



**Coordinating Committee for Geoscience Programmes  
in East and Southeast Asia**

**BEST PRACTICES OF MINE REHABILITATION AND  
DECOMMISSIONING PROGRAMMES OF SUCCESS STORIES  
IN EAST AND SOUTHEAST ASIA**



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**BEST PRACTICES OF MINE REHABILITATION AND DECOMMISSIONING  
PROGRAMMES OF SUCCESS STORIES IN EAST AND SOUTHEAST ASIA**

Editor: Dhiti Tulyatid

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## PREFACE

Mining usually has both positive and negative impacts on its surrounding environments. Once the ore of the operating mine is exhausted, a mine closure process will be executed. The process usually comprises several steps, which are shutting down, decommissioning, remediation or reclamation, followed by the post-closure or monitoring programs. The general public has an impression that the mine closure process is generally carried out at the end of the mining operation. However, the mining operations often begin their closure and remediation during their active operations. The recent advancement of technology and the new environmental management have contributed to the reduction of the environmental impact of mining and minimize the footprint of the activities throughout the mining cycle.



This CCOP's book project on "the Best Practices of Mine Rehabilitation and Decommissioning Programmes of Success Stories in East and Southeast Asia" was originally proposed by the Mines and Geosciences Bureau, Republic of the Philippines in 2013. The proposal was aimed to encourage CCOP Member Countries to participate in the project and contribute their successful case studies of how the mining companies have taken their efforts to maintain and protect the environments and their mining locations. This book project officially started in 2015 with a total of three meetings in 2015, 2017 and 2018. The majority of the Member Countries have participated in this activity.

This book has gathered successful stories from nine CCOP Member Countries, including: Indonesia, Japan, Korea, Lao PDR, Malaysia, Myanmar, Philippines, Papua New Guinea and Thailand. Each country has a different background, mining history & situation, and study cases. The materials should provide a good source for information and education, especially on the mine closure and monitoring.

I would like to express my sincere appreciation to those who participated in the meeting and contributed to the publishing of this book, especially the authors of each chapter. CCOP TS was responsible for the gathering and editing of the manuscripts. We would like to express our special gratitude to China Geological Survey for their kind printing of the book.

Let the book tells us for itself on the mine rehabilitation and decommissioning programmes of success stories in East and Southeast Asia. This book is another successful project of our CCOP Member Countries.

Bangkok, 20 August 2018

A handwritten signature in blue ink, appearing to read "Adhikari". The signature is fluid and cursive.

Director of CCOP Technical Secretariat

## **CONTENTS**

	<b><u>PAGE</u></b>
<b>PREFACE</b>	
<b>CONTENTS</b>	
1. INTRODUCTION	1
2. INDONESIA	7
3. JAPAN	25
4. REPUBLIC OF KOREA	44
5. LAO'S PEOPLE DEMOCRATIC REPUBLIC	70
6. MALAYSIA	80
7. MYANMAR	102
8. PAPUA NEW GUINEA	125
9. THE PHILIPPINES	140
10. THAILAND	167

## 1

**INTRODUCTION**

*Dhiti Tulyatid, CCOP Technical Secretariat.*

East and Southeast Asia lies along the Pacific Ring of Fire, where geological processes are generally more active and complex. These processes, over a long period of time, give rise to different types of minerals, which serve as important materials of many products nowadays. Generally, mining operations cause environmental disturbance which is always a challenge for mining companies to minimize. As a measure, an environmental protection and enhancement program is always incorporated in the management even before the commencement of actual operation that will last until the final mine rehabilitation, thus, exercising the “responsible mining”.

However, several sectors of our society are not aware of and informed about the efforts of mining companies to maintain and protect the environmental integrity of their mining locations. The main reason for this is the lack of sufficient solid campaign materials to inform people.

Minerals industry, particularly in countries where mining is being opposed, should continuously provide public sector information on the best practices and success stories in mining especially in terms of rehabilitation. These best practices and stories should be well documented in able to come up with appropriate and solid Information Education Campaign (IEC) materials. Several media are available to choose from depending on the target sector. Books, documentary, journals and TV advertisements are only a few of the possible options for IEC.

The proponent initially compiled success stories of mine rehabilitation that have been published in the internet. These include Misima Mine in Papua New Guinea, Golden Cross Underground Mine in New Zealand, Xstrata Coal in Newcastle and Coal Mine at Wangaloa.

The proponent and its group found out that only a few success stories are published on the internet and details of rehabilitation strategies are often missing. It only proves that there is really lack of information on mine rehabilitation success stories including best practices.

This project was originally proposed in 2013 by Mines and Geosciences Bureau, Republic of the Philippines, represented by Dr. Elmer B. Billedo at that time. The kick-off meeting of the book project was held during 21-26 June 2015 in Manila and Palawan, the Philippines. Other meetings were held in Cebu City on 15 October 2017 and in Vientiane on 8 May 2018.

This book is a compilation of mine rehabilitation success stories within East and Southeast Asia with an aim to identify about 10 mine rehabilitation success stories.



**Figure 1.1** A group photograph of participants in the Regional kick-off meeting on the production of CCOP Book: Best Practices on Mine Rehabilitation and Decommissioning, Greenhills Elan Hotel Modern, Manila, the Philippines, 22 June 2015.



**Figure 1.2** A group photograph of participants on their site visit to Rio Tuba Nickel Mining Corporation, Bataraza, Palawan, The Philippines, 24 June 2015.



**Figure 1.3** A group photograph of participants of the Book Project Meeting: Best Practices on Mine Decommissioning and Rehabilitation in CCOP Region, Waterfront Cebu City Hotel, Cebu City, Philippines, 15 October 2017.



**Figure 1.4** Photographs taken from the meeting of the Book Project held in Vientiane, Lao PDR, as a part of the Mine Closure Legal Framework in ASEAN Member States held on 8 May 2018.

In this book, we have gathered articles from nine Member Countries, which are: Indonesia, Japan, Korea, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines and Thailand. The book provides the most up-to-date information on each of the country's background, mineral industry and the best practices of mine rehabilitation and decommissioning. A total of 21 case studies have been presented here in this book from nine countries mentioned, which are:

**Indonesia:** There are two cases including PT Kelian Equatorial Mining (PT KEM) and the Petangis Mine (PT BHP Kendilo Coal). PT KEM, a jointed venture of Anglo-Australian mining company Rio Tinto (90%) and PT Harita Jayaraya Inc. (10%), is a gold mine in Kelian area of Kutai District, East Kalimantan Province. The Petangis Mine is the first Coal Contract of Work (CCoW) mine closure in the Indonesian coal industry.

**Japan:** Matsuo Mine (sulfur and Iron sulfides) is located to the east of Hachimantai volcano, Iwate Prefecture, northern Japan. Here we can learn about the rehabilitation and monitoring of Acid Mine Drainage.

**Republic of Korea:** There are four successful cases for best practice of mine rehabilitation and decommissioning in Gangwon Province through the use of "tourism". The work include the hosting of Winter Olympic Games; Developing an attractive tour spots with casino business; transform a mining site to a mining museum and a cave theme park.

**Lao PDR:** Two main projects have been highlighted in this chapter: the Phu Kham copper-gold mine at Phu Bia Mining and Sepon gold-copper mines of Lane Xang Minerals Limited (LXML).

**Malaysia:** There are two case studies: Selinsing Gold Mine Manager Sdn Bhd (SGMM) of Monument Mining Limited in Malaya; and the J Resource Sdn Bhd on the Penjom gold mine, the largest gold producer in Malaysia.

**Myanmar:** There are two examples of mine rehabilitation and decommissioning cases: the Monywa Copper Mine owned by the Myanmar Government Mining Enterprise 1 and the Sabetaung Copper Mine. The latter involves the mine closure design on a seepage barrier to protect the aquifer from acidic water within the mine pit.

**Papua New Guinea:** PNG presents a case of Misima Gold Mine that operated during 1987 – 2004. The mine was jointly owned by Placer Dome (80%) and the state-own Orogen Minerals (20%). This is one of the successful cases on mine closure and rehabilitation.

**The Philippines:** The oldest and biggest producer of nickel ore in the Philippines, Rio Tuba Nickel Mining Corporation (RTNMC) has been operated since 1975 in Baangay Rio Tuba, Bataraza, Palawan. The mine was visited by participants of the kick-off meeting of the project held during 22-24 June 2018; and

**Thailand:** The country presents a total of six cases on mine rehabilitation and decommissioning, three cases (Ratchaburi, Chiang Mai and Nan provinces) have been carried out by the government offices and the other three include Padaeng Industry Public Company Limited, Mae Moh Coal Mine, Electricity Generating Authority of Thailand and Siam Cement Group (SCG).

Many people have involved in this book project since the beginning. Thanks to authors of the countries' manuscripts:

- Introduction:** **Dr. Dhiti Tulyatid**, CCOP Technical Secretariat.
- Indonesia:** **Mr. Didi Wiranata** and **Mr. Moehamad Awaludin**, Ministry of Energy and Mineral Resources of Indonesia.
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- Korea:** **Ms. Hayoung Noh**, **Dr. Joo Sung Ahn**, **Dr. Seong Yong Kim**, **Dr. Young Joo Lee**, Korea Institute of Geoscience & Mineral Resources (KIGAM); and **Dr. Tae-Heok Kim**, Mine Reclamation Corporation (MIRECO)
- Lao PDR:** **Mr. Vongthong Thimahaxay**, Department of Mines; and **Mr. Thanongsinh Huangvilay**, Department of Geology and Minerals, Ministry of Energy and Mines.
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- Thailand:** **Mr. Anont Nontaso**, Department of Mineral Resources, Ministry of Natural Resources and Environment; and **Mrs. Naiyana Kallappravith**, Department of Primary Industries and Mines, Ministry of Industry.

This book cannot be finished without the contributions of participants from Member Countries.

Their names have been listed below.

<b>Cambodia:</b>	Mr Yin Ratanak, Mr Sou Phires;
<b>Indonesia:</b>	Dr. Lana Saria, Mr. Didi Wiranata;
<b>Japan:</b>	Dr. Toshihiro Uchida;
<b>Korea:</b>	Dr. Chan Hee Lee, Dr. Young Joo Lee, Mr. Hee Soo Kim, Ms. Su Bin Choi;
<b>Lao PDR:</b>	Mr. Vongthong Thimahaxay & Mr. Inpong Homsombath;
<b>Malaysia:</b>	Mr. Hisamuddin Termidi, Dr. Shamsul Kamal Sulaiman, Mrs. Salmiah binti Nawi;
<b>Myanmar:</b>	Mr. Kyaw Zin Oo & Mr Ohn Lwin;
<b>Papua New Guinea:</b>	Mr. Seymour Pok, Samuel Himata, Mr. Gregory Palavo Valavue & Mr. Winterfold Irioehe Eko;
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<b>Thailand:</b>	Mr. Arnon Songsirikul, Mrs. Pet-hiang Subtavewung, Mr. Siripong Pornpipat, Mr. Sathaporn Kavinat, Mr. Anont Nontaso & Dr. Dhiti Tulyatid;
<b>Timor-Leste:</b>	Mr. Nelio Marcelo Marques, Mr. Victor Aleluia de Sousa Vicente;
<b>Vietnam:</b>	Dr. Trinh Minh Cuong & Dr. Quach Duc Tin;
<b>CCOP Technical Secretariat:</b>	Dr. Adichat Surinkum, Dr. Kamaludin Bin Hassan, Mr. Simplicio P. Caluyong, Ms. Piriya Boonsit & Ms. Thanitnunth Invakul.

## 2

**INDONESIA***Didi Wiranata and Moehamad Awaludin***2.1 Country Information****Figure 2.1** Map of Indonesia(Source: Badan Informasi Geospasial, <http://www.big.go.id/peta-nkri/>)

Indonesia, officially the Republic of Indonesia, is a unitary, transcontinental sovereign state located mainly in Southeast Asia, with some territories in Oceania. Situated between the Indian and Pacific oceans, Indonesia is the world's largest island country, with more than thirteen thousand islands. At 1,904,569 km<sup>2</sup> (735,358 sq.mi.), Indonesia is the world's 14<sup>th</sup> largest country in terms of land area and the 7<sup>th</sup> largest in terms of combined sea and land area. With over 261 million people, it is the world's 4<sup>th</sup> most populous country as well as the most populous Austronesian and Muslim-majority country. Java, the world's most populous island, contains more than half of the country's population.

Indonesia lies between latitudes 11°S and 6°N, and longitudes 95°E and 141°E. It is the largest archipelagic country in the world, extending 5,120 km (3,181 mi.) from east to west and 1,760 km (1,094 mi.) from north to south. According to a geospatial survey conducted between 2007 and 2010 by the National Mapping Agency, Indonesia has 13,466 islands, scattered over both sides of the equator, and with about 6,000 of them are inhabited. The largest islands are Java, Sumatra, Borneo (shared with Brunei and Malaysia), Sulawesi, and New Guinea (shared with Papua New Guinea). Indonesia shares land borders with Malaysia on Borneo, Papua New Guinea on the island of New Guinea, and East Timor on the island of Timor. Indonesia shares maritime borders across narrow straits with Singapore, Malaysia, Vietnam, the Philippines, and Palau to the north, and Australia to the south.

According to International Energy Agency (IEA), Indonesia was the 10<sup>th</sup> top natural gas producer in 2009: 76 billion cubic meters (bcm) 2.5% of world production of which 36 bcm was exported. In 2009, Indonesia was the 5<sup>th</sup> top coal producer: 263 million tonnes hard coal and 38 million tons brown. The majority of this, 230 Mt of hard coal, was exported.

## 2.2 Mining History

The current mining policies in Indonesia have evolved from the Dutch mining policies during the colonial era. There have been four periods of mining regulatory development in Indonesia: the Dutch colonial period; the Post-colonial period (1945-1966); the New Order period (1966-1998); and the reform and regional autonomy period (1998 – today).

During the colonial period, the Dutch had all mining rights. The policy was gradually relaxed due to pressures from the private sector to include the Netherlands Indies (present day Indonesia) and the increased needs of coal in the 1850s. As a response, the colonial government created a Special Committee for Mining in 1852, which later became the Colonial Mining Office (Dienst van het Mijnwezen). The main task of this organisation was to conduct geological exploration in several areas expected to have coal deposits. As a result, Ombilin mining, located in Sawahlunto, West Sumatera (1866) commenced operation in 1891. It is important to note that during this period, there had been some rejection in the Dutch Parliament of the involvement of the private sector in mining, which led to the direct involvement of the colonial government in this industry. In 1899, the Indische Mijnwet (Indies Mining Law) was introduced, to provide a basic classification of the minerals and authorities to govern the mining of minerals, including oil and gas. This law was amended twice, in 1904 and 1918, to further govern mining in the Dutch Indies areas. Similarly, in 1907, the colonial government introduced a set of operational regulations (Mijnordonnantie) targeting mining safety.



**Figure 2.2 A.** Coalmine Ombilin at Sawahlunto circa 1915

**B.** An entrance to the Ombilin coal mine in 1971

Source: [https://en.wikipedia.org/wiki/Ombilin\\_Coal\\_Mine](https://en.wikipedia.org/wiki/Ombilin_Coal_Mine)

The issuance of Government Regulation in Lieu of Law 37/1960 was one of the first regulations for minerals mining in Indonesia, replacing the Indies Mining Law of 1899. Similar to Law 44/1960, this law also provides that all mining resources at the surface and below the surface within Indonesian territory are ‘national wealth’ and are controlled by the state (Article 2 of the Law 37/1960).

In 1967, two laws were enacted: Law 1/1967 on Foreign Investment and Law 11/1967 on Basic Provisions of Mining, to allow foreign capital to enter the mining sector in Indonesia. The immediate result was the arrival of Freeport mining operations. The company began to invest in gold and copper mining in Papua and developed the first generation of Contracts of Work (CoW).



**Figure 2.3** Grasberg Open-Pit Mine, PT Freeport Indonesia  
Source: Inspection documentation, 2018.



**Figure 2.4** View of PT Freeport Indonesia  
Source: <https://ptfi.co.id/en/media/photo-gallery/kegiatan-operasi>

Law 11/1967 introduced the CoW scheme, under which mining investors and operators are defined as ‘contractors’ of the Indonesian Government. The CoW was defined as a contractual agreement between the Indonesian Government and foreign mining investors. It established rights and obligations such as taxes, royalty production and import duties, and employment of Indonesian nationals.

Law 4/2009 on Mineral and Coal Mining is the principal legislation that governs the mining sector in Indonesia, replacing its 1967 predecessor. Consequently, the 2009 mining law provides the framework for all of the country’s mining concessions and has brought about numerous changes to the previous mining regulatory regime of Indonesia. Most notably, this includes: the change of the Contract of Work regime (CoW/CCoW) to a licensing regime (Ijin Usaha Pertambangan or IUP), the designation of mining areas, recognition of the 100% foreign investment (with its divestment policy); a tender process; the utilisation of local content; as well as a ban on raw material exports and its value added policy.



**Figure 2.5** Coal Mining at PT Bukit Asam (Persero) Tbk site using Bucket Wheel Excavator. Source: <http://www.ptba.co.id>

### **2.3 Status of Minerals Industry**

Indonesia’s coal reserves at the end of 2015 reached 32.3 billion tons. The distribution of coal reserves is concentrated in three regions, East Kalimantan (43%), South Sumatra (38%) and South Kalimantan (11%). In the mineral mining sector, Papua has primary gold, copper and silver reserves amounted to almost 80% of total national reserves. Almost all tin reserves are located in Bangka Belitung. The island of Kalimantan holds many iron and bauxite reserves in West Kalimantan. In 2015 about 90% of coal production activities are concentrated on the island of Kalimantan because coal infrastructure is mostly found on the island of Kalimantan.

Chart 17. Coal production in 2011-2015

**Figure 2.6** Coal production in 2011-2015.

Source: Mineral &amp; Coal in 2011-2015, Directorate General of Mineral and Coal

Table 29. Volume of main minerals production in 2011-2015

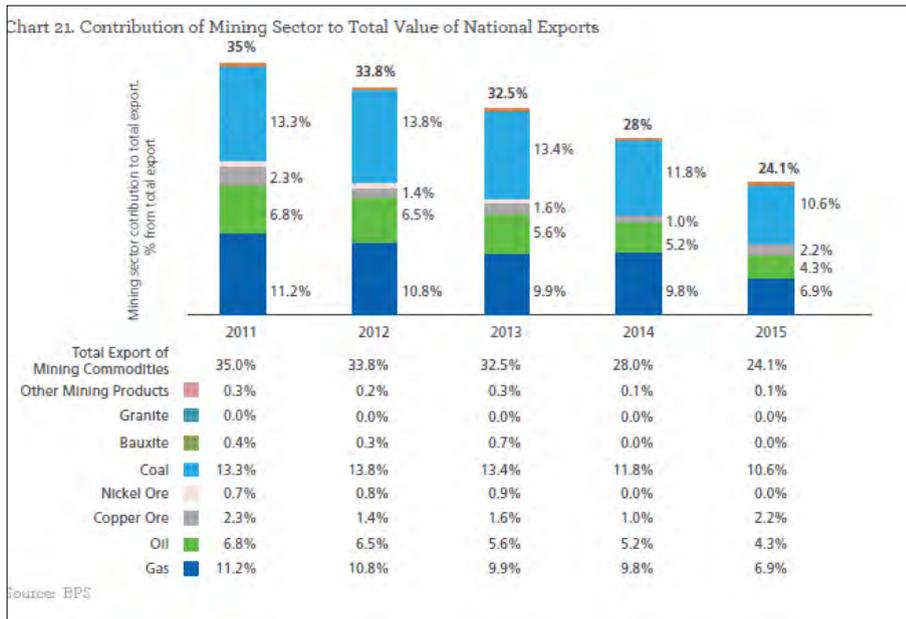
Main minerals	Unit	2011	2012	2013	2014	2015
Copper	Ton	543,942	410,228	521,025	617,840	197,634
Gold	Ton	76	53	57	69	97
Silver	Ton	200	203	208	252	318
Tin	Ton	31,169	130,809	82,954	60,038	70,073
Nickel Matte	Ton	68,000	72,899	78,074	80,341	82,440

Source: Mineral &amp; Coal in Figures 2011-2016, DG Minerals and Coals

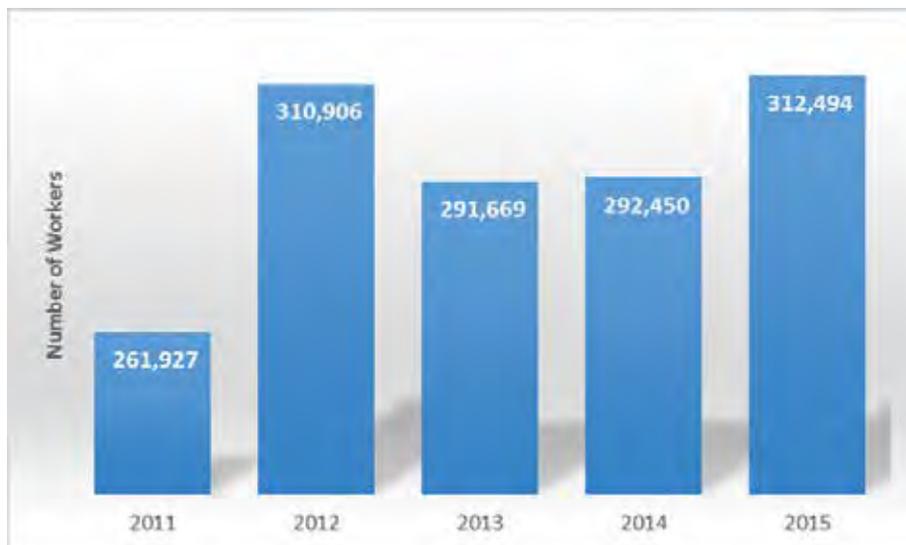
**Figure 2.7** Volume of main minerals production in 2011-2015.

Source: Mineral &amp; Coal in 2011-2015, Directorate General of Mineral and Coal

The contribution of mining export to total national export value is significant, ranging from 24% -35%. The export value is dominated by export value from oil, gas and coal. In 2011-2015, coal export reaches 10-13% of the total value of national export. Data from Directorate General of Mineral and Coal presents the number of workers in the mining sectors, which is around 312.494 people in 2015.



**Figure 2.8** Contribution of Mining Sector to Total Value of National Exports.  
Source: BPS



**Figure 2.9** Number of Workers in the Mining Sector in 2011-2015.  
Source: Indonesian Mining Outlook 2018, Directorate General of Mineral and Coal

In Central Government Financial Report (LKPP) 2015, state revenues from oil and gas and mineral and coal sectors contributed Rp224.24 trillion or 15% of total state revenues, consisting of oil and gas revenues of Rp161.76 trillion (11%) and revenues from mineral and coal sector amounting to Rp62.48 trillion (4%). The revenue decreased from the previous year, which contributed 27% of total state revenues, consisting of oil and gas revenues of Rp341.25 trillion (22%) and revenues from mineral and coal sector amounting to Rp69.97 trillion (5%).

State Revenue 2014 and 2015 from Mineral and Coal Sector

Type of Revenue	2014	2015
	(in Trillion Rupiah)	(in Trillion Rupiah)
<b>TAX REVENUE</b>		
Mining Income Tax	34	32
Other Tax	-	-
<b>NON-TAX REVENUE</b>		
Royalty	18	16
Land Rent	-	-
Sales Revenue Share	16	11
<b>TOTAL MINING REVENUES</b>	<b>69</b>	<b>62</b>
<b>TOTAL STATE REVENUES</b>	<b>1,550</b>	<b>1,508</b>
<b>Revenue Ratio</b>	<b>4%</b>	<b>4%</b>

(\*) Consist from Corporate Income Tax of coal and lignite mining, metal ore mining, mining and other excavation along with mining-services.

Source: LKPP 2015

**Figure 2.10** State Revenue 2014 and 2015 from Mineral and Coal Sector.  
Source: LKPP 2015

## 2.4 Best Practices of Mine Rehabilitation and Decommisioning

### 2.4.1 PT Kelian Equatorial Mining

#### Company Information

PT Kelian Equatorial Mining (PT KEM) is a mining company registered under Indonesian law. PT KEM is 90% owned by Anglo-Australian mining company Rio Tinto (the biggest mining company in the world) and the rest 10% by PT Harita Jayaraya Inc, which is an Indonesian company. PT KEM signed a Contract of Work with the Indonesian government in 1985 for a 286,233.5 hectare concession. This agreement allows PT KEM to explore for and mine gold in the Kelian area of Kutai district in East Kalimantan province. The primary gold ore deposits are on the slopes of Prampus Barat and Prampus Timur. The mineable ore is estimated at 53.5 million tons with a gold content of approximately 1.97 g/t.



**Table 2.1** Timeline History of PT KEM

YEAR	ACTIVITIES
1976	Rio Tinto found Kelian's deposit
1985	Contract of Works signed in Jakarta
1990	Constuction of process plant commences
1992	Process plant commences production
1994	Knelson concentrator trial started
1997	Construction of Nakan Waste Rock Dam Completed
1998	Mine closure statement
2000	- stockpile 24 dug off, finished feeding to crushers - stockpile 5 opened for feeding to crushers
2001	Mine Closure Steering Committee is formed
2002	- October, mine closure socialization to local community - December, Society Development Program transferred to Yayasan Anum Lio
2003	- Highest monthly level of gold production recorded - Nakan Waste Rock Dam structure strengthening is started
2004	Production of gold ceased on May
2005	Environmental rehabilitation continues, monitoring of dams to continue indefinitely

## 2.4.2 Best Practices of Mine Rehabilitation and Decommisioning

### Land Rehabilitation

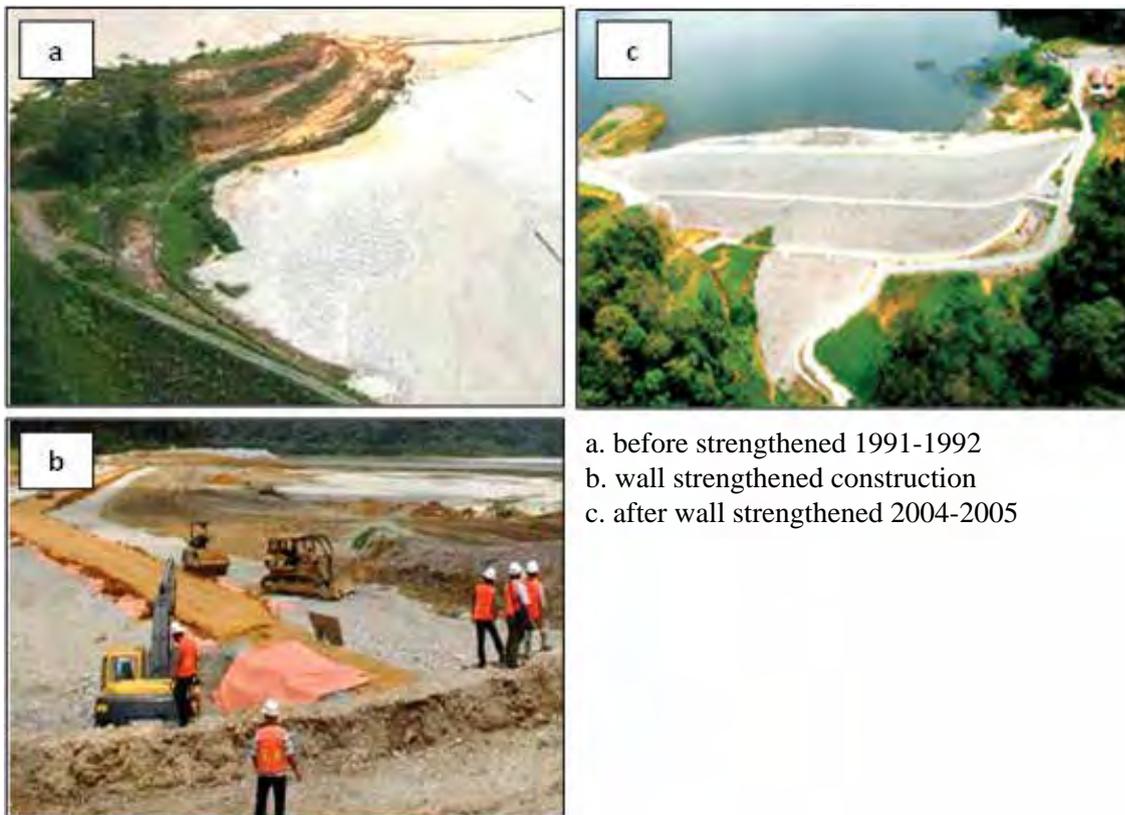
- Mine area is 1,192.20 hectares or 17.66% from total lease area (6,750 hectares)
- Areas that can not be rehabilitated due to flooding are replaced on replacement land.
- Rehabilitation activities conducted from 1992 up to now have reached 92% (1,095.53 hectares) of 1,192.20 hectares. Covers: Rehabilitation on the replacement area in Soeharto Hill (450 Ha), rehabilitation on the replacement area in Dataran Tinggi Lingau (398.32 Ha) and Spillway Nakan rehabilitation (21.30 Ha).



**Figure 2.13** PT KEM Area Rehabilitation Activities.

### **Wall Strengthening Tailing Dam Namuk**

- The Dam Tailing Namuk wall is strengthened to meet the ICOLD (International Commission for controlling large-scale dam construction worldwide), minimum safety factor 1.5.
- Creating emergency spillway – for Probable Maximum Flood capacity (PMF).
- Wall strengthened build from 2004 to 2005.
- In mid-2005, thw water level was raised to cover the tailing.
- Conduct wastewater monitoring and management to comply the regulation.
- Water biota monitoring.



**Figure 2.14** Namuk Tailing Dam wall strengthened.

### **Alluvial Sterilization**

- PT KEM starting alluvial sterilization in 2006. Sterilized areas are former processing plant, accommodation, office and warehouse.
- Local community around the company is involved.
  - Verification Team – supervising wetland area no longer contained gold, safe environment and informed to the local people,
  - The Grade Control Team – to identified location that contain gold, and
  - The Contact Team – to associate if there is a problem.
- Sterilization is done until all parties believe there is no more gold in the company's location so that environmental conservation and forest protection are more secure.
- Alluvial process end in July 2007

## Wetland construction

- Wetland is an aerobic water treatment method, which reduces dissolved metals in water such as Manganese (Mn) and Zinc (Zn) before being flowed to rinsing pond.
- Wetland area is about 20 hectares. Wetland trials begin since September 2005. The result is that the dissolved metal reduce until 90%.
- Biofiltration trial area near Namuk are planted with four species of local aquatic plants that are able to live in wet area (*Cyperus Sp B*, *Typha Orientalis*, *Sceleria Sumatrensis*, *Rhynchospea corymbose*) and three others species that can live in intermittent area like *Eleocharis Variegata*, *Scirpus Juncoides*, and *Cyperus Digitatus*.



Figure 2.15 Wetland trial with four species of local aquatic plants.

- Wetland construction in July 2007.
- Cell A and Cell C planted with local water plants since 2007.
- Down rinse pond and culvert construction is done. Water from the rinse pond has been streamed into ke Kelian River.

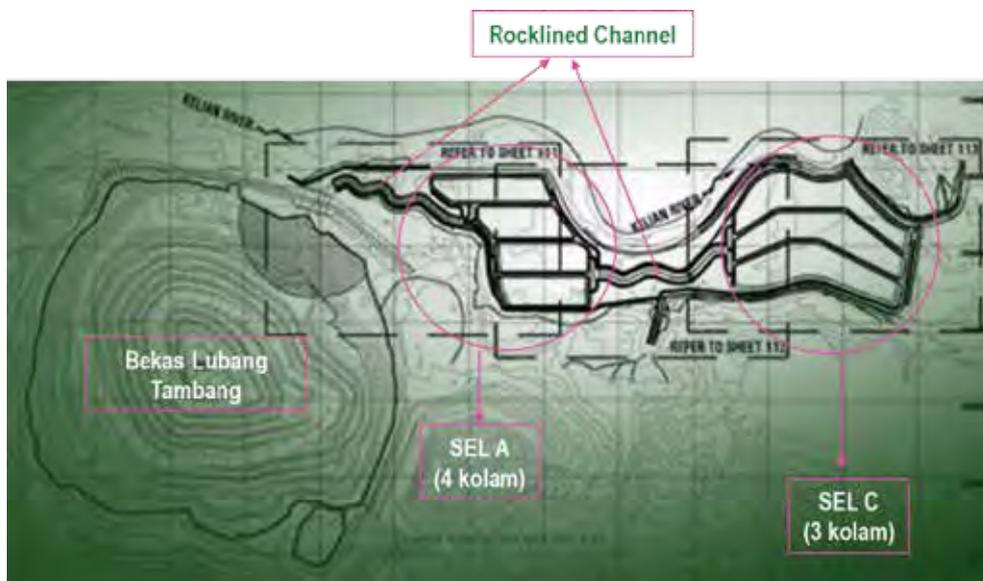


Figure 2.16 PT KEM Wetland Design.



**Figure 2.17** PT KEM wetland construction.

### **Social Development**

- Since 2003, PT KEM social development is delivered to Rio Rinto Foundation which known as YAL Local Foundation.
- YAL foundation role in improving West Kutai quality of life through agricultural, health and cultural programs.
- YAL foundation established Agricultural Vocational High School (SMKP) Ave Bungen Tana.
- The government strongly approved and supports PT KEM's proposal to utilize the partnership fund "OUR FOREST IS OUR FUTURE" to rising SMKP.
- SMKP is a long term need to improve human resources capacity and create food security in West Kutai.
- Student receive full scholarship and partial shcolarship. In school year 2007-2008 SMKP received 35 students from 28 villages around PT KEM.



**Figure 2.18** Agricultural Vocational High School (SMKP) Ave Bungen Tana.

### 2.5.1 Petangis Mine (PT BHP Kendilo Coal)

#### Company Information

Exploration of the Petangis site commenced in 1979 and mine operations in 1993. The average production was one million tons per year. The coal reserve was spread over seven pits, the total area of the mine covering 613 hectares. During the operation period, the mine employed 700 local people living in the surrounding area.

The coal processing begins with crushing and then washing in order to produce coal compliant with the market. The clean coal is transported and stockpiled at the port and then loaded on to a barge for transportation to a ship loading port. In some cases, the barges load to a ship via an offshore trans-shipment facility.



Figure 2.19 Location of Petangis Mine (PT BHP Kendilo Coal).

#### Best Practices of Mine Rehabilitation and Decommisioning

The Petangis mine is the first Coal Contract of Work (CCoW) mine closure in the Indonesian coal industry. By commencing planning well ahead of closure and progressively rehabilitating the site during its operational period, rehabilitation was completed in record time for Indonesia.

During the life of mine, each area is re-vegetated on the conclusion of mining operations. Even though mining operations concluded in 2002, the company remained at the Petangis site until 2005. During this period the sole activity was re-vegetation. Thus, in some parts of the mine, trees have been growing for nearly as long as the duration of the mine. In fact the youngest trees are already two to three years old.

**Table 2.2** Petangis mine closure process

YEAR	MINE CLOSURE ACTIVITIES
1993	Start to mining (production phase)
1995	Start to reclamation of disturbed areas from mining activities
1998	Start to intensive consultation and stakeholder involvement in designing closure plan
2002	- Receive mine closure plan approval - Mining activities complete
2004	Reclamation, maintenance and monitoring complete
2005	- Receive approval of results of mine closure plan implementation - Asset hand over to government
2006	Return “Pinjam Pakai” to Forestry Minister – receive approval



**Figure 2.20** Petangis Mine – the basic method of rehabilitation.

Learning from Petangis Mine Closure process:

- Intensive consultation and involvement of stakeholders in process of closure and designing final land use has given significant contribution in the process of land relinquishment process.
- 5 years stakeholders involvement before mining operation ceased has triggered the local government and community to define and develop the area to optimize the benefit of the ex-mining area and its infrastructures
- Who are involved in Petangis mine closure: the locals, NGOs, district and provincial governments, central government (Ministry of Energy and Mineral Resources, Ministry of Forestry, etc.), contractors and consultants including independent consultants.
- A feature of closure plan was to focus on working with local stakeholders to develop opportunities that provide additional benefits to the local community.
- The team has cooperated with the local government in which ownership of the land rest, to transform the ex-mined area into forestry use, including water tourism, forestry study and research, deer farming and aqua culture.



Figure 2.21 Ex- Petangis Mine area– Forestry study and Research (Tahura) Lati Petangis.



Figure 2.22 Ex- Petangis Mine – Deer Farming.



**Figure 2.23** Ex- Petangis Mine – Water Tourism and Aqua Culture.

## 3

## JAPAN

Toshihiro Uchida

## 3.1 Country Information

The country of Japan consists of 6,852 islands, among which the four largest islands are Hokkaido, Honshu, Shikoku and Kyushu from north to south (Figure 3.1). The land area is approximately 378,000 km<sup>2</sup>, of which 73% is mountainous and 66% is forested. The area of the territorial water is about 430,000 km<sup>2</sup>. The population of Japan is approximately 127 million, but it is gradually decreasing since around 2010. Most of the large cities are located on rather flat plains near the coastlines.

Japan is situated on a tectonically active region where four tectonic plates, namely Eurasia Plate, North America Plate, Pacific Plate and Philippine Sea Plate, meet. The geology of the Japanese Archipelago is relatively young - a 240 million-year-old formation in central Honshu Island is known to be the oldest - and very complicated. Active faults distributed all over Japan cut geological formations into blocks. Lava and ash from volcanoes cover up the rocks below.

This complicated geological setting makes Japan subject to numerous natural disasters. Felt earthquakes, some of them are devastating, occur anywhere and almost every day. There are 111 active volcanoes, several of which erupt frequently. Dormant volcanoes sometimes suddenly erupt without any warning. However, this geological setting also provides the country with many benefits, including mineral resources, oil and gas, and geothermal energy.

The mineral and energy resources produced in the county played a big role in modernization and industrialization of Japan in the 19<sup>th</sup> and 20<sup>th</sup> centuries. However, most of these mines have been depleted or closed due to the higher cost compared to overseas materials by the end of the 20<sup>th</sup> century. Today Japan imports the majority of mineral and energy resources as well as many agricultural and fishery products to meet the demands from the industry and the people in Japan.



**Figure 3.1:** The four main islands of Japan. Red dots are major mines mentioned in this report.

## **3.2 Mining History**

The geological setting of the Japanese Archipelago has generated various types of mineral deposits, both metallic and non-metallic, by sedimentation, metamorphism and volcanic activities. Although the size of each deposit is generally not very large, metallic minerals including gold, silver, copper, iron, lead and zinc had been actively mined in Japan until a few decades ago. On the other hand, a few types of non-metallic minerals such as limestone are still being intensively produced.

Utilization of mineral resources such as bronze and iron tools started at the dawn of Japanese civilization several centuries before Christ. The technology for utilizing metallic materials was brought by the people migrated from the continent to Japan. An example of intensive usage of metals for a single artificial structure recorded in the history is the “Great Buddha of Nara” at Todaiji Temple, Nara Prefecture, central Honshu. The 15.8 m tall Buddha, the biggest bronze statue in the world, was constructed in AD 752 using 499 tons of copper, 8.5 tons of tin, 2.5 tons of mercury and 440 kg of gold. The copper is estimated to be brought mainly from western Honshu, while most of the gold from Tohoku District, northern Honshu. Though the original basement remains, most of the other parts were repeatedly destroyed by earthquakes or fires and restored later.

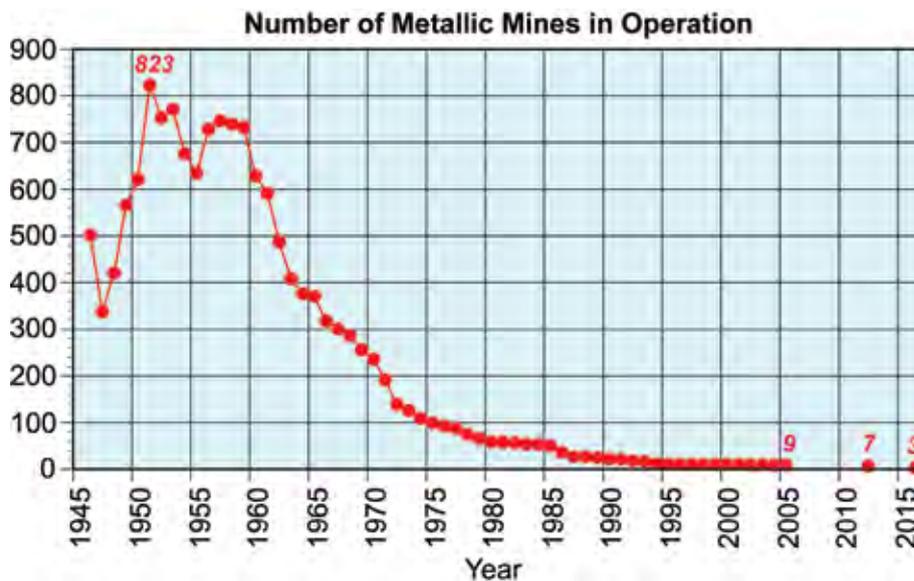
Another example of intensive usage of gold is Konjiki-do (Golden Hall) constructed in AD 1124 in Chusonji Temple, Iwate Prefecture, northern Honshu. About 150 kg of gold and 70 kg of silver were used for a group of Buddha statues in Konjiki-do. Marco Polo (1254-1324), an Italian merchant who travelled to China, left a message for his book “The Travels of Marco Polo” that Japan was an intensive producer of gold.

The Edo shogunate promoted the development of gold and silver mines. The Sado gold mine (central Japan) started its production at the beginning of the 17<sup>th</sup> Century when Edo Era started. Gold from the Sado mine was used to support the currency system of the Edo shogunate. Japan became one of the largest gold producers in the world in the 17<sup>th</sup> Century (Izawa and Nakanishi, 2014).

Two large copper mines, Ashio (central Honshu) and Besshi (Shikoku), were also discovered in the 17<sup>th</sup> Century in Edo Era. Japan was the largest producer of copper in the world during the Edo Era. Copper was mainly exported to the Netherlands and China (Japan Oil, Gas and Minerals National Corporation [JOGMEC], 2005).

When the Meiji Era started in 1868, the government further promoted the development of natural resources in order to accelerate industrialization. Coal (Kyushu and Hokkaido), iron (Kamaishi Mine, northern Honshu), copper (Ashio, Besshi, and Hitachi Mines in central Honshu) and lead/zinc (Kamioka Mine in central Honshu) had been actively produced since then until World War II (1939-1945).

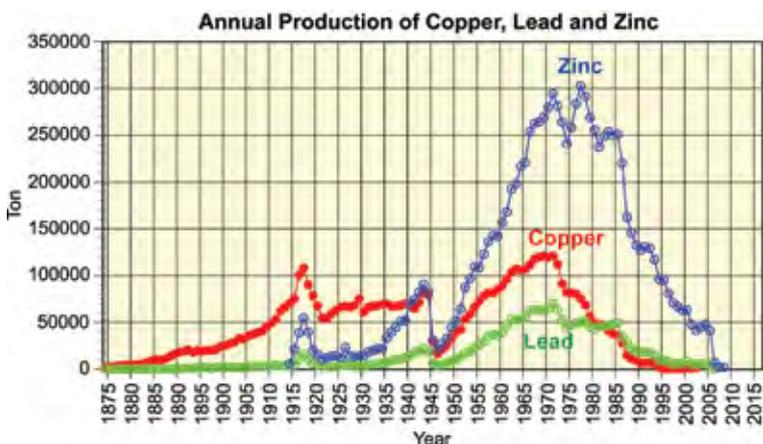
After World War II, as the Japanese industry was gradually recovered, the production of mineral resources had grown rapidly in the 1950s and 1960s as the primary industrial materials. However, the production of copper dropped sharply in the 1970s, followed by the decline in that of silver, lead and zinc in 1980s mostly due to the weak cost-competitiveness against imported minerals. Many mines had been gradually closed: in 1994 the last major copper mines in the Hokuroku Area (northern Honshu) were closed, and the major lead-zinc mine (Toyoha Mine, Hokkaido) was closed at last in 2006. Since then, Hishikari Mine (Kyushu), which started the production of gold and silver in 1985, is the only metallic mine currently operating at large-scale in Japan (Figures 3.2-3.4).



**Figure 3.2:** Number of operating metallic mines in Japan after World War II (data source: Ministry of Economy, Trade and Industry [METI] (2017a, 2017b)).



**Figure 3.3:** Annual production of gold and silver in Japan since 1874. The data until 1924 are from the Ministry of International Trade and Industry [MITI] (1963, 1964) and those in 1925 and after are from METI (2017a). Hishikari Mine is the only major mine currently producing gold and silver.



**Figure 3.4:** Annual production of copper, lead and zinc in Japan since 1874. The data until 1924 are from MITI (1963, 1964) and those in 1925 and after are from METI (2017a). The production of zinc finished in 2008.

### 3.3 Current Status of Mining Industry

#### 3.3.1 General

There are several major Japanese metal mining companies that are active internationally. Their major businesses include development and operation of metallic mines in foreign countries and the smelting of mineral ores imported from overseas or metallic materials brought from cities as recycle wastes. There are 17 non-steel smelters in Japan and they have a capacity in total of smelting 1,885 k-ton of copper, 397 k-ton of lead, and 655 k-ton of zinc annually (source: METI).

The current status of operating metallic and non-metallic mines in Japan is shown in Table 3.1. Japan can produce limestone 100% domestically for the industrial demand. Except it, the economic contribution of the mineral production from domestic mines to the whole industry is not significant in Japan today.

On the other hand, the production of metals utilizing imported ores or recycled metallic materials has been steady. Table 3.2 shows the production of several metals in 2016 from smelters and recycling facilities in Japan.

**Table 3.1:** Number of operating metallic and non-metallic mines, their employment and annual production in 2012 and 2016 (data source: METI (2017b)).

	2012			2016		
	NO. OF MINES	EMPLOYMENT (PERSONS)	MINERAL PRODUCTION n (BJPY)	NO. OF MINES	EMPLOYMENT (PERSONS)	MINERAL PRODUCTION n (BJPY)
<b>METALLIC</b>	7	203	26.7	3	204	35.7
<b>NON-METALLIC</b>	1,270	11,521	249.2	1,276	12,669	333.9

**Table 3.2:** Production of major metals from domestic ores, imported ores and recycled wastes in Japan in 2016 (data source: METI (2017a) and JOGMEC (2018)).

	<b>GOLD (TON)</b>	<b>COPPER (K-TON)</b>	<b>LEAD (K-TON)</b>	<b>ZINC (K-TON)</b>
Smelted metal from domestic ores	6.5	0	0.0	0
Smelted metal from imported ores	69.6	1,259	84.7	439
Reprocessed metal from recycled metallic materials	55.0	29.4	155.2	117

### 3.3.2 Environmental Issues and Counter Activities

As far as it is known, there used to be 5,000 mines in Japan, almost all of which have already been closed. Approximately 450 closed mines are said to require some environmental counter measures (JOGMEC, 2013).

There are three laws primarily related to the rehabilitation of closed mineral mines: the Water Pollution Prevention Act enacted in 1971, the Act on Special Measures for Pollution Caused by the Metal Mining Industry, etc. (“Mine Pollution Prevention Act” in short hereafter) enacted in 1973, and the Basic Environment Law enacted in 1993.

The Water Pollution Prevention Act defines the effluent standards for the drainage discharged from industrial factories including mineral mines to surface water or groundwater. The allowed concentration of harmful substances and items for living environment in the drainage are shown in Table 3.3. The Basic Environment Law defines the environmental quality standards that local governmental authorities must observe in the quality control of water for living usage (Table 3.4).

**Table 3.3:** Examples of the standards of harmful substances and items relating to living environment defined by the Water Pollution Prevention Act.

POLLUTANTS	STANDARDS IN EFFLUENTS (DRAINAGE)
Cadmium and cadmium compounds	< 0.03 mg/l
Cyanogen compounds	< 1 mg/l
Lead and lead compounds	< 0.1 mg/l
Hexavalent chromium compounds	< 0.5 mg/l
Arsenic and arsenic compounds	< 0.1 mg/l
Total mercury	< 0.005 mg/l
Alkyl mercury compounds	must not be detected
Copper	< 3 mg/l
Zinc	< 2 mg/l
Soluble iron	< 10 mg/l
Soluble manganese	< 10 mg/l
Total chromium	< 2 mg/l
pH	5.8 – 8.6

**Table 3.4:** Examples of the standards of items relating to the health in the environment defined by the Basic Environment Law.

POLLUTANTS	STANDARDS IN ENVIRONMENT
Cadmium	< 0.03 mg/l
Total cyanogen	must not be detected
Lead	< 0.01 mg/l
Hexavalent chromium	< 0.05 mg/l
Arsenic	< 0.01 mg/l
Total mercury	< 0.0050 mg/l
Alkyl mercury	must not be detected

Based on the enactment of the Mine Pollution Prevention Act, the Ministry of Economy, Trade and Industry (METI) started a 10-year-term mine pollution prevention program in 1973 in order to promote the rehabilitation works of the 450 closed mines that had pollution problems. About 40% of them do not have responsible owners. In such cases, the local government has to take over the rehabilitation. METI provides financial supports to the local governments had to take over the rehabilitation works. METI provides a subsidy of 75% of the total expenses for the rehabilitation works at a closed mine to the local government or the private company. However, the subsidy to the company can be applied only to the pollution problems for which the company can be applied only to the pollution problems for which the company is not responsible: e.g., pollutions caused by natural origins. The number of mines for which METI has provided subsidies in the 10-year-term program is shown in Table 3.5. The program is now at the 5<sup>th</sup> term (2013-2022) (Figure 3.5).

The company of a currently operating mine (only three mines now) has to pay a pre-defined amount of the Reverse Fund for Preventive Operation of Pollution to JOGMEC every year in order to secure the fund for conducting the pollution prevention works after the closure of the mine in the future. The paid amount is tax-deductible for the company. JOGMEC is responsible for managing the Fund.

**Table 3.5:** The number of closed mines for which the Japanese government planned to provide financial supports in the 10-year term program for the rehabilitation works to remove pollution sources and for the treatment of mine drainage.

TERM	1	2	3	4	5
YEAR	1973-1982	1983-1992	1993-2002	2003-2012	2013-2022
Remove pollution sources (no responsible owner / local government)	180	93	86	32	20
Remove pollution sources (company)	255	39	30	19	28
Mine drainage treatment (no responsible owner / local government)			24	24	24
Mine drainage treatment (company)			56	56	55



**Figure 3.5:** Closed mines where the rehabilitation and drainage treatment are being carried out under the METI's rehabilitation project in 2013-2022 (reproduced from JOGMEC (2013)). A pink dot indicates a mine that has a responsible owner (61 mines), while a cyan dot is a mine for which a responsible owner does not exist now (36 mines).

### 3.4. Rehabilitation of Matsuo Mine, Northern Japan\*

\*Most figures in this chapter refer to Iwate Prefectural Government and JOGMEC (2014) unless otherwise mentioned in the captions.

#### 3.4.1 Brief of Matsuo Mine

The Matsuo Mine is located on an eastern flank of Hachimantai Volcano, Iwate Prefecture, northern Japan (Figure 3.6). The main commodities were sulfur and iron sulfides. The operation of the mine started in 1914 and ended in 1971. The size of the deposits was approximately 1,500 m in north-south and 1,500 m in east-west. The thickness of the deposits varied from 25 m to 150 m. The total estimated reserve of the ores was 230 million tons. Elevation of the mine area is 870 - 1,048 m above sea level. The main mining operation started in underground galleries and the open-pit operation was added later.

The total production during the operation of 58 years was approximately 29 million tons of ores (sulfur and iron sulfides), 2.1 million tons of sulfur, and 10 million tons of materials for sulfuric acid. The mine achieved the maximum annual production in 1952: approximately 1 million tons of ores and 80,000 tons of sulfur, which accounted for about 30% of the domestic sulfur production at that time. A town was built specially for the mining operation. The town called a “paradise above the clouds” had the maximum population of 15,000 in its golden time (Figures 3.7-3.9). However, it was totally abandoned after the closure of the mine.



**Figure 3.6:** Location of Matsuo Mine (modified from Iwate Prefectural Government and JOGMEC (2014)).



**Figure 3.7** A view of the Matsuo Mine Town during the golden time of the mining operation.



**Figure 3.8** Products and supplies were transported by cableways.



**Figure 3.9:** Sulfur smelter in the mine.

### 3.4.2 Pollution by Acid Mine Drainage

The total length of the underground galleries was about 255 km. The deepest gallery was 3ML and top one was 248ML; their elevation difference was 284 m (Figures 3.10 and 3.11). The open pit operation was carried out to the level range from 270ML to 130ML later.

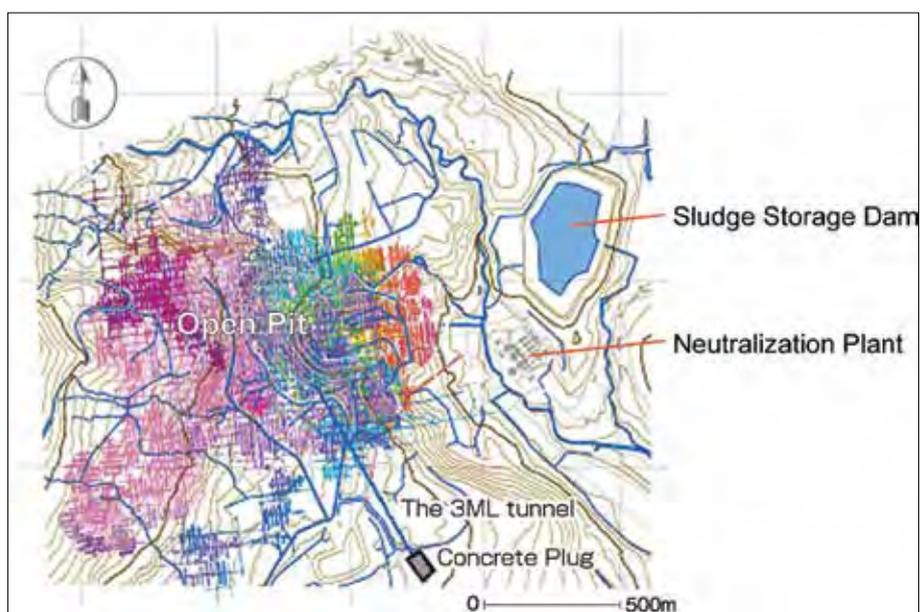
This large network of underground galleries allowed rain water to infiltrate into the underground easily. The water dissolved iron sulfides in the deposits and a large volume of highly acidic water containing iron sulfate was generated.

At first, the acidic water flowed out from the 3M-level gallery to the local Akagawa River. After the 3M-level gallery was plugged in 1970, it began to flow out from the 100M-level gallery to the river, then from the 112M-level gallery after the collapse of the galleries in 1972 (Figure 3.11).

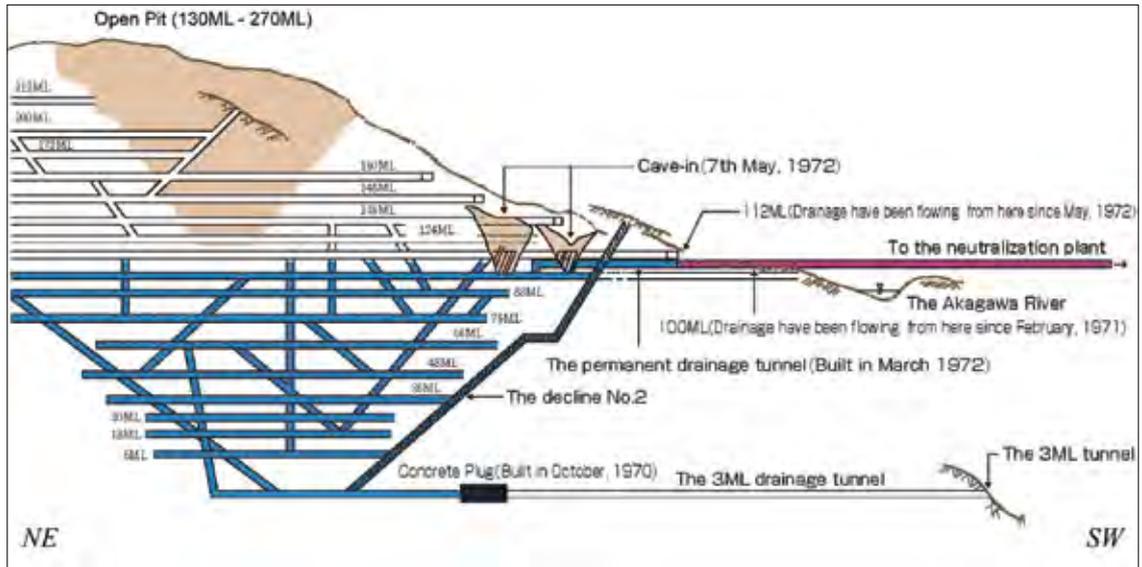
After the closure of the mine, the mining company went bankrupt and the Matsuo Mine continuously drained a large quantity of highly acidic water (pH=2). The water flowed into Akagawa River polluted the main river (Kitakami River) downstream (Figures 3.6 and 3.12).

Responding to the request from the local government (Iwate Prefecture) to support the mitigation of the pollution of the Kitakami River in 1971, the central government decided to build a neutralization plant of the acid mine drainage (AMD) in 1976, and started the construction of the neutralization plant (a budget of 6.2 B JPY) and a new sludge storage dam (3.1 B JPY) in 1977. The neutralization plant and the sludge storage dam started the operation in 1981, and the facilities have been operating almost without stopping until present. The water quality of Kitakami River has improved to the level at a time before the mine started its operation in 1914 (Figures 3.13 and 3.14). Varieties of fish came back and the water is now used for agriculture, industry and living in the area.

In 1982, Japan Oil, Gas and Minerals National Corporation (JOGMEC) started the maintenance of the plant under the contract with Iwate Prefecture with a budget of approximately 500 M JPY per year.



**Figure 3.10** A plan view of the open pits and underground galleries (modified from Iwate Prefectural Government and JOGMEC (2014)).



**Figure 3.11** General cross-section of the Matsuo Mine. Galleries shown in blue are filled with groundwater.



**Figure 3.12** Matsukawa River (left: downstream of Akagawa River) was significantly polluted by AMD in 1974. The right is the main stream of Kitakami River. This location is shown as “photo point” in Figure 3.6.



**Figure 3.13** Water quality of Matsukawa River (left) has significantly improved after the neutralization plant started its operation (photo in 2010). The same location as that of Figure 3.12.



**Figure 3.14** Kitakami River in Morioka City, the capital of Iwate Prefecture (photo in 2009).

This location is about 15 km downstream of that of Figures 3.12 and 3.13.

### 3.4.3 AMD Neutralization Plant

The Japanese Water Pollution Prevention Act defines the pH of water drainage discharged from industrial facilities to be between 5.8 and 8.6 (Table 3.3). Because the water of Akagawa River was originally acidic even before the mining operation, the government set a target value of pH as greater than 4 at the outflow from the AMD neutralization facility to Akagawa River. They expected the pH of the water would increase to the level required by the Act when the river meets the main Kitakami River.

The neutralization facility utilizes iron oxidizing bacteria to change ferrous iron ( $\text{Fe}^{2+}$ ) to ferric iron ( $\text{Fe}^{3+}$ ) and uses calcium carbonate ( $\text{CaCO}_3$ ) to neutralize the acidic water. Harmful iron and arsenic compounds precipitate in the process and are removed from the polluted water.

Considering the total volume of approximately  $9 \text{ M m}^3$  AMD water flowing out from the mine per year, the neutralization facility was designed to operate continuously treating the AMD water with the maximum flow rate of  $36 \text{ m}^3/\text{min}$  throughout a year.

The AMD water in the mine is drained from the 100ML gallery to the neutralization facility through the Permanent Drainage Tunnel. The water is sent to the Oxidation Tank, where iron oxidizing bacteria is used, the Bacteria Recovering Tank, the Neutralization Tank, where  $\text{CaCO}_3$  is added, and then the Solid-Liquid Separation Tank. The neutralized sludge precipitated in the Solid-Liquid Separation Tank is sent to the Sludge Storage Dam and the clarified supernatant water of the tank is discharged into the Akagawa River (Figures 3.15 - 3.23).



**Figure 3.15** A view of the construction work of the AMD neutralization plant in 1979 (photo courtesy of Iwate Prefecture).



**Figure 3.16** The AMD neutralization plant after completion in 2005 (photo courtesy of JOGMEC). This view angle is similar to the one in Figure 3.7.

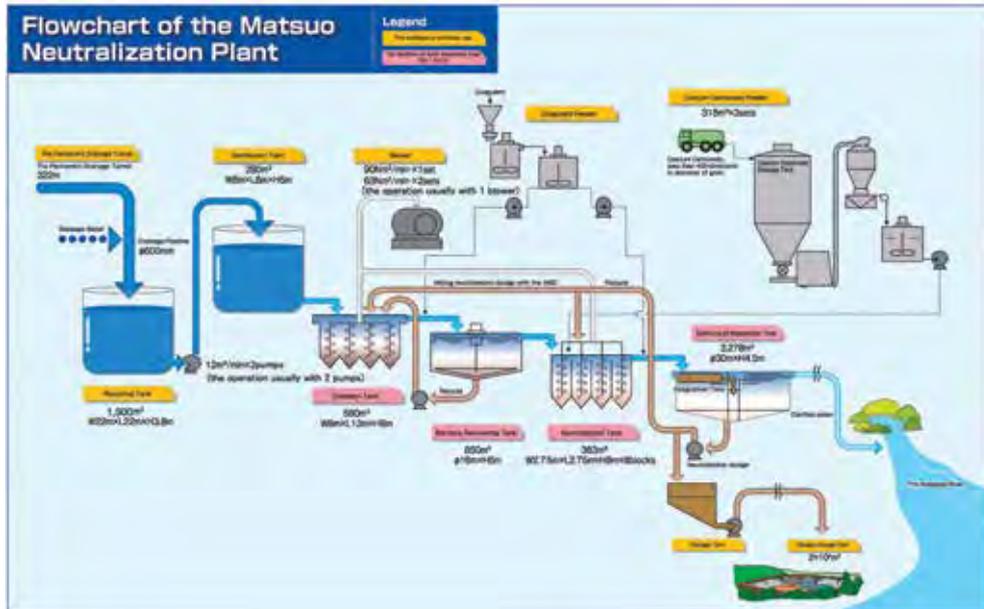


Figure 3.17 A schematic flowchart of the AMD water treatment.



Figure 3.18 The Permanent Drainage Tunnel completed in 1984. The total length of the tunnel is 322 m and the inner diameter of the hard vinyl chloride pipe is 600 mm.



**Figure 3.19** Oxidization Tank.

Iron oxidizing bacteria change ferrous iron ( $\text{Fe}^{2+}$ ) in the AMD water to ferric iron ( $\text{Fe}^{3+}$ ).



**Figure 3.20** Bacteria Recovery Tank.

The bacteria absorbed in iron sludge is returned to the Oxidization Tank and the water is sent to the neutralization tank.



**Figure 3.21** Neutralization Tank. Calcium carbonate ( $\text{CaCO}_3$ ) slurry is added to neutralize the acidic water and iron sludge is then precipitated.



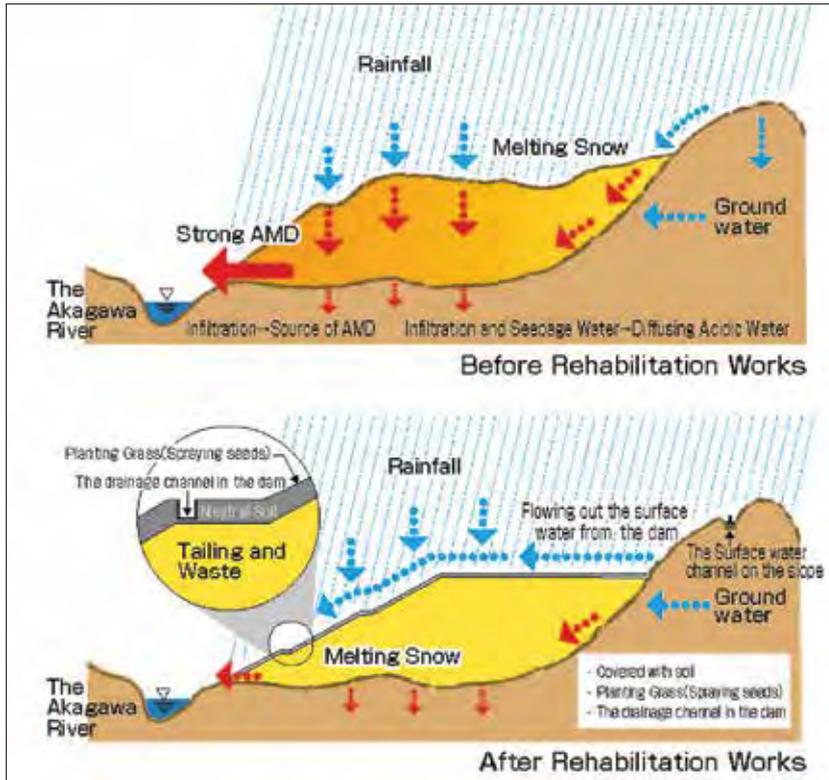
**Figure 3.22** Solid-Liquid Separation Tank. Coagulant is added to accelerate the settlement of neutralized sludge. The clarified supernatant water is discharged to the river.



**Figure 3.23** Sludge Storage Dam. Its capacity is 2 million  $\text{m}^3$  and the accumulating rate is approximately 20,000  $\text{m}^3$ /year.

### 3.4.4 Rehabilitation Works against the Sources of AMD

In addition to the neutralization of the AMD water, curbing the generation of the AMD in the mine is also important. The rehabilitation measures applied include the following (Figure 3.24): 1) Reclamation of the open pit and covering it by soil and planting, 2) Reclamation of tailing and waste dams and covering them by soil and planting, and 3) Construction of surface water channels on the hillside to avoid the water flowing into the mine area.



**Figure 3.24** A schematic diagram of rehabilitation works for reducing the generation of AMD.



**Figure 3.25** Open pit mine during the production period (photo courtesy of Iwate Prefecture).



**Figure 3.26** Rehabilitation work by planting trees in 2016 (photo courtesy of Iwate Prefecture).



**Figure 3.27** The open pit after the rehabilitation work (photo in 2009).

### 3.4.5 Monitoring of AMD and Treated Water

The annual total volume of the treated AMD water has been almost constant, between 8 and 10 M tonnes, since the facility started its operation in 1982 (Figure 3.28). A good correlation is observed between the amount of the treated water and rainfall. The pH of the AMD water, 1.93 in 1982, has been gradually increasing and is 2.31 in 2016, while that of the treated water has increased from 4.1 in 1982 to 4.3 in 2016 (Figure 3.29).

The concentration of iron in AMD was about 500 mg/l in 1982, decreasing to 193 mg/l in 2016 (Figure 3.30). The concentration of arsenic in AMD was about 2.84 mg/l in 1982, and has lowered to 0.9 mg/l in 2016 (Figure 3.31). This seems to be mainly due to the reduction of the source of AMD, i.e., the infiltrated rainwater, and suggests that the rehabilitation works are effective. The concentration of iron and arsenic in the treated water has always been far below the standards defined by the Water Pollution Prevention Act (Table 3.3).

The reduction of the electric power consumption in the neutralization plant in early 2000s (Figure 3.32) was achieved by the energy-saving improvement of a few facilities of the plant.

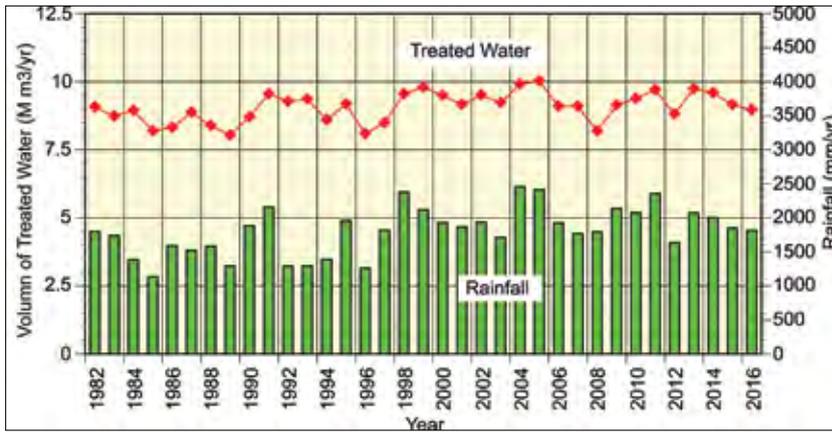


Figure 3.28: Volume of treated water by the neutralization plant and rainfall since 1982 (data source: JOGMEC).

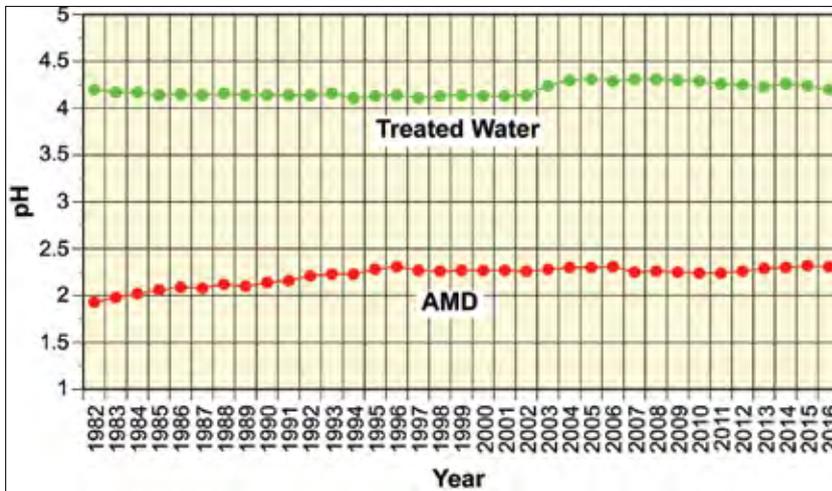


Figure 3.29 pH of AMD (red) and treated water (green).  
Data source: JOGMEC.

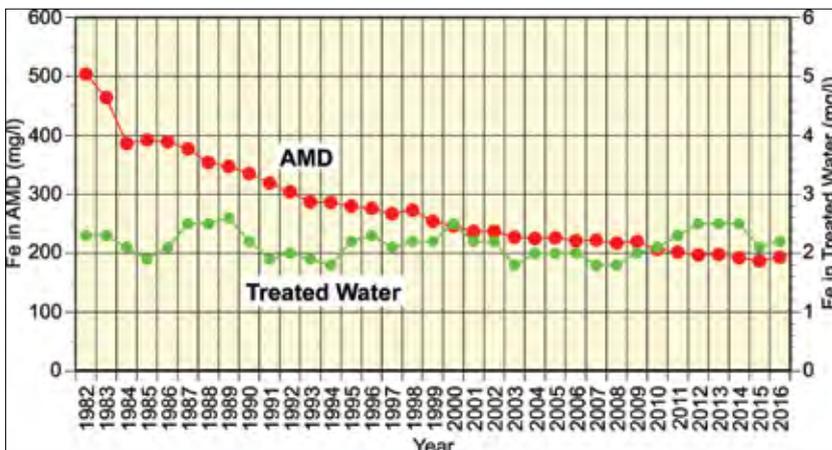
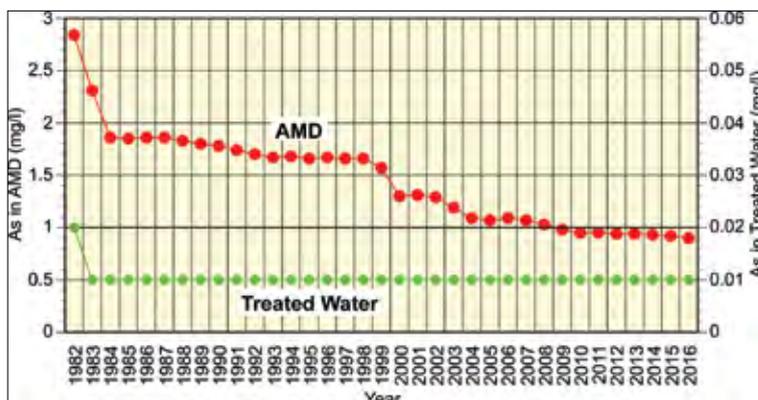
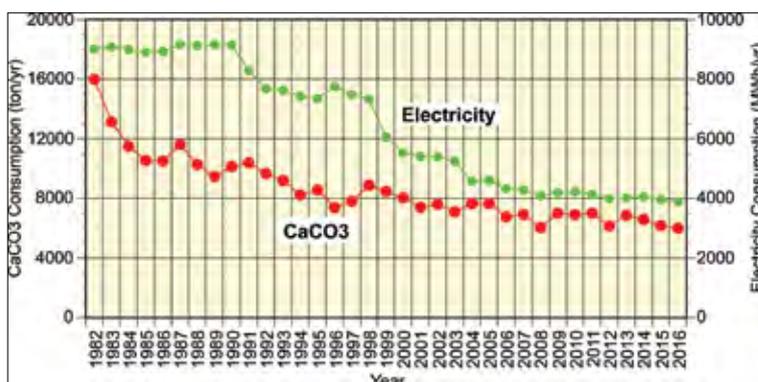


Figure 3.30 Total iron in AMD (red, left axis) and in treated water (green, right axis). Data source: JOGMEC.



**Figure 3.31** Arsenic in AMD (red, left axis) and in treated water (green, right axis). Data source: JOGMEC.



**Figure 3.32** Consumption of calcium carbonate (red, left axis) and electric power (green, right axis) in the neutralization plant. (data source: JOGMEC).

## Acknowledgements

This report was prepared based on the information provided by Japan Oil, Gas and Minerals National Corporation (JOGMEC), Iwate Prefectural Government, and the Ministry of Economy, Trade and Industry (METI). The author is grateful for these organizations.

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## 4

**REPUBLIC OF KOREA**

*Hayoung Noh, Joo Sung Ahn, Seong Yong Kim,  
Young Joo Lee, and Tae-Heok Kim*

**4.1 Country Information****Republic Of Korea Overview**

<b>Country Name:</b>	Republic of Korea
<b>Capital City:</b>	Seoul (since 1394)
<b>National Anthem:</b>	Aegukga
<b>National Flag:</b>	Taegeukgi
<b>National Flower:</b>	Mugunghwa (Rose of Sharon)
<b>Language:</b>	Korean
<b>Land Size:</b>	223,433 km <sup>2</sup> , 100,295 km <sup>2</sup> (South Only)
<b>Geographical Location:</b>	The Korean Peninsula (lat. 33°N~ 43°N; long. 124°E ~ 132°E)
<b>Standard Time:</b>	UTC +9 hours
<b>Population:</b>	51.45 million (2017)
<b>Political System:</b>	Free democracy, Presidential Republic
<b>President:</b>	Moon Jae-in (Since 2017)
<b>Economic Indicator (2016):</b>	- GDP: US\$1,411 billion - Per Capital GNI: US\$27,561 - Currency: won (US\$1 = 1,208won) - GDP growth rate: 2.8%

**Figure 4.1** The Map of Korea (Sources: Map from Korea Hydrographic & Oceanographic Agency (KHOA), General Info from KOREA.NET (Ministry of Foreign Affairs, www.mofa.go.kr)). (<http://www.khoa.go.kr/kcom/cnt/selectContentsPage.do?cntId=51207220>)

**4.1.1 Geographical and Topographical Features**

The Korean Peninsula (lat. 33°N - 43°N; long. 124°E - 132°E) lies in the middle of Northeast Asia, flanked by China to its west and Japan to its east. The peninsula is 950 km long and 540 km wide, and has a total area of 223,433 km<sup>2</sup>, of which the Republic of Korea occupies about 100,295 km<sup>2</sup> (2015). The northern end of the peninsula is joined to the Asian Continent. The peninsula is predominantly mountainous, with flat land accounting for only 30% of the entire territory. Mountains over 1,000 m above sea level make up only 15% of the mountainous areas, while mountains lower than 500 m account for 65%.

**4.1.2 Tourism: Historical Heritages & Hallyu (Korean Wave, K-Culture) in Today**

Seoul, the capital of the Republic of Korea, is itself an important part of Korea's cultural heritage and the most popular attraction among overseas visitors to Korea. Although it is now one of the very largest modern metropolises in the world, its downtown area is enclosed by historic walls that were originally built over 600 years ago and contains a number of valuable historical heritage including Royal Palaces, fortress gates, and old residential districts.



**Figure 4.2** Gyeongbokgung Palace of Joseon (1396). (<http://www.korea.net/>)



**Figure 4.3** Sungnyemun (Namdaemun or South Gate, 1398, National Treasure No. 1). (<http://www.korea.net/>)

Hallyu or the “Korean Wave”, a term now widely used to refer to the popularity of Korean entertainment and culture across Asia and other parts of the world first appeared during the mid-1990s. Korean pop music, especially dance music, began to gain popularity in Asian countries, and now it spreads to the world as the rising genre in our daily lives, especially with K-Dramas, K-Movies, K-Foods, K-Cosmetics, and K-Lifestyles.



**Figure 4.4** K-Pop Idol (<http://www.korea.net/>)



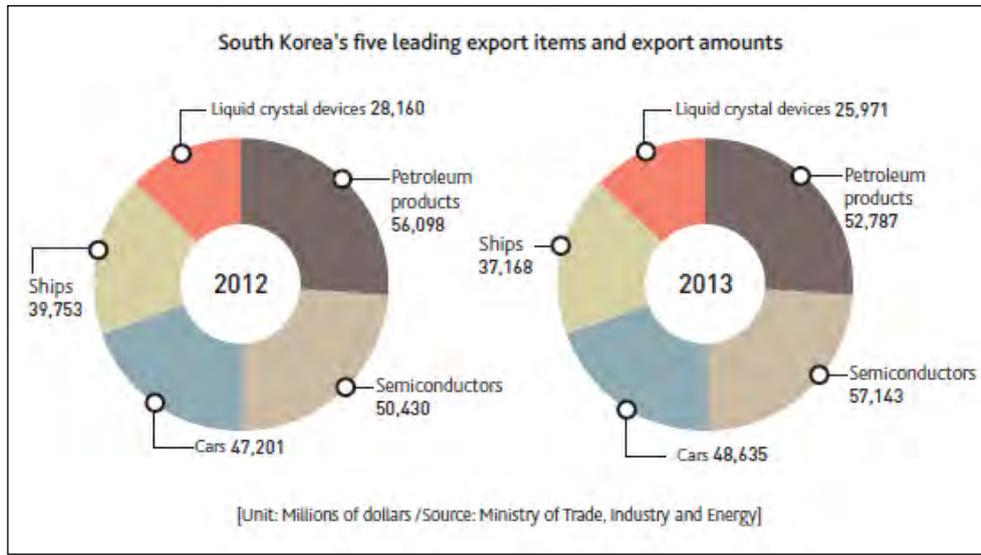
**Figure 4.5** K-Star Fan Meeting in Spain (<http://www.korea.net/>)



**Figure 4.6** K-TV Dramas <http://www.imbc.com/broad/tv/drama/daejanggum>”, MBC, Descendants of the Sun, “<http://www.kbs.co.kr/drama/sun>”, KBS

### 4.1.3 Economy

Republic of Korea has achieved economic growth at an unprecedented speed. Observers called what the country has accomplished the “Miracle of the Han River”, as most of the country’s industrial facilities were destroyed during the three-year-long Korean War (1950~1953), and the country was devoid of capital and natural resources.



**Figure 4.7** Leading Export Items & Amounts in Korea.  
(<http://www.korea.net/>)

The Republic of Korea is now recognized as a Regional Logistics Hub in Asia making preparations for a period when its combined export/import volume is expected to reach US\$2 trillion. The country is investing heavily in automation and the sophistication of export/import cargo stevedoring facilities, with the aim of greatly enhancing its logistics competitiveness.

## 4.2 Mining History (BC 100 ~ AD 1945)

### 4.2.1 Prehistoric Records in Korea's Mining History (100 BC ~ AD 300)

In Korean history, chronological evidence is from the Paleolithic period. Emerging of a nation begins as early as 5000 B.C., and the beginning of the Iron Age in the Korean Peninsula started between 100 B.C. ~ AD 200, and the new forces formed nations in the peninsula. During this period, the Iron Ore Mines and metallurgy are important to maintain social order and hierarchy. Among the ancient allied 'GAYA' nations (located southeastern part of Korea) are especially well-known iron metallurgical products such as weaponry and luxurious items producers, and active in the trade as far to today's India.



**Figure 4.8** Mass of Iron Pieces KIMHAE Yangdong No.162 Tomb. (<http://tadream.tistory.com/14679>, <http://bit.ly/152N5Ed>)



**Figure 4.9** Mass of Iron Piece KIMHAE Daesungdong No.2 Tomb. (<http://tadream.tistory.com/14679>), (<http://bit.ly/152N5Ed>)



**Figure 4.10** Ancient Industrial Complex Excavation Remains KIMHAE Jinyonghagueri. (<http://tadream.tistory.com/14679>), (<http://bit.ly/152N5Ed>)

### 4.2.2 Mineral Activities in the Goryeo and Joseon Dynasties

#### Goryeo Dynasty (AD 918 ~ AD 1393, 417 Years)

Minerals, especially metallic minerals are one of the very important national assets. All metallic mines are forbidden to own by the private sectors, and officially fully controlled by the royal monarchies for 417 years. During the Goryeo Dynasty, the kingdom was struggling with uneasy foreign affairs and frequent wars, which led to a large scale of iron mining for weaponry productions. In Kaegyong (the Capital City of the Goryeo Dynasty, today's Kaeseong in North Korea), large-scale central government offices, called 'GUN-GI-GAM', and 'JANG-YA-SOE' were established for supervising mines and mining activities in overall, including the precious metals like gold and silver mining, copper and iron mining industries. The size of metallic productions was rapidly increasing due to the industrial and commercial growth in the 1200s. Not just for the weaponry and agricultural tools, the needs of currency expanded as the market and trades and commodity exchange level grew. Furthermore, the Buddhism was fundamental royal monarchy's ruling ideology. The needs of building temples and following Buddha statues and religious ritual components were dramatically increased. As those demands increased, the national finance and wealth came from the entirely controlled national mining activities. Also, the non-metallic mining activities were increased due to the worldly famous Goryeo Celadon Prunus Vase and similar potteries which led developments of clay minerals such as white clay, feldspar and kaolin.



**Figure 4.11** National Treasure No.45, Buddhist Statue from Goryeo Dynasty.



**Figure 4.13** 'JIK-JI' from 1377 Buddhist Scriptures Metal Type.



**Figure 4.12** Inlaid Celadon Prunus Vase (12<sup>th</sup> Century)

**Source:**

**Figure 4.11** ([http://www.heritage.go.kr/heri/cul/culSelectDetail.do?VdkVgwKey=11,00450000,37&pageNo=5\\_2\\_1\\_0](http://www.heritage.go.kr/heri/cul/culSelectDetail.do?VdkVgwKey=11,00450000,37&pageNo=5_2_1_0))

**Figure 4.13** (<https://post.naver.com/viewer/postView.nhn?volumeNo=14989687&memberNo=38594388>).

**Figure 4.12** ([http://www.heritage.go.kr/heri/cul/culSelectDetail.do?pageNo=5\\_2\\_1\\_0&ccbaCpno=1121114520000#](http://www.heritage.go.kr/heri/cul/culSelectDetail.do?pageNo=5_2_1_0&ccbaCpno=1121114520000#))

**Joseon Dynasty (AD 1392 ~ AD 1910, 519 Years)**

In the Joseon Dynasty, the fundamental principles about all mines managements were controlled by the country. As the time went by, however, the numbers of mines were consigned to mega-merchants by the mid-16<sup>th</sup> century. The types of mainly focused mining were different from time to time. Mainly developed mines were iron, sulfur, gold, silver, and non-metallic minerals.

Joseon's mining activities and developments can be divided into five periods; the first period was divided into 40 years from the founding to 1432 (12<sup>th</sup> year of King Sejong). During this period, the use of gold and iron were restricted to the prime ministers, and they were directly supervised.

The second period is the 100 years from 1433 (13<sup>th</sup> year of King Sejong) to 1530 (25<sup>th</sup> year of King Jongjong). During this period, gold was mined to civilians. Various kinds of metal minerals had been found and mined in various parts of the country, and the iron production area reached 82 places. Since then, the period is categorized the following 240 years from 1531 (26<sup>th</sup> year of King Jongjong) to 1772 (48<sup>th</sup> year of King Yeongjo).

From this time, we allowed private mining of various minerals and dispatched mining cadets to each province. At that time, only silver caviar water customs officers were installed in 41 towns. However, when damage to farmland was increased, there were times when gold mining was completely prohibited in 1777.

The fourth period is the next 60<sup>th</sup> year from 1723 (49<sup>th</sup> year of the King Yeongjo) to 1832 (32<sup>nd</sup> year of the King Sunjo). At that time, 3,000 gold and silver pits were established. During this time, poor peasants were pouring into the stone pits, and farmland-based Joseon Dynasty tax payment system started to shake, which later on caused the weakness of the kingdom's financial integrity in the 19<sup>th</sup> century.

Finally, the fifth period estimated to begin from the mid-19<sup>th</sup> century (King Hunjong) to the collapse of the Joseon Dynasty (King Kojong). At this time, foreigners were also allowed to mining. Sadly enough in Korean history, it was the start for the invasion of the kingdom's

economic sovereignty. In 1891, the Japanese were granted permission for the Gold mining rights of Janggang gold mine in Changwon for a period of 10 years. In 1896, Gold mining rights were granted to Americans, respectively. In 1897, the Germans were also granted the right to mine gold in Gangwon Province. In 1899, 25% of the mining profits were paid to the foreign mining settlements.

### 4.2.3 An Overview of Modern Mining History

The Joseon Dynasty opened its door to the foreign powers in 1876, and the many mining rights began to handover to the foreign powers until 1905. Then, the total national sovereignty was ceased by Japan in 1910 and recovered Korea's independence in 1945. During this time, Korea mining activities were utilized as military logistics for 36 years.

The Western Imperial Powers and Japan had actively proceeded on geological mapping and geological surveys on various mineral ores in the Korean Peninsula since the late 19<sup>th</sup> century. The mining pits were 796 sites in 1911, but it drastically increased up to 6,513 sites in 1937, and the amount of mining fund was increased 20 times in 1944 than it was in 1931, which was reaching up to 5 Billion Won.



**Figure 4.14** Results of researches produced during the period of Korean Empire. (a): a general geological map showing geological distribution and mining sites of the Korea (scale 1:1,500,000) based on the survey results of Inoue (1907a) (source: Geological Survey of Japan). (b): an example of geological map around Syu-an (Su-an in Korean) mine described by Inoue (1907b) (source: Geological Survey of Japan). (c): the first report on mining survey published in June, 1910, and displayed in the KIGAM archive (source: KIGAM).



**Figure 4.15.** Series of the Geological Map of Joseon published by the Geological Survey (scale 1:50,000) of the Japanese Government-General of Korea, which composed of 61 geological maps in 19 volumes. All volumes were registered on Cultural Properties No. 603 on 2 September 2014, and displayed in the KIGAM archive (source: KIGAM).



**Figure 4.16** The Geological Map (scale 1:1,000,000) of Korea produced by Korean geologists in 1956. It is meaningful that this geological map was edited and produced by efforts of Korean geologist for the first time. This geological map was registered on Cultural Properties No. 604 on 2 September 2014, and displayed in the KIGAM archive (source: KIGAM).

### **Mining Activities in Progress, Republic of Korea (1945~)**

The government of the Republic of Korea was established on 15 August 1948. Immediately after the nation's foundation, a five-year plan for economic development was established in 1949. The mining industry was under control of the Bureau of Mine, Ministry of Commerce and Industry.

On 4 May 1950, the 'Korea Coal Act' was promulgated and the Korea Coal Corporation was established in November of the same year to produce and supply anthracite coal (hard coal) as household fuel for the public. According to the statistics, over 121 mines and 200 mine pits were approved to the contracted leasers as of November 1951. After the Korean War, DAEHAN Coal Corporation has developed eight mining sites (Jangseong, Gyeonggi, Eunseong, Hwasun, Hambaek, Najeon and Hwaseong), and it has played a central role in the development of Korea's coal industry. Korea Coal Corporation occupied 80% of the production of anthracite coal by operating the coal mines directly. As a government-funded institution, Korea Coal Corporation had coordinated the supply and demand of anthracite coal, contributing to establishing anthracite coal as a national fuel along with other private mines, and contributing to preventing recklessly harmful random deforestation of the land.

Also, the United Nations Korean Reconstruction Agency (UNKRA) funded with \$10 million (USD) to the mining sector in 1951~1958, and the core investments for the projects were focused on mining recovery and transportation facilities which were devastated during the Japanese colonized period and the Korean War. The UNKRA fund helped the Korea's mining activities from re-organizing infrastructures to market supplies. In 1954, the UNKRA Mineral Laboratory was established in Daejeon for stabilization of produced mineral quality in market. In 1958, the Korea-US Agreement on KOMEP (Korea Mining Evaluation Project) was signed; it was about the mining equipment supply and rental as an aid for stable anthracite coal (hard coal) production to mobilize Korea's destructive economy.

In 1967, the Korean government announced the ‘Korea Mineral Resources Act’ to establish an official organization for handling the overall mineral management strategically. With this intension, Korea Resources Corporation (KORES) was found as the comprehensive mining business entity. The share of mining production to the gross national product is 1.7% ~1.8% during the first economic development five-year plan (1962-1966), which is much larger than 1.4% in 1960 and 1961.

During the late 1980s to the early 1990s, the mining industry rapidly declined and many communities near mines also collapsed. The main reason was that the prices of domestic mineral were higher than those imported minerals due to high production costs of domestic mining methods. It led to the disappearance and abandonment for the most of domestic mines.

In 2000s, as the size of the economy grows, the relicenses on the energy and mineral resources increases, especially in Korea’s case with the third/fourth level industries. However, the self-sufficiency of the domestic mineral resources is far below than what the Korean economy relies on. As a result, Korea acts on more vigorously the overseas developments and investments for the energy and mineral resources.



**Figure 4.17** Sangdong Mine Dressing Plant Gangwon Province in 1958. (<http://news.zum.com/articles/6741240?t=t&pr=014?c=02>)



**Figure 4.18** United Nations Korean Reconstruction Agency (UNKRA), Archives from 1950s. (<https://unarchives.wordpress.com/into-the-archives/>)



**Figure 4.19** Whasoon Coal Mine Community in JeollaNamdo 1960s. (<http://greenjeonbuk.org/?p=48055>)



**Figure 4.20** Korea’s Mine Workers and Nurses in West Germany 1960s. (<http://www.etnews.com/201304010142>)



**Figure 4.21** Opening POSCO in 1968.  
([http://biz.chosun.com/site/data/html\\_dir/2011/12/14/2011121400878.html](http://biz.chosun.com/site/data/html_dir/2011/12/14/2011121400878.html))



**Figure 4.22** POSCO's A Blast Furnace of Steel.  
([http://biz.chosun.com/site/data/html\\_dir/2015/09/07/2015090700686.html](http://biz.chosun.com/site/data/html_dir/2015/09/07/2015090700686.html))



**Figure 4.23** Mining Mechanization in Jangsung Station in 1970s.  
([http://azine.kr/m/\\_webzine/z.php?c=34&b=36204&g=](http://azine.kr/m/_webzine/z.php?c=34&b=36204&g=))



**Figure 4.24** Abandoned Taebek-Yuongwol Mining Stations in 1990.  
(<http://www.travellife.co.kr/news/articleView.html?idxno=149>)



**Figure 4.25** Yuongwol Mining Theme Park in Gangwon Province.  
([http://www.hanwharesort.co.kr/irsweb/resort3/resort\\_plan/spot.asp?pl=81](http://www.hanwharesort.co.kr/irsweb/resort3/resort_plan/spot.asp?pl=81))



**Figure 4.26** Hosting the PyeongChang Winter Olympics & Rebooting Energy in Abandoned Mining Community.  
(<http://www.yonhapnews.co.kr/bulletin/2018/02/22/0200000000AKR20180222046800009.HTML?from=search>)

## 4.3 Korea Mineral Information 2016

### 4.3.1 Overview of Korean Mineral Commodity Market

Korean economic growth in 2016 was 2.6%, which was the same as that of 2017. The market sentiment on the economic growth has worsened because of the political uncertainty, corporate restructuring and a drop in exports. The 2017 outlook for the Korean economy is bleak. Major domestic economic research institutes' growth projections for the country's economy range between 2.6% and 2.1%. The Organization for Economic Cooperation and Development (OECD) also lowered its growth projection for the country from 3% to 2.6%, adding to the alarm.

Apart from Korean economy, the Korean mining industry in 2016 growth jumped 12% by an increase in non-metallic production. Because of the construction activity, the amount of non-metallic mineral production increased 8.2% compared to that of the previous year. Most of the increased mineral productions are related to limestone for cement production. However due to the decreasing metal prices, several metal mines such as iron ore and molybdenum were closed bringing the production of metal mines to decrease by 26%.



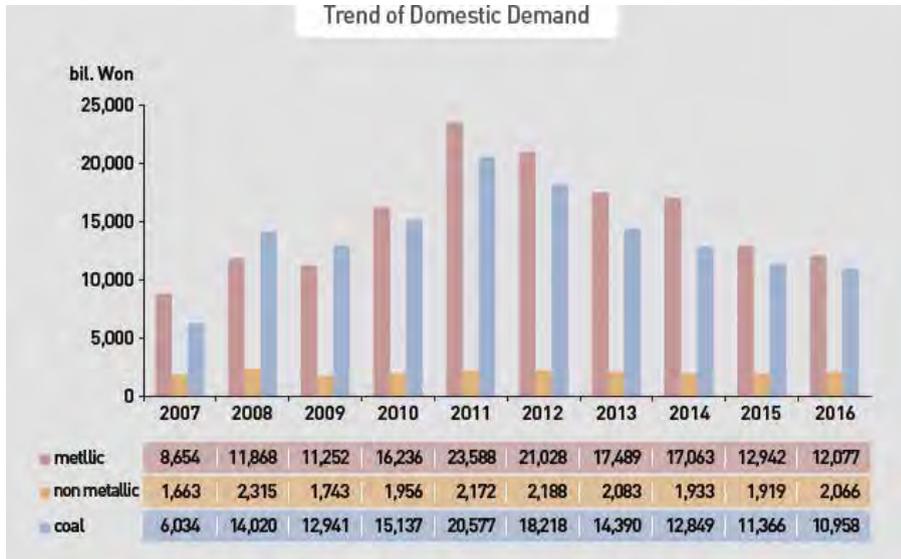
• Source : Bank of Korea, World Economic Outlook 2017 Apr, IMF

**Figure 4.27** Correlated Index for Korea GDP & Mining Industry (Cited Source: KIGAM Korea Mineral Information 2016).

(<http://www.kigam.re.kr>)

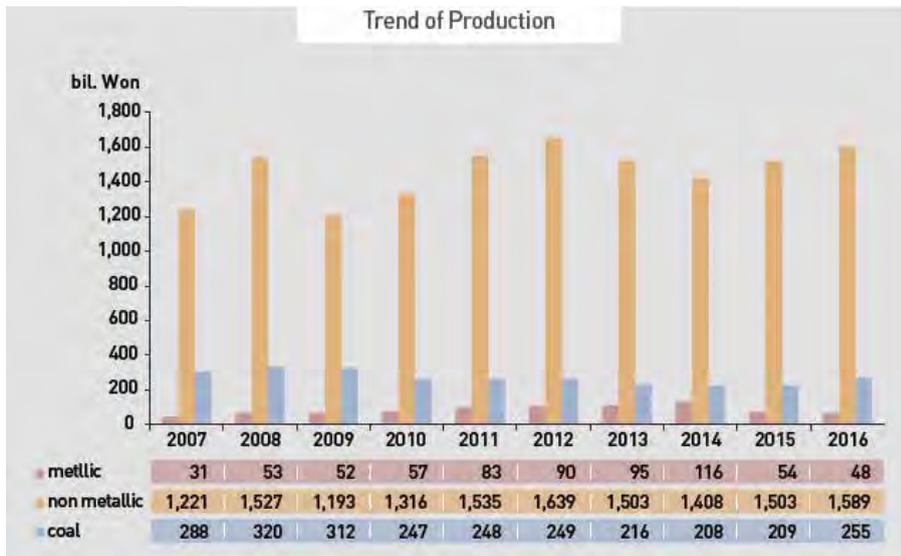
### 4.3.2 Korea's Major Mineral Indicators

#### Trend of Domestic Demands for Mineral Status



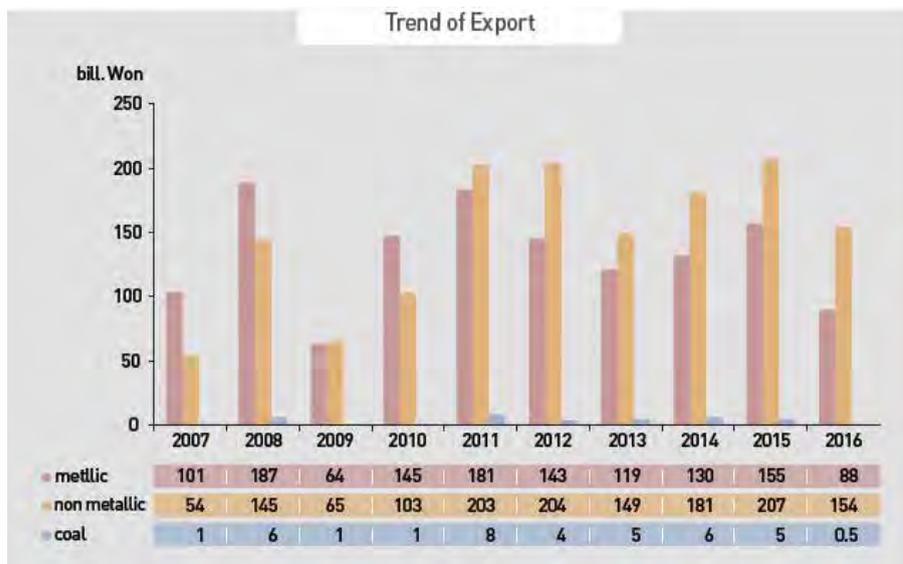
**Figure 4.28** Domestic Demands for Metal, Non-Metal & Coal (Cited Source: KIGAM Korea Mineral Information 2016).(<http://www.kigam.re.kr>)

#### Trend of Mineral Production in Korea



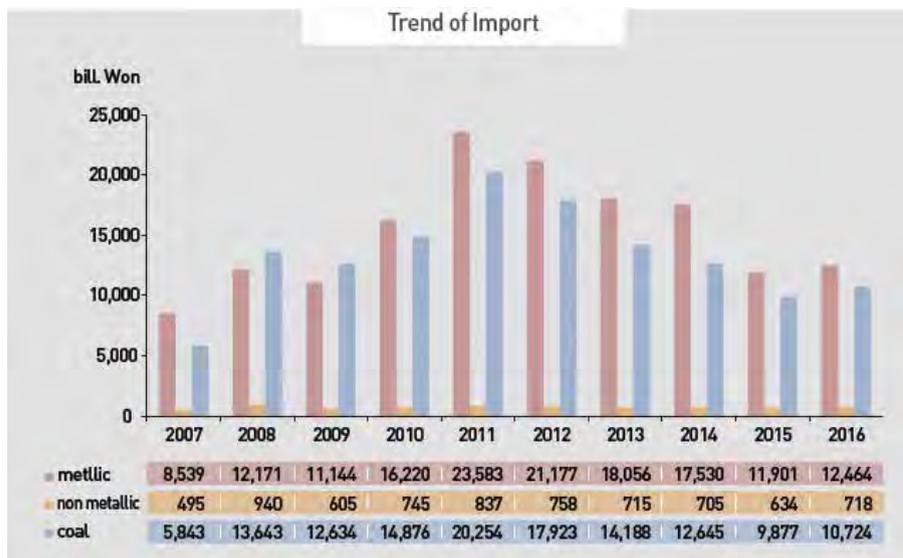
**Figure 4.29** Domestic Productions for Metal, Non-Metal & Coal (Cited Source: KIGAM Korea Mineral Information 2016).(<http://www.kigam.re.kr>)

### Trend of Mineral Export in Korea



**Figure 4.30** Export Amount for Metal, Non-Metal & Coal (Cited Source: KIGAM Korea Mineral Information 2016). (<http://www.kigam.re.kr>)

### Trend of Mineral Import in Korea



**Figure 4.31** Import Amount for Metal, Non-Metal & Coal (Cited Source: KIGAM Korea Mineral Information 2016). (<http://www.kigam.re.kr>)

## Major Mineral Productions in Korea

### Major Mineral Production

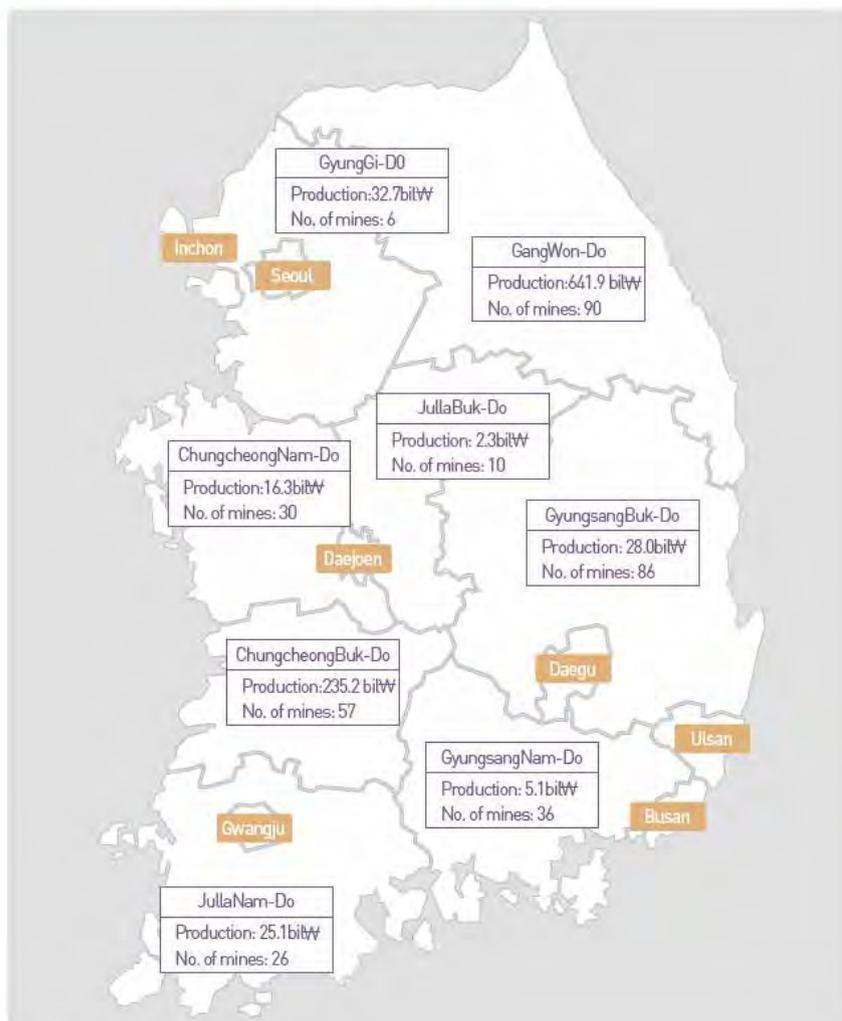
Mineral	Unit	2012	2013	2014	2015	2016
Gold*	Kg	337	413	284	269	205
Silver*	Kg	2,649	2,925	3,289	4,586	6,579
Lead ore	MT	3,879	5,000	5,527	5,842	5,679
Zinc ore	MT	2,868	3,497	3,838	4,139	4,513
Iron ore	MT	592,743	663,045	693,262	445,318	444,677
Titanium ore	MT	201,976	229,723	240,892	204,082	166,900
Talc	MT	21,625	2,808	5,484	6,371	2,247
Pyrophyllite	MT	483,133	524,881	622,865	596,860	590,000
Feldspar	MT	360,413	343,241	528,958	601,030	654,398
Clays	MT	1,910,947	1,780,910	1,523,243	1,615,659	1,505,876
Limestone	MT	86,912,153	88,590,107	91,183,974	93,051,727	95,890,937
Silica stone	MT	4,184,432	4,193,639	4,056,655	3,569,603	3,777,510
Silica sand	MT	708,850	747,381	731,518	661,341	682,241
Diatomite	MT	6,000	34,000	65,893	15,310	20,564
Serpentine	MT	160,572	201,814	160,779	59,461	153,042
Mica	MT	25,594	25,143	24,205	17,405	12,934
Zeolite	MT	245,285	221,298	203,051	191,207	121,730

\* The data of Gold and Silver are mine production

**Figure 4.32** Major Mineral Productions in Korea  
(Cited Source: KIGAM Korea Mineral Information 2016). (<http://www.kigam.re.kr>)

## South Korea's Mining Activity by Provinces (Administrative Districts)

Mining Activity by Region (Non-Fuel Minerals) 2016



\* The production of Sulfur is excluded

**Figure 4.33** South Korea's Mining Activity by Provinces  
(Cited Source: KIGAM Korea Mineral Information 2016). (<http://www.kigam.re.kr>)

## 4.4 Best Practice of Mine Rehabilitation & Decommissioning

### 4.4.1 Successful Cases for Saving Dead Mining Towns in Korea

The Gangwon Province is a blessed region with the gift of nature. It is a mountainous province, (a much greater part is occupied by mountains) and is divided into two areas, Yeongdong and Yeongseo, with the Taebaek Mountains, which forms the backbone of the Korean Peninsula, in the middle. The area east of the Taebaek Mountains is marked by steep slopes with few coastal plains, while the western area is marked by gentle slopes and mountains containing the headwaters of some of Korea's largest rivers, such as the Namhan and Bukhan Rivers.



**Figure 4.34** Natural Terrains of the Gangwon Province  
(<http://eng.gwd.go.kr/gw/eng>, [http://eng.gwd.go.kr/gw/eng/sub04\\_04\\_02](http://eng.gwd.go.kr/gw/eng/sub04_04_02))



**Figure 4.35** The Taebaek Mountains in between Yeongdong and Yeongseo Regions in Gangwon Province, Korea.  
([https://www.researchgate.net/publication/225661570\\_What\\_Is\\_Responsible\\_for\\_Increasing\\_Flood\\_Risks\\_The\\_Case\\_of\\_Gangwon\\_Province\\_Korea](https://www.researchgate.net/publication/225661570_What_Is_Responsible_for_Increasing_Flood_Risks_The_Case_of_Gangwon_Province_Korea))

The Gangwon Province was well-known for various kinds of the mining town. From 1957 to 1966, the decade was the golden age of the Korean coal industry. The coal mine development actively engaged by both the public and private sectors, and the number of coal mines increased rapidly mainly in Gangwon Province. Demand had also increased and the market size had expanded every year. In order to meet the high demand on coal, the production had changed from manually to automatically in 1960s. Nationwide household heating system and power plant vastly relied on coal until the 1980s.

The Korean government continued to increase production while taking drastic measures under the 'Act on Expansion of Coal Production'. There was complacency in the coal industry in the state of increasing coal production. The supply system has not been continuously supplemented with the increase in demand. Finally, in October 1966, the so-called 'briquetting wave' led the government to focus on fuel policy, and the peak period of the coal industry came to an end.

In the late 1970s~mid 1980s, the communities based on coal industries started to collapse and workers leaving the towns for the better-paying jobs in the cities. During that time, many small cities in Korea was experiencing similar problems of which the young labours and families deserted their hometowns, mostly rural areas, in search of better living conditions concerning mainly with higher salaries, better education, housings and so on.

The abandoned mining towns faced with many problems especially on the deteriorating environment, ecology for habitats and chemical contamination in soil and groundwater. Also, the severe destructions of the terrain and geological topography were obvious in most of the mining towns. In other words, it was difficult to change the area from abandoned mine to other forms of industries or land utilization.

Since the 1990s, Korea proactively has filled up the gaps between the major cities and the rural areas about the noticeable socio-economic unbalanced developments. After the 'Golden Age' of mining days in the Gangwon Province, the central principles for the economic developments were: (1) Legal plans based on the Special Act on Balanced National Development; (2) Emphasize competitive regions that can respond to globalization; (3) Pursue specialized local development based on local features; (4) Pursue co-development through cooperation and win-win between regions; and (5) Convert to local-initiated developmental systems through decentralization and self-government.

By applying the above strategic principles to the real world, the Gangwon Province came up with TOURISM to save dying mining towns. The working plans include: (1) Hosting the Winter Olympic Games; (2) Developing an Attractive Tour Spot with the Casino Business; and (3) Remodelling the Actual Mining Sites as Mining Museums.

## **Hosting the Winter Olympic Games**

### **The 2018 PyeongChang Winter Olympic as the New Energy in Deserted Mining Towns**

The XXIII Olympic Winter Games, which was more familiar with ‘2018 PyeongChang Winter Olympic’ was held between 8~25 February 2018 in Pyeongchang County, Gangwon Province, Republic of Korea. Hosting the winter Olympic was the dream for all citizens in Gangwon Province because they knew that the Olympic-level of international sports game will blow a fresh breeze into the declining local economy.

It was the least developed region in Korea. Once, it was the leading mining communities linking the mountainous environment. Today, the Gangwon Province needs to solve the troublesome issues, such as underdevelopment in abandoned mines, are typical examples of the backward vitality.

As a part of revitalizing the declining mining towns, the Gangwon Province came up with the idea on the hosting of the grand international-level sports games since the early 1990s. Gangwon Province began preparing for the Bidding Process of 2002 and 2006 Olympic Winter Games from 1993, when the province participated in the bid for 1996 Asian Winter Games.

The economic effects are largely divided into direct and indirect ones. The direct economic effects include the operation of the Organizing Committee, the expenditure on consumption by domestic and foreign tourists, and the construction of stadium infrastructures for hosting the Olympic Games. Also, considering direct effects of the Olympics such as increasing jobs and commercial influences and the indirect economic effects such as local awareness which later on cause tourism is immense.

According to the Hyundai Economic Research Institute, the indirect economic effects of the 2018 PyeongChang Winter Olympic Games will be a total of ₩43 trillion Won (KWR), including ₩32.2 trillion Won (KWR) in tourism revenue and ₩11.6 trillion Won (KWR) in profits from the rise in the country's image for the next 10 years.

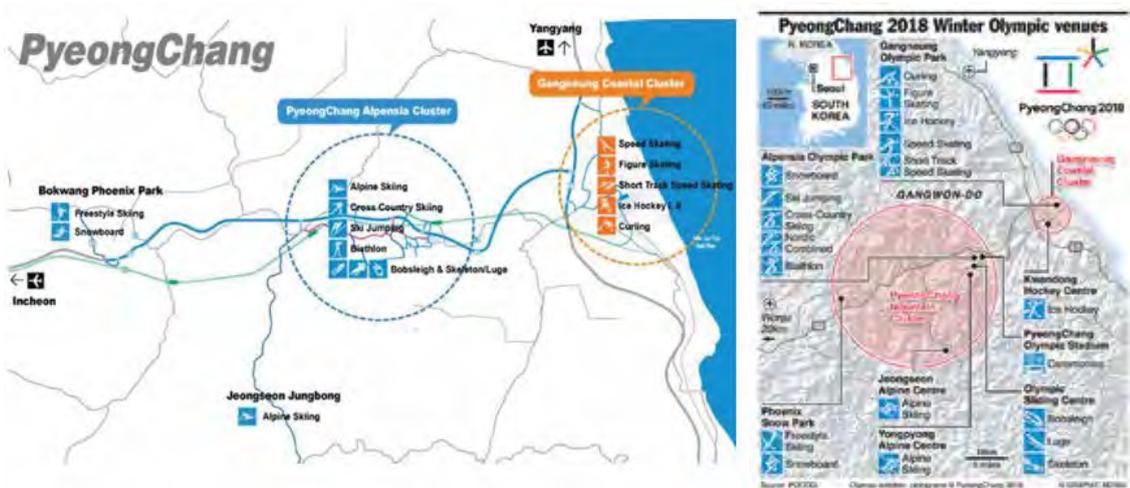
The so-called ‘PyeongChang Effects’ were influencing the near cities as the umbrella beneficiary effects. For Example, Sokcho, which gained distributional effects from Seoul-Yangyang East-West Expressway. The city has been attracting major business attentions as an investment prospective area due to its role as a transportation hub in Gangwon Province, where provides 152 transportation transactions.

The Gangwon Province now leaps toward the future after the PyeongChang Olympics. For instance, the central/regional governments and local communities put agendas for the mutual economy development plan. The initial joint efforts are to build localized policies and regional innovation systems to attract high value-added tourism demonstration models such as health and meditation related industries to create the future heritage of PyeongChang Winter Olympic Games.



**Figure 4.36** The Emblem and the Mascots ‘SOOHORANG’ and ‘BANDAVI’ for the 2018 Winter Olympics.

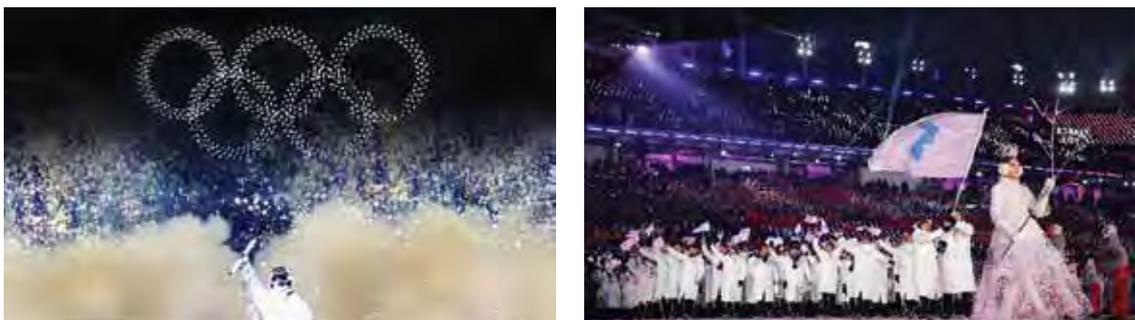
(<http://pub.chosun.com/client/news/viw.asp?cate=C01&mcate=M1007&nNewsNumb=20180227863&nidx=27864>)



**Figure 4.37** 2018 PyeongChang Winter Olympic Venues in All Over the Gangwon Province.

(<https://www.roadtrips.com/winter-games/2018-pyeongchang-packages/venues/>),

([https://www.graphicnews.com/en/pages/35102/PYEONGCHANG\\_2018\\_Olympic\\_venues](https://www.graphicnews.com/en/pages/35102/PYEONGCHANG_2018_Olympic_venues))



**Figure 4.38** The Opening Ceremony for the 2018 PyeongChang Winter Olympic.

(<http://allvod.sbs.co.kr/allvod/vodEndPage.do?mdaId=22000261874>)

## Casino Business

### Rejuvenating the Dead Mining Communities with Ultimate Resort: Kangwonland



**Figure 4.39** The Frontal Views of Kangwonland.  
(<http://kangwonland.high1.com/eng/aboutKangwonland/html.high1>)

The 'Kangwonland' is a versatile entertainment resort where visitors can enjoy skiing, golfing, casino, and more. Establishing the 'Kangwonland', is owned by Gangwon-do Development Corporation, is a joint promotional project run by the national government and the provincial office of Gangwon-do for the abandoned mine area district in accordance with a special law. It is the core project suggested during the planning for the promotion and development of the abandoned mine area. Due to a special act, Kangwon Land Hotel & Casino is the ONLY casino that accepts Koreans.

As much as people's income level increase in Korea, the statistics has shown that the domestic and overseas tourisms dramatically began to grow since the 1990s. The tourism industry will continue to expand due to the sharp increase in national income, advanced tourist/leisure activities, and more foreign tourists using marine and air transportation to visit Korea.

Since its articles of association are to save dead mining town, the 51% of the pure profit reverts to the local communities. The facility holds the great growth potential to benefit the Gangwon province. Although there is no doubt that the 'Kangwonland' returns the earned income to the mining towns, the ongoing controversial arguments are always inevitability followed due to its gambling business nature.



**Figure 4.40** The Iconic 'Kangwonland' CASINO.  
(<http://kangwonland.high1.com/eng/aboutKangwonland/html.high1>)



**Figure 4.41** Supporting Local Welfare by 'Kangwonland'.  
(<http://sports.donga.com/3/all/20141005/66959946/1>)

## Mining Museums

### Educational Experience for the Juniors, Nostalgic Memories for the Seniors

By 1988, the famous mining towns (TaeBeak, SamChuk, YoungWol, JeongSeon) in Gangwon Province population reached up to 12% of the entire Province population gross. However, the Korean government got on with the ‘Act of Coal Industry Rationalization’ considering to the declining coal dependency level in the general economy. Series of occurrence in abandoned mines, the exodus of mine workers seeking jobs, leaving towns due to the local economy recessions were noticed especially once in the active mining zones.

The Gangwon Province decided to make use of nature as they are the mining highlands in the four towns for making a tourism infrastructure through the construction of expressways with 4 lanes to link all mining regions in the southern Gangwon Province.

The newly created areas provided valuable historical meanings about mining industries and unique cultures among mine workers in town. Conservation and restoration of mining sites are more than exhibitions of replicas. As an on-site educational place, it is well-recognized as a part of modern industrial emergence.



**Figure 4.42** Experiencing Mine workers in Tunnel.  
([http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view\\_1552029.jsp?gotoPage=176&listType=](http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view_1552029.jsp?gotoPage=176&listType=))



**Figure 4.43** Replica of 1970s Mining Sites.  
([http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view\\_1552029.jsp?gotoPage=176&listType=](http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view_1552029.jsp?gotoPage=176&listType=))



**Figure 4.44** Mining Tunnel Open to Tourists.  
(<http://www.chamnews.net/news/articleView.html?idxno=53939>)



**Figure 4.45** Exhibited Old Mining Air Compressor Machines.  
([http://dh.aks.ac.kr/Encyves/wiki/index.php/%EC%98%81%EC%9B%94\\_%ED%83%84%EA%B4%91%EB%AC%B8%ED%99%94%EC%B4%8C](http://dh.aks.ac.kr/Encyves/wiki/index.php/%EC%98%81%EC%9B%94_%ED%83%84%EA%B4%91%EB%AC%B8%ED%99%94%EC%B4%8C))



**Figure 4.46** A Time Capsule to 1960s~1970s in Mining Town (Replica Set) in YongWol MaCha Culture Town. ([http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view\\_1552029.jsp?gotoPage=176&listType=](http://korean.visitkorea.or.kr/kor/bz15/travel/content/C0313/view_1552029.jsp?gotoPage=176&listType=)) ([http://korean.visitkorea.or.kr/kor/bz15/where/where\\_main\\_search.jsp?cid=895963](http://korean.visitkorea.or.kr/kor/bz15/where/where_main_search.jsp?cid=895963))



**Figure 4.47** Tourists at the Museum. (<http://m.monthly.chosun.com/client/news/viw.asp?ctcd=J&nNewsNumb=201207100037>)



**Figure 4.48** Mine Labor Propaganda in 1960s. (<http://www.jbnews.com/news/articleView.html?idx-no=456852>)

## The Gwangmyeong Cave Theme Park

### Reborn! From A Polluted Mining Region to A Cave Theme Park in Korea

The Gwangmyeong Cave opened to the public in August 2011 was once Siheung Mine established in 1912. At the start of excavating the mine in 1912 during the Japanese colonial rule of Korea, it was said that the mine was carved out from an outcrop of gold. This outcrop is truly the starting point of Siheung Mine. The first record of Gwangmyeong Cave is traced back in 1903 when Siheung Mine was established at Gahak-ri, Gwagmyeong City.

Siheung Mine was, then, the largest metal mine in the metropolitan area and produced gold, silver, bronze, zinc and other minerals for 60 years. During the Korean War, the mine became a shelter for residents. After overcoming the ages of Korea's historical hardships, the Siheung Mine was again valued as an important asset to the Korea's rapid industrial development. However, the mine was closed in 1972 because the economic feasibility of producing the metallic ores was lower considering other land utilizations of that time and the increase of the contamination of the environmental issues. In 1978-2010, it was used as a storage place for salted shrimps from Sorae Port. In 2011, the land was purchased by Gwangmyeong City and transformed into a cave theme park, retaining its industrial heritage and cultural values.



**Figure 4.49** Using Abandoned Mines as Salted Shrimp Storehouse.

([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=1998188))



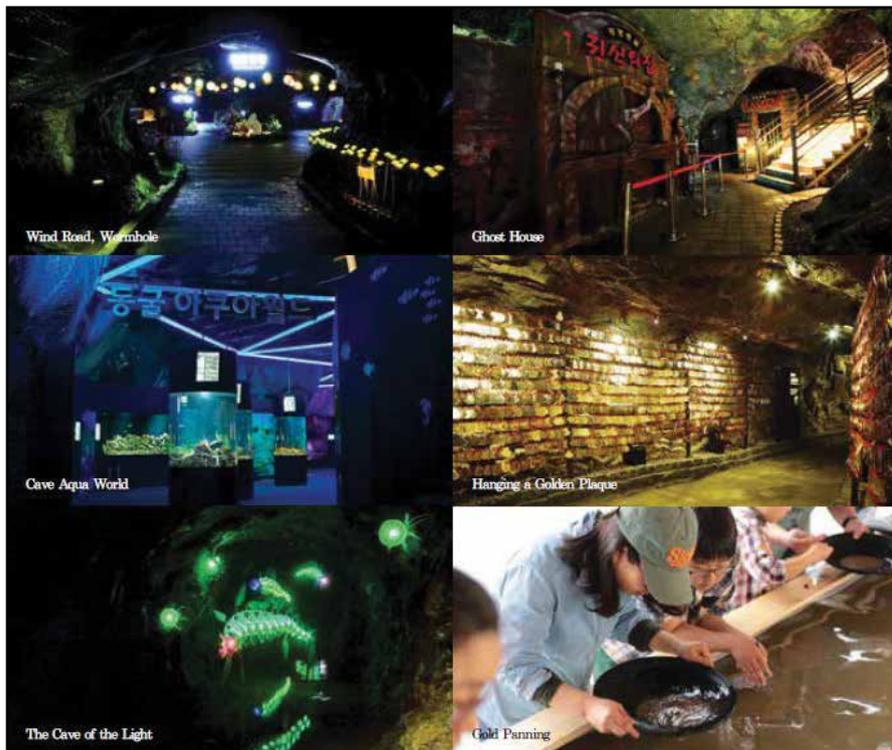
**Figure 4.50** 'Siheung Mine' Abandoned Mining Pits in 1980s.

([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=1998188))

Since the cave was opened to the public in 2011, multiple events were hosted including movie screenings, concerts, fashion shows and exhibitions. In-cave attractions include 'Wormhole Square' (light theme experiences in cave), 'Cave Underground World' (underground passage that miners once carried the mined ore), 'Cave Underground Lake', 'Golden Road' (road of 'Long Life, Happiness and Peace'), 'Modern History Museum', 'Aqua Cave World on Fishes', and so on.

Gwangmyeong Cave is evaluated to be Korea's best cave theme park which holds a combination of a value as an industrial heritage and a cultural value. The cave achieved a miracle of the abandoned mine which took the world by surprise, attracting more than 1.4 million tourists per year.

### A Trip to the Cave, Ahead of Your Imagination: One of Korea's 100 Must-See Destinations



**Figure 4.51** Transformation of Abandoned Mining Site (Gwangmyeong Cave) as multi-entertaining places for families.

([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=1998188))

The spatial differentiation and rarity of a cave formulate a new creative culture by combining it with cultural art content. Starting with the Cave Art Center, Gwangmyeong Cave offers various works made through cooperation with many artists in several places, and the light and new media against the backdrop of darkness satisfy a viewer beyond imagination.

Mineshafts which are regarded as just only an industrial spot have been transited to a wine cave to be used as a space of communication, offering a new cultural lifestyle. Regenerating an abandoned mine into a complex culture and art space, Gwangmyeong Cave is now on the spotlight as a cultural creation space in Korea and beyond.

## **Two Million Tourists per Year, the Age of Global Tourism**

Gwangmyeong Cave attracts two million tourists to Gwangmyeong City in 2017. Gwangmyeong Cave has developed a plethora of new contents for the year of 2017, including the VR (virtual reality) horror-experiencing zone, combined with the media facade show with cutting-edge media, and the Barbie doll collection exhibition with the aim of 1.5 million visitors. Those visitors spent 12 billion won alone for the cave programs and near facilities, which led creating 400 new employees' working chances.



**Figure 4.52** Transformation of Abandoned Mining Site (Gwangmyeong Cave) as Art Center.  
([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1_1.jsp?cid=1998188))

## **Gwangmyeong Cave & UNESCO World Heritage Lascaux France**

The delegation from Gwangmyeong City has visited Paris in late May 2016 with the invitation of France's Parliament and the Council of Dordogne, and earned much acclaim via the presentation of the 'Successful Example of Gwangmyeong Cave and the Meaning of the Lascaux International Exhibition at Gwangmyeong Cave'. The City of Gwangmyeong is also passing on the success story of Gwangmyeong Cave to the government of Lao PDR. There are countless visitors from around the world who visit Gwangmyeong Cave to benchmark its success.

Taking an opportunity of international tour of 'Lascaux International Exhibition at Gwangmyeong Cave', The Lascaux Exhibition Zone of Gwangmyeong Cave was built by Jean Nouvel, a master of architecture as a certification project in the cultural heritage exhibition field during the years of Korea-France Mutual Exchange 2015-2016. The exhibition zone bears a philosophy of industrial recycling.

The Lascaux Exhibition Zone features Korea's largest beam projector system and is in the spotlight as a space where the world famous complex art, like media art, promotions and conferences is performed.



Jean Nouvel, a World-Famous Architect and Pritzker Prize awardee, known as the 'Nobel Prize of architecture.'

**Figure 4.53** Collaboration with UNESCO World Heritage Lascaux France at Abandoned Mining Site (Gwangmyeong Cave).

([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=1998188))

## **Reuse Space: Abandoned Mining Sites to Modern Industrial Heritage.**

The Gwangmyeong Cave still has both a 7.8-km shaft spanning up to the level 7 underground from the level above ground and a site of Mineral Processing Plant, a sorting site, though 104 years have passed since its opening.

Along with the site for Mineral Processing Plant, the underground mining shaft within Gwangmyeong Cave is also living evidence which one can learn about the working conditions in the underground tunnel, including the methods of developing the mine, wind circulation, and ventilation. Also, in addition to a value as such an industrial and historic spot, the graffiti and drawings from the miners hold a historic and industrial value, despite the 40-year-layered dust that had accumulated over those graffiti and drawings.

From its tragic beginning as a scene of exploitation by Japanese imperialism to its pivotal role in the modern industrialization of Korea, Gwangmyeong Cave passes onto us both the material and immaterial heritage of its 104-year-old long history. Now, Gwangmyeong Cave will be remembered as a successful example of urban restoration through preservation as a modern industrial heritage and utilization for urban restoration by way of culture and art.



**Figure 4.54** Transformation of Abandoned Mining Site (Gwangmyeong Cave) as Mining Modern History Museum.

([http://english.visitkorea.or.kr/enu/ATR/SI\\_EN\\_3\\_1\\_1\\_1.jsp?cid=1998188](http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=1998188))

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## LAO PEOPLE'S DEMOCRATIC REPUBLIC

*Thanongsinh Luangvilai & Vongthong Thimahaxay*

### 5.1 Country Information

Laos, officially the Lao People's Democratic Republic (Lao PDR), is located in Southeast Asia, in the centre of Mekong River region. The country is landlocked; it is bordered by Myanmar and People's Republic of China to the northwest, Vietnam to the east, Cambodia to the south and Thailand to the west. Laos has a population of 6.8 million (2017) and a land area of 236,800 km<sup>2</sup>. It has significant natural resources like minerals and hydroelectric power, timber, rubber and agricultural land. It is also a rising power in exporting electricity to the neighboring countries. The Lao economy is accelerating rapidly due to the demands of its metals. The motto of Laos is "Peace, Independence, Democracy, Unity and Prosperity".

Laos is characterized by steep terrain and narrow river valleys. The topography is largely mountainous in the northwestern part of the country with elevations typically ranging several hundreds of meters excluding of the plain of Vientiane and the Plain of Jar in Xiengkhoang Province. The country has a tropical monsoon climate. The rainy season begins in May and continues to October. Precipitation varies from about 1,200 mm per year in the lowlands to over 3,000 mm in the mountainous areas, which exceeds evaporation (around 1,000 mm per year). Average temperatures range between 15°C to 35°C, with the coolest period between December and January, and the hottest months around March to April. A dry and cool season is from November through February, and a hot dry season prevailing in March and April. Temperature range from highs around 40°C along the Mekong River valley in March and April to lows of 5°C in the highlands. The country's average humidity varies between 87% in rainy season and 69% in a hot dry season.

Laos has a rich cultural history which dates back hundreds of years. The most famous dynasty ruled in the country was the Lan Xang Kingdom from the 14<sup>th</sup> century. In the relatively modern part of its history the country was a colony of France obtaining partial independence in 1949.

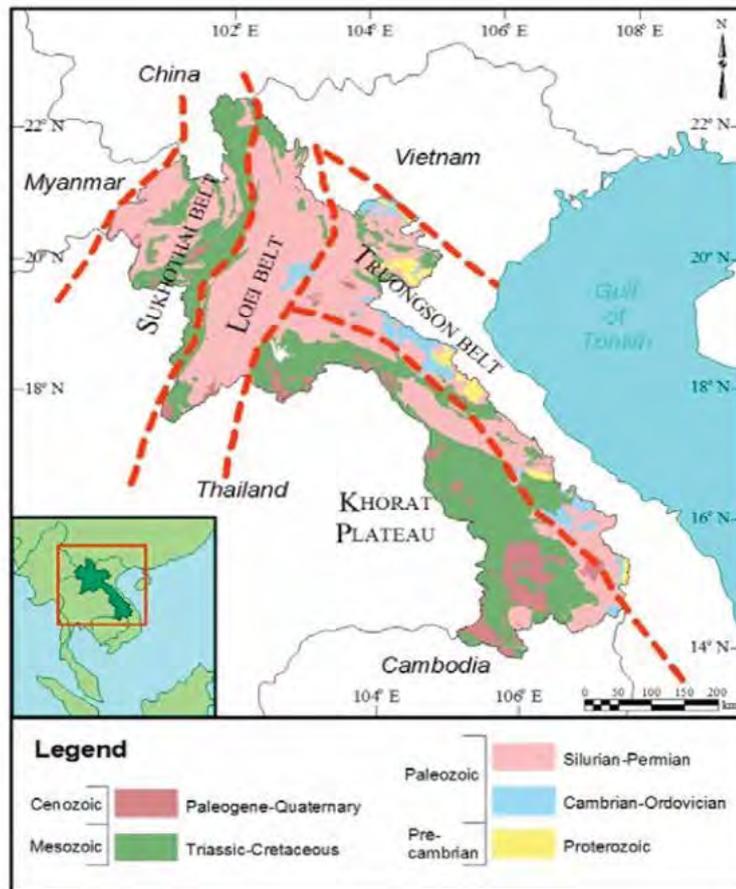
Laos has also been dragged into several civil wars and after a period of violence gained full independence in 1953. This was followed by civil war and political disruption leading to the establishment of the Lao People's Revolutionary Party as the sole legal political party and declaration of the People's Democratic Republic in 1975.

Today Lao PDR's per capita GDP was US\$ 2,338 in 2017. The country has been rapidly developing and a number of reforms towards market-oriented economy have taken place.

In spite of the liberalizing reforms, the Lao People's Revolutionary Party has maintained its role as the only political party. The country is administrated according to the rules of the constitution. There is a president in the highest position of administrative power elected by the National Assembly for a period of 5 years. The country is divided into 18 provinces which are further divided into districts. The capital city of the Lao PDR is Vientiane with an estimated population about 900,000 (2017).

## 5.2 Mining History

The development of the Lao PDR as a mining country with good geological potential for additional discoveries has taken place in two large-scale mining operations: MMG's Sepon and PBM's Phoukham copper-gold mines. Even though the large scale mining has only a short history in the Lao PDR, the mineral potential of the country has been known for a long time dating back to ancient artisanal gold mining and excavation operation of cassiterite along Nam Pathere River from 1920's till present. The recent development with the proven mineral potential of the poorly explored country, combined with rises of commodity prices has attracted a number of foreign and domestic mining companies to become active and now more than 200 exploration licenses have been granted. Based either on known discoveries of geological analogy the most abundant mineral resources expected to be found in the Lao PDR are gold, copper, zinc, lead, tin, aluminum, gypsum, potassium, iron, platinum group metals, nickel, chromium, rare earth elements, high-tech metals and coal. Mineral industry is significant source of foreign currency earning and thus a key factor for the development of the country. Nearly 600 sites have been found to have economic minerals but only 50 sites have been further investigated in more detail in order to determine the current mineral concentration. So far only little exploration work has been done in Laos in spite of the fact that it is composed of geological settings that are favourable to mineralization; all the threefold belts and Khorat plateau have proven mineral potential.



**Figure 5.1** Geological map of Lao PDR showing major geological units and fold belts of the country.

### 5.3 Status of Minerals Industry

Mining and processing of minerals in Lao PDR before 1990s, the investment of mining was based on state-owned enterprises such as tin, gold, barite, coal used for cement, stone, sand and other construction materials. After Lao PDR has adopted the constitution in 1991 the government had set the policy to open wide investment by domestic and foreign investment, the actual investment of private domestic and foreign investment in Laos increasingly up to now there are 77 companies with 138 activities are allowed to invest in mining sector with over 20 types of minerals.

- Production and distribution

By 2017, local and foreign companies were allowed to produce minerals valued at US\$ 1,302,802,000 and sold at US\$1,332,302,350, equivalent to 27% of GDP. The main products include gold, copper, copper concentrate, gold and silver alloys, gypsum, coal, potash, barite, iron ore, tin and other minerals.

- The National income contribution

By 2017, the mining sector contributed to the national income of 141,198,600 US dollars these include: concessions, natural resource costs, profit tax, tax revenues, mining tax, tax revenues, dividends, consumption tax, value-added tax, contract payments, and so on.

### 5.4 Best Practice of Mine Rehabilitation and Decommissioning

Mining in Laos is relatively new compare to other countries in the world. Laos has started developing mining in 2002 and none of the mining project has been closed yet. However there are two mining projects provided for case studies, which are: Phu Kham Copper-Gold Operation and Sepon Gold-Copper Project.

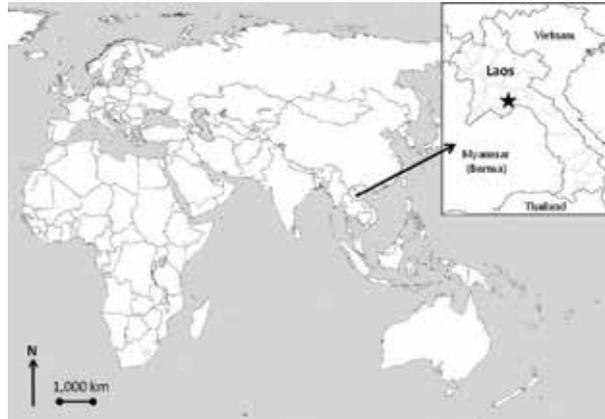
#### 5.4.1 Phu Kham Copper-Gold operation, Phu Bia Mining

Phu Kham is located in the Northern Highlands area of Laos, in the Xaisomboun District of Vientiane Province, approximately 140 km N-NE of Vientiane, the capital of Laos (Figure 5.3). The operation comprises an open-pit mine feeding ore to a conventionally milling and flotation operation which produces a copper and precious metals concentrate for export to custom smelters mainly in Asia. The concentrate contains approximately 23% copper, 9 g/t gold and up to 60 g/t silver. Phu Kham's concentrate is trucked in covered containers with 80% transported to the ports of Vung Ang or Hon La in Vietnam (approximately 650 km from Phu Kham) with the remaining 20% trucked to Sriracha Harbour in eastern Thailand (approximately 1,000 km from Phu Kham) for export to smelters mainly in Asia.

Phu Bia Mining Limited (PBM) has operating assets and associated commitments in the developing Asian region in Laos and Thailand. Pan Australian Resources Limited (PanAust) currently owns a 90% interest in PBM through the company's wholly owned subsidiary Pan Mekong Exploration Pty Limited, with the Government of Laos owning 10%. PanAust is an international emerging gold and copper producer listed on the Australian Stock Exchange. PBM has a Mineral Exploration and Production Agreement (MEPA) with the Government of Laos to develop gold and copper resources in the Xaisomboun District of the Vientiane Province. The Phu Kham Copper-Gold Project ('Phu Kham') is the second phase of PBM's development of assets in Laos.

Mining operations commenced at Phu Kham in 2008 with an estimated mine life of 14 years. The Phu Kham project involves open cut mining and processing of the sulphide copper-gold resource underlying the Phu Kham Gold Cap. Ore is processed using conventional flotation techniques to produce a copper-gold concentrate and no cyanide is used. The current life-of-mine plan for Phu Kham will see production ending in early 2023, and closure planning is currently at a conceptual stage.

### SITE LOCATION



**Figure 5.2** Location of the Phu Kham Mine.

The Phu Kham deposit is located in hilly terrain characterized by sharp ridgelines and steep sided valleys, with elevations between 700 and 1,200 mASL. Phu Kham project infrastructure lies within the Nam Mo River catchment, which is a tributary of the Nam Ngum River. The Nam Mo River joins the Nam Ngum River approximately 14 km southwest of the Phu Kham deposit. The Nam Ngum reservoir is approximately 40 km downstream of the project area.



**Figure 5.3** a) landscape around the Phu Kham Mine, b) community development aquaculture initiatives

### Social setting

Xaisomboun Province is traditionally one of the poorest and least populated areas of Laos. Prior to the commencement of PBM operations, the region had minimal industrial activity and was primarily based on a subsistence economy. Agricultural land is limited to lowland rice paddy cultivation and upland rice agriculture and the Nam Ngum catchment and its tributaries provide food sources for nearby villages. There is a mixed ethnic population in the two villages nearest the mine; Ban Nam Gnone and Ban Nam Mo. Villager's ethnic origins include Khmu, Hmong, Tai Deng, Tai Dam and Ethnic Lowland Lao.

Demographically, Laos is a young country, with about half of the population under the age of 20. Recently, PBM has funded the construction of a number of additional schools in villages close to the Phu Kham operation through the medium of its Community Development Fund. Almost all villages now have primary level education and some lower secondary level education, however, the adult population of the region has received little or no formal education. Adult education is now provided through PBM Community Development programs.

The standard of village living is low with only basic housing, water supply and sanitation facilities in most villages. Houses in the Phu Kham area are generally bamboo or semipermanent. Sanitation facilities have been improved due to a continuous awareness programme on health and hygiene and investment by PBM.

PBM conducted extensive data collection for social and economic information relating to the communities impacted by the Phu Kham operations. This included baseline surveys in 2003 and 2005 for the purposes of the Environmental and Social Impact Assessment (ESIA) and follow-up socio-economic surveys conducted in 2007, 2008 and 2010. The most recent data show continuing migration into the village nearest to the mine, Ban Nam Gnone. This shift is primarily due to the increased opportunities closer to the PBM operations relative to the time prior to the mine's arrival. PBM's Community Development Fund provides significant support to local social investment programmes, with a current annual spending commitment of US\$300,000. The projects are identified in consultation with local and district authorities and are subject to approval by provincial authorities. A perpetual fund has not yet been considered. Current community development objectives are geared toward promoting local ownership of initiatives, addressing root causes of socio-economic disadvantage and ensuring benefits are shared fairly and equally. Existing programs target assistance in the areas of agriculture, aquaculture, horticulture, local infrastructure, education, health, microfinance and small business development. Villagers have eagerly participated in a Village Savings and Credit Fund program which enables micro-financing opportunities for small business ventures, including livestock, fish farming and drinking water.

Nevertheless, a fundamental issue for mine closure in all countries, but particularly developing nations, is that the mine may bring many economic and employment opportunities into a region where previously there were none. The challenge for closure planning is how these opportunities can be managed to provide ongoing community benefit following closure (Roldan and Purvance, 2011).

There has been some concern on the part of residents of villages near the Phu Kham operation that people are becoming too reliant on the mine for employment and assistance. However, a primary principle of PBM closure planning has been to develop local livelihood opportunities that last beyond mine closure. For example, a microfinance-funded bottled drinking water company in Ban Nam Mo wished to sell all of their products to the Phu Kham Mine. Rather than purchasing 100% of the total supply available, increasing the dependence of the water company on the mine, PBM contracted for only 50%. The same recognition and management of dependency hold for livestock, aquaculture and other small business ventures funded by the scheme. The fund also provides for business development training to assist village businesses to establish other markets outside of the region.

### **Existing Phu Kham Regulation**

Although there is no specific guidance on mine closure regulatory requirements currently available in Laos, there are mineral development regulations as well as general environmental and social regulatory frameworks already in place that have been used to provide the initial direction to closure planning.

## MEPA agreement

The Mineral Exploration and Production Agreement (MEPA) between the Government of Laos and PBM specifies the requirement for a Mine Closure and Rehabilitation Plan to be developed. However, the MEPA does not describe the structure, contents, level of detail or any specific local requirements required in the closure plan, nor does it specify a timeframe for completion or implementation.

There is a provision in the MEPA for the establishment of an environmental protection fund to be funded by PBM at the rate of US\$1/ounce of gold and US\$1/t of copper sold. The purpose of the fund is to undertake rehabilitation in accordance with the Phu Kham Environmental and Social Management and Monitoring Plan (ESMMP). There is also a requirement for PBM to provide any additional funds required to complete agreed rehabilitation at completion and closure of the operation.

## Lao decree on environmental protection

The Lao Decree on Environmental Protection (DEP) states that a plan must be developed to close the mine site and to restore the environment in mining areas, as well as budgeting for the implementation of the plan. In accordance with the Ministry of Natural Resources and Environment (MoNRE), prior to closing the mine site, a project developer must produce a plan on closure and restoration of the mining area. This plan must be submitted to MoNRE for consideration and approval prior to being implemented. A social development plan must also be finalised for the post-closure period and be approved prior to closure. However, similar to the MEPA agreement, there is no guidance on what detail or content the plans should contain or the timing for plan development.

## World Bank funding requirements (World Bank, 2010)

PBM has not obtained funding by the World Bank for the Phu Kham operation. However, PBM voluntarily aims to comply with the International Finance Corporation (IFC) and Equator Principles. These require PBM to reserve funds sufficient to close its operation at any point and address the impacts associated with closure.



**Figure 5.4** Left to right: a) rehabilitation staff inspecting seedling progress, b) completed rehabilitation of disturbed landform

## **Applying international guidance as proxy regulation**

A conceptual MCP for Phu Kham was drafted in January 2009 upon commencement of the Phu Kham operation. This MCP was designed to be a guide for the closure of the Phu Kham site to satisfy requirements of license and lease conditions, the expectations of community stakeholders, regulatory obligations, and standards set by PBM's Australia-based parent company PanAust.

In 2011, PBM identified the need to update its conceptual MCP to reflect current conditions and changes in life-of-mine plans, and to align it with a leading international environmental and social performance standard in closure planning. Key objectives were to understand closure risks better, identify further studies and planning that would be required during the remaining life-of-mine and allow development of an improved closure liability cost estimate.

PBM engaged Golder Associates Pty Ltd (Golder) (the consultants) to undertake a gap analysis of the Phu Kham operation's existing MCP and to benchmark it against leading international practice in closure planning. Further work involved scoping studies required to address any planning gaps identified. In the absence of detailed regulations to specify how the mine closure requirements of Lao PDR and the MEPA are to be implemented, the consultants recommended a number of international guidelines that could be used to synthesise a standard upon which future revision of the Phu Kham MCP could be based. This analysis, together with a site visit by consultant project staff and their PBM staff's experience of leading practices at other mine sites, formed the basis to develop a revised MCP for Phu Kham. The consultants identified international mine closure standards and guidelines that are relevant to the PBM operation, including:

- International Finance Corporation (IFC), Environmental, Health and Safety Guidelines for Mining (IFC, 2007).
- International Council on Mining and Metals (ICMM), Planning for Integrated Mine Closure: Toolkit (ICMM, 2008).
- IFC Environmental and Social Policy and Performance Standards (updated 2012).
- Minerals Council of Australia (MCA), Enduring Value (MCA, 2005).
- ANZMEC/MCA Strategic Framework for Mine Closure (ANZMEC/MCA, 2000).
- Western Australian Department of Mines and Petroleum (DMP) and Environmental Protection Authority (EPA), Guidelines for Preparing Mine Closure Plans (DMP/EPA, 2011).

The overall finding of the Gap Analysis and Scoping Study was that PBM had, in most areas, adopted leading practice approaches to its management during operations. However, in order for this same social and environmental performance to be demonstrable following closure and gradual reduction and final cessation of PBM contributions to the region, what was now required was to re-orientate these activities and directly link towards a closure planning perspective. For example, community development and social programs were operating effectively for the contemporary scenario, but there was little consideration given to engaging local stakeholders in the closure planning process.

Closure planning must also operate at a broader scale than just the immediate locale (Sklenička and Kašparová, 2008) and is often defined by catchment or regional approaches to planning (McCullough and Van Etten, 2011). Whilst Phu Kham closure planning was found to be good at a local scale, it was identified that there was a need to extend planning to incorporate the regional context and influences such as regional farming practices and potential post-closure land uses.

Studies were recommended to address these existing gaps and to strengthen PBM's mine closure planning and introduce systems for review which would provide a roadmap for future management teams. Apart from Stakeholder Engagement Planning, the team also identified additional water modelling for pit lake and tailings storage facility water balance and water quality, rehabilitation reviews, closure cost estimating and closure planning for human resources to fill remaining gaps in the identified leading practice standards. A risk assessment workshop incorporating employees, technical advisers and stakeholders of potential risks at closure and how these may be mitigated was also proposed.

Prior to the revision of the MCP, the consultants also developed a Corporate Closure Standard (CCS) and MCP template to provide the principles and framework for life of mine closure planning at all PBM sites. As per the gap analysis and MCP review, the CCS and MCP templates were, based upon the former review of international leading closure practice, PBM's current business approach and practices during operations and a review of other comparable company closure standards and strategies.

The new PBM CCS refers to international and Australian standards as well as PanAust and PBM policies and procedures and provides a working reference for management teams to provide a consistent structure and approach to closure planning. Golder Associates is now updating the MCP for the Phu Kham operation according to the targets and strategies developed as part of the corporate standard.

## **Conclusions**

A lack of local regulations was not a significant hindrance to the development of leading practice mine closure planning in this case study. This case study demonstrates how an existing sound approach to management of environmental and social issues during the operational phase of mining can be reorientated to a closure planning view. The identification and application of international mine closure guidelines and standards can provide a framework for advising existing mine closure planning and directing future planning, through a systematic understanding of knowledge gaps and closure risks.

General and narrative closure planning guidance documents are already available for mines operating in developing countries and regions. Detailed and more prescriptive planning guidance can also be sought from nations and regions where closure planning is more developed as long as it is always placed in context of the operating nation's economic environmental and social setting. For example, the ICMM and the IFC performance standards and guidelines can be supplemented with more detailed closure planning guidance from mining nations and states such as the Western Australian Government's guidance for mine closure planning.

PBM is now planning further studies through the remaining operational years to develop future revisions of the MCP documents that are progressively more detailed and informed at significantly higher levels. As decommissioning and closure approaches, closure planners will become increasingly equipped with sufficient project and contextual knowledge to further develop leading practice closure scenarios with the required higher levels of detail to achieve good closure outcomes for both company and stakeholders.

#### **5.4.2 Sepon Gold-Copper project, Lane Xang Minerals Limited (LXML).**

Sepon is an open-pit copper mine in the Savannakhet Province, southern Laos. The registered name of the operating company is Lane Xang Minerals Limited (LXML), of which MMG owns 90% and the Lao Government owns 10%. The operation commenced production in 2005.

#### **COPPER**



Sepon produces 99.9% copper cathode using a whole-of-ore leach, solvent extraction and electro winning (SX-EW) process. The operation's copper cathode is registered as Copper - Grade A quality by the London Metal Exchange (LME). Hence, Sepon copper is eligible for delivery to LME-approved warehouses. Copper cathodes are transported via road and sea to manufacturers of cable, wire and tube in Asia and Europe. In 2017 Sepon produced 62,941 tonnes of copper cathode. MMG expects to produce 70,000 to 80,000 tonnes of copper cathode at Sepon in 2018.

#### **GOLD**



The Sepon gold project yielded its first gold and silver doré in December 2002. In early 2005, an expansion of the original gold processing facility was completed, doubling the capacity of the gold processing plant to 2.5 million tonnes of ore per annum. During its operations, the Sepon gold operation produced over 1.2 million ounces of gold through open pit mining and conventional treatment of oxide gold ore. MMG ceased gold operations in December 2013 due to depleting ore reserves and lower margins. The gold plant has been placed on care and maintenance while the Sepon operation focuses on copper production.

## Mine closure planning

We are committed to minimising the legacy impacts on the environment post-closure of our operational activities. We adopt a life-of-asset approach to closure planning which includes technical assessment, forecasting, and consulting with relevant stakeholders. The content and level of detail in our Closure Plans depends on the timeframe to closure and decommissioning of the asset. We focus our business resources on assets within five years of expected closure.

We also aim to manage the impacts of mine closure on employees, host communities and economic development through our workforce transition strategies and the social development programs we implement during operations. By aligning our social development programs with our Life-of-Asset Plans we are focusing on longer-term economic development which is not reliant on mining and can be sustained post-closure.

In preparation for the completion of mining, MMG invested more than US\$19.8 million in rehabilitation at Century during 2013 and 2014. Key activities during this period included:

- Construction and monitoring of three trial cover systems for long-term encapsulation of the Century tailings;
- Construction of store and release cover systems on two waste rock dumps to prevent water seepage;
- Relocation of water material associated with activities during project feasibility;
- Construction of topsoil pockets to enhance biodiversity;
- Small earth work projects relating to sediment management, clean water diversion, seepage interception and the realignment of a creek diversion; and
- Collection of native seeds from the area for re-vegetation of waste rock dumps, in consultation with Traditional Owners.

This program of mine closure planning, rehabilitation and related works will continue up to and following the completion of Century open-pit production. The ultimate aim of Century's rehabilitation program is to return the area to its pre-mining use low intensity cattle grazing and native habit. This may take up to approximately 40 years.

6

## MALAYSIA

### 6.1 Country Information

Malaysia (Figure 6.1) is one of the active mining countries in Southeast Asia with significant mineral reserves at an estimated value of RM235 billion (USD55 billion) (JMG, 2016). These mineral reserves are inclusive of coal, ferrous and nonferrous metal, and industrial minerals not including oil and gas.



Figure 6.1 Map of Malaysia.

Mining in Malaysia is an activity associated with minerals defined in the Malaysian Mineral Development Act 1994 and State Mineral Enactment as any substance, whether in solid, liquid or gaseous form, the occurring naturally as a result of mining in or on the earth or as a result of mining in or under the sea or seabed, formed by or subject to a geological process, but excluding water, and rock material as defined in the Malaysian National Land Code and petroleum as defined in the Malaysian Petroleum Act 1966. The Mineral Development Act 1994 defines power of the federal government to regulate mineral exploration, mining, and mining-related activities whereas the State Mineral Enactment gives the state the power to issue mineral prospecting and exploration licenses, and mining leases.

The National Mineral Policy 2 of Malaysia sets out the principles leading to sustainable mining. It emphasizes the sustainable development of mineral resources, environmental stewardship, and progressive and post-mining rehabilitation. The objectives of the National Mineral Policy 2 are:

- To ensure sustainable development and optimum utilization of mineral resources;
- To promote environmental stewardship that will ensure the nation's mineral resources are developed in an environmentally sound, responsible and sustainable manner;
- To enhance the nation's mineral sector competitiveness and advancement in the global arena;
- To ensure the use of local minerals and promote the further development of mineral-based products; and
- To encourage the recovery, recycling and reuse of metals and minerals

The National Mineral Policy 2 is supported by nine major thrusts for the effective management of the objectives above. Thrust 3, Environmental Stewardship, highlights the will to ensure that the mineral resources development activities are undertaken in a sustainable manner and that environmental stewardship will be incorporated throughout the development process.

## 6.2 Mining History

Malaysia has a long mining history since the glorious era of tin mining in the 1820s in Perak and Selangor. Since then, the mining industry has been instrumental in contributing to the growth and development of the economy of the country by producing tin, gold, iron ore and others.

In 1880, large tin deposits were discovered in the district of Kinta, these tin deposits proved to be rich and extensive. Kinta Valley then became the largest tin field in the world, however, the world largest and deepest opencast tin mine was located in Klang Valley, which was the Sungei Besi Mines (Figure 6.2). The mine reached a depth of 634 feet (193 m) and was more than one mile (1.6 km) long and half a mile (0.8 km) wide at the surface. Today, the water-filled pit became a Mine Resort City (Figure 6.3), a complex of hotel, shopping mall, office buildings, residential and recreational parks developed over the ex-mining land.



**Figure 6.2** The Sungei Besi Mines previously (above) and now (below- The Mines Resort City (Figures 6.3)).

Another historical tin mine in Malaysia was the Sungai Lembing Tin Mine in Pahang. This mine was the most productive underground tin mine which operated for more than a century until the late 1990s. Now a part of the abandoned adits has been reclaimed as an underground museum for tin mining heritage as part of Sungai Lembing Museum (Figures 6.4 and 6.5).



**Figure 6.3** The Mines Resort City build over ex-mining land.



**Figure 6.4** Part of the tunnel in Sungai Lembing Tin Mine reclaimed as underground tin museum.



**Figure 6.5** A display in the underground tin mine museum.

In Malaysia, it has been shown that land in which all the economic minerals have been mined-out could be rehabilitated and transformed into other forms of economically sustainable development as new sources of growth and wealth for the nation.

### **6.3 Status of Minerals Industry 2016**

In 2016, the Malaysian real Gross Domestic Product (GDP) economy recorded a growth of 4.2%. An increase in domestic demand and growth in the country's exports contributed to the economic growth. The output of the Mining and Quarrying sector recorded a modest growth of 2.7%.

Global mining industry in 2016 faced a challenge year due to slower economic growth, lower demand and low commodity prices, Malaysia's domestic mineral production experienced a decrease of 21.8% in total output valued at RM5.58 billion in 2016 compared with RM7.14 billion in 2015. The decrease in value was caused mainly by lower production of minerals. Shown in Table 6.1 are the mineral production rates and values of the minerals in 2016, not including oil & gas.

**Table 6.1** Malaysian mineral production and value for the year 2016

	<b>TYPE OF MINERALS</b>	<b>PRODUCTION (TONNES UNLESS OTHERWISE SPECIFIED)</b>	<b>2016 VALUE (RM MILLION)</b>
(i)	Mettalic Mineral		
	Tin-in-concentrates	4,158	35.49
	Bauxite	342,924	388.76
	Gold (gram)	2,248,990	780.82
	Ilmenite	4,316	1.51
	Iron ore	1,914,232	443.35
	Manganese	700,717	82.21
	Rare earth minerals	1,880	14.13
	Struverite	77	1.49
	Rutile	3,810	7.62
	Zircon	653	1.63
	Silver (gram)	1,075,325	2.52
	Subtotal		1,191.80
(ii)	Non-Mettalic		
	Aggregates	133,072,882	2,263.17
	Sand and gravel	44,944,336	819.94
	Limestone	25,431,150	351.39
	Clays	5,794,833	62.36
	Earth materials	25,490,877	259.81
	Silica sand	5,408,814	249.30
	Kaolin	392,932	35.52
	Feldspar	441,857	25.76
	Mica	4,701	2.82
	Subtotal		4,070.07
(iii)	Energy Mineral		
	Coal	2,414,765	316.11
	<b>Grand Total</b>		<b>5,577.98</b>

The main metallic minerals produced in Malaysia are gold, iron ores, tin-in-concentrates, bauxite and manganese. For non-metallic minerals there are aggregates, sand and gravel and limestone. In the year 2016, there were 126 mines throughout the country (JMG, 2016), which comprised tin mines (18), bauxite (3), iron (41), kaolin (19), gold (12), silica sand (8), coal (8), manganese (10), mica (2) and feldspar (5).

Mineral Trade in Malaysia showed an 8.7% (RM5.47 billion) decreased in the total export value in the year 2016 compared to RM5.99 billion in 2015. The main minerals exported were metallic minerals such as iron ore, bauxite, copper, manganese, and non-metallic minerals such as aggregates and limestone flux. The significant decrease in export value was contributed by lower bauxite production due to the implementation of the moratorium.

In 2016, the top three mineral commodities exported were Iron ores (USD 819.3 million), Bauxite (USD 151.7 million) and Copper ores and concentrates (USD 52.92 million). Malaysia has mainly exported minerals to a number of countries including China, Singapore, Japan, Vietnam and Thailand. In term of employment, the mining industry employed a total of 5,029 workers, of which, 1,405 people worked in tin mining, 1,357 people in gold mining and 776 people in iron mining and the rest were in other minerals mining. The mineral royalties received in 2016 was USD 15.402 million. Fees related to mineral tenement issuance was USD 0.4 million.

Mineral resources in Malaysia has the potential to be developed so that the mining sector continues its contribution towards the country's economic development supported by various policies and regulations implemented by the government.

## 6.4 Best Practices of Mine Rehabilitation and Decommissioning

### 6.4.1 Selinsing Gold Mine Manager Sdn Bhd

#### Company Information



**Figure 6.6** Aerial View of SGMM

Selinsing Gold Mine Manager Sdn. Bhd. (SGMM) is 100% owned by Monument Mining Limited (Monument), a Canadian gold mining production and exploration company operating in Malaysia. Consists of the Selinsing Gold Deposit and the Damar Buffalo Reef Explorations properties, SGMM has a current total land size of approximately 2,220 acres. Selinsing is an open-pit gold mine (Figure 6.6) in Malaysia, approximately a two-hour drive from Kuala Lumpur, in Pahang State, which is the largest gold producing state in Malaysia. Based on the currently defined resources, SGMM has a mine life of around 10 years from 2009.

Ore is excavated from the SGMM open-pit by drilling and blasting. Excavated ore is crushed and screened then transferred via conveyor to the crushed ore stockpile. Crushed ore is combined with quick lime and transferred to the mill via conveyor where it undergoes grinding and classification. Gold is recovered from the host rock by a series of steps that includes a gravity

circuit, carbon-in-leach process, acid washing, elution, carbon regeneration, electro winning and smelting. A tailings storage facility (TSF) is designed to hold ground waste rock from the milling process. Waste rock disposal facilities have been constructed to manage waste rock from the open pit. Detoxification ponds are designed to neutralize the cyanide concentration and reduce the levels of metals generated from gold processing activities prior to discharge to existing drainage, Sg. Selinsing.

#### Project History

- June 2007: Selinsing and Buffalo Reef properties acquired
- November 2007: Preliminary Assessment report completed
- June 2008: Capital raising to fund mine construction completed
- October 2008: Construction decision announced
- October 2009: First gold pour from gravity circuit
- June 2010: Construction of CIL circuit completed
- September 2010: Commercial production declared
- December 2011: Tailings Storage Facility expanded to accommodate 1M tonnes per year for 10 years
- June 2012: Process Plant expanded to 1M tonnes per year capacity
- September 2015: Constructed Intec pilot plant for Intec Trial Testing Program
- November 2016: Updated Resources and Reserves at Selinsing/Buffalo Reef
- May 2017: Commenced FEED and internal DFS using BIOX Process for the Selinsing Gold Mine

### **Best Practices of Mine Rehabilitation and Decommissioning**

#### **Safety and Health**

SGMM is committed to the protection of life, health and the environment. The company believes in the necessity of providing a safe work environment for all SGMM employees, as well as contributing to the safety and protection of the community. SGMM will focus its resources to achieve shareholder profitability in all of its operations without neglecting its commitment to sustainable development.

SGMM respect the needs and culture of the local communities, and their employees are responsible for incorporating the actions necessary to fulfil this commitment into their planning and work.



**Figure 6.7** An employee inspecting processing plant.

To meet its responsibilities, SGMM provides its employees with the necessary resources to:

- Design, construct, operate and close its facilities to comply with applicable local regulations and laws and to meet international guidelines.
- Promote employee commitment and accountability to this policy and enhance their capabilities in its implementation through the use of integrated management systems.
- Promote the development and implementation of effective, realistic systems to minimize risks to health, safety and the environment. Be proactive in community development programs so the communities are not reliant on the mines for their future.
- Communicate openly with employees, local stakeholders and governments on its plans, programs and performance.
- Work cooperatively with government agencies, local communities, educational institutions and suppliers to achieve safe handling, use and disposal of all our materials, resources and products.
- Use the best technologies to continuously improve the safe, efficient use of resources, processes and materials.



**Figure 6.8** At work training.

## **Environmental Management**

The topography of SGMM project is gently undulating with a relief of about 90 m in elevation from the highest point on the hill slopes along the western boundary and lowest point at the south eastern boundary. The local geology comprises quartz veins and stockwork mineralization within the shear zone, amidst host rock of cataclastic mylonite, purple argillite and yellow siltstone.

Before current operations by SGMM commenced, the mine was an existing mine operated by another entity. Apart from the forest reserve bordering the mine on the southeast and north and a secondary forest to the west of the TSF, none of the original forest cover remains. The remaining surrounding area has been converted to oil palm plantations. As such, from a closure perspective, biodiversity is not a critical concern. However, sustainable development issues will be considered as part of an integrated mine closure plan and in line with SGMM's closure objectives for measures that are able to sustain a natural habitat.

The development of a mining operation, including associated processing facilities and infrastructure, usually involves the temporary and permanent alteration of existing landforms, disturbance to vegetation and flora and disruption of fauna habitats. These impacts can generally be described as either primary or secondary from the direct destruction of habitats at the mine site to supporting activities beyond the immediate mine site, such as access and haul roads. Therefore, the closure plan has considered the following sustainability criteria:



**Figure 6.9** Environmental monitoring using biological method (fish).

- The post-mined landscape is compatible with the existing ecology;
- The post-mining land use is clearly defined, takes into consideration plans for future land use and meets community and government expectations; and
- The success criteria are agreed with relevant stakeholders, monitored and reported to stakeholders.

The final reclamation period would begin when mining ends. This would be followed by post-closure monitoring for up to two years to ensure all issues relating to the closure aspects comply with regulatory requirements. During the current pre-closure stage, closure planning considerations will be made in terms of information available, the scale of operations, and mine planning to better facilitate the transition from mine's operation towards closure. Issues such as Acid Mine Drainage (AMD), re-vegetation, slope stability, erosion and drainage control will be addressed at this stage to assess the area of weakness and methods of prevention or mitigation to deal with such recurring risks throughout the mine closure plan.



**Figure 6.10** SGMM Orchard is part of rehabilitation area planted with fruit trees.

At the closure stage, once operations of facilities cease, decommissioning for machinery and plant takes effect. Final re-contouring and cover of disturbed areas takes place. The post-closure stage will primarily comprise of the operation of detoxification plant, monitoring and maintenance activities. The detox plant is expected to treat and detoxify the residues contained in the existing TSF and detox ponds prior to their ultimate closure. Monitoring will provide information on the progress of the closure plan to address closure issues such as AMD, slope stability and re-vegetation of disturbed land. Ideally, maintenance of implemented measures such as drainage and erosion control will be minimal and decrease as the post-closure monitoring period progresses. The time frame required for this stage shall be in agreement with local regulatory committee or agency to achieve compliancy. For SGMMM, it is expected that the post-closure period will be for a two-year period.



**Figure 6.11** SGMM Nursery grows plant for revegetation of disturbed area.

Consideration on closure issues were identified at the onset of mining activities and will continue to be reviewed and assessed during closure planning. By identifying crucial issues, environmental impact will be prevented due to proper mitigation prevention measures. Issues concerning physical and geochemical stability will present an on-going and long-lasting reputational and financial risk if these concerns are not addressed appropriately. Therefore, prior to the actual closure, issues such as AMD, erosion, drainage and slope stability control including re-vegetation will be given precedence. The AMD and stormwater drainage as well as the slope and re-vegetation plans.

## **Social Development**

SGMM recognises its socio-economic responsibility in the development of the Selinsing Gold Mine. Supply of materials, equipment and services to support mining and exploration operations, workforce hire, the payment of royalties to Government, corporate and other taxes all contribute to the economic stimulus of the local community and the state government of Pahang.

Economic activities of the communities surrounding the mine are mainly centred around agriculture, subsistence fishing, small holder oil palm plantation and tourism such as home stay activities. About 83% (164 persons out of 197 workers currently employed) of the mine workers are employed from the surrounding villages. Socio-economic impacts will be limited to potential loss of business to the mine vendors such as local businesses and contractors and loss of employment of locally employed staff.



**Figure 6.12** Education support to school children.

As part of its commitment to be a responsible corporate citizen and community development program, SGMM has implemented programs such as scholarships, periodic community dialog and engagement, and sponsorship programs. SGMM Community Social Responsibility (CSR) programs are designed to support the cultural and socio-economic development of the local Malaysian community. Financial support to various community groups in the State of Pahang is provided to assist in carrying out their social objectives. The Company is actively working to provide scholarships to a selection of local students to pursue an education in mining and mineral processing related courses at local universities. Ongoing educational support is also given to students from the local primary and secondary schools for conducting their education activities (Figure 6.12).



**Figure 6.13** SGMM mine workers are mostly employed from the surrounding villages.

There are many stakeholders with interest in or who will be affected by the mine closure. Stakeholder engagement by SGMM in the planning and decision making is important in order to:

- Understand the likely environmental, social and economic impacts of mine closure on affected communities;
- Take into consideration the interests and expectations of the respective stakeholders;
- Ensure the process of closure occurs in an orderly, cost-effective and timely manner;
- Establish a set of indicators which will demonstrate the successful completion of the closure process;
- Establish completion criteria to the satisfaction of the responsible authority;
- Ensure support for closure decisions; and
- Enhance public image and reputation.

Stakeholders relevant to SGMM include government agencies, local businesses and the local community. An initial list is provided below with a preliminary Stakeholder Engagement Plan:

- Government agencies
- Land Office
- Department of Minerals and Geoscience
- Department of Environment (DOE)
- Department of Drainage and Irrigation (DID)
- Local businesses such as SGMM vendors and contractors
- Local communities including villages and schools.



**Figure 6.14** Native support program with the aboriginal people in Kuala Lipis.

The CSR programs work closely with the local medical system to promote health within the local community. Discussion and dialogue with the medical clinics in Sungai Koyan and Kuala Lipis occurs on a regular basis to help the Company understand the health issues and needs within the community so that remedial intervention may be considered. For example, SGMM has assisted the local clinic by addressing shortfalls in some emergency medical supplies. e.g. anti-venom for snakes, especially the viper and the cobra families. Continuous community engagement is seen as critical in the ongoing operation of the Selinsing mine.

#### **6.4.2 J Resources Sdn Bhd**

##### **Company Information**

The Penjom gold mine was Malaysia's largest gold producer and was developed by Avocet after applying modern technology to grass roots exploration in an area of historic alluvial mining. The mine is located in Pahang State, approximately 120 km north of Kuala Lumpur.



**Figure 6.15** Aerial View of Kalumpang Pit of Penjom Gold Mine (2018).

The mine was commissioned in December 1996 with reserves of 223,000 ounces. Successful resource development means Penjom has produced over one million ounces of gold to date and still has over 1.2 million ounces of resource. In the late 1990s, Avocet was able to overcome initial problems of carbonaceous ore at Penjom by developing unique processing systems, including complex gravity circuits and resin-in-leach (RIL) technology. These processes have potential applications at the other carbonaceous orebodies.

In 2008 Penjom expanded its mining and plant capacity with plant throughput increasing from 570,000 to over 700,000 tons per annum to compensate for decreasing mined grades. In 2012, the Avocet assets were acquired by PT J Resources Nusantara (JRN), then placed under J Resources Asia Pasifik Tbk.

## Safety and Health

It is the ambition of the J Resources to become a safety leader, and to create a workplace without fatalities, injuries or occupational diseases. Their success depends on our ability to change and improve safety performance by implementing their EHS Policy as well as rolling out the Integrated Management System. To achieve this strong safety and health ambition they need to resolve challenges that arise and are committed to transforming At-risk behaviours at all levels of the organization to become Safe-behaviours. J Resources is committed to compliance with the requirements of the OHSAS18001 Guideline and as such all operations, including Head Office, achieved certification in Q1-2016.



Figure 6.16 PPE Awareness at Penjom Gold Mine.

## Environmental Management

Pit revegetation: Pit revegetation in Penjom Gold Mine were done on waste dump and mining areas. The activities for revegetation are tree planting, landscaping, slope control, grass seeding (Figures 6.17-6.22), siltation ponds, water sampling and nursery.

The types of tree planted are:-

- Merawan Siput Jantan
- Meranti Demak Tipis
- Khaya
- Sentul
- Meranti bukit, kapur
- Karas (Gaharu)
- Jelutong
- Others



**Figure 6.17** 1 Employee 1 Tree Program.



**Figure 6.18** Grass on pit revegetation area.



**Figure 6.19** Successful revegetation on mine site.



**Figure 6.20** New trees planted on North East Dump in 2016.



**Figure 6.21** Trees planted on North Dump in 2004.



**Figure 6.22** Trees planted on Tailings Dump in 2012.

**Nursery Facilities:** The nursery facilities here cater for landscaping and rehabilitation area around the mine site (Figures 6.23-6.24). The total rea for nursery is 5200 m<sup>2</sup> which was launched officially in August 2016. This facility consists of seedling area, composting shed, germinating shed, soil mixing area, hardening bed, surau, toilet and office. The maximum capacity of trees sapling at one time is approximately 20,000 saplings.



**Figure 6.23** Penjom Gold Mine nursery.



**Figure 6.24** Selected plants grows in nursery for tree planting  
Erosion Control: A method of Erosion Control on exposed soil in Penjom Gold Mine is by using Cover Cropping and Fibro mat (Figures 6.25-6.27).



**Figure 6.25** Fibro mat for cover cropping are made from recycled paddy hays.



**Figure 6.26** Cover Cropping and Fibromat.



**Figure 6.27** Successful Cover Cropping and Fibromat.

## **Social Development**

J Resources took CSR very seriously and presently focus on three areas; Sustainable Development Approach; Corporate Social Investment (CSI) programs, and Sustainable Development (SD) Reporting. It is a major undertaking and is always work in progress, they call it “continuous improvement”.



**Figure 6.28** Community service to help flood victims.

Their Sustainable Development Approach includes:

- Reducing Resource Consumption – the company is reliant on non-renewable resources to conduct its business. The efficient use of these resources is of utmost importance and directly contributes to the resilience of the company, whilst assisting it to adapt to an environment that is increasingly resource constrained.
- Minimizing our Environmental Impacts – They adopt a pro-active management approach when considering potential environmental impacts. The minimization, mitigation and management of these impacts are key components of the Company’s duty of care.
- Creating a Safe and Healthy Working Environment – J Resources promotes a culture of zero harm and responsible care. Their workforce is the most valued asset and their continued good health and safety will always be priority.
- Developing and Retaining of their People – Their human resource strategy is to engage, develop and retain professional and first-class employees. They consider this to be a key element in achieving operational excellence.
- Optimizing Community Benefit - the operations are mostly based within existing socio-economic environments. They benefit from mining and their other activities during the life of these operations and in turn they regard it as their moral obligation to contribute to the sustainable socio-economic growth of the communities in which they operate.

J Resources Corporate Social Investment (CSI) programs strive to add value within the immediate communities in which they operate. They also understand that due to location, political climate and demographics each community may have its own set of dynamics and the intention is therefore not to dictate to the communities, but rather to provide a structured method by which everyone can align themselves with the J Resources CSR Policy and the CSI approach.

Their Sustainable Development (SD) Reporting is a commitment to develop and implement Sustainable Development reporting based on current best practice. The Company has decided to start by compiling an internal report for 2015 and to follow that up by full public reporting from 2016 onwards.

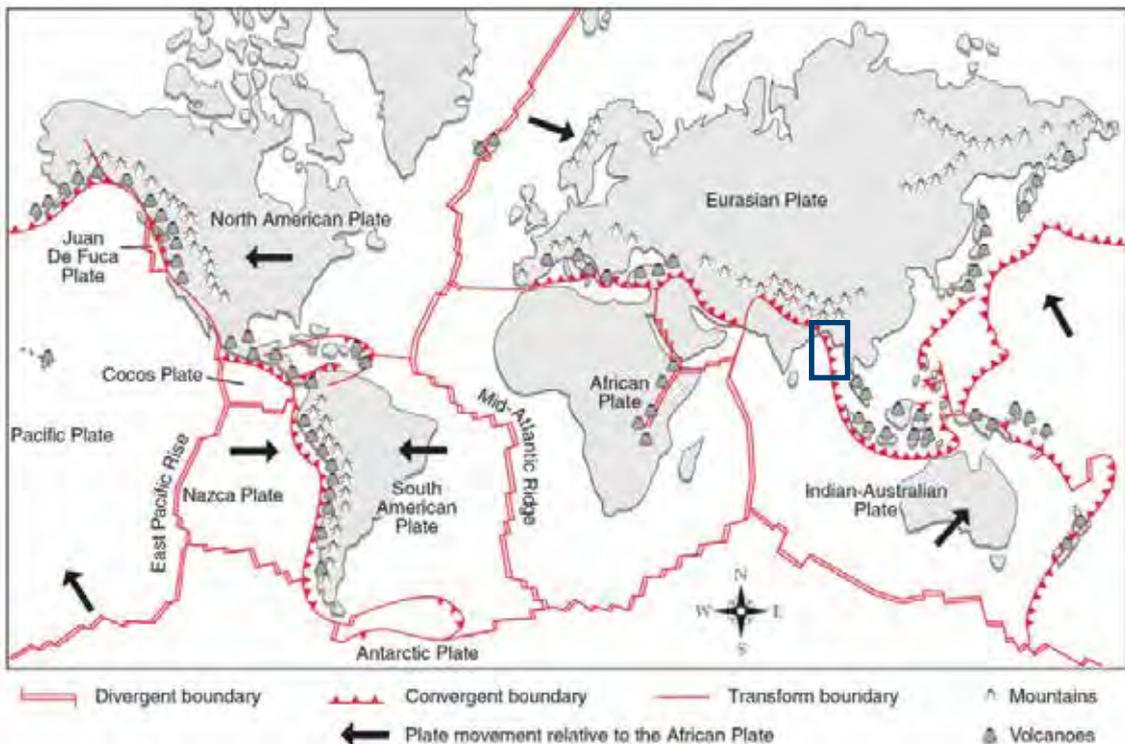
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## MYANMAR

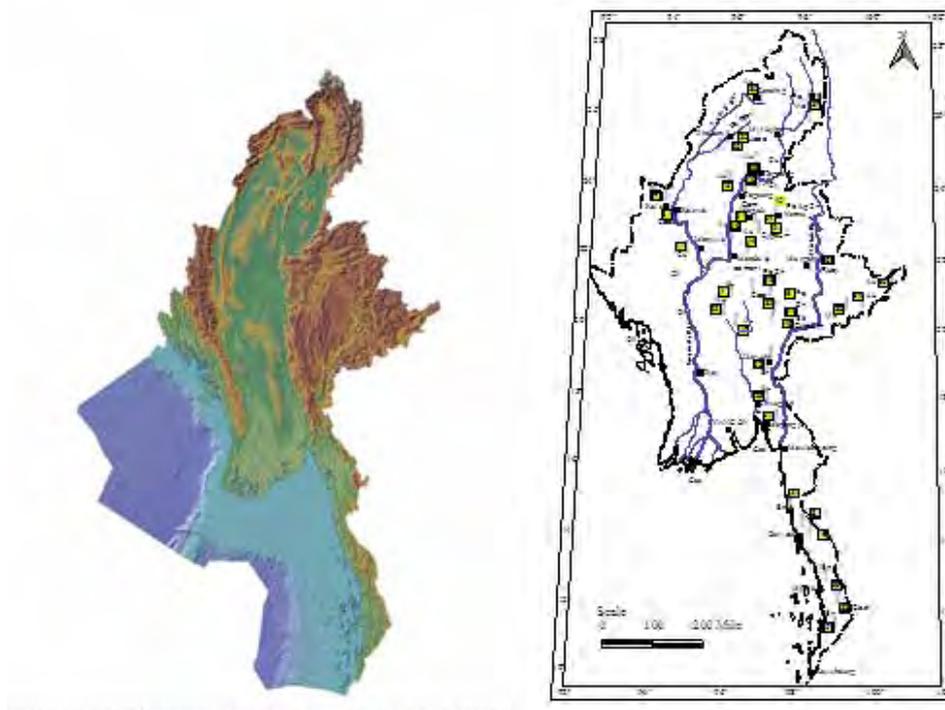
### 7.1 Country Information

The Republic of the Union of the Myanmar covers an area of 678,528 km<sup>2</sup> with the coast line of 2,000 km long. The population of the country is about 58 million with more than 135 different ethnic groups. Myanmar shares its 4,000-km-long borders with Bangladesh to the W; India to the NW; China to the N and NE; Lao' Peoples' Democratic Republic to the E; and Thailand to the E and SE. The Union includes seven states and seven regions.



**Figure 7.1** Location of Myanmar in the Plate Tectonic Boundary Map.

Myanmar has adopted the market orientated economic system in 2012. New legal instruments are encouraging the private sectors, and allowing Foreign Direct Investment (FDI). And also initiating institutional changes and promoting external trade by streamlining export and import procedures.



**Figure 7.2** Geomorphology and Major Mining Area Map of Myanmar.

The Government of Myanmar was seeking to encourage the participation of foreign and local investors in part to draw in industry experts who have the knowledge of how to develop the country's mineral industry. The Union of Myanmar's Mine Law went into effect in September 1994, and the rules related to the law were implemented in December 1996. The Ministry of Natural Resources and Environmental Conservation is the Government entity responsible for implementing the Government's mineral policy, for planning, and for enforcing the laws and regulations related to the mineral sector. The Ministry evaluates and processes all license applications for the prospecting, production and beneficiation of minerals in accordance with the Mines Law and regulations.

The government of the Union of Myanmar has already created short and long-term environmental policy which balances environmental needs and development requirement. There are also environmental policies for using natural resources; there are laws, rules and regulations to control pollutions and other undesirable consequences that resulted from development activities. The national environmental policy, in short, is sustainable development.

## 7.2 Mining History

Myanmar has a potential for development of a large variety of minerals, including antimony, coal, chromium, copper, Jade and gemstones, gold, iron, lead, zinc, tin-tungsten, manganese, natural gas, nickel, crude petroleum, and as well as platinum group metals. A portion of the production was consumed domestically. However, most of the productions of ores and concentrates of chromium, copper, manganese, tin-tungsten and zinc, jade and gemstones and refined lead were exported principally to the Asian market.

In November 1988, the Government adopted an open-door policy, enacted a Foreign Investment Law, and formed an Investment Commission to attract foreign companies to participate in joint exploration and development of mineral resources in Myanmar. Production of copper, lead, silver, zinc, chromite, coal, iron, manganese, nickel, steel and industrial minerals was controlled by the state-owned No. 1 Mining Enterprise. Production of antimony, gold, tin and tungsten was controlled by the state-owned No. 2 Mining Enterprise and other small scale private and joint government-private mining enterprises. Production of jade and gems was controlled by the state-owned Myanmar Gems Enterprise.

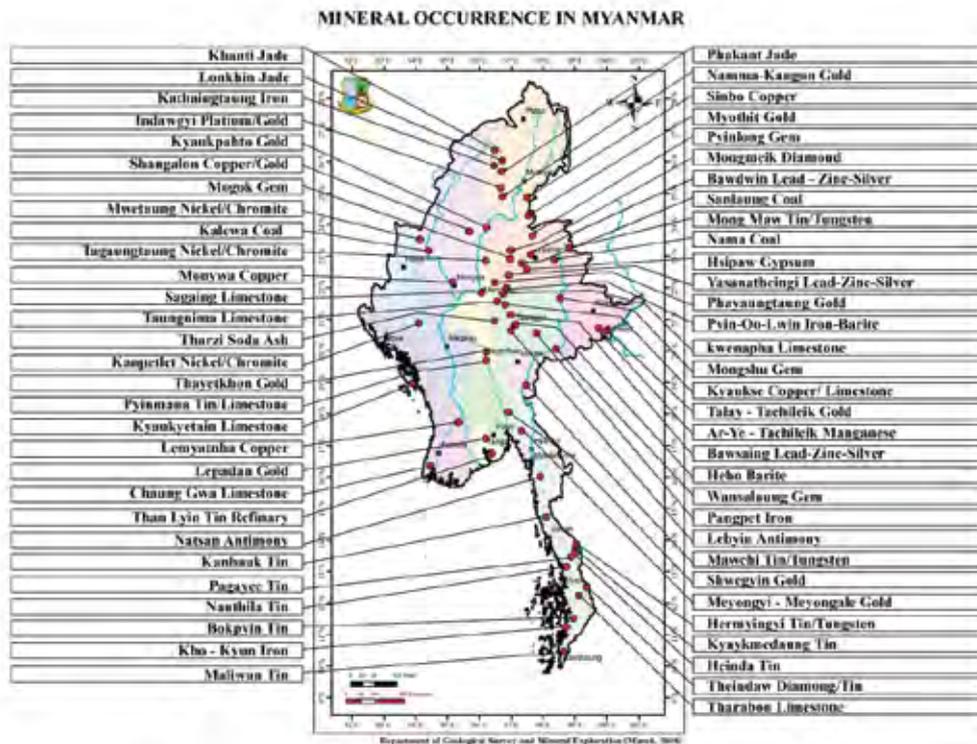


Figure 7.3 Major Mineral Occurrences in Myanmar.

Myanmar has several copper occurrences, including world-class high-sulphidation Cu  $\pm$  Au deposits west of Monywa on the west bank of the Chindwin River. There are three major copper deposits – Sabetaung and Sebetaung South (67 Mt @ 0.25 % Cu), Kyisin taung (391 Mt @ 0.31 % Cu and Letpadaung Taung (1478 Mt @ 0.37 % Cu).

The Monywa copper deposit was operated by Myanmar Ivanhoe Copper Company Ltd. (MICCL) from 1998 and was later taken over by Myanmar – Wanbao Company of China in 2011. The Sabataung and Sebetaung South pits have produced over 400,000 tons of copper cathodes. Heap leaching and Electro-Winning (SXEW) methods are employed for copper production.



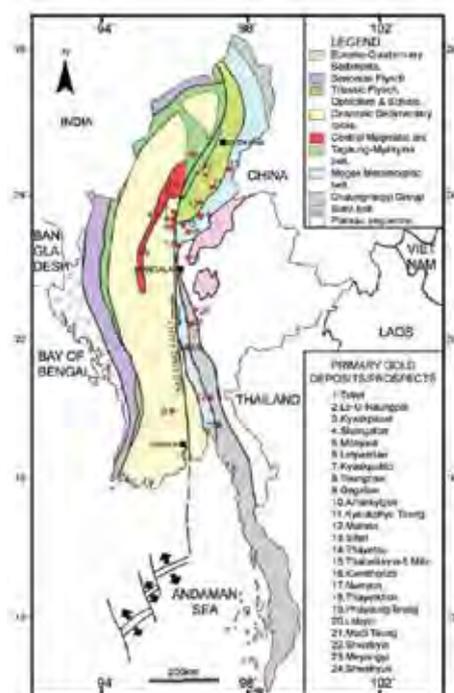
**Figure 7.4** Photograph shows Sabetaung Open-pit, Monywa Copper Mine, Sagaing Region.

The production of lead, silver and zinc mostly was from both open pit and underground operation at the Bawdwin Mine in Northern Shan State, Myanmar. The underground mine at Bawdwin was estimated at 5 million metric tons averaging 7.46% lead, 3.17% zinc, 0.14% copper, and 4.58 g/t silver. Ore reserves for the open pit mine at Bawdwin were estimated at 9 million metric ton averaging 5.17% lead and 4.00% zinc. The less known Bawsaing Mine, near Kalaw in the Shan State, and the Yadanatheingi Mine, near Kyaukme in Shan State produced small quantities of lead sulphide and lead carbonate concentrate; and the Longh Keng Mine, near Mong Pawn in Shan State, produced a small quantity of zinc carbonate.



**Figure 7.5** Bawdwin Open-pit Mine (2013).

Myanmar has more than 300 gold occurrences. Many of these deposit are currently being or have recently been exploited, mostly on a small scale by Licensed concerned.



**Figure 7.6** Major tectonic belts and location of major gold deposits and prospects in Myanmar (compiled after Mitchell et. al., 1999; Khin Zaw et al., 1999; 2014; 2015; Ye Myint Swe et al, 2004).

The Production of tin and tungsten is gradually increased owing to increased output from the Government and private joint venture. Most of tin and tungsten were produced from the Mawchi Mine in Kayah State, at the Heinda and Kanbauk open pit mines in Tanintharyi Region.



**Figure 7.7** Mawchi Tin and Tungsten Mine, Kayah State.

Myanmar also produced a variety of industrial minerals in small quantities and significant amounts of precious and semiprecious stone. Production of industrial minerals, such as barite, bentonite, clays, dolomite, feldspar, gypsum and limestone are mainly for domestic consumption. Production of precious and semiprecious stones, such as jade, rubies, sapphires, and other gemstones was exported.



**Figure 7.8** Rubies (Left) and Sapphires (Right) of Myanmar.

### **7.3 Status of Minerals Industry**

Myanmar is richly endowed with mineral resources and is one of the largest producers and exporters of jade. Myanmar produced a variety of mineral commodities, including natural gas, petroleum, coal, copper, precious and semi-precious gemstones, tin, tungsten, and zinc. According to the Central Statistical Organization, natural gas accounted for 29% of exports and gemstones for 10% of exports during April 2013 – March 2014 and the extractive sector is the second largest source of foreign direct investment.

The mining sector operates both through granting concessions to private investors and through State Owned Mining Enterprises placed under the authority of the Ministry of Natural Resources and Environmental Conservation (MONREC).

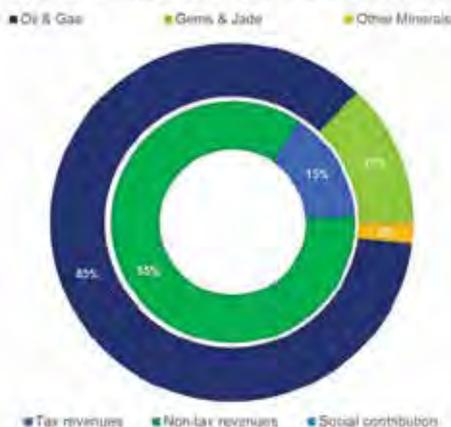
In the gemstones subsector, around 90% of the world's supply of rubies comes from Myanmar and the country is also the world's largest single source of Jade. The Government of Myanmar prohibits the extraction of precious gemstones by foreign investors.

*Figures in million MMK*

Sub-sector	Tax revenues	Non-tax revenues	Social contribution	Total revenues	%
Oil & Gas (*)	433,285	2,129,972	5,736	2,568,993	85%
Gems & Jade	-	380,197	8,570	388,767	13%
Other Minerals	3,303	52,711	2,017	58,031	2%
<b>Total</b>	<b>436,588</b>	<b>2,582,680</b>	<b>16,323</b>	<b>3,015,791</b>	<b>100%</b>

(\*) Including revenues collected from transport of oil and gas

Figure 1: Relative size of revenue stream and sub-sectors



**Figure 7.9** Relative size of revenue stream and sub sectors  
(Source: EITI Report, 2015).

Minerals	Production value (in million MMK)	in %	Export/Sold value (in million MMK)	in %
Lead, Zinc, Copper, Iron and Antimony (reported by ME 1)	8,775	3%	9,057	19%
Gold, Tin, Tungsten and Sheelite (reported by ME 2)	65,423	24%	37,950	79%
Coal, Manganese, Nickel, Barite, Limestone (reported by ME 3)	204,813	73%	1,123	2%
<b>Total</b>	<b>279,011</b>	<b>100%</b>	<b>48,130</b>	<b>100%</b>

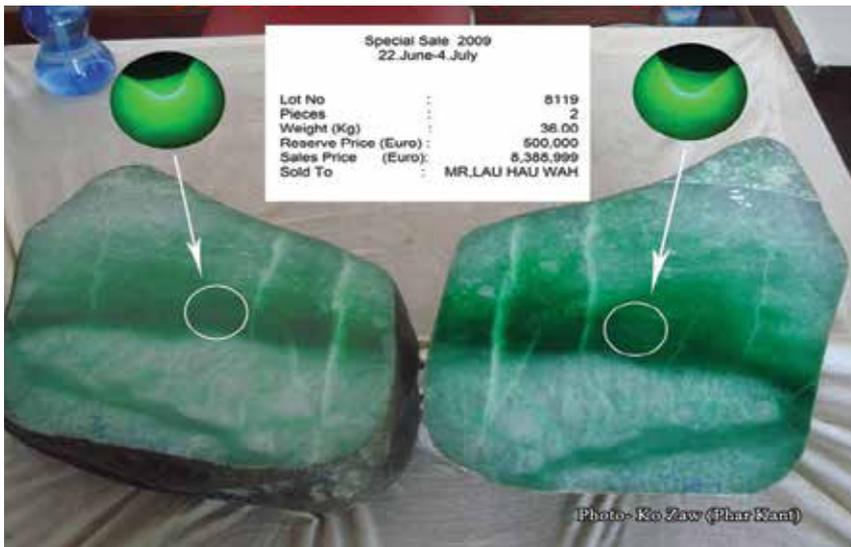
**Figure 7.10** Production and export of other minerals (Source: EITI Report, 2015).

Major minerals produced and exported are cathode copper, refined lead, refined silver, zinc concentrate, refined tin, tin concentrates, tin-wolfram mixed concentrates and coal while gold, iron and steel, limestone, barites and other industrial minerals are produced for domestic consumption. Barites powder produced is used by foreign oil companies working in Myanmar and by the State-owned Myanma Oil & Gas Enterprise (MOGE). Gemstones such as rubies, sapphire, coloured gemstone and jade are also exported.

**Gemstones and Jade:** The best rubies and sapphire in the world are produced from Mogok, Upper Myanmar known as the Land of Rubies since 13<sup>rd</sup> century. The precious stones sold out through annual gemstones emporium and gem trading centres. Jade: Jade is produced from the Kachin State in upper Myanmar. The world famous Jadeite deposits of Myanmar occurs as both Primary and Secondary occurrences in the Jade Mine area, Kachin State. Secondary Jade deposits are more favourable for mining than primary deposits and occur along the Uyu River valley, in Phakant area.



**Figure 7.11(a)** Large Jadeite jade boulder  
(approximately 174,600 kg; 5.79 m x 4.57 m x 4.26 m).



**Figure 7.11(b)** The price of rough Jadeite Emporium 2009.

**Cathode Copper** is produced from: Sabetaung and Kyisintaung (S&K) mine and Letpadaung open-cut located in the Monywa District, Myanmar. The (S&K) mine started its commercial production in January 1999 and annual production at present is approximately 27,000 tons. Recently the S&K Mine and Latpadaung open-pit is operated by Wanbao Mining Limited with the name of Myanmar Yang Tse Copper Limited – MYTCL. The Mine is expected to reach a production capacity of 100,000 tons of Copper cathode within two years.



Figure 7.12 Monthly Production of Copper Mine.



Figure 7.13 Copper Cathodes in SX-EW Plant.

**Refined Lead/ Refined Silver and Zinc Concentrates:** Mining operations in Namtu Bawdwin lead zinc mine started since the fifteenth century. Other lead/zinc mines are Yad-anatheingi and Bawsaing mines all of which are situated in the Shan States. Bawdwin underground mine has its own concentrating plant for the upgrading of sulphide ores of lead, where after the concentrates are fed into smelter at Namtu to produce refined lead and refined silver and zinc concentrates.

**Refined Tin, Tin Concentrate, Tin Wolfram mixed concentrates:** Mawchi mine, situated in Kayah State was well known for its tin tungsten scheelite mixed concentrate in the world market before the second world war. Tin and Tungsten mixed concentrates are also produced from various mines in Taninthayi division. (Heinda, Kanbauk and Kalonta mines). All tin and tungsten mines have been privatized and at present, there is no State-owned operation in tin-tungsten mine apart from the tin smelter in Thanlyin.

**Coal:** Private owned, coal mines in Sagaing and Magwe Region, and Shan State are operated by local entrepreneurs for local consumption. 120 MW coal-fired power plant is being built at Tigyit in the Shan State and coal production will increase significantly in the near future.

**Iron and Steel:** No.1 Iron and Steel Plant at Pyin Oo Lwin smelts iron ore from Kyatwinye mine, 26 miles southeast of Pyin Oo Lwin. No.1 iron steel plant produces sponge iron, pig iron and steel, steel grinding balls and steel round bars. The products are consumed locally for construction works.

**Limestone:** Two types of limestone are produced in Myanmar. Limestone with high in CaO content is used for cement production while limestone with beautiful texture and colour is used as decoration, known as dimension stones. Limestone production is sufficient for the local cement industry.

**TagaungTaung Nickel Deposit** has been operated since 2011. It has been estimated at 40 million tons of lateritic nickel ore with an average grade of 2.02% Ni based on 1.40% cut-off grade in Tagaung Taung area.

## 7.4 Best Practices of Mine Rehabilitation and Decommissioning

### 7.4.1 Monywa Copper Mine

#### Company Information

In 1987, a Myanmar government owned No. 1 Mining Enterprise (ME.1), began for developing the Sabetaung and Kyisintaung copper deposits at Monywa. In 1996 the Sabetaung and Kyisintaung project became a joint venture between ME1 and Ivanhoe Myanmar Holdings Ltd., a subsidiary of the Canadian company. In 2010 the Monywa project (including both Sabetaung and Kyisintaung (S&K) and the Letpadaung mine) was taken over by the UMEHL (The Union of Myanmar Economic Holdings Limited) and the Chinese state-owned enterprise, China North Industries Corporation (NORINCO). From 2010/11 the Monywa project has been operated by Wanbao Mining Ltd., and subsidiary Myanmar Yang Tse Copper Limited, a wholly owned subsidiary of NORINCO operates the Sabetaung Kyisintaung and Letpadaung Taung open pits.



**Figure 7.14** Location of Sabetaung, Kyisingtaung and Letpadaung Taung Copper deposits.

Previously, the copper production at (S&K) was operated about 25,000 tons per year from 2011 to 2015. Up to now, the annual production is about 50,000 tons per year according to the SX-EW plant capacity. The mining operation was completed at the Sabetaung Pit in August 2014, with back-filling of the pit proposed by using waste from the Kyisintaung mining operation.



**Figure 7.15** Monywa Sabetaung Copper Mine Operation in 2014.



**Figure 7.16** Monywa Kyisingtaung Copper Mine Operation in 2014.



**Figure 7.17** Monywa Letpadaung Taung Copper Mine Operation Started in 2015.



Figure 7.18 Re-plantation Plan of Sabetaung – Kyisingtaung- Letpadaung Copper Mine.

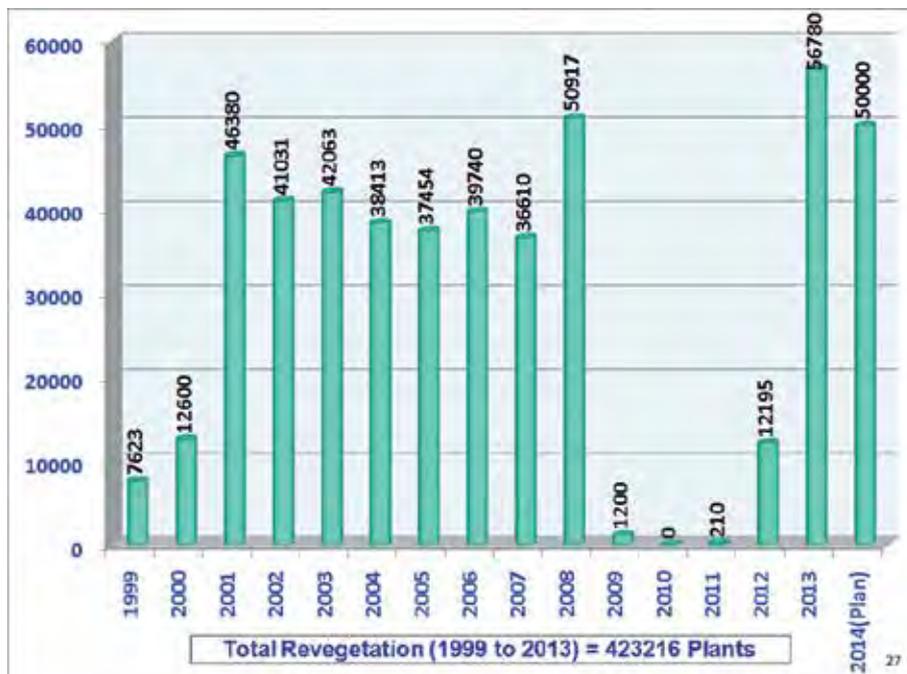


Figure 7.19 Re-plantation of Sabetaung – Kyisingtaung- Letpadaung Copper Mine.



**Figure 7.20** Re-plantation near Sabetaung Open pit.



**Figure 7.21** Tree Planting Activities near Leaching Pad.



**Figure 7.22** Plan Map of the Sabetaung – Kyisingtaung- (S&K) Copper Mine.



**Figure 7.23** Preparation the Drainage channel of Copper Mine.



**Figure 7.24** Tree Planting Activities along mines boundary.

### **Social Development**



**Figure 7.25** The Company donates ambulance to local authority.



**Figure 7.26** The Company donates ambulance to local community.



**Figure 7.27** Donation of school building by company.



Figure 7.28 Development Plan for 19 villages near mine town area.

**Social Status of villages near MYTCL Area**

Sr	Village	Library	School	Dam	Electricity	Play Ground	Drinking Water	Access Road	Clinic/hospital	Number of monastery	Number of house	Number of family	Population		
													Male	Female	TOTAL
1	Kan Kone	No	BEHS donated by MWMCL	No	Good	YES	donated by MYTCL	GOOD (repaired by MYTCL)	clinic	4	659	668	1372	2633	4005
2	Mine Town	YES	BEHS	No	Good	YES	donated by MYTCL	GOOD	Hospital	1	742	742	1469	1484	2953
3	WarTam	No	BEPS	GOOD (repaired by MYTCL)	donated by MYTCL	No	donated by MYTCL	GOOD (repaired by MYTCL)	No	2	260	266	418	800	1218
4	Tel Pin Kan	YES	BEPS	GOOD (repaired by MYTCL)	donated by MYTCL	YES	donated by MYTCL	GOOD (repaired by MYTCL)	No	2	148	177	423	441	864
5	Shwe Pan Khine (old)	No	BEPS	No	No	No	GOOD	GOOD (repaired by MYTCL)	No	3	91	98	215	247	462
6	Shwe Pan Khine (new)	No	No	GOOD (repaired by MYTCL)	No	No	donated by Gov.	GOOD (repaired by MYTCL)	No	no	29	32	85	71	156
7	The Taw Gyi	donated by MYTCL	No	No	No	No	GOOD	GOOD (repaired by MYTCL)	No	1	80	55	128	151	275
8	Ywar Thar	No	BEPS	No	Good	No	NoGood	GOOD (repaired by MYTCL)	No	1	180	201	412	400	812
9	GoanTaw	No	BEPS	No	Good	YES	NoGood	GOOD (repaired by MYTCL)	No	1	185	188	532	486	1018
10	DoanTaw	YES	BEMS	No	Good	No	donated by MYTCL	GOOD (repaired by MYTCL)	No	4	370	430	1009	1001	2010
11	Yey Xyi Pin (old)	No	BEPS	No	No	No	GOOD	NoGood	No	1	146	156	1024	1149	2173
12	Yey Xyi Pin (new)	No	No	No	No	No	NoGood	GOOD	No	29	29	29	372	396	768
13	Kyay Sar Kya	No	BEPS	No	Good	No	GOOD	GOOD	No	1	251	269	539	554	1093
14	See Hsinn Taw Gyi	No	BEPS	No	Good	No	GOOD	GOOD	Clinic	1	418	420	1345	1267	2412
15	Mya Yait	No	BEPS	No	No	No	GOOD	NoGood	No	1	240	563	648	1211	1859
16	Mya Sein	No	No	No	No	No	GOOD	NoGood	No	No	32	32	89	105	194

Figure 7.29 Social Status of 16 villages near mines town.

## Mine Closure Plan of the Sabetaung Copper Mine

The pit closure design includes a seepage barrier to protect the Kangon Aquifer from contact with potentially impacted acidic waters within the pit. The seepage barrier requires a low permeability cohesive material, such as the highly expansive black cotton soils. When the black cotton soils are wetted they will be capable of exerting high lateral pressures against the pit walls and should improve sealing of the interface between the seepage barrier and the pit walls when substantially pressed by the waste rock.



**Figure 7.30** Sabetaung (south) & Sabetaung pit during 2011.



**Figure 7.31** Mine closure stage of Sabetaung Pit, 2014.



Figure 7.32 Back-filling activities of Sabetaung Pit during 2014.



Figure 7.33 Report Cover of Sabetaung Pit Closure Plan Design.

The proposed pit backfill design is based on the assumption that the waste rock from the Kyisintaung Pit will be potentially acid forming and prone to leaching metals, particularly under acidic conditions, and that it will be highly reactive within a short time to acidification and leaching.

The groundwater level data were contoured at three separate time intervals. The early period (January 2007) and middle period (June 2010) data only had groundwater level data from the monitoring bores, with no village well data. The late time period data (a composite data set from March to August 2014) included a series of village well data. The groundwater contours show that the regional groundwater flow direction is to the N-E and that there is a well-developed drawdown cone associated with the Sabetaung Pit dewatering operation resulting in radial groundwater flow towards the pit from the Kangon Sands and from the Yama Stream. Monitoring wells will need to be installed in the back-fill material to monitor the water treatment process. The monitoring wells should be installed such that detailed data on the pore water chemistry within the saturated zone of waste at 25 m vertical intervals can be obtained as backfill progresses.

The detailed pit closure plan combines several complementary technical and design investigations, assessments and analyses. Geotechnical investigations took place to confirm the delineation of the Kangon sands within the Sabetaung Pit. A key objective of the closure plan is to prevent the acid water in the pit from migrating into the highly permeable Kangon Sands, which occurs at the relatively shallow depth of approximately 3 m to 10 m below ground surface and is linked to both the Chindwin River and the Yama Stream. The Kangon Sands is visible on the northern and eastern walls of the Sabetaung Pit.

Myanmar Yang Tse Copper Limited (MYTCL) requested to Knight Piésold for the development of detailed mine closure plan for the Sabetaung Pit. The earlier development of a pit closure plan is to be back-filled, with mine waste materials from Kyesintaung that could include potentially acid forming (PAF) waste. In order to reduce the migration of acid rock drainage (ARD) from the pit into an adjacent aquifer in the longer term, the PAF waste will need to be hydraulically isolated from the regional groundwater system. This document comprises a detailed pit closure report that will form part of the overall site closure plan.

## **7.4.2 Reclamation at Maw Taung Coal Mine**

**The Maw Taung coal mine** near Taninthayi, has estimated to be 3.6 million tons of sub-bituminous coal. Saraburi Coal Co., Ltd. has produced coal from Maw Taung, which covers more than 8,000 Hectares. The coal deposit lies approximately 25 km W of Thai - Myanmar borderline near Prachuab Khirikhan province.



**Figure 7.34** Maw Taung Coal Mine, Tanintharyi Region.



**Figure 7.35** Reclamation at Maw Taung Coal Mine after production.

## 8

## PAPUA NEW GUINEA

*Seymour Pok, Penawa Andrew & Vincent Johnny*

## 8.1 Country Information

Papua New Guinea (PNG) is located in the Oceania Region that occupies the eastern half of the island of New Guinea and shares its land border with Indonesia and maritime borders with Australia, the Federated States of Micronesia, the Solomon Islands, and New Caledonia (France). Its capital is Port Moresby which is located along its southeastern coast.



**Figure 8.1:** Location of Papua New Guinea

(Source: [https://en.wikipedia.org/wiki/Papua\\_New\\_Guinea](https://en.wikipedia.org/wiki/Papua_New_Guinea)).

The PNG mainland and its 600 islands have a total land area of 452,860 sq.km.<sup>1</sup> It has estimated population of more than 8 million people<sup>2</sup>. Papua New Guinea is largely mountainous, and much of it is covered with tropical rainforest. It has a climate characterized by high temperatures and humidity throughout the year. The North West Monsoon season is from December to March while the South West moon season is from May to October<sup>3</sup>. Rainfall is at its heaviest in the highlands with average annual precipitation varying between 2,000 and 5,000 mm.

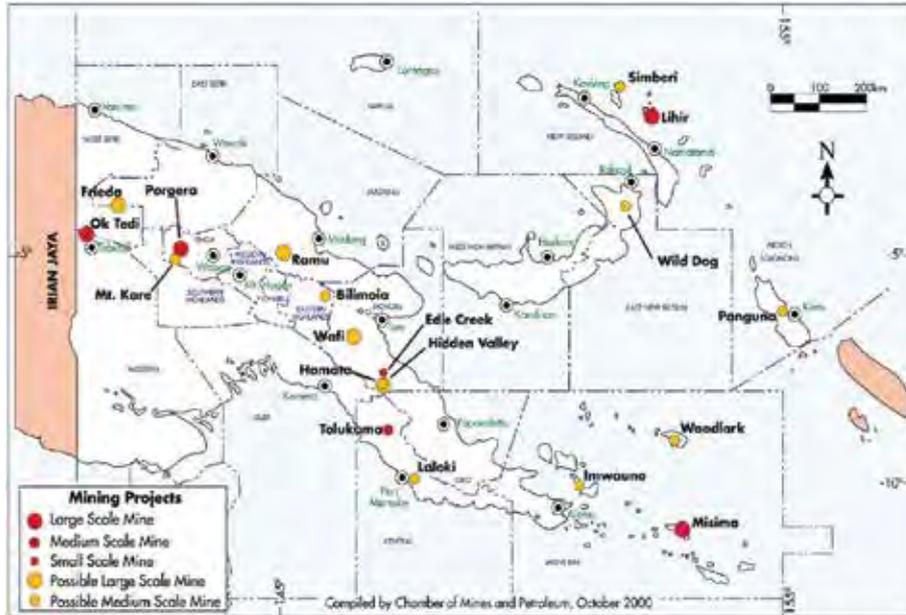
<sup>1</sup> [https://en.wikipedia.org/wiki/Papua\\_New\\_Guinea](https://en.wikipedia.org/wiki/Papua_New_Guinea)

<sup>2</sup> United Nations Department of Economic and social Affairs: Population Division

<sup>3</sup> <https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine-in-Papua-New-Guinea>

## 8.2 Mining History

Papua New Guinea has an extended history of large-scale open pit mining since the late 1960s mining given its favourable setting in the Pacific Ring of Fire. Its geology harbours large quantities of mineral reserves ranging from high-grade gold, copper and silver to nickel and molybdenum which offer great potential for exploration and development.



**Figure 8.2.** Map showing both the exploration projects and existing mines in PNG (Source: PNG Chamber of Mines & Petroleum).

The development of two giant the world-class copper mines, Panguna Copper Mine and Ok Tedi Mine early in the 1960s and 70s respectively consolidated the country's position as a major mineral producing country in the global arena<sup>4</sup>. These were followed by several large-scale mines coming on stream in the early 1990s in the likes of Porgera Gold Mine, Lihir Gold Mine, Misima Gold Mine, and more recently the Ramu Nickel Cobalt project. In addition, a number of small to medium scale mines also came into production including the Eddie Creek, Sinivit and the Crater Mountain. Apart from the other mines, Misima was closed in 2004 followed by Sinivit which ceased operations under controversial circumstances linked to cyanide spillage in the nearby river system<sup>5</sup>.

## 8.3 Status of Minerals Industry

The PNG minerals industry is largely metallic based with copper, gold, silver nickel and cobalt being major exports. Exploration efforts are currently underway through the Geological Survey Division of the Mineral Resources Authority to diversify the country's mineral base into other metallic minerals such as manganese, bauxite, zircon and other rare earth metals. There is also an untapped potential for developing non-metallic minerals such aggregates, limestone, sand and clays in commercial quantities for export. However, this sector is under-regulated and is confined to servicing the local civil works for public use.

<sup>4</sup> Panguna ceased operations in 1994 due to secessionist uprising on Bougainville whist Ok Tedi is currently in operation.

<sup>5</sup> Sinivit mine was abandoned by Canadian owned New Guinea Gold in 2014 after cyanide spillage into the nearby Warangoi River. Heap leaching method was used by the company for mineral recovery.

### 8.3.1 Operating Mines

PNG has been at the forefront of attracting foreign direct investments into the mining industry during a decade of high mineral prices. According to the Mineral Resources Authority, the regulatory body for the mining industry, by March 2012, a total of 299 explorations issued and 275 applications for exploration licenses were received from 132 different companies.

With the global downturn in commodity prices after 2012, interest in exploration declined sharply relegating junior exploration companies either into farm-in arrangements with majors albeit pulling out completely from their ventures due to inability in raising finance to sustain their work programs. The list of operating mines and the potential future mining projects are shown below in Tables 8.1 and 8.2 respectively.

Table 8.1 Current Operating Mines (Source: PNG Mineral Resources Authority, updated as of 2016).

CURRENT OPERATING MINES						
PROJECT	LIHIR	OK TEDI	PORGERA	HIDDEN VALLEY	RAMU NICKEL	SIMBERI
MINING METHOD	Conventional open pit	Conventional open pit	Open pit & underground mining	Conventional open pit mining	Open pit/Strip mining	Conventional open pit mining
MINERALS	Gold	Gold, silver and copper	Gold and silver	Gold and silver	Nickel and Cobalt	Gold and silver
PROVINCE	New Ireland	Western	Enga	Morobe	Madang	New Ireland
YEAR MINE OPENED	1997	1984	1989	2009	2012	2008 (production)
MINE LIFE	30+ yrs	42 yrs (Extension of 10 yrs from 2016 to 2026)	36 yrs (Extension of 11 yrs from 2016)	15 yrs	20+ yrs	20 yrs
TENEMENT	ML 125, 126	SML 1 (O)	SML 1 (P), ML 101	ML 151	SML 8	ML 136
APPROX. PRODUCTION OUTPUT/YEAR	800,000 oz	500,00 oz Au, 170,000t Cu	500,000 oz Au, 90,000 oz Ag	200,000 oz Au	31,000t Ni, 3,300t Co	72,000 oz Au

<sup>6</sup> PNG Chamber of Mines and Petroleum- <http://pngchamberminpet.com.pg/mining-in-png/>

Table 8.2 Potential Upcoming Mines (Source: PNG Mineral Resources Authority).

Potential Project	Mineralization	Proposed Method of Mining	Development Stage	Company
Solwara 1	Submarine massive sulphide	Deep sea minng	ML granted, Mining expected in 2020	Nautilus
Woodlark	Medium epithermal Au	Open cut	ML granted in Jul 2014	Kula Gold
Hessen Bay	Iron sands	Dredging	ML application	Katana Iron
Frieda River	Large porphyry Cu-Au	Open cut	Feasibility	PanAust
Wafi Golpu	Epithermal gold (Wafi) Large porphyry Cu-Au (Golpu)	Open cut initially Underground block-caving afterwards	ML application in March 2018	Harmony Gold
Yandera	Large porphyry Cu-Mo	Open cut	Feasibility	Marengo Mining

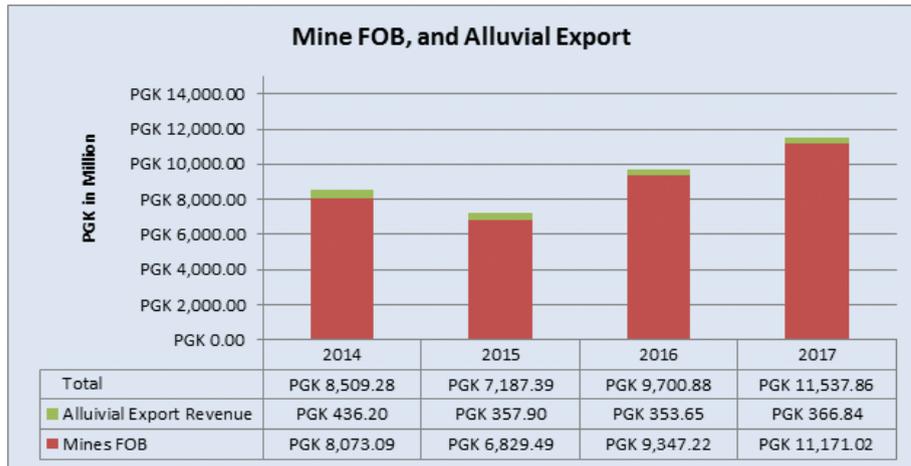
### 8.3.2 Economic Contribution

#### a) GDP/GNP

Papua New Guinea's economy is largely dependent on the resource sector which accounts for more than 60% of the country's GDP through direct export revenues and indirect benefits such as local business contracts, employment, corporate income tax, mineral rents and equity dividends. The mining sector is currently one of the two largest export revenue earners for PNG, LNG being the other. In 2016 mining alone contributed about 38% of the country's export revenue, while LNG contributed 36%.

#### b) Mineral Exports

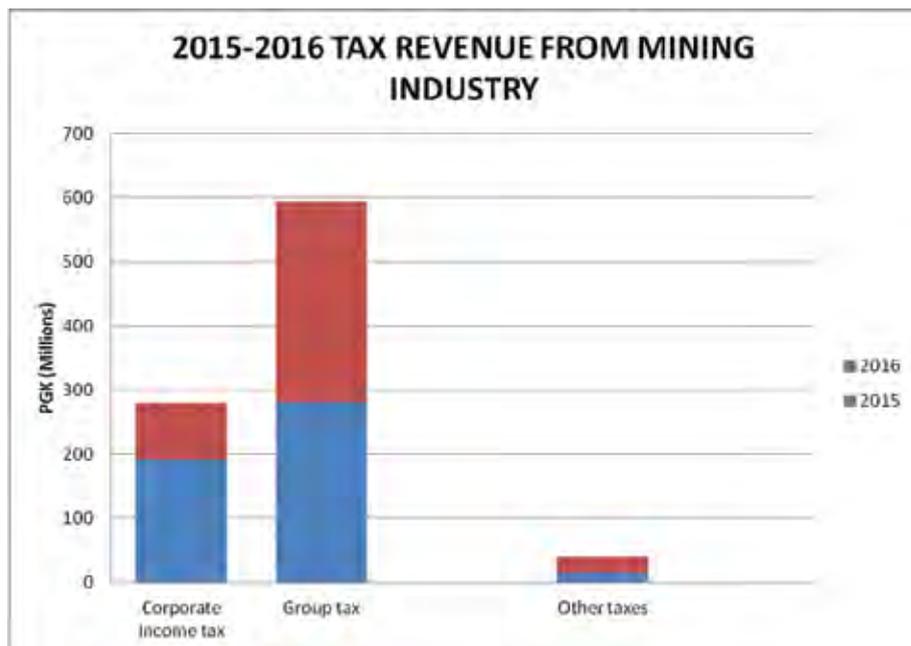
The resource industry in PNG had experienced an unprecedented period of activity and growth until 2012 but was then hard hit by three years of low mineral commodity prices and temporary key mine closures. This contributed to the current decline in the country's economy and lack of foreign exchange. However, the mineral commodity situation reversed from 2016 with 2017 revenue and production at record levels reaching well over US\$ 354 million in mineral revenue (which includes the 2<sup>nd</sup> highest reported alluvial revenue of US\$122.56 million). Analysts expect key minerals of gold, copper, nickel, cobalt and chromium to be in demand going forward as the majority of these are base components for the sudden world growth in the electric vehicle and battery industries.



**Figure 8.3** FOB Earnings from Mines relative to Alluvial Export Revenue for PNG (2014-2017)  
(Source: PNG Mineral Resources Authority).

### c) Employment

Employment in the mineral sector also increased from 15,000 employees in 2016 through 17,057 to by 2017. Of significance is that these figures indicate PNG workers represent 86% of that total and the number of women working in the industry has increased to 13%. Mining sector employees also contribute a significant portion of group tax through the income tax apart corporate income tax revenue generated from mining companies.



**Figure 8.4** Revenue from the Mining Industry (2015-2016)

## **8.4 Best Practice of Mine Rehabilitation and Decommissioning in the ASEAN Countries- Misima Gold Mine, Papua New Guinea.**

### **8.4.1 Current Practice in PNG**

Existing mining policy and regulatory framework in Papua New Guinea does not provide a clear pathway to mine closure planning. Although there are salient provisions in both the environment and mining legislation- which pertain to physical, biophysical and social aspects of mine closure, there is a lack of regulatory guidance in the domestic mining policy with respect to proper mine closure planning and the financing of closure obligations.

In practice, the requirement for mine closure planning is usually captured in a standard Community Development Agreement template for mining projects in PNG. Whilst the agreement is legally binding for the parties including the State, developer(s), and the landowners for purposes of benefit sharing, in some cases developers have argued against having mine closure planning in the agreement based on the premise of separating compliance matters from benefit sharing arrangements. Logically this meant that companies were under no legal obligation to put in place proper closure plans besides taking responsibility for the closure liabilities.

Despite the policy gap, major operating mines in the country have taken initiatives to put together their mine closure and rehabilitation plans through active consultations and input from relevant stakeholders including impacted communities, landowners, Provincial and Local Level Governments, and regulatory agencies to solicit support and approval for the closure plans. Fundamental to this ‘voluntary’ approach by the mining industry is the necessity to obtain social license to operate besides the need to protect their corporate image in the global community.

Increased awareness especially in mining jurisdictions around the world on the International Finance Corporation’s (IFC) Performance Standards on Environmental and Social Sustainability and Equator Principles has prompted governments and impacted communities to demand greater corporate social responsibility from mining companies even in the absence of relevant domestic policy and legislation. This has been the case for the PNG mining industry in recent times in which mining companies have been urged to take proactive steps towards mine closure planning in both operational and regulatory aspects.

From a practical point of view, the biophysical and civil infrastructure aspect of mine closure is relatively easy to identify, describe, quantify, and decommission and perhaps regulate. However, determining the financial implications is quite challenging particularly with respect to fluctuating mineral prices, environmental concerns, and technological changes, and community expectations for post-mining land use. This holds true in the PNG regulatory context given the lack of enabling legislation and regulations for mine closure including regulatory guidance on determining financial assurance quantum.

### 8.4.2 Mine Closure Requirement under Proposed Mining Policy & Legislative Reforms

The Government of Papua New Guinea through the Department of Mineral Policy & Geohazards Management since 2009 undertook a comprehensive review of the Mining Act 1992 and Mining (Safety) Act 1977 with the intent to align the legislative framework with international best practice standards as well as addressing some of the domestic policy issues which have evolved over the years. As a result, the proposed Mining Bill 2016 includes a number of key provisions and regulations on mine closure and sustainability.

These proposed legislative requirements are as follows:

- Mining project closure planning must be an integral component of mining project planning. Policy framework adopted from IFC international best practice standards for mine rehabilitation and closure requirements.
- Requirement for project developer as part of its development proposal to submit a Mine Rehabilitation and Closure Plan at the feasibility stage.
- Closure planning to involve consultation at all levels of governments, landholders, affected communities and other relevant stakeholders.
- Emphasis on sustainable development initiatives and post closure community livelihood strategies including ownership and transfer of mining project facilities
- Clear demarcation of roles and responsibilities of MRA and CEPA in the approval and regulation of the Mine Rehabilitation and Closure Plan. Environmental aspects of the Mining Project Closure Plan to be dealt with by CEPA during the environment permitting process whilst MRA will oversee the physical decommissioning, dismantling and safety aspects of the MCP.
- Developers to provide financial security upfront to meet its closure obligations under the Mine rehabilitation and Closure Plan.
- Mining Project Closure Plan to be updated periodically to reflect any material changes in the mine plan, the quantum of financial security or any major changes to the project as prescribed by legislation.

Apart from the legislative amendments, the recent collaboration with the Inter-Governmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) on developing the ‘APEC Mine Closure Checklist Pilot Project’ and the project ‘Capacity Building for Mine Waste Management’ jointly undertaken with JICA are some of the policy initiatives pursued on the diplomatic arena to enhance PNG’s local capacity to effectively regulate mine closure.

### 8.4.3 Company Information: Misima Gold Mine

Misima Gold Mine commenced operations in 1987 and operated until 2004. The mine was a joint venture between Placer Dome (80%) and the then State-owned Orogen Minerals (20%). Placer Dome shares were acquired by Barrick Gold Ltd in 2006. According to Placer Dome, the mine produced 3.7 million ounces of gold from 1990 until the mine closed in 2004. Final mine site closure and mine site rehabilitation was completed in April 2005 under Barrick Gold Ltd and its planning commenced five years prior to completion of mine site operations<sup>7</sup>.

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<sup>7</sup> Placer Dome, 2001



**Figure 8.5.** Misima Mine Layout in 2001  
(Photo credit: Roger Gunson, Mineral Resources Authority, 2017).

Mining at the Misima Gold Mine was conducted using conventional open pit techniques, and operations with 3 shifts per day, seven days a week. The pit is about 2.3 km long and 300 m to 600 m wide with a total area of about 92 hectares.

Misima Mine timeline:

- 1988 - Misima Mine construction commenced
- 1989 - Official opening
- 1992 - Production reached 1 million ounces of gold
- 1995 - Production reached 2 million ounces of gold
- 2001 - Mining from open-pits ceased
- 2004 - Milling of ore ceased
- 2005 - Deconstruction completed
- 2012 - Relinquishment achieved (April)<sup>8</sup>

<sup>8</sup> Barrick Ltd, December 07, 2012

## Mine Closure Planning and Costing

Misima was the first mine closure in PNG where there was no defined process. Barrick Gold Ltd had to define the process and the framework, working closely with the government. This process had to demonstrate that the agreed closure criteria were met before relinquishment was granted in April 2012 (Ila Temu, Barrick's PNG Country Manager)<sup>9</sup>.

Planning for closure with objectives and targets was very crucial. Barrick's closure standard was good and detailed. Its focus in mine closure planning was properly done and its success was a result of ongoing stakeholder consultation, which involved a number of groups and strategies. One such strategy is the formation of the Misima Mines Closure Committee, which included Barrick, landowners, the regulators and government representatives.

The committee's goal was to implement the sustainability plan to ensure environmental, social and economic impacts from the mine's closure were addressed at each stage of the process. That included everything from rehabilitating the land and ensuring clean water, to helping local people find job opportunities at the end of mine closure and reclamation<sup>10</sup>.

Regular mine tours of the old mine site were conducted by the company to show the local community the results of the re-vegetation as it was developing. The company also relied on the advice and feedback from its employees, 90% of whom were from the local community. There were also numerous meetings and reporting to regulatory bodies. The relinquishment was possible due to a decade of monitoring the reclamation activity that began with Placer and continued with Barrick.

A great deal of that monitoring involved managing the water quality. A baseline for the comparison was established by measuring the presence of sediment and metals in water from the northern, undisturbed side of the island and comparing it to the southern part, where the Misima site was located. The aim was to achieve a similar water quality level in its impact zone on the south coast as demonstrated by the mine-pit lake water treatment facility in Figure 8.6 below. According to the Reclamation and Closure Superintendent, a lot of the process was about using common sense and having everyone work together to do the right things<sup>11</sup>.

The Misima Mine Rehabilitation & Decommissioning exercise is estimated to cost about US\$ 30 - US\$50 million. Costs include physical decommissioning, environmental rehabilitation and socio-economic aspects identified in the rehabilitation plan.

<sup>9</sup> <http://barrickbeyondborders.com/environment/2012/12/a-look-back-at-the-misima-mine-closure/>

<sup>10</sup> Barrick Ltd December 07, 2012

<sup>11</sup> Walter Benko, Barrick's Reclamation & Closure Superintendent, Australia-Pacific regional business unit), Barrick Ltd December 07, 2012

In <http://barrickbeyondborders.com/environment/2012/12/a-look-back-at-the-misima-mine-closure/>.



**Figure 8.6** Mine Pit-Lake Water Treatment for Mt. Sisa- Misima.  
(Mine Photo credit: Courtesy of Roger Gunson, Mineral Resources Authority, 2017)

## Stakeholder Engagement

The single most important concept about mine closure planning resulting from the experience at Misima is to ensure that the stakeholder engagement process is initiated during early stages of mine development so that all the issues can be thoroughly examined and consequent courses of action are incorporated into the closure plan. Indeed, it is now considered world best practice to begin closure planning at the actual inception of a mining project. In conjunction, all stakeholder groups must be represented in the closure planning issue identification to ensure all issues are actually identified, but even more crucially, what each stakeholder expects or desires as an outcome for each issue is also clearly stated<sup>12</sup>.

Another important conceptual outcome from the Misima Mine closure is that mine closure planning goes far beyond ‘simply’ removing the residual on-site mining infrastructure and environmental remediation of mining disturbed areas such as various pits and waste rock dumps. The ‘traditional’ definition of mine closure as the act of surrendering the mining lease by the mine operator to a relevant regulatory authority is increasingly being superseded by the mine operator no longer being the sole decision maker on when and how the closure will be affected, and that wider societal expectations such as stewardship for future land users must be taken into account.

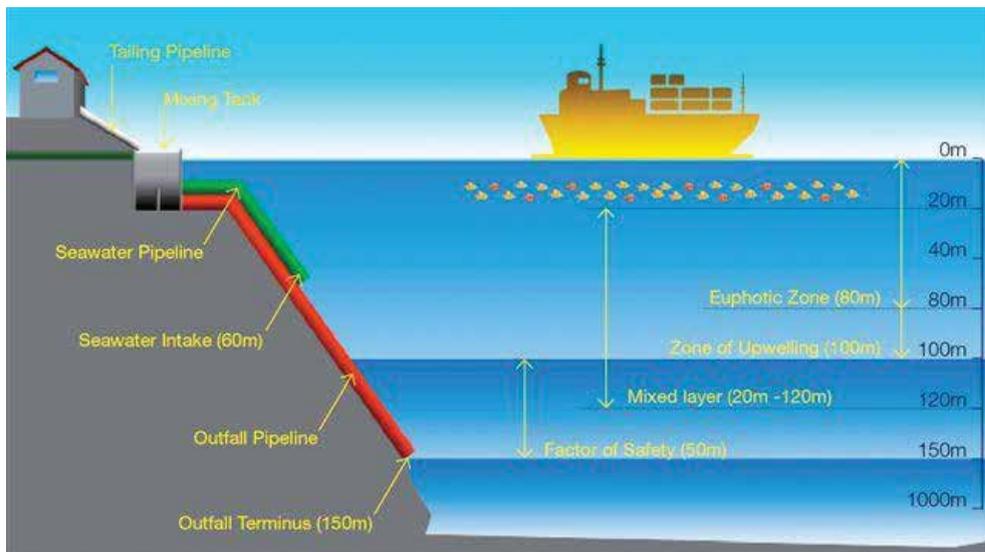
<sup>12</sup>R. Petueli, et al, 2005: p. 3

Such changing expectations and requirements for mine closure planning is part of the overall rapid increase in awareness by society of the social and environmental impacts of mining and consequent demand for change over the previous 10-15 years. Unfortunately, this pressure for change is not necessarily based upon an objective assessment of the issues, nevertheless, such ‘changing goal posts’ increase the difficulty in achieving mine closure planning and outcomes that satisfy stakeholders<sup>13</sup>.

## Environment Management

It can be argued that closure planning at Misima did indeed begin at project inception with the selection of deep sea submarine tailings disposal (Figure 8.7) instead of using a traditional tailings dam. In addition to the risks associated with a tailings dam in a high rainfall, seismically active area such as Misima which were totally eliminated by use of deep-sea submarine tailings disposal, issues such as land alienation, long-term stability and maintenance, revegetation and future land uses for the tailings and possible poor-quality leachates were also eliminated, consequently removing a ‘traditional’ mine closure issue generally part of a mine closure plan.

While deep-sea submarine tailings disposal had many benefits at Misima, it is not a panacea and requires the correct set of circumstances to be successful.



**Figure 8.7** An example of a schematic diagram of a typical Deep Sea Tailings Placement system (Source: [www.mpi.org.au/tag/dstp/](http://www.mpi.org.au/tag/dstp/)).

A progressive rehabilitation strategy was used at Misima involving the revegetation of mining disturbed areas of the lease as soon as possible after mining of each particular area had been completed. So, instead of leaving rehabilitation of the mining disturbed landscape to the end of the mine life, the progressive revegetation resulted in the entire disturbed area at Misima being under vegetation, at the same time, the final deconstruction was completed.

<sup>13</sup> R. Petueli, et al, 2005: p. 3-4



**Figure 8.8** The Misima Mine plant site before (left) and after (right) deconstruction  
(Photo Credit for Figure 8.8 & 8.9, Barrick Gold Limited 2001).



**Figure 8.9.** Reclamation and Re-growth of Vegetation on Mt. Sisa (Tonowak mine pit)  
(Photo Credit for Figure 8.8 & 8.9, Barrick Gold Limited 2001)

Progressive revegetation of the Misima Mine site had many benefits. Firstly, it is actually cheaper to get things done, due to economies of scale, while the full support facilities of the operational mine are available for revegetation activities. Secondly, considerable goodwill is generated with various stakeholders, as they can actually see the mine closure plan in action. Finally, lease relinquishment criteria will invariably involve an ecological component. Therefore, the sooner the ecosystem is reestablished, the sooner a mine operator can expect to get lease relinquishment at the eventual closure of the mine and this in itself will save considerable money in post-closure monitoring costs.

The deep sea submarine tailings disposal and the progressive rehabilitation are examples of ‘closure planning’ that the company was doing internally throughout the life of the mine. The closure planning with a view to external stakeholders and the actual eventual cessation of all mining related activities resulted in the distribution of a publication titled the “Sustainability Plan – consultation document” in the year 2000.

Rather than having specific plans and details of what the company would do with regards to closure, this document detailed the various issues, relevant background information and some possible options available to the various stakeholders. This was done consciously by the company in order to “kick-start” various stakeholders into thinking seriously about the eventual closure of the mine and what that might mean for the various groups involved<sup>14</sup>. This result is probably due to the ongoing community consultation programme regarding routine mine operation that was in place throughout the life of the mine. For example, mine site tours were regularly conducted for community, school and business groups in which individuals could actually see the land being progressively revegetated<sup>15</sup>.



**Figure 8.10** 1<sup>st</sup> and 2<sup>nd</sup> Phase Rehabilitation of Mt. Sisa Mine Pit (Photo Credit, Barrick Gold Limited 2001)

## Social Development

A number of community development programs were carried out by the company during the life of the project. A Sustainability Planning Advisory Committee was formed which brought together representatives from government, civil society and small business to work together to plan for their future in the post closure period. Community expectations were also featured in the planning process especially socioeconomic utilities including:

- Provision and maintenance of public infrastructure
- Electricity, telecommunications, road maintenance, water supply
- Public health and hygiene
- Provision of medical services

<sup>14</sup> R. Petueli, et al, 2005: p. 4-5

<sup>15</sup> R. Petueli, et al, 2005: p. 6

However, the issue of sustainability has been a major challenge for the Misima community in light of the fact that most of these social services have been neglected by local level and provincial government. This raises the question of what is expected of the company to include in the ‘mine closure plan’, especially in areas under the responsibility of civil government, over which a private commercial company has little real control, yet would be expected to achieve agreed upon outcomes.

## **Reasons For Success**

A flight over Misima Island today reveals two lakes nestled between a vast landscape of native plants and trees. What many visitors can’t spot from above, or even on parts of the ground of this small island about 200 km east of the Papua New Guinea (PNG) mainland, is evidence of a once-operating gold mine<sup>16</sup>.

The lush terrain left behind is the result of years of reclamation planning that dates back to 2000, long before shovels stopped scooping ore from the ground. The 12 km<sup>2</sup> of land, half of which was disturbed by mining, was returned to the Misiman people for their long-term use. Today, the land is used for food production and other uses, such as house-building for the roughly 5,000 Misiman people who live on the island. The relinquishment was possible because the mine closure was planned early and handled properly.

From experiences with the Misima Mine, successful rehabilitation and decommissioning is achievable by building closure programmes and initiatives based upon existing entities. Institutional partnerships are also very crucial companies, governments and local communities need to work together to in mine closure planning.

Accomplishing the successful rehabilitation and decommissioning of the Misima Mine is attributed to the establishment of transparent and complete consultation between all relevant stakeholders during the closure planning. Stakeholder engagement is very crucial in the mine closure planning process to come up with a “Win-Win” situation making sure that what is included in of the closure plan in terms of benefits, continue after mine closure.

PNG does provide for the Decommissioning, Rehabilitation, Mine Closure and monitoring and post-monitoring obligations, financial assurance to meet mine closure obligations and addressing the challenges faced with and experiences learnt from the Misima Gold Mine project.

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<sup>16</sup> Barrick Ltd, December 07, 2012

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Mineral Resources Authority, PO Box 1901, PORT MORESBY, National Capital District, Papua New Guinea.

**Note** This PNG Country Report is endorsed for release by Mr. Harry Kore, Secretary, Department of Mineral Policy & Geohazards Management.

## THE PHILIPPINES

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### 9.1 Country Information



**Figure 9.1** A map of The Philippines

The Republic of the Philippines is a sovereign state in archipelagic Southeast Asia, with 7,107 islands spanning more than 300,000 km<sup>2</sup> of territory. It is divided into three island groups: Luzon, Visayas, and Mindanao. The Philippines was named after Prince Philip (later King Philip II) of Spain, by the Spanish explorer Ruy Lopez de Villalobos during his 1542-1546 expedition to the islands.

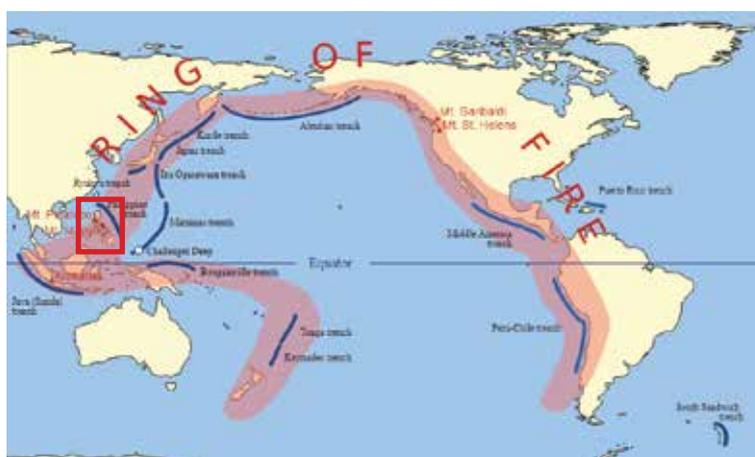
The Philippines is a unitary presidential constitutional republic, with the President of the Philippines acting as both the head of state and the head of government. It proclaimed its independence from the Spanish Empire on 12 June 1898 following the culmination of the Philippine Revolution. It is a founding member of both the United Nations (UN) and the Association of Southeast Asian Nations (ASEAN). It has embassies and consulates in 62 countries around the world.

The country's primary exports include electronics, semiconductors, transport equipment, construction materials, and minerals. As an open economy, the Philippines trades with other economies around the world: it considers Japan, the United States, China, South Korea, and Germany as its top export markets.

The Philippines was host to a record high of 4.7 million foreign tourists in 2013, thanks to country's tourism brand, "It's More Fun In The Philippines." Among its top tourist drawers are Boracay Island in Aklan, Puerto Princesa Underground River in Palawan, Chocolate Hills in Bohol, Mayon Volcano in Albay, and the Banaue Rice Terraces in Ifugao, as well as the cities of Manila, Baguio, Vigan, Cebu, and Davao. (Source: <https://www.gov.ph/about-the-philippines>).

## 9.2 Mining History

The Philippines straddles in the western fringes of the Circum-Pacific Ring of Fire, a ground very rich in economic mineral deposits where plate tectonics have caused the deposition of rich minerals in this part of the world. The areas defining the convergence of the plates are the world's primary sources of copper and gold today (Figure 9.2). Hence, the Philippines is endowed with vast metallic (gold, copper, nickel, iron, chromite, etc.) and non-metallic (Sand and gravel, limestone, marble, clay, aggregates, etc.) mineral resources across the country (Figures 9.3 and 9.4).

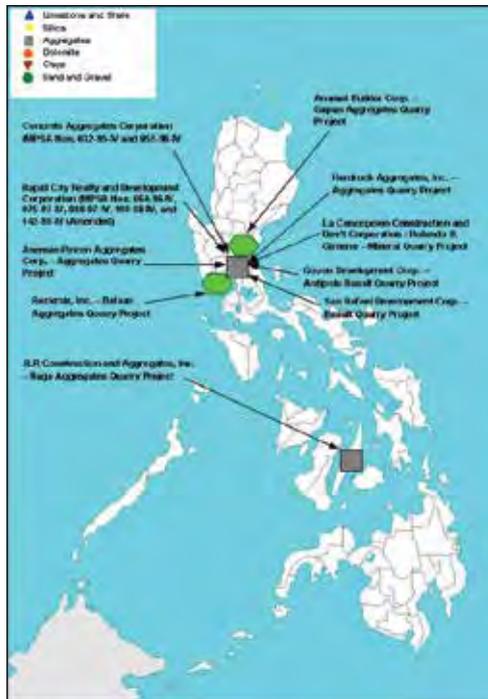


**Figure 9.2** Location of the Philippines in the Circum-Pacific Ring of Fire.

(Source: [https://commons.wikimedia.org/wiki/File%3APacific\\_Ring\\_of\\_Fire.svg](https://commons.wikimedia.org/wiki/File%3APacific_Ring_of_Fire.svg))



**Figure 9.3** Relative location of operating metallic mines in the Philippines. Source: Mines and Geosciences Bureau.



**Figure 9.4** Relative location of operating non-metallic mines in the Philippines.  
Source: Mines and Geosciences Bureau.

The Philippines has a long, well-established tradition of mining, pre-dating the arrival of the Spaniards in the 15<sup>th</sup> century that's why the country attained the prominence in the global minerals industry for so many years. Since then, the country was among the world's top ten producers of gold, copper, nickel and chromite – the major metallic minerals produced in the country (Cabalda et al., 2002).

Various archaeological excavations throughout the country have shown that gold, silver, copper, bronze and lead were found to have been used by the early inhabitants as ornaments, tools and even part of beliefs, rituals and traditions. There are also accounts mentioned that gold is one of the commodities exchanged by the Filipinos with the Chinese. Like farming, mining was a community-based activity wherein members of families with claims to a particular portion of a mountain worked individually or in groups. Occasionally, they mined in common, each receiving an equal share of the gold produced, but the headman receiving a large share for supervision.

Since then, various indigenous methods of mining and milling processes were developed particularly by the Igorots, Surigaonons, and Bicolanos. Later on, the mining activities and milling processes were influenced by the Chinese and Indians.

Even before the advent of Spanish rule, metals, particularly gold, played an important role in creating conditions for social and economic changes in the country. The high value which the early inhabitants ascribed to gold shaped the tradition and ritual, indigenized certain features of their systems of belief, and developed patterns of wealth, power and authority.

When the Spanish reached the Philippines in the second half of the 16<sup>th</sup> century, the spirit of Spanish expansionism was at its crest. The archipelago became the base of further efforts to conquer and evangelize new areas and design new trade routes in search primarily of spices but also of gold and other precious merchandise. The Spanish soldiers who came to the Philippines desired to duplicate the success of Spaniards in exploring the rich mines of Mexico. Information about the potential mines to be developed in the Philippines abounded in the accounts of travellers and explorers. A mineral map thus emerged from unsolicited observations of travellers.

Masbate is a mineral district in the 14<sup>th</sup> century since its gold mines were reported by various exploration accounts that include evidence of placers and lodes mines, like old tunnels and open cuts.

Thorough exploration and mapping activities commenced in Bicol region in the quest for gold and iron deposits in 1571. Fortunately, potential deposits of sulphur were located in Bicol while confirming the deposits of gold.

The Cordillera in the northern part of Luzon were also penetrated for the existence of rich gold deposits. However, the Ygorrotes refused the outsiders of any race to explore and locate their gold mines. The Spanish troops failed several times in conquering the coveted gold mines in the 1660s.

Butuan and Surigao in the early accounts of the Spaniards were the first gold-rich areas identified in the 1560s. Some historical reports include gold washing by the natives in the river to which gold particles flowed from the mountains of Butuan and Surigao.

Accounts from Magellan's trip to Cebu revealed that Cebu has rich deposits of gold including Sooloo and smaller islands near Leyte and Masbate. On the island of Luzon, the provinces of Pangasinan and Pampanga were mentioned in a 1662 account to be very rich sources of gold. Some accounts reported the existence of gold mines Nueva Vizcaya and in the towns of Tuy, Lobo and Maribago in Batangas.

The heads of exploratory forces in the Philippines noted painstakingly and in detail the products and resources of each island and places they visited. Reports about the presence of gold deposits in many islands rather than spices had raised high hopes for viable colonial operations.

The abolition of the galleon trade in 1815 led the opening of the Philippines to world commerce. The Spanish authorities began to legislate the institutional regulating of the mining industry in the 19<sup>th</sup> century. Before then, regulation of mining activities was achieved only through specific *cedularios* and *expedients* (rules and regulations). These pertained to mineral deposits in various districts in the country, the pacification of the Igorots in the gold district of the Cordilleras, dealings of specific mining groups with the hacienda and discussion of benefits for specific groups interested in pursuing mining activity.

The Decrees of the Superior Civil Government on 29 January 1846 introduced the Regalian Doctrine that stipulates that all minerals and substances underneath all lands public or private belongs to the State. In effect, the law rests on the principle of eminent domain which reserves to the state the right to develop the mines on its own initiative or through private concessions.

Subsequent legislation such as Spanish law of 7 July 1859 and Royal Decree of 14 May 1867 served as a foundation of colonial mining policy in the Philippines. The said laws set procedures for prospecting, locating and developing mines. The Royal Decree of 3 April 1860 stipulated that the chief responsibility for administering the mining industry was assigned to the Inspector-General of Mines under the jurisdiction of the Governor-General and the Minister of Development in Spain.

The circular of the Director-General of Civil Administration clarified the procedures for the registration of a mine through the Inspector-General of Mines. The agency that administered all mines during the Spanish colonial period was the *Inspeccion General de Minas* created by virtue of Royal Decree of 9 March 1837.

The *Inspeccion General de Minas* had three support agencies: the Commission on Mining which had two sections, one for Luzon and other for Visayas and Mindanao; the Commission for Geologic Studies; and the Commission on Mineral Waters. The specific functions of the *Inspeccion* related to the administrative aspects of its operation; the inspection of all mining activities; initiating geologic studies; and the collection of statistical data pertaining to the industry and others. The findings of various geologic studies in the Philippines were to be relayed to the *Inspeccion General de Minas* and the *Comision del Mapa Geologico de España*.

Under the Philippine Revolutionary Republic, the Departamento de Fomento, translated as Department of Public Welfare was created by virtue of the decree signed by Gen. Emilio Aguinaldo on 28 November 1898. On 29 November 1898, the President signed a decree creating the four (4) divisions of Departamento de Fomento and one of these divisions was the Industry and Agriculture Division. The Mines Section and the Mountains Sections were also formed, wherein the former was under the director of Industry and Agriculture, and latter was under the director of Publicas.

The renewed interest in mining spurred many geologic studies in the Philippines in the 19<sup>th</sup> century. In fact, several islands were confirmed with the presence of gold deposits such as Paracale, Mambulao and Labo in Camarines Norte; the mountainous periphery of the Caraballo; Gapan in Nueva Ecija; Atimonan in Tayabas; Misamis and Surigao in Mindanao; Cebu; Mindoro; Panay; Sibuyan; Rapu-Rapu; and other islands.

Various military drives were launched in the Mountain Province since the gold territory remained impenetrable to the Spanish military authorities. Iron, on the other hand, was considered the second most important mineral during the colonial period for the manufacture of tools and war materials.

Mining in the Philippines dates back to the Spanish Regime where the Spanish Royal Decree of 1837 laid the foundation of the current mining law. The Spanish Royal Decree provided the Regalian Doctrine or the ownership of the minerals by the State. Thus, the State has the responsibility to develop, utilize and conserve the country's mineral resources.

During the American Regime, the Philippine Bill of 1902 was the governing law for mineral resources development. Mining rights were issued through mining patents wherein the holders were granted title over the land and ownership of the minerals therein.

In 1963, when the Philippines was granted independence by the American Government, the Commonwealth Act No. 137 became the governing law on mining, reinstating the Regalian Doctrine. Mining rights were granted through lease contracts, giving the lessee the right and responsibility to explore, develop, utilize and conserve the minerals within the lease contract.

In 1974, a new mining law, Presidential Decree (PD) No. 463, was issued providing a new dimension in mineral resources development. Lease contracts were maintained as the mining rights for the exploration, development, utilization and conservation of the country's mineral resources. PD No. 463 provided for minimal environmental protection and mine closure requirements. The environmental protection requirements were implemented. However, the industry found the mine closure requirements unrealistic, and thus, PD No. 463 was not implemented.

The 1986 Philippine Constitution paved way for the new mining scheme through the Mineral Production Sharing Agreement, Co-Production Agreement, Joint Venture Agreement, and Financial or Technical Assistance Agreement. In the absence of an enabling law for those these schemes, interim laws, through Executive Orders and Administrative Orders, were issued in order for the government to grant mining rights. On 3 March 1995, the Republic Act (RA) No. 7942, the Philippine Mining Act of 1995 was enacted into law, finally paving the way for mining provisions in the 1986 Constitution.

The declaration of policy of RA No. 7942 states that “all mineral resources in public and private lands within the territory and exclusive economic zone of the Republic of the Philippines are owned by the State. It shall be the responsibility of the State to promote their rational exploration, development, utilization and conservation through the combined efforts of the Government and private sectors in order to enhance national growth in a way that effectively safeguards the environment and protects the rights of affected communities.” The declaration reiterates the Regalian Doctrine of the ownership of the government of the mineral resources. It also highlights the three pillars of sustainable development-economic development, environmental protection and social development. The initial implementing rules and regulations (IRR) of RA No. 7942 was issued in August 1995. However, a need to revise the IRR to be more responsive to environmental protection and social equity was undertaken in 1996. The revised IRR was issued in December of the same year. Various amendments were issued from 1997 to 2009. These amendments were consolidated resulting in the Consolidated IRR in 2010.

In 2004, the government saw the potential of the mineral industry as a development option that could boost the economy of the country through investments, government revenues including taxes and fees, generation of employment and development of the countryside. Executive Order (EO) No. 270 and 270A, or the “National Policy Agenda on Revitalizing Mining in the Philippines” was issued shifting the government’s stance on mining from tolerance to promotion. The EO provided, among others, the promotion of mining, strengthening environmental and social safeguards, rehabilitating abandoned mines, considering the benefits of small-scale mining etc.

The Mining Policy of the current administration was provided under Executive Order No. 79 title “Institutionalizing and Implementing Reforms in the Philippine Mining Sector, Providing Policies and Guidelines to Ensure Environmental Protection and Responsible Mining in the Utilization of Mineral Resources.” EO No. 79 highlights the importance of a rational sharing of government from mining projects, strict implementation of environmental laws, no-go zones for mining, rationalizing small-scale mining, primacy, consistency of local ordinances to the constitution and national laws, etc.

(Source: Lopez, Salvador P., ‘Isles of Gold: A History of Mining in the Philippines’, Commissioned by the Chamber of Mines of the Philippines, Oxford University Press Pte. Ltd. 1992.)

## 9.3 Status of Minerals Industry

### a. Number of Operating Mines

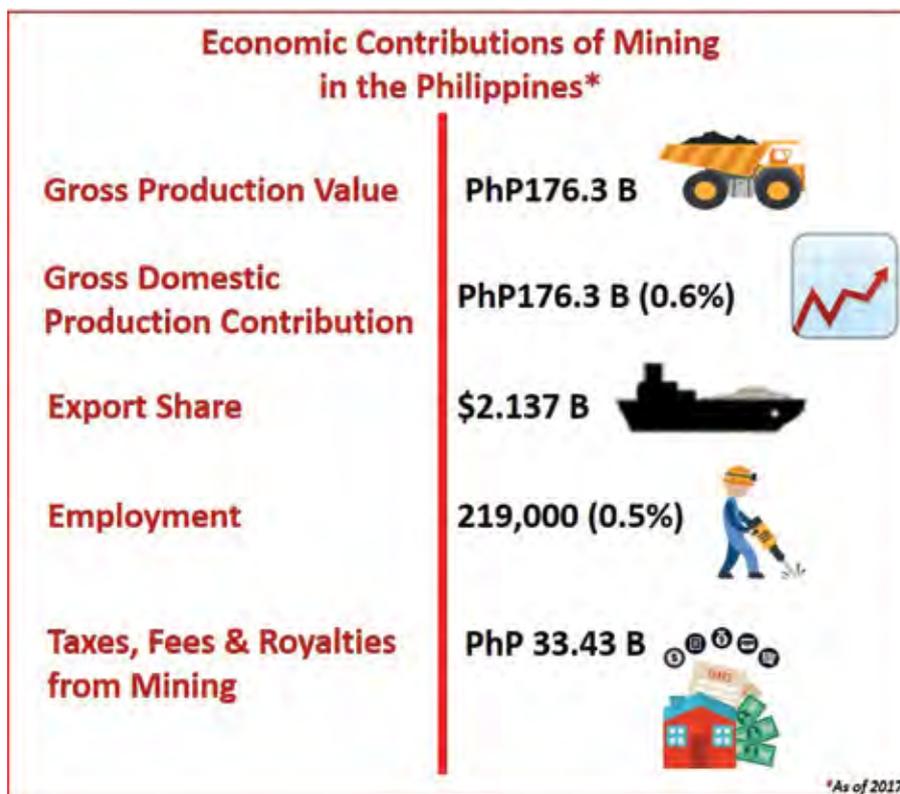
1. Metallic
2. Non-metallic



**Figure 9.5** Operating Mines in the Philippines, Source: [www.mgb.gov.ph](http://www.mgb.gov.ph)

### b. Economic Contribution

1. Gross Domestic Product
2. Mineral Exports
3. Employment
4. Taxes paid



**Figure 9.6** Economic Contributions of Mining in the Philippines, source: [www.mgb.gov.ph](http://www.mgb.gov.ph)

## 9.4 Best Practices of Mine Rehabilitation and Decommissioning

### 9.4.1 Coral Bay Nickel Corporation

In 2002, the HPP (Hydrometallurgical Processing Plant) of Coral Bay Nickel Corporation (CBNC) was established through the combined efforts of its Japanese partners Sumitomo Metal Mining Co. (SMM), Mitsui & Co., Ltd. (MBK), Sojitz Corporation (SC), and its Filipino Partner, Rio Tuba Nickel Mining Corporation (RTNMC).

Through the process of High Pressure Acid Leaching (HPAL), low-grade nickel ore, which was considered as mine wastes of the earlier RTNMC operations, is utilized to produce Nickel/Cobalt Mixed Sulfide containing 57% Ni and 4% Co. This is subsequently refined in Japan and the nickel and cobalt metals are used in the production of stainless steel and other applications. HPP Line 1 was designed to produce 10,000 tons of nickel and 750 tons of cobalt per year. HPP Line 1 began commercial operation in April 2005.

Due to the technological and commercial success of HPP Line 1, a second HPP Plant was established. Following the proven technology of its HPP, construction began on HPP Line 2 in February 2007. Commercial operation of HPP Line 2 began in June 2009. With continuing improvements learned from the operation of HPP Line 1, HPP Line 1 & 2 could now produce a combined output of 24,000 tons of Nickel and 1,860 tons of Cobalt per year.

The CBNC plants are located in Rio Tuba, Bataraza, Palawan, within the mine site of RTNMC. Total investment for the project was US\$500 Million.

### Safety and Health



**Figure 9.7** Plantwide 3S activity Participated by All Employees and Contractors.



**Figure 9.8** Plantwide 3S activity Participated by All Employees and Contractors.



**Figure 9.9** Work at Heights with Full Body Harness and 100% tie-off.



**Figure 9.10** Contractors Toolbox Meeting before the start of activity.

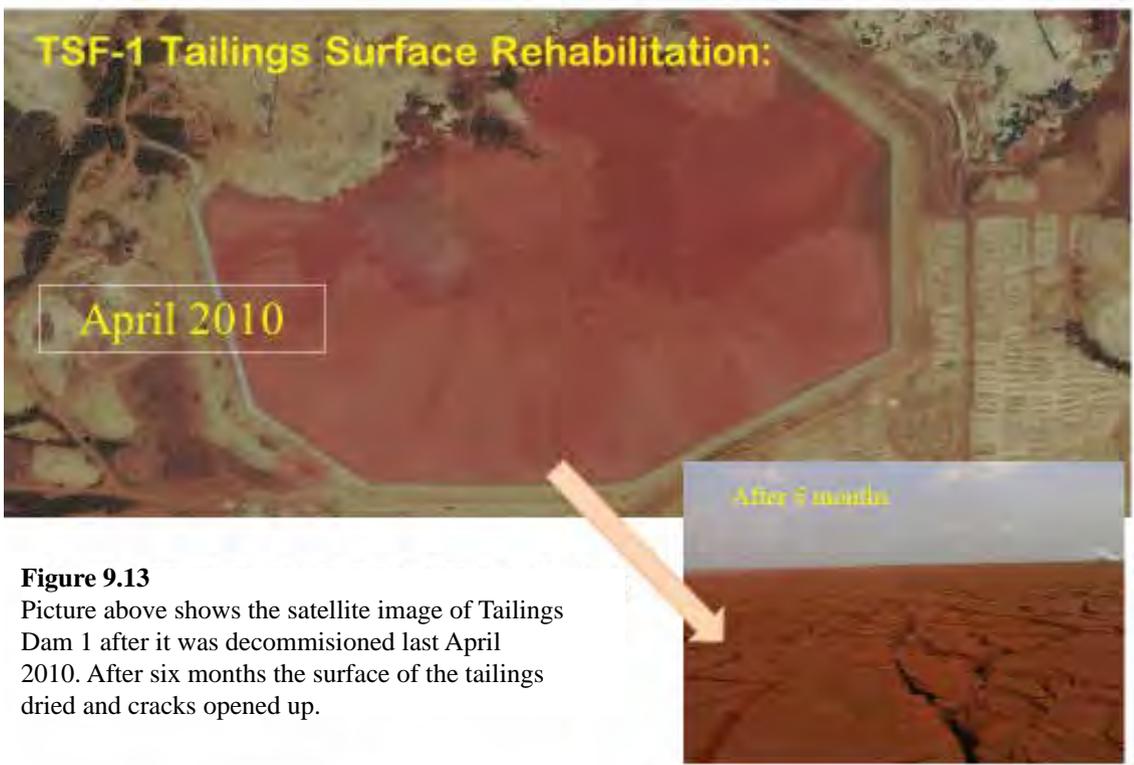


**Figure 9.11** Risk Assessment prior to start of activity.



**Figure 9.12** Improvement of the working area.

## Environmental Management



**Figure 9.13**

Picture above shows the satellite image of Tailings Dam 1 after it was decommissioned last April 2010. After six months the surface of the tailings dried and cracks opened up.



**Figure 9.14**

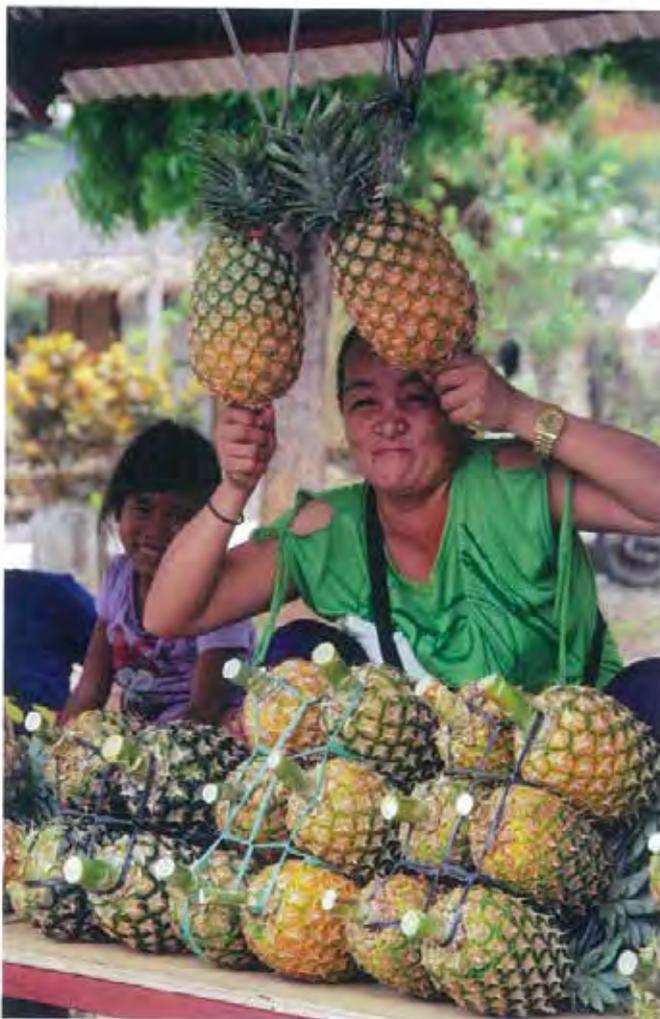
As of last July 2016 TSF1 has completely been planted with grass vines and shrubs. High value crops, fruits, vegetables and flowers were added as evidence that the tailings can be converted to a productive agricultural land. Now, the TSF1 is continuously being maintained and developed into tourist spot for local and international visitors and will eventually serve as evidence of CNBC's good environmental stewardship.



**Figure 9.15**

Pandan and wild sugarcane not only helps in the greening of the tailings surface and make it visually acceptable. It is also being used as raw materials for TSF1 souvenir items intended for local and international visitors

## Social Development



**Figure 9.15** A woman selling pineapple thru SDMP.



**Figure 9.16** Swine Production Project



**Figure 9.18** Provision of story books for the pre-school students.

#### **9.4.2 RIO TUBA NICKEL MINING CORPORATION (RTNMC)**

RTNMC is the oldest and biggest producer of nickel ore in the Philippines. It was founded in 1969 and operated since 1975 in Barangay Rio Tuba, Bataraza, Palawan. It is operating in 990 hectares of approved Mineral Processing Sharing Agreement (MPSA) No. 114-98-IV mineable from the year 1998 to 2023. It was also issued an Environmental Compliance Certificate (ECC)-CO-9612-008-302 that was amended on 16 March 2015 as ECC-CO-1312-0043 for the increase of its production volume capacity.

In a joint venture with a Japanese company at 60% Filipino and 40% Japanese, RTNMC engaged in shallow surface mining operation involving the extraction, sizing and sorting, crushing, screening, and solar drying of the ore before shipping to customers overseas. The commodity being mined is in the form of nickel laterite ore comprising limonite and rocky saprolite of grades varying between 1.5 to 2.5% Nickel which is sold to international buyers who make various products that are vital to modern society and are used extensively in products essential to daily living. It made a total of 770 offshore shipments with the accumulated volume of 32,135,755 WMT of ores as of 31 December 2016. Meanwhile, the low grade ores averaging 1.29% nickel was meticulously piled from 1969 until it hosted the birth of the world's most successful Hydrometallurgical Processing Plant of Coral Bay Nickel Corporation (CBNC) where these low-grade ores are now sold and processed beginning 2005. The Company has produced and made available to the world market a total of 61,629,725 WMT of ores including the delivery of about 29,493,950 WMT of ores to CBNC.

RTNMC was able to develop the Rio Tuba Export Processing Zone (RTEPZ) through the Presidential Proclamation No. 304 on 13 December 2002. It facilitated the establishment and hosting of other companies that bring jobs to immediate communities. Currently, Coral Bay Nickel Corporation (CBNC) and Unichamp Minerals Philippines, Inc. (UMPI) are the registered locators at the said Ecozone. Likewise, a total of nine (9) large companies, fifteen (15) local contractors and service providers are operating within the area.

Over 4,000 people (including contractors) are working related to the operations of RTNMC which has an organic workforce of 2,751 regular and outsourced employees, the majority of which (84.7%) hail from Palawan. The Company has also 8% higher entry level salary rate than the mandated MIMAROPA minimum wage.

The project site, mines and facilities of RTNMC are located in Barangay Rio Tuba, Municipality of Bataraza, Province of Palawan bounded by 8° 33' 15" N latitude and 117° 22' 13" E longitude and approximately 850 km from Manila. It is accessible from Manila via two main routes, namely: direct flight from Manila to the site by private plane or ship; or through Puerto Princesa City, the capital of Palawan. In the latter route, Puerto Princesa City is a 1-hour flight from Manila or an 18-hour commercial boat ride. From Puerto Princesa City, the project site is accessible by 4- to 5-hour land trip or a 1-hour trip by a single-engine aeroplane.



**.Figure 9.19** Aerial view of Rio Tuba mine operation

## Safety and Health



**Figure 9.20** Toolbox Meeting of Limonite Department.



**Figure 9.21** Health Awareness Promotions thru Toolbox Meetings and IEC.



**Figure 9.22** First Aid Training conducted by Philippine Red Cross.



**Figure 9.23** Fire Brigade Team after Fire Drill at CPFMS.

## Environmental Management



**Figure 9.24** First Aid & Fire Fighting Drill at Plant Site on 22 June, 2017.



**Figure 9.25** Liquor Test Activity conducted every start of each shift.



**Figure 9.26** Tree planting activity at the mined-out area.



**Figure 9.27** Lower Togpon Silt Containment Pond.



**Figure 9.28** Plantation of local wheat (Batad).



**Figure 9.29** Kadyos beans grown at the nursery.



**Figure 9.30** Fire line planted with banana at NGP area.



**Figure 9.31** Mangrove plantation at Logpond, Sitio Kinurong, Barangay Rio Tuba.



**Figure 9.32** Aerial photo of the tree planting activity during the celebration of the 2017 World Environment Day.

## Social Development



**Figure 9.33** Launching of TB Prevention and Control Program.



**Figure 9.34** Training on Organic Farming.



**Figure 9.35** Provision of school supplies at Igang-Igang Elementary School.



**Figure 9.36** Conduct of Medical and Dental Mission.



**Figure 9.37** An IP Elder teaching her granddaughters how to make a native basket.



**Figure 9.38** Conduct of Brigada Eskwela for an IEC activity.



**Figure 9.39** Graduates of Indigenous Learning System.

## 10

## THAILAND

*Anont Nontaso and Naiyana Kallapravith*

## 10.1 Country Information

## 10.1.1 Kingdom of Thailand



Figure 10.1 Location of Thailand (green) in ASEAN (dark grey) and Flag.

- **Official language** : Thai
- **Spoken languages** : Central Thai, Isan, Kam Mueang, Pak Tai
- **Capital and largest city** : Bangkok (13°45'N 100°29'E 13.750°N 100.483°E)
- **Ethnic groups (2009-2011)** : Thai
  - 34.1% Central Thai
  - 24.9% Khon Isan
  - 9.9% Khon Muang
  - 7.5% Southern Thai
  - 14% Thai Chinese
  - 12% Others (incl. "Hill tribes")
- **Religion** : 94.50% Buddhism
  - 4.29% Islam
  - 1.17% Christianity
  - 0.03% Hinduism
  - 0.01% Unaffiliated
- **Monarch Maha** : Vajiralongkorn
- **Prime Minister** : Prayut Chan-o-cha
- **Area**
  - Total : 13,120 km<sup>2</sup> (198,120 mi<sup>2</sup>) (50<sup>th</sup>)
  - Water (%) : 0.4 (2,230 km<sup>2</sup>)
- **Population**
  - 2016 estimate : 68,863,514
  - 2010 census : 64,785,909
- **Density** : 132.1/ sq.km (342.1/sq mi)
- **Currency** : Baht (฿) (THB)

Thailand, officially the Kingdom of Thailand and formerly known as Siam, is a unitary state at the centre of the Southeast Asian. The country comprises 77 provinces. At 513,120 km<sup>2</sup> and over 68 million people, Thailand is the world's 50<sup>th</sup> largest country by total area and the 21<sup>st</sup> most-populous country. The capital and largest city is Bangkok, a special administrative area.

Thailand is bordered to the north by Myanmar and Laos, to the east by Laos and Cambodia, to the south by the Gulf of Thailand and Malaysia, and to the west by the Andaman Sea and the southern extremity of Myanmar. Its maritime boundaries include Vietnam in the Gulf of Thailand to the southeast, and Indonesia and India on the Andaman Sea to the southwest.

Thailand is a founding member of ASEAN and a long-time ally of the United States. Thailand is considered a regional power in Southeast Asia and a middle power in global affairs. With a high level of human development, Thailand is classified as a newly industrialized economy which was heavily dependent on exports. Manufacturing, agriculture, and tourism are leading sectors of the economy. Its economy is the second-largest in Southeast Asia.

### **10.1.2 Geography**

With a total area of 513,120 km<sup>2</sup> (198,120 mi<sup>2</sup>), Thailand is the 50<sup>th</sup> largest country by total area. It is slightly smaller than Yemen and slightly larger than Spain. Thailand comprises several distinct geographic regions, partly corresponding to the provincial groups. The north of the country is the mountainous area of the Thai highlands, with the highest point being Doi Inthanon in the Thanon Thong Chai Range at 2,565 m (8,415 ft) above sea level. The northeast (Isan) consists of the Khorat Plateau bordered to the east by the Mekong River. The centre of the country is dominated by the predominantly flat Chao Phraya river valley, which runs into the Gulf of Thailand.

The Chao Phraya and the Mekong River are the indispensable watercourses of rural Thailand. Industrial scale production of crops uses both rivers and their tributaries. The Gulf of Thailand covers 320,000 km<sup>2</sup> (124,000 sq mi) and is fed by the Chao Phraya, Mae Klong, Bang Pakong, and Tapi Rivers. It contributes to the tourism sector owing to its clear shallow waters along the coasts in the southern region and the Kra Isthmus. The eastern shore of the Gulf of Thailand is an industrial centre of Thailand with the kingdom's premier deep-water port in Sattahip and its busiest commercial port, Laem Chabang.

The Andaman Sea is a precious natural resource as it hosts the most popular and luxurious resorts in Asia. Phuket, Krabi, Ranong, Phang Nga and Trang, and a number of islands, all lay along the coasts of the Andaman Sea and, despite the 2004 tsunami, they are a tourist magnet for visitors from around the world.

Thailand's climate is influenced by monsoon winds that have a seasonal character (the southwest and northeast monsoon). Thailand has three seasons. Due to its inland nature and latitude, the north, northeast, central and eastern parts of Thailand experience a long period of warm weather. During the hottest time of the year (March to May), temperatures usually reach up to 40°C (104°F). In contrast, high air pressure from China can bring colder temperatures; in some cases (particularly the north and northeast) close to or below 0°C (32°F). Southern Thailand is characterized by mild weather year-round with less diurnal and seasonal variations in temperatures due to maritime influences. Most of the country receives a mean annual rainfall of 1,200 to 1,600 mm (47 to 63 in).

## 10.2 Mining History

Mining has been the fundamental industry that significantly benefits to Thailand's economy for centuries. Thailand has relatively complex geological settings that favourable for various kinds of mineral deposits, both onshore and offshore, throughout the country. More than 40 mineral deposits have been found and mined at present. Tin was one of the most important minerals, which also include Gold, Lead, Zinc, Wolfram, Aggregate rock and Gemstones. Phuket and nearby, southern Thailand were rich in Tin deposit. The historical evidence indicated that Phuket could be the first area of Tin mines in Asia.

In B.E. 2061 (A.D. 1518), Thailand started trading Tin with Portugal.

In B.E. 2228 (A.D. 1685), Thailand started trading Tin with France.

In B.E. 2450 (A.D. 1907), the miner from Australia stated using Tin Dredging mine in Thung Kha Bay (Tongkah Harbour), south Phuket. Since then, Tin production was increased rapidly. Tin was among the top 4 of exported goods including rice, teak and rubber, for many decades.

Mining history in Thailand, from incidentals sequence, is divided into 3 periods.

1. Early period of Mining (during B.E. 2434 (A.D. 1891) - B.E. 2510 (A.D. 1967))
2. Middle period of Mining (during B.E. 2510 (A.D. 1967) - B.E. 2560 (A.D. 2017))
3. Present period of Mining (from B.E. 2560 (A.D. 2017) - Present)

### 1) Early period of Mining (during B.E. 2434 (1891) - B.E. 2510 (1967))

King RAMA 6 established the Royal Department of Metallurgical and Geology (Department of Mineral Resources), on 1 January B.E. 2434 (A.D. 1891), under Ministry of Agriculture, responsible for geological exploration, mineral exploration, mining, concession licensing, mining control, mineral royalty, etc. At that time, the Royal Department of Metallurgical and Geology gave precedence to Tin mine, Gold mine and Gemstones mine.

**Mining Act B.E. 2444 (A.D. 1901)**, the first Mining Act of Thailand was enforced in B.E. 2444 (A.D. 1901). The most important reasons for Mining Act B.E. 2444 (A.D. 1901) enforcement was that Thailand has open the country for trading, business, and investment with foreigners, including mining business. The most important minerals and mines were Tin, Gold, Lead, Zinc, Wolfram, Molybdenum, Aggregate rock and Gemstone. The southern part of Thailand was the most important area of those minerals and mines. Afterwards, the Royal Department of Metallurgical and Geology has been changed to Department of Metallurgical, under Ministry of Interior. In B.E. 2485 (1942), the Department of Metallurgical was affiliated to the Ministry of Industry.

Seventeen years later, **Mining Act B.E. 2461 (A.D. 1918)**, the second Mining Act of Thailand, was enforcement and replaced the first Mining Act B.E. 2444 (A.D. 1901).

### 2) Middle period of Mining (during B.E. 2510 (1967) - B.E. 2560 (2017))

The middle period of mining began when the Minerals Act B.E. 2510 (1967) was enforcement and replaced the Mining Act B.E. 2461 (1918) in B.E. 2510 (1967). During the middle period of mining, modern technology of mineral exploration and mining in Thailand were applied, for example airborne geophysical survey, underground mining and solution mining, etc. Minerals Act B.E. 2510 (A.D. 1967) covered all aspects of minerals exploration and mining with 13 chapters; General Provisions, Committee, Prospecting and Exclusive Prospecting, Mining, Artisanal Mining and Ore Panning, Purchase, Sale, and Storage of Minerals, Payment of Royalty, Possession, and Transport of Minerals, Mineral Processing, Metallurgical Processing, Reimbursement of Royalties, Import and Export of Minerals, Punishment and Transitory Provisions.

During this period, minerals exploration and mining activities in Thailand have reached the highest peak. Thailand was ranked 110 of the 123 countries with minerals deposit potential. Top 5 minerals production in value, during 2007-2016, were Limestone and other Industrial rocks, Lignite, Gypsum, Gold and rock salt, respectively.

More than 40 mineral deposits found in Thailand, with potential areas of 99,730 km<sup>2</sup> or 19% of the country area. At the ends of the period, Thailand has totally 1,023 mining concessions, 89 special exploration licenses and 7 exploration licenses.

### 3) Present period of Mining (B.E. 2560 (A.D. 2017) - Present )

The Present period of Mining in Thailand began when The Minerals Act B.E. 2560 (A.D. 2017) was enforcement and replaced the Mining Act B.E. 2510 (A.D. 1967) in August, 29 B.E. 2560 (A.D. 2017). It was one of the newest laws of Thailand. The acts focus on management of mineral and mining .

**The Minerals Act B.E. 2560 (A.D. 2017)** gives precedence to mineral management and covers all related aspects of minerals exploration and mining, with 16 chapters; Mineral Management Policies, Minerals Committee and Provincial Mineral Committee, General Provisions, Mineral Exploration, Mining, Underground Mining, Small-Scale Mining, Mineral Business Operation, Mineral Dressing and Metallurgy Operation, Survey, Rejection of Applications and Cancellation, Correction and Revocation of Permission, Mineral Royalties, Fees, and Special Subscription, Development and Promotion, Civil Liability, Control and Inspection, Penalties and Transitory Provisions.

## 10.3. Status of Minerals Industry

### 10.3.1 Thailand GDP from mining

GDP from mining in Thailand increased to 60,256 M. Baht in the fourth quarter of 2017 from 57,549 M. Baht in the third quarter of 2017.

Thailand had a GDP in 2017 was 15.450 trillion Baht (US\$455 billion), the 8<sup>th</sup> largest economy of Asia and mining contributed about 2.5% to Thailand GDP.

GDP from Mining in Thailand averaged was 42,965.12 M. Baht from 1993 to 2017.

GDP from Mining in Thailand reached an all-time high of 63,557 M. Baht in the first quarter of 2016 with a record low of 20,064 M. Baht in the first quarter of 1993.



Figure 10.2 Thailand GDP from mining.

### 10.3.2 Mines in Thailand In 2018

1. Operation Mine: 940 concession blocks in 57 provinces
2. Mineral exploration License: none
3. Exclusive Mineral Exploration License: 6
4. Special Mineral exploration License: 97
5. Ore types in Thailand: 51
6. The concession certificate expires (April 2018): 1,851 concession blocks
7. The concession certificate will expires (Next 5 years (2018-2023)): 395 concession blocks
8. The mineral royalty
  - 8.1. in 2016: 4,214.01 M. Baht
  - 8.2. in 2017: 4,106.05 M. Baht
  - 8.3. in 2018 March: 1,765.50 M. Baht
9. Number of labor
  - 9.1. In 2016: 11,098 persons
  - 9.2. In 2017: 10,752 persons

### 10.3.3 Mineral Production of Thailand (2016 – 2017)

In 2016, Total Mineral Production in value was 66,370.2 M. Baht. In 2017 Total Mineral Production in value was 73,723.9 M. Baht, 19.47% decreased.

Quantity: Tones, Value: Baht

Ore Name	2016(Jan-Sep)		2017(Jan-Sep)		Percentage	
	Quantity (Tonnes)	Value (Million Baht)	Quantity (Tonnes)	Value (Million Baht)	Quantity	Value
1. Limestone Industrial rock-construction	76,629,737	13,793,30	71,810,859	12,926.00	-6.29%	-6.29%
2. Limestone Industrial rock-cement	54,479,879	13,619.90	52,167,514	13,041.90	-4.24%	5,759,427
3. Lignite	13,216,001	12,687.40	10,943,576	10,505.80	-17.19%	-17.20%
4. Basalt (industrial rock)	10,585,672	2,117.10	8,404,108	1,680.80	-20.61%	-20.61%
5. Gypsum (unground)	8,118,358	5,390.60	6,201,203	4,033.50	-23.62%	-25.18%
6. Granite Industrial rock	6,722,281	1,344.50	5,528,631	1,105.70	-17.76%	-17.76%
7. Industrial rock - others	4,860,198	1,215.00	5,475,916	1,369.00	12.67%	12.67%
8. Shale (industrial rock-cement)	5,759,427	1,439.90	4,805,403	1,201.40	-16.56%	-16.56%
9. Anyhydrite	995,010	660.70	1,030,924	666.60	3.61%	0.89%
10. Feldspar Sodium (unground)	835,170	584.60	975,898	683.10	16.85%	16.85%

### 10.3.4 Mineral Consumption of Thailand 2016-2017

In 2016, total mineral consumption in value was 75,019.9 M. Baht. In 2017 Total mineral consumption in value was 73,723.9 M. Baht, 1.73% decreased.

Quantity: Tonnes, Value: Baht

Ore Name	2016		2017 (Preliminary)		Percentage	
	Quantity (Tonnes)	Value (Million Baht)	Quantity (Tonnes)	Value (Million Baht)	Quantity	Value
1. Limestone Industrial rock-construction	100,549,964	17,251.50	91,273,052	16,429.20	-9.23	-4.77
2. Limestone Industrial rock-cement	71,766,737	16,887.20	71,533,290	17,883.30	-0.33	5.90
3. Lignite	16,279,093	15,627.90	16,573,182	15,910.30	1.81	1.81
4. Basalt (Industrial rock)	13,408,790	2,580.00	11,443,013	2,288.60	-14.66	-11.29
5. Industrial rock-others	6,546,690	1,530.20	7,218,999	1,804.70	10.27	17.94
6. Granite Industrial rock	8,621,425	1,653.80	7,376,550	1,475.30	-14.44	-10.79
7. Shale (Industrial rock-cement)	7,375,868	1,752.30	6,501,094	1,625.30	-11.86	-7.25
8. Gypsum	4,139,376	2,748.50	3,608,298	2,362.30	-12.83	-14.05
9. Cement clay	4,770,726	429.40	3,054,931	274.90	-35.97	-35.98
10. Dolomite	2,092,334	1,150.80	2,256,527	1,241.10	7.85	7.85

### 10.3.5 Mineral Export of Thailand (2016-2017)

In 2016, total mineral export in value was 201,40.00 M. Baht. In 2017, total mineral exported in value was 12,860.20 M. Baht, 36.15% decreased.

Quantity: Tonnes, Value: Baht

Ore Name	2016		2017		Percentage	
	Quantity (Tonnes)	Value (Million Baht)	Quantity (Tonnes)	Value (Million Baht)	Quantity	Value
1. Silver metal (unit:gram)	33,953,635	712.50	-	-	-	-
2. Gypsum Unground	6,460,030	4,329.60	5,731,950	3,663.70	-11.27	-15.38
3. Gold metal (unit:gram)	4,292,946	6,039.90	-	-	-	-
4. Anhydrite - Unground	-	-	1,449,160	896.20	-	-
5. Dolomite - Unground	1,261,885	547.40	1,080,416	487.20	-14.38	-11.00
6. Feldspar Sodium (Ground)	638,497	569.40	660,876	579.50	3.50	1.77
7. Limestone Industrial rock-construction	611,270	271.00	546,023	219.60	-10.67	-18.97
8. Iron ore	57,668	61.30	-	-	-	-
9. Fluorite (Metallurgical grade)	32,174	174.20	20,733	111.50	-35.56	-35.99
10. Kaolin (Washed)	13,785	82.10	17,340	100.80	25.79	22.78

### 10.3.6 Mineral Import of Thailand (2016-2017)

In 2016, total mineral import in value was 57,874.32 M. Baht. In 2017, total mineral import value was 66,110.02 M. Baht, 14.23% increased.

Ore Name	2016		2017		Percentage	
	Quantity (Tonnes)	Value (Million Baht)	Quantity (Tonnes)	Value (Million Baht)	Quantity	Value
1. Coal Solid Fuels from Coal	11,335,865	17,816.00	12,135,732	23,170.20	7.06	30.05
2. Bituminous coal	10,172,204	23,061.70	9,903,771	25,517.00	-2.64	10.65
3. Limestone	76,654	27.50	374,399	93.70	388.43	240.73
4. Flint	19,705	14.10	303,909	90.30	1,422.26	540.43
5. Lignite	91,721	120.10	198,926	209.40	116.88	74.35
6. Silica sand	143,315	277.30	190,852	380.10	33.17	37.07
7. Talc	137,350	1,646.50	140,289	1,634.20	2.14	-0.75
8. Anthracite	181,673	777.40	138,649	573.20	-23.68	-26.27
9. Bentonite	107,646	758.00	120,287	776.60	11.74	2.45
10. Basalt	40,860	298.30	90,726	235.00	122.04	-21.22

## 10.4 Best Practices of Mine Rehabilitation and Decommissioning

### 10.4.1 Laws

1) **Minerals Act B.E. 2560** (A.D. 2017): Department of Primary Industry and Mines (DPIM) is responsible for mineral exploration and mining license under Mineral Act 2560 (A.D. 2017) and related Ministerial Regulations as well as Rehabilitation. Minerals Act B.E. 2560 (A.D. 2017) indicates parts of Rehabilitation are Section 54(2), Section 68(8), Section 68(9) and Section 70.

Section 54. Any person who intends to apply for a concession certificate shall submit an application to the local mineral industry official. The applicant for a concession certificate must furnish the following documents or evidence together with the application:

(2) plans on the rehabilitation, development, exploitation and surveillance of impacts on the environmental quality and public health during the mining and after the closure of the mine;

Section 68. A holder of a concession certificate has the duties as follow:

(8) to rehabilitate the mined area, during the mining and subsequent to the closure of the mine, in accordance with the plans on the rehabilitation, development, exploitation and surveillance of impacts on the environmental quality and public health as approved by the Minerals Committee;

(9) to place such security, for the purposes of rehabilitating the mined area and providing remedies to persons affected by the mining, as determined by the Minerals Committee, and, with respect to the mining in Class 2 and Class 3, to take an insurance against liability for loss of life, physical damage and property damage of third parties in such an amount as required by the Minerals Committee;

In the case where environmental conditions have changed, the concession certificate issuer has the power to require revision of the plans on the rehabilitation, development, exploitation and surveillance of impacts on the environmental quality and public health under (8) and revision of the placement of the security under (9) in line with the revised plans.

Section 70. In the case where a holder of a concession certificate fails to comply with section 68 (8) or fails to provide remedies to persons affected by the mining, the Department of Primary Industries and Mines shall apply for the money from the security or the compensation from the insurance under section 68 (9) to the payment of costs incurred in the action concerned and notify the holder of the concession certificate to place security or take an insurance to maintain the original amount within fifteen days as from the date of receipt of the notification

In the case where a holder of a concession certificate has completely complied with the conditions specified by the concession certificate issuer or has completely rehabilitated the mined area in accordance with the rehabilitation plan or has provided remedies to persons affected by the mining, the remaining security under section 68 (9) shall be returned to the holder of a concession certificate.

In preparations to open mine, the holder of the concession has to follow EIA Mitigation Report. During mining, the holder of the concession has to do rehabilitation plan as indicated in EIA Mitigation Report. At the end of mining, the authority will check in the Report Form for expired license. The holder of a concession certificate has to report a plan and result of rehabilitation to DPIM, every 3-5 years, depending on mitigation approved by the Minerals Committee and reported to DPIM. The rehabilitation report consist of

1. History of concession license
2. Present mining area (picture & Lay out mining)
3. Pattern of land use in the end. (picture & Lay out mining)
4. Result area planting. (picture & Lay out mining)
5. Plan of rehabilitation for next 3-5 years (picture & Lay out mining)
6. Funds for rehabilitation.

Before admit the holder to close mine. The regulators (local officers) have to evaluate the mine and check the Expired License Form, as listed below:

1. History of concession license, such as name the holder, address, type of ore, A period of concession certificate, an area, a possessory right in the land
2. Physical and chemical stability: present area, slope stability, the hole, the remaining security, the rest of ore, building, equipment for mining, waste rocks, etc.
3. Funds for rehabilitation remain
4. Activities rehabilitation, follow EIA report
5. Operation mine according mitigation plan
6. Recommend and others
7. Conclusion to closure mine or not and do something

2) **Environment Law:** Improvement and Conservation of National Environmental Quality Act B.E. 2535 (A.D. 1992); the holder of the concession has to follow the Law, e.g., Environmental Impact Assessment Report.

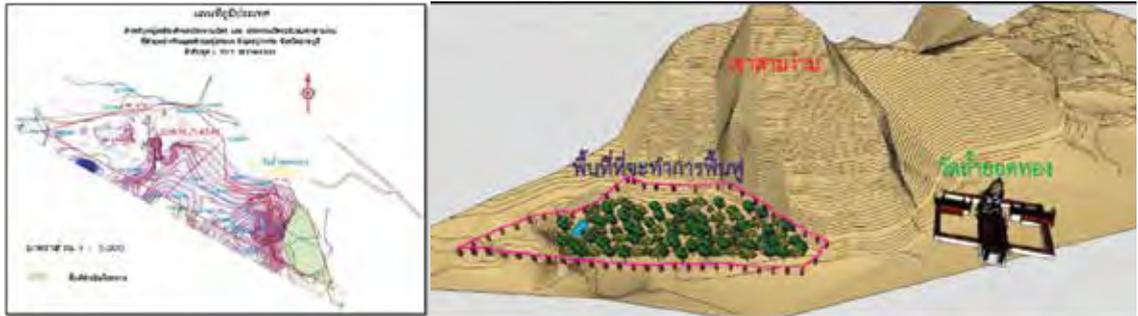
3) **Forestry Laws;** the holder of the concession has to follow the Law, e.g., forestation.

4) **National Mineral Policy:** National Mineral Strategies 20 years ( B.E 2560 – 2579 (A.D. 2017-2021) and Master Plan of Mineral Management B.E. 2560-2564 (A.D. 2017-2021) The holder of the concession has to follow the Policy issued by National Mineral Policy Board, e.g. mineral management policy.

## 10.4.2 Government

Best practices of mines rehabilitation and decommissioning (abandoned mines) was carried out by the Royal Thai Department of Primary Industry and Mines (DPIM), some of them are in Ratchaburi province, Chiang Mai province and Nan province.

### 1) Rachaburi Province (2015)



**Figure 10.3** Design model for Rehabilitation mine.



**Figure 10.4** Abandoned mine before reclamation.



**Figure 10.5** Soil filling in abandoned mine areas.



**Figure 10.6** Level the ground.



**Figure 10.7** Transfer plants from nursery house.



**Figure 10.8** Local trees planting.



**Figure 10.9** Watering after planting.



**Figure 10.10** Growth plants in reclamation mine area after 1-2 year.



**Figure 10.11** Plants growth & honeycomb come back in reclamation mine areas (after 3 years).



## 2) Abandoned mine in Chiang Mai Province (2016-2017)



**Figure 10.12** Location map of the abandoned mine area for reclamation in Chiang Mai Province.



**Figure 10.13** Abandoned mine before reclamation.



**Figure 10.14** Level the ground.



**Figure 10.15** Fence and railing.



**Figure 10.16** Walking pathway in reclamation areas.



**Figure 10.17** Playground for children.



**Figure 10.18** Monitoring water after reclamation.



**Figure 10.19** Monitoring & Maintenance the plant after reclamation.



**Figure 10.20** Interview the people around area after reclamation for 2 years.

### 3) Abandoned mine in Nan Province (2017)



Figure 10.21 Location map and aerial photograph showing the location of the concession area.



Figure 10.22 Abandoned mine before reclamation.



**Figure 10.23** Interview the people before starting of the reclamation.



**Figure 10.24** Ground leveling.



**Figure 10.25** Plantation Day, local people participated in the rehabilitation areas.

### 10.4.3 Company Information

Best practice: There are three case studies carried out by the mining companies for rehabilitation:

1. Padaeng Industry Public Company Limited (PDI)
2. Mae Moh Mine Electricity Generating Authority of Thailand
3. Siam Cement Group (SCG)

#### 1) Padaeng Industry Public Company Limited (PDI)

Padaeng Industry Public Company Limited owned a zinc mine, with ore smelter in Tak province, West Thailand. Ore Production was 150,000 MT/year with a high grade of 20% Zn 85,000 tonnes/year and concentrates of 25%Zn 65,000 tonnes/year. Concession certificate No.30769/15525, period operation 11/7/2002-10/7/2017, run rehabilitation. Concession certificate No.30779/15797, period operation 8/4/1908-7/4/2023, stop operation and run rehabilitation.

Concept for Environmental Rehabilitation of PDI Mine

- Rehabilitation in-between Mining Activities
- Set The Environmental Rehabilitation Fund
- Non-contaminated Topsoil Procurement
- Vetiver Grass Planting for Soil and water conservation
- Local Trees Planting



**Figure 10.26** Open Pit Mining.



**Figure 10.27** Land used in PDI Mine.



**Figure 10.28** Overburden Collecting Area.



**Figure 10.29** Mine pit in 2003.



**Figure 10.30** Overburden Collecting Area.



**Figure 10.31** Environmental Rehabilitation in 2013.



**Figure 10.32** Present Photo of Mine Pit, 2018.



**Figure 10.33** Present Photo of Overburden Collecting Area after Mining, 2018.



**Figure 10.34** PDI Office Building, developed to be Zinc Museum, 2018.

## 2) Mae Moh Mine, Electricity Generating Authority of Thailand

Mae Moh Mine, Electricity Generating Authority of Thailand, Lampang province, is the biggest coal mine in Thailand. Coal is used as energy source in Coal Power Plant located next to the mine to generate electricity. Coal has been mined for 15 MT/year feeding the electrical power plant. Several concessions were expired, operation stopped with a follow-up process of rehabilitation.

Reclamation Master Plan objectives

- To conduct Reclamation Master Plan in accordance with the major changes in Mining Plan.
- To reclaim the mined area to make it similar to its previous stage

In the Reclamation Master Plan, a total area to be reclaimed is approximately 16,840 acres with the end-use land are reforestation 93%, reservoir 3% and recreation Area 4%. Reclamation Activities include:

1. Performance results of Reforestation Programme: Ground Preparation, Seeding, Planting and Maintenance
2. Performance results of Environmental Protection: Ground Cover Planting and Green belt.



**Figure 10.35** Mae Moh Mine open pit in 2018.



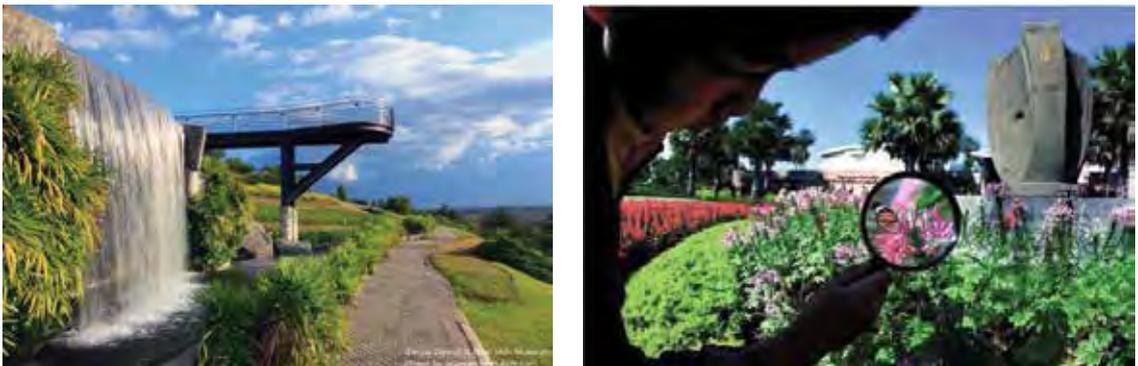
**Figure 10.36** Part of Reclamation includes maintenance activities of the recreation areas to keep the place clean and attractive all the time.



**Figure 10.37** Green belt (left) and Playground (right)



**Figure 10.38** Playground, recreation area and tourist attraction.



**Figure 10.39** Botanical Garden.

### 3) Siam Cement Group (SCG)

Siam Cement Group (SCG) is one of the biggest mine groups in Thailand. Limestone is mined and used for the cement industry in several parts of the country, e.g., Lampang, Saraburi and Nakorn Srithammarat. Several Concessions were expired, the operation ceased, remaining only rehabilitation activities.

Objectives of Quarry Rehabilitation & Biodiversity Management

- To rehabilitate mined area integrated with preserve biological diversity in mining areas including species

diversity and ecosystem for both local plants and animals. Also, to be a pilot model on best practices in quarry

rehabilitation & biodiversity management for all related stakeholders.

#### Quarry Rehabilitation

Phase 1

- Quarry Reclamation
- Green area
- Fast growing species

Phase 2

- SCG Cement Rehabilitation Committee
- Rehabilitation & Biodiversity Policy
- Rehabilitation Master Plan
- Rehabilitation Fund
- Plant selection : Local species

Phase 3

- Forest Restoration & Framework Species method
- Rehabilitation Learning Center
- Rehabilitation Handbook
- Expand to regional biz. & other mines

#### Biodiversity

Phase 1

- Flora survey
- Fauna survey

Phase 2

- WWF Thailand
- Apply Biodiversity into the Rehabilitation pilot area

Phase 3

- Ecosystem restoration
- Biodiversity Management Plan
- Ecosystem Service Review

#### Next step:

To be Net Positive Impact

- Biodiversity Offset Program
- Natural Capital Protocol
- Social Return on Investment (SROI)



Figure 10.40 Mine pit (Thung Song mine) in 2010.



Figure 10.41 Mine pit (Thung Song mine) in 2017.



Figure 10.42 Rehabilitation & Biodiversity Learning Center.

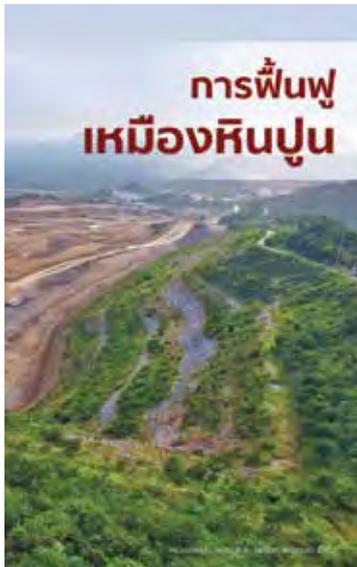


Figure 10.43 SCG Rehabilitation & Biodiversity Handbook.



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