabilitation area.

Our project gains strength through partnerships

It is not possible to execute a project of this magnitude solely through our own efforts. The Turkish Nature Protection Society (TTKD) is with us in the field for monitoring and reporting tasks. The closure plan prepared by Dokuz Eylül University was strengthened with the support of valuable academic institutions like Istanbul Technical University and Ankara University. Furthermore, the ideas and participation of the local community played a critical role in the success of our project. In our meetings with the local residents, we determined the plant species to be used in the rehabilitation based on their suggestions. In this way, we created a plan that is both suitable for the regional environment and will contribute to the livelihoods of the local people.

With "Hüsamlar Yeniden", We Have Lit a Light for the Future

The "*Hüsamlar Yeniden* (Hüsamlar Renewed)" project is not a task for us, but a responsibility. We aim to complete the planting of 300,000 plants by the end of 2025 and to rehabilitate a total area of 1,363 hectares by 2032. Through this project, we aim to go beyond merely restoring former mine sites to nature and to realize a pioneering effort in post-mining environmental improvements in Turkey with the exemplary rehabilitation work we will implement.

During our pilot application, we observed that bird species not seen in the region for a long time have returned to the ponds in the mine site. This natural activity demonstrates nature's power to regenerate and how much the right human intervention can accelerate the process. We plan to establish a bird-watching center to examine these observations more closely. We are leaving a beautiful legacy for future generations

As Yeniköy Kemerköy Energy, we are thinking not only of our region's present but also of its future. By the year 2040, we aim for these restored areas—which the people of Milas will also be able to benefit from—to fully achieve the appearance of a forest and to leave behind a legacy for the future. This project is being carried out with an approach based on understanding and respecting the dynamics of nature. Every piece of work we do in the field helps nature continue its own cycle.

"Hüsamlar Yeniden" is not just a project for us; it is a philosophy.

On this journey to restore nature, create a sustainable future, and repay our debt to the environment, we are taking every step with great care. This project will serve as an example of nature conservation awareness and will be an inspiration for future generations.

It is our responsibility to return what we borrow from nature in a stronger state. As Yeniköy Kemerköy Energy, we are proud to fulfill this responsibility through the "Hüsamlar Yeniden" project.

Burak Işık *brings over 20 years of leadership experience in sustainability and investment management. He currently serves as Deputy General Manager at Yeniköy Kemerköy Elektrik Üretim ve Ticaret A.Ş., where he leads the company's ESG strategy, corporate communications, and governance initiatives. He holds a degree in Engineering from Middle East Technical University (METU) and an MBA from Koç University. In addition, he completed executive education in sustainability leadership at the Harvard T.H. Chan School of Public Health.*

Zollverein UNESCO World Heritage Site as a Place for Encounters

Meltem Küçükyılmaz

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Abstract

My world heritage? Would it be imaginable to be a place for everyone? How will it be possible to win over the people of the neighborhoods and involve them in the transformation process of Zeche Zollverein?

As everyone knows, Zollverein has always been a place where history was written. First, as a technical marvel and the most efficient coal mine in the world. Then, as an industrial monument and architectural jewel, which was declared a UNESCO World Heritage Site in 2001, and finally as the epitome of structural change in the Ruhr region. Today, the Zollverein World Heritage Site is a future and transformation location where the raw materials of the 21st century are mined: Ideas, innovation, knowledge, and creativity.

So, how can the transformation process of such a place like Zollverein be successful? Through more acceptance and consent from the people living there?

The transformation can only succeed on the premise of participation and only if everyone involved recognizes diversity as an opportunity and difference as a prerequisite for productive social coexistence.

This is also the intention of the "Zollverein - The Neighbourhood" project, which is an invitation to the people of Katernberg, Stoppenberg, and Schonnebeck to contribute their experiences, wishes and ideas and to shape a living World Heritage Site together.

As a place of encounter and cooperation, Zollverein takes up impulses from the districts and realizes free offers for children, young people, and adults to open up the World Heritage Site as a creative place.

The tasks and goals of this project are:

- a platform for participation and exchange
- a network for projects and local communities
- a platform for cooperation and togetherness

"Zollverein - The Neighbourhood" project works to break down barriers. Therefore, it depends on a large extent on the quality of its relationships, appreciative exchange, and good contacts, especially with cooperation partners, also with the Ruhr Museum, among others. Thanks to this cooperation, it was possible to build a bridge between the two institutes and open both the Zollverein and the Ruhr Museum to the outside world and to change the visitor profile.

According to UNESCO, cultural and natural heritage sites do not belong only to the state where they are located, but to humanity as a whole. Exactly in this spirit Zollverein defines itself as a field of encounters and attaches great importance to sustainable relationships with its neighbours.

Keywords: Zeche Zollverein, world heritage site, transformation, neighbourhood, diversity, participation

Meltem Küçükyılmaz
is a cultural scientist and diversity manager at the Ruhr Museum in Essen, Germany, where she develops inclusive strategies to make cultural heritage accessible and meaningful for diverse audiences. Her work focuses on industrial and post-industrial heritage as platforms for dialogue, participation, and intercultural exchange. By integrating themes such as migration, identity, and social inclusion into exhibitions and programs, she strengthens the museum's role as a place of encounter and shared experience. In her presentation "Zollverein UNESCO World Heritage Site as a Place for Encounters," she emphasizes the site's potential not only as a preserved industrial monument but also as a living cultural space connecting history with contemporary discussions on diversity and community.

The Ruhr Museum – Memory and Showcase of the Ruhr Metropolis

Achim G. Reisdorf

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Abstract
The Ruhr Museum in Essen is a regional museum on the nature, culture and history of the so-called Ruhr metropolis. It is located on the Zollverein UNESCO World Heritage Site, once the largest coal mine in Europe, in the spectacular building of the former coal washing plant. With its 120-year history, the Ruhr Museum does not define itself as a classic industrial museum, but rather as the memory and showcase of the Ruhr metropolis. The Ruhr Museum has extensive collections of natural history, archaeology, numismatics, history and photography. Among the outstanding components of its natural history collections are objects of the Krupp Collection and the former Fuhlrott Museum in Wuppertal. All of these collections are available to the scientific community for research purposes. The Ruhr Museum also has several outposts, e.g. the Central Storage Facility and Schaudepot, the Mineral Museum Essen and a pre-industrial ironworks and forge (Hallbachhammer). Last but not least, the regional museum works closely with the GeoPark Ruhrgebiet. As a result of this cooperation, the opening of a Geopark Information Center in the Ruhr Museum is planned for the end of 2024.

As a multi-discipline museum, the Ruhr Museum presents the entire natural and cultural history of the Ruhr region, whose origins are inextricably linked to its natural mineral raw materials, bog iron and hard coal, on 5000 m^2 of the permanent exhibition area and 1000 m^2 of space for special exhibitions. Since the 18th century, the geological conditions for the formation of these raw materials, their mining and processing have led to an unprecedented industrialization of an agricultural region that existed for centuries on glacial loess soils and resulted in a mining and industrial region with a metropolitan character, the landscape of which is now largely anthropogenic. Coal mining at the Zollverein colliery ended in 1986, and Germany's last coal mine closed in 2018. The accompanying and still ongoing structural change, namely the new post-mining period of the Ruhr metropolis, is given a great amount of space in the Ruhr Museum, as are its protagonists - e.g. local miners and miners from Poland and Zonguldak (Turkey).

Keywords: Ruhr Museum, Ruhr region, regional museum, nature, culture, history

Dr. Achim G. Reisdorf *is a geologist and curator of the Natural History Collections at the Ruhr Museum in Essen, Germany. His professional focus lies in the curation, research, and presentation of geological and natural history materials that document the evolution of the Ruhr region within both local and global contexts. As curator, he develops exhibitions and research projects that highlight the scientific and cultural significance of natural history collections, linking them to the industrial and cultural heritage of the Ruhr Metropolis. Through his interdisciplinary approach, he integrates geology with broader historical and societal narratives, making the museum a bridge between science, heritage, and public engagement. In his presentation "The Ruhr Museum Essen – Memory and Showcase of the Ruhr Metropolis," he explores how the museum functions as both a scientific archive and a cultural landmark.*

INTERNATIONAL POST-MINING SYMPOSIUM
22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Restructuring of the Territorium after Uranium Mining. The Case of Moravia

Milada Šťastná*, Antonín Vaishar

ABSTRACT

Under the previous regime, uranium mining was a strategic priority. However, in the present day, it is no longer financially feasible. This has resulted in the cessation of mining activities and a gradual decline in related operations. Addressing landscape restoration is essential, but it's equally crucial to consider the societal impact. Former uranium industry workers are accustomed to high wages, determined not by their skills, but by the risks associated with their jobs. This makes restructuring particularly challenging. Given the region's characteristics, a shift towards tourism is possible, although it may not align with the skills and mindset of the local workforce.

Keywords: uranium mining, post-mining landscape, social restructuring, Czechia

Introduction

In 1898, Marie Curie-Skłodowska discovered radium from uranium ore in the Czech town Jáchymov. Initially, radium was mainly used in the health sector. Uranium ore mining developed after World War II in connection with nuclear weapons and later energy production. In the 1970s, 60,000 workers were employed in the uranium industry in the Czech Republic. However, later on mining declined due to economically inefficient mining in increasingly complex geological conditions. In 2017, uranium mining in the Czech Republic has definitively terminated (Fig. 1). According to Michálek et al. (2014), a total of 112,250 tons were mined (9th place in the world, René, 2018), where all was going to the USSR and to Russia, respectively. However, uranium ore reserves have not yet been exhausted and mining could be resumed under more favorable economic conditions.

Uranium ore was mined in the Czech Republic at 32 locations that can be grouped into five mining areas. This paper is dedicated to the bearing that ended its activity as the last one. It is the 2nd largest Dolní Rožínka deposit in the Vysočina region. It is situated in the high-grade metasediments series of the Moldanubian Zone. Mining took place up to a depth of 1,200 meters. The deposit was in operation from 1957 to 2017. During this time, 14 million tons of ore were mined, from which 20 thousand tons of uranium were obtained. In 1970, there was 4,100 people employed. As of 2000, it was the last uranium deposit within EU countries and probably the longest mined uranium deposit in the world. Reclamation and research are currently underway.

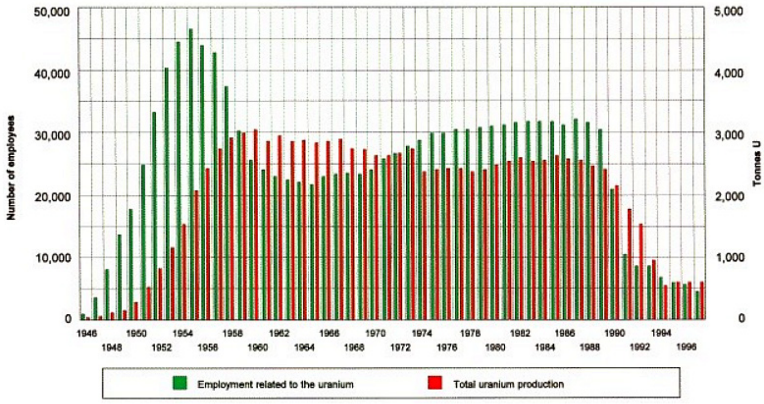

Figure 1 Trends in uranium production and related employment in Czechia. Source: Kališová (2017)

The locality

The mining deposit is located in the Bohemian-Moravian Highlands, on the inner periphery of the Czech Republic, on the historical border between Bohemia and Moravia. The settlement consists of small and very small villages. The small towns of Bystřice nad Pernštejnem (population 7,900), Nové Město na Moravě (population 9,900) and Tišnov (population 9,300) are the natural centers of the region, where housing construction for mine employees was located.

Currently, follow-up activities are taking place after the end of mining (Vokurka, 2019). The following three issues need to be addressed: reclamation of the landscape, solution of social consequences and transformation of the local economy.

Adressing The Problems

Uranium mines require significant financial and personnel costs even after mining has ceased. The state enterprise DIAMO, which employs 550 people in Dolní Rožinka, is responsible for physical reclamation. Its tasks include mine water treatment, remediation of sludge ponds (Trojáček, 2004), inspection of the mouths of abandoned tunnels, forestry reclamation of dumps, and monitoring of radiation and environmental effects. In 2023, no negative effects on the environment were detected. The total effective dose of a representative person in none of the monitored municipalities in 2022 did not exceed the dose optimization limit of 250 μSv. The main potential problem is radioactive sludge disposal sites. Although there are currently no environmental impacts recorded, in the event of a potential breach of the dam, there would be a risk of radioactive contamination of the Svratka River, which passes through the regional capital of Brno.

Le Berre and Bretesché (2020) found that miners are subjectively more concerned about the risks associated with mining (collapses, gas, etc.) than the risks of working with radioactive material. In the case of the Czech uranium mines, the fact that (political) prisoners worked in some of them, whose protection was not sufficiently considered, played a role. However, that was not the case in the chosen region.

Social problems are also significant. Uranium mines were the second largest employer in the Žďár nad Sázavou district. Between 1960 and 1985, 25,000 employees took turns here. The company built housing estates in Dolní Rožínka, Bystřice nad Pernštejnem, Nové Město na Moravě, Tišnov (in total 2,819 flats). At the same time, the company built many cultural, educational and social facilities. This development fluctuated the population development of the micro-region (Fig. 2). In the 1970s, there was a rapid increase in the number of inhabitants, and after 1990 a significant decrease. Recently, the situation is stabilizing which may have contributed to increased foreign immigration.

Originally a poor agricultural region with a stable population has turned into an intensively living region with high migration and above-average earnings. High earnings were not conditioned by high qualifications but by hard and dangerous work (65 fatal accidents were registered, of which 63 occurred during the first years since mining began). Miners formed a very specific stratum of the population, with a different way of life.

Although it is a small peripheral area, its individual parts are different. The common element is the natural conditions, which are suitable for organic farming and low-demand tourism, including a second home. However, the position of the individual parts is different. The situation is better in Tišnov and its surroundings.

The area can benefit from the proximity of the regional metropolis of Brno, which offers a wide variety of job opportunities in attractive sectors. Tišnov is a node of the integrated transport system of the South Moravian Region, which enables fast and frequent public transport.

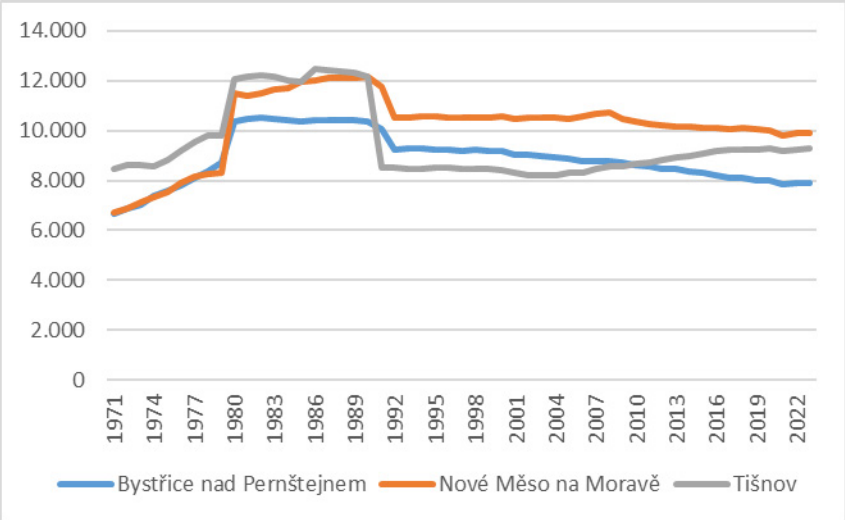

Fig. 2 Population development in three micro-regional centres 1971 – 2022. Source: Public database. Czech Statistical Office Praha; own elaboration

Nové Město is the traditional service center of the Žďár nad Sázavou district with a hospital and other services. It has a specialized production of surgical instruments and skis. It is also an internationally renowned center for winter and summer sports especially skiing and biathlon. The most problematic situation is in Bystřice nad Pernštejnem. Efforts to replace the decline of mining by creating an industrial zone were only partially successful due to the town's remoteness (Vaishar, Kallabová, Zapletalová, 2002). The territory naturally belongs to Brno, but administratively it is a remote part of the Vysočina region.

The Future

The reclamation of the landscape is under control and does not seem to present a problem at the moment. The level of radioactivity is also normal. The main problem is social and economic restructuring. A greater number of workers accustomed to high salaries, but with lower qualifications and little potential for retraining, were released from their jobs. This is taking place against the background of the transition to a post-material economy, which does not allow a return to agriculture or industry. Some population decline is normal under these circumstances. A new economic profiling of the region must be sought. The conditions of the three parts of the region are different.

In addition to landscape reclamation, social and economic restructuring is an important task of post-mining regions. While large cities look to the future in the application of quaternary functions (universities, culture, research, technical heritage tourism), rural mining areas focus on a combination of factors with a significant share of less demanding tourism. Of course, it is necessary to take into account that the population of rural post-mining regions cannot return to their original way of life, because they are already different people. The situation has a natural tendency to stabilize at a lower level. However, restructuring would still have to occur in connection with the transition to a post-material economy. Small towns will play a key role in this process (Lipovská, Vaishar and Šťastná, 2012). Post-mining mining regions can sometimes be used as industrial or geo-tourism cultural heritage (Nita and Myga-Piatek, 2014).

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INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Post-Mining Practices in Poland – Legislation, Protection of Industrial Heritage, Tourism

Anna Ostręga[1]

Abstract

The article presents the Polish experience of mine reclamation and revitalisation of post-mining areas, with a special focus on the protection of industrial heritage. As a background, the scale of mining activities in Poland, the area of land occupied by these activities, and the progress in reclamation and redevelopment of post-mining areas are shown. Legislation relating to reclamation and revitalisation is cited, indicating the entities obliged to conduct reclamations, sources of funding, restructuring of the mining industry and energy transition. Examples of anticipatory design of the target revitalisation were given at the Reclamation Documentation stage. The heritage of the mining industry was shown as a potential for the development of tourism and cultural services.

Keywords: post-mining areas, reclamation, revitalisation, legislation, financial aspects, heritage protection, examples of revitalisation

1. INTRODUCTION

Exploited in the Neolithic period and the early Bronze Age (c. 3900-1600 BC), the flint mines are an example of the oldest mining activity in Poland, and an example of mining heritage protection and industrial tourism development. The flint mines were discovered in 1922, and over the following decades, a group of archaeologists, geologists and miners conducted research and preparatory work to make them accessible for tourism [1], [2]. Since the 1970s, the AGH University of Krakow, specifically Zenon Duda, PhD, Eng., has significantly contributed to making the mine accessible for tourism. Zenon Duda was the main designer of the mining and conservation works and designed the world's longest underground tourist route to visit this prehistoric mine [3], [4], [5]. In 2019, the flint mine, together with the Krzemionka Prehistoric Striped Flint Mining Region, was inscribed on the UNESCO World Heritage List [5].

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Mining is one of the pillars of the Polish economy. Currently, energy minerals (hard coal and lignite, crude oil, natural gas, methane), metallic minerals (copper), chemical minerals (rock salt, sulphur) and rock raw materials (e.g. dolomites, limestone, broken and block stones, sands and gravels, clay raw materials, glass raw materials, peat, filler sands) are mined [6]. There are 7,410 mining companies in Poland: 31 underground, 7,276 open-pit and 103 borehole, which together employ 170,445 people (as of 31.12.2023, [7]). In accordance with the law, decommissioned underground mining companies engaged in tourism, therapeutic and recreational activities are also under mining supervision. As of December 2023, there were 15 underground tourist trails (falling within 7,410). These are [7]:

1) Hard Coal Mining Museum – GUIDO Historic Coal Mine in Zabrze.

2) Historic Silver Mine and BLACK TROUT Adit in Tarnowskie Góry.

3) NAGÓRZYCKIE Grottoes Underground Tourist Route in Tomaszów Mazowiecki (in a sandstone deposit).

4) KRZEMIONKI Archaeological Museum and Reserve in the Municipality of Bodzechów.

5) BOCHNIA Salt Mine Ltd.

6) WIELICZKA Salt Mine JSC.

7) Old Gold Mine in Złoty Stok.

8) Old Nickel Mine in Szklary.

9) Old Lead and Silver Mine NOWY FILIP in Lutynia.

10) Old Uranium Mine in Kletno.

11) Old Hard Coal Mine in Nowa Ruda.

12) Old JULIA Hard Coal Mine in Wałbrzych.

13) KOWARY Adit Underground Tourist Route in Kowary (uranium mine).

14) Old PODGÓRZE Mine in Kowary (uranium mine).

15) Old Magnesite Mine SOBÓTKA in Sobótka.

Statistics on land occupied by mining activities have not been kept since 2012. However, in order to show the scale of the mining land reclamation problem, data for the years 2000-2011 will be presented (Table 1). In contrast, the progress of rehabilitation and development is presented against the total amount of degraded and devastated land (Figure 1).

*Table 1. Reclamation and redevelopment of land transformed by mining activity**

Mineral type		Land under mining activity (as of 31 December)	Land during the year		Reclaimed and redeveloped land transferred to other users
			reclaimed	redeveloped	
		in hectares			
Total	2000	44 991	2340	574	1511
	2005	39 286	1123	765	1331
	2009	37 080	512	428	301
	2010	37 584	510	243	369
	2011	**38 065**	**1131**	**480**	**316**
Hard coal		6 132	71	9	33
Lignite		16 602	266	152	142
Copper ores		294	-	-	-
Zinc and lead ores		511	20	-	-
Sulphur		1627	256	253	12
Salt		253	27	26	1
Petroleum and natural gas		997	26	23	50
Mineral resources		11 650	465	18	78

Concerns land lawfully incorporated by mining enterprises and the land of other users (Source: Statistics Poland, 2012 on the basis of data of the State Mining Authority

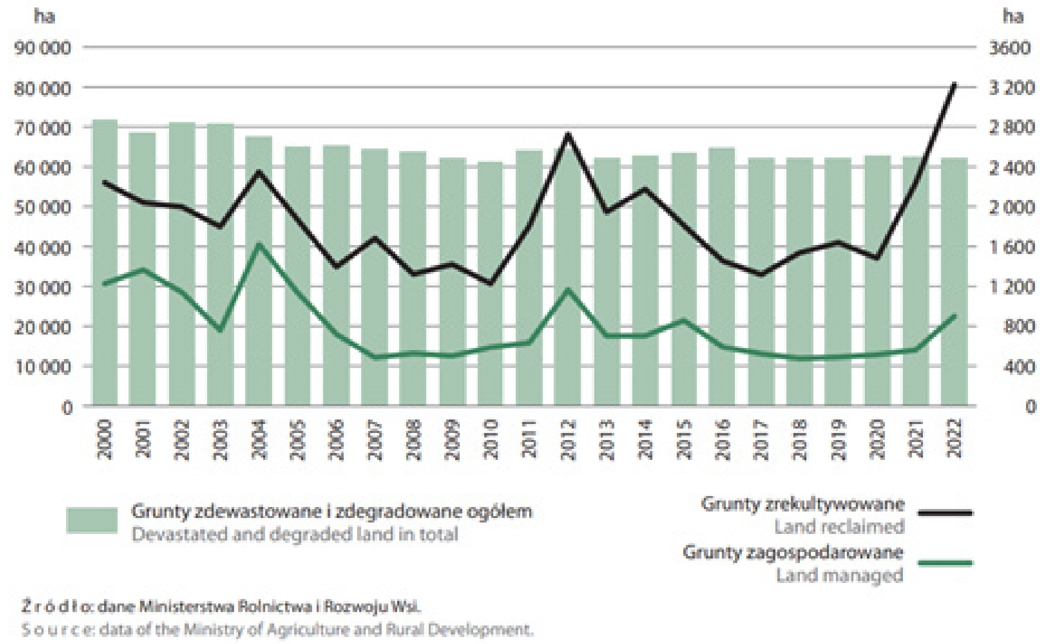


Fig. 1 Devastated and degraded land as well as reclaimed and redeveloped (source: Environment 2023)

Two issues should be mentioned in the context of mine closures and post-mining land reclamation. The first relates to the restructuring of the hard coal mining industry, which took place in the 1990s and was a consequence of the political transformation and the need to adapt to the conditions of a market economy. Between 1990 and 2009, 39 hard coal mines were closed and 269 thousand miners lost their jobs [10]. Although a reform programme was introduced and a dedicated company was set up for the decommissioning and reclamation of mines (Mine Restructuring Company S.A.), and financial resources, the effects of the restructuring are still being faced today.

The energy transition currently taking place due to the EU's CO_2 reduction targets for 2050 is resulting in the accelerated closure of hard coal and lignite mines, which is increasing the problems even further. The 18 hard coal mines currently in operation are scheduled to close by 2049 (in practice, this is happening earlier, as can already be observed). The reclamation or revitalisation process itself is difficult, but the existing state of knowledge and experience allows it to be properly implemented. The problem is the scale of the post-mining areas and facilities requiring intervention, not only in the context of reclamation, but also in terms of creating new jobs and ensuring energy security (coal had been the guarantor of this until now).

The large scale of the problem requires a systemic approach, understood as the application of legal, financial, and organisational solutions that create a framework for action for a specific purpose. Revitalisation programmes such as the IBA Emscher-Park 1989-1999 or the IBA Fürst-Pückler-Land 2000-2010 are a model example [11]. They were organised during a limited period of time when all the attention and efforts of decision-makers, experts and the public were focused on revitalising post-industrial sites. The projects implemented were characterised by innovation and high standards.

The process of reclamation and subsequent revitalisation should be the answer to the problems mentioned. Post-mining areas (not only in coal mining) should be treated as a potential for further development, after reclamation understood as the preparation of land and facilities for reuse. Mining activities always involve the disturbance of the environment and living conditions of the local community. Therefore, the effects of reclamation and revitalisation can be a form of compensation for society, e.g. a ski slope on an overburden dump, a swimming pool in a post-mining pit or a cultural centre in a historic mine building. Properly conducted reclamation and revitalisation improve the image of mining and thus increase acceptance for the development of new deposits.

This article aims to identify good solutions and shortcomings in the reclamation and revitalisation of post-mining areas in Poland, with a particular focus on heritage protection, based on a review of experience, both in terms of legislation and practical achievements.

2. LEGAL BASIS FOR THE RECLAMATION OF POST-MINING AREAS

2.1. Obligation to reclaim post-mining areas

Laws related to post-mining land reclamation are scattered among many pieces of legislation. This makes them difficult to interpret and, as a consequence, may translate inrehabilitate post-mining areas belongs to the mining entrepreneur. The two main objectives of reclamation are to reduce or remove the nuisance of the post-mining area and prepare it to introduce new economic, social or natural functions. The scope of reclamation follows from the definition and includes: shaping the surface of the land, improving physical and chemical properties, regulating water relations, restoring soils, strengthening slto the quality of the decisions made, as well as the reclamation itself. Nevertheless, they provide a framework for performing this duty reliably. The obligation to opes and rebuilding or building necessary roads [12]. While the scope of activities concerning the infrastructure of a mining plant is not apparent from this definition, they should not go beyond securing the facility, especially windows and doors, against devastation.

Reclamation is carried out for different functions, including: forestry, agriculture, water, economic (servicing, manufacturing), services (recreation, education, culture, sport, tourism) and nature, also taking into account the natural succession of nature. Agriculture and forestry used to be the most common reclamation options. The development of industry after World War II, population growth and urbanisation of the country influenced the loss of agricultural land, hence the need to restore it in the reclamation process [13]. Reclamation for forestry often results from obligations included in lease agreements if mining has been carried out on forest land. Another issue is that forests up to 40 years old are exempt from property taxes, so in the case of difficulties in disposing of the post-exploitation land, the entrepreneur is not exposed to tax burdens. The selection of an appropriate mode of reclamation and target redevelopment (revitalisation) should be preceded by an analysis of factors that may introduce preferences, restrictions or prohibitions. The following factors should be analysed: formal-legal, environmental, hydrogeological, technical, economic, social, spatial and cultural [14].

Leaving post-mining areas for the spontaneous encroachment of natural habitats is already a conscious decision. Based on natural succession, the natural function should result from the vulnerability of the post-mining area to plant encroachment or the presence of rare species. Experts even consider that, “from an ecological point of view, reclamation is a human intervention in the succession process, and succession is a factor regulating human-induced disturbance” [15]. Vegetation from natural succession can also be used as an indicator of the rate of overgrowth and incorporated into the process of biological reclamation - planting vegetation [2016]. It is also emphasised that the phenomenon of natural succession should be used rationally and should not replace reclamation in every case [13]. A number of post-mining areas rehabilitated by natural forces are known, and they are protected by law today as areas of natural value (e.g. Fig. 2 a, b).

Figure 2. (a) LIBAN Quarry – historical infrastructure and nature, 2024 (photo: A.Ostręga)

(b) LIBAN Quarry – receiving pit covered by natural succession, 2009 (photo: A. Ostręga)

The method of reclamation is specified in various documents from the early stages, i.e. exploration activities, mineral extraction, and mine closure. Mining activities last for decades, sometimes more than 100 and 200 years, so the reclamation method can and should be updated. The method of reclamation is also determined in the municipality’s planning documents, which form the basis for issuing decisions and opinions on mine closure and reclamation. The procedure for adopting the municipality’s planning documents and issuing opinions on the Reclamation Decision or agreeing on the Decommissioned Mine Plan is an opportunity to confront the plans of the mining company and the municipality (or other investor). This is important because costly earthworks related to the shaping of the post-mining area can be carried out at the reclamation stage or even in the final phase of operation.

Successive reclamation is justified by the reduction of mining company operating costs. The completion of reclamation, confirmed by a decision of the district governor, is the basis for ceasing to pay the tax for the economic use of land, usually set by the municipal council at the highest level, i.e. PLN 1340/ha (EUR 311/ha per year) [17], as well as other fees, such as the annual fee for excluding land from agricultural or forestry production.

It was only in 2013 that the development of Reclamation Documentation was made mandatory. The mining plant operations manager approves it and forms the basis for implementation and for considering reclamation as completed (in addition to field inspection). The descriptive part of the Reclamation Documentation specifies, among other things, the mode of reclamation, the location of construction facilities, methods of shaping the surface relief, methods of soil restoration, the method of regulating water relations on the reclaimed land, the method of anti-erosion protection of the reclaimed surfaces and the schedule of work implementation. The graphic part includes maps showing the progress of reclamation. How, then, can the scope and method of reclamation be planned without first outlining the target redevelopment? In the case of agricultural or forestry reclamation, such documentation may be sufficient - as the key is to have the land with the proper slope for the functions listed. However, in the case of plans for other end uses, the Reclamation Documentation should be based on a revitalisation concept. The Reclamation Concept is not required by law, but it nevertheless indicates, e.g. the traffic layout, the positioning of the buildings (to be built), the location of the beach, car parks, etc. Thus, it should form the basis for the development of the Reclamation Documentation, which can realistically reduce costs and avoid collisions of functions. A model of such a procedure for the NIELEPICE Limestone Mine is presented in section 3.4 of this article.

At the reclamation stage, the obligations of the mining entrepreneur within the framework of the activity for which it has been granted a licence end. However, the effects of reclamation are crucial for further development, understood as the execution of target treatments ensuring the appropriate use of the reclaimed land for forestry, agricultural, water and other functions. Therefore, the objectives and modes of reclamation should be subordinated to the modes of subsequent redevelopment (revitalisation) and thus correspond to the expectations of the municipality and its residents. The development process is the responsibility of the legal successor of reclaimed areas after mining activities, but is not an obligation required by law. There are exceptions when the mining entrepreneur redevelops the area for new functions after reclamation is completed. A spectacular example is the construction of the GÓRA KAMIEŃSK Sports and Recreation Centre - a ski and snowboard slope, bobsleigh track, and bicycle trails along with social facilities on the reclaimed external overburden dump at the BEŁCHATÓW Lignite Mine [11]. Another example is the development of disused sand and gravel pits into a restaurant and hotel resort, swimming pool and event venue – MIŁOCIN Park, near Wrocław [18].

We have formally been using the term ‘revitalisation’ since 2004. It was defined for the purposes of operational programmes, which were the basis for obtaining funds from the European Union. Indeed, the priorities included the revitalisation of post-industrial, post-military and urban areas. The definition itself was not introduced into the legal system until 2015, when the Revitalisation Act was passed. Revitalisation was defined as: the process of bringing degraded areas out of crisis through integrated actions for the benefit of the local community, space and economy, which is territorially concentrated [19]. A crisis state is understood as an accumulation of negative environmental, economic, spatial-functional and technical and social phenomena. Although the provisions of the Act are directed at the revitalisation of urban spaces, the revitalisation instruments contained in the Act can also be applied to post-industrial areas. The precondition is to plan such revitalisation investments that counteract the negative social phenomena.

2.2. Sources of funding for reclamation

The main source of funding for reclamation is the Mine Decommissioning Fund (MPDF) created under the Act of 9 June 2011 Geological and Mining Law [20]. Funds are allocated to the MPDF as follows:

- for underground and borehole mines - the equivalent of at least 3% of depreciation charges for fixed assets of a mining plant, determined in pursuance of regulations on income tax;
- for open-pit mines, the equivalent of at least 10% of royalties.

The funds accumulated in the Mining Plant Decommissioning Fund can be used in the event of the decommissioning of a mining plant or part of it (after approval of the Decommissioned Mine Plan). On the other hand, the ongoing reclamation is financed from the mining plant's current funds.

The need to collect funds for the MPDF is certainly a necessary solution, but is it sufficient? It is important to consider that in the end-of-life phase, revenues from the sale of production decrease and disappear completely in the decommissioning phase. However, the MPDF has only been in place since 2002, so not all mining companies will manage to accumulate adequate funds. Moreover, how payments are calculated for the MPDF does not reflect the actual financial needs for decommissioning and reclamation. An example is one coal mine in Silesia, operating between 1983 and 2017, where the funds accumulated for the MPDF were less than 5% of the actual decommissioning and reclamation needs [21]. An audit by the Supreme Audit Office (NIK), carried out back in 2010, showed that the legal regulations imposing an obligation on entrepreneurs to accumulate funds for the future decommissioning of mining plants did not have the intended effect – they were imprecise, created problems of interpretation, and their methodological assumptions were not appropriate [21]. For this reason, some mining companies create financial reserves based on estimated projected decommissioning and reclamation costs, which are made on the basis of deposit exploitation forecasts and technological and economic expertise [22]. Provisions for decommissioning are made, for example, by a copper mine (KGHM Polska Miedź), lignite mines, as well as some limestone mines and hard coal mines.

The obligation to create an MPDF does not apply to small mining plants. This category includes mining plants exploiting minerals, using the open-cast method, not owned by the State Treasury when the annual output does not exceed 20,000 m^3, blasting means are not used, and the area of the documented deposit does not exceed 2 ha [20]. However, as noted by Uberman [23], although small, they account for about 60% of all mining plants in Poland, and the area occupied by them represents more than 30% of the area of all open-pit mines. Thus, the quality of their reclamation has a significant impact on spatial and environmental conditions.

The second type of funding for reclamation is external funding. One such type is the National Fund for Environmental Protection and Water Management (NFEPWM). In a situation where the mining company does not exist, i.e. the current owner is not responsible for the degradation of the site, it can obtain funds from the NFEPWM. One of the objectives of the fund is the reclamation of post-mining areas. Funds for this purpose come from mining royalties paid by mining companies (40% of royalty goes to the NFEPWM budget and 60% to the municipalities budget).

In the context of pursuing climate neutrality, funding can be acquired from the Just Transition Fund (JTF) [24]. The JTF targets areas facing serious socio-economic challenges resulting from the energy transition. It offers funds not only for reclamation, but also for revitalisation, retraining of miners, job creation and renewable energy sources. Not only reclamation, but also revitalisation can be subsidised with EU funds under regional operational programmes. These programmes have tailored priorities to the circumstances of individual voivodeships, in particular those affected by the energy transition.

2.3. Protection of industrial heritage

The tangible heritage of the mining industry is worth protecting not only for its cultural value (historical, architectural, sentimental, etc.) and potential for tourism, but also for the preservation of natural mineral resources and the environment. This second area of research, i.e. the reuse of infrastructure in the revitalisation of mines (as well as other sites), has been frequently addressed in recent years and is referred to as the circular economy in construction [e.g. 25]. In this regard, it is important to link the legislation on mining activities with the legislation on historic preservation and building law appropriately and to develop incentives for investors.

The principles of heritage protection are contained in the Act on the Protection and Care of Monuments [26]. However, the key decisions are those made under the Geological and Mining Law [20] and the Regulation on mining plant operation plans [27]. Indeed, at the stage of drawing up and approving the Decommissioned Mine Plan, a decision is made on how to deal with the company's infrastructure, i.e. whether it is to be decommissioned or secured in order to be adapted for other functions. According to the regulation, the entrepreneur is obliged to list the mining plant's construction facilities designated and not designated for demolition, and for the latter group, this is to determine the envisaged forms of development and use. The Decommissioned Mine Plan is agreed upon with the local authority. This legal obligation encourages discussions and arrangements to be made at an earlier stage. Local authorities should express their desire to preserve the infrastructure and identify the needs of the municipality that could be realised in the process of its adaptation to new functions. However, are such discussions taking place? It should be taken into account that maintaining the infrastructure of a mining plant, in the absence of interest from the municipality or another investor, is costly (e.g. property taxes, compulsory technical inspections, security). However, the law provides tools to reduce these burdens, as discussed in section 2.4.

The Act on the Protection and Care of Monuments indicates that the following are subject to protection and care, regardless of the state of preservation:

- immovable monuments which are objects of technology, especially mines, steelworks, power plants and other industrial plants;

- movable monuments, which are products of technology, and in particular equipment, means of transport, machines and tools testifying to material culture, characteristic for old and new forms of economy, documenting the level of science and civilisation development.

The Act also indicates the forms of protection of monuments, e.g. 1) Register of Monuments, 2) Monument of History, 3) Cultural Park, 4) establishment of protection in a planning document. Many times, while still in operation, selected buildings of the mining plants are entered in the Register of Monuments (in Polish: Rejestr Zabytków) or in the Records of Monuments (in Polish: Ewidencja Zabytków). One example is the WUJEK Hard Coal Mine in Katowice (Silesia Region). In operation since 1899, the mine witnessed the greatest crime of martial law - the pacification of the strike on 16 December 1981, during which nine miners died and dozens were injured. A cross was erected at the site of the tragedy and the former clothing warehouse of the mine was adapted into the Silesian Center for Freedom and Solidarity - the WUJEK Mine Memorial Museum [28]. The museum operates as an independent entity from the mine, and its curators, who talk about the tragedy, are the miners - participants in the historic strike. The museum building and the mining changing room with pulleys and chains located on the active mine site are listed in the register of historical monuments. Several other buildings located within the active mine are included in the register of historic buildings (Fig. 3).

Figure 3. Current development of the WUJEK Hard Coal Mine, with a presentation of selected facilities: 1) Forge and locksmith shop, 2) Mining changing room with pulleys and chains, 3) Rescue station, 4) Compressor house and pit water treatment plant, 5) Lechia shaft engine house, 6) Krakus shaft hoist house, 7) Electrical workshop, 8) Pithead waiting room, 9) Silesian Centre of Freedom and Solidarity, 10) Boiler house (now Dalkia Polska Energia S.A.) , 11) Management building, 12) Monument to the NINE FROM WUJEK

(Source: own study on the basic of https://emapa.katowice.eu/jarc-gui/views/main.xhtml, photos: A. Ostręga)

It should be noted that the Records of Monuments is not a form of protection, but documents the object (contains information about the monument). Objects entered in the Records of Monuments may be protected under the condition that they are included in the spatial planning document. They are also the subject of a communal conservation programme, but are not covered by conservation supervision. The provisions of the Construction Law, in relation to buildings and areas included in the communal register of monuments, require that a permit for the construction or demolition of a building be issued after an agreement has been reached with the provincial conservator of monuments. On the other hand, entry of an object into the Register of Monuments is associated with stricter protection and introduces new obligations and rights for the owner of the monument. The obligations concern [26]:

- drafting of conservation documentation defining the state of conservation of the monument and the possibilities of its adaptation, taking into account its historical function and value;
- drafting of a conservation work program for the monument, determining the scope and manner of its conduct and indicating the necessary materials and technologies to be used, the program is subject to agreement with the voivodeship conservator of monuments;
- drafting of a program for the development of the monument together with its surroundings and further use of the monument, taking into account the highlighting of its value, the program is subject to agreement with the voivodeship conservator of monuments;
- obtaining the consent of the voivodeship conservator of monuments for the construction works on the monument
- obtaining the consent of the voivodeship conservator of monuments for the demolition of the monument.

The above-mentioned obligations make owners of industrial infrastructure unwilling to enter them in the Register of Monuments. This is because it lengthens procedures and generates higher costs, including for construction and conservation works. However, in the case of monuments not covered by any form of protection, the conservation authorities do not have the authority to control their care.

Unfortunately, the establishment of a legal form of protection is not always a guarantee for the preservation and conservation of technical monuments. Lack of conservation work on a monument may lead to its ruin, which is grounds for applying for its removal from the Register of Monuments and demolition. Conversely, the adaptation of a mining industry heritage that is not legally protected but has a sensible owner who cares about the identity of the place may be the best protection.

The preservation and adaptation of industrial heritage should not be a coincidence. In order to avoid such a situation, it would be advisable to inventory and valorise industrial heritage and identify the most valuable elements to be preserved. An example worth following is the National Industrial Heritage Plan being developed in Spain (In Spanish: Plan Nacional de Patrimonio Industrial, first version from 2001) [29], [11]. Within the framework of the Plan, definitions and criteria for the selection of sites were developed and, on this basis, (post)industrial sites representing different industries and stages of the industrialisation process and coming from different regions were selected for inclusion in the plan (initially 100 and, as the work developed, 177 sites, identifying among them those that should receive immediate attention). As a reaction to the energy transition currently taking place and the closure and thoughtless demolition of CHP plants, a report on the cultural value of CHP plants was prepared [30].

2.4. Tools to protect the mining heritage

The chance for greater interest in the protection and adaptation of mining heritage are various types of legal and financial incentives. The following are legally guaranteed:

- Exemption from property tax for land and buildings entered individually in the Register of Monuments, provided that they are maintained in accordance with the regulations on the protection of monuments, with the exception of parts used for business purposes [17]. This instrument can be used in relation to mine infrastructure that has already been decommissioned and entered in the register of monuments and is located on the premises of an active mining plant. Often, due to maintenance costs and taxes, a decision is made to demolish such facilities.

- A subsidy to subsidise conservation, restoration or construction works on a monument entered in the Register of Monuments (up to 50% of expenditure), and if the monument has exceptional historical, artistic or scientific value or requires the performance of technologically complex conservation, restoration or construction works, the subsidy may be granted for up to 100% of the expenditure.

In addition, there are a number of operational programmes based on European Union funds from which it is possible to obtain subsidies for the preservation of monuments, highlighting their cultural values and adapting them to new functions, e.g. economic or cultural. Grants from foundations and funds supplement funding from European programmes. Limitations may be the requirement to include a monument in the register or the necessity to realise the investment in partnership and the high level of bureaucracy.

It is up to the municipalities to reduce or exempt from taxes in exchange for carrying out protective or conservation work on a monument. This will be particularly important for the owners of objects included in the Records of Monuments, which does not entitle them to apply for funding for conservation works from the state budget, as in the case of monuments entered in the Register of Monuments.

3. EXAMPLES OF RECLAMATION AND REVITALISATION OF POST-MINING AREAS

3.1. First reclamation and revitalisation in Poland - a park in a quarry

The park created at the Twardowski School quarry in Kraków is the oldest example of comprehensive reclamation and revitalisation of a post-mining area in Poland. There is no precise information about the beginnings of limestone mining in the quarry, but it is clearly marked on the 1796 plan of Podgórze drawn up by Austrian officers [32].

The quarry's transformation into a park followed the idea of a 'school surrounded by gardens in a healthy beautiful location'. This idea was born in 1872 on the initiative of the eminent social activist and engineer Emil Serkowski and became the binding canon of school design in Podgórze. In 1884, Wojciech Bednarski, a teacher and councillor of the city of Podgórze (until 1915 a separate city, today a district of Kraków), received, at his own request, a then disused part of the quarry, with the intention of creating a garden there, from the municipality. The reclamation, consisting of fertilising the fertile soil, shaping the alleys, and planting plants, was a major challenge, all the more so because it was carried out without the help of the city. Nevertheless, with the help of young people and with his own funds, Bednarski created a garden in the rocky outcrop full of greenery - flowerbeds, rows of trees and places for sports and exercise games for young people [33]. The first stage of work - the 'school garden' - was completed in 1891. This fact convinced the city authorities of the rightness of Bednarski's action; consequently, a project for the extension of the 'garden' was drawn up, and funds were provided in the city budget. In 1896, the grand opening of the park took place. Subsequently, other parts of the park were put into use. The works outlined and started by Bednarski were also carried out after his death (in 1914), e.g. the playground turned into a slide in winter [32]. In 1907, the park was named after its founder – Wojciech Bednarski Park.

The park covers an area of 8.22 ha. Compositionally, it is divided into five gardens. The park layout includes elements of the earth fortress surrounding the quarry from the end of the 18th century, which serves as an alley on the slopes. A gloriette, a buffet, a viewing terrace, and a gardener's house were built. Care was taken to create attractive views from the park to Old Kraków and Podgórze.

The transformation of an inactive quarry into a recreational park should be considered a phenomenon of this type of undertaking, as it was carried out over 130 years ago, i.e. at a time when there was no scientific basis or legal acts obliging reclamation. Reclamation and revitalisation of the quarry were carried out successively for 20 years in the exploited parts of the quarry and were based on good cooperation between Bednarski and the management of the mining plant [32]. In 1976, Bednarski Park was entered into the Register of Monuments (A-586), as part of the urban layout of the Podgórze district, due to its high natural, dendrological and ecological values, as well as urban, artistic and historical value. In the years 2022–2023, it was subject to revalorisation.

Figure 4. (a) BEDNARSKI Park in 1902 (source: Dom Historii Podgórza) *(b) BEDNARSKI Park in 2024 after rehabilitation (photo: I. Kowalik)*

3.2. Protection of salt heritage – WIELICZKA Salt Mine tourist route

The WIELICZKA Salt Mine Tourist Route is the most important and most visited mining heritage in Poland. Wieliczka is a town of less than 28 thousand located 16 km from Kraków, which owes its development and recognition to rock salt deposits and the tourist route in the Salt Mine.

In the Wieliczka region, salt was already obtained from brine heated in clay vessels on small hearths in Neolithic times. At the turn of the 11th and 12th centuries, due to the disappearance of salt springs, brine was sought by building wells. The evaporated salt obtained in this way caused the development of the Wieliczka region - residential settlements and stone churches were established, and trade and crafts flourished. In the 13th century, rock salt deposits were found while digging salt wells. This discovery made it possible to obtain salt using mining methods, and the first shaft was dug already in the second half of the 13th century. Until 1964, rock salt was extracted mechanically and then by the method of leaching chambers, which allowed for the achievement of the production peak in 1976: 260 thousand tons of evaporated salt. In the following years, extraction decreased due to the depletion of deposits and the reorientation of the mine towards tourist and service activities. The mine ceased its operations as a mining plant in 1996. However, the Desalinated Water Utilisation Plant still operates, utilising brine from natural mine seeps, producing approximately 12,000 tons of evaporated salt of the highest purity in Poland (99.99% NaCl) per year [34].

The underground world shaped by over 700 years of exploitation looks like this in numbers [34]:

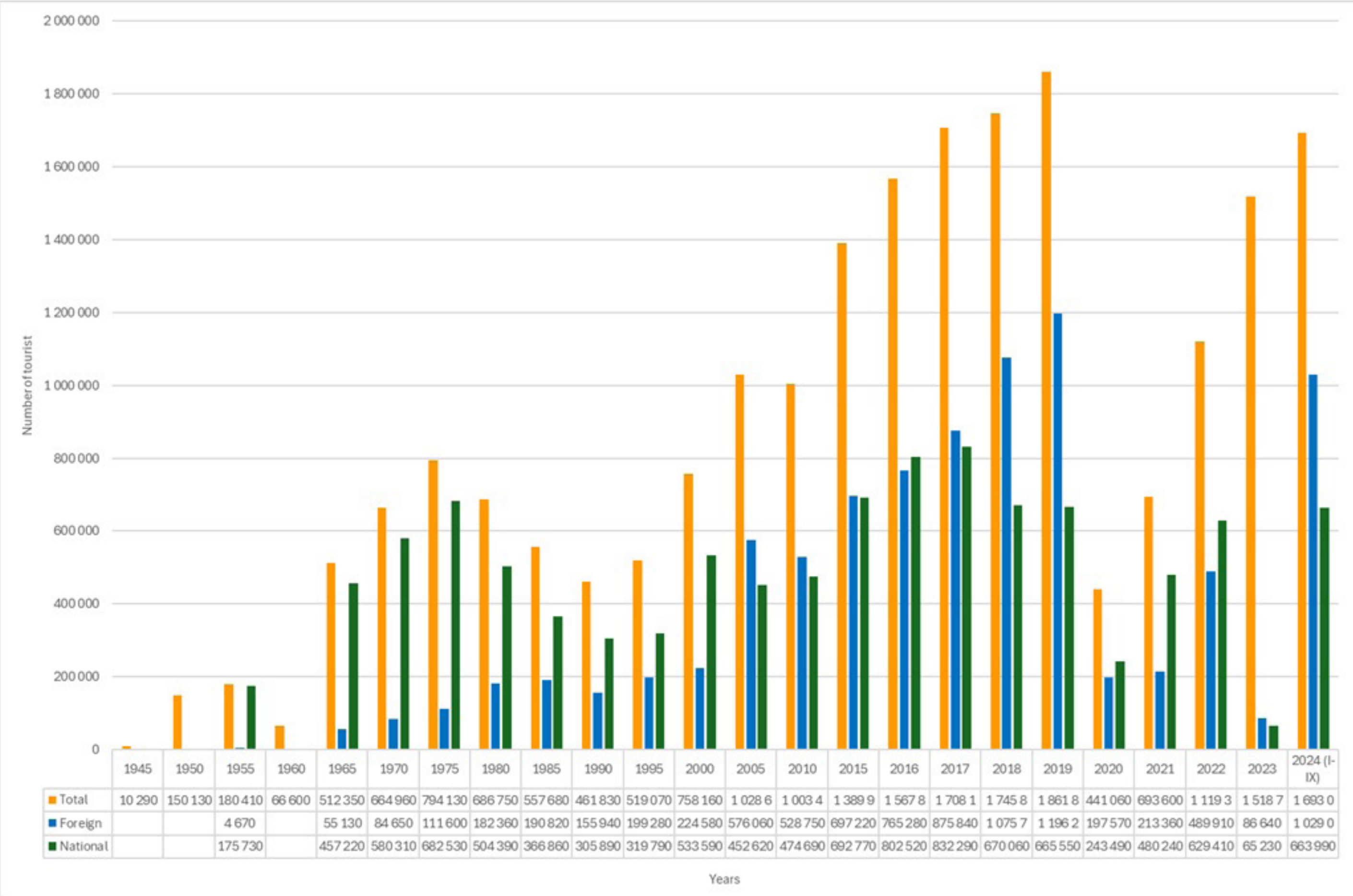
- 9 exploitation levels
- 26 mining shafts (6 still active today)
- 180 inter-level shafts
- 2391 chambers
- 245 km of galleries
- 9 million m³ of post-exploitation voids
- 327 m maximum depth.

Only 2% of the salt underground is open to the public.

The underground world is made up of historic chambers, chapels with altars carved in salt, statues and other works of art. Some of the pits have been given new functions, such as conference, catering or trade facilities. On the initiative of Alfons Długosz – a Wieliczka painter, teacher and social activist, the Kraków Saltworks Museum was established. Długosz saved the tools and devices used for extracting and transporting salt from destruction. Mining exhibits, as well as the fate of the mine and the city, are exhibited in 14 underground chambers[2].

2 information from the Kraków Saltworks Museum

Tourist activity in the Wieliczka Salt Mine has been developing since the 15th century, although only a few had such an opportunity at that time and only with the king's consent. Among the first visitors were world-famous personalities such as Johann Wolfgang Goethe, Friedrich Chopin, Jan Matejko and rulers such as Emperor Franz Joseph I of Habsburg [34]. After the first partition of Poland, when the administration of the Kraków salt mines passed into the hands of the Austrian authorities, the potential of the mine began to be used, and routes were organised, not only for the elite, but also for ordinary tourists [35]. Today, tourists are offered the following: the Tourist and Mining Route. The number of tourists tends to increase (except during periods when tourist traffic was halted by hoist machine repairs (1960, 1987-89 and the Covid-19 pandemic). For example, in the 18th century, the salt mine had 120 visitors per year. In 1876, it had 3,717[3]. The number of tourists after 1945 is shown in Figure 5. Sales of travel services account for as much as 91.9% of the total sales revenue [34].



	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024 (I-IX)
Total	10 290	150 130	180 410	66 600	512 350	664 960	794 130	686 750	557 680	461 830	519 070	758 160	1 028 6	1 003 4	1 389 9	1 567 8	1 708 1	1 745 8	1 861 8	441 060	693 600	1 119 3	1 518 7	1 693 0
Foreign			4 670		55 130	84 650	111 600	182 360	190 820	155 940	199 280	224 580	576 060	528 750	697 220	765 280	875 840	1 075 7	1 196 2	197 570	213 360	489 910	86 640	1 029 0
National			175 730		457 220	580 310	682 530	504 390	366 860	305 890	319 790	533 590	452 620	474 690	692 770	802 520	832 290	670 060	665 550	243 490	480 240	629 410	65 230	663 990

Figure 5. Number of tourists in the WIELICZKA Salt Mine (source: Info from WIELICZKA Salt Mine)

3 information from the Kraków Saltworks Museum

There are 400 guides employed on a contract basis to operate the tourist routes. The Cracow Saltworks Museum employs around 100 people (data from the Museum). The Wieliczka Salt Mine employs over 800 workers, including 451 miners [34].

The miners carry out repair and restoration work aimed at maintaining and making the historic chambers, corridors and shafts accessible to tourists, as well as decommissioning the non-historic part. This activity is mainly financed by grants from the state budget. Three methods are used to secure underground spaces:

- Construction of wooden structures supporting the ceiling, is the oldest method.
- Anchoring the walls of the excavations using special glass-epoxy anchors.
- Complete or partial filling of underground spaces with so-called backfill, i.e. a mixture of sand and brine. This method is used in non-historical areas of the Mine.

They also monitor water leaks and protect the mine from the effects of fresh water, which could dissolve the salt rock.

Figure 6. (a) The restored Regis Shaft located in the former Salt Market - once used to transport salt to the surface, and today is used to transport tourists to the Mining Route (https://www.kopalnia.pl/)

(b) St Kinga Chapel in the Wieliczka Salt Mine (https://www.kopalnia.pl/)

The Salt Mine also functions as a spa and has religious, educational, cultural and sporting functions. It invests in the salt industry heritage located on the surface. The Regis Shaft (the oldest surviving shaft) has been restored, along with the square that constituted the former Salt Market, the salt baths (now the Grand Sal Hotel) have been rebuilt on the basis of archival materials and a brine graduation tower has been built. In an attempt to keep tourists occupied for longer (than just visiting the salt mine), the city is also revitalising public spaces, emphasising the link with the salt mine. For example, the town square was decorated with 3D street art entitled Salt World by Ryszard Paprocki and a sculpture of salt miners made according to old drawings.

The Wieliczka Salt Mine was entered on the first UNESCO World Heritage List in 1978. In 2013, the Bochnia Salt Mine was added to the UNESCO list and today they are known as the Royal Salt Mines in Wieliczka and Bochnia. The mining facilities entered on the UNESCO list also include: the Tarnowskie Góry Lead, Silver and Zinc Ore Mine and the Underground Water Management System (2017) and the Krzemionki Region of Prehistoric Striped Flint Mining (2019).

3.3. Coal Mining Museum in Zabrze.

The centuries-long exploitation of hard coal in the Upper Silesian Coal Basin resulted in the rapid development and urbanisation of the Silesian region. One of the cities that owe their development to hard coal mining is Zabrze. The first mine (LUIZA QUEEN) was established here in 1791, and after World War II, the city was called the ‘capital of Polish mining’. This fact probably determined the location of the Coal Mining Museum (CMM) in Zabrze, which took place in 1981. The collections of the Museum are gathered in the historic building of the District Office – tools and devices illustrating the development of technical thought, rich archives, geological collections, as well as exhibits from the sphere of culture and tradition. In 2013, the Museum was merged with the Historical GUIDO Mine and the LUIZA QUEEN Mine Adit complex (a complex of excavations of the LUIZA QUEEN Mine and the Main Key Heritage Adit) (Figure 7). The CMM is organised by the Zabrze Municipality and the Silesian Region [36].

Figure 7. Structure of the Coal Mining Museum (source: own study, photos: CMM)

The opening of the LUIZA QUEEN Mine (Kopalnia KRÓLOWA LUIZA) (1791) was the beginning of the industrial revolution in Upper Silesia. In 1799, the digging of the innovative Main Key Hereditary Adit (Główna Kluczowa Sztolnia Dziedziczna) began. Its task was to dewater the excavations and transport the coal from the LUIZA QUEEN mine as well as several dozen other mines. LUIZA QUEEN mine is the oldest preserved hard coal mine in Poland, closed in 1998. The most valuable preserved facilities are the shallow excavations from the beginning of the 19th century (5-15 m deep), active machines, equipment and technological lines illustrating the technological process of extracting and transporting the coal, as well as the historic complex of surface buildings with the first chain bathhouse in Silesia, recently restored and used for tourist functions [37]. The Main Key Hereditary Adit is the continent's longest engineering structure related to coal mining - proof of mining and hydro-technical art from the turn of the 18th and 19th centuries [38], [37]. It runs under the city and measures 5 km.

The GUIDO Mine was founded in 1855. After World War II, it lost its importance, only to see a revival in 1967, when it was transformed into the "M-300" Experimental Coal Mine. New mining equipment and machines were tested there, while a small amount of coal was extracted. In 1982, the GUIDO Mining Open-Air Museum was established, open to visitors, and in 1987, it was entered into the Register of Monuments [39]. In 2000, as a result of the need to reduce costs in the coal industry, the dismantling of underground workings began. The director-liquidator had funds only for the mine liquidation, not for security and maintenance. Failure to fulfil this obligation risked disciplinary consequences [Owczarek 2003]. The involvement of many institutions, primarily the Zabrze city government, the Silesian Voivodeship Marshal's Office and private individuals, led to the cessation of liquidation activities and the establishment of the GUIDO Historic Mine in 2007 as a cultural institution [40].

The historic GUIDO Mine has the deepest tourist route in coal mining in Poland and authentic mining excavations equipped with original machines and devices (elevators, electric suspended railways and many others). The route entitled "Dark of the Mine" leads to the deepest and most austere areas of the GUIDO Mine - to the active mining wall, exploited in the second half of the 20th century as the last one, which has been preserved in the state in which the miners left it. The offer also includes the "Shift", during which tourists dress in a foreman's uniform, receive a full set of equipment and then perform mining tasks, e.g., conveyor belt assembly. The tour ends with a shower in the mining baths.

The museum also conducts cultural and educational activities, organises concerts, theatre performances, events such as an industrial-style wedding and mining-related celebrations. Several chambers have been adapted for these purposes in the GUIDO Mine: the compressor chamber, the mechanical workshop, Research Chamber No. 8 and the pump hall [40].

The buildings preserved on the surface and the underground workings of both mines have been entered in the Register of Monuments. In the case of the GUIDO Mine, the entries were made in 1987, 2014, and 2017 and concern the shaft headhouse with the headframe, the shaft hoist house, and the underground workings. The movable monuments - the hoisting machine used in the vertical transport of tourists and the compressor are also protected. In the case of the LUIZA QUEEN Mine, entries were made in 1993, 2007, 2010, 2013, 2015, and 2021 and cover eight buildings, including the oldest mining chain bathhouse in Silesia and the underground workings (Zabrze City Monument Care Programme for the years 2023-2026).

The GUIDO Mine has so far been visited by 2,614,610 tourists (since 2007) and the LUIZA QUEEN Mine by 1,254,667 tourists (since 2016) (data from the Coal Mining Museum in Zabrze). Detailed data is presented in Figure 8. The mines are among the most popular sites on the Industrial Monuments Route of the Silesian Voivodeship [42]. The Coal Mining Museum in Zabrze is also home to the International Centre for Documentation and Research on Industrial Heritage for Tourism.

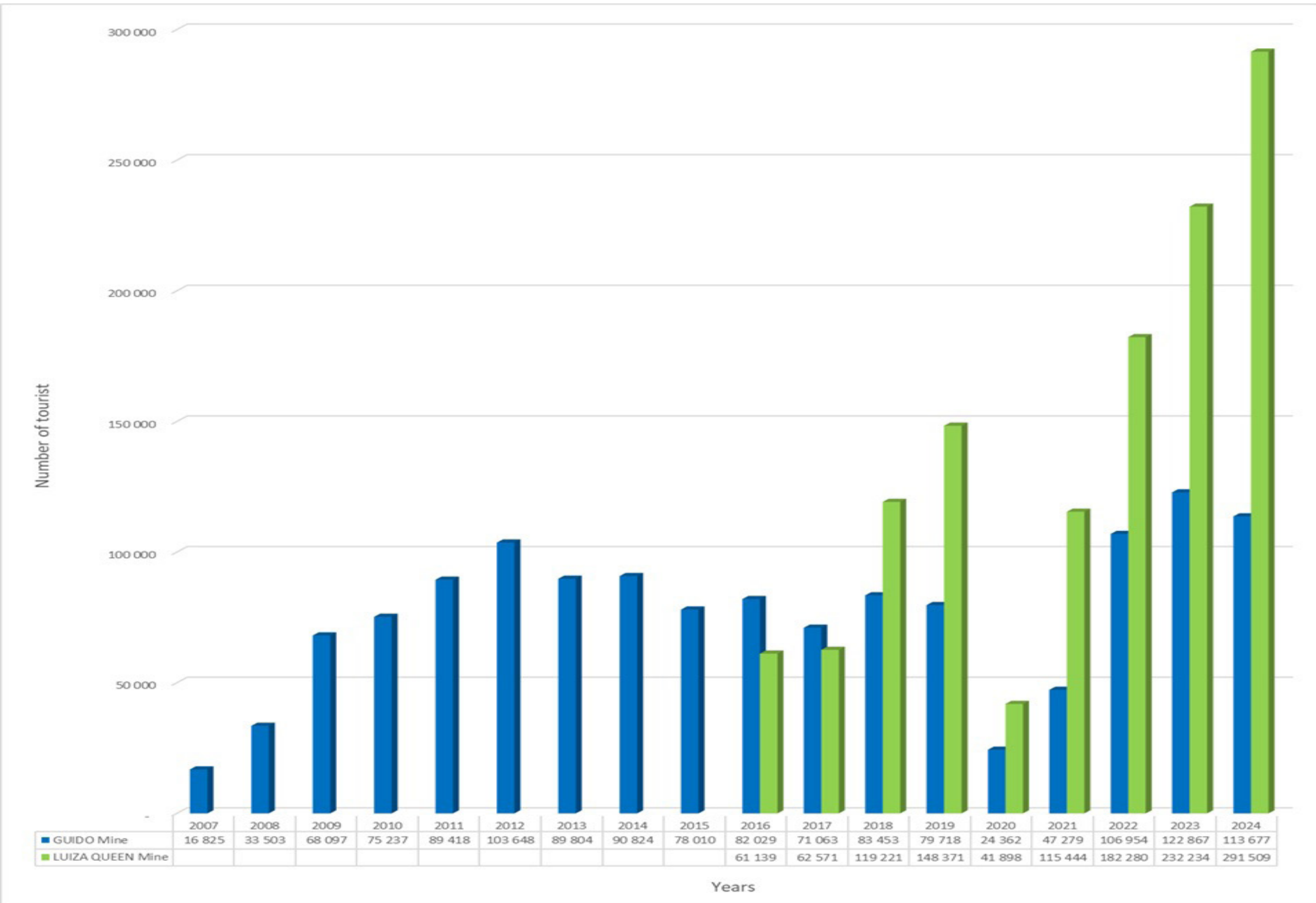


Figure 8. Number of tourists that have visited the GUIDO Mine and LUIZA QUEEN Mine (source: Info from CCM)

The Coal Mining Museum in Zabrze offers the only original underground excavations, being one of 15 underground tourist routes in Poland. It testifies to the deep-rooted mining traditions of Zabrze and the Upper Silesian region. It is also a symbol of the now-vanished coal age, which influenced the socio-economic development and shaped the history of Silesia. However, it is important to note that despite the great importance of Zabrze's mines, much of the surface infrastructure has been demolished. The museum collection has been placed in the district office building (instead of the original mining buildings). This is to the detriment of the originality and comprehensiveness of the protection of mining heritage in Zabrze. Thus, the greatest value of this historic mine in Zabrze is the authentic underground workings and adit.

3.4. Revitalisation planning at the stage of Recultivation Documentation – limestone quarry example

Based on the assumption that the Reclamation Documentation that a mining entrepreneur is required to prepare should be based on the target programmatic and spatial concept of revitalization (not required by law), an example of one entrepreneur's model approach will be presented.

The example concerns the NIELEPICE limestone mine located near Kraków, which operated from the 1960s to 2015. The quarry, the external dump and other areas (processing plant, social, administrative and storage facilities, and access road) occupy 12 ha. The depth of the excavation is from 20 to 53 m, the height of the floors is from 11 to 23 m, the slope inclination is up to 70^{o}, and in some places, it is steeper due to erosion. As a result of the cessation of exploitation, the excavation and adjacent areas have been largely covered by natural succession [43].

Figure 9. (a) Limestone Mine – general view (photo: ZRGiW AMC, 2020)

(b) Natural succession at the Limestone Quarry (photo: A. Ostręga, 2020)

The entrepreneur commissioned the development of Reclamation Documentation for the limestone mine. The landscape attractiveness of the quarry prompted the entrepreneur to abandon reclamation solely for forest functions in favour of functions expected by society and investors, which required conceptual solutions. Therefore, a revitalisation concept was developed, understood as development resulting in socio-economic and natural revival (Figure 10). The concept took into account the undeniable attractiveness of the quarry - rock outcrops and nature from natural succession, as well as existing limitations (erosion of rock walls). The development area was divided into two zones: commercial (individual pavilions with a sauna and terrace constituting a year-round holiday village; mini-spa with atrium, outdoor pool, restaurant) and public (footbridge - educational and nature trail, educational pavilions, stone gardens, a small chapel enabling the organization of religious ceremonies, climbing and viewing tower). The bottom of the quarry was planned as an open public space, a place for meetings and walks.

Figure 10. Elements of the quarry interior development: promenade, climbing and viewing tower, lookouts, mini-spa pavilions and a restaurant (author: 55Architekci s.c., 2020)

The conceptual study was the basis for developing the reclamation documentation, the scope of which was defined as follows [43]:

- geotechnical protection of slopes exposed to loss of stability through: a) controlled removal of overhangs using the mechanical (alpine) method; b) stabilization with anchors and steel meshes of places most exposed to the detachment of rock blocks; c) shaping protective embankments protecting against detaching rock blocks and people’s direct access to the walls;
- use of the existing effects of natural succession as afforestation and forest reclamation by incorporating existing tree clusters into the new development;
- securing buildings as a base for future investments;
- tidying up the area of the remains of technical installations.

With a target development concept and the Reclamation Documentation based on it, the mining entrepreneur could significantly limit the scope of reclamation (originally, it was supposed to be forest reclamation). For forest reclamation, the geometry of the quarry should be changed (reduced slope inclination), fertile soil should be fertilized, and trees should be planted in places not yet covered by natural succession. The revitalisation concept showed that the current shape of the quarry is much more attractive and can be used for recreational and tourist development, while allowing for further development of natural functions. It was also possible to defend the position on the recognition of natural succession as fulfilment of the reclamation obligation.

All this was possible thanks to the familiarisation of the bodies responsible for reclamation issues with the developed revitalisation concept, which presented a sustainable approach to the reclamation and future redevelopment of post-mining areas.

4. SUMMARY AND CONCLUSION

Mining is an important branch of the Polish economy. Currently, energy, chemical, metallic and rock minerals are extracted. The energy transition that is taking place may result in the faster closure of hard coal and lignite mines and, therefore, an increased supply of land for reclamation, as well as the need for new jobs and alternative energy sources.

The legal regulations regarding reclamation specify the requirements for the performance of this obligation by the mining entrepreneur, the bodies supervising the implementation of reclamation on time and in accordance with the documentation, and the sources of financing. However, the dispersion of legal regulations, difficulties in interpretation, or the imperfect methodology for collecting funds in the Mine Decommissioning Fund make the reclamation process sometimes problematic.

The design and implementation of reclamation based on the concept of target redevelopment (revitalisation) makes it possible to maximise the potential of the post-mining area and to attract the interest of residents and investors. Such an approach may also limit the scope of reclamation (e.g. related to land shaping or tree planting) and thus the costs of its implementation. The example of the NIELEPICE Limestone Mine also shows that the effects of natural succession can be considered as forest reclamation while leaving room for commercial redevelopment.

The presented examples of revitalisation are significant achievements in this field. The BEDNARSKI Park created in a limestone quarry or the GUIDO Historic Coal Mine, created in a coal mine, are evidence of grassroots determination to preserve the industrial heritage and exploit its potential for residents and tourists. The creation of an underground tourist route and museum is a use of the WIELICZKA Salt Mine’s delight in the underground world. However, these are individual examples. The best results come from revitalisation programmes organised on a wider scale, e.g. regionally (such as the IBA Emscher Park in the Ruhr 1989-1999), or plans for the inventory and protection of industrial heritage sites (National Plan For Industrial Heritage 2016 [29]).

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INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Designing and operating a mining project towards a post-closure vision and sustainable local benefits

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Abstract

Mine closure is the longest individual process in a mining project. Closure planning and estimation of costs starts early in the feasibility phases of the project, closure activities and closure management are carried out throughout the life of mine and they continue well into the post-closure phase to allow safe utilization of the site after mining has ceased. The current mine closure paradigm advocated by the mining industry emphasizes progressive closure in which liabilities are continuously reduced during the operation by closing facilities as they reach then ends of their service lives. Ideally, financial sureties required for mine closure should be designed to encourage this mode of operation. In addition, current mine closure practice emphasizes the need to create sustainable local and regional benefits from mining projects that have an inherently limited lifetime. This means targeted activities throughout the mining project designed to leverage the increased economic activity brought to the area by the mining project to diversify the local economic structure with activities that can be sustained after the mine has closed. One major component in this are the high value post closure uses of the site. These should be designed early in the project, involving local stakeholders as much as possible for best outcomes. These planned activities then guide all design and closure activities, acting as a vision of the post closure site. This also forces all stakeholders to view the mining operation as a project of a limited, although long, duration, designed to leave behind a positive legacy and sustainable local benefits.

Keywords: continuous mine closure, progressive closure, post closure vision, positive legacy

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INTERNATIONAL POST-MINING SYMPOSIUM

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Waste Management in Post Mining Era for Sustainable Underground Coal Mine Closure

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Abstract

In abandoned underground coal mines, various wastes such as backfill materials, machinery, oils, PCB, and support materials pose environmental risks, particularly during the post-mining process as mine water levels rise. This study provides a comprehensive review of waste materials, their sources, and the challenges encountered in coal mining. It offers insights into the interactions between waste and mine water during rebound, crucial for mitigating adverse impacts on surface and groundwater.

Drawing from experiences in the Ruhr area, Germany, where mine water has risen during water level rebound for decades, the study utilizes the in-house DMT mine water program (Boxmodell program) to predict water dynamics, chemistry changes, and contaminant evolution. Findings reveal insights into water-waste interactions and contaminant transport in the post-mining era. Utilizing knowledge gained nationally and internationally, support is offered for planning mine closures globally, ensuring environmental protection and sustainable practices.

Keywords: Waste in underground coal mine, BOX Model, Mine water level Rebound

INTERNATIONAL POST-MINING SYMPOSIUM

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Post-Closure Mine Land Use: Perspectives from South Africa

Herman Cornelissen[1], Hakan Arden Kahraman[2]

ABSTRACT

South Africa has a long history of mining and presents numerous examples of interesting options for alternative land uses after mine closure. While these projects have not always been successful, all of them serve as examples. As with all mining towns and mines, the mineral resource is eventually exhausted and the community that is left behind must deal with the remnants of mining, regardless of how well the reclamation was done. This paper presents some of the more creative post-closure land uses that have bene employed in South Africa and draw conclusions from the author's observations to share these experiences and to provide insights to others.

Keywords: mine closure, post-mining land use, South Africa, land use

Introduction

This paper provides a perspective on post-mining land use in South Africa. As a country with a long history of mining, South Africa has also had its share of mine closures - both successful and less successful. While most mine closure projects attempt to simply restore the land to a state as close as possible to the pre-mining natural environment, there is always some natural capacity loss. However, South Africa has also been a host to many examples of more creative end land uses for mining land after closure. The purpose of this paper is to share these experiences in the interest of professional development and perhaps inspiration to practitioners in the field.

A Synopsis of The History of Mining in South Africa

Mining has a rich history in South Africa and, indeed, in Africa. There are records of pre-historical mining having taken place in southern Africa since before the early Bronze Age [1]. Early European settlers to the Cape recorded native accounts of copper mining and readily discovered tin and silver in the vicinity of Cape Town. The systematic exploration of the country started towards the end of the Industrial Revolution as coal supplies in Scotland dwindled and the immigration of Scottish and English miners, geologist and engineers to South Africa increased [2]. The discovery of diamonds in Kimberley in the mid-1800's led to an immediate diamond rush, which drew even more geologists, explorers and adventurers to the country, resulting in the discovery of gold in short order and eventually, the world's largest known deposits of Platinum Group

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Metals (PGM's). This vast treasure trove of minerals has driven the country's economic and industrial development for over a century until the 2000's. While mining has declined as a contributor to the economy since then, it remains an important employer and South Africa remains the largest known global source of chrome, PGM's and manganese.

This history of mining has left the country with a legacy of an estimated 6,000 abandoned mines. The legislation guiding mine closure in South Africa has kept pace with others in the world. The country's legacy of old mines and the results of past practices of mining and closure and mine land abandonment is not unique to the country. In this context, the country has seen its share of creative end land uses after mine closure, and it is from these examples that lessons can be drawn.

Mine Closure and Alternative Mine Land Uses

Mine closure is a well-regulated and fairly generic process around the world. Institutions like the International Standards Organization (ISO) International Council for Mining and Metals (ICMM), International Finance Corporation (IFC) and others have published well-known guidelines for mine closure [3], [4], [5]. The overarching principles of responsible practice and shareholder interest in maintaining a good public image are strong driving forces of good corporate behaviour and responsible mine closure, especially for the larger mining houses.

Post-mining land use is, however, not regulated by law, regulation, or any other form of guidance. The concept is clear, but the goals remain vague. Terms like "alternative land use" or "acceptable end land use" are often quoted, but rarely clearly defined. In many cases, the approach of governments is to not define the end goal of mine closure, but rather the objectives of what mine closure must achieve. In doing so, governments often reason that the use of the land after mining and agreement on acceptable alternative land uses is the responsibility of the mining company in consultation with the affected community.

In most cases, mines choose to simply return the affected land as far as possible to its natural state. In recent years, the concept of biological offsets has also emerged. The concept of offsets acknowledge that the productive capacity of mined land cannot be fully restored, so offsets provide a basis to calculate and negotiate terms where some other piece of land is improved to offset the irreparable damage done to mined land. Nevertheless, the legislation and guidelines hardly ever challenge mines and communities that are affected by mining to do anything creative with the mined land after closure. It is the responsibility of the mine to seek these opportunities and to do something more creative than to simply plant vegetation to return the land to grazing land or agricultural use.

This paper looks beyond what is normally done at mine closure to some more creative land uses. Several examples of such creative land uses after mine closure from South Africa are used. These examples will hopefully inspire more such creative end land uses after mine closure and for both miners, communities, academics and the service industry practitioners to look more creatively at old mines as potentially valuable assets.

Examples of Creative Post-Mining Land Use From South Africa

The following examples from past projects in South Africa serve to illustrate the options of what to do with abandoned mine land or closed mines:

Mines as Places for Storage

In the first place, mines have been used as places to hide important things, even temporarily. In this application, we have the record of Sir Winston Churchill, who would go on to become Prime Minister of Great Britain, who had to hide in a coal mine during his flight from the Boers during the Anglo-Boer war in 1902 [6]. In later years, the Apartheid government of South Africa used coal mines to store the country's strategic oil reserve during the sanctions and oil embargoes of the 1960's [7]. The use of old mines for oil storage is a well-known practice in several countries.

Mines as tourist attractions and for selective farming applications

The historical diamond mining town of Kimberley is home to the Big Hole, which remains as a monument to the mining that started there and an interesting museum, is also now a regional centre of commerce and government. Underground, investigations have found that both the temperature and humidity remain stable and this creates a viable growing space for mushrooms to grow. The underground tunnels and mine voids were developed and used for years to grow oyster mushrooms in the old mining excavation under the city for the local market[8], [9].

Diepkloof in the Mpumalanga province was once the site of a large underground asbestos mine. The block cave mining method allowed the asbestos to be mined out to surface. After mining stopped, the cavity naturally filled up with water. Following the rehabilitation of the asbestos dumps around the site, a minor investment in capital has developed the site into a top-class international training site for nitrox and technical divers [10].

Other Uses of Mines After Closure

The create end land uses of mines following their closure includes several other mines which are currently operating as facilities with a useful economic purpose other than farming or grazing land. These include:

a. Kleinsee, a former diamond mining town developed by De Beers which had its ponds repurposed for marine aquaculture to farm seaweed and shellfish [8].

b. AngloGold West Wits Mine, where the old gold processing ponds were redeveloped into a fish farm for decorative aquarium fish [8].

c. The former Bellville Stone Quarry, which was developed as a shopping mall and waterfront properties, after being used in the past as a jail and a cycling track [11].

d. The former Pretoria Stone quarry, which was redeveloped as a retirement estate [12].

e. The SWAT shooting range in Pretoria, which was developed on a former mine dump. [13]

Other post-mine land uses are still in concept or development stage or are under consideration. South Africa is home to the deepest mines in the world, and these already have water pumping infrastructure to allow for cooling underground. Facilities such as these have potential and are being investigated for development as ultra-deep underground pumped energy storage facilities to help with the current energy crisis in South Africa [14].

Of course, not all such developments are successful. Examples are also on record of the redevelopment of former mines in or near town into useful facilities for the community that fail due to lack of maintenance or lack of skills or lack of funds to maintain the facilities that have been developed. The case of the old Mill site redevelopment at Prieska is one such example [15].

The Acceptability of Post-Closure Land Uses

From the best international practice, it is clear that mine closure is a known and regulated process all over the world. The state of the environment and the infrastructure left behind after mining, affects a community that is decades older than the mine's original planning and development. In today's rapid consumption culture, social media is a formidable force with the ability to rapidly influence public opinion. The right decisions about mine closure require careful consideration and an acute awareness of the social acceptability of feasible options for land use after closure. The utility of the mine infrastructure will be measured by the current generation, not the former generation that opened the mine.

A mine site that delivers utility after closure, and in full compliance with modern social norms, has the best chance of sustainability. This requires the building of capacity outside of mines in a deliberate effort, involving mining companies, state institutions and civil society. With this consideration, an argument could be made that mining people may not have the right skills to determine appropriate social media campaigns, skills transfer to municipalities or utility structures, and long-term maintenance of post-mining facilities after closure.

This consideration brings two perspectives on success factors of post-mining land use: Critical Mass and Span of Control. Let us expand on these as follows:

Critical Mass

Mining towns often "create themselves", meaning that the presence of the mine attracts other industries and services and more people to the area that have nothing to do with mining, e.g.: schools, daycare, clothes retailers, funeral undertakers, hairdressers, universities, etc. The industries diversify and eventually include all the services that normal towns have. This creates opportunities for diversification and re-integration of the post-mining infrastructure into the economy. The longer the town exists and the larger it grows, the more diversified its economy and the higher the land value, the more potential uses it will offer for the mine's infrastructure to be redeveloped after closure.

The capacity of institutions and professionals in the community around the mine also develop to provide the skills that can help to re-integrate the post-mining land use back into the remaining town.

Span of Control

Mining houses contemplating mine closure must consider which aspects of the post-closure land use is in their control and which are not as they approach closure and consider post-mining land use options.

Most often, the mining company has direct control over:

a. The physical properties of infrastructure and landscape features that are left behind. If a clear plan for closure and life after mining exists, the mine may take actions to contour the landscape and leave such building as aid in the redevelopment.

b. In considering the design for alternative end states of the mine and alternative uses, the mine planners can choose to remain flexible and leave certain options open to later action, once the demand for the mine land is better known.

c. The mine can also employ the right people or use creative planning events, like design competitions involving local schools or other entities to develop ideas for alternative land uses after closure of the mine.

d. Preparation of the financial, human resource and institutional support structures after closure. It is common practice that mines had over some assets to local entities like municipalities, thus reducing their liability. Most often, however, consideration of the ability and capacity of those structures to maintain the assets over the longer term is overlooked.

e. Understanding the accounting trade-offs. Mines have the ability and capacity to calculate the differential costs of various closure options and to avoid certain closure costs by redirecting assets to other uses and selling them to other users.

An aspect of the post-closure land use that is reasonably, but not completely within control of the mining company is the community's acceptance of the preferred end land use option. In this respect, mines can manage expectations through continuous engagement. The acceptability of a chosen end land use can be significantly improved with pro-active engagement of the affected community.

Aspects that are beyond the control of the mine as it relates to closure, is the legislative and regulatory system that allows for alternative land uses. Most governments are receptive to alternative end land uses, provided that sustainable value is delivered.

Discussion

In all the examples from South Africa that were presented here, several factors are common and serve to illustrate the more and less effective strategies for sustainable alternative land uses after mine closure.

First, in the successful cases, there was a clear use case, driven by an economic opportunity. The surrounding community presented a market large enough to support the alternative land use.

Second, the mine worked closely with the community to understand their needs and made a concerted effort in engagement, providing alternative employment and in providing capital and securing the right knowledge to redevelop the former mine assets to other uses.

Lastly, where these end land uses have failed, it is because of a lack of capacity to maintain the post-mining features, no communal interest in the post-mining solution, and an absence of income generating potential from the post-mining solution.

No cases are recorded where governments or other entities opposed creative end land uses for mines after closure.

Conclusion

In summary, the identification of alternative, creative and sustainable end land uses after mine closure is the result of a deliberate effort on the part of mines, within an enabling environment, and with the guidance and acceptance of the remaining community. Many examples of sustainable post-closure end land uses are presented here. In all cases, a specific alternative land use was found with a clear understanding of market demand. Mines must ensure that they employ the right people, and the right skills set to plan for such closures. Mine operators are also well advised to remain cognisant of their span of control in these considerations. With regard to critical mass of the town and economy that has developed around the mine during its operating year, neither the mine nor the community or government has control over this but is does have bearing on the scope of potential alternative uses that may be feasibly considered.

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INTERNATIONAL POST-MINING SYMPOSIUM

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TUMAD Mining: Rehabilitation and Reintegration into Nature in Operations

Naim KARTAL

ABSTRACT

TÜMAD Mining, as the first Turkish mining company in Turkey, operates in full compliance with the International Cyanide Management Code through its two facilities. It carefully evaluates and monitors the decommissioning, closure, and rehabilitation processes of Heap Leach and Dry Waste Storage Areas, in line with Environmental Impact Assessment (EIA) commitments and Responsible Mining Principles. The company places great importance on pre-operational conditions, biodiversity, and visual impacts, implementing control and monitoring during the operational phase and conducting rehabilitation efforts in areas where activities have ceased. Upon completion of production, TÜMAD adheres to its principle of restoring areas in a manner suitable for their habitats, as initially planned before mining activities began. The company has developed relevant plans and procedures for the closure of cyanide-using areas, ensuring these processes are insured and financially secured, while aiming to effectively manage the decommissioning, closure, and rehabilitation of its facilities using appropriate methods.

Keywords: Mining, Gold Mine, Rehabilitation, Biodiversity, Mine Closure Plan, Heap Leach, Dry Waste Storage Area

INTRODUCTION

TUMAD Mining is a 100% Turkish capital mining company established in 1989 under Nurol Holding for aggregate production. In 2011, the company entered the metallic mining sector and began searching for licenses, acquiring the Ivrindi Operation license in 2012. In 2014, it acquired the Lapseki Operation license, expanding its exploration activities, and after completing the construction activities following the environmental impact assessment (EIA) processes at the Lapseki Operation, it achieved its first gold pour in 2017. Simultaneously, TUMAD conducted construction activities at the Ivrindi Operation, completing them in 2019 and achieving its first gold pour. Both projects were financed by the EBRD (European Bank for Reconstruction and Development) and are audited by independent auditing organizations. As the first Turkish mining company in Turkey, it operates two facilities fully compliant with the International Cyanide Management

Code and is meticulously evaluating and monitoring the closure, rehabilitation, and reintegration processes of its Heap Leach and Dry Waste Storage Areas in line with its EIA commitments and Responsible Mining Principles. It emphasizes pre-operation conditions, biodiversity, and visual aesthetics in mining activities, ensuring control and monitoring during the operation process and working to reintegrate areas back into nature after operations are completed. TUMAD adopts the principle of implementing closure and rehabilitation activities that are suitable for habitats, as planned before mining, after mining activities are completed. The company has developed relevant plans and procedures for the closure of areas where cyanide is used, executing these processes with insurance and cost coverage while aiming to carry out the closure, rehabilitation, and reintegration of facilities using appropriate methods.

1.RehabilitationProcesses

Rehabilitation and closure plans are assessed under five headings.

1.1. Physical Stability: After the closure of the mine, the open-pit walls, waste dump slopes, and waste storage/heap leach steps will be physically stable in the long term. The slope angle will be rearranged for long-term stability conditions through additional excavation or blasting.

1.2. Chemical Stability: During the mine closure period, project units such as waste, pit, and waste storage/heap leach facilities will be arranged to ensure chemical stability. If project units do not meet chemical stability requirements, additional mitigation measures will be developed.

1.3. Compliance with Regulations: Rehabilitation plans for forests, pastures, and public properties will be submitted and approved before starting to use the land for mining purposes, and these areas will not be improved without the knowledge of the local administration.

1.4. Land Use and Visual Richness: Despite the absence of legal obligations, the visual richness of rehabilitated mining areas is significant. The rehabilitated areas are especially utilized by the local population. Enhancing the visual appeal of rehabilitated areas is also important for the company's reputation.

1.5. Human Health and Safety: The primary objective of rehabilitation is to ensure the long-term protection of the health and safety of local residents, considering the principles mentioned above. Through the control and management of all these headings, closure activities can be conducted sustainably.

2. Operational Controls

• The Dry Tailing Storage Area (TSF) for the Lapseki Gold-Silver Mine and Concentration Facility will complete its usage period at the end of operations and will undergo closure work. The area will be closed once fully filled. The objectives of the area closure include:

- Reducing environmental damage and completely preventing it where possible.
- Restoring the land to its initial use or an acceptable alternative use.

• During the closure of TSF, cyanide levels, reduced to below limit values through the INCO SO2 air process, will also meet the discharge criteria specified in Table 7.1 of the SKKY (WPCR). At the same time, WAD cyanide levels will be reduced to 10 mg/l or lower as specified by the EU Directive 2006/21/EC. The area will be graded, covered for rehabilitation, and natural drainage will be restored. A geosynthetic clay will be laid to ensure impermeability, with a buffer layer thickness of at least one meter. A drainage layer will be created to drain rainfall and prevent seepage into the closed waste area. To achieve compatibility with the environment upon closure, a fertile topsoil layer will be applied to facilitate greening.

• The heap leaching system at the Ivrindi Operation will operate under a zero discharge principle during both operating and closure periods. The existing drip system will be used to wash the heap with clean water, ensuring that cyanide and other component levels within the heap, which has a pH of 9.5-10, are reduced. This process will also consider the needs for hydrogen peroxide (H2O2) and chemical treatment.

• The heap being washed will have WAD cyanide levels reduced to 10 mg/l or lower as specified by the EU Directive 2006/21/EC. During the closure phase, the side slopes of the heap will be reshaped and sloped again.

• The upper cover used to ensure impermeability will consist of a buffer layer and a clay impermeability layer. A drainage layer will be placed over the impermeability layer, topped with at least 10 cm of topsoil.

• After the upper cover is established, planting will be done to support the growth of local plant species.

Regular sampling and analysis will be conducted based on the groundwater monitoring program from observation wells opened in the source and downstream areas for heap leach monitoring.

• Water quality monitoring will be conducted in the heap leach area and surrounding surface waters, covering both the operating and post-closure periods. Regular monitoring activities will be conducted from the lower drainage collection system to detect any seepage in the heap leach liner material.

• In the Waste Storage Area where mining has been completed, if Acid Rock Drainage is not expected, the area will be graded and covered with topsoil for reintegration into nature.

• Two types of reintegration processes will be applied in Open Pit operations after mining is completed:

a) Open Pit Lake

b) Backfill System

• In the closure processes of the Dry Waste Storage Area and Heap Leach Area, once activities are completed and treatment processes are finalized, a geomembrane and clay impermeability layer will be created, followed by a drainage layer, and appropriate thickness of topsoil will be applied for reintegration into nature.

• An Emergency Plan has been developed for unexpected situations that may lead to temporary or permanent closures in TUMAD Mining operations. Additionally, the closure guarantee insurance provided by the International Cyanide Management Code (ICMC) certification held by both operations ensures that these matters are covered. With this certification, the closure costs of the operations are insured, ensuring that all necessary safety and closure conditions are met in case of any adverse events. According to the Emergency Plan, the first phase involves reassessing closure activities and identifying critical tasks. Upon completion of closure, closure activities will be finalized according to the Mine Closure Implementation Plans.

3. Unexpected Situation Action Plan

3.1. Conducting assessments to determine the status of the operational area (to identify environmental risks).
3.2. Removing and washing all mobile equipment and machinery from underground and open pit operations and parking them upon cessation of mining.
3.3. Protecting groundwater levels and continuing monitoring.
3.4. Continuing surface water controls and monitoring.
3.5. Maintaining the security of the site perimeters, including access control.
3.6. Processing remaining ore stocks if possible.
3.7. Cleaning ore stock areas, conveyor systems, and crushing and screening facilities, ensuring all areas are cleaned and washed before equipment lubrication.
3.8. Returning excess stored materials, oils, fuels, chemicals, and spare parts to suppliers if possible.
3.9. Ensuring all water pools have sufficient capacity to handle the worst-case scenario of maximum rainfall over 24 hours for a hundred years.

3.10. Keeping buildings and infrastructure operational, including main access roads.
3.11. Activating the Emergency Action Plan if any serious environmental or safety issues are detected according to monitoring results, including ensuring compliance with procedures and instructions for the potential departure of workers.

Afforestation (Rehabilitation) Activities in Decommissioned Areas

Hydroseeding Activities for Visual Impact Improvement

Recreation Activities in Decommissioned Areas

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INTERNATIONAL POST-MINING SYMPOSIUM

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Sustainable Compliance Of Post Mining Nature Reinforcement Activities

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ABSTRACT

Upon completion of mining operations, very large soil-free lands are formed through stockpiling of residues of rock fragments (waste rock) are extracted from open pit mines and don't have the value of mine minerals- as huge hills. Vegetating the slopes of open-pit mines, whose operations are completed, the slopes of hills that are formed through stockpiling of waste rock or slopes, which are formed through refilling materials into the opened holes, is a very important process both in terms of stability and in terms of returning the area to the nature and speeding up the process of getting the damaged ecosytem back to its previous condition. The biggest obstacle in returning these slope piles and the bare excavated lands, back to the environment which are open to erosion and landslide, the incapability of holding the plant nutrients and water which will contribute to the soil formation and is needed by plants to survive. Both direct main rock surface and the lands formed of small and large pieces lack the soil which is capable of holding water. It's necessary to vegetate the land first with floor shutters to protect the particles from erosion and to promote soil formation. These particles join the environment as a result of physical decomposition of rock pieces and they have the ability to hold the water. For the efficient and sustainable harmony of reintroduction activities to nature, it is very important to reclaim every element of the environment, from biodiversity to soil, from air to water. This presentation is aimed to providing information about the environmental performance management required to ensure sustainable compliance of post-mining nature reinforcement activities.

Keywords: soil free lands, waste rock storage area, biodiversity, sustainability, nature reinforcement, environmental performance management

INTRODUCTION

The main cause of environmental problems is the disruption of the ecological balance that exists in the world, mostly by human beings. All industrial activities, including mining, which play an important role in this degradation, have a temporary and/or permanent impact on the environment. It is imperative to restore an area that has been degraded due to improper land use and industrial activities to an environmentally stable state in order to ensure that a clean environment and natural resources are passed on to future generations. However, when a degraded area is left alone, it may take many years for it to regain ecological balance and repair itself. Human assistance is needed to reintroduce these areas to nature within a suitable period of time

[2].

Mining and agriculture are two of the most important elements that provide raw material needs for countries. In every period of life, the mining sector has been seen as one of the important factors that increase the welfare levels of countries. For this reason, laws have been enacted for its utilization regardless of the characteristics of the area where it is located, or articles have been added to existing laws for its authorization. However, despite its contributions to the economy, it has often been criticized for its environmental damage. Preventing or minimizing the direct and indirect damage of mining, which continues in this economy-ecology dilemma, on areas of agricultural or natural importance should be seen as the first step to be taken.

Mining is carried out by open pit mining and underground mining methods. Open pit mining is the oldest known mining method. Open pit mining is the method of operation of ore deposits that are economically feasible to be mined by directly excavating the outcrops or by removing the covering layer and then producing the ore. Today, this method is used in approximately 70% of the world's mineral production. Half of metallic ores, 1/3 of coal and all non-metallic construction materials are produced by this method. The direct impact of open pit mining on the environment is the destruction of soil and vegetation and land degradation [3]. It is more effective in terms of surface destruction compared to the underground mining. In open pit mining, the natural structure is affected due to the direct disturbance of the ground for extraction and the storage of the materials that have no economic value.

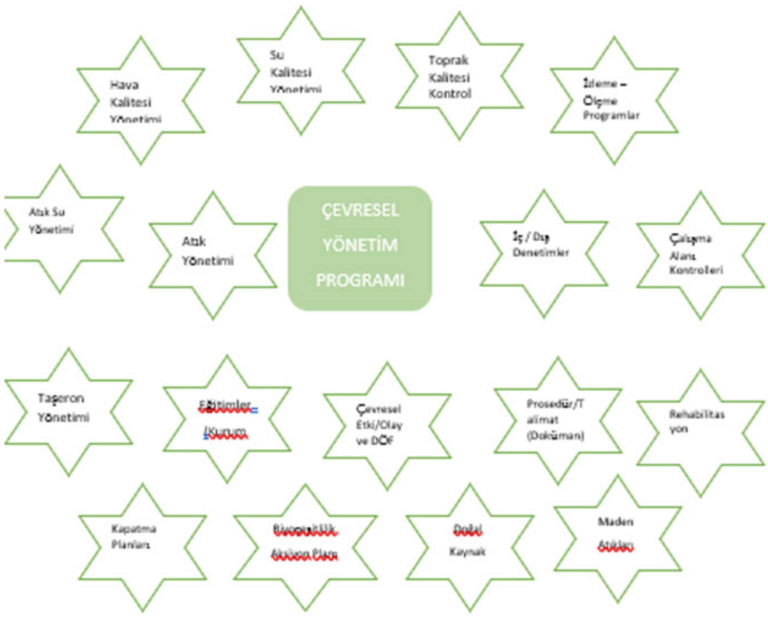
lthough mining activities are increasing day by day, unfortunately, reclamation activities in the mines where mining activities have been completed have not been given the same importance. Recently, obligations and comminments have been imposed on enterprises engaged in such activities within the scope of environmental legislation. Thus, reclamation activities, which have been ignored until today, have started to gain importance. Especially in such studies, the examples of which are increasing in our country, it is of great importance to determine the methods of planting on soil-free lands and the processes related to appropriate methods.

The methods and success rates of reclaiming the area left behind during or after mining activities vary at sectoral level. Depending on the geological structure, some mines are excavated and the material is taken out of the area, while others are left behind after the ore is extracted as a result of some processes. In both cases, the topographical shape of the area left behind and the physical and chemical interactions with the soil or vegetation are different. Disturbance of the topography creates problems in terms of both de-soilization and ground stability. This situation makes it very difficult to restore nature of the area. Figure 1.2 shows an image of a waste rock storage resulting from the excavation and removal of material.

Figure 1 Acacia Gökırmak Copper Mine Waste Rock Storage Area

Nature reclaiming work in areas disturbed by mining activities should be more than a remediation effort; it should be an effort to re-establish the degraded ecosystem.

Reclamation/rehabilitation of areas degraded by mining activities to nature should not be considered as the last step. On the contrary, it is of great importance to identify all environmental impacts that may occur in the area when mining activities are started to be planned and to determine the necessary corrective and preventive actions to minimize these impacts and to implement them during the operation. The identified corrective and preventive actions should be categorized as project phase, operation phase and post-operation phase and should be implemented at every stage of mining. In this way, the negative impacts that may be given to the environment during the mining operation and the recovery of raw materials can be minimized, and it will provide important facilities for the restoration of the degraded area to nature after the mining activity. For this, Environmental monitoring program and Environmental field studies are of great importance at every stage of mining activities. Monitoring of all environmental impacts such as Air Quality, Water Resources, Waste water, Sediment transport, Monitoring of ARD/AMD potential, Noise / Vibration, Biodiversity, Soil Quality, Hazardous / Non-Hazardous waste generation, etc. in pre-construction - construction phase - operation - closure and post-closure periods and minimizing the negative impacts detected are very important for the realization of a sustainable nature reclamation.



Environmental Management Program

Important Criteria for Ensuring Sustainable Adaptation of Nature Reclamation/rehabilitation Efforts

Importance of TopSoil

Mining activities are carried out in the area where the ore is located, the land qualities in the mining areas vary. The storage of the topsoil stripped from each activity area, especially in the area close to the mining area, and the use of the topsoil stripped from the relevant area in the rehabilitation works of each area will minimize the changes in soil qualities. It is extremely important to comply with the necessary criteria to ensure the stabilization of the storage area of the topsoil, to prevent transport by rainwater and the formation of crevices, to prevent slipes and to preserve its vitality. In addition, it is necessary to carry out soil quality analyzes, including microbiological soil analyzes, at every stage in terms of monitoring.

Importance of Biodiversity Studies

In this context, one of the most important studies to be carried out for a sustainable rewilding is to determine the biodiversity of the area before mining activities and to ensure that rewilding activities are carried out in a site-specific manner. For this purpose, biodiversity studies to be carried out in pre-construction - construction phase - operation - closure and post-construction periods, especially in accordance with both EIA commitments and IFC PS6 standards, will be beneficial in terms of ensuring the continuity of the ecosystem specific to the area after mining activities.

* Endemic species identification, seed collection, delivery to the gene bank, translocation and conservation area creation

* Nursery installation

* Tree translocation

* Identification and removal of invasive species

* Ensuring that fauna individuals with low mobility are translocate to suitable areas

* Identification of crossing areas for animals

* Artificial nests in safe areas far from the activity area

* Biodiversity Action Plan and BAP Monitoring Studies etc.

Examples of Acacia Mine Biodiversity Studies

Transplanting the excavated clumps of Dianthus Varankii species into pots (Flora Studies)

According to the findings of Biodiversity Monitoring Studies conducted with expert biologist academics in 2023, as part of in-situ conservation efforts in the autumn of 2019, 15 clusters of the regionally endemic plant species *Astragalus kastamonuensis* were removed from the Pasa Storage Area and transplanted to an area designated as the “Endemic Plant Conservation Area.” It was observed that the success rate of this translocation was extremely high, with all 15 clusters successfully continuing to live, blooming, and remaining healthy. Therefore, the in-situ conservation efforts for Astragalus kastamonuensis through translocation were evaluated as highly successful (100% successrate).

Before initiating activities, the area should be monitored for its flora and fauna. This includes ensuring the translocation of endemic species from the area, establishing conservation areas, setting up greenhouses for the production of species specific to the area, and using these species for restoration efforts. These measures will significantly contribute to the continued vitality of the local flora even after the activities are completed.

Endemic Plant Protection Area

Photographed in the wetland of the mining site, the Great Egret (Casmerodius Albus) (Ornithological Studies)

Installation and Monitoring of Artificial Squirrel Boxes (Fauna Studies)

As part of the Biodiversity Monitoring Plan, flora, fauna, and aquatic ecosystem monitoring activities are conducted at least twice a year by expert biologist academics in their respective fields. The reports prepared are submitted to the Sinop Directorate of Nature Conservation and National Parks.

Within the framework of biodiversity studies to be conducted during the pre-construction, construction, operational, closure, and post-closure phases, the use of camera traps is an important monitoring tool. These camera traps allow for the tracking of fauna individuals at each stage of mining activities and enable the evaluation of the ecosystem's revitalization process following restoration efforts.

After the closure of mines and restoration efforts, the creation of small water ponds in the areas is considered one of the effective practices for revitalizing the ecosystem.

The Importance of Applications that Assist in Rehabilitating Soil-Free Lands in Nature Restoration
Following mining activities, especially the accumulation of non-mineralized or processed waste rock fragments (waste rocks) from open-pit mines in large mounds, vast areas of soil-free lands are formed (Figure 1.3). The planting of slopes on these soil-free lands, which are left as mounds or filled into pits after the completion of open-pit mining operations, is a crucial step both for stability and for the restoration of the area to nature, as well as for accelerating the process of ecosystem recovery. These mounds, which are susceptible to erosion and landslides, present the greatest challenge to restore the bare excavation surfaces to nature due to their inability to retain essential plant nutrients and water needed for the growth of vegetation that contributes to soil formation. Surfaces consisting of either bedrock or large and small rock fragments lack soil that can retain water. The capacity of soil-less grounds to retain water is directly proportional to the increase of colloidal-sized particles in the environment. However, plant-free surfaces and sloped topography lead to erosion, and as a result, fine materials are carried away since they are the easiest to transport. To prevent erosion and encourage soil formation, surfaces need to be planted with ground cover plants, which can protect the fine particles that can retain water. However, the planting of soil-less grounds faces significant challenges.

Figure 2: Waste Rock (Non-Economic Rock) / Waste Rock Surface

The most suitable method for planting soil-free grounds in open-pit mines to prevent erosion involves identifying plant species that will provide the quickest results in these types of grounds, as well as determining the supporting materials and substances that will accelerate planting in such soils. Establishing trial areas before the main studies and identifying the most suitable plant species, special planting methods, and auxiliary materials/substances based on these trials will significantly contribute to slope stabilization and the rehabilitation process.

In a 2016 Master's Thesis titled " Vegetation Implementations on soil-free lands in open-pit " the slopes of waste rock areas and the slopes of areas that had been backfilled with waste rock material from completed open-pit mines were selected. In the study, a total of 23 trial plots were established across 3 different areas with varying slope and soil characteristics. In the trials, hydroseeding, synthetic, and natural plant fiber seed mats were used. The results of the study concluded that it was necessary to use planting materials to prevent the erosion of small water-retaining particles found in small amounts within waste rock and rubble areas. Additionally, the germination and growth success rates were compared based on soil conditions and seed varieties. [4]

- Hydroseeding Materials (Mulch, Fertilizer, Soil Bacteria)
- Synthetic Seed Mat
- Organic Seed Mat

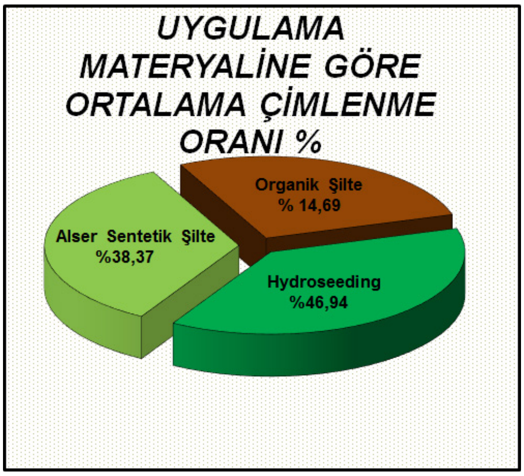
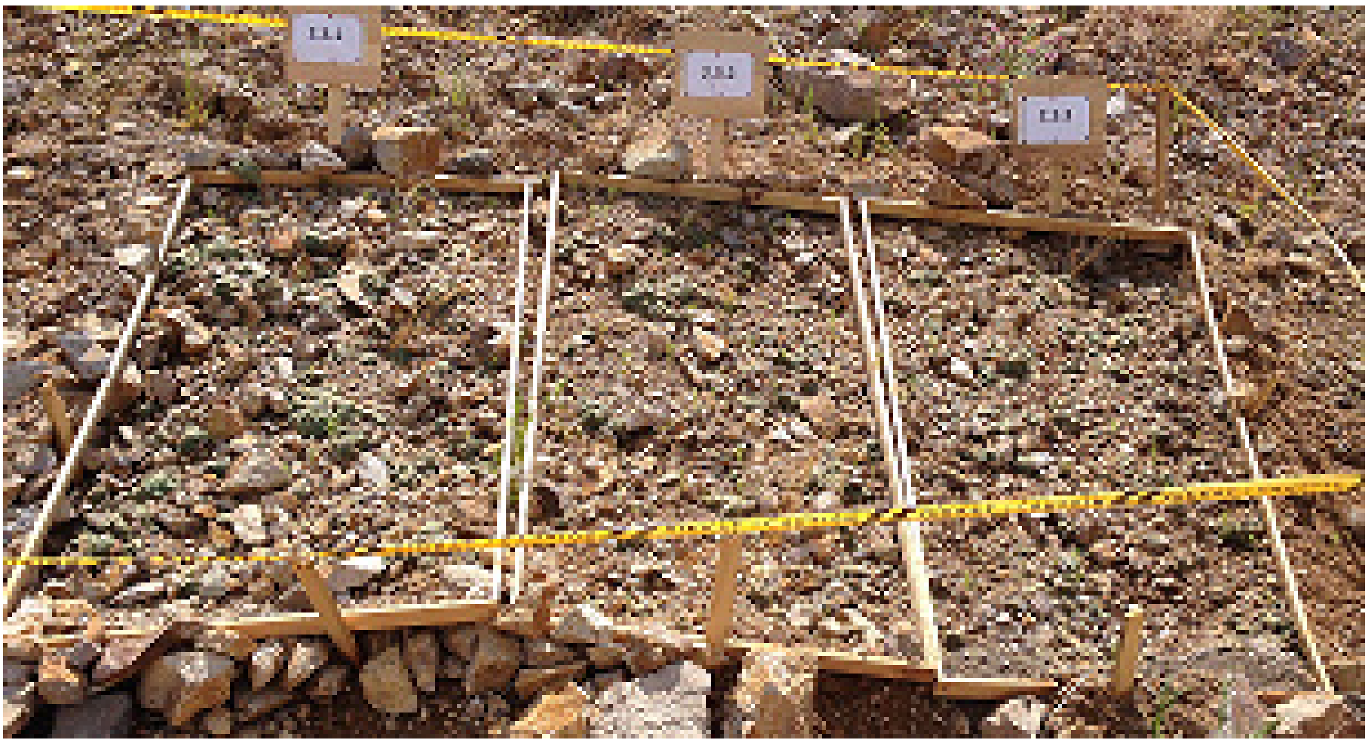


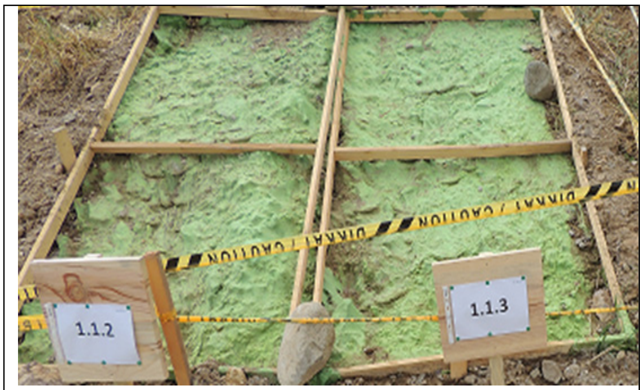
Figure 2 - Proportional distribution of average germination according to application material

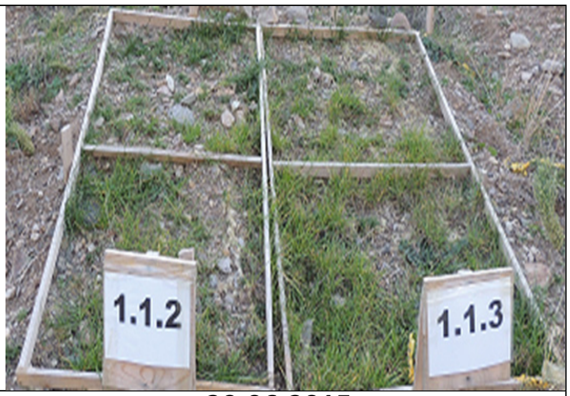
Studies have shown that the use of application materials has been highly beneficial in ensuring that plants and seeds blown into the area by wind (with the support of nitrogenous water irrigation and the opportunity to grow alongside other plants) remain in the area, leading to high germination and growth rates. It was observed that in the natural surrounding areas of the test plots, plant coverage was much more sparse compared to the areas within the plots. It was also found that on surfaces left to nature, soil formation would be delayed, and erosion would be highly effective. Therefore, it was concluded that accelerating planting and using seed application materials (hydroseeding and seed mats) to keep small surface particles formed by decomposition and wear in place is very useful.

Slope of the Waste Rock Area – Application Studies



Slope of the Waste Rock Area – Soil-Free Land





19.06.2015 | 30.06.2015

Synthetic Seed Mat Application

19.06.2015 | 30.06.2015

Organic Seed Mat Application

Hydroseeding Application - 30.06.2015

In the studies, the **hydroseeding** method was determined to be the most suitable among the seed sowing systems used, due to its ease of application, ability to be applied to hard-to-reach areas (such as steep slopes), and its higher germination rates and plant development compared to other systems.

Slope Effects

Applying seed sowing systems in sloped areas is more challenging, and the germination and plant development rates tend to be lower. Therefore, for soil-less grounds formed due to open-pit mining activities, organizing the slopes with a 30-33 degree angle and terracing before rehabilitation will enhance the efficiency of vegetation efforts and ensure slope stability.

Climate Effects

Before planting soil-free grounds in open-pit mine areas, the climatic characteristics of the area should be evaluated based on past meteorological data. This will allow for the selection of suitable seed sowing systems and seeds that are adapted to the local climatic conditions, which in turn will increase germination and plant growth rates in the area.

Seed Quantity and Irrigation Plan

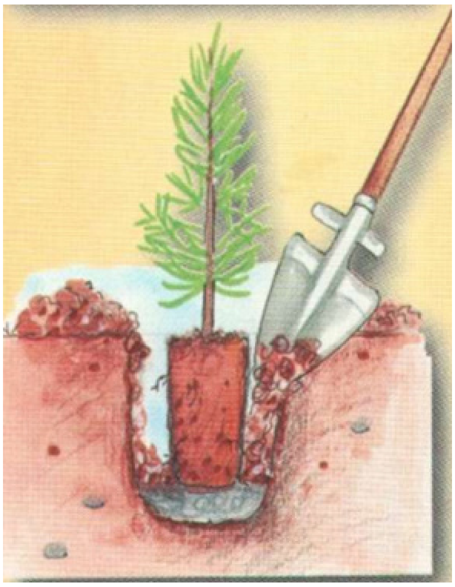
Before planting on soil-less grounds in open-pit mining areas, it would be beneficial to conduct a skeletal analysis using soil samples taken from the area. By doing so, in areas with a high proportion of large material, the amount of seeds can be increased, which will improve germination and plant growth rates.

Furthermore, based on the results of the skeletal analysis, particularly in areas with a large material composition, it will be suitable to increase the irrigation periods due to the high likelihood of water flowing into the material through cracks. In these areas, seed mats should be considered as the first option.

The contribution of auxiliary materials used in the revegetation of soil-less grounds in open-pit mines to germination and plant growth, as well as their costs, has also been examined. Since labor and application services for seed sowing systems can vary depending on the site characteristics and conditions, it would be more suitable to conduct an economic evaluation after determining the labor costs specific to the ground and area.

· **Tree/Sapling Planting on Soil-free Lands**

- Soil Analysis
- Selection of plant/sapling species
- Fertilization and supplementation for root development
- Ensuring water retention in the planting area
- Irrigation water quality



- Covering the planting hole with topsoil
- Adding mineral fertilizers, mycorrhiza, etc., to meet the needs of the sapling's roots
- Covering the top with topsoil
- Adding supplementary fertilizers and minerals needed for the sapling's roots in the initial phase
- Placing the sapling into the hole
- Covering with vegetation

One example of a hydroseeding application that has successfully rehabilitated an area and revitalized the ecosystem in a short period is the Çorakoğlu Waste Rock Storage Area Rehabilitation carried out at Acacia Mining Operations Inc.'s Gökırmak Copper Mine.

With the start of mining activities, from March 2017 to June 2022, a total area of 1,550,000 m² was used for Waste Rock Storage at the Çorakoğlu Waste Rock Storage Storage Area. In 2021-2022, rehabilitation work was carried out over 1,000,000 m² using hydroseeding and manual seed scattering techniques, achieving significant success. A total of 40 tons of *Onobrychis sativa* (alfalfa) and *Vicia sativa* (vetch) seed mixture was applied during the rehabilitation efforts. The mixture consisted of 20 grams of alfalfa, 10 grams of vetch, and 10 grams of basal fertilizer per square meter. Due to the rainy spring season of 2023, the success exceeded the expected level.

Additionally, a total of 94,524 saplings were planted on the Çorakoğlu site, including 1,304 walnut, 90,608 acacia, 1,237 Scots pine, 3 tall blue spruce, 9 tall cedar, 135 cedar, 28 tall yellow pine, 50 tubed rose hips, 150 tubed yellow pine, 200 cornelian cherry, 300 almonds, 100 jujubes, and 400 wild apples.

The area has been transferred to the General Directorate of Forestry, and afforestation efforts continue in cooperation with the Forest Directorate.





Waste Rock Storage Area – 2021 (BEFORE)

Waste Rock Storage Area - 2022

Waste Rock Storage Area – 2023 (AFTER)

METHODOLOGY

- Systematic literature review on the topic of revegetation practices on soil-free grounds in open-pit mines
- Review of existing studies and synthesis of results and findings

CONCLUSION

Nature restoration activities in areas degraded by mining activities should be more than just an improvement effort; they should aim to recreate and restore the damaged ecosystem.

The restoration of areas degraded by mining activities should not be viewed as a final stage. Instead, when mining activities are first planned, it is crucial to identify all potential environmental impacts that may occur in the area and to determine the necessary corrective and preventive actions to minimize these impacts. These actions should be implemented throughout the operational phase.

The identified corrective and preventive actions should be classified into stages such as project phase, operational phase, closure&post-closure phase and applied during each phase of the mining process. This approach will not only minimize the potential negative environmental impacts during the mining and raw material extraction process but will also provide significant advantages for restoration/rehabilitation of the degraded area to nature after the activities have concluded.

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Reclamation Plan for EÜAŞ's Mining Areas After Mining Operations

Özgür Yıldırım

SUMMARY

EÜAŞ carries out electricity generation, wholesale trade, and electricity procurement activities on behalf of the public. It conducts the operation, maintenance, repair, rehabilitation, and modernization of its power generation facilities and mining areas. Additionally, it carries out the necessary technical work to make the mining sites under its legal license available for investment.

The regulation and ecological restoration of decommissioned coal mining sites are integral parts of mining activities. In this context, reforestation activities began in 1987 at the Kışlaköy Mine of the Afşin-Elbistan Lignite Basin owned by EÜAŞ, following the completion of mining operations. A restoration plan covering the period from 2011 to 2044 was prepared for this area. Afforestation efforts aimed at restoring the excavation and dumping areas of the South Aegean Lignite and Yeniköy Lignite Enterprises, licensed to EÜAŞ, started in 1991 following the conclusion of mining activities.

In this study, information will be provided about the afforestation activities carried out in the licensed areas of EÜAŞ.

Keywords: Lignite, Rehabilitation, Afforestation Activities.

Introduction

More than a quarter of the world's energy demand and approximately 40% of electricity production are met by coal. It is estimated that the known coal reserves will be sufficient for more than 200 years, based on the 1990 production data. This duration is approximately four times longer than the period estimated for natural gas or oil. Even for countries without fossil fuel reserves, coal imports are considered safer than oil or natural gas imports due to the wide availability resulting from its broad geographical distribution worldwide. For these reasons, the dominance of coal in electricity production is expected to continue increasing (Çakıroğlu 2001).

The Afşin-Elbistan Lignite Basin, which holds the largest potential among our country's lignite deposits, spans an area of 120 km² between the districts of Afşin and Elbistan in Kahramanmaraş province. Our Kışlaköy Open Pit Mining Operation covers an area of 28 km² and is situated at approximately 1150 meters above sea level.

The initial studies in the Afşin-Elbistan Basin began in 1966 through German technical assistance, in collaboration with the German company Otto Gold GmbH and the Mineral Research and Exploration Institute (MTA). As a result of systematic drilling, the first lignite deposit was discovered in 1967. Feasibility reports for the basin were prepared in 1969-1970, and investment activities commenced in 1973.

As a result of the studies and explorations conducted throughout the basin, 4.3 billion tons of proved reserves and 3.4 billion tons of mineable reserves were identified. These reserves consist of three main sectors named Kışlaköy, Afşin, and Çöllolar, along with their extensions. The Kışlaköy Open Pit, known as the Afşin-Elbistan (A) Project, represents the first open-pit operation of the basin, and it was determined that this area contained approximately 582 million tons of lignite reserves as of May 1984.

In the integrated project initiated by the Turkish Electricity Administration (TEK), the mining section was separated in 1972 and transferred to the Turkish Coal Enterprises (TKİ). TKİ began its operations as the Facility Directorate on 21.03.1972, and due to the expansion of its activities, the Facility Directorate was upgraded to the Institution Directorate on 07.04.1975.

The institution was established to evaluate the existing lignite assets of TKİ Institution in the licensed areas it owns and will own in the South-East Anatolia Afşin-Elbistan Lignite Basin, to construct and operate the facilities that constitute the mining part of the Afşin-Elbistan Integrated Project and that will operate according to the production programs, to provide required amount of the fuel necessary for energy production of the thermal power plant and to cooperate with TEK for this purpose, to establish facilities that will produce domestic fuel coal (which will provide dry coal or similar production opportunities) by utilizing low-calorie lignite and to carry out technological, economic, commercial, legal and social activities related to these issues.

The institution was connected to the General Directorate of the Turkish Electricity Production and Transmission Corporation on 06.02.1995 and transformed into an Operation Directorate. The institution was connected to the General Directorate of the Electricity Production Corporation (EÜAŞ), which was established on 01.10.2001 with the division of TEAŞ into three, and continued its activities until 30.11.2018 and has been continuing as the Afşin-Elbistan Lignite Control, Coordination and Operation Directorate since this transfer date.

As for the Yatağan and Milas Fields, with the Privatization High Council decision dated 19.02.2015 and numbered 2015/124 and the High Planning Council decision dated 30.07.2015 and numbered 2015/T-14, all remaining assets of our subsidiaries YEAŞ and KEAŞ General Directorates and the licenses covering the mining areas were transferred to the EÜAŞ General Directorate.

Reclamation

Reclamation refers to the rehabilitation of areas whose topography has changed during or as a result of mining exploration and operation activities, ensuring environmental safety and conforming to the project, and making them compatible with the environment as specified in the relevant legislation.

It is a project that involves the restoration of lands, sites, and areas degraded due to the activities of investors, operational processes, and entrepreneurs. The project includes ensuring biological sensitivity, carrying out necessary corrective measures, spreading plant soil, planting vegetation, sowing seeds, creating recreational areas based on the characteristic features of the land structure, and preparing the necessary landscaping (vegetation and afforestation) processes within a planned framework.

According to the Regulation on the Reclamation of Lands Degraded by Mining Activities, issued by the Ministry of Environment, Urbanization, and Climate Change in December 2007 and revised on January 23, 2010 with the number 27471, obligations have been made mandatory to eliminate the damages caused by mining activities in forest and non-forest areas and to ensure the rehabilitation of abandoned sites.

In mining activities conducted outside areas classified as forests, operators are required, in addition to obtaining Environmental Impact Assessment (EIA) permits of all scopes, to prepare a Reclamation Plan/Environmental Management Plan (for minerals such as sand, gravel, etc.) and to commit to implementing this plan exactly as submitted to the relevant authorities.

Operators who have obtained the operation permit are required to submit a "Reclamation Plan" to the Provincial Directorate of Environment, Urbanization, and Climate Change **within 1 year at the latest**. In forested areas, it has become mandatory for operators applying for a forest operation permit to prepare a rehabilitation project. Additionally, for operators who were active before this Regulation came into force and have not submitted a reclamation plan, the reclamation format shall be prepared by the institutions and organizations authorized to prepare an Environmental Impact Assessment report or project introduction file.

Phases of the Reclamation Plan

a) Determining the current status before the activity by considering the flora, fauna, soil, water, air, natural and cultural landscape values, geological conditions, geomorphological and hydrogeological factors, geological risks, as well as socio-economic and cultural factors in the activity area and its surroundings.

b) Ensuring the physical, chemical, and geological stability of the activity area.

c) Rearrangement of the activity area.

ç) Implementation of soil, water, and air management practices.

d) Execution of landscaping works.

e) Improvement of the activity areas.

f) Closure and abandonment of the activity areas.

g) Implementation of monitoring and inspection methods.

After the box-cut was opened for mining activities in the Kışlaköy Lignite Mine site, the extracted overburden material was deposited in the designated external dumping area. Additionally, a reclamation plan covering the period from 2011 to 2044 was prepared. In this context, approximately 743,285 trees of species including Cedar, Black Pine, Acacia, Mahaleb, Maple, Ash, Pagoda Tree, False Acacia, Blue Spruce, Melye, Juniper, Plane Tree, and Oleaster were planted on an area of about 907.6 hectares in the external dumping area of the Kışlaköy Lignite Mine.

Afforestation activities aimed at the reclamation of the excavation and dumping areas in the South Aegean Lignite and Yeniköy Lignite Enterprises started in 1991 following mining operations. Species such as Acacia, Stone Pine, and Black Cypress were planted in the external dumping areas, while Olive trees, which are the most widespread and economically valuable in the region, were planted in the internal dumping areas. In the afforested areas, wildlife is rapidly developing, and the reclamation of nature is largely achieved. Between 1991 and 2012, a total of 1,940,504 trees were planted over an area of 1,081 hectares by the General Directorate of TKİ in GELİ and YLİ (Muğla-Yatağan and Yeniköy).

In Yatağan-Eskihisar and Milas-Karacaağaç, the olives from the olive trees are harvested annually by the EÜAŞ General Directorate and processed into olive oil at the Agricultural Sales Cooperative. The extra virgin olive oil used in the EÜAŞ General Directorate Cafeteria is produced from Gemlik variety trees located on 550 acres of land in the Milas and Yatağan regions of Muğla Province, affiliated with EÜAŞ. In 2023, a total of 31,150 kg of olives were harvested, yielding 5,729 kg of olive oil. The tree species planted in the reclaimed mining sites of the South Aegean Lignite Operation and Yeniköy Lignite Operation include Acacia, Ailanthus, Olive, Ash, Maple, Black Cypress, Ligustrum, and Stone Pine.

Conclusion

Afforestation activities have been conducted in the areas where dumping operations were completed at the external dumping site of the Kışlaköy Lignite Mine in Kahramanmaraş. The areas where afforestation has been completed have been transferred to the Regional Directorate of Forestry. In the external dumping areas of Muğla, species such as Acacia, Stone Pine, and Black Cypress were planted, while Olive trees, which are the most widespread and economically valuable in the region, were planted in the internal dumping areas. In the afforested areas, reclamation to nature has been largely achieved. As EÜAŞ, reclamation planning will continue in areas where mining activities have been completed.

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The Lavrion Mines Restoration Project Under The Digital Twin Concept

Dimitris Kaliampakos

Professor NTUA/Vice-President AMDC (LTCP)

Abstract

The Lavrion Technological Cultural Park (LTCP) is an initiative of the National Technical University of Athens (NTUA), dealing with the restoration and regeneration of an abandoned mining area with a history of more than 3000 years. The city of Lavrion, located in the southern part of Attica peninsula, is well known for the extensive silver-lead mining and metallurgical exploitation both in antiquity and modern times. The French Mining Company of Lavrion (FMCL) the largest and longer lasting enterprise of the sector in Greece, operated for more than a century (1875-1989). It has been the first and biggest foreign investment in Greece and a driver of major technological advancements, a pioneer in both the first and second industrial revolution. However, the third industrial revolution along with the depletion of the rich mining ores pushed this activity aside and finally it ceased operation, as it happened in many traditional mining sites worldwide.

LTCP was founded on the abandoned industrial complex of FMCL in order to rescue a major industrial monument integrating the intangible culture value that contains and, at the same time, reanimate the place on a productive way. In order to do so, an extended building restoration program along with a huge environmental rehabilitation one have been undertaken until now, implementing several innovative remediation technologies and methods.

One of the most promising tools coming with the 4th revolution, in the context of smart mining, is the digital twins. The Mine.io project, funded by the Horizon Europe research and innovation program, aims at developing a digital twin of the whole process of mining, from mining survey to the reuse of mine waste and restoration. LTCP is an ideal pilot site of Mine.io for the presence of all phases in one place and the complicated issues born from the long mining past and the new potential that modern technologies reveal.

INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

The Lived Space of Mining City and New Possibilities: Zonguldak

Nazlı Arslan[1], Server Funda Kerestecioğlu[2]

ABSTRACT

Zonguldak, which has experienced a process of deindustrialization with the decline in production capacity over the years, accumulates special values due to the ongoing production activities on both sides of the surface. As a mining city, the production of coal underground and space on ground reveals the contradictions between meta and space production. These contradictions physically and conceptually reveal the tangible and intangible spatial values of the city as part of its urban capability. The extraordinary routines that exist in the city's production-based daily life have the potential to define the new economy as part of its urban ability. Not only coal production, but also urban life on the axis of coal production can be defined by micro and macro indicators. These indicators refer to the signs of the new future. Physical and conceptual indicators reflecting the mining identity gain meaning through experiences and contribute to the perception of urban reality. If the traces of this identity can be followed in the post-mining life as well as in the processes of mining activities, the city can continue its existence. Physical and conceptual indicators reflecting the mining identity can be sustained with different approaches and carried on to new generations. The three main topics that define post mining life are sustainability of identity, creative environment and new economy.

Keywords: De-industrialization, Lived Space, Mining Town, New Possibilities

Introduction

Nowadays, there has been a shift from the fordist type of production to the post-fordist type of production, and the necessity for the parts that make up the industry to remain in a single location has disappeared. In this sense, the spatial division of labour is realized and each city assumes certain roles within the economic

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unit. However, it is also the case that the role taken by cities within the framework of the spatial division of labor loses its importance in the following period, falls out of favour and cannot find a place for itself in the new division of labor. Cities that are specialized in a specific industry and have no other alternatives emerge as the settlements most affected by periods of de-industrialization.

If the transformation of the industry on a global scale is analyzed through the coal sector, in addition to cheap labor, reserve status, geological formation and production costs have caused the coal industry to shift to different geographies over the years. If the deindustrialization processes of coal geographies are summarized, 5 main phases can be mentioned. The pre-industrial exploration period is followed by industrialization and the planning and implementation phase. The economy, which entered the stagnation phase with global crises, enters a revitalization process with rapid growth within the framework of needs. The phase of dramatic rapid growth is followed by a period of decline, with declining reserves, production costs and environmental crises. This downturn requires the creation of possible future scenarios for industrial cities whose production activities are in risk. This necessity can be realized by exploring new economies that will emerge from the city's mining capability and derive from the city's unique values. Especially cities that define their economy with coal production and related industries are caught between reserve status, production costs and environmental problems, and their future concerns have increased. The fact that coal is an exhaustible resource has caused the economic environment of the cities to shrink as the ore that brought the cities into existence has ceased to exist underground over the years. This shrinkage causes the social and physical environment to lose its physical and conceptual features as well as its economic ones (Figure 1).

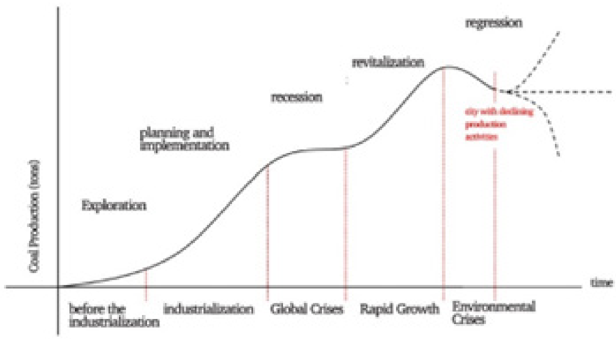

FIGURE 1. INDUSTRIALIZATION PROCESS OF MINING CITY

On a local scale, Zonguldak is a characteristic mining city where production has declined over the years. The production capacity, which was 5 million tons of hard coal in 1974, declined to 1 million after 2000. This decline in production also affects the number of workers and the industrial enterprises that continue their activities. According to the statistics of the Turkish Hard Coal Enterprises, the number of workers working in coal production has decreased and out-migration has become compulsory for citizens in need of new livelihood strategies. In need of a new economic strategy, the city is channelling the mining knowledge and skills it has accumulated over the years into new generation sectors. The declining production capacity over the years causes the disappearance of conceptual and physical indicators reflecting the mining identity. In this framework, the space of the mining city should be defined, and spatial identity indicators should be determined. These identity indicators will contain the codes of the new economy to be created in the future. Sustaining the existing knowledge and skills with new approaches will ensure environmental, social and economic progress.

Materials And Methods

In order to define the mining city, it is a priority to identify all the physical and conceptual indicators of on ground and underground. As a two-storey city, a holistic evaluation of above and below makes it possible to analyze the contradictory and dependent relation between meta and spatial production that has developed over the years. This relation points to many realities from the urban structure to the conceptual values that bring it into existence. All these realities can be identified by analyzing space and meta. Lefebvre pointed out the three dimensions of space and emphasized its social aspect as a constantly living organism. According to him, space is social in its perceived, conceived and lived dimensions.

Identifying the different dimensions of space in the case of Zonguldak is possible by analysing the changes in the physical, social and economic environment from the past to the present. Therefore, the city maps, texts and creative industry elements that have changed from the past to the present, as well as the indicators of the city's daily life and physical environment have been analyzed, and the physical and conceptual values that form the characteristic of the city have been identified. Within the framework of these values, new economic possibilities referring to the future are discussed with their potentials, and the existing mining ability of the city and the new values derived from it are discussed.

Results And Discussion

The three dimensions of space can be evaluated with all physical and conceptual indicators on ground and underground in the mining city. Hence, the perceived space of the mining city is the underground spaces formed by galleries, shafts and panels underground and the urban space emerging on the surface. The reflections of the conceived space on the surface are city and regional plans, while underground they are production plans. The lived space includes the values experienced as a complement to the designed and perceived space indicators. It is the daily life shaped by collectivity and the claim for rights on ground, while underground experiences include traumas and stories of survival (Figure 2).

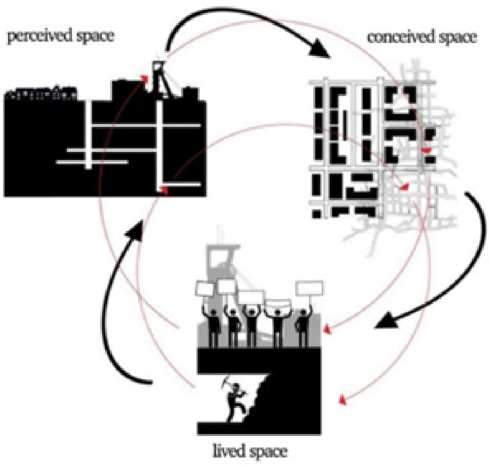

Figure 2. Three dimensions of space in mining city

The perceived space of the city can be analyzed in layers. When natural and built environment parameters are evaluated, buildings and roads can be considered as layers of the built environment. Within the rough topography, stairs expressing pedestrian transportation are among the characteristics of the city. Climate data shapes the green silhouette of the city and this silhouette is the most important indicator of the natural environment. The phenomena that take place in these spaces reflect the traces of the lived space. The lived space, which is shaped on a human basis, reveals the daily routines specific to the mining city and the urban ability that develops within the framework of these routines. If this urban capability is discovered, new possibilities can be discussed.

The city refers to a topography consisting of physical and conceptual values. The topography of mining cities is shaped by the values it contains on ground and underground. These values are the lived spatial realities that exist within a liveable city. As defined in the Habitat II and III Human Settlements Summit, when it comes to "liveability" and "liveable cities", the principles and values agreed upon by many reports and organizations are gathered under the headings of ecology, land use, public spaces, transportation, health, safety, design, education, culture and development. In this respect, a liveable city is a healthy city.

The perceived space that shapes our space-oriented practices and habits is defined by the components that define the urban structure. These components express the criteria of a liveable city. While the structure of an industrial city is characterized by roads, industrial network, natural topography and built environment, for a mining city these components are specialized in sub-headings. Accordingly, roads are railroads, highways, bridges and tunnels above ground, while galleries, decovil lines and shafts underground. Workshops, lavatories, additional facilities and shaft heads are the reflections of the industrial network on ground, while underground they are production panels and technical spaces. The topography of the mining city is defined by coasts, natural landscape and waterways, as well as the geological structure of the underground. The built environment designed to regulate the continuity of coal production and urban life points on ground with buildings, monuments, landmarks and public spaces, and underground with galleries, floors and shafts.

Conclusions

The three main topics that define post mining life are sustainability of identity, creative environment and new economy. Sustaining the city's identity as the core value of the post mining activities will create awareness in future generations. The creative environment refers to the new industry. The existence of the creative class in the city will bring along all written and interpretive history studies to be produced about the city. Within the framework of the new economy, social and physical rehabilitation can be achieved with new alternative fields of work to coal production. With this rehabilitation, the healthy city will be able to create its own economy again by converting into a liveable and attractive location.

In order to sustain the urban identity, it is useful to comprehend the entire story by experiencing the structural values from history. Physical and conceptual indicators reflecting the production history can be sustained through different methods. Illustrations or conceptualized expressions of urban reality can prepare the ground for highly motivated work. This ground contributes to the development of new sectors that will shape the present and future economy as well as coal production. Even without specific coal production, the continuity of this culture can be enabled through different production systems.

The stories of the social environment in the context of difficult working conditions constitute the basis for social sciences and the creative industry. Citizens who experience the city and witness the changes in life are the potential producers of the creative environment with their stories. The story of the underground can only be described by those who can experience its reality. In order to prevent the disappearance of the traces of mining identity from the past to the present, it is a priority to increase the printed, visual and audio-visual media products that describe the story of the city. At this point, local demand for these products is valuable and this is an incentive for future production. The creative industry products used for the analysis of the lived space reflect the reality of the city at that time. From the working conditions in the mines to the reflections of the movement of coal in the city on daily life, many indicators can be identified through creative industry elements.

The human-oriented problems that the city hosts and arise from production point to the subject of study for certain disciplines. The problems that emerge because of coal production create a diversity of cases and incidents for the relevant disciplines. In addition, researchers from different levels involved in new production models can increase their motivation with the support of the local community and produce studies that refer to the new economy. Shaped by mining culture and production strategies, the city contains potential for new economic expansions. At this point, new tourism models, alternative productions and collaborations appear. The development of university-industry collaborations and the continuation of industrial collaborations as a habit from the city's history point to the advantage of the new economic environment of the city. Developing successful projects in the city is an incentive for new ones and reveals the possibilities of realization in the process of deindustrialization.

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Management of the Cultural Heritage In Mining Projects

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Abstract

The Anatolian geography, which has hosted many civilizations from prehistoric times to the present day, and the created cultural heritage in this geography are the common heritage of not only us but all humanity. Protecting the cultural heritage and transacting it onto future generations is one of our main responsibilities. However, rapid urbanization, economic development priorities, lack of awareness of the preservation of cultural heritage and some deficiencies in conservation measures sometimes lead to unexpected negative results in the protection of our cultural heritage and its transfer to future generations.

Both mines and cultural heritage are limited and consumable resources. Deficiencies and neglect in the planning that will put these resources into use may cause rapid destruction of both resources. However, with detailed planning and resource management, these resources can be evaluated both as an economic development tool and sustainably transferred to the future.

To evaluate and suggest possible solutions to eliminate the negative effects on cultural heritage assets that may be affected by mining projects and how to ensure sustainable cultural heritage are the main objectives of this study. Thus, in line with the planning of mining projects, a road map can be drawn to transfer cultural assets, which are the common heritage of humanity, to future generations without being damaged.

Keywords: Culture, Cultural Heritage, Cultural Property, Tangible Cultural Heritage, Intangible Cultural Heritage, Conservation of Cultural Heritage, Cultural Heritage Impact Assessment, Mine, Mining, Mining Sites.

Introduction

Minerals are natural substances characterized by their unique composition, atomic structure, and physical and chemical properties, and are typically extracted from the earth in solid or liquid form for the purposes of utility and profit.

The stable and sufficient supply of raw materials demanded by society, industry, and the economy, particularly for the production of essential goods and for use in infrastructure development, constitutes one of the fundamental requirements of adaptation to and advancement in modern life.

Similar to many countries around the world, Türkiye is geologically endowed with a wide range of naturally occurring raw materials essential for construction and industry. The complex geological and tectonic structure of the country has enabled the formation of diverse mineral deposits. While approximately 90 types of minerals are produced globally today, production in Türkiye encompasses 60 types. According to data from the General Directorate of Mineral Research and Exploration (MTA), Türkiye ranks 28th among 132 countries worldwide in terms of total mineral production value, while it holds the 10th position in terms of mineral diversity. The country is particularly rich in industrial raw materials, several metallic ores, lignite, and geothermal resources. Indeed, Türkiye hosts 2.5% of the world's industrial raw material reserves, 1% of coal reserves, 0.8% of geothermal potential, and 0.4% of metallic mineral reserves[1].

According to one analysis, mining currently affects more than 19 million square miles (50 million square kilometers), corresponding to 35% of the Earth's terrestrial surface excluding Antarctica. Of these mining areas, 8% overlap with protected regions, 7% with key biodiversity areas, and 16% with wilderness zones[2].

Whether located underground on the surface, or within marine and other underwater contexts, these resources exist within historical and natural environments. Such environments constitute the primary domains directly impacted by global mining activities. Among the most critical elements within these environments is *cultural heritage*.

The purpose of this study is to propose methods that effectively manage the planning and governance processes of resources in mining areas, thereby ensuring a sustainable supply of minerals for the prosperity, infrastructure, and quality of life of the nation, while simultaneously safeguarding cultural heritage assets as a legacy for humanity and science, ensuring their transmission to future generations.

Culture, Cultural Heritage, and Their Sub-Concepts

In its simplest form, ***culture*** can be defined as the entirety of ways of life created by human beings in order to sustain their existence. ***Cultural heritage***, on the other hand, refers to the collection of assets that embody both local and universal values, relate to a society's past, provide identity, and have endured to the present alongside the continuity of human life. These assets, which have been transmitted from the past to the present, are products of humanity's shared and ever-evolving values, beliefs, knowledge, and traditions. Emerging through the interaction of humans, space, and time, they may encompass both tangible and intangible elements.

Both tangible and intangible components (such as oral traditions, performing arts, rituals, etc.) are defined as ***cultural properties***. These include elements associated with science, culture, religion, and the fine arts, as well as those pertaining to social life, which possess unique scientific and cultural significance. They may be located above ground, underground, or underwater (e.g., shipwrecks, submerged remains, or cities), and may belong to prehistoric or historical periods. As carriers of documentary evidence of past cultures, these properties may exist in *movable* form (paintings, sculptures, coins, manuscripts, archaeological artifacts, etc.) or in *immovable* form (monuments, archaeological sites, historic urban fabric, etc.).

The aforementioned elements have developed through historical processes within a natural environment, shaped by interaction with humans, societies, and cultures. Geographical areas that encompass such elements, featuring cultural and natural resources, wildlife, domesticated animals, associations with historical events and activities, or diverse cultural and aesthetic values, are defined as ***cultural landscapes***[3].

The Importance of Cultural Heritage

Cultural properties serve as documentary sources both for the present and for the past. By providing answers to the questions of who, what, why, where, when, and how, they constitute primary resources essential for understanding the formation of human history. Data obtained from philological, archaeological, anthropological, ethnological, folkloric, and other types of cultural research, when examined through scientific methods, enable us to gain invaluable insights into past lifeways and cultures. For instance, artifacts unearthed during archaeological excavations, such as written documents, ceramic fragments or objects, items crafted from stone or metal, architectural remains, or organic materials including bones, seeds, and pollen can provide comprehensive information about the socio-cultural structures of a given period (such as governance, religion, or art). At the same time, they can shed light on numerous aspects of life in that era, including climatic conditions, kinship relations, dietary habits, agricultural techniques, life expectancy, and gender distribution.

1 https://www.corlutso.org.tr/uploads/docs/dunyada_ve_turkiyede_madencilik_sektoru.pdf (15.02.2024 tarihinde ulaşılmıştır).

2 UNFCCC COP 2023:1-2.

3 https://www.iucn.org/resources#resource_types-resource_type_publication (Accessed on 15 February 2024).

Moreover, cultural properties illuminate not only the history of the regions in which they are located but also the broader narrative of human history across the world. Like mineral resources, cultural heritage assets are exhaustible resources and non-renewable. Once destroyed, they cannot be replaced.

Cultural properties are continually exposed to risks of destruction arising from both natural and human caused threats. Such losses do not merely signify the disappearance of physical entities but also entail the permanent erasure of portions of human history, effectively consigning them to oblivion. Analogous to mineral resources, cultural heritage assets may also be considered sustainable resources. The definition of "sustainable development" introduced in 1987 by the United Nations World Commission on Environment and Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" encompasses the conservation, management, and presentation of cultural properties in harmony with society, economy, and nature. To ensure the sustainability of cultural heritage, it is essential to undertake processes of identification, risk assessment, risk management, awareness-raising, and the planning and implementation of protective measures. For certain cultural properties, economic benefit-generating strategies may additionally be incorporated. Only through the accurate and effective implementation of such measures can cultural heritage assets be safeguarded and transmitted to future generations in a sustainable manner.

The Organic Relationship Between Mining Sites and Cultural Heritage Assets

Anatolia, owing to its geological structure, is exceptionally rich in mineral deposits. Minerals are finite, irreplaceable resources that can only be processed in the locations where they are found. For this reason, societies that settled in the region throughout history often established their communities directly on or in close proximity to mineral reserves in order to exploit these resources. Human engagement with minerals not only transformed and advanced social life but also enriched cultural expressions. Consequently, certain historical periods have been chronologically defined according to advances in metallurgical technologies, such as the Chalcolithic Age, the Bronze Age, and the Iron Age.

Before mastering the use of metals, humans collected brightly coloured minerals and ores to be employed primarily as pigments. This stage, referred to as the *Preparatory Phase* of mining history, also known as the *Pre-Metallic Period* (prior to ca. 8200 BCE), predominantly used the red minerals, chiefly hematite.

By the end of the 9th millennium BCE, humans began to work native copper collected from surface deposits. This era, termed the *Initial Phase* or the *Single-Metal Period* (after ca. 8200 BCE), saw communities transport native copper pieces to their settlements, where they were first cold-hammered and subsequently annealed heated and hammered into sheets to craft beads, small pins, fishing hooks, and similar objects. Thus, humanity not only discovered a new raw material but also, for the first time, harnessed fire for technological purposes rather than merely for protection against cold and wild animals. This innovation laid the foundation for mining, one of the principal drivers of societal development.

After 5000 BCE, the *Development Phase* began, marking the onset of extractive metallurgy. During this period, metallurgists employed smelting techniques to obtain copper, which they then manipulated through various methods.

By the 4th millennium BCE, advanced mining activities spread across Anatolia, entering the *Organizational/Experiential Phase*. Metallurgical workshops capable of smelting and processing metals were discovered in nearly every settlement. Not only in Anatolia but across the Near East, ores collected from mining fields were transported to settlements, where they were smelted and processed as needed. Unlike earlier practices limited to surface collection, miners now extracted deeper deposits and exploited complex polymetallic ores[4].

A significant example of settlements established directly upon or near mineral reserves is Marmara Island (ancient *Prokonnesos*), located south of the Propontis (Sea of Marmara), near the Arktonessos Peninsula[5]. Known since antiquity for its marble quarries, particularly in its northern half composed largely of marble, the island's quarries date back at least to the 6th century BCE. During the Roman period, Prokonnesos marble gained prominence in monumental urban construction. Under Emperor Tiberius (14–37 CE), the quarries were reorganized and designated as imperial quarries. Archaeological and epigraphic evidence indicates that Prokonnesos marble was extensively used from the mid-2nd to the mid-6th century CE, especially during Late Antiquity. Marble extracted and processed at Prokonnesos was exported widely, from mainland Greece

4 Yalçın 2016: 3-8

5 Beykan 2004: 2

to Italy. These quarries continued to be exploited during the Classical Ottoman period, when they were operated under state authority[6].

Today, however, modern quarrying activities on Marmara Island threaten the ancient quarries, erasing archaeological evidence. With contemporary techniques relying on the extraction of large blocks, quarry sites are being deepened, and the island's marble landscapes are losing their topographic integrity[7].

Another striking example illustrating that the mining industry in antiquity operated in ways similar to modern mining practices was identified in 2007 near Derekutuğun Village, west of Bayat District in Çorum Province. The site is of great significance for the history of Anatolian metallurgy. Native copper deposits discovered in Derekutuğun, along with the Mazıönü mining galleries and ore fields in the nearby Erikli area, were found to have been exploited between the 4th and 2nd millennia BCE. These sites underscore the importance of prehistoric mining operations in Anatolia's metallurgical history. Archaeological evidence suggests that, nearly six millennia ago, Derekutuğun mines supplied pure copper to numerous nearby settlements[8]. With copper ores containing up to 99% purity, the region remains an active centre for modern copper extraction.

These examples demonstrate that throughout history, humans established settlements within or adjacent to mining sites in order to exploit mineral resources, thereby maintaining constant interaction with mineral deposits. This also explains the frequent discovery of archaeological settlement traces within modern mining fields. Accordingly, mining areas and their immediate surroundings must be recognized as high-potential zones for encountering cultural heritage assets.

Legal Framework for the Management of Cultural Heritage in Mining Sites in Türkiye

Within the borders of the Republic of Türkiye, cultural heritage is protected under the Constitution[9] as well as relevant laws and regulations. Cultural heritage assets located within mining areas are similarly safeguarded under this legal framework.

As in other countries, cultural heritage in Türkiye is evaluated within the environmental context. Therefore, understanding the principles governing the utilization of mining sites and the protection of the environment, and cultural heritage assets is of critical importance.

- Article 168 of the Mining Law No. 3213 states:

"Natural wealth and resources are under the sovereignty and control of the State, and the right to explore and exploit them belongs to the State. The conditions to be observed by real and legal persons, as well as the supervision, inspection procedures, principles, and sanctions to be applied by the State, are specified in the law."

- Article 56 of the Law on the Protection of Cultural and Natural Property No. 2863 stipulates:

"Everyone has the right to live in a healthy and balanced environment. It is the duty of the State and citizens to improve the environment, protect environmental health, and prevent environmental pollution."

- Article 62 of the Environmental Law No. 2872 affirms:

"The State ensures the protection of historical, cultural, and natural assets and values and takes supportive and incentivizing measures for this purpose." In the mining sector, obtaining a mining license alone does not suffice to commence mining activities. According to Article 7 of the Mining Law No. 3213 (June 4, 1985), prior to any investment, the potential environmental impacts—including those on cultural heritage—must be assessed, and the opinions of relevant institutions must be obtained.
This consultation process is carried out during the *Environmental Impact Assessment* (EIA) phase, commonly referred to by its Turkish acronym *ÇED*. Within the scope of Environmental Law No. 2872, EIA is defined as: *"The studies undertaken to determine the potential positive and negative impacts of proposed projects on the environment, to prevent adverse effects or reduce them to a minimum level that will not harm the environment, and to assess alternative sites and technologies, as well as to monitor and control project implementation."*
In Türkiye, the concept of EIA first appeared in 1983 under Article 10 of Environmental Law No. 2872 and

6 Beykan 2004: 13
7 Beykan 2004: 5
8 Sir-Gavaz 2020: 171
9 2709 Sayılı Türkiye Cumhuriyeti Anayasası, Madde 63

was formally integrated into environmental legislation. The first EIA regulation, based on the Environmental Law, was published in 1993[10].

In mining areas, the evaluation of impacts on cultural heritage assets is conducted through the institutional consultation process carried out during the EIA stage.

How the EIA System Operates for Cultural Heritage

In mining, the Environmental Impact Assessment (EIA) process, which also evaluates impacts on cultural heritage, is conducted immediately after the Exploration and Operating Licenses are obtained, and prior to the acquisition of Property Permits. This process is carried out in accordance with the national EIA Regulation, published in the Official Gazette No. 31907 on 29 July 2022.

Projects subject to *Screening and Selection Criteria* may either require an EIA or be exempted from it, depending on the magnitude of their potential adverse environmental impacts. For mining projects requiring an EIA, the company, approved by the Minister of Environment, Urbanisation and Climate Change to manage the EIA process, applies to the relevant Regional Council for the Conservation of Cultural Property in the province where the project is located to obtain the official institutional opinion regarding cultural heritage. The institution evaluates the application and conducts site-specific assessments, which may include field surveys, inventory studies, or a combination of both, to identify cultural heritage assets within the project area. If cultural heritage assets are identified, the physical relationship between the asset and the project is assessed by the Regional Council for the Conservation of Cultural Property, and an official decision is issued and communicated to the relevant stakeholders. During project implementation, adherence to this decision is mandatory. However, for mining activities exempted from the EIA process, the above steps are not undertaken. As a result, there are significant gaps in the impact assessment process regarding cultural heritage assets.

Is the EIA System Effective in Protecting Cultural Heritage?

In principle, EIA studies aim not only to ensure the protection of cultural heritage assets that are already included in the national inventory or have been previously identified, but also to safeguard cultural assets that are first detected during the project EIA phase and subsequently added to the national cultural inventory. However, the statistical study conducted by Dölek presents striking findings regarding this issue[11]. In his research, Dölek examined a total of 235 EIA reports issued with a positive decision in 2019, focusing on sectors expected to have the highest interaction with cultural heritage assets—namely mining, energy, electricity transmission lines, water (including dams, hydroelectric power plants, reservoirs, and irrigation projects), transportation, and tourism (*Fig. 1*).

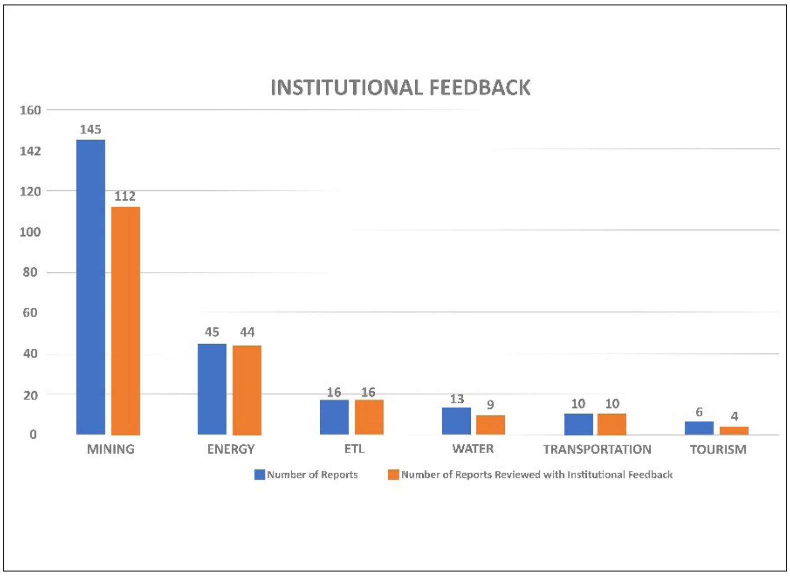


Fig. 1 Distribution of EIA Reports by Sector (2019)[12]

Out of the 235 EIA reports examined, it was determined that official opinions from the Regional Councils for the Conservation of Cultural Property were provided for 112 of the 145 applications in the mining sector, 44 of the 45 applications in the energy sector, 9 of the 13 applications in water-related sectors, and 4 of the

10 Dölek 2021: 25

11 Dölek 2021

12 Dölek 2021: 63

6 applications in the tourism sector (*Fig. 2*).

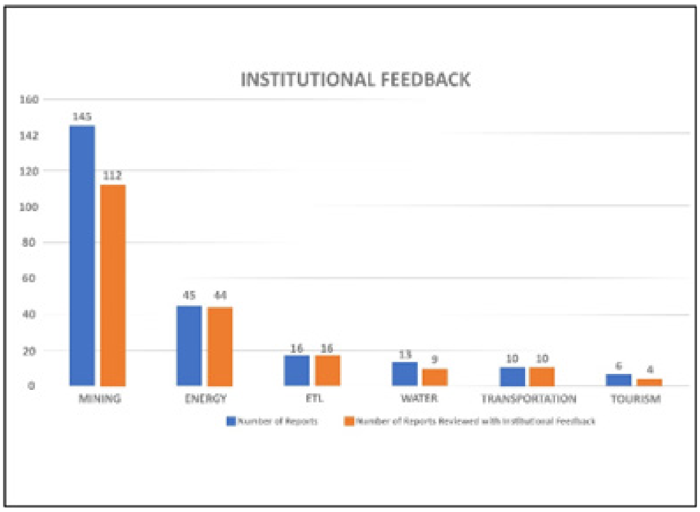


Fig. 2 Status of Institutional Opinions Regarding Cultural Heritage [13]

Of the 112 institutional opinions provided for the mining sector, on-site (field) inspections were conducted in 99 cases, while no on-site inspections were carried out in 13 cases (*Fig. 3*).

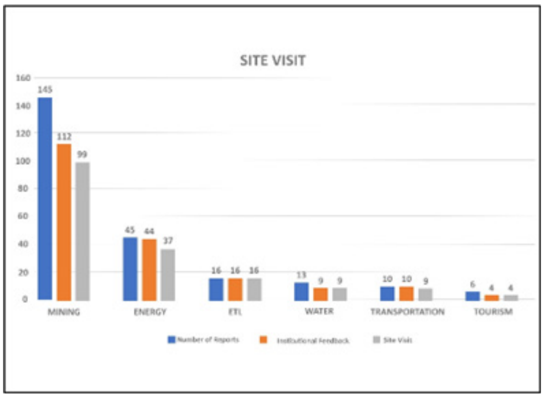


Fig. 3: Status of On-Site Inspections Regarding Cultural Heritage [14]

According to the examination results, the distribution of identified cultural heritage assets by sector is as follows: Mining 19, Energy 11, Electricity Transmission Lines 12, Water 6, Transportation 6, Tourism 0 (*Fig. 4*).

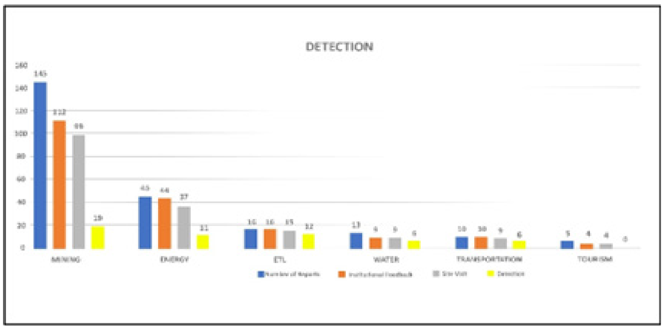


Fig. 4: Status of Cultural Heritage Identification [15]

The number of recommendations made to mitigate the impacts of project activities on identified cultural heritage assets is as follows: 12 for cultural heritage assets affected by the mining sector, 5 for those affect-

13 Dölek 2021: 64
14 Dölek 2021: 65
15 Dölek 2021: 66

ed by the energy sector, 7 for the electricity transmission lines sector, 5 for the water sector, and 6 for the transportation sector. In analyses related to the tourism sector, no cultural heritage assets were included in the assessment studies (*Fig. 5*).

Fig. 5: Status of Measures Regarding Cultural Heritage and Number of Cultural Heritage Experts [16]

The most striking statistical information pertains to the number of cultural heritage experts involved in the preparation of EIA reports. Accordingly, out of 145 reports prepared for the mining sector, only 2 included a cultural heritage expert; for the energy sector, 4 out of 45 reports included an expert; for the transportation sector, 6 out of 10 reports included an expert; and for the electricity transmission lines, water, and tourism sectors, none of the prepared reports included a cultural heritage expert[17].

These statistical findings indicate significant gaps in the EIA process and regulations with respect to cultural heritage. Due to these gaps, the occurrence of irreversible impacts and consequences on cultural heritage assets may become inevitable.

Where and How to Begin

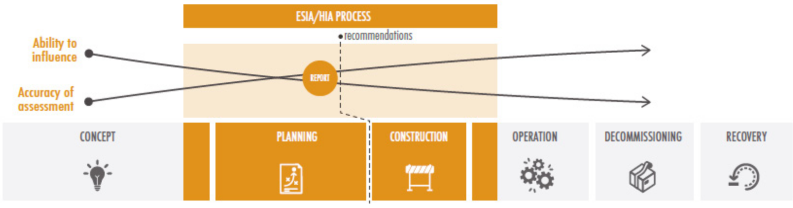
It must be acknowledged that mining activities have the potential to negatively impact cultural heritage and that cultural heritage may interact with the project. In mining projects, the identification and documentation of cultural heritage assets, as well as their sustainable management within a structured planning framework, can be achieved by not only adhering to national legislation but also by utilizing various tools and best practice examples.

Cultural Heritage Impact Assessment (CHIA) has emerged since the turn of the millennium as a tool distinct from traditional "environmental impact assessment." CHIA facilitates the evaluation of impacts on cultural heritage assets using specialized methodologies, balancing conservation with development objectives, and providing recommendations to mitigate adverse effects. It can be effectively applied to assess the impacts of mining projects on cultural heritage.

Today, CHIA is widely recognized and applied internationally. However, in Türkiye, CHIA is primarily employed in projects financed from abroad or in World Heritage Sites. Projects implemented at national or local scales still rarely integrate CHIA adequately.

Numerous international institutions and organizations committed to ensuring the sustainability of cultural heritage have published CHIA guidelines and principles. Among these, the International Council on Monuments and Sites (ICOMOS) "Guidance on Cultural Heritage Impact Assessment" serves as a leading reference on where, how, and when CHIA should be applied. In addition to ICOMOS, organizations such as the World Bank (WB), European Bank for Reconstruction and Development (EBRD), and International Finance Corporation (IFC) have developed standards and requirements for cultural heritage impact assessment, which are published as guidance documents. Notably, EBRD Performance Requirement 8 (PR8) and IFC Performance Standard 8 (PS8) provide sector-specific guidance related to cultural heritage.

According to the ICOMOS Cultural Heritage Impact Assessment Guidance (2022) for mining sites, mitigating potential adverse impacts of mining on cultural heritage and ensuring its sustainability requires that CHIA be initiated at the project concept stage of mining activities. Early identification and intervention are essential to determine both the effects of the mining project on cultural heritage assets and the influence of heritage studies on project planning. The later the cultural heritage assessments are conducted, the lower their potential to positively influence project outcomes. Consequently, cultural heritage assessments should commence during the ***exploration*** phase of mining projects and continue through decommissioning and even recovery phases.



16 Dölek 2021: 67-68

17 Dölek 2021: 62-68

Fig. 6: ICOMOS Cultural Heritage Impact Assessment Phase [18]

According to the ICOMOS Cultural Heritage Impact Assessment Guidance, the impact assessment should be initiated and conducted as soon as the project concept is developed, employing accurate and comprehensive evaluation methods. The assessment must determine the potential impacts on cultural heritage assets and be compiled into a formal report. The Cultural Heritage Impact Assessment (CHIA) report should be prepared with recommendations for conservation and sustainability and made available for use prior to the commencement of mining activities. The CHIA report must encompass the impacts during all phases of the project planning, construction, operation, decommissioning, and recovery and include mitigation measures for potential adverse effects arising in each of these phases. This project-specific report should remain in use throughout the entire life cycle of the project (*Fig. 6*).

The content of the report to be prepared during the Cultural Heritage Impact Assessment (CHIA) phase, as well as the methodologies employed to develop this content, is of critical importance. These content elements and methodologies are separately defined for tangible and intangible cultural heritage in both the EBRD Performance Requirement 8 (PR 8) and the IFC Performance Standard 8 (PS 8) on Cultural Heritage. The stages of a Cultural Heritage Impact Assessment study are presented in *Fig. 7*. Accordingly, the first stage of CHIA involves identifying the cultural heritage potential within the project area. These identifications can be conducted through desk-based studies and fieldwork. Additionally, data verification can be achieved using techniques such as remote sensing, non-intrusive research methods (surface surveys), geoarchaeological analyses, and intrusive research methods (trial excavations, etc.).

Following these identification studies, the impact assessment can be conducted by considering the project's sources of impact. Based on the results obtained, measures to mitigate pressures on cultural heritage can be developed. For managing the impacts on cultural heritage assets identified as being affected, a Cultural Heritage Management Plan should be prepared. Even when all the aforementioned research is conducted, there remains the possibility that some cultural heritage assets, which were not previously identified and remain buried underground, may exist within the project's impact area. In such cases, guidance on what and how to manage these findings should be provided in a Chance Finds Procedure document.

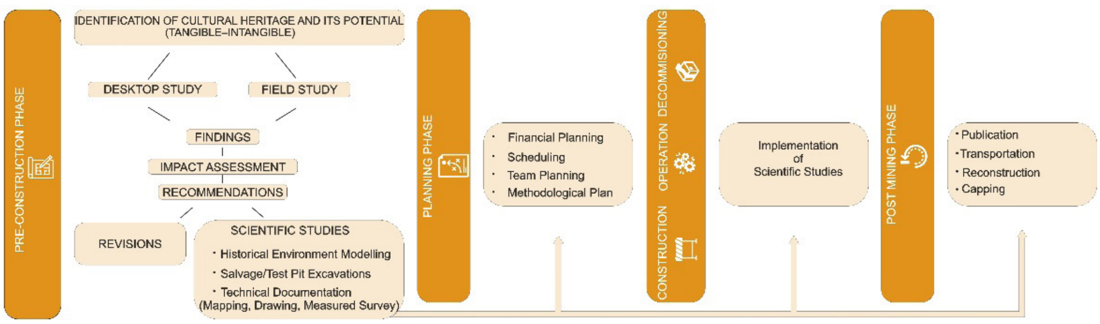


Fig. 7 CHIA Phase Steps

Mitigation measures developed according to the intensity of the negative impacts that mining activities may have on cultural heritage assets, along with recommendations for these measures, should not only focus on the protection of the assets but also aim to document them using scientific techniques for transmission to future generations. For the preservation of an archaeological asset located within a mining site, salvage excavations may be conducted, and techniques such as surveying, planning, and mapping can be employed. Particularly for open-pit mining activities that may disrupt the topography, the modeling and documentation of archaeological assets and the existing "historic environment" can also be included among the recommended mitigation measures (*Fig. 7*).

Following the recommendations, the planning phase should commence, involving the active participation of all stakeholders. This phase must define the methodology to be used for mitigation measures, as well as the team responsible for its implementation, the timeline, and the budget. Planning should be designed so that the activities carried out during construction, operation, and extraction phases can proceed without obstructing the mining operations (*Fig. 7*).

The fundamental principle in the conservation of an immovable cultural heritage asset is its preservation in accordance with its original context. However, if on-site use and conservation cannot be carried out during or after a scientific excavation, an alternative is to relocate the exposed cultural asset to a different exhibition area and display it in a manner that approximates its original condition. In any case, the cultural heritage

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asset must be documented to the highest possible standard using advanced technological tools, ensuring that the records are suitable for international standards and can serve as a resource for scientific research. These records should then be shared under appropriate conditions with the wider public for educational and informational purposes.
Promotional and educational activities related to cultural heritage assets identified and researched within project areas can increase awareness of cultural heritage conservation at both local and national levels. This contributes, even indirectly, to the sustainability of cultural heritage. Promotion and education represent the most important approach to explaining the purpose of conservation and provide the most effective and accessible means of disseminating information. Therefore, in addition to scientific field studies conducted for cultural heritage assets within the project impact area, post-mining activities should include publications such as books, brochures, electronic bulletins, scientific articles, and similar materials regarding any cultural heritage assets present and researched within the project site. Such initiatives can demonstrate that mining activities are conducted in harmony with cultural heritage and can serve as best practice examples.

Examples of Cultural Heritage Practices in Mining Sites in Türkiye
In Türkiye, there are several notable projects where mining activities and cultural heritage studies are conducted concurrently. The first of these is the GELİ salvage excavations, initiated in 2014 and continuing to the present. These excavations were launched under the terms of a protocol signed between the General Directorate of Cultural Heritage and Museums and Yeniköy Kemerköy Elektrik Üretim ve Ticaret A.Ş. (YKEÜTAŞ), with the support of Türkiye Kömür İşletmeleri (TKİ), Güney Ege Linyitleri İşletmesi (GELİ), and YLİ Müdürlüğü.

The other project is the Seyitömer Hoyuk salvage excavation, located on a 12-million-ton high-quality coal reserve approximately 25 km northwest of Kütahya, shedding light on both the early and late periods of Anatolia. The Seyitömer Hoyuk Salvage Excavations have been conducted by four different institutions over the period from 1989 to the present: Afyon Museum, Eskişehir Museum, Kütahya Dumlupınar University, and Kütahya Museum. In both mining sites, TKİ and the Republic of Türkiye Ministry of Culture and Tourism coordinate efforts to ensure collaboration in the protection of cultural heritage assets (*Fig. 8*).

Fig. 8 Seyitömer Hoyuk[19]

One of the best examples of preserving a cultural heritage asset within its original context is the Stratonikeia Ancient City, located southeast of the GELİ Eskihisar coal mine. Despite the presence of a coal reserve amounting to 4,358,879 tons beneath the ancient city, the site has not been exploited for mining and has continued to be preserved in its original context.

19 https://www.aa.com.tr/tr/kultur-sanat/seyitomer-hoyugunde-kurtarma-kazisi-yeniden-basladi/1577932 (Accessed on March 8, 2024).

For the purpose of protecting cultural heritage assets, TKİ provides not only financial support but also technical assistance. For instance, in the GELİ excavations, the locations of buried cultural heritage assets within the mine have been investigated by the TKİ geophysics team since 1996. Cultural assets that have been excavated and scientifically documented, but cannot be preserved in situ, have been relocated and displayed in the archaeopark area in Ören Neighborhood, Milas District (*Fig. 9*).

Fig. 9 Milas Ören Archaeopark Area (Open-Air Museum)[20]

This park, planned as an open-air museum, is also significant as the first comprehensive example of its kind in Türkiye. The movable cultural heritage assets uncovered during the salvage excavations are exhibited in the “Yatağan Termik Enerji A.Ş. Excavations Hall” at the Muğla Museum, which opened in 2021 (*Fig. 10*).

Fig. 10 Yatağan Termik Enerji A.Ş. Excavations Exhibition Area; Muğla Museum[21]

20 https://kvmgm.ktb.gov.tr/TR-192020/milas-oren-arkeopark-alani-acik-hava-muzesi.html (Accessed on 08 March 2024).
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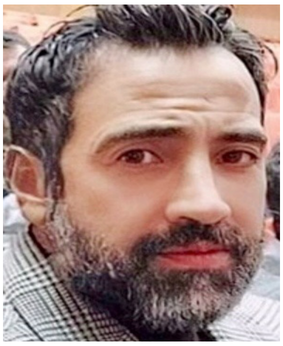


Abdullah Halim Özatay *is a Senior Archaeologist and Cultural Heritage Expert with more than 25 years of experience in archaeology, cultural heritage management, and international development projects. He has led the preparation of Cultural Heritage Impact Assessments (CHIA), Cultural Heritage Management Plans, and Chance Find Procedures for numerous large-scale infrastructure, energy, mining, and transportation projects across Turkey and the Middle East. Working in compliance with EBRD PR8, IFC PS8, and UNESCO World Heritage standards, Özatay has played key roles in major projects such as TANAP, BTC, Nabucco, TurkStream, Ankara-Niğde Motorway, 1915 Çanakkale Bridge ensuring that cultural heritage preservation is fully integrated into project planning and implementation. By combining his academic background with extensive field experience, he has contributed significantly to the integration of cultural heritage into environmental and social sustainability frameworks. He possesses wide experience in heritage monitoring, reporting, stakeholder coordination, and capacity building for cultural heritage preservation. Özatay stands out for his work linking the protection of both tangible and intangible cultural heritage with the principles of sustainable development.*

INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Within Coal Deposit Seyitömer Höyük

Nazlı Azerhan EKİN,

Seyitömer Mound, located 26 km northwest of Kütahya city center, is 150x140 m. 23.5 m in diameter. It is a high settlement. The mound is located on a blue-green colored clay rock called "MARN". Its most important feature is that it is located on lignite deposits.

Excavations have been initiated to make the coal (12 million tons) under the mound usable. The excavations, which were first started by the Eskişehir Museum Directorate in 1989, were continued by the Afyon Museum Directorate in 1990. Only one tenth of the mound was excavated during the studies carried out between 1989 and 1995. However, the excavations were then suspended for a while, and in 2006, a 5-year protocol was signed between Dumlupınar University and the General Directorate of Turkish Coal Enterprises, and the Seyitömer Mound excavations were restarted. Excavations are still continuing by Dumlupınar University Faculty of Science and Letters, Department of Archeology. Since 2019, the excavation has continued as a rescue excavation by the Kütahya Museum Directorate with the support of the Ministry of Culture and Tourism and the sponsorship of Çelikler Holding. Rescue excavation in brief; It is defined as excavations carried out to continue work in public investment areas. The excavations, which started in 1989, ended in 2022. Seyitömer mound, which was excavated for 48 seasons in total, is considered important from a mineral perspective because it is located on lignite deposits, and from an archaeological perspective, excavations were carried out throughout the mound.

1. Architecture in Seyitömer Höyük

It has been determined that the first settlement in the mound was from the Old, that is, Early Bronze Age period. The settlement, which appears to be located by the stream, is surrounded by walls. Settlements surrounded by a wall system are considered important, especially for the Middle Bronze Age, as they show that the region, that is, the settlement, is in danger. During the contemporary Hittite period, it is considered important because the Hittite tribe surrounded their cities with walls to protect themselves from external attacks, especially from Kashka, and generally settled in the highest places of the region. In Seyitömer, just like their contemporary Hittites, they surrounded the settlement with this wall system against external threats and dangers.

In the settlement where there is uninterrupted life, there is a settlement system on top of the structures used in the previous period in terms of architecture. In other words, we can see that architectural structures (houses) are shaped according to need. For this reason, we see that the settlement in the mound expanded beyond the settlement in later periods.

During the Phrygian Period, it was surrounded by thick and high city walls, and in its last periods, a long staircase structure was built on the northern slope of the mound, and a large structure with stepped terrace walls was built on the west. The Classical and Hellenistic period structures on the upper plain of the mound were completely excavated and unearthed. During this period, the mound was surrounded by thick walls reinforced with towers. The buildings have large square and rectangular plans adjacent to each other and have smooth or herringbone underglaze stone walls. The element of commonality of walls in the adjoining layout system is noteworthy and therefore the exposure to fire is higher. As a matter of fact, the fire that broke out after the earthquake in the Middle Bronze Age proves this situation.

In terms of construction technique, it has been observed that spaces were sometimes built by simply laying the stones straight, and sometimes by placing mortar between them and covering them with plaster. In later periods, the use of adobe became widespread.

2. Temple in Seyitömer Mound

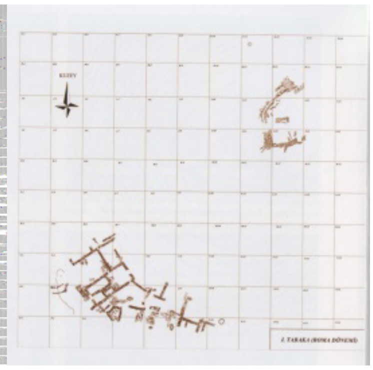
The inhabitants of the mound have been worshiping the mother goddess since the Early Bronze Age, and in the Roman Period they have been worshiping the father God Zeus. Figures, idols and animal statues related to these have been found in abundance. The temple belonging to the Early Bronze Age phase is important. This place has a megaron type. The megaron building style is the prototype of the Greek temple system that emerged in the Aegean region. It is a building style suitable for the longhouse model, with a rectangular shape and a two-column entrance with a hearth system inside, with entrance provided through the short wall.

3.Seyitömer Quarry Areas

In the Early Bronze Age, the reuse of the fire-exposed layer was enabled and new areas of use such as warehouses, workshops, residential areas and hearths and, as an important element, ovens were built in architectural construction. In the Bronze Age, structures containing single and double horseshoe-shaped hearths were built in the mound surrounded by walls. In the upper phase of this period, remains of workshop furnaces working with iron and iron ingots were found. It is possible to see traces and remains of the fire in all areas.

4.Various Daily Use Areas in Seyitömer

During the Early Bronze Period, it became a center for pottery made using molds instead of pottery made by hand. For this reason, many ceramic kilns were unearthed in the mound, and since these kilns are supported by wooden pillars, they are important in terms of showing the traces of the fire that occurred after the earthquake.



The Roman Period also yielded remarkable finds in Seyitömer. Notable examples among these ruins are a large room and an S-shaped canal. An oil lamp and lamp fragments, various coins from the Roman Period, and hundreds of terracotta bull figurines, including one marble, were unearthed in the room. Many animal bone fragments and terracotta bull figurines were recovered from the canal. Based on these findings, researchers thought that this place could be a sacred area, that is, a temple and its courtyard.

5. Seyitömer Findings

In the excavations carried out since 1989, in addition to clay, many marble, marl, opal, sandstone, natural stone, bone and especially metal samples were unearthed in each excavation season. Such human-shaped idols prove how intertwined belief and life phenomena have been since the Early Bronze Age. The development of a society that started with faith, along with both economic and agricultural activities, has been an indication that it has commercial relations with different cultures. Thus, it can be said that the people of Seyitömer were influenced by other societies in terms of religion.

Metal Finds

The raw material, which is one of the most basic necessities of life both in the past and today, is undoubtedly metal. We can see the importance of metal in making living standards a little easier, starting from the Early Bronze Age.

As a result of the analysis made here with the XRF method; Many finds were unearthed from the mound located within the borders of Kütahya, a region extremely rich in terms of raw materials.

It has been determined that the raw materials of most of the finds were obtained from the region, and the most striking example among the finds is a hilt made of iron. Apart from that, in addition to the arrowheads used in wars, the axes used in daily use and the casting molds from which these axes are made also attract attention. Additionally, hair pins, pins, neck rings and necklaces for daily use were also found. All these finds dating back to the Early Bronze Age and the Roman Imperial period are included in the inventory list.

6. Burying The Dead

In Seyitömer, both extramural, that is, outside the settlement, and intramural, that is, within the settlement, were practiced. The dead were buried in simple soil, jar or stone chest graves. It has been seen in examples of simple earthen graves that the dead were placed in the hocker position, that is, as if they were in the fetal position in the mother's womb. The majority of the dead died in the fire that broke out here and were probably buried hastily in stone chests or cube graves.

7. Conclusion And Comment

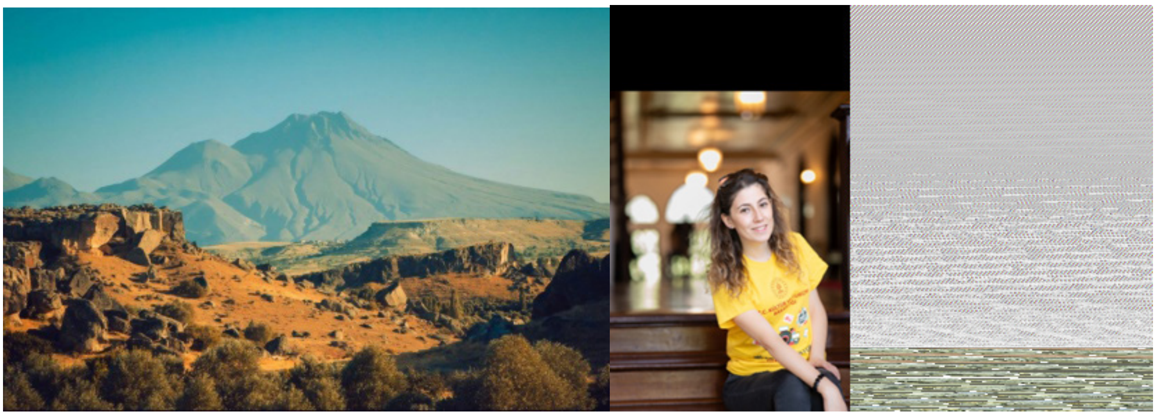
In short, Seyitömer has an element that can be considered as a settlement nourished and shaped by religious elements. It is a point that is shaped with its temples, attracts attention with its burial methods, and most importantly, I believe that it will attract more attention in the future with the conclusion I have reached.

It is a remarkable and important element that this place faced a great fire during the Middle Bronze Age (which can also be called the Hittite Period). However, the main point that needs to be taken into consideration is the fact that the earthquake caused the fire. During the archaeological excavations, the traces left by the earthquake and the fire that broke out after the earthquake in the Seyitömer society were seen in every area. It was possible to see the traces of this fire in houses, temples and daily use areas. Recent studies have already shown that fire was a reason for the destruction of Seyitömer.

The fire incident following the earthquake in Seyitömer was not the first in Anatolia. Undoubtedly, the reason for the increase in casualties after the 1970 Gediz earthquake was the fire that broke out after the earthquake. This terrible incident that took place in Seyitömer 4000 years ago ended up repeating itself. The fire incident that occurred after the earthquake created fear in people, and while they were trying to rush out of their homes, the situation they were experiencing at that moment revealed at every moment that it was an extremely painful and chaotic environment. For example; It is an undeniable fact that these people, who left their homes in a hurry, died on the doorsteps of their homes, and as a result, they were buried in a hurry.

Earthquake rifts are an indication that settlements such as Seyitömer from the Middle Bronze Age will provide important data in all areas of the scientific world. In some areas (trenches), burnt skeletons were unearthed, and in some areas, carbonized brain parts were found in the soft tissues among the burnt skulls.

As a result, Anatolia is a geography where earthquakes have occurred frequently since the early ages. As a Near-Asian archaeologist, I have always seen that in the earthquake and post-earthquake mound studies where traces of fire were observed, there were always studies on the theme of the archeology of fear. In other words, archaeological data blended with fear have been unearthed in areas where traces of the events experienced in fear were found. This situation occurred in the same way in prehistoric times, especially in the Neolithic Age, in Çatalhöyük in the Çumra District of Konya. There, as a result of the eruption of the Hasandağı volcano after the earthquake, the volcano flowed into the residential area. The result was the same, and the state of panic and fear that people experienced is the same as the archaeological data obtained.



We can see burn marks, classic wall paintings of that period showing their haste, and examples of skeletons unearthed in front of doors in every region of Anatolia. For example; Alişar Mound in Yozgat, Boğazköy in Çorum, Minoan Civilization in Continental Greece. With the hope that in the future, the reality of earthquakes will be clarified as an issue that the entire scientific world should investigate together...

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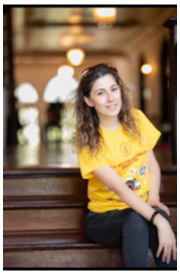

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Post-Mining Activities in Türkiye

***Metin Aktan*[1]**

ABSTRACT

This study aims to provide an overview of post-mining rehabilitation efforts in Turkiye, with a particular emphasis on afforestation initiatives, cultural contributions, and the role of the government institutions like Turkish Coal Enterprises (TKİ) and Turkish Hard Coal Enterprises (TTK) in facilitating archaeological discoveries during coal mining operations.

The TKİ has been actively involved in reclamation projects following mining activities to mitigate environmental impacts and promote sustainable land use practices. Afforestation is one of the key strategies employed by TKİ for post-mining rehabilitation. The organization has implemented extensive tree planting campaigns across various mining sites throughout the country. These afforestation efforts not only contribute to ecosystem restoration but also help enhance biodiversity and mitigate soil erosion.

In terms of afforestation statistics, TKİ has planted a significant number of trees across its mining sites. To date, it has successfully planted 10 million trees encompassing a diverse range of species suitable for reforestation purposes and were planted in over 5.000-hectares. This wide variety ensures ecological resilience while promoting local flora diversity.

Furthermore, beyond environmental considerations alone, TKI recognizes the importance of preserving Turkey's cultural heritage during mining operations. The organization actively collaborates with archaeologists and historians to ensure that any archaeological artifacts or remains discovered during excavations are properly documented and preserved.

In this study, environmental awareness of the Turkish Mining Industry will be investigated and the history of 65 years' success of TTK & TKI will be given in details in terms of contribution to environment, culture and tourism.

Keywords: post-mining, TTK, TKİ, reforestation, reclamation, environment, industrial heritage

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Introduction

Being a developing country, Turkiye has been one of the fastest growing economies among EU and OECD member countries with its increasing economic experiences sustained growth in energy demand. Increasing energy demand brings high investment in the mining sector.

Investing in the mining sector and producing many mines causes damage to land as well. For that reason, life cycle for a mine should end with a good rehabilitation project.

Post-Mining is known as rehabilitating mines at the closure stage of a mine. Rehabilitating mines that have completed their economic life and ceased production and opening them to the desired use is as important as mining activities (Bilen & Ozarslan, 2024).

Turkiye's geological location is very diversified for all kinds of minerals. Türkiye stands as a very promising region for miners and explorers as the least explored portion of Tethyan Belt.

For that reason, post-mining is an important challenge for Turkiye. But there aren't enough studies in post-mining. Bilen & Ozarslan (2024)'s study related to post-mining activities In Türkiye, focusing on coal mines. Most of the other studies in post-mining activities are related to rehabilitation cases. This study focuses on a historical journey of Turkish mining in terms of post-mining and rehabilitation projects.

Mining & Post-Mining

Mining is a finite process that becomes unsustainable once deposits are depleted or unprofitable. Its ecological impacts are lasting and irreversible. The life cycle of mining includes four stages illustrated in Figure 1:

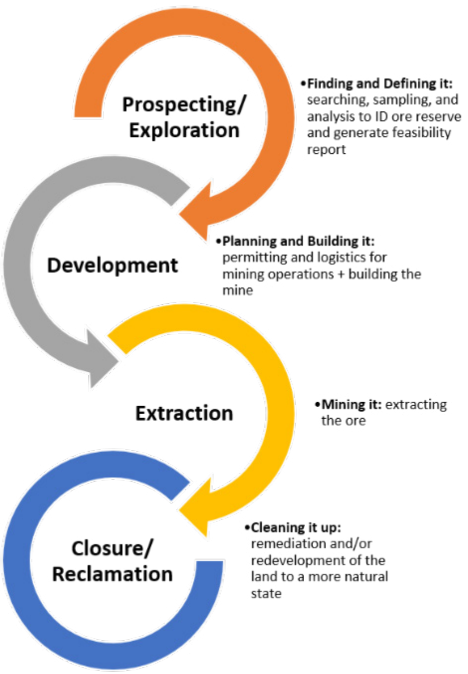

FIGURE 1. CYCLE OF MINING (SRC WEBSITE, 2024)

The stages in the life cycle of a mine are:

I. **Prospecting and Exploration:** A brief assessment of deposit profitability.

II. **Development:** Ongoing exploration and feasibility studies.

III. **Extraction:** A long phase until deposits are exhausted, influenced by economic conditions.

IV. **Closure/Reclamation (Post-Mining Stage)**: This stage involves managing significant environmental changes, termed "Ewigkeitslasten" in Germany, which signifies ongoing responsibilities (Figure 2).

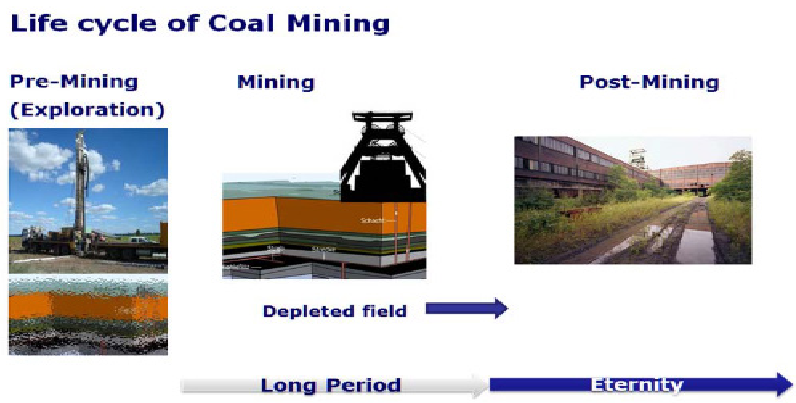

FIGURE 2. MINING CYCLE (KRETSCHMANN ET AL. 2017)

Figure 2 is a simple explanation of the mining cycle including post-mining phase.

Mining companies have historically prioritized the first two stages, often neglecting long-term environmental and economic consequences, leading to societal costs and reduced public support for mining (Bilen & Ozarslan, 2024).

Mining areas often suffer from environmental pollution, ecological degradation, and abandonment post-operation. Remediation can restore ecological, economic, and aesthetic values, enabling sustainable land use. Different reclamation methods are needed for open-pit and underground mines, with open-pit mining causing significant disruption and pollution, while closed-pit mining poses higher costs and risks (Bilen & Ozarslan, 2024).

Reclamation aims to repurpose derelict areas, focusing on new sustainable uses rather than restoring them to their original state. Rehabilitation improves ecological conditions, while restoration seeks to recreate pre-disturbed environments. Successful reclamation can provide social, ecological, and economic benefits. The reclamation process includes preserving water sources, reorganizing the landscape, addressing pollution, and planning new land use (Mert, 2019).

Mining companies reap huge benefits by extracting valuable minerals, but often at a cost to surrounding communities and the environment. Regulating these activities mainly depends on national frameworks and policies, but implementing good practices remains problematic. To truly shift to "sustainable mining," governments and companies must recognize the social impacts of mining and enact laws and regulations that require community consultation throughout the life of a mine (IISD, 2024).

The concept of post-mining has generally been seen as an afforestation and restoration activity in Türkiye. In fact, it is still known this way today. It is an extremely important issue to eliminate the confusion of concepts here. Post-mining should not be seen as an activity program that only includes post-mining. Post-mining is the integration of mining with society, providing benefits to society and leaving a more livable nature to future generations with minimum damage, and providing the integrity of social-cultural-economic and environmental benefits for the development of society during mining activities. From this perspective, it would be more accurate to classify post-mining into three. In other words, post-mining should be classified in three stages:

I. Before mining,

II. During mining activities and

III. After mining activities.

There are lots of good examples of post-mining activities in developed countries. In Turkiye, good examples are increasing but not enough.

In this study, history of mining, history of post-mining and an outlook of post-mining activities will be given respectively.

History of Mining Activities in Türkiye

Archaeological studies show that history of mining in Türkiye goes back to 7000 BC. Mining activities played an important role in the development of the ancient civilizations in Anatolia, such as those of Phoenicians, Hittites, Phrygians, and Lydians. Some mines operating even now in Turkiye were originally discovered and mined by the people of ancient civilizations (Engin, 2002).

Anatolia has historically acted as a cultural bridge between East and West, significantly contributing to the development of various resources, especially minerals. Mesopotamian civilizations relied on Anatolian sources for precious stones, metals, and timber. Archaeological evidence indicates that materials like obsidian and flint were traded from Anatolia during the Neolithic period (Bilen & Ozarslan, 2024).

Mining activities in Anatolia began thousands of years ago, with the use of copper around 7000 BC and bronze from 3000 to 1200 BC. Ancient civilizations, including the Hittites and Lydians, developed metallurgy and mining operations. The marble quarries in Afyon and Iscehisar were particularly important for art and architecture (Bilen & Ozarslan, 2024).

The mining industry thrived during the Roman, Byzantine, and Seljuk periods, receiving state support in the early Ottoman Empire. However, it started to decline in the 18th century due to modernization challenges, leading to the importation of European engineers in the 19th century for revitalization. Currently, Turkiye produces around 60 types of minerals, with significant reserves in marble, boron, and chrome and lignite coal (Bilen & Ozarslan, 2024).

There are five main minerals being produced in Türkiye:

1. **Coal:** Coal mining in Turkiye is a key area of growth over the next few years, substantial coal demand growth for electricity generation in the country.

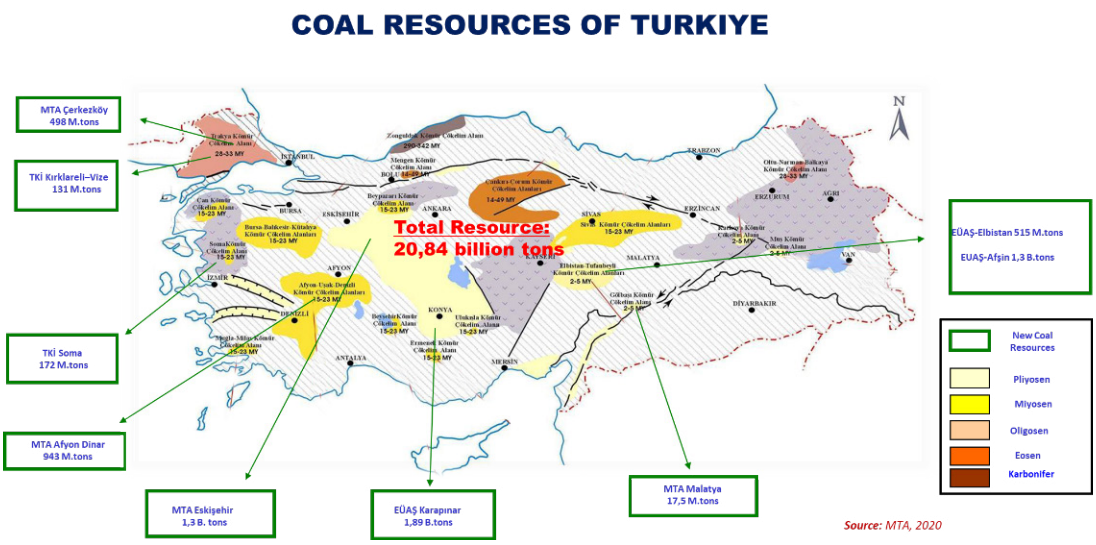

FIGURE 2. COAL RESOURCES OF TÜRKIYE

In 2005, Türkiye had 8.3 billion tons of coal, but with the advent of new prospecting technologies, the reserves have doubled to 20,84 tons *(Figure 2)* and they will continue to increase in the future. According to the policy of using domestic sources in energy, MTA (Mineral Research and Exploration Institute) has been searching for coal intensely since 2005. Between 2005 and 2018, totally 2,9 million meters of drilling distance were achieved. 12 new coal resource sites were revealed, 4 of which are the biggest in terms of resource (Afşin Elbistan, Konya Karapınar, Eskişehir Alpu and Afyon Dinar).

2. **Gold:** Türkiye's gold sector will experience solid growth over coming years on the back of a strong pipeline of new projects and improving gold prices. It is expected that Türkiye's gold sector to receive the largest share of mining industry investment as several companies bring their projects into production.

3. **Chromite:** Turkish chromite mining is well established sector in Turkiye, it has recently been fortified by the rising commodity prices and demand.

4. **Copper:** Turkiye has three important copper reserves: the East Black Sea, Southeast Anatolia and Thrace. There is excellent potential for both Cyprus-type and Kuroko-type VMS deposits in Türkiye, especially in the productive north-eastern Black Sea coast area (the Pontide Belt).

5. **Marble:** In terms of natural stones, and especially marble, Türkiye has sample resources since it is located in the Alp's mountain range. Turkiye has been one of the oldest marble producers in the world with its 4,000 years of background in marble production starting on the Marmara Island. According to the studies, the capacity of marble that can be processed in Turkey is 3.8 billion m^3. For travertine, it is 2.7 billion m^3 and the capacity for granite it is 995 million m^3. In Türkiye, there are approximately 1000 functioning quarries and more than 7000 workshops and 1500 factories processing the stone (Natural Stones, 2024).

Booming domestic demand for electricity, strong growth in steel production and domestic governmental support will make the Turkish mine sector more reboot than other European players.

History of Post-Mining Activities in Türkiye

Even though history of mining dates to 7000 BC in Anatolia, history of post-mining regulations and actual activities in Türkiye dates to establishment of Turkish Republic. In 1935, with the establishment of mining institutions Eti Maden and MTA (Mineral Research and Exploration Institute), mining activities had gained an important growth. In 1957 TKİ (Turkish Coal Enterprises) established, and coal production accelerated with a big increase. Since most of the mines in those years were open pit mines, afforestation activities were carried out after the end of mining production. For that reason, reforestation and reclamation work were done successfully before regulations.

Following the regulations that included the obligation of rehabilitation, which came into effect in 2007, post-mining activities were carried out within a certain systematic manner.

Post-Mining in Türkiye

Zonguldak, which is located in north of Türkiye, known as the capital of mining. Zonguldak has a mining history of over 200 years. Industrial heritage practices are abundant in Zonguldak, where the French also have a mining past. Archaeological sites in a few operations are also supported as post-mining activities.

The underground coal mines of Zonguldak, which were operated by the French in the past and by our country after the Republic, have contributed to our country's mining industry in addition to providing many things in terms of sociological-cultural and industrial heritage.

Thanks to mining, the welfare and education level of the people living in the Zonguldak region has increased visibly compared to many regions of Türkiye. Apart from the Zonguldak example, there are also mining cities in western Anatolia belonging to TKİ. The most important of these are Manisa Soma, Kütahya Seyitömer, Tavşanlı, Tunçbilek settlements. Many cultural structures, from schools to health centers, swimming pools where social activities are held, to cinemas, have been established in the settlements established close to the mines and offered to the service of the employees. Even today, although the structures built in those years still preserve their cultural identities, they are gradually becoming old due to the lack of sufficient renovation investments. It is extremely important to protect these cultural and industrial heritages.

Apart from the cultural and industrial heritages mentioned above, there are also important rehabilitation projects carried out by TTK and TKİ after mining.

Examples of landscape restoration primarily focus on rehabilitation, often converting closed mining sites into recreational green spaces and picnic areas. These restoration efforts have been mandated since 2007.

The TKİ has been actively involved in reclamation projects following mining activities to mitigate environmental impacts and promote sustainable land use practices. Afforestation is one of the key strategies employed by TKİ for post-mining rehabilitation. The organization has implemented extensive tree planting campaigns across various mining sites throughout the country. These afforestation efforts not only contribute to ecosystem restoration but also help enhance biodiversity and mitigate soil erosion.

Furthermore, beyond environmental considerations alone, TKI recognizes the importance of preserving Turkiye's cultural heritage during mining operations. The organization actively collaborates with archaeologists and historians to ensure that any archaeological artifacts or remains discovered during excavations are properly documented and preserved.

Notable projects include the TKİ/Yatağan/Yeniköy-Kemerköy Open-Pit Coal Mines in Muğla, TKİ/Çan Open-Pit Lignite Mine in Çanakkale, TKİ/Tunçbilek/Seyitömer Open-Pit Lignite Mines in Kütahya and TKİ/Soma Open-Pit Lignite Mine in Manisa. Additionally, various afforestation projects in the Aegean region are highlighted as key examples (See Figure 3,4 and 5).

FIGURE 3. STRATONIKEIA ANCIENT CITY, ESKIHISAR OPEN PIT MINE, MUĞLA

FIGURE 4. ANCIENT ROCK TOMBS, ESKIHISAR OPEN PIT MINE, MUĞLA.

FIGURE 5. SEYITÖMER TUMULUS, KÜTAHYA

In terms of afforestation statistics, TKİ has planted a significant number of trees across its mining sites. To date, it has successfully planted 10 million trees encompassing a diverse range of species suitable for reforestation purposes and were planted in over 5.000-hectares. This wide variety ensures ecological resilience while promoting local flora diversity (See Figure 6 and 7 respectively).

FIGURE 6. RECLAMATION AFTER COAL MINING, WEST PART OF TURKIYE

FIGURE 7. RECLAMATION AFTER COAL MINING, DIFFERENT PARTS OF TURKIYE

In addition to afforestation, TKİ has diversified the livelihoods of the local people by supporting agriculture and animal husbandry. (See Figure 8, 9 and 10 respectively).

FIGURE 8. APICULTURE AFTER COAL MINING, WEST PART OF TURKIYE (MUĞLA REGION).

FIGURE 9. PLANTING OLIVE OIL, WEST PART OF TURKIYE (MUĞLA REGION)

FIGURE 10. GELİ SEKKÖY YAYLIKTEPE COAL MINE, RECLAMATION AND THE LAKE AFTER MINING, 2009

Apart from the examples of TTK and TKİ regarding post-mining, there are also many good applications made by the private sector. Apart from Aydın Lignite, Aydem Energy, Kollin Energy and Yeniköy Kemerköy Electricity Production and Trade Inc. (YK Energy) that produce coal for electricity production, there are also many private sector organizations such as TÜPRAG, TÜMAD, Öksüt, Çayeli Bakır, and Acacia that deal with metal mining. These distinguished companies of our country also make significant contributions to the region and to our country by developing many archaeological, environmentally compatible habitats and various social responsibility projects.

In addition to the mining companies mentioned above, we should not forget the contributions of Mining Turkey (MT) Magazine, which also carries out important work in the media field (See in Figure 11). MT provides a very important service by creating an interactive website and offering all these important rehabilitation and post-mining areas to the use of the relevant parties. In addition to MT, MAPEG, which is on the state side, has also created a similar interactive website and offered it to the service of the users (See in Figure 12).

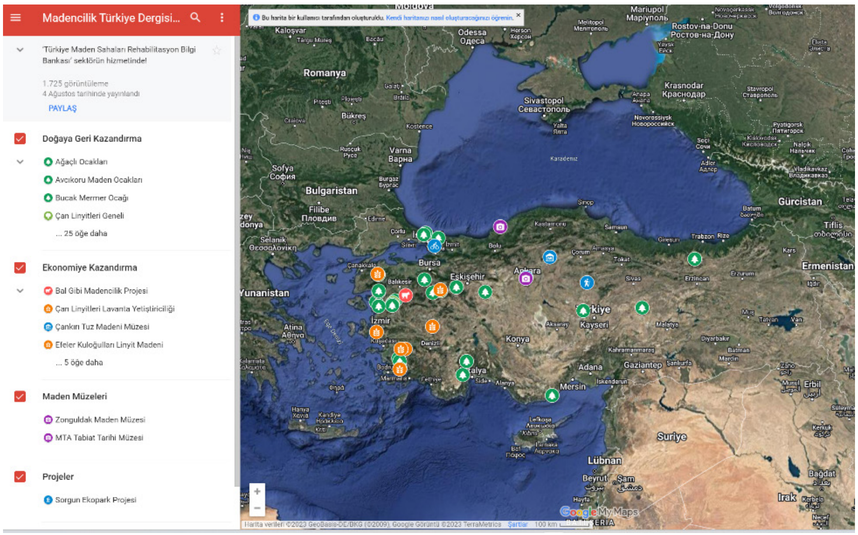

FIGURE 11. MT'S WEBSITE ON REHABILITATION PROJECTS OF TÜRKIYE (MT, 2024).

FIGURE 12. MAPEG'S WEBSITE ON REHABILITATION PROJECTS OF TÜRKIYE (MAPEG, 2024)

Conclusions

Mining is an important economic area for Türkiye. Post-mining applications are predominantly made as landscape reclamation and there are very successful examples in Türkiye. Industrial heritage practices are abundant in Zonguldak and west part of Türkiye. Archaeological sites in a few operations are also supported as post-mining activities.

The concept of post-mining has generally been seen as an afforestation and restoration activity in Türkiye. In fact, it is still known this way today. It is an extremely important issue to eliminate the confusion of concepts here. Post-mining should not be seen as an activity program that only includes post-mining. Post-mining is the integration of mining with society, providing benefits to society and leaving a more livable nature to future generations with minimum damage, and providing the integrity of social-cultural-economic and environmental benefits for the development of society during mining activities.

In this study, environmental awareness of the Turkish Mining Industry is investigated and the history of 65 years' success of TKI is given in details in terms of contribution to environment, culture and tourism.

It is very important to bring the advanced stages of post-mining to the agenda of Türkiye, to introduce the current applications and best practices.

Acknowledgment

I would like to extend my heartfelt gratitude to Halim Demirkan, "Professional Development Association of Mining Engineers" in Türkiye, for his invaluable insights and unwavering support.

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INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Research Center of Post-Mining and Its Projects on Reactivation and Transition

Tansel Doğan[1]

ABSTRACT

The last two remaining coal mines were closed in Germany at the end of 2018. Closure of hard coal mines in Germany has taken place for years and brings a wide range of tasks that have to be fulfilled. In the scope of these tasks first of all in 2013 the graduate program "Geoengineering and Post Mining" and then in 2015 the "Research Center of Post-Mining" were established at the TH Georg Agricola University. The Research Center of Post-Mining is carrying out its researches in the scope of its 4 pillars: "Perpetual tasks and mine-water management"; "Geomonitoring in post-mining"; "Material sciences for the preservation of cultural heritage" and "Reactivation and transition".

The fourth pillar "Reactivation and transition" analyses the political, economic and legal frameworks needed to successfully reactivate former industrial locations and their infrastructures. In this way, the foundations are created for establishing new residential districts and business parks, recreational areas or renewable energy facilities in places where raw materials were once mined. The Project "Green-JOBS", one of the ongoing projects in the Pillar IV and funded by the Research Fund for Coal and Steel, focuses on repurposing end-of-life underground coal mines by deploying emerging renewable energy and circular economy technologies to promote sustainable local economic growth and maximise the number of green, quality jobs.

Keywords: post-mining, reactivation, transition, green jobs

Introduction

The environmental issues at abandoned mines, which can be also called as Post-Mining Legacies given in Figure 1., will be faced in every mining country.

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In Germany, industrial underground mining of hard coal began in the early 19th century. Approximately 200 years ago, there were several hundred mining companies of different sizes mostly located in the Ruhr Area and Saar Region. In 1968, the remaining mining companies in the Ruhr Area merged their coal activities under the supervision of the Ruhrkohle AG with the aim of creating a healthy, economic, and social basis for the coal industry and its employees. In 1997, Ruhrkohle AG underwent a significant restructuring and was renamed RAG Aktiengesellschaft (RAG AG). In 2007, the Federal Government of Germany, the State Governments of North- Rhine Westphalia and Saarland, the Trade Union for Mining, Chemistry and Energy, as well as RAG AG agreed to discontinue subsidized support of hard coal mining in Germany by the end of 2018 in a socially acceptable manner. Based on this agreement, the RAG Foundation was established on 26 June 26, 2007, in order to liquidate the German hard coal industry in a socially acceptable way and to finance the perpetual tasks of hard coal mining. These three perpetual tasks are mine water management, polder measures and ground water purification as given in Figure 2. All of the perpetual tasks deal with the resource water [1, 2].

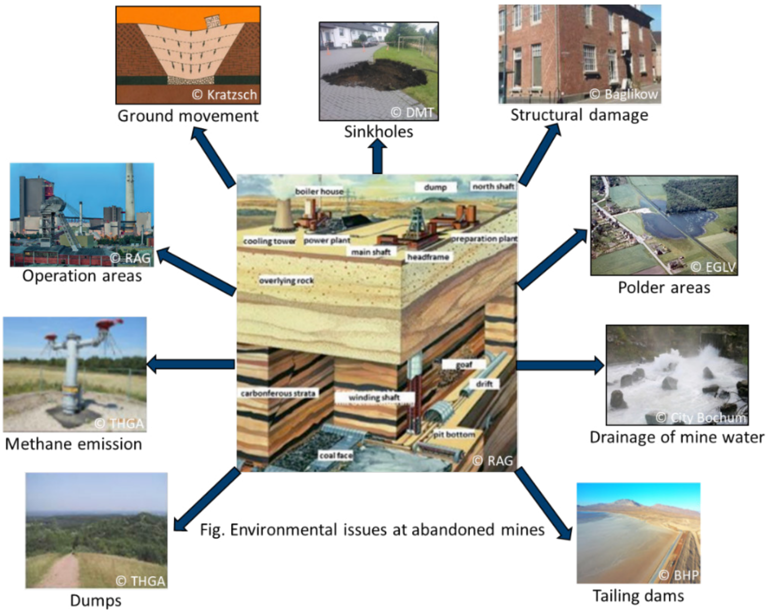

Figure 1. Environmental Issues at Abandoned Mines

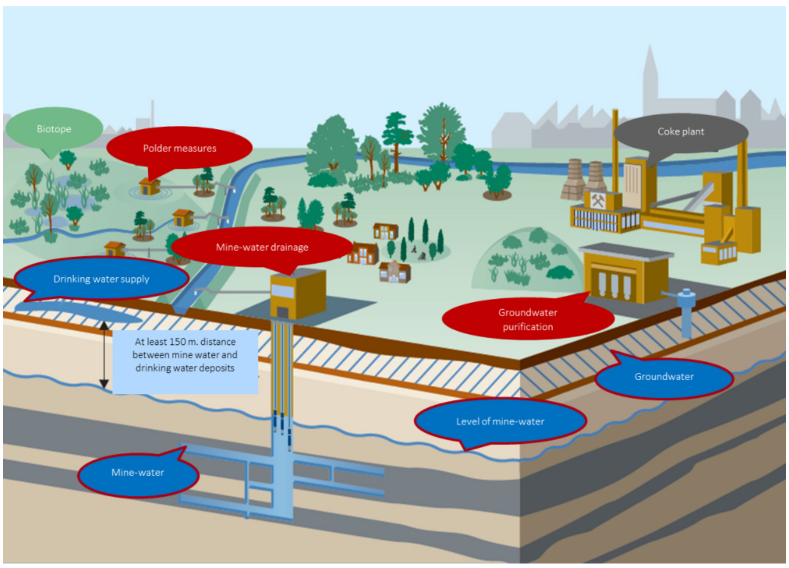

FIGURE 2. ETERNAL TASKS OF THE FORMER COAL MINING IN THE RUHR [3]

RESEARCH CENTER Of POST-MINING

Closure of hard coal mines in Germany has taken place for years and brings a wide range of tasks that have to be fulfilled. In the scope of these tasks first of all in 2013 the graduate program "Geotechnical Engineering and Post-Mining" was established at the TH Georg Agricola University. The Research Center of Post-Mining, which is the only one in the world of its kind, was established in 2015 and is carrying out its researches in the scope of its 4 pillars as given in Figure 3 [4].

FIGURE 3. RESEARCH FOCUSES OF THE RESEARCH CENTER OF POST-MINING [4]

The research aims of the first pillar, "Perpetual Tasks and Minewater Management", are comprehensive understanding of the hydrological system, identification of specific solutions and reconciliation of the needs of people with those of the environment, creating concepts for the near-nature reshaping of water resources in former mining regions.

In the scope of the second pillar, "Geomonitoring in Post-Mining", the researchers collect and combine a diverse range of geoinformation and use this as a basis for developing detailed 3D models. The long-term purpose of the innovations is to digitally simulate potential processes and create a viable risk management system for the post-mining phase.

The research aim of the third pillar, "Material Sciences for the Preservation of Industrial Heritage", is the preservation of industrial culture, not only abandoned collieries, coking plants and blast furnaces, but also individual machines and equipment, by assessing and recording the environmental influences on materials and developing new investigation techniques.

In the scope of the fourth pillar, Reactivation and Transition, the researchers analyse the political, economic and legal frameworks needed to successfully reactivate former industrial locations and their infrastructures. In this way, the foundations for establishing new residential districts and business parks, recreational areas or renewable energy facilities in places, where raw materials were once mined, are created.

GREENJOBS PROJECT

In the frame of the European Research Fund for Coal and Steel (RFCS), project GreenJOBS (Leveraging the competitive advantages of end-of-life underground coal mines to maximise the creation of **green** and quality **jobs**) focuses on repurposing end-of-life underground coal mines by deploying emerging renewable energy and circular economy technologies to promote sustainable local economic growth and maximise the number of green, quality jobs. The GreenJOBS project consists of a collaboration between eight European universities, companies, institution and foundation, including University of Oviedo, Hunosa, FAEN and Magellan & Barents from Spain, GIG and Weglokoks Kraj from Poland, Premogovnik Velenje from Slovenia as well as TH Georg Agricola University from Germany, and is scheduled to run from the beginning of July 2022 and the end of December 2025 [5].

In the scope of the project, five competitive advantages of underground coal mines will be leveraged:

1. mine water for geothermal and green hydrogen;
2. connections to the grid that can be adapted to inject the electricity produced;
3. large waste heap areas for installing photovoltaic/wind;
4. deep infrastructure suitable for unconventional pumped hydro storage using dense fluids; and
5. fine coal waste for recycling into dense fluids, soil substitutes for restoration and rare earths

The main aim of the project is the development of innovative business plans for virtual power plant, taking advantage of the mining areas for the production of electricity, and for a green hydrogen plant where renewable hydrogen will be produced by electrolysis of mine water and green electricity as given in Figure 4. In order to achieve this goal, the project has been carried out under seven work packages as seen in Figure 5.

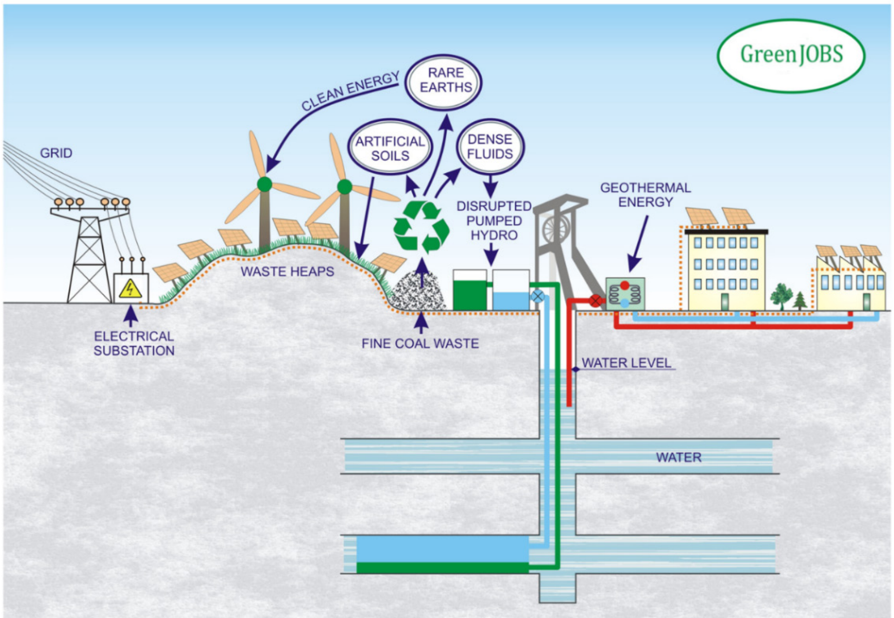

FİGURE 4. AİM OF THE PROJECT [5]

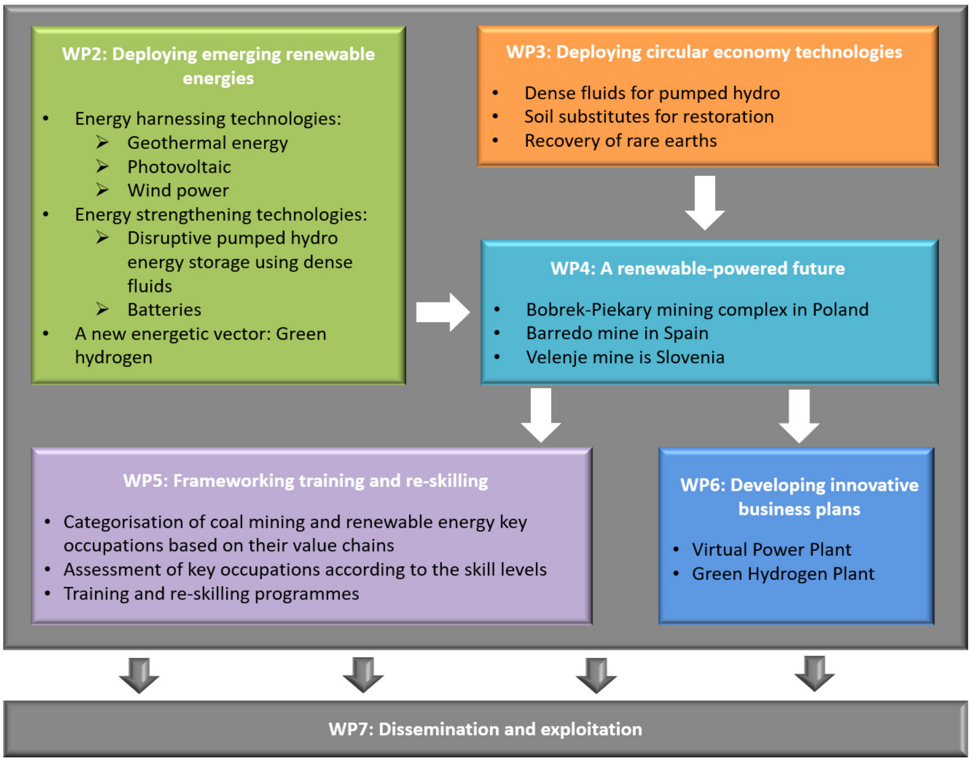

FIGURE 5. WORK PACKAGES OF THE PROJECT [5]

The main objective of the Work Package 1 “Project Coordination and Management” is to manage the different elements of the project, ensuring the smooth running of the project and the efficient use of resources.

The Work Package 2 “Deploying emerging renewable energies” is dealing with the analyse of the deployment of energy-harnessing technologies, energy-strengthening technologies and green hydrogen.

The aim of the Work Package 3 “Deploying Circular Economy Technologies” is to analyse the deployment of circular economy technologies for the three case studies (Hunosa in Spain, Weglo in Poland, PV in Slovenia) based on the valorisation of fine coal waste.

The Work Package 4 “A Renewable Powered Future” is dealing with the planning of specific deployments of selected emerging renewable energy and circular economy technologies for the three case studies.

The Work Package 5 “Frameworking Training and Re-skilling” aims to provide free assistance in planning and updating training and re-skilling programmes to all interested regional authorities in the coal regions in transition to maximise and facilitate the implementation of the project results.

In the scope of the Work Package 6 “Developing Innovative Business Plans” two business alternatives for each case study will be designed: a Virtual Power Plant and a Green Hydrogen Plant.

The main objective of the Work Package 7 “Dissemination and Exploitation” is to support the communication and dissemination of project knowledge and contribute to the exploitation of project results.

CONCLUSION

In the scope of the paper the Research Center of Post-Mining, which is the only one in the world of its kind, and the project GreenJOBS funded by the Research Fund for Coal and Steel (RFCS) were presented shortly.

ACKNOWLEDGMENT

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Additional to her teaching and researching experiences, she worked for DMT GmbH in Essen in 2012 and for EUROQUARZ GmbH in Dorsten between October 2017 and March 2019.

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Mining Site Rehabilitation and Success Criteria

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Abstract
In recent years, mining site rehabilitation has become a crucial component of environmental protection efforts. Today, mining activities play a critical role in the development and economic progress of countries. However, these operations can cause serious damage to the natural environment, disrupting ecosystems and leading to the degradation of the natural landscape and an increase in environmental pollution. Therefore, the detailed analysis and management of environmental impacts throughout all stages of the mining process has become mandatory.

Within the scope of sustainable mining practices, the protection of soil and water resources, the effective implementation of successful rehabilitation plans, and waste management measures are of great importance. Environmental Impact Assessment (EIA) reports are among the legal obligations of mining companies, and these reports identify environmental impacts and determine the necessary measures to mitigate them. However, the mere preparation of these reports is not sufficient. The clear definition of rehabilitation goals and stages, the development of success criteria to be used, and the regular monitoring of the implementation are necessary.

The first step in the rehabilitation process is to obtain the necessary permits and secure the financing. Mining licenses should be issued in accordance with mining and environmental legislation. Additionally, the costs that may arise during mining activities and the closure phase should be calculated in advance, and sufficient financial resources should be provided to cover these costs. There should be close collaboration between the mining authority, rehabilitation experts, decision-makers, and legal authorities during the planning and implementation stages of the rehabilitation process.

At the beginning of mining activities, the detailed examination of the land's topographic, geological, and ecological characteristics is of critical importance. The natural landscape of the region, sensitive areas, water resources, and biodiversity elements should be carefully analyzed, and the most suitable land should be selected. Particularly, biologically valuable areas and drinking water basins should be kept as far away from mining activities as possible. Additionally, the visual quality of the land should be considered, and mining operations should be positioned in areas that are not visible from main transportation routes and tourist areas. In the land preparation stage, the careful stripping and storage of the topsoil is of great importance. Generally, the first 15 cm of soil is considered as topsoil, and if there are different soil types, they should be handled separately. The stripped topsoil should be stored in a way that protects it from erosion and drainage problems. The storage height should not exceed 4-5 meters. Additionally, the existing infrastructure elements (roads, drainage channels, etc.) should be transported and reorganized without any damage.

The land changes caused by mining activities (subsidence, dust problems, water accumulation, etc.) should be addressed carefully. Drainage systems should be installed, and necessary stabilization measures should be

taken to solve these problems. In the stage of reshaping the land, the final topography of the land should be planned, considering the topographic and soil characteristics. Excavation-fill calculations should be made to bring the land into the most suitable shape.

The re-spreading and improvement of the soil is one of the critical steps in the rehabilitation process. The stored topsoil is spread on the prepared land, compacted, and drainage problems are resolved. By increasing the nutrient and organic matter content of the soil, a suitable environment for planting is created. The selection and planting of plant species appropriate for the region is of great importance for the restoration of biodiversity. Vegetation maintenance should be continuously monitored for the healthy development of the plants.

One of the most critical stages of the rehabilitation process is regular monitoring and maintenance. Parameters such as surface water flow, erosion, soil quality, and flora-fauna diversity should be monitored regularly, and quick solutions should be developed for emerging problems. Additionally, an effective management system should be established during and after the mine operation, and mine closure plans should be prepared. In the final closure stage, the extent to which the rehabilitation goals have been achieved should be evaluated, and necessary revisions should be made.

The fundamental aim of all these efforts is to minimize the negative impacts caused by mining activities and to restore the mining site to a condition as close as possible to its previous state, in a sustainable manner. In this context, factors such as landforms, the re-establishment of ecological balance, the protection of water resources, waste management, and social participation should be considered. The clear definition of success criteria and their regular evaluation are vital for measuring the effectiveness of the rehabilitation process and making the necessary improvements.

In conclusion, the rehabilitation of mining sites with a responsible and holistic approach will provide a sustainable future both environmentally and economically. The correct determination of goals and criteria, the effective management of the gradual implementation, and long-term monitoring are critical for successful rehabilitation.

The rehabilitation of mining sites is important not only for the protection of the environment and nature, but also for the future use of the rehabilitated areas. Appropriate rehabilitation efforts can enable the use of these areas for various purposes such as agriculture, forestry, and recreation, creating an environmentally and economically sustainable future.

Throughout all stages of the rehabilitation process, the planning, implementation, and monitoring steps must be carefully managed. Effective collaboration between mining companies, regulatory authorities, experts, and local communities is vital for successful rehabilitation. Only through this approach can mining sites be reorganized in a sustainable manner with the least possible damage to the natural environment.

Keywords: Mining site rehabilitation, Land reshaping and restoration, Rehabilitation goals and success criteria.

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INTERNATIONAL POST-MINING SYMPOSIUM

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New Beginnings: Strategic Dialogues on Industrial Hemp Cultivation in Post-Mining Areas

Emine Yılmaz Can

ABSTRACT

From the beginning of history, underground and surface mining have been used to meet energy needs and achieve wealth, with mineral reserves being discovered and extracted for extensive use. During the use of these minerals, the stages of production, transportation, and enrichment have adverse effects on environmental assets. Due to these effects, following mining activities, the destruction of natural vegetation damages the natural food chain and material cycles, causing negative changes in the structure and quality of surface and groundwater in the mining area. This leads to geomorphological changes, climate alterations, harm to living organisms in the area and soil, and loss of fertile topsoil. Globally, there are many such affected, abandoned, and unused mining sites. These sites cause numerous problems such as environmental pollution, soil degradation, and contamination of water resources. To address these problems, the sustainable and financially attractive reuse of these areas has become important. More comprehensive applications are needed in these areas beyond traditional afforestation activities. Methods to improve the ecological function of degraded habitats in polluted soils involve both economic and technical challenges. Thus, post-mining degraded areas and destroyed ecosystems can be rehabilitated for different uses, creating new ecosystems. Traditional remediation methods (such as surface excavation and removal, burning, soil washing) used as solutions are costly and potentially harmful to the land. Today, an innovative and environmentally friendly technology known as phytoremediation is proposed to solve this issue. This alternative new strategy is an inexpensive, nature-compatible, and publicly acceptable technique for cleaning polluted areas using plants to capture metals from the environment. One of the newly studied plant species for phytoremediation is industrial hemp (Cannabis sativa L.), which has the potential to phytoremediate pollutants depending on the elements and toxicity levels in the contaminated area. In this regard, industrial hemp is highlighted as a versatile plant that aligns with the European Union Green Deal, can help mitigate climate change, has soil rehabilitation properties, is compatible with nature in rural and manufacturing industries, gives back more than it takes, produces zero waste, and has sustainable multi-purpose uses. Industrial hemp is also an industrial product with the potential for various bioproducts, with a sub-market worth billions of Euros. From this perspective, it is understood that the hemp industry should not only be considered as an application area for soil rehabilitation but also as a sector that should be addressed as a national development project. Hemp offers effective solutions for sustainability, one of today's leading environmental and economic issues. By ensuring economic recovery and development with clean biomass post-harvest, it can offset the costs of phytoremediation, potentially providing a competitive advantage over other phytoremediation options.

Keywords: Industrial hemp, post-mining ecological rehabilitation, climate change, hemp industry, sustainability

Introduction

Growth is necessary for improvements in living standards, increases in population and productivity, urbanization, and more. The increase in urbanization is also expected to reach 60% by 2030 (1). However, this transformation causes significant changes in the Earth's ecosystem, adversely affecting the environment through air pollution, topsoil pollution, groundwater contamination, and water pollution. The dynamic development of economic activities worldwide has led to a significant increase in the demand for raw materials and energy for their processing in industries. This increase has resulted in the release of large amounts of waste, sewage, and waste gases into the natural environment, creating the danger of the gradual degradation of the natural environment (2,3).

It has been observed that environmental pollution (soil, water, and atmosphere) has rapidly increased since the beginning of the industrial revolution. The rapid development of the mining sector plays a significant role in this pollution and constitutes one of the most serious environmental threats (1-4). Mining has great economic benefits but pollutes water and soil, especially through exposure to discharges (processed or unprocessed). These discharges contain toxic heavy metals, thereby contaminating soil, vegetation, water systems, and marine life. Soil pollution is defined as the accumulation of persistent toxic compounds, chemicals, salts, radioactive materials, or disease-causing agents in the soil that adversely affect plant growth and animal health. The accumulation of anthropogenic heavy metals in soil is a significant form of pollution, and since these potential toxic elements are not biodegradable, they persist as a threat to human and environmental health for many years (5). Soil contamination with heavy metals has negative impacts on the environment, particularly on soil quality and plant growth. The accumulation of heavy metals in plants causes the plants to die due to the disruption of photosynthesis and protein synthesis. Due to the irreversible nature of the damage, the removal of heavy metals is difficult and remediation is necessary. Therefore, planned efforts to rehabilitate ecosystems degraded by mining, minimizing or eliminating the detected degradation in water, soil, and air, are required. Phytoremediation is a remediation method that provides ecological benefits, is cost-effective, and is highly accepted by the public in this regard (5-10).

What Is Phytoremediation?

There is a great need for environmental remediation worldwide. Environmental toxic accumulations are becoming increasingly common, resulting in many abandoned areas that need to be cleaned. Since heavy metals are toxic and biologically non-degradable, they are persistent in the environment and have the potential to enter the food chain through crop plants. Long-term exposure can lead to their accumulation in the human body. As a result, heavy metal pollution poses a serious threat to human health and ecosystems. Therefore, remediation measures are necessary to prevent heavy metals from entering terrestrial, atmospheric, and aquatic environments (1,3-6).

Traditional remediation methods used as solutions for cleaning contaminated areas are costly and potentially damaging to the land. These approaches developed for the recovery of heavy metal-contaminated soil are mainly based on mechanical or physicochemical techniques. These techniques include soil incineration, excavation and storage, soil washing, solidification, and electrokinetic applications. However, some limitations have been reported with these approaches, such as high cost, inefficiency when contaminants are present at low concentrations, and irreversible changes in the physicochemical and biological properties of the soil. These issues lead to the degradation of the soil ecosystem and the formation of secondary pollutants. Therefore, there is a need to develop cost-effective, efficient, and environmentally friendly remediation technologies for the recovery of heavy metal-contaminated soil (6,7,11). Today, a solution to this problem is proposed with a new, innovative, and environmentally friendly technology known as phytoremediation.

Phytoremediation is the process of cleaning contaminated areas using plants. In this cleaning method, plants can stabilize the contaminant in place or absorb the contaminant into plant tissue. Phytoremediation technology is classified into phytoextraction, phytostabilization, phytodegradation, rhizodegradation, rhizofiltration, phytovolatilization, hydraulic control, buffer strips, and vegetative cover systems. This alternative new strategy is a cost-effective, nature-compatible, and sustainable technique that uses plants to capture metals from the environment for cleaning contaminated areas. It is a clean process that reestablishes the ecosystem in place and offers a competitive alternative to traditional methods that either eliminate or harm biotic elements in the area and leave behind a barren land.

Phytoremediation cleans contaminated soil in a non-invasive way by placing plants in the soil rather than removing the soil along with the contaminants and stripping the biological and physical environment. Using plants to remove various contaminants is necessary to rebuild the environment and ecosystem of the degraded area as quickly as possible. Phytoremediation helps reestablish the ecosystem around the area by stabilizing the soil and stimulating microbial activity, which supports the return of local flora and fauna and the repopulation of the region (2,6).

Fast-growing, low-maintenance, non-edible commercial plants can be used for phytoremediation purposes. Bast fiber plants, typically non-edible crops with short life cycles, are important crops with many industrial applications due to their continuous fiber supply and ease of maintenance. Because of their low maintenance requirements and minimal economic investment, bast fiber plants are a good option for phytoremediation and are widely used (1,2). Plant fibers known as bast fibers are found between the epidermis and the phloem in the bark parts of plants. These plants have the ability to remove metals from the soil through their deep roots, making them an ideal candidate for phytoremediation purposes as a profitable crop. Therefore, comprehensive studies are needed to better understand the morphology and phytoremediation mechanisms of four commonly used bast fiber plants: hemp (Cannabis sativa L.), kenaf (Hibiscus cannabinus), jute (Corchorus olitorius), and flax (Linum usitatissimum) (1). These plants are also used in the production of various products such as paper, textiles, rope, packaging materials, and baskets, which can improve the socioeconomic conditions of people living in contaminated areas or using polluted soils for agricultural purposes. One of these plants, industrial hemp (Cannabis sativa), is a promising candidate for phytoremediation (2,5,8,9,11,12).

The Role of Industrial Hemp in Phytoremediation

Hemp is a plant with high added value that can be beneficial to many sectors, from pharmaceuticals to paper production, from fabric manufacturing to automotive, making it a politically and strategically important crop. An acre of hemp produces as much oxygen as 25 acres of forest. It absorbs 9-13 tons of CO_2 per harvested hectare (carbon sink) and is one of the most effective plants for wetland drainage (13).

In addition to all these properties, hemp is one of the plants that accumulates contaminants in the soil. For this reason, it has been used to clean toxic waste sites where other remediation efforts have failed. After the Chernobyl nuclear disaster in Ukraine in 1986, industrial hemp was planted on approximately 10,000 acres around the abandoned Chernobyl nuclear power plant in the early 1990s to clean radioactive isotopes from the soil and groundwater. It was successfully used to reduce the soil toxicity of radioactive substances (14,15,16). Ten years later, in 2001, a research team in Germany confirmed the results from Chernobyl by demonstrating that the plant could remove lead, cadmium, nickel, and other heavy metals from a soil contaminated with sewage sludge (17).

In 2008, in an Italian agricultural area contaminated by a nearby steel plant, hemp was cultivated to remediate contaminants such as dioxins from the soil [18]. Dioxins are considered toxic because they cause cancer, affect reproduction and development, damage the immune system, and interfere with hormones. After remediation, the dioxin-containing plant material can be used for energy production. Beyond soil cleaning, research is being conducted on using hemp fibers to create adsorption materials that can filter metals from contaminated water [19].

Since then, industrial hemp has become a viable option for cleaning many industrially contaminated sites around the world due to the numerous advantages it offers over traditional remediation approaches. Its rapid growth and ability to absorb heavy metals and other pollutants into its tissues have made it an attractive potential phytoremediator.

Hemp, which can grow up to 6 meters high, has a high biomass yield (7-15 tons of fiber per hectare) and a well-developed taproot system that can reach depths of approximately 2 meters, allowing it to absorb and accumulate contaminants from deeper soil layers and address widespread pollution. Its short growth cycle (4 months), lack of need for pesticides, minimal plant maintenance, adaptability to various soil conditions, ability to grow in different climates, and its ability to absorb and store metals such as lead, copper, nickel, and cadmium make it an ideal candidate for phytoremediation (2,5,8,9,12-15,20,21). The success of hemp as a phytoremediator can vary depending on factors such as the amount of pollutants in the soil, growth duration, and other environmental conditions. Studies show that during one growing season, hemp can remove 50% of cadmium and 90% of lead from contaminated soil (19,22). In a study conducted in Poland, hemp (Cannabis sativa) was planted to rehabilitate soil degraded by open-pit lignite mining (2014-2018). A five-year experiment conducted on a total area of 7.5 hectares demonstrated that hemp is a useful species for rebuilding soil organic matter. The study observed increases in plant height, biomass, soil organic matter, growth in the humus layer, and mineral content. In 2019, wheat was planted and harvested in the relevant soil, enabling its return to agriculture (23). Due to its durable and fast-growing characteristics, hemp is a strong candidate for cultivation in contaminated areas (1,2,5-9,11-15,20,21). The economic benefits of hemp can offset the setup and maintenance costs of the phytoremediation process. Another factor to consider when using hemp for phytoremediation is how to properly dispose of the contaminated plant material. When used for phytoremediation, toxins can accumulate in the roots, leaves, and stems (5,18,23). Therefore, leaves are not harvested for food or personal care, but stems can be used for construction materials, paper, fabric, and biofuels (22,24-27). Hemp is used to clean metals, pesticides, solvents, explosives, crude oil, polycyclic aromatic hydrocarbons, and toxins. Hemp harvested from remediation sites can be safely distilled into ethanol for use as a biofuel (24-27). A comparative cost analysis has shown that hemp is a profitable commodity for producing both biofuels and value-added products (26,27).

The advantages of using industrial hemp for phytoremediation to achieve sustainable economic and socio-cultural improvements are summarized below:

- Reduces environmental pollution.
- Conserves soil and water resources.
- Increases biodiversity.
- Promotes economic development.
- Creates new job opportunities.

Conclusion

The sustainable and financially attractive reuse of abandoned mining sites will provide significant contributions to both the environment and the economy. Phytoremediation is an environmentally friendly, viable, economic, and sustainable approach that can be used to economically replant soil contaminated with heavy metals. Industrial hemp is an extremely valuable plant with beneficial properties for human and environmental health. It cleans the soil by absorbing heavy metals, prevents erosion, and supports ecological and socio-economic development in the area. The use of industrial hemp for phytoremediation will not only support sustainable ecological balance and socio-economic development but also foster community engagement.

Let us remember:
"Hemp nourishes nature, nourishes the soil, and nourishes people.
Hemp heals nature, heals the soil, and heals people."

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INTERNATIONAL POST-MINING SYMPOSIUM

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Tailings Management After Flotation at Zn-Pb-Cu (Gümüşhane) Mine: A Case Study

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ABSTRACT

Effective management of tailings remaining after mineral processing is of great importance to the environment. Acid Mine Drainage (AMD), a common problem especially in sulphide-containing metallic ore deposits, is primarily responsible for water and environmental pollution.

In this study, the AMD potential of the materials in the tailings pond where the post-flotation tailings in a Pb-Zn-Cu mine are accumulated, and the solutions for the impermeability of the tailings pond are discussed. Firstly, acid-base calculation (ABA) analyses, also called static tests, were performed on 10 samples taken from the site to determine AMD potential. The sulphide-sulfur (%S-2: 2.92-3.98, n= 10), net neutralization potential (NNP: -32 kg CaCO3/t -149 kg CaCO3/t, n= 10) and neutralization potential ratio (NPR: 0.20-0.80, n= 10) tests included in the ABA analysis showed that the sulfur-bearing tailings have acid-generating potential. The rock mass permeability of the boreholes drilled in the reservoir area and the axis of the tailings pond was determined by lugeon tests and it was determined that the permeability of the area was (K= 2x10-6 m/s). To make the reservoir area, which was determined to be permeable, and impermeable, 40-50 cm thick clay was laid and compacted, and then geotextiles such as geosynthetic clay membrane and geomembrane were laid, and drainage geocomposite on the bottom of the reservoir area to prevent a possible chemical leakage. In the infiltration analysis modeling using finite elements, the discharge value obtained at 5 meters under the bedrock was recorded as 5.63x10-8 m3/s. In contrast, the permeability value of the bedrock mass was determined as 9.79x10-10 m/s. These applications help to prevent surface and groundwater pollution caused by the potential acid production of post-flotation tailings accumulated in the tailings pond.

Keywords: Tailings management, Pb-Zn-Cu mine, Environmental impact, Acid mine drainage, Tailing pond, Permeability

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Introduction

The primary environmental impacts of mining activities include the contamination of soil, groundwater, and surface water with chemicals from mining operations. In addition to causing environmental damage, contamination from the leaching of chemicals also affects the health of local populations. Among the primary effects is Acid Mine Drainage (AMD), which poses significant ecological risks during and after mining activities.

AMD/Acid Rock Drainage is generally defined as a process where sulfide minerals (primarily pyrite, but also pyrrhotite and chalcopyrite), under atmospheric conditions (such as water, oxygen, and carbon dioxide), and sometimes with the contribution of microbiological organisms (e.g., Acidophilic bacterium, Acidithiobacillus ferrooxidans), react with air (oxygen) and water to undergo chemical oxidation (e.g., [1]-[10]).

This process, also known as pyrite oxidation, is characterized by the formation of sulfuric acid and dissolved iron (Fe) because of a typical chemical reaction. The dissolved Fe and the decrease in pH lead to the mobilization of other metals (such as Cu, Pb, Al, Mn, and U).

Especially in open-pit mines, when the pH of acidic water is increased either by contact with fresh water or neutralizing minerals, metals such as Fe+3 ions, which were previously soluble, are oxidized and release $Fe(OH)_3$, a yellow-orange solid.

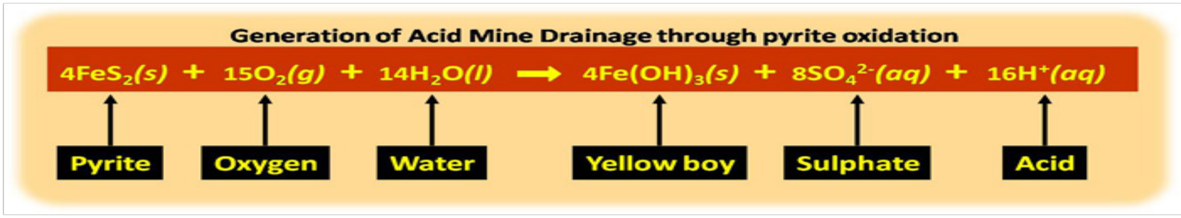

Figure 1. Generation of Acid Mine Drainage Through Pyrite Oxidation

Similarities between AMD and AMD are sometimes expressed in practice. However, AMD is generally caused by anthropogenic activities (mining activities, road construction, slope breaking or leveling for protection against natural hazards, etc.). On the other hand, AMD occurs when it is formed because of natural erosion, weathering, and degradation without any human influence.

There are some tests applied to determine AMD. One of them is static tests. These are given in Table 1.

Tablo 1. Static Tests

STATIC TESTS
Whole Rock Chemistry
Contact Leakage Tests
Acid-Base Accounting (ABM) Test
Net Acid Generation (NAG) Test
Identification of Acid Producing Minerals
Can be done in a short time

The other tests applied in AMD determination are kinetic tests and are given in Table 2.

Tablo 2. Kinetic Tests

KINETIC TESTS

Kinetic tests are the next step after static tests and are essentially simulation tests.

They are carried out to reduce uncertainties in static tests, verify the data obtained, identify the determinant reactions, determine the rate of acid production, and determine the drainage water quality.

Here, oxidation and weathering are simulated using tests on rock and process residue samples that have been exposed to air and moisture for a long time.

Long periods are needed for follow-up

In this study, the Acid Rock Drainage (ASD) formation of the irrigated sanitary landfill located in the Organised Industrial Zone in the Central District of Gümüşhane Province, Gümüşhane Province and constructed by the private sector for the Zinc-Lead-Copper Enrichment Plant was determined and the potential for ASD development and the measures to be taken in case of possible ASD development were presented. Within the scope of the study, systematic samples were taken from the irrigated landfill and the lithology (side rocks) on which it was built, and static tests were carried out to determine the potential for ACD formation.

Material And Method

Location And Geology of The Study Area

The mining site, which is the subject of the study, is located in the northeastern part of Tekke Town, which is approximately 10 km east of Gümüşhane city center and close to the Harşit Stream passing through the city center.

The ore stockpile and waste storage area, which is being operated within the scope of mining activities, is observed within the Alibaba Formation, which consists of Eocene-aged andesite and basalt and pyroclastics of these rocks.

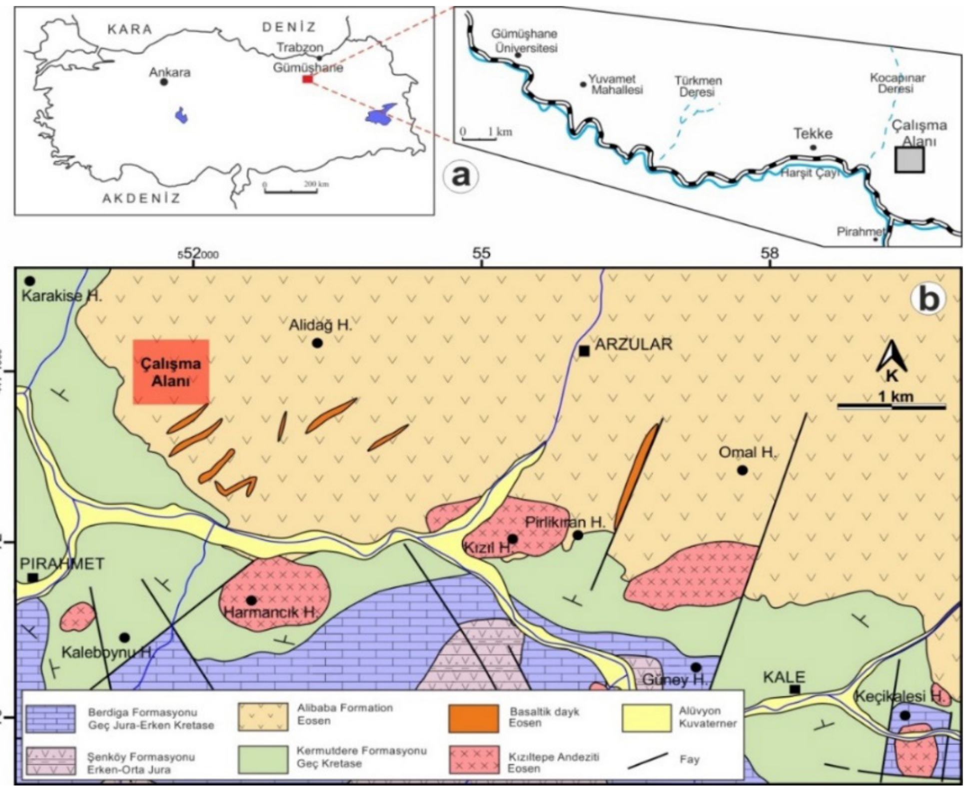

Figure 2. (a) Location map. (b) Geological map of the study area (modified from [11])

Sampling Carried Out in The Field

Within the scope of the study, 10 samples (AB1-AB10) were taken from the irrigated sanitary landfill to determine the potential for ACD formation (Figure 5). Whole rock geochemistry analyses, contact leachate, and acid-base accounting (ABA) tests were performed on the samples.

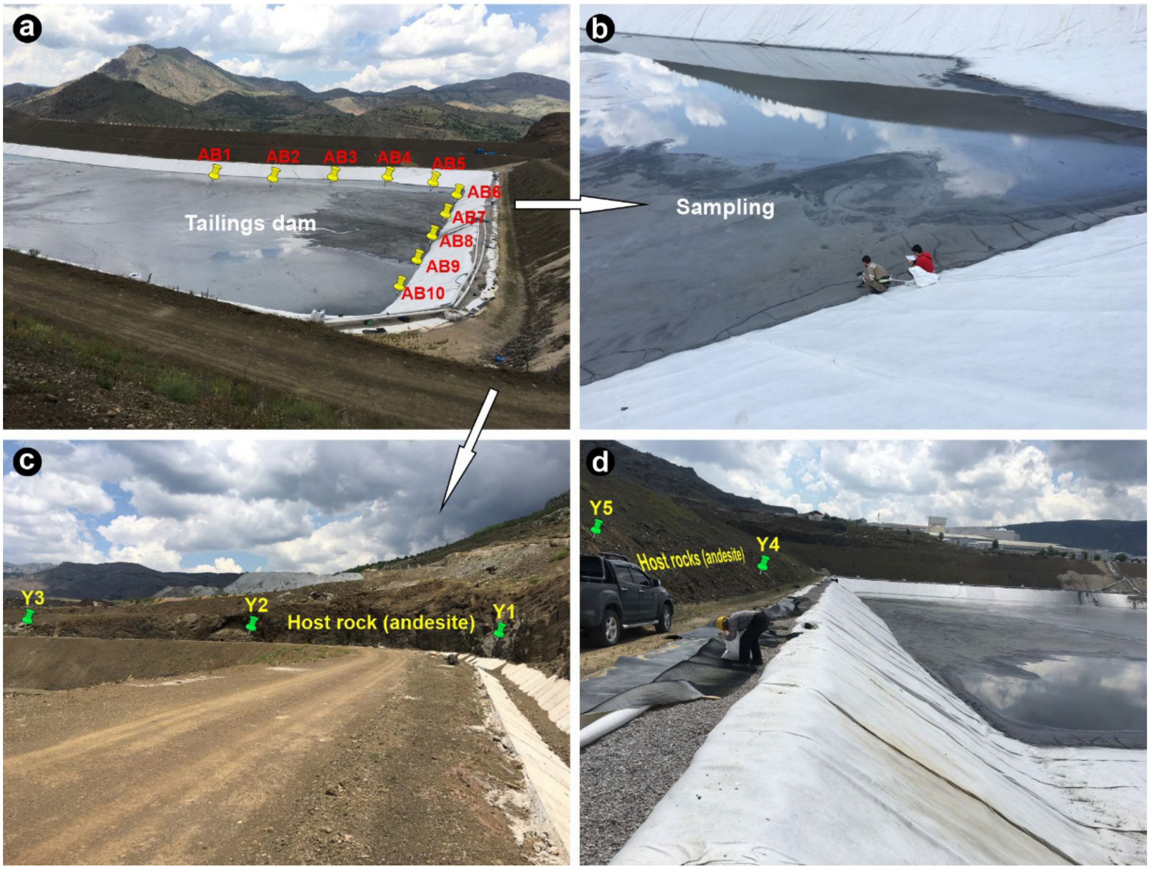

Figure 3. (A) Distribution Of Samples Taken From The Tailings Dam And (B) Sampling Process. (C) Host Rock (Andesite) And (D) Sampling from The Host Rock

Contact leakage tests

Contact seepage tests allow the evaluation of the leaching behaviour of metals, which are identified as elements with the potential to cause water pollution. Contact leaching tests were carried out at Gümüşhane University Central Research Laboratory (MALUAM) to observe the short-term leaching behaviour of ore tailings and side rock samples. In the tests carried out using deionised water with 3:1 liquid/solid ratio for 24 hours according to 'Modified US EPA 1312' standard, 2% HNO3 solution was prepared, and one drop was added to the water samples to prevent precipitation. Trace element concentrations were measured by Agilent 7700 ICP-MS and the results were evaluated in ppm (mg/l) and ppb (µg/l) and compared with water quality standards. The results were combined with other tests to determine the potential for AKD and used in metal release analyses.

Acid-Base Accounting Tests

ABM is an evaluation method consisting of compositional analyses and calculations used to determine the mineral abrasion potential that will cause AMD when materials are exposed to oxygen and water. In metallic mining activities, the sulfide monoatomic ion (S-2) in ores and side rocks is oxidized by the effect of oxygen and water, resulting in a decrease in the pH (increased acidity) of groundwater and surface water and deterioration in water quality. Especially carbonates containing Ca and Mg constitute the Neutralisation Potential (NP) to a great extent, therefore NP is interpreted as the amount of calcite (CaCO3) required to neutralize the acid that is predicted to be released, and kgCaCO3/ton unit is used.

Acid-base accounting (ABA) tests were carried out in an accredited private laboratory. In the analysis, TS

12089 EN 13137 was used for carbon (total) and carbonate measurements, ISO 15178 for sulphur (total) measurements, SOBEK for the Fizz test and TS EN 15875 analysis/measurement method for other parameters.

Results And Discussion

Contact Leakage Tests

Contact leakage tests were carried out in order to evaluate possible leakages in the irrigated landfill and adjacent rocks and the results are given in Table 3. The results obtained were also compared with continental water quality standards. Contact seepage tests allow the evaluation of the dissolution of metals, which are determined as elements that have the potential to cause water pollution, and their leaching with water.

The pH values of the ore waste samples taken from the irrigated landfill vary between 9.55-10.60 (n= 10). The pH values obtained indicate a basic rather than acidic environment. When these values are compared with the quality classification of continental water resources, they represent fourth class (IV) quality waters in terms of pH parameter (Table 3). In terms of other elements (Na, Al, Mn, Ba) and potentially toxic metal (Cd, Co, Cr, Cu, Fe, Ni, Pb, Zn) contents, they correspond to first class (I) quality waters. However, Zn concentration in two of the effluent samples (AB 1 and AB 7) was above the acceptable limit value (5.4 mg/l and 7.2 mg/l, respectively) (Table 3).

	pH	Na	Al	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn	Ba
Quality criteria of continental surface water resources*													
I	6.5-8.5	125	≤0.3	≤0.002	≤0.01	≤0.02	≤0.02	≤0.3	≤0.1	≤0.02	≤0.01	≤0.2	≤1
II	6.5-8.5	125	≤0.3	0.005	0.02	0.05	0.05	1	0.5	0.05	0.02	0.5	2
III	6.0-9.0	250	1	0.007	0.2	0.2	0.2	5	3	0.2	0.05	2	2
IV	<6.0 veya >9.0	>250	>1	>0.007	>0.2	>0.2	>0.2	>5	>3	>0.2	>0.05	>2	>2
Sample	**Ore-bearing tailing samples**												
AB 1	10.40	2.36	0.015	<0.002	<0.001	<0.002	0.015	<0.001	0.002	0.001	0.0061	**5.405**	0.001
AB 2	10.10	5.49	0.005	<0.002	<0.001	<0.002	0.016	<0.001	0.003	0.002	<0.001	0.482	0.001
AB 3	10.15	5.00	0.034	<0.002	<0.001	<0.002	0.029	<0.001	0.002	0.002	<0.001	0.116	0.001
AB 4	10.25	3.34	0.013	<0.002	<0.001	<0.002	0.011	<0.001	0.002	0.001	<0.001	0.166	0.001
AB 5	10.25	6.44	0.005	<0.002	<0.001	<0.002	0.013	<0.001	0.003	0.001	<0.001	0.254	0.001
AB 6	10.12	8.21	0.017	<0.002	<0.001	<0.002	0.014	<0.001	0.005	0.001	<0.001	0.250	0.001
AB 7	9.55	4.29	0.045	<0.002	<0.001	<0.002	0.009	<0.001	0.006	0.001	0.0039	**7.205**	0.001
AB 8	10.43	1.86	0.022	<0.002	<0.001	<0.002	0.010	<0.001	0.002	0.001	0.0012	0.207	0.001
AB 9	10.10	1.82	0.000	<0.002	<0.001	<0.002	0.010	<0.001	0.003	0.001	0.0011	0.219	0.001
AB 10	10.60	3.44	0.006	<0.002	<0.001	<0.002	0.008	<0.001	0.002	0.002	<0.001	0.045	0.001

Table 3. Contact Leachate Test Results Of Samples Taken From The Tailing Dam (Mg/L)

Tailing products, climatological conditions, and mineral phases that influence the nature of acid mine drainage can be analyzed using Ficklin diagrams ([12]). These diagrams are used to differentiate between different types of sediment in mine drainage water chemistry by plotting the sum of base metals such as Zn, Cu, Cd, Pb, Co, Ni against pH (e.g. [14], [12]-[13]). These metals, unlike the more common elements such as Fe, Al and Mn, are distinctive among geological controls.

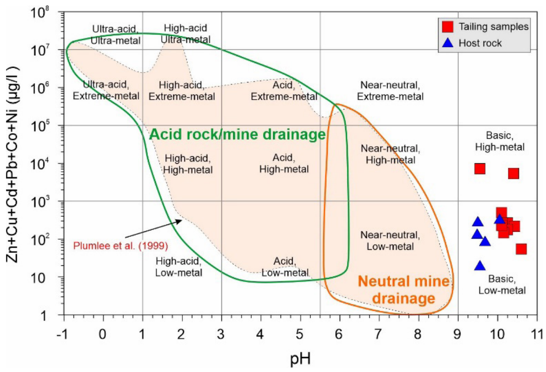

Figure 4. Ficklin Geochemical Discrimination Diagram For The Ore-Bearing Tailing Samples And Host Rocks

According to the Ficklin diagram, ore tailings (except AB 1 and AB 7) and side rocks are located in the 'basic/low metal' area, while AB 1 and AB 7 samples are located in the 'basic/high metal' area with high Zn content. All values are outside the 'acid rock/mineral drainage' and 'neutral mineral drainage' and do not indicate an ACD potential.

Acid-Base Accounting (ABA)

There is always a risk that metallic mine tailings will form ACD (Acid Rock Drainage). Sulphide minerals are oxidised by oxygen and water, lowering the pH of the water, which adversely affects water quality. Acid Base Accounting (ABA) tests are applied to determine the potential for ACD. The evaluation is based on pH, sulphide (S-2), Acid Potential (AP), Neutralisation Potential (NP), Net Neutralisation Potential (NNP) and Neutralisation Potential Ratio (NPO) parameters (Table 4).

acid-base accounting (ABA)	Screening criterion	AMD potential
Macun pH	< 6 > 6	Acid generating Non-potential acid formation
Sulphide-Sulphur (% S^{-2})	< 0.1 > 0.1	Non-potential acid formation Potential acid formation (static and, if necessary, kinetic tests are performed)
Sulphur (total %S)	< 0.05	Non-potential acid formation
Net neutralization potential (NNP)	< –20 < 5 < 10	Potential acid formation ([15]) Potential acid formation ([1]) Potential acid formation ([16])
Neutralization potential ratio (NPO)= NP/AP	< 1 > 3 1<NP/AP<3	Acid generating Non-potential acid formation ([17]) Uncertain (kinetic tests are performed)
**The unit of measurement is kg CaCO3 per ton, or equivalent parts per thousand $CaCO_3$*		

Table 4. Static Test Interpretation Parameters

The potential for mine tailings to form acid rock drainage (ASD) is always present. Sulphide minerals oxidize, lowering the pH of the water and degrading water quality. Acid-base accounting (ABA) tests are applied to determine this potential. In ABA tests, acid-generating potential (AP) and neutralisation potential (NP) are calculated in kg $CaCO_3$/tonne. AP is determined by multiplying the sulphide sulphide by 31.25% and NP is determined by the neutralisation capacity of carbonate minerals. The net neutralisation potential (NNP) and neutralisation potential ratio (NPO) are calculated from the AP and NP values. The paste pH value also provides additional information on the neutralisation capacity. According to the ABA test results, wastes with AKD potential are disposed of with precautions, cautious methods are applied in uncertain cases and wastes with no potential are disposed of without any treatment. In this study, ABA tests were performed on the samples taken from the landfill to evaluate the potential of the waste (Table 5).

The paste pH values of the ore waste samples taken from the irrigated landfill ranged between 10.00-11.04 and pH was above 6 in all samples analyzed. Therefore, paste pH values do not indicate acid-generating potential (Table 5). Sulphide-sulphur (S-2) ratio, which is another important parameter in the characterisation of mine wastes and side rocks, was also taken into consideration; materials with S-2 content above 0.1% are considered as 'potential acid producers and in this case, static or kinetic tests are required. The S-2 values of the samples taken from the study area were found between 2.92-3.98%, which is well above 0.1%. Therefore, all samples were considered to have acid formation potential and were included in the 'potential acid producing' area in the NPO-Sulphide-Sulphide graph (Figure 5).

	Paste pH	Carbon (C) (total)	Carbonate ($CaCO_3$)	Sulphur (S)	Sulphide-Sulphur (S^{-2})	Sulphate (SO_4^{-2})	NP[1]	AP[2]	Net NP[3]	NPO[4]
Unit	–	%	%	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	
Sample					**Ore-bearing tailing samples**					
AB1	10.09	14.46	72.30	5.77	3.85	1.92	48.25	180.31	-132.06	0.27
AB2	10.42	14.07	70.34	4.93	3.29	1.64	122.50	154.06	-31.56	0.80
AB3	11.04	13.72	68.58	4.51	3.01	1.50	100.00	140.94	-40.94	0.71
AB4	10.94	14.10	70.49	5.31	3.54	1.77	55.00	165.94	-110.94	0.33
AB5	10.66	13.98	69.92	5.62	3.75	1.87	58.75	175.63	-116.88	0.33
AB6	10.43	14.16	70.82	5.31	3.54	1.77	55.00	165.94	-110.94	0.33
AB7	10.14	14.68	73.41	5.25	3.50	1.75	50.00	164.06	-114.06	0.30
AB8	10.36	14.46	72.29	5.97	3.98	1.99	37.50	186.56	-149.06	0.20
AB9	10.00	14.33	71.67	4.38	2.92	1.46	37.50	136.88	-99.38	0.27
AB10	10.08	13.31	66.56	5.67	3.78	1.89	97.50	177.19	-79.69	0.55

[1]NP (Neutralization potential) = 50 x (1 N HCl x total added HCl - 0.1 N NaOH x total NaOH (from [1]),

[2]AP (Acid potential) = %Sulphide-Sulphur x 31.25 (from [1]),

[3]NNP (Net neutralization potential) = NP-AP,

[4]NPO (Neutralization potential ratio) = NP/AP

Table 5. ABA Analysis Results and Calculations Performed On The Samples

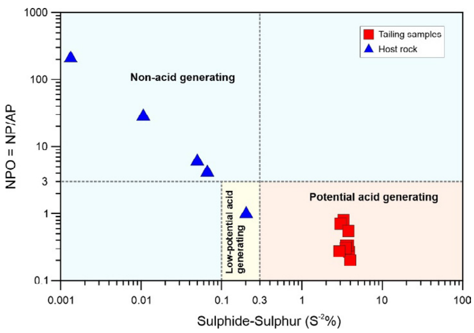

Figure 5. NPR Vs Sulphide-Sulphur (%) Diagram Showing Acid Prediction Zones and Distribution of Studied Samples.

NNP and NPO parameters were used to evaluate the acid-generating potential (AP) of the samples taken from the site. NNP (Net Neutralisation Potential) is obtained by subtracting AP (Acid Generating Potential) from NP (Neutralisation Potential) and expressed in kg CaCO3/t. Sobek et al. suggest that the NNP value should be less than -5 for a rock to be an acid producer ([1]), Ferguson and Morin suggest that this value should be below -20 ([15]), while Day considers it sufficient for the NNP to be <10 ([16]). The NNP values of the ore waste samples obtained in the study area varied between -32 and -149 kg CaCO3/t; these results show that all samples have acid-generating potential in line with the limit values of different researchers (Table 5).

Another important parameter used to evaluate the acid-generating potential of mine tailings is NPO (Neutralisation Potential Ratio), which is obtained by dividing NP by AP. The limit values proposed by Brodie et al. stipulate that samples with NPO<1 should be considered as 'acid producing', samples with NPO>3 as 'non-acid producing' and samples in the range of 1<NPO<3 as 'uncertain zone' ([17]). The NPO values of the ore waste samples analyzed in the study ranged between 0.20 and 0.80, and these values reveal that they have the potential to produce acid according to Brodie et al. criteria ([17]). In summary, when both NNP and NPO values are analyzed, it is determined that all of the ore waste samples in the site have acid-generating potential in terms of ACD (Figure 9).

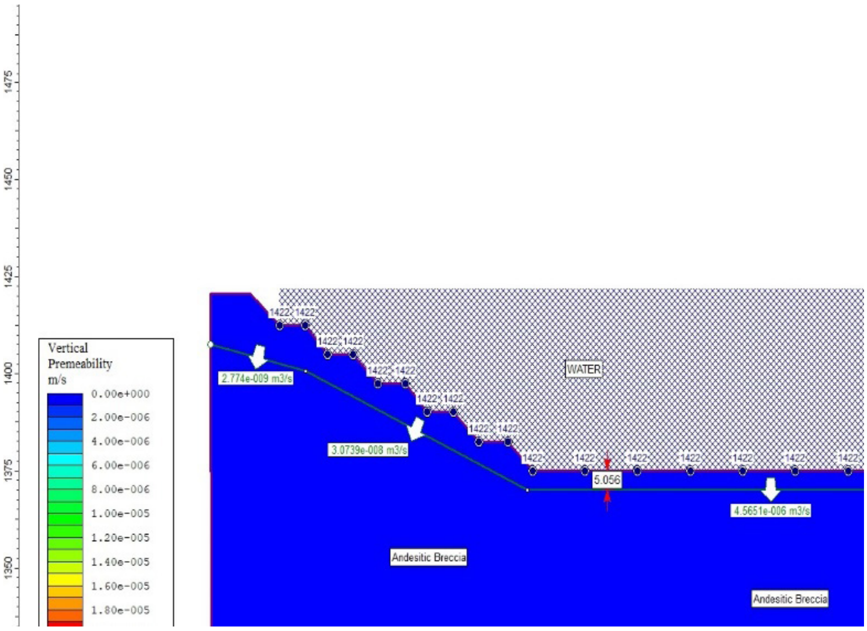

Figure 6. Classification of The Samples in Terms of AP and NP Parameters.

According to the Acid Base Accounting test results, although the ore waste samples have potential acid-generating properties due to their sulphur content, the fact that the element concentrations of the side rocks in the tailings storage facility are similar to the OYKO- OYKOx3 distribution and the pH values of all samples are basic (9.48-10.60) prevents the formation of acid rock drainage (AKD) that will cause environmental problems. Ficklin diagram analyses and paste pH values (>6) also indicate that the possibility of ACD formation is low. Therefore, it is recommended to construct an impermeable foundation rock to minimize environmental impacts at the landfill facility.

Study For İmpermeability At The Base Of The Tailings Storage Dam

According to the acid base accounting test results, as a precaution against the acid-forming potential of ore waste samples, waste material discharges at depths of 5m-10m were evaluated by modeling in the finite element network system after 50cm thick impermeable clay material was laid and compacted to make the waste storage dam foundation rock impermeable.

Accordingly, the discharge value obtained at a depth of 5m at the base is 5.63*10-8m3/s, 1.64*10-8m3/s at the left slope, 1.70*10-8m3/s at the right slope and the permeability value of the base rock mass is 9.79*10-10m/s. These discharge values indicate that the waste storage dam lake area is impermeable.

In addition to the clay compaction process, as another measure, geosynthetics (geosynthetic clay membrane, geomembrane and drainage geocomposite) were used in the lake area of the tailings storage dam and the upstream slope of the dam body to make the environment completely impermeable. With these measures, groundwater pollution caused by possible acid rock drainage will be prevented.

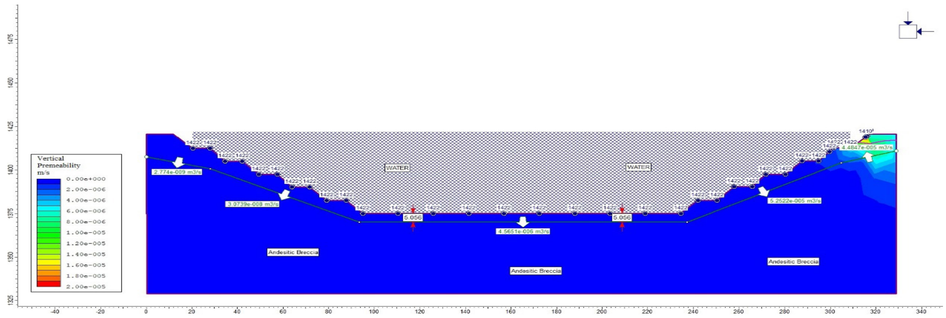

Figure 7. Finite Element Infiltration Analysis For The Tailing Dam (Phase 8.0)

Conclusions and Recommendations

- The fact that the pH values (between 9.48-10.60) of all samples (tailings and side rock) subjected to contact seepage test indicate basic environment and class IV water quality, whereas the concentrations of all toxic metals analysed (Cd, Co, Cr, Cu, Fe, Ni, Pb, Zn, Ni, Pb, Zn) indicate class I water quality. The potential for acid rock drainage to occur in the tailings dam is very low, all samples are concentrated outside the Acid Mine Drainage formation area in the Ficklin diagram prepared by using the contact seepage test analysis results,

- The paste pH values of all samples were >6 and there was no acid generating potential; according to S-2 analysis results, the ore waste samples had acid generating potential, whereas the side rocks did not have acid generating potential; according to NNP and NPO values, all of the ore waste samples had acid generating potential, whereas the side rocks did not have acid generating potential,

- According to the Acid Base Accounting test results, in order to prevent the acid formation potential of ore waste samples, waste material discharges at a depth of 5m-10m were evaluated by modelling in the finite element network system after 50cm thick impermeable clay material was laid and compacted in order to make the waste storage dam foundation rock impermeable,

- These discharge values indicate that the tailings storage dam lake area is impermeable. In addition to the clay compaction process, as another measure, geosynthetics (geosynthetic clay membrane, geomembrane and drainage geocomposite) were used in the lake area of the tailings storage dam and the upstream slope of the dam body to make the environment completely impermeable. With these measures, groundwater pollution caused by possible acid rock drainage will be prevented.

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INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Investigation of the Use of Post- Flotation Tailings of Pb-Zn Mine (Gümüşhane) in Concrete Pavement Production

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Abstract

Metallic mine wastes generally emerge following the mineral processing and due to the minerals and chemicals they contain, they have the potential to generate environmental risks. However, it is possible to use these wastes in concrete pavement production by subjecting them to some processes. In this research, experiments such pozzolanic activity and mortar were conducted on specimens with the aim of assessing the feasibility of incorporating the post-flotation tailings of a Pb-Zn mine located in Gümüşhane into concrete production. The results of the pozzolanic activity index test show that the 7 and 28-day strengths of the waste material comply with ASTM and TSE standards. However, other properties of the waste material (fineness, S+A+F content) are insufficient in terms of the values specified in the standards. In order for the materials to be evaluated as pozzolana, the material content above 45 microns should be maximum 34% and S+A+F content should be 70%. The material is not fine-grained (62.20%) and does not have a sufficiently amorphous structure (high silica amount). Moreover, it contains a very low amount of "S+A+F" total (16.78%). Experimental studies on the waste material used in the study show that it does not have both properties. However, when the waste material is used instead of cement in concrete, it exhibits equal and high strength values compared to the control concrete and this may be due to the fine grain structure of the material and its high specific surface area. This study investigated the use of mine waste materials in concrete and tried to shed light on future studies.

Keywords: Concrete pavement, Mine waste, Pb-Zn enrichment, Pozzolan, Strength activity.

INTERNATIONAL POST-MINING SYMPOSIUM

22-24 MAY 2024 ZONGULDAK / TÜRKİYE

Marble Quarry Applications and Waste Management in Rehabilitation of Mine Sites

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ABSTRACT

Marble production has had an important place in Turkish mining for many years. Marble exports constitute approximately half of Turkish mineral exports. Turkish marble, located in the Alpine-Himalayan belt, has become a world-renowned and preferred brand with its variety of colors and patterns. This interest has enabled many marble mining licenses to be obtained and quarries to be opened in our country.

In marble quarries, discontinuities due to formation processes sometimes create structures that are very broken and have low block yield. In this type of fields, block efficiency drops to 2-3%. This situation creates high amounts of waste or residue. One of the differences that distinguishes marble quarries from other mining areas is that these residues are largely in calcium carbonate composition, so they can be used as animal feed, mosaic, lime-cement raw material, etc. in many areas and does not pose any environmental pollution risks since it does not contain chemical waste.

In marble quarries, when production is stopped for various reasons such as depletion of reserves that meet quality criteria, disappearance of demand, etc. the field must be rehabilitated and returned to nature. The general approach in the rehabilitation of mining sites is land regulation, soil reclamation, revegetation, and afforestation. Marble quarries also offer various opportunities for alternative solutions.

Marble quarries, especially with their steep benches, solid rock structure having colorful patterns and unique texture offer an environment suitable for different architectural applications and eco-tourism.

In this study, alternative solutions for waste management and rehabilitation or reuse of the fields in marble quarries were examined..

Keywords: Marble quarries, reclamation, rehabilitation, reuse, eco-tourism.

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Introduction

Rocks that can be extracted from the quarry in blocks, turned into slabs and then processed using different techniques are defined as marble. These rocks, which are described as marble commercially, can be of sedimentary, igneous or metamorphic origin. However, carbonate-based rocks, which offer a wide variety in terms of color, pattern and texture in our country, are mostly called marble.

When the mineral export figures are examined, it is seen that marble products constitute 30-50% of all mineral exports. Among the most exported mineral product groups in 2023, metallic ores ranked first with 9.8 million tons and 2 billion USD, followed by Natural Stones with 6.3 million tons and 1.9 billion USD, industrial minerals with 11.9 million tons and 1.1 billion USD, ferro alloys with 88.8 thousand tons and 261.1 million USD [1]. Therefore, marble production occupies a large place in the mining sector. This situation also arises when mining licenses with operating permits are examined.

The high number of marble quarries shows that the number of marble quarries that will need rehabilitation will be high with the abandonment of the mine sites.

In this study, the recreation and reclamation potential of post-mining works, which are generally identified with rehabilitation practices, was examined specifically in marble quarries..

The Place of Marble Quarries In Mining Activities

The ratio of the number of licenses can be used as an indicator to understand the place of marble mining in the rehabilitation of mines. The ratio of marble licenses in Turkiye, especially among the operating licenses, will give information about the number of mines that will need rehabilitation. As can be understood from Table 1, a significant part of the mining licenses with operating permits and operating are II(b), that is, marble licenses. Therefore, considering the rehabilitation of mines, marble mines will constitute an important proportion of them.

LICENSE PHASE	I(b) GROUP	II(a) GROUP	II(b) GROUP	II(c) GROUP	GROUP III	GROUP IV	GROUP V	SUM
Number of Operating Licenses (December-2023)	563	2.777	3.092	83	66	3.480	9	**10.070**
Number of Exploration Licenses (December-2023)	0	14	1.224	0	1	3.452	2	**4.693**
Grand Total (Dec-2023)	563	2.791	4.316	83	67	6.932	11	**14.763**
Number of Operating Permits (December-2023)	478	2.240	2.079	68	60	2.638	7	**7.570**
Running in 2022	283	1036	1515	27	53	1188	1	**4103**

Table 1. Number of Licenses in Turkiye By Mining Group [2]

Another data to be followed to determine the number of mining sites that will need rehabilitation is the number of mining licenses abandoned for various reasons. An analysis of the data obtained from MAPEG (Figure 1) shows that 500 quarries have been abandoned during the average operating phase over the years [2]. Considering that approximately 30% of this is marble license, it can be concluded that approximately 150 marble mines need to be rehabilitated every year.

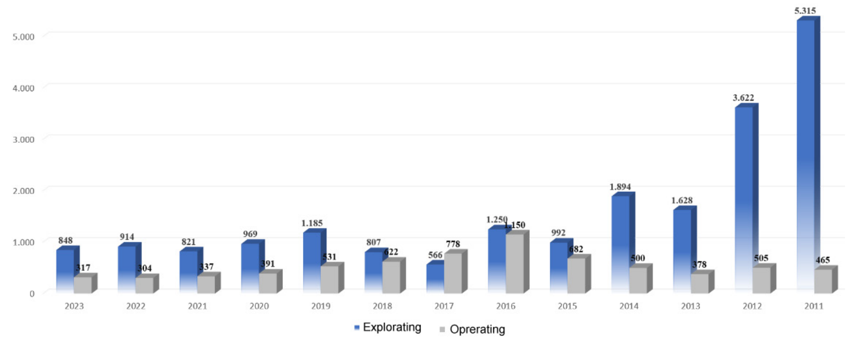

Figure 1. Abandoned Mining Licenses in Turkiye Over The Years

Characteristics and Environmental Effects of Marble Quarry Wastes

In general, mines have the following environmental impacts due to their wastes:

- Air Pollution
  Dust generation caused by drilling, blasting, crushing, screening

- Water Pollution
  Acid mine drainage (AMD), heavy metals, various chemicals (mostly from mineral processing plant waste)
- Soil Contamination

  Waste casting, Acid mine drainage (AMD), heavy metals, various chemicals, fine solid wastes (mostly from mineral processing plant wastes)

Marble quarry production processes differ greatly from classical open pit mining. In general, in an open pit mining, the first stage starts with the size reduction processes by drilling-blasting, then continues with the excavation-loading and transportation stages, and the last stage ends with the single and/or secondary crushing-screening stage. In marble mining, on the other hand, drilling-blasting is not applied, and block production is carried out directly with diamond wire or chain saw cutters. Therefore, the wastes that may occur in marble quarries can be listed as follows:

- Rubble (marble under the economic dimensions formed as a result of mountain cutting)
- Fragment (Marble formed after shaping)
- Fine dust (Diamond wire cutting process residue)

As shown in Figure 2, the ratio of marble blocks that can be sold commercially in a marble quarry, especially depending on the frequency and orientation of discontinuity, to the total excavation volume is often below 10%. Therefore, the biggest waste that can have an environmental impact in marble quarries is the rust formed by marble pieces with a volume of less than 1 m^3.

Figure 2. The Appearance of Waste Formed During Production in Marble Quarries And its Ratio to Waste

Considering the environmental effects of marble quarries more broadly, it can be said that it creates soil pollution due to the mixing of water and rubble, pieces and dust cutting residues into the soil due to cutting wastes rather than air pollution.

Since the marble quarries create a great deal of contrast due to the significant color difference of the marble produced from the surrounding vegetation, the visual disturbance is more than other mines. Therefore, visual/aesthetic pollution can be said as another environmental effect.

Unlike other mines, marble quarry wastes have the opportunity to be reused in different areas since their chemical composition is largely calcium carbonate.

Since a significant part of the marble quarry wastes is rubble and piece-sized waste, it can be used as a cement factory raw material (Afyon, Bilecik Söğüt example-300.000t/year). Apart from this, it is used as rubble-piece filling material for seas, dams, roads, etc., and as aggregate raw material for concrete plants, roads, etc. [3,4].

In cases where these cannot be achieved, the main goal is to elimination the wastes with mine rehabilitation.

Post-Mining Activities and Marble Quarry Applications

The practices carried out after the abandonment of the mining sites are examined under the headings of rehabilitation, reclamation and restoration. Rehabilitation of Mining Sites: It is expressed as the back of the quarries whose activities have been completed in the mining area to the nature (by improving them in terms of harmony with the natural environment). Reclamation/recreation of mining sites: It is to bring the mined areas to the desired state (it can be used for a different purpose than its original state). Restoration of Mining Sites, on the other hand, is expressed as the restoration of the quarries whose activities have been completed in the mining area to their former natural/original state [5]. It may not be possible to talk about a full restoration due to a certain volume of excavation and topography change. Therefore, rehabilitation and recreation/reclamation, in other words, making it ready for use for a new/different purpose and harmonizing it with the environment are seen as prominent solutions in the improvement of mining sites.

Rehabilitation Practices

Rehabilitation works, which are expressed as restoring to nature the quarries whose activities have been completed in the mining area (by improving them in terms of harmony with the natural environment), are at the forefront of post-mining activities. Rehabilitation practices include the following studies [5,7]:

- Shaping the land:
    - Good planning
    - Ensuring the stability of the field
        - Physical (Slope safety - Erosion protection)
        - Chemical
        - Biological
    - Construction and periodic maintenance of drainage structures
- Waste Remediation
    - Identification (composition-size)
    - Dewatering
- Improvement
    - Laying soil
    - Planting
- Providing Visual Aesthetics
    - Form, shape, color harmony
- Monitoring - Auditing

As can be seen from the process steps, rehabilitation works actually cover all processes from the mineral exploration stage to the abandonment of the quarry. Therefore, it includes a long-term and comprehensive planning.

Examples of rehabilitation works carried out in marble quarries are given in Figures 3-6.

Figure 3. Rehabilitation of the Waste Field in Mersin Silifke (MEDMAR)

Figure 4. Rehabilitation of The Marble Field in Afşin, Kahramanmaraş (DİMER) [8]

Figure 5. Rehabilitation of the Marble Field in Göksun, Kahramanmaraş (DİMER) [8]

Figure 6. Rehabilitation of Marble Quarry in Burdur (ILTAŞ)

Recreation/Reclamation in Marble Quarries
Recreation literally means recreation, and reclamation means defining a new purpose. Therefore, these practices mean that the abandoned quarries are made ready for use for a new/different purpose. The following uses can be targeted in reclamation or recreation work [9]:

- Outdoor habitat areas, resource conservation areas, recreational uses such as horse riding, hiking or bird watching can be included.

- Passive parks, botanical gardens, golf, water-based recreation activities can be developed.

- It can be used for growing agricultural products and beekeeping.

- It can be used to help conserve water, for the purpose of storing / re-obtaining water.

- Conversion of land into a different land use for possible urban developments, residential, industrial or commercial developments (open-air cinema, concert area, yoga, performing arts, exhibition space, etc.)

- It can operate as a regular solid waste storage area and after the gaps in it are filled, it can be used for secondary land uses such as passive parks and open spaces.

Decision-making methods are used in modern practices to determine the Recreation/Reclamation target for abandoned quarries [6]. With multi-criteria decision-making methods such as analytical hierarchy process, Fuzzy modeling, Fuzzy AHP, Fuzzy TOPSIS, Fuzzy analytical network process, the most appropriate usage target of the relevant area is determined after mining.

Çınar and Öçalır [7] defined a methodology to determine the best future land use alternative for active marble mining sites. GIS, multi-criteria decision-making method and fuzzy logic methods were used together to create a land use suitability model as a decision support tool for 715 marble mines. The best option was investigated between agricultural areas (A), afforestation (F), recreation area (R), industrial area (I) and storage area (L). As a result of the study, the recreation area came out in the second place in the ranking of the highest usage area for the fields examined.

Therefore, it is understood that rehabilitation is not the only option for the recovery of post-mining sites for marble quarries, and recreation-reclamation has more potential than thought.

Examples from around the world of reclamation-recreation studies carried out in marble quarries are given in Figure 7-15.

Figure 7 and Figure 8 give an example of the reclamation of an abandoned marble quarry in China for a different use. A concert stage was set up in the quarry and the steps were made safe by combining them with stairs.

Figure 7. Recreational Work In An Abandoned Marble Quarry In Dinghu Village (China) [11]

Figure 8. Concerts and Theater Events Organized After The Works (Dinghu Village)

Another example of the use of abandoned marble quarries is a group of marble quarries in the Toscana region of Italy, which is given in Figure 9. In these quarries, the marble benches served as a canvas for the artists.

Figure 9. The Use of The Steps of The Marble Quarry in Tuscany (Italy) as a Canvas [12]

An example of the recreation of abandoned underground marble quarries is given in Figure 10 and Figure 11, a marble quarry called Cava Arcari, located close to the city of Venice, Italy. Here, the underground operation wastes was cleaned and made safe with the dewatering process, and it was put into use as a concert and event area.

Figure 10. An Underground Marble Quarry Called Cava Arcari (Venice, Italy) Abandoned and Remodeled and Put Into Use [13]

Figure 11. A View from The Concert Held in Cava Arcari

Another example of the reuse of abandoned underground marble quarries is a marble quarry located in Carrières des Lumières, Marseille, France. As shown in Figures 12-14, as a result of the work done inside the quarry, it has been turned into a very striking activity area.

Figure 12. Carrières des Lumières, an Abandoned Underground Marble Quarry in Marseille, France [14]

Figure 13. Remastered and Reworked Version of The Carrières des Lumières [14]

Figure 14. An Example of Demonstrations Held At The Carrières des Lumières

Examples of recreation and reclamation of marble quarries from Turkiye are still in their infancy. The marble quarry, shown in Figure 15, is located in Ekizce, Antalya [14]. A conceptual study for the reuse of the site for another purpose after it was abandoned was carried out by Architect Rıdvan Çelik. In this study, it is planned that the steps of the marble quarry will form the basis of the residential area such as small hobby houses, which are expressed as "tiny houses". The steps were connected by stairs and the bottom of the quarry was used as a swimming pool (Figure 16).

Figure 15. Abandoned View of A Marble Quarry in Ekizce, Antalya

Figure 16. A Conceptual Study for The Reclamation of a Marble Quarry in Ekizce, Antalya

Conclusion and Recommendations

Marble quarries constitute a significant proportion of abandoned mines. Their environmental impact is lower, especially compared to metallic mines. Calcium carbonate compositional wastes can be used as raw materials in other areas of industry.

Considering the step structures, slope angles, visual attractiveness and other features of marble quarries, there is a high potential for recreation or reclamation as well as rehabilitation.

Appropriate definitions should be made in the relevant regulations for these quarries, which have been reused with the aforementioned recreational practices, and closure permission should be given.

The abandonment and rehabilitation of marble quarries should be carefully evaluated by MAPEG and other relevant institutions. In the marble sector, where the concept of fashion is prevalent, there should be no rush to start rehabilitation of quarries that have been closed because they are not in demand. Recommissioning may be possible.

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INTERNATIONAL POST-MINING SYMPOSIUM

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3D Modelling and Monitoring Studies of ZBEU Geomatics Engineering Department for Post-Mining Related Activities

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ABSTRACT

The 3D modelling and monitoring activities of Department of Geomatics Engineering (Zonguldak Bülent Ecevit University, Türkiye) has been briefly introduced in this paper. The case studies are mostly subjected the continuing and following the underground mining activities of Zonguldak Hard Coal Basin, varied deformation and landslide monitoring caused by the mining activities, 3D modelling by both photogrammetric and laser scanning techniques of industrial heritage, monitoring and 3D modelling the safety risks of accidents, cartographic modelling the mining maps, prevention and exhibition of historical surveying instruments, documents and maps etc.

Keywords: 3D modelling, monitoring, microwave sensing, photogrammetry, laser scanning.

Introduction

Department of Geomatics Engineers in Zonguldak Bülent Ecevit University has been founded in 11th July 1992 with the same foundation law of the University. The first academic staff consisted of the members of Department of Mining Engineering which was based on the first technical higher school (corresponding of the university in our century), Highschool (College) of Mining Engineering founded in 1924 as the first decided to its foundation of the Republic of Türkiye. This high school completed a necessary of technician in the hard coal mine industry in Zonguldak Region. The hard coal has been discovered in mid of 1800s, and the European companies managed this industry with the license given by Ottoman Empire. Considering the

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technical requirements of this industry, geospatial information was necessary before, during and after the mine activities. The Department carries the legacy of these activities and continues the mine-related research activities before and since its foundation.

As a brief information of the Department, 1296 students in undergraduate, 118 students in master science, and 22 students in doctorate programs since their foundation years of 1994, 1993 and 2005, respectively. The Department has currently fourteen academic and two administrative personals, and two laboratories, i.e. Space Technology and Spatial Analysis Laboratory and Surveying Laboratory. This paper briefly presents the educational, research and social responsibility activities of the Department not only in Zonguldak but also in other mine locations.

Educational Activities

Courses for the geospatial information related studies for mining, such as Mine Surveying in the undergraduate program, were mandatory between 1994 and 2011, and is selective since 2011. Master science program has the selective courses such as Exceptional Mine Surveying, Subsidence Engineering, Analysis of Deformations by Geodetic Methods. A technical visit to the training colliery of TTK (Turkish Hard Coal Enterprise) in Üzülmez District. Figure 1 illustrates a visit and a book by Kuşçu [1]. An education course was organized for TTK personals [2].

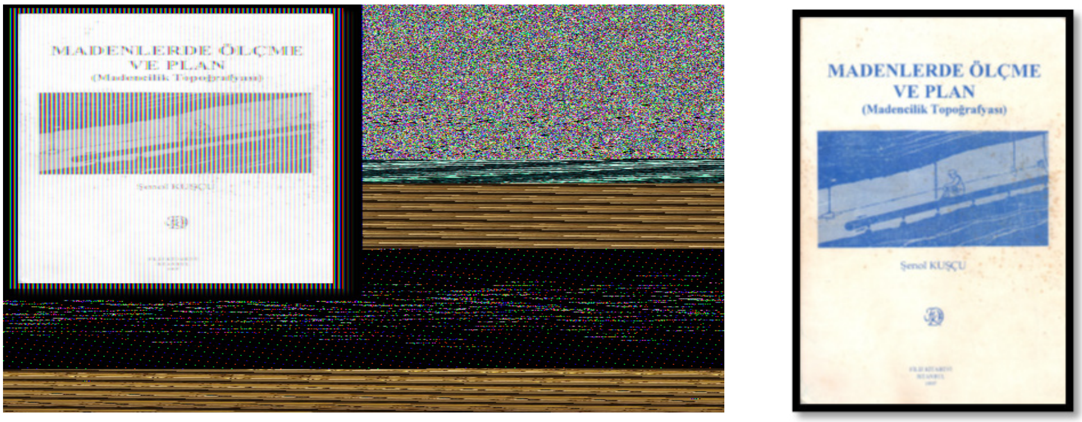


Figure 1. A Technical Visit to Training Colliery of TTK in Üzülmez District, And Book For Mine Surveying

Research Activities

The research for mine activities can be classified in the following topics.

1) 3D modelling of existing mine maps, pillar isohips, mineshafts,
2) Monitoring and mitigating the risks such as fire, subsidence, accidents etc.,
3) Deformation (subsidence) monitoring and analysing the geodetic, InSAR (Interferometric Synthetic Aperture Radar), and multidiscipline,
4) Detecting illegal colliery by InSAR,
5) Estimating the landslide susceptibility,
6) Regulations of mine activities such as mine subsidence,
7) Environmental monitoring caused by post mining,
8) Modelling and collecting the cultural heritage of mining, and
9) Social responsibility activities.

A few study could be kept out of these classes, i.e. [Akçın and Şekertekin [3], Akçın and Şekertekin [4]] investigated the height estimation for open mines. The topics will be handled in the separate sections. Totally 88 of 964 publications (book, thesis, conference papers and articles) were related to the mining. As a bibliographic analysis, it can be said that 3 of 20 books (%15.0), 10 of 118 master science thesis (%8.5), 3 of 22 doctorate thesis (%13.6), 27 of 291 papers in international events (%9.3), and 20 of 186 in national events, 11 of 221 articles in SCI-E (Science Citation Index-Expanded) (%5.0), 6 of 15 international articles not indexed in SCI (%40), and 14 of 58 national articles (%24.1), 8 of 102 projects (%7.8) and 3 of 16 scientific events organised by the Department (%18.) were related to mining.

3D Modelling

At the beginning of 2000s, one of the main challenge was to digitize the 2D/2.5D mine maps mostly printed on a paper etc. This topic was also handled by Koçak and Kuşçu [5]. Şahin [6] conducted a master study coding in AutoLISP to automatic digitize the 2.5D maps into 3D in computer environment [7] (Figure 2). Similar studies such as mine mapping and pillar isohips drawing, and 3D modelling of mineshafts were handled by Akçın, et al. [8], Akçın, et al. [9] and Can, et al. [10]. The capacity of unmanned aerial vehicles for mine activities were handled by Karakış, et al. [11].

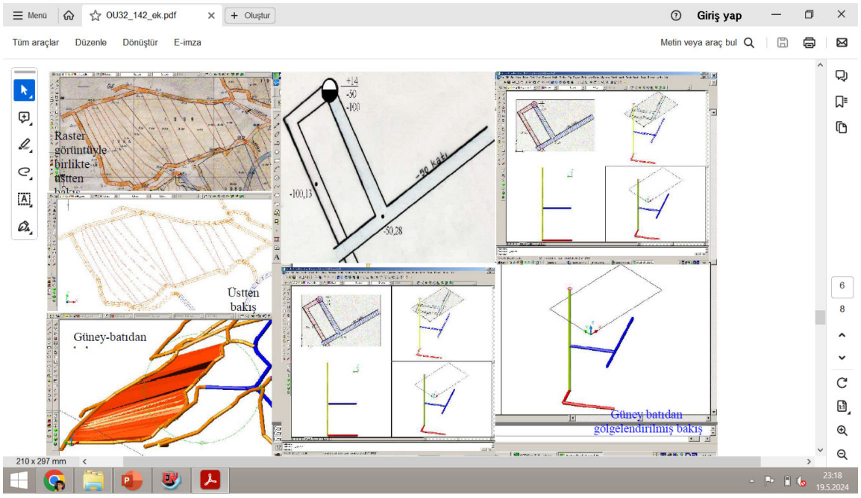


Figure 2. A Sample of Şahin [6] For Digitizing The 2D/2.5D Maps Into 3D By Autolisp.

Risk Assessment

The risk assessment is a crucial topic for safely mine activities. This topic has been evaluated with respect to fire query by Sargınoğlu [12] and Akçın, et al. [13], and relationship between fires and subsidence by Akçın and Çakır [14]. The accidents in collieries were assessed [Eksert and Akçın [15], Eksert [16], Eksert and Akcin [17], 18] (Figure 3). The subsidence-related building risk assessment were handled by Akçın [19]. A flood risk has been studied by Akçın, et al. [20] in Soma-Eynez (Manisa). The occupational health and safety were also studied by Kuşçu, et al. [21] and Akın, et al. [22]

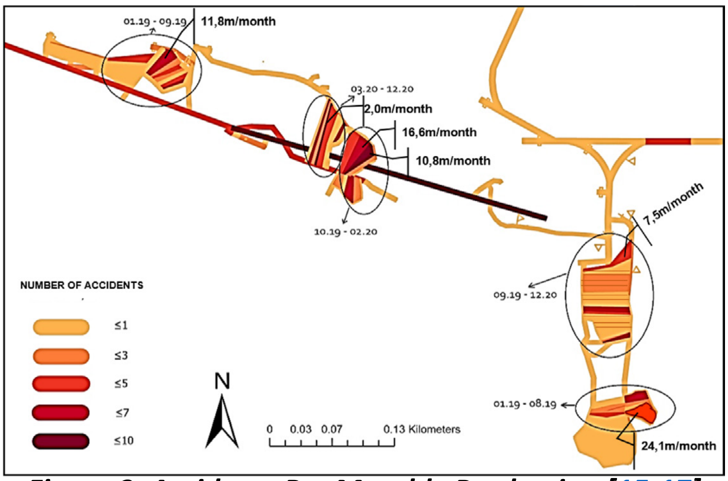


Figure 3. Accidents Per Monthly Production [15-17]

Deformation (Subsidence) Monitoring and Analysing

Deformation (subsidence) is one of the most important effect of following the underground mining. The gaps caused by mining causes the collapse and it effects the subsidence for surface. This issues has been subjected by Akçın [23], and [24, Can [25]] using geodetic techniques (Figure 4). They have continued their studies in the publications such as [Can and Akçın [26], 27-35]. Akçın [23] searched an adjustment approach to evaluate the deformations.

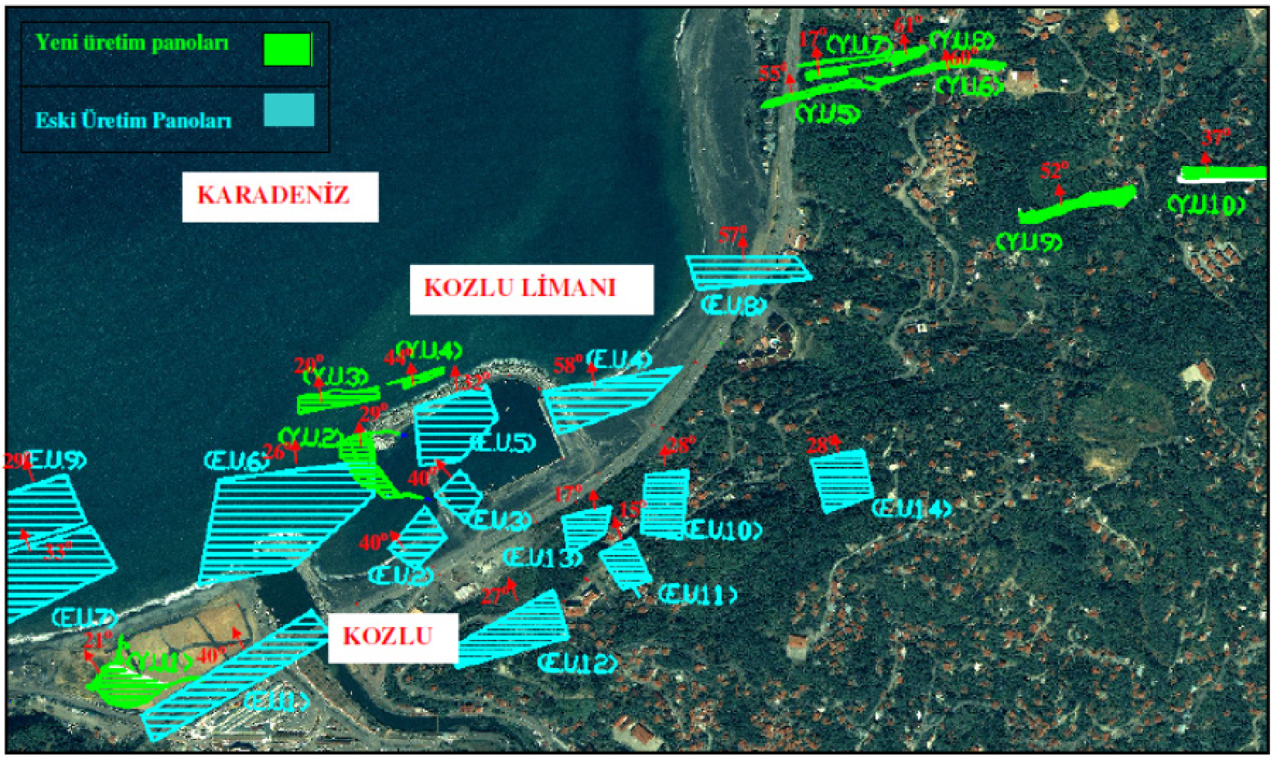


Figure 4. Deformation Analysis By GNSS (Can, 2011)

However, the most of deformation analysis studies were handled by using the InSAR techniques. These studies have been started in 2006 within the cooperation between the Department and JAXA (Japan Aerospace Exploration Agency) by [36-38], and followed by [39-46]. Figure 5 illustrates sample results for Zonguldak city centre.

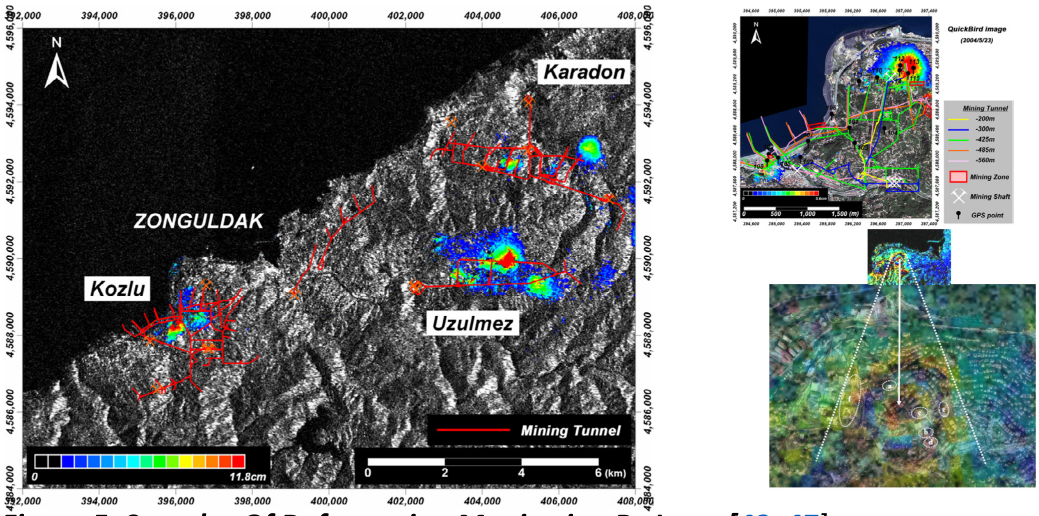


Figure 5. Samples Of Deformation Monitoring By Insar [42, 47]

The first doctorate thesis has been completed by [Kemaldere [47], 48], and the evaluation of this topic was continued by [49-54, Kutoglu, et al. [55], Parlak and Kemaldere [56]]. A multidisciplinary project has been completed in 2012 in the cooperation of the Department, Zonguldak Governorship, AFAD (Disaster and Emergency Management Presidency), and Anadolu University using the geodetical, geophysical, geological, geotechnical and structural engineering methods [57]. Figure 6 shows a sample building damaged by the subsidence. Besides, Ünlü, et al. [58] in Kozlu District (Zonguldak) and Yılmaz, et al. [59] and Akçın, et al. [60] in Tire (İzmir) evaluated various data sources for deformation analysis. Figure 7 shows a sample result from Ünlü, et al. [58]. The last study on this topic is from Bayık, et al. [61] for a gold mine in İliç (Erzurum).

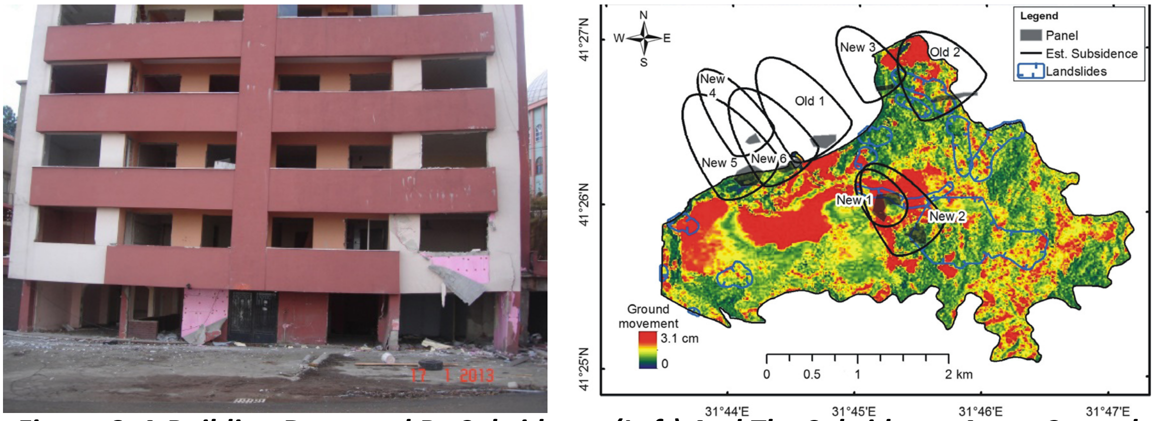


Figure 6. A Building Damaged By Subsidence (Left) And The Subsidence Areas Caused By The Coal Mining (Right) In Zonguldak City Centre

Detecting Illegal Colliery by InSAR

Deformation analysis could be carried out for illegal collieries by this technic that their deformation could be estimated by InSAR and compared by the official ground truth, i.e. mining maps. For instance, Kutoğlu, et al. [44] and Kutoğlu, et al. [62] estimated illegal collieries in Karadon District (Zonguldak) by InSAR and mining maps (Figure 8).

Estimating the Landslide Susceptibility

Landslide susceptibility is another hot topic in mining areas. Arca et al. (2018) focused on this topic with the case study for Kozlu in Zonguldak, and by Akar (2019) for Afşin-Elbistan (Kahramanmaraş) (Figure 9). Another study was conducted by Becek, et al. [63]

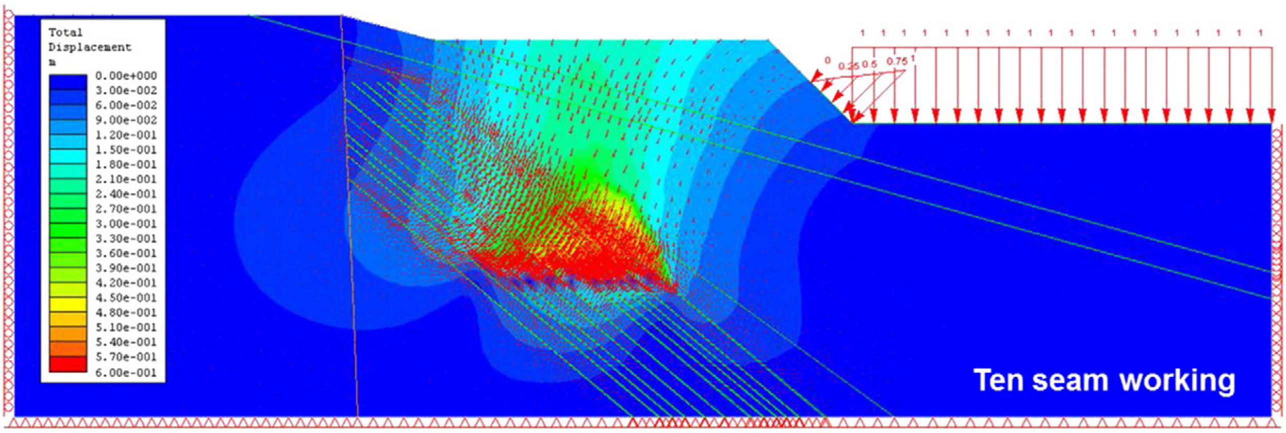


Figure 7. A Sample Of Total Displacements Contours And Vectors (75 Times Exaggerated) By Ünlü, Et Al. [58].

Figure 8. A work on illegal collieries by Kutoğlu, et al. [44] and Kutoğlu, et al. [62]

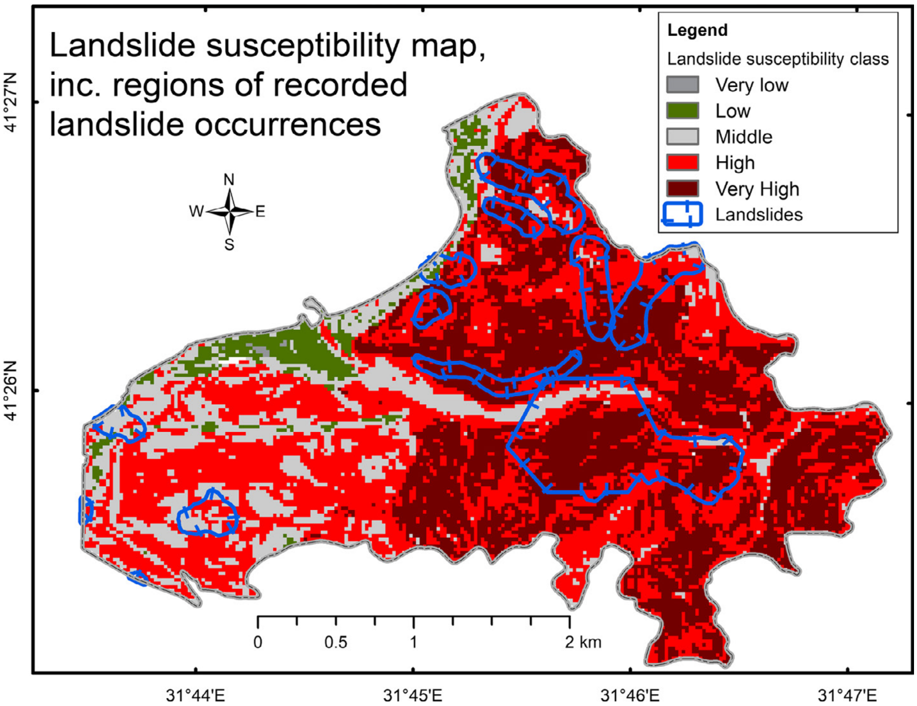


Figure 9. Landslide Susceptibility Map For Kozlu By Arca, Et Al. [64] in Left, And for Afşin-Elbistan By Akar [65] In Right.

Regulations of Mine Activities
Mining activities must be evaluated with respect to the regulation domain. This issue was handled by Aslan [66] for reviewing the various regulations of subsidence. Another issues are the property ownership such as in Zonguldak Hard Coal Basin [67], and the rule of geomatics engineering in the mining activities [68, 69]. The open mines were evaluated by Özada [70] as a case stuy of Narman (Erzurum).

Environmental Monitoring
Although the mining activities are made in underground in Zonguldak Hard Coal Basin, their environmental effects are seen on the surface and sea. The main problem is the shale of coal following their washing. This mass was stored on the coastal zones of Zonguldak up to 2010s. This problem was pointed by [Akçın [71], Koçak and Kuşçu [72]], and studied by Oruç [73], Buzkan, et al. [74], Akçın, et al. [75], Akçın and Çakır [76], Şekertekin, et al. [77], Marangoz, et al. [78], Marangoz, et al. [79]. Water pollution was analysed on by Akçın and Şekertekin [80] and Şekertekin, et al. [81], and deforestation by Akçın, et al. [82]. The environmental effects were monitored by Şekertekin [83] and Şekertekin [84]. Figure 11 illustrates a sample of heat island of Zonguldak Province having highest points in the city centres and iron-steel fabrics in Karadeniz Ereğli (Zonguldak), as results of coal-based industry.

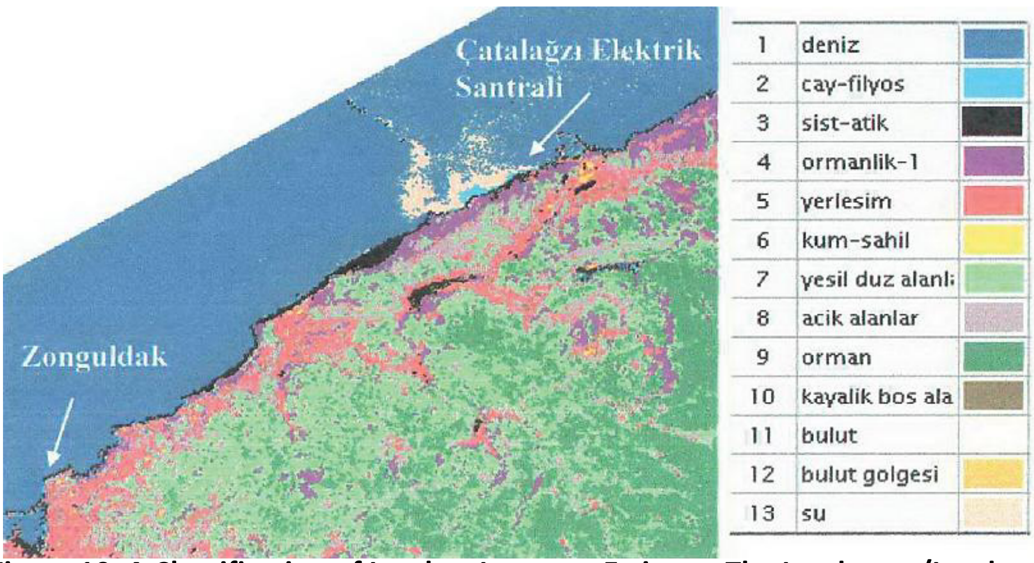


Figure 10. A Classification of Landsat Image to Estimate The Landcover/Landuse [73].

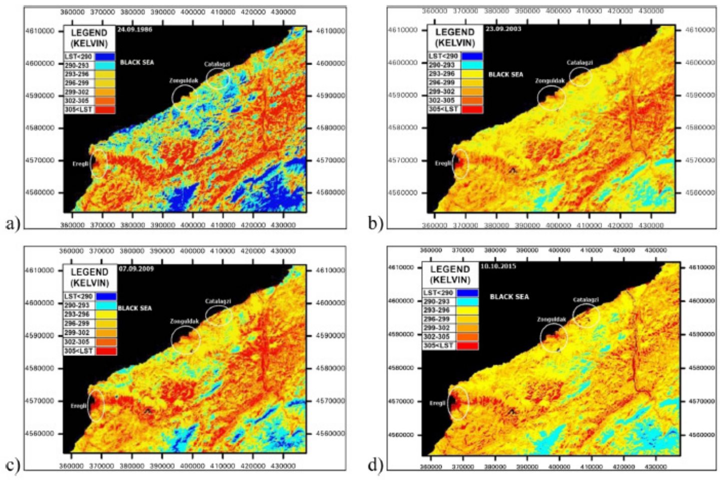
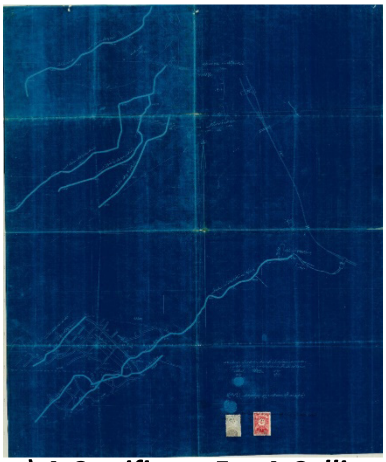


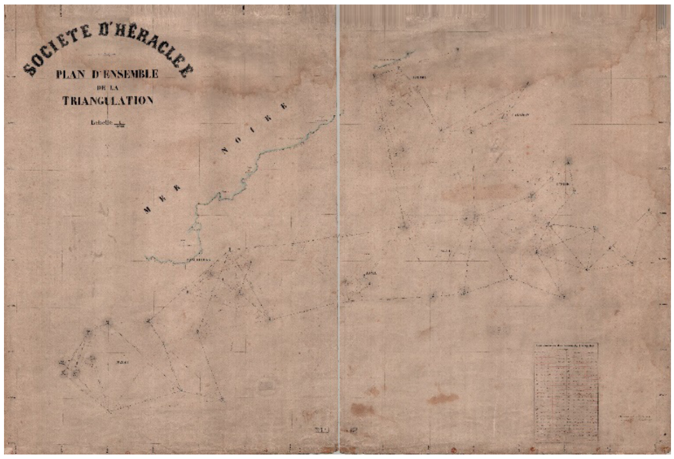
Figure 11. Heat Islands Of Zonguldak Province [84]

Cultural Heritage

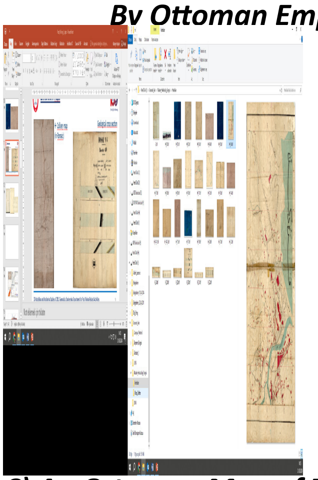
The cultural heritage of all mining activities in Zonguldak for about two centuries effected the social, historical, economic and environmental domains. The Department carries the responsibility of both scientific research and also the social responsibility. For instance, post mining activities needs the collecting and saving the cultural heritage, as shown by Zonguldak Mine Museum, or the special collection of the Department. In other word, the Department has a special collection exhibiting the historical surveying equipments, calculation notebooks, and maps in the Engineering Faculty Main Building. Figure 12 shows some samples of this collection. Another study is to 3D modelling of historical or monumental structures such as Uzun Mehmet Monument, Fevkani Bridge, Kozlu headframe, and Coke Plant's chimney (Figure 13).



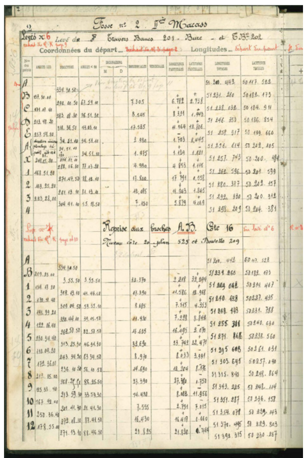
a) A Certificate For A Colliery Given By Ottoman Empire



b) A geodetic network made by French company



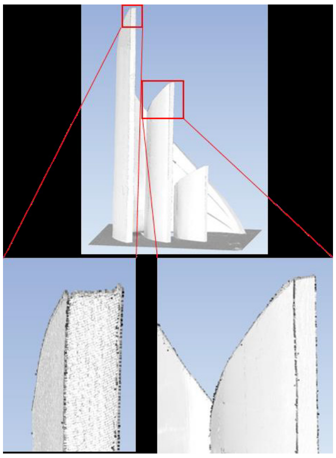
C) An Ottoman Map of Zonguldak Made By Tevfik Çakmakçı.



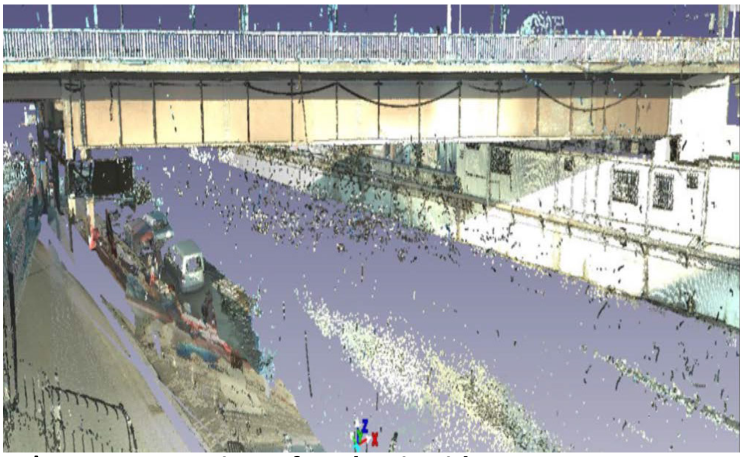
D) A Notebook for Coordinate Calculation

F) Historical Surveying Equipments

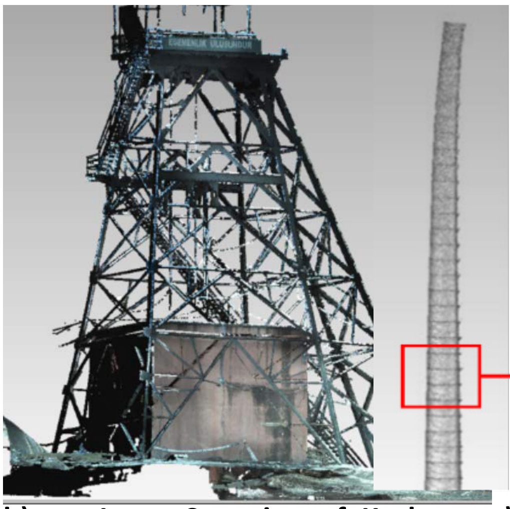
Figure 11. Samples of Historical Collection of The Department.



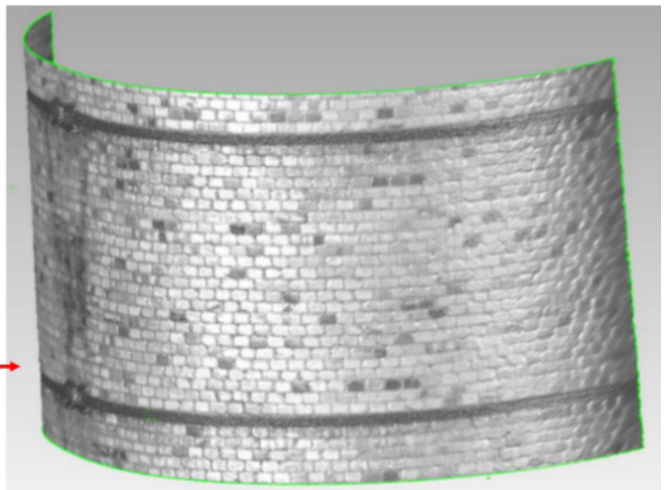
Point Cloud of Uzun Mehmet Monument [85].



a) Laser Scanning Of Fevkani Bridge.



b) Laser Scanning of Kozlu Headframe.



c) 3D modelling of chimney of historical Coke Plant.

Figure 12. 3D modelling of historical mining structures.

Social Responsibilities

The Department carries the social responsibilities of saving, educating, searching, and promoting all mining-related activities and their heritage, as exampled above. Apart from the topics above, the Department run some social activities. For instance, members of Department are in the execute committee of Zonguldak Coal Geopark, Kutoğlu [86] highlighted the importance of saving the industrial heritage, and the Department organized a conference given by Tuna Aratoğlu, the retired geomatics engineer from TTK, who search the industrial heritage of Zonguldak Hard Coal Basin (Figure 13 and 14).

Figure 13. Kutoğlu Giving a Presentation On Industrial Heritage In a Zonguldak Coal Geopark Meeting (21.12.2021 In BEUN)

Figure 14. Aratoğlu Giving a Conference on Industrial Heritage of Zonguldak Hard Coal Basin (02.11.2023 In BEUN)

Conclusion

This paper presented the various kinds of educational and research activities of Department of Geomatics Engineering carrying and sensing their responsibility of mining related activities. The studies were classified in nine topics, and some sample figures of all publications were presented. Those studies did not consist only the pre-mining activities, but also during and after works were handled. It can be concluded that the variety of these studies is not satisfied because they can be able to widen and to go deeper. It is expected that those studies were considered by TTK, Zonguldak Municipality, and other local and national authorities to manage the productivity of coal mine, and to run and mitigate its environmental and socio-economic effects.

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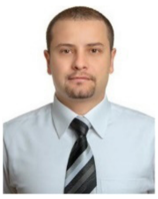

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Monitoring the Stability of Mining Sites Using Satellite Data

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ABSTRACT

The February 13, 2024, landslide incident in Erzincan's İliç district brought attention to the dangers associated with mining sites. Surface movements are commonly measured using the efficient remote sensing technique known as Interferometric Synthetic Aperture Radar (InSAR), with motions precisely and reliably established using Sentinel-1 SAR satellite photos provided free of charge by the European Space Agency. This study aims to investigate the landslide that occurred in the area using the Small Baseline Subset InSAR (SBAS) technique. The displacements that took place between 2015 and 2024 are evident from the operations carried out with the open-source LiCSBAS time series application package (An Open-Source InSAR Time Series Analysis Package Integrated with the LiCSAR). In the study, displacements in the Line of sight (LOS) direction were obtained from images of ascending and descending orbits covering the region. In addition, horizontal and vertical movements were determined using both of these trajectories. The results highlight the effectiveness of the InSAR method in detecting movements in the region and its high-resolution imaging capability. The analysis shows the continuation of the movement over a period of 9 years and the dynamic nature of the movement in the region. This study aims to contribute to the determination of more comprehensive risk assessments and preventive measures in similar risky areas.

Keywords: InSAR, Mining, deformation, Disaster, LiCSBAS.

Introduction

Mining accidents cause significant risks to human life, infrastructure and the environment. Regular monitoring of these areas is critical to identify and mitigate the dynamics of emerging risks. Although GNSS measurement is effective and accurate, it has several limitations. The most important of these is that they are point-based and the points used in terrestrial measurements are damaged. Interferometric Synthetic Aperture Radar (InSAR), which is used for monitoring large areas, provides an advantage in this respect. The InSAR method allows the determination of deformations caused by sudden natural events such as earthquakes, landslides, landslides, etc. in mm/year. In the method, the interferogram image created by using a pair of data differences and the displacement values along the Line of Sight (LOS) of the satellite are obtained. The method is largely successful in determining both short-term and long-term deformation values [1].

In order to generate deformation information from an image pair, the image pair must have optimum geometric and temporal basis values [1]. However, since these optimum conditions are not always achieved, advanced DInSAR methods have been developed. Within these methods, two general approaches are applied, namely Persistent Scatterer Interferometric (PSI) and SBAS methods [2-4]. The PSI method was developed to reduce the adverse conditions caused by the DInSAR method [2]. In this method, multiple image sets (n>20, n: number of images) are used. One of the images is selected as the master image and all images are matched with this image to create n-1 interferograms from n images. With this method, small displacement values occurring in a long time period can be obtained by time analysis. In the analysis, a temporal analysis is performed by finding the dominant scatterers that remain constant within a pixel over a long time period.

In another method, SBAS, deformation analysis is performed by minimizing the temporal and geometric baselines with threshold values. In this approach, instead of selecting a single master image, the number of interferograms is increased by trying to create pairs from all images. Thus, only image pairs with high correlation are selected. In this method, small displacement values occurring in a long time period can be obtained by time analysis [3-4, 7-8].

The InSAR method, which is also used in studies conducted in mining areas, has been used to determine surface movements over large areas. Abdikan et al. [9] detected subsidence in Zonguldak coal mining area using ALOS-1 data covering the years 2017 and 2010. Gong et al. [10] investigated landslides, surface fractures and erosions occurring in the dump area of an open pit mining area. In the study where SBAS method was applied, approximately 20 cm movement was observed with Sentinel-1 data covering the years 2016-2019. Wei et al. [11] used Sentinel-1 data covering the years 2018 and 2022 with multi-temporal InSAR analysis to investigate surface subsidence and landslides in an open mining area in the northern region of China. Eker et al. [12] determined the landslide triggered by the open mining area with Sentinel-1 data using PSI and SBAS methods. The large movements occurring on the surface were detected with the data used before the landslide.

In this study, the predictability of the accident that occurred on February 13, 2023 at the mining site located at Eski Değirmen in İliç district of Erzincan province was investigated. This research aims to contribute to the understanding of slip dynamics and the development of early warning systems by analysing pre-accident displacement amounts. Within the scope of the research, images obtained from SAR satellites were used and velocity vectors of the study area were determined by InSAR method. Sentinel-1 satellite images of the region in both horizontal and vertical directions were obtained and analysed and time series were created. It was observed that the surface movements spatially started to occur in the time period extending before the accident.

Material And Methods

Study Area

The mining accident considered in this study occurred on February 13, 2024 at Çöpler gold mine in the İliç district of Erzincan (Figure 1). It occurred when a pile of soil stored after cyanide leaching in the gold mine turned into a landslide due to time-dependent deformation. The pile turned into a landslide and slid down a 200-meter slope towards Sabırlı Creek. The approximate volume of the pile is estimated to be about 10 million m³ and the area of the pile is 300 acres [13].

Figure 1. Çöpler Gold Mine in the İliç District of Erzincan

Data and Methodology

The research utilized Sentinel-1 satellite imagery provided free of charge by the European Space Agency (ESA). Sentinel-1 has a C-band. Sentinel-1A and Sentinel-1B pass over the same region every 6 days, shortening the temporal base length and minimizing the possibility of decorrelation between images. In this study, the open source LiCSBAS was used to process the InSAR data. Since LiCSBAS is integrated with LiCSAR, there is no need to generate interferograms from Single Look Complex (SLC) data (Figure 2). The Generic Atmospheric Correction Online Service (GACOS) is provided by the Generic Atmospheric Correction Online Service [14] to remove possible tropospheric effects in the generated interferograms.

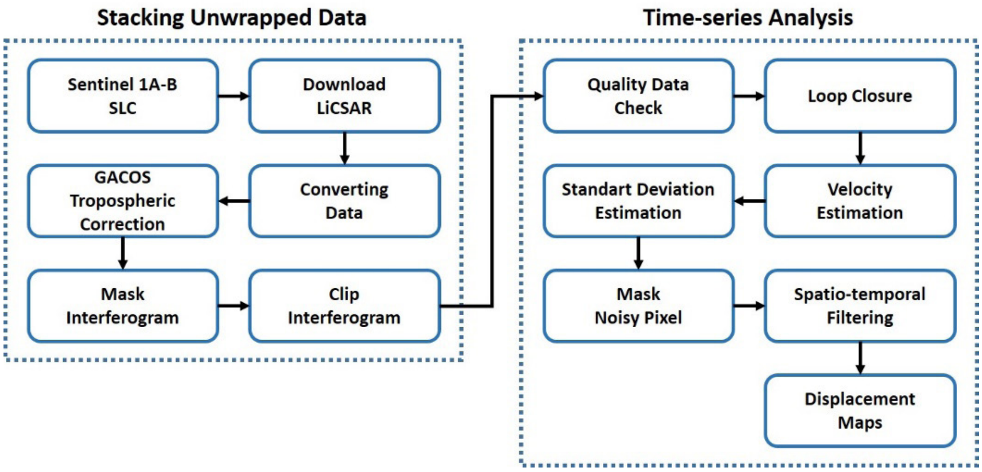

Figure 2. Licsbas Workflow

With this platform, users can perform time series analysis quickly and easily [15-17]. This method has been frequently used in mine subsidence and landslides in open areas [18-19], and surface movements such as landslides [20-22]. In this study, the SBAS method was used with the processed data of Sentinel-1A IW SLC images with VV polarization (Table 1) downloaded from the COMET-Lics (The Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics) online portal called LiCSAR developed by Morishita et al. [23]. These approaches have been shown to be an effective technique for determining the velocity fields and deformation values of deformations occurring in large areas over a long time interval.

Sensor	Sentinel-1	
Track No	123	116
Orbit	Ascending	Descending
Wavelength	C-band: ~5,6 cm	
Polarization	VV	
Period	06.01.2015-07.01.2024	05.01.2015-13.12.2023
No. of Interferogram	1237	1358

Table 1. Characteristics of Sentinel-1 satellite images.

Results And Dicussions

Using the SBAS technique, the amount of deformation that occurred in the landslide area over a period of approximately 9 years was determined. The displacements before the landslide, which is the focus of this study, were analysed. According to the results obtained in the ascending orbit, displacements up to 0 - -12 mm/year were detected in the slip zone (Figure 3). Similarly, in the descending orbit, displacements of 0 - -11 mm/year were determined. For a better understanding of the landslide, horizontal (east-west) and vertical displacement maps of the region were produced by combining the ascending and descending orbits (Figure 4). According to these results, it was determined that the area where the landslide occurred (white star in Figure 3-B) had been in subsidence for about 9 years before the slide (Figure 5). In addition, it was determined that there was a continuous movement towards the east in this area. The results obtained show that the landslide occurred in parallel with the results obtained before the event. In the light of these long-term results, it is predicted that if similar areas are monitored regularly, possible displacements can be determined and necessary precautions can be taken. Furthermore, it is suggested that analysing the displacement amounts before landslides using the InSAR technique can contribute to the understanding of slide dynamics and the development of early warning systems.

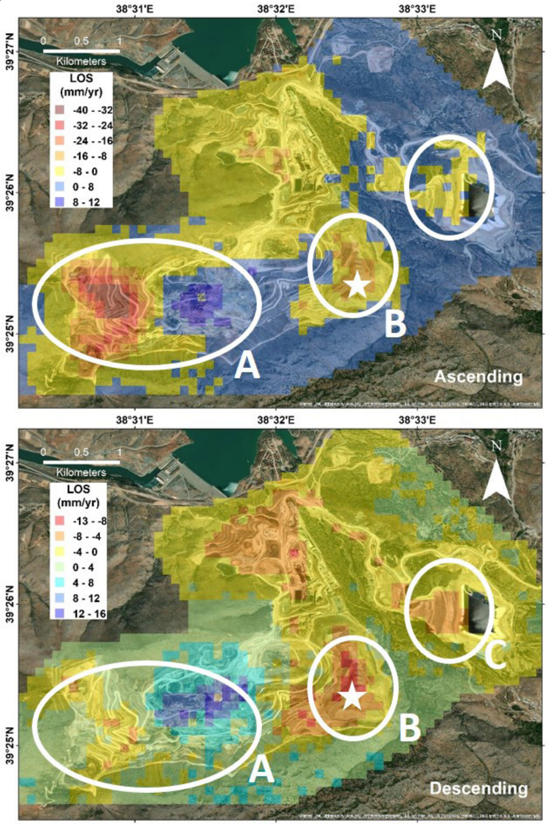

Figure 3. Average Velocity Values for Sentinel-1 Ascending and Descending Orbits. In The Figure, Negative Values Represent the Distance Away from The Satellite and Positive Values Represent the Approach to The Satellite

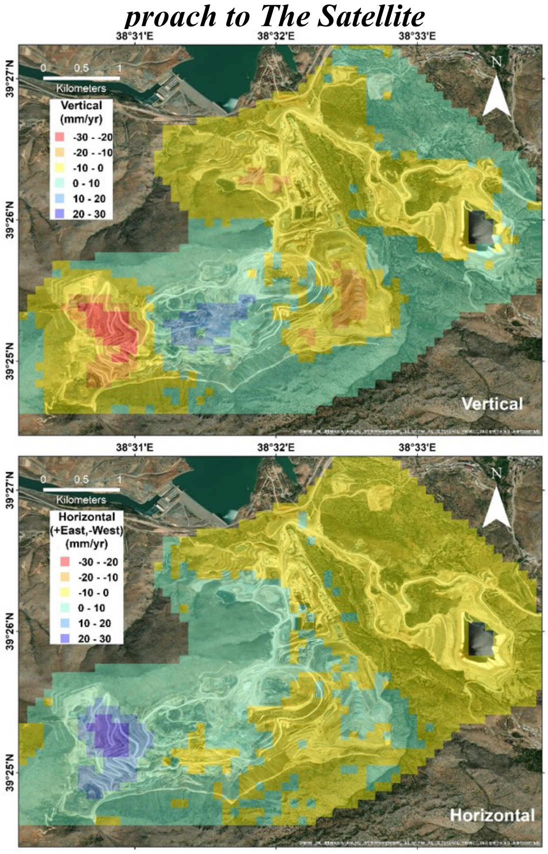

Figure 4. Sentinel-1 Horizontal (East-West) And Vertical Mean Velocity Values

Another point to be noted in the results of the research is that there is more displacement in the western part of the mine site (Figure 3-A) compared to the area with slippage. As can be seen in Figure 4, high displacements were detected in this area. In addition, significant displacements were also observed in the embankments of the settling pond (Figure 3-C).

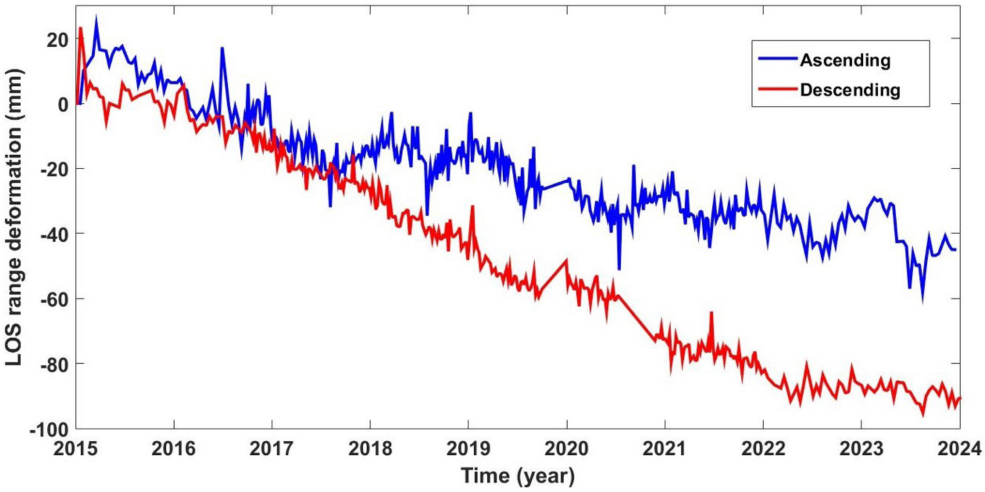

Figure 5. Time Series of Sentinel-1 Ascending And Descending Orbits (White Star In Figure 3-B).

However, it was determined that there was a continuous movement towards the east in this region. The results obtained show that the landslide occurred in parallel with the results obtained before the event. In the light of these long-term results, it is predicted that if similar areas are monitored regularly, the displacements that may occur can be determined and necessary measures can be implemented. In addition, it is also suggested that analysing the amount of displacement before landslides using the InSAR technique can contribute to the understanding of landslide dynamics and the development of early warning systems. Another point to be noted from the results of the study is that there is more displacement in the western part of the mine site (Figure 3-A) compared to the area where the landslide occurred. In addition, significant displacements were also observed in the embankments of the settling pond (Figure 3-C).

Conclusion

This long-term assessment highlights not only the high resolution capacity of the InSAR method, but also the importance of detecting potential hazards at an early stage in such sensitive areas. This would allow for timely interventions to prevent potential accidents or infrastructure degradation. The research also contributes to the literature advocating the need for continuous monitoring of such hazardous areas with remote sensing technologies. The findings suggest that long-term ground motion data can play a major role in recognizing ground instabilities in advance, allowing for more effective risk assessments and preventive measures. This study provides valuable guidance for the development of safety measures and mitigation of environmental risks, which are crucial for the sustainable management of mining operations. It clearly demonstrates that InSAR-based monitoring systems, especially in geologically unstable regions, have significant potential in preventing disasters and ensuring the safety of operations in the long term.

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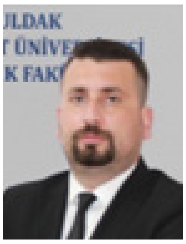

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Post-Mining Activities Legislation

Şahin ÖZDEMİR

ABSTRACT

The mining sector is an industry that encompasses the exploration, extraction, processing, and marketing of mineral resources, playing a critical role in Turkey's economic development. However, minimizing the environmental and social impacts of these processes is vital for building a sustainable future. In this context, post-mining rehabilitation and closure activities become essential. Successful post-mining rehabilitation projects in Turkey demonstrate the sector's commitment to environmental sustainability. For instance, the Kemerburgaz mining site in Istanbul has been rehabilitated in accordance with its natural characteristics following the cessation of mining activities. Similarly, the Çankırı Salt Mine Museum has transformed into a tourist attraction, providing both economic and environmental benefits during this process.Mining activities in Turkey are regulated by a series of legal frameworks, including the Mining Law (Law No. 3213) and the Environmental Impact Assessment (EIA) Regulation. These regulations govern the rehabilitation and closure processes of mining sites. EIA reports are prepared and approved to assess the environmental impacts of mining projects and to mitigate these effects. Additionally, the management of mining waste and the control of water and air pollution are crucial considerations in post-mining processes. Natural resources refer to water, minerals, forests, wind, and solar energy that are available in nature and can be utilized to meet human needs. These resources are generally categorized into renewable and non-renewable resources. Renewable resources, such as solar energy, wind energy, hydroelectric energy, and biomass, can be replenished through natural processes. In contrast, non-renewable resources, including oil, natural gas, coal, and minerals, cannot be replaced once consumed or take a very long time to regenerate. Sustainable management of these resources is crucial for meeting the needs of future generations. Canada is one of the leading countries in environmental protection and resource management. The merger of the Department of Energy and Mineral Resources with the Department of Forestry in Canada represents a significant step towards environmental protection and sustainability goals. Such mergers provide a more effective and holistic approach by consolidating environmental management and protection processes under one umbrella. Canada's federalism and the initiatives it has undertaken in environmental protection clearly demonstrate the benefits that arise from such mergers. Globally, projects like the Golden Cross Gold-Silver Mine in New Zealand and a mining site in Shanghai highlight the importance of post-mining rehabilitation on an international scale. In New Zealand, mining sites have been restored to their natural state through ecosystem restoration efforts after mining activities ceased. In Shanghai, an old mining site has been transformed into a hotel and pond project through innovative approaches. At Mitto Consultancy, we support investors throughout the entire lifecycle of mining activities with our technical knowledge and expertise. Our goal is to promote sustainable mining practices and ensure that projects are conducted in compliance with international standards. We provide comprehensive services related to compliance with environmental regulations, fulfilling legal obligations, and preparing rehabilitation plans. Post-mining rehabilitation and closure activities are crucial for fulfilling the sector's environmental responsibilities. Successful examples in Turkey and worldwide showcase the economic, environmental, and social benefits of these efforts. At Mitto Consultancy, we take pride in contributing to the sustainability goals of mining projects with our experience in this field. Sustainable management of mining activities is key to leaving a livable world for future generations, not just for today's. Therefore, we reiterate the importance of post-mining rehabilitation and closure effort

Keywords: Mining Sector, Environmental Sustainability, Post-Mining Rehabilitation, Closure Activities, Natural Resource Management, Environmental Impact Assessment, Ecosystem Restoration

Mining Sector in Turkey

The mining sector in Turkey is an industry that covers the exploration, extraction, processing, and marketing of underground and aboveground mineral resources and plays a critical role in the economic development of the country. This sector provides strategically important minerals such as coal, boron, gold, and copper, as well as raw materials used in the industrial and construction industries such as marble and natural stones, which are identified through geological surveys and drilling activities.

Mining Activities in Turkey, Laws And Regulatıons

1. Mining Law (Law No. 3213) and Mining Regulation
2. Mining Law Implementation Regulation
3. Environmental Impact Assessment (EIA) Regulation
4. Occupational Health and Safety Law (Law No. 6331)
5. Regulation on the Assessment of Environmental and Social Impacts at Mining Sites
6. Waste Management Regulation
7. Regulation on Health and Safety Conditions in Underground Mining Operations
8. General Directorate of Mineral Research and Exploration (MTA) Law
9. Implementation Regulation of Article 16 of the Forestry Law
10. Turkish Hard Coal Corporation (TTK) Law
11. Ministry of Energy and Natural Resources Regulations
12. Water Pollution Control Regulation
13. Air Pollution Control Regulation
14. Environmental Permit and License Regulation
15. Regulation on Air Quality Assessment and Management
16. Regulation on the Protection of Groundwater Against Pollution and Degradation
17. Regulation on Workplace Opening and Operation Licenses
18. Environmental Noise Control Regulation
19. Mining Waste Regulation
20. Regulation on the Protection of Drinking and Potable Water Basins
21. Regulation on Control of Soil Pollution and Point Source Contaminated Sites
22. Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals
23. Regulation on Monitoring of Greenhouse Gas Emissions
24. Regulation on Landfilling of Wastes
25. European Landscape Convention
26. Law No. 5403 on Soil Conservation and Land Use
27. 2023-2024 Hunting Period Central Hunting Commission Decision
28. Regulation on the Protection of Wetlands
29. Waste Oil Management Regulation

30. Regulation on Control of Vegetable Waste Oils
31. Regulation on Control of Waste Batteries and Accumulators
32. Regulation on Control of End-of-Life Tires
33. Regulation on Control of Medical Waste
34. Procedure and Instructions on Compulsory Liability Insurance for Dangerous Goods-Sulak

Laws And Regulatıons in Turkey

1. **Ownership of Mines:** The State of the Republic of Turkey owns all minerals within the country's borders. This means that the licenses granted for the exploration and exploitation of minerals are controlled by the state.
2. **Licensing:** Individuals or companies wishing to engage in mining activities must obtain a license by fulfilling certain conditions.
3. **Environmental and Social Responsibility:** Mining activities are carried out subject to the preparation and approval of Environmental Impact Assessment (EIA) reports. This ensures that environmental and social impacts are assessed and sustainable mining practices are adopted.
4. **Occupational Health and Safety:** Regulations aimed at improving the health and safety conditions of workers in the mining sector are supported by strict inspections. Occupational safety measures are constantly updated to prevent occupational accidents and occupational diseases.
5. **Economic Contribution:** Revenues from the operation of mines are shared between the state and the operators in certain proportions. These revenues make significant contributions to the national economy and provide resources for local development projects.

Mining Laws and Regulatıon in Turkey

New regulations are introduced through amendments to the law in response to economic, social, and environmental changes. For example, updates to occupational health and safety legislation have led to better protection of workers in the mining sector.

Turkey has become a party to various international agreements to comply with international mining standards. This increases the global competitiveness of the Turkish mining sector and attracts foreign investors.

Legal Regulations and Permıt Processes in The Mining Sector

1. **Waste Management:**
    - Waste classification, safe storage, and disposal methods.
    - Prioritization of recycling and reuse.
2. **Water and Air Pollution Control:**
    - Protection of water resources and wastewater treatment.
    - Control of dust and gas emissions and regular monitoring.
3. **Occupational Health and Safety:**
    - Setting occupational health and safety standards.
    - Protection of workers.
4. **Mining Law:**
    - Basic law for mining activities.
    - Processes of exploration, extraction, operation, and abandonment of minerals.
5. **EIA Regulation:**

   - Environmental Impact Assessment report preparation and approval process.
   - Public participation and consultation.
6. **Mining Regulation:**
   - License applications, renewal, and cancellation procedures.
   - Operation activities and inspection processes.

Permitting Processes in The Mining Sector

1. **Exploration License Application:**
   - Application
   - Evaluation
   - Granting License
   - Exploration Activities
2. **Environmental Impact Assessment (EIA):**
   - EIA Report Preparation
   - Public Participation
   - EIA Approval
3. **Operation License Application:**
   - Application
   - Evaluation
   - Granting License
   - Exploration Activities
4. **Activity Permits:**
   - Temporary Activity Certificate
   - Occupational Health and Safety Permit
   - Water Use Permit
   - Waste Management Authorization
5. **Operation Activities:**
   - Mineral Extraction
   - Environmental and Occupational Safety Measures
   - Regular Inspections
6. **Rehabilitation and Closure Plans:**
   - Rehabilitation Plan
   - Naturalization
   - Closure Approval

Eia Permit Process

Average 19 months
Note: Ministerial Approval is uncertain and accepted for an average of 1 month.

1. Conducting Background Studies
2. Preparation of the EIA Application File
3. Performing Public Participation Meeting
4. Preparation of EIA Report
5. Conducting Review and Evaluation Commission Meeting
6. Finalized EIA Report Presentation
7. EIA Report ASKI Process
8. Submission of the Final EIA Report
9. Authority Approval
10. EIA Positive Certificate

Property Permit Process
Pasture Permit Process-Drilling
Average 25 months

Pasture Permit Process- Exploration Activity

1. Application to MAPEG to write to the Provincial Directorate of Agriculture
2. Writing to the Provincial Directorate of Agriculture by MAPEG
3. Establishment and approval of the Pasture Commission by the Provincial Directorate of Agriculture
4. After the Pasture Commission, writing the letter regarding the collateral fee and the contract
5. Preparation and presentation of Pasture Recycling Project
6. Deposit of the guarantee
7. Signing the Letter of Commitment and Protocol
8. Pasture permission for drilling

Forest Permit Process- Permits for Excavation-Required Operation Infrastructure Facilities
Average 3 months

OBM: Regional Directorate of Forestry

OGM: General Directorate of Forestry

1. EIA Not Required/ EIA Positive
2. Obtaining institutional opinions by Circular 2014/1
3. Preparation of Forest Permit File
4. Submission of the file to OBM
5. Forwarding the file to the Business Administration
6. Forwarding the File to the Chief and Field Inspection
7. Forwarding the file to the Operation Administration
8. Submission of the file to OBM

9. Forwarding the file to OGM
10. Obtaining consent by Circular 2018/8
11. Obtaining a Forest Permit

Non-Agricultural Use Permit Process
Average 8 months

1. Application to MAPEG to write to the Provincial Directorate of Agriculture
2. Writing to the Provincial Directorate of Agriculture by MAPEG
3. Fieldwork and examination of the file by the Provincial Directorate of Agriculture
4. Submitting the parcels that require public interest under 5403 to MAPEG
5. Preparation of Public Interest project
6. Formation of a committee by MAPEG and approval of the committee
7. Obtaining public interest consent
8. Obtaining the Ministry's Approval
9. The Ministry writes to the Governorate for the relevant parcels and public interest
10. Preparation and submission of the Soil Conservation Project
11. Approval of the permission for non-agricultural use by the Governorate

Workplace Opening and Working License- 1st Class
Average 1 months

1. Preparation of the application file to the Department of Investment and Coordination in metropolitan cities and the Special Provincial Administration license unit in non-metropolitan cities
2. Approval of the EIA business license committee report and property permit if requested
3. Gathering of the Review Board, going to the field
4. Appointment of responsible manager
5. Branch opening
6. Obtaining a road crossing permit
7. Obtaining the fire department report
8. GFB or Environmental Permit Certificate (may be a commitment)
9. Obtaining the license

Environmental Regulations and Responsibilities
Environmental regulations and responsibilities in mining activities are determined to ensure the sustainable use of natural resources and minimize environmental impacts. In Turkey, these regulations are carried out in line with various laws, regulations, and international standards. Here are the main environmental regulations and responsibilities to be considered in mining activities:

1. **Environmental Impact Assessment (EIA):**
    - Obligation to prepare an EIA report for mining projects.
    - Assessment of environmental impacts of projects and obtaining approval from the Ministry of Environment, Urbanization and Climate Change.
    - Public participation and consultation.

2. **Waste Management:**
    - o Classification of waste as hazardous and non-hazardous.
    - o Safe storage, transportation, and disposal methods.
    - o Prioritization of recycling and reuse.
3. **Water and Air Pollution Control:**
    - o Protection of water resources and wastewater treatment.
    - o Control of dust and gas emissions, regular monitoring and reporting.
    - o Filtration systems and air quality improvement.
4. **Soil Protection and Noise Management:**
    - o Prevention of erosion and protection of soil fertility.
    - o Rehabilitation and reforestation of mine sites.
    - o Measures to reduce noise pollution and compliance with standards.
5. **Protected Areas and Biodiversity:**
    - o Limitations on national parks, nature parks, and protected areas.
    - o Measures to be taken for the protection of biodiversity.
6. **Authorization and Inspection Mechanisms:**
    - o License and permit processes for mining activities.
    - o Monitoring of activities through regular inspections and control of compliance with legislation.
7. **Rehabilitation and Closure Plans:**
    - o Implementation of environmental rehabilitation plans for mine sites.
    - o Restoration and landscaping as close as possible to their natural state.
8. **Training and Awareness Raising:**
    - o Training of employees on environmental responsibilities.
    - o Environmental awareness campaigns and training programs.

EXAMPLES OF MINE CLOSURES IN TURKEY

Mining Site Kemerburgaz İstanbul

Maden Sahasının Rekreasyon Park Alanına Dönüştürülmesi Örneği (Öncesi

Maden Sahasının Rekreasyon Park Alanına Dönüştürülmesi Örneği (Sonrası),

Çankırı Salt Mine Museum

(Öncesi)

(Sonrası)

Altıntepe Gold Mine Ordu

(Öncesi)

(Sonrası)

Kırka Boron Mine Eskisehir

(Öncesi)

(Sonrası)

Kızılbük Lignite Mine Kutahya

Çine Feldspar Field Aydin

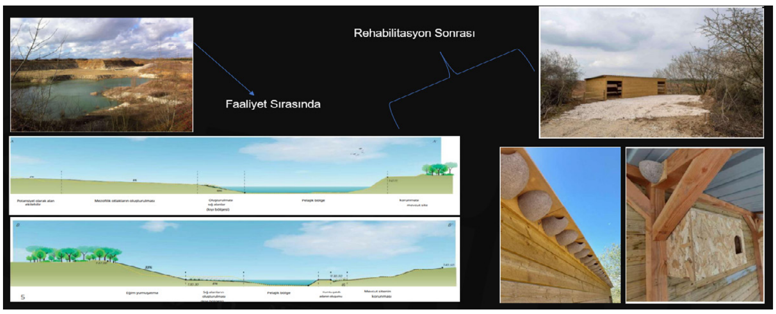
Asbestos Mine Greece

- Terrace construction on slopes (horizontal surface: 308 acres, sloping surface: 340 acres, excavation: 3 million m³)
- Flood and erosion protection works
- Spreading topsoil on the slopes (145,000 m³)
- Planting (75,000 trees, 130,000 small plants, 215 kg of seeds)
- Automatic irrigation system (200 km long)
- Appropriate Safety Precautions

Source: greenasbestosmine. gr

Biodiversity and Ecological Land Restoration – Provins, France

- Savins quarry Biodiversity & Ecological Land Restoration
- During Activity
- After Rehabilitation



EXAMPLES OF REHABILITATION IN THE WORLD

Golden Cross Gold Silver Mine New Zealand

- Between 1991 and 1998, the mine produced about 205 tons of gold and 52 tons of silver

(Öncesi) (Sonrası)

- With this project, a significant portion of the sediments (40%) were rehabilitated while ensuring the necessary safety conditions and effective response to restore the area.

Mining Quarry China Shanghai

- The mine pit is 100 m deep. The hotel has 19 floors and rehabilitation works were carried out as a pond project.

(Öncesi) (Sonrası)

Flambeau Copper Mine, ABD

Mardis Mine Site (GOLF COURT)- ABD

- During the 50-year mining history between 1950-1999, 347 acres of sand and gravel were mined.

(Öncesi) (Sonrası)

Source: chaneyenterprises.com

Successful Closure Operations and Challenges Encountered
Successful Closure Operations:

- **Environmental Rehabilitation:**
  - o Soil Stabilization: Soil loss is prevented by controlling erosion.
  - o Vegetation Restoration: Ecosystem restoration is achieved by planting with native plant species.
  - o Water Management: Prevent acid miner drainage (AMD) and protect water resources.
- **Community Acceptance and Communication:**
  - o Community Outreach: Continuous communication with local people to address their concerns.
  - o Employment Support: Alternative employment opportunities are offered to the workforce lost with the cessation of mining activities.
- **Legal and Financial Regulations:**
  - o Legal Compliance: Compliance with national and international environmental legislation is ensured.

Challenges Encountered:

- **Environmental Challenges:**
  - o Acid Mine Drainage (AMD): Poses a serious environmental threat, especially in areas where sulfide-containing minerals are present.
  - o Soil and Water Pollution: Cleanup and management of contaminated soil and water resources.
- **Technical Challenges:**
  - o Safety of Underground Structures: Collapse risks of old mine tunnels and galleries.
  - o Waste Management: Safe disposal of mine waste.
- **Social and Economic Challenges:**
  - o Impacts on the Local Economy: Damage to the local economy with the cessation of mining activities.
  - o Community Health and Safety: Negative impacts of post-mining structures and areas on community health.
- **Legal and Regulatory Challenges:**
  - o Regulatory Compliance: The challenge of adapting to ever-changing environmental and mining legislation.
  - o Financial Obligations: High costs of closure and rehabilitation and meeting these costs.

Comparison of Mine Rehabilitation Studies in Turkey with Other Countries
Türkiye
Mine Closure Legislation:

- **Mining Law No. 3213:** Regulates the operation and closure of mines.
- **Environmental Impact Assessment (EIA) Regulation:** Assessment of environmental impacts during the closure process.

- **Waste Management Regulation:** Management of wastes generated during the closure process.

Legal Framework of Mine Closure Processes:
- **Revocation of Operating License:** Termination of operation activities and revocation of the license.
- **Closure Plan Approval:** Preparation and submission of the closure plan to the relevant authorities and obtaining approval.
- **Compliance with Legislation:** Carrying out the closure activities by the relevant legal regulations.

Closure Plan Obligations:
- **Detailed Closure Plan:** Preparation of a detailed plan for the closure of the mine site.
- **Determination of Activities:** Planning of all activities to be carried out during closure.
- **Cost Analysis:** Determination and budgeting of closure and rehabilitation costs.

Environmental Rehabilitation:
- **Restoration to Natural Condition:** Restoring the mine site as close as possible to its natural state.
- **Reforestation:** Local vegetation and afforestation efforts.

Australia:
- **Legal Framework:**
  - Mining Act and Environmental Protection Act: Rehabilitation standards and obligations.
  - Closure and Rehabilitation Plan: Detailed closure and rehabilitation plans are mandatory.
- **Practices:**
  - Ecosystem Restoration: Full ecosystem restoration with local flora and fauna.
  - Soil and Water Management: Re-fill and water management strategies.
- **Monitoring and Reporting:**
  - Long-term Monitoring: Long-term post-closure environmental monitoring and maintenance.

Canada:
- **Legal Framework:**
  - Canadian Environmental Assessment Act: Rehabilitation Requirements.
  - Mine Reclamation Requirements: Specific mine closure and rehabilitation standards.
- **Practices:**
  - Landscape Rehabilitation: Restoring the landscape to its natural state.
  - Biodiversity: Projects targeting biodiversity enhancement.
- **Monitoring and Reporting:**
  - Community Participation: Local community involvement in the rehabilitation process.

South Africa:
- **Legal Framework:**
  - Minerals and Petroleum Resources Development Act: Rehabilitation and environmental management standards.

  - o National Environmental Management Act: Approval of closure and rehabilitation plans.

- **Practices:**
  - o Closure and Post Closure Use: Planning for future use of mine sites.
  - o Economic Development: Rehabilitation projects support the local economy.
- **Monitoring and Reporting:**
  - o Social and Environmental Monitoring: Monitoring of both environmental and social impacts.

“Before mining operations begin we do all necessary works to enable you to make an investment that is right for you. Utilising on our experience and technical knowledge we regularly inform investors about technical difficulties throughout the mining operations and make sure their project is in line with the international standards.”

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Areas Used in Mining Activities in Türkiye and the Obligations of Mining License Holders Under Turkish Legislation

Dr. Kerem Canbazoğlu [1,2]

ABSTRACT

This study examines the legal regulations for areas used in mining activities in Turkey and the obligations of mining license holders within the scope of the legislation. Environmental impact assessment processes are conducted throughout the project duration for areas where mining activities will take place; following the project, it is expected that the operational areas will be brought into environmental compliance, rehabilitated, or restored to their natural state. The study addresses provisions in post-mining land regulation within legislation such as the Mining Law No. 3213, the Environmental Law No. 2872, the Forestry Law No. 6831, the Pasture Law No. 4342, and the Soil Conservation Law No. 5403, recommending a simplification of the existing legal framework for improved legal clarity.

Keywords: mining, environmental impact assessment, land regulation, land restoration

1.Area Utilization Permits of Mining Activities

As known, mining is a temporary activity conducted within a specific area defined by a mining license. During mining operations, large volumes of materials can be displaced both underground and on the surface depending on the location of the ore. Therefore, the utilization of areas in mining is crucial due to needs such as mineral processing and storage of materials which emerge after the processes.

Environmental Impact Assessment (EIA) processes are implemented to determine and monitor the effects within the project area and designated impact area where mining activities are to be conducted, both before and after operations commence. These assessments includes evaluation of the current state of the area to be affected by activities before commencement and for the implementation phase monitoring interactions with receiving environments such as air, water, and soil to ensure compliance with threshold values, and for the post-activity period to conduct monitoring periods in lign with the dimensions of the projects to evaluate environmental impacts. During those processes, responsible public institutions for special status areas such as forests and pastures, shall be included as a member to the Review and Evaluation Committee to provide their opinions on the EIA Report. Following final adjustments, the EIA Report undergoes a final evaluation, leading to a Positive EIA Decision.

Although various public institutions provide opinions during the Environmental Impact Assessment (EIA) process regarding the use of areas for projects, these opinions do not constitute final permissions of those public institutions for the utilization of these areas. Different procedures and processes are defined in each single legislation, such as "*permission*," "*allocation purpose change*," or "*non-agricultural land use decision*," for the mining purposes of these areas.

For each of these areas, specific conditions, obligations, and responsibilities that mining license holders must fulfill after the cessation of activities are separately defined.

The absence of a single unified regulation and the existence of different processes under various laws and regulations administered by different authorities make it challenging to determine post-activity obligations, responsibilities and the how to release out of these obligations, responsibilities for mining license holders regarding the use of these areas.

Frequently, legal disputes arise between relevant public institutions and mining license holders on these matters. It's important to note that this issue isn't solely a legal relationship between permitting authorities and license holders; local residents residing near project areas may also become involved in legal processes concerning these issues.

2.Legal Framework of Land Use in Mining and Other Stakeholders

From legal point of view, mining can be defined as the activity of benefit from natural resources listed in the Mining Law using scientific methods to maximize added value. Natural resources, and thus the State's authority over mines, are expressed in the Constitution under Article 168 as being "*under the authority and at the disposal of the State*" Apart from natural resources and assets, the Constitution also addresses principles related to areas with different statuses. Among these, it is essential to consider regulations concerning forests and land ownership, which are frequently relevant to mining activities.[3] Furthermore, individuals living in areas where mining activities are conducted can participate in legal processes concerning themselves within the framework of rights defined in the Constitution.[4]

Mining activities during and after operations and restoration of the area to its former character and condition necessitate the active involvement of the state due to constitutional fundamental rights and the protection and usage conditions of areas defined under special statuses in the constitution. Individuals can demand regulations and audit from the state that do not interfere with their fundamental rights. On the other hand, for holders of mining licenses authorized to explore and operate natural resources, legal predictability and certainty principles require that all general and specific regulations ideally be consolidated into a single law.

3.Legislation, Terminological Preferences and General Framework Regarding the Post-Activity Regulation of Areas Used for Mining

In a mining site, it is common to encounter situations such as operational areas overlapping with forested land, individual parcels used for agricultural production, and parcels designated as pasture areas. Each of these areas requires adherence to different laws and regulations depending on their status when it comes to the permitting processes for mining operations. For individual parcels designated as agricultural land, decisions regarding non-agricultural land use require obtaining a public interest decision during the expropriation process or acquiring these parcels from individuals by investors or after obtaining land use for mining through lease-consent, a non-agricultural use permit must be obtained according to the type of land in accordance with Law No. 5403. For forest lands remaining in the operation area, a forest permit application must be made and a forest permit must be obtained. As for areas designated as pasture parcels, the utilization of these areas require a change in allocation purpose based on the original allocation to the respective village legal entity, ensuring compliance with the designated purpose. One of the conditions for these permits includes planning activities, reporting the activities, oversight by authorities and providing assurances regarding the implementation of commitments related to the pre- and post-activity conditions.

The main provisions regarding the reclamation of areas used for mining activities are stipulated in the Mining Law No. 3213 and the Environment Law No. 2872. In the Mining Law, the terms "*closure*" and "*harmonization with the environment*" are preferred for post-activity reclamation. The Environment Law uses the concept of "*rehabilitation to nature*." In addition to these main regulations, if the used area is pasture, winter pasture, or summer pasture, the Law on Pastures No. 4342 and its legislation expect the area to be "restored to its former quality and capacity" after the activities. Similarly, the Soil Preservation and Land Utilization Law No. 5403 uses the terms "*restoring to its former quality at the end of the allocation period in terms of agricultural lands*" and "*making the land suitable for agricultural production*" for agricultural lands permitted for non-agricultural use. The generally accepted concept of "*rehabilitation*" for post-activity reclamation is actually the term preferred in the Regulation issued under Article 16 of the Forestry Law No. 6831, which regulates permits for mining activities.

Generally, in the Mining Law, activities referred to as "*harmonization with the environment*" are included as a section in the operational project submitted by the license holder. This section details the process and commitments of the mining license holder regarding how the topography of the area will be left after activities, the safety measures to be taken, and the removal of facilities, buildings, and foundation concrete from the area after activities. The environmental compliance guarantees taken within this scope are held to cover the costs of any work that may be carried out by the relevant institutions if these commitments are not fulfilled. The license holder must bring the area into compliance with the environmental harmonization plan within a maximum of 1 year following the end of their activities. The environmental compliance guarantee is withheld annually as 30% of the operation license fee. The return of the guarantee will be carried out if all the permits obtained under Article 7 for the operational license are returned to their institutions and there are no outstanding debts on the license from previous periods.

From the perspective of environmental legislation, rehabilitation to nature will be evaluated and formed as a whole within the framework of the opinions of public institutions and organizations involved in the Environmental Impact Assessment (EIA) process. Within this framework, the rehabilitation efforts committed during the EIA process are regularly monitored by provincial directorates.

a) Mining Law No. 3213 and Mining Regulation

For activities to be carried out in mining license areas, the fundamental terms preferred in the Mining Law and its associated legislation are "*closure*" and "*harmonization with the environment*" All activities related to the closure and environmental harmonization of mining operations are considered part of mining activities.

Harmonization with the environment will be carried out within the framework of commitments defined as the "*Environmental Harmonization Plan*" in Section V of the Mining Operation Project format, provided in Annex-13 of the Mining Regulation. An environmental harmonization plan is also provided for raw material production permits of public institutions and organizations, and for licenses that need to be operated together due to technical necessities.

As a guarantee for the commitments to implement the environmental harmonization plan, 30% of the annual license fee paid by the license holder is taken as an environmental harmonization guarantee. The environmental harmonization fee is refunded after the site is brought into compliance with the environment and the areas permitted under Article 7 are returned to their respective institutions, provided there are no outstanding debts related to the license. The environmental harmonization guarantee is one of the preliminary financial conditions introduced to ensure that all requests related to the license area by the license holders are considered. During the inspection and auditing of activities, it is checked whether the operations are conducted in accordance with the environmental harmonization plan.

In the event of the termination or abandonment of a license, the license holder is required to take necessary safety measures and bring the site into compliance with the environment within a maximum of one year, according to the operational project (Section 5 Environmental Harmonization Plan). During the on-site inspection of abandonment requests or inspections related to terminated sites, compliance with the environmental harmonization plan is also examined. If compliance with the environmental harmonization plan is not achieved, the abandonment request is not accepted. If this is not completed within the specified time, the relevant forest authority will ensure compliance with the environmental harmonization plan in forest areas, and provincial special administrations will do so in other areas, with costs covered by the environmental harmonization guarantee. If the guarantee does not cover the costs, the remaining amount must be paid by the license holder within 30 days. If not, it will be collected from the license holder according to Law No. 618, The Law on the Collection Procedure of Public Receivables.

b) Environment Law No. 2872 and the Regulation on the Rehabilitation of Lands Degradated by Mining Activities

In environmental legislation, the terminology preferred for the post-activity status of lands where mining activities are conducted is expressed as "*restoration of the natural structure*" and "*rehabilitation to nature*" and the associated obligations are shaped around these terms.

The environmental legislation obligations of mining license holders for pre- and post-activity phases are regulated by the Environment Law (1983)[5], Regulation on Environmental Impact Assessment (2022), and the Regulation on the Rehabilitation of Lands Degradated by Mining Activities (2010)[6].

The Regulation defines the terms "*rehabilitation to nature*"[7], "*rehabilitation to nature plan*"[8], "*closure*"[9], and "*mining activities*"[10]. According to the Regulation, before starting the operations, the operator must prepare a "*rehabilitation to nature*" plan to restore the degradated natural structure, establish ecological balance, and make the site safe for future use by humans or other living beings. This plan is evaluated and finalized as part of the Environmental Impact Assessment (EIA) process for the respective mining activity.[11] Rehabilitation to nature activities are started simultaneously with mining, excavation, or dumping operations, continue during the activity period, and end after the site is made suitable for post-activity use.[12] In the case of a license extension, the implementation schedule is updated according to the extension date and submitted to the Provincial Directorate of Environment and Urbanization.[13] The entire operational area must be made suitable for post-activity use by the operator within two years after the completion of the mining activities.[14] The operator's responsibility for carrying out the rehabilitation works in the operational area is monitored for an additional three years beyond the two-year completion period. The monitoring periods related to the EIA are also considered. The commitments made in the rehabilitation to nature process are confirmed by the Provincial Directorate of Environment and Urbanization based on the opinions of municipalities or provincial special administrations. Responsibility ends once these commitments are fulfilled.[15] In areas where rehabilitation to nature work is carried out (for those not classified as forest, agricultural, or pasture land), the Ministry of Environment, Urbanisation and Climate Change is responsible for monitoring and supervision. The operator must submit annual monitoring reports based on the implementation schedule prepared for the rehabilitation to nature activities to the Provincial Directorate of Environment and Urbanization by the end of January each year. At this stage, all sampling and analysis costs are covered by the operator.[16] For rehabilitation to nature work in agricultural areas, forests, or pastures, the relevant ministry is responsible for monitoring and supervision.[17] If the operator permanently halts the rehabilitation to nature activities for any reason other than force majeure or transfer to a new operator, the relevant public institution will carry out the rehabilitation activities at the operator's and those responsible's expense in accordance with the provisions of Law No. 6183.[18] The operator must report to the Provincial Directorate of Environment and Urbanization within 5 business days if they fail to fulfill their commitments under the rehabilitation to nature activities or suspend their activities temporarily or permanently, or if new conditions require changes in the rehabilitation to nature activities.[19] In the case of a license transfer, the responsibility for rehabilitation to nature is also transferred to the new license holder. If different operators are working on the same license area, the responsibility for rehabilitation to nature lies with the license holder. The cancellation of the license does not remove this responsibility. Rehabilitation to nature of the area operated before the cancellation must be completed within 6 months of the notification of the cancellation decision.[20]

c) Law on Pastures No. 4342 and Regulation on Pastures

With the change of allocation for mining purposes, the pasture areas used for mining are expected to be restored to their "*former status and capacity*" by the mining license holder after the activities are completed.

As known, pastures (meadows, wintering grounds, and summer pastures) are under the jurisdiction and control of the state, which is a status termed as 'state domain and control,' including natural resources, coastlines, and cultural heritage. The right to use these areas can be allocated to one or more villages or municipalities based on their needs. Pastures are designated for livestock grazing, meadows for forage production, wintering grounds for winter housing of animals, and summer pastures for animals during the summer months, either allocated or historically used in this manner. (Law on Pastures Art. 3)

Pastures cannot be used for purposes other than their designated use. Costs for restoring pastures, summer pastures, and wintering grounds to their original condition due to out of purpose are collected from the responsible parties. They cannot be subject to private ownership. Lands designated as pastures are registered in the special registry.

Both exploration and operational activities on mining license areas may overlap with pasture lands. The process of changing the allocation purpose for exploration activities is not implemented on pasture lands.

According to the Mining, Petroleum, and Geothermal Laws, in areas where reserves are determined at the end of exploration activities, and for the locations required for these activities, the purpose of allocation may be changed by the Governorate upon the request of the relevant Directorate (MAPEG), and the approval of the Pasture Commission and the Provincial Treasury. The registration of these locations is made in the name of the Treasury. (Law on Pastures Art. 14)

Operators requesting a change in the allocation purpose are obligated to conduct their activities in a way that does not harm the environment or the remaining pasture areas and to restore the allocated areas to their former status at the end of the allocation period. These areas are registered in the special registry at the end of the allocation period. (Law on Pastures Art. 14)

With the 2013 amendment to the Law on Pastures, there is a provision for the issuance of a regulation on the procedures and principles of mining and petroleum exploration and operation activities. (Law on Pastures Art. 12/5)

Before starting exploration activities in pastures, the holder of the mining exploration license must apply to the provincial directorate. Following a 30-day review period, the principles to be followed are determined, and permission is granted without changing the allocation purpose. (Mining Regulation Art. 115) After these activities, the areas affected must be restored to an environmentally compliant condition within a maximum of six months. According to the Regulation on Pastures, before starting the activities, a guarantee must be deposited for restoring the affected area to its former status and a Pasture Rehabilitation Agreement must be signed. If these conditions are not met before starting the activity, the exploration permit will be revoked. If the pasture area is not restored to its former status and capacity within one year after the activities, the Pasture Commission will carry out these procedures, and costs along with the loss of pasture will be collected.[21]

d) Law No. 5403 on Soil Preservation and Land Utilization Regulation on Conservation, Use and Planning of Agricultural Land

The Soil Preservation and Land Utilization Law defines the mining license holder's obligation within the framework of "*restoring to its former state at the end of the allocation period*" and "*making the land suitable for agricultural production*." To conduct activities on agricultural lands that overlap with mining license areas, a permit for non-agricultural use must be obtained. Non-agricultural use permits for mining activities on agricultural lands may be granted by the Ministry of Energy and Natural Resources under the condition that there are no alternative areas available for the public interest decision of mining activities.

Operators who obtain a permit for non-agricultural use of agricultural lands for mining activities under the public interest decision from the Ministry of Energy and Natural Resources are required to carry out their activities in a manner that does not harm the environment and agricultural lands and to restore the allocated areas to their former state at the end of the permit period. (Law No. 5403, Art. 13)

It is mandatory to comply with Soil Conservation Projects in the uses to be carried out on lands with a non-agricultural use permission is given.

Governorships are responsible for taking and enforcing necessary measures to monitor and prevent soil pollution and degradation resulting from agricultural or non-agricultural activities. (Law No. 5403, Art. 16) Relevant provisions of the environment law are applied to those who pollute the soil.

Violations such as starting non-agricultural uses without permission, using the area in ways that do not comply with the permit, and failing to adhere to the soil protection project result in administrative measures and sanctions that progressively escalate. (Soil Preservation and Land **Utilization Law, Art. 21)**

In cases of unauthorized or non-compliant use, the activity is first halted, and administrative fines are imposed on the landowner and the party causing damage to the land. A one-month period is granted to obtain the necessary permit. If the permit is not obtained or the application is not made within this period, a two-month period is given to restore the land to agricultural use. If this restoration is not completed within the given period, a threefold administrative fine is imposed, and the activity is suspended. The costs for restoring the land to agricultural use are covered by the Ministry, and the expenses are collected from the responsible parties by the Ministry through the municipality or provincial administration.

In cases of non-compliance with soil protection projects, an administrative fine calculated based on the area of the degraded land is imposed, and a two-month period is granted to achieve compliance with

the project. If non-compliance continues after this period, the activity is halted, the permit is revoked, and a threefold administrative fine is imposed. Within one month, the land must be restored to agricultural use, and the related costs are collected from the responsible parties by the Ministry.

For damages resulting from the failure to prepare soil protection projects, inadequacies, or failure to make necessary amendments on time, those who decide that no project is required, or if a project is prepared, those who prepared and approved the project are responsible for the resulting damages. (Law No. 5403, Art. 21)

e) Law No. 6831 on Forest and the Regulation on Implementing Article 16 of Forest Law

Article 16 of Law No. 6831 regulates the permitting process for mining activities. Under this article, the terms "*rehabilitate*" and "*rehabilitation*" are used for areas at the end of the permit period. The implementations to be carried out under this article are explained in the Regulation on Implementing Article 16 of Forest Law (Article 16 Regulation).

As stated in the Article 16 Regulation, rehabilitation activities shall be carried out according to the Rehabilitation Project.[22] In the Article 16 Regulation, the concept of "*rehabilitation*" is defined as "*the process of improving the land during the period from the beginning to the end of the permit to ensure environmental safety and make the land environmentally compatible using afforestation and silviculture techniques to establish a forest ecosystem*."[23] Article 18 of the Article 16 Regulation regulates the Rehabilitation Project seperately and in detail. Accordingly, the project must be prepared by the forestry office, taking into account the determination of the new topography that can be created through rehabilitation, soil improvement, and the principles of forest establishment.[24] The permit holder is required to conduct activities in accordance with this project. If conditions arising during mining activities necessitate changes to the rehabilitation project, it must be revised and submitted to the regional directorate within 3 months. If additional land is requested for forest permits, a revision of the rehabilitation project is also required. The rehabilitation project specifies the areas for storing soil taken from the permitted area, which will also be used in the rehabilitation **process. No soil or materials from outside the permitted area may be brought in. Soil stored under other permits in the same license area may be used for the rehabilitation of other permit areas under the same license.[25] If the forest permit areas within the same license area are contiguous, they can be managed under a single rehabilitation project. Similarly, a single rehabilitation project can also be prepared for contiguous forest permit areas, even if they are within different license areas. If multiple permit areas are requested simultaneously within the same license area, a single rehabilitation project can be prepared for them as well.[26] The content of the rehabilitation project is expected to include the following: ensuring a safe environment for all living beings[27], specifying measures to prevent waste accumulation or ore dusting from affecting forested areas due to water and air flows[28], ensuring long-term stability in slope openings to be created,** ensuring that it is stable in its natural state **and** taking precautions **to ensure safe surface runoff.**

In addition to the rehabilitation project for the heaps of tallow, a phased closure plan must also be arranged.[29]

According to Article 16 Regulation, the phased closure plan, which is one of the important concepts related to rehabilitation, is defined as "*a plan that shows the closure and reintegration into natüre of disposal areas such as tallow dumps and tailings dams to their final state, in accordance with afforestation and silvicultural techniques for the establishment of a forest ecosystem, from the beginning to the end of the permit period*."[30]

Another concept related to the rehabilitation of forest areas after mining permits is the Technical Report. According to Article 16 Regulation, this is defined as "*a report to be prepared annually to check that mining activities and soil filling permits are conducted in accordance with the purpose of the permit and the rehabilitation project/soil filling project, and to verify that the current year's fees have been paid*."[31]

The legal framework for the post-activity rehabilitation of forest areas is established during the permitting process for these areas. In this context, it is regulated in Article 16 Regulation that the rehabilitation project or the phased closure plan must be included among the documents to be attached to applications for mining exploration, operation, facility, and permits.[32]

When it comes to the transfer of forest permits, it must be declared that the Rehabilitation Project provided by the current permit holder is also fully committed to by the party taking over the forest permit, to the forest administration.[33]

In forest permits, the extension of the definite permit period may come up for various reasons. In such cases, one of the prerequisites for the extension of the forest permit period is the submission of a revised Rehabilitation Project according to the current situation, based on the Project provided during the initial permit process.[34] Otherwise, the failure to submit a revised Rehabilitation Project when requesting a definite permit extension is one of the reasons that leads to the cancellation of the forest permit.[35] Another condition that may cause the cancellation of the forest permit is the failure to comply with the Rehabilitation Project within the six-month period given by the forest administration after detecting non-compliance.[36] Similarly, non-compliance with the provisions in the commitment document taken during the forest permit process and failure to report the detected deficiencies can also be grounds for cancellation. This demonstrates that the Rehabilitation Project, along with the definite permit commitment document to the Forest Administration, is one of the most important elements and conditions for obtaining and maintaining forest permits.

In addition to these regulations, the Fifth Section of Article 16 Regulation, which contains three articles, is entirely dedicated to this topic. The title of this section is "*Rehabilitation, Rehabilitation Project, Monitoring and Control*."

In Article 17 of the Fifth Section of Article 16 Regulation, titled "*Rehabilitation*" it is stipulated that the forest permit holder must rehabilitate the area where activities will be conducted according to the Rehabilitation Project.[37] Claims such as the area being barren or unproductive before use cannot be used as reasons to not perform rehabilitation.[38] The same article specifies that rehabilitation is not an activity to be postponed until after operations; it must be carried out simultaneously with the commencement of activities within the permitted area under the forest permit. Rehabilitation activities must be completed by the end of the permit period. However, if rehabilitation is not completed by the end of the permit period or in the event of permit cancellation, an additional one-year permit is granted to the permit holder to complete the rehabilitation. The permit holder must also pay land use fees for this period. If rehabilitation is still not completed within this additional period, the necessary actions will be taken by the Forest Administration. Costs incurred will be deducted from the environmental compliance guarantee, which is 30% of the annual permit fee paid by the permit holder. Any remaining amounts will be collected through legal means if not paid by the permit holder.[39] Infrastructure facilities remaining in areas where the forest permit period has ended or permits have been canceled must be removed from the forest area within one year without any notification from the Forest Administration. Unremoved facilities and infrastructure will be transferred to the Forest Administration free of charge if needed. Otherwise, these will be removed from the forest area at the expense of the permit holder. For facilities and infrastructure such as tallow dumps and tailings dams that cannot be moved, the rehabilitation procedures specified in the Rehabilitation Project for these areas will be applied.[40] For mining exploration requiring excavation or infrastructure facilities not requiring a Rehabilitation Project, the topography of the permitted area must be aligned with its pre-permit topographic structure, as no separate Rehabilitation Project is required. Otherwise, the Forest Administration will carry out this work, and the cost will be collected from the permit holder.[41]

The monitoring and control of compliance with the Rehabilitation Project is also regulated in Article 19 of the Article 16 Regulation.

The technical report is defined in the Article 16 Regulation as "*a report that will be prepared annually to check whether the mining activities and soil filling permits are carried out in accordance with the purpose of the permit and the rehabilitation project/soil filling project, and whether the current year fees have been paid*."[42]

The technical report shows the stages and current status of the permit area and the rehabilitation. In addition, a copy of the operational activity report and a receipt proving the payment of the additional state right must be attached to the report.[43]

The technical report is prepared annually by the forestry office or the forest engineer and/or senior forest engineer employed by the forestry office and submitted to the Regional Directorate. In newly issued permits, a technical report is not required within the year the permit is granted. If the technical report is not submitted within the specified period, fieldwork is not allowed until the technical report and renewed collateral are provided.[44]

4.Evaluation and Conclusion

As seen, different public institutions, within the scope of their respective duties and authorities, define the expected post-activity conditions using different terms according to the provisions of their own laws and regulations.

In this context, it can be argued that the separate procedures handled by each authority and the resulting varied interpretations among the parties can transform the closure of mining sites into a complex and perpetually unresolved cycle.

To resolve this issue, establishing legal clarity for the post-activity conditions of mining sites could be achieved by integrating fundamental texts such as the Mining Law, Environment Law, Forest Law, Law on Pastures and Soil Preservation and Land Utilization Law. Instead of navigating the disparate provisions within each law, a unified legal framework could be created to address the matter comprehensively.

Furthermore, managing these sites post-activity requires financing. If permit holders fail to fulfill these obligations, public institutions must bear the costs, with the intent of recovering these expenses from the responsible parties in the future. Thus, there is a pressing need for alternative arrangements, such as insurance or other financial instruments, to enhance the security of financial guarantees for post-activity operations.

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[2] *I hereby acknowledge and extend my appreciation to Ms. Özge Balcıoğlu's, Trainee Lawyer at CAC Law, for her hard work and valuable contrubution for the preperation of this paper.*

[3] In Article 44 of the Constitution under the title "*Land Ownership*" the state's objectives include "*to maintain and develop efficient land cultivation, to prevent its loss through erosion*". Article 45, titled "*Protection of agriculture, animal husbandry, and persons engaged in these activities" states that "facilitates farmers and livestock breeders in acquiring machinery, equipment and other inputs in order to prevent improper use and destruction of agricultural land, meadows and pastures and to increase crop and livestock production in accordance with the principles of agricultural planning*". Article 169 addresses regulations related to forests, stating that "*The State shall enact the necessary legislation and take the measures required for the protection and extension of forests. Burnt forest areas shall be reafforested; other agricultural and stockbreeding activities shall not be allowed in such areas. All forests shall be under the care and supervision of the State. The ownership of state forests shall not be transferred. State forests shall be managed and exploited by the State in accordance with the law. Ownership of these forests shall not be acquired by prescription, nor shall servitude other than that in the public interest be imposed in respect of such forests*."

[4] *Article 17 of the Constitution guarantees the right of individuals to protect and improve their corporeal and spiritual existence. Article 20 of the Constitution, one of the most broadly interpreted fundamental rights, guarantees the right to privacy and protection of private life, stating, "Everyone has the right to demand respect for their private and family life." Similarly, Article 56 of the Constitution titled "Health services and protection of the environment" states, "Everyone has the right to live in a healthy and balanced environment. It is the duty of the State and citizens to improve the natural environment, to protect the environmental health and to prevent environmental pollution."*

[5] *Environment Law, Supplementary Article 1 (2006) "b) Procedures and principles for the restoration of the natural structure degradated by excavation, dumping, and waste left on the land for quarrying and mining activities, material and soil supply, will be determined by a regulation to be issued by the Ministry, based on the opinions of relevant institutions."*

[6] In this section and in the footnotes, it will be briefly referred to as the "***Regulation on the Rehabilitation of Degradated Lands***". Although the title emphasizes mining, it is not solely a regulation for mining activities; it also covers issues related to the restoration of the natural structure degradated by excavation, dumping, and waste left on the land for material and soil supply beyond just mining activities. It does not cover forest, agricultural, or pasture lands, which are subject to separate regulations. The terms related to land reclamation, obligations for rehabilitation, and the rehabilitation plan are included.

[7] "***The improvement of areas whose topography is altered during or as a result of mineral exploration and extraction activities, ensuring environmental safety, and restoring them in accordance with the project and environmental compliance with the relevant legislation***" *(Regulation on the Rehabilitation of Degradated Lands, Definitions, Art. 3)*

[8] ***"All the activities related to the rehabilitation to nature process"*** (Regulation on the Rehabilitation of Degradated Lands, Definitions, Art. 3)

[9] ***"The completion of the stages of the rehabilitation to nature process and the permanent abandonment of the operational site."*** (Regulation on the Rehabilitation of Degradated Lands, Definitions, Art. 3)

[0] ***"Mining excavation activities, blasting, crushing, ripping, drilling, dry or wet screening, and grinding, as well as ore preparation and enrichment processes using chemical methods in addition to these physical processes, conducted to obtain economically valuable materials from soils and rocks."*** (Regulation on the Rehabilitation of Degradated Lands, Definitions, Art. 3)

[1] ***Regulation on the Rehabilitation of Degradated Lands, Art. 5/1***

[2] ***Regulation on the Rehabilitation of Degradated Lands, Art. 5/5***

[3] ***Regulation on the Rehabilitation of Degradated Lands, Art. 5/6***

[4] *Regulation on the Rehabilitation of Degradated Lands, Art. 5/7*

[5] *Regulation on the Rehabilitation of Degradated Lands Art. 5/8 and 8/2*

[6] *Regulation on the Rehabilitation of Degradated Lands, Art. 9/1-2-3*

[7] *Regulation on the Rehabilitation of Degradated Lands, Art. 9/4*

[8] *Regulation on the Rehabilitation of Degradated Lands, Art. 8/3-4*

[9] *Regulation on the Rehabilitation of Degradated Lands, Art. 13*

[20] *Regulation on the Rehabilita20tion of Degradated Lands, Art. 12*

[21] *With the 2013 amendment to the Law on Pastures, there is a provision for the issuance of a regulation on the procedures and principles for mining and petroleum exploration and operation activities. (Law on Pastures Art. 12/5).*

[22] *A project to be prepared for the rehabilitation of the area where mining activities are carried out, ensuring the reorganization of the disrupted natural structure, the restoration of its natural balance, and making the area safe for use by humans or other living beings.*

[23] *Article 16 Regulation, Art. 3/1-gg*

[24] *Article 16 Regulation, Art. 18/1*

[25] *Article 16 Regulation, Art. 18/4*

[26] *Article 16 Regulation, Art. 18/5*

[27] *Article 16 Regulation, Art. 18/6*

[28] *Article 16 Regulation, Art. 18/7*

[29] *Article 16 Regulation, Art. 18/11*

[3]*0 Article 16 Regulation, Art. 3/1-u*

[31] *Article 16 Regulation, Art. 3/1-jj*

[32] *Article 16 Regulation, Art. 4/1-g*

[33] *Article 16 Regulation, Art. 9*

[34] *Article 16 Regulation, Art. 10*

[35] *Article 16 Regulation, Art. 11*

[36] *Article 16 Regulation, Art. 11*

[37] *Article 16 Regulation, Art. 17/1*

[38] *Article 16 Regulation, Art. 17/2*

[39] *Article 16 Regulation, Art. 17/3*

[40] *Article 16 Regulation, Art. 17/4*

[41] *Article 16 Regulation, Art. 17/5*

[42] *Article 16 Regulation, Art. 3/3-jj*

[43] *Article 16 Regulation, Art. 27*

[44] *Article 16 Regulation, Art. 19/2*