Status and Future of the North Korean Minerals Sector

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Prepared for:

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January 6, 2011

NAUTILUS INSTITUTE

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1. Introduction

The minerals industry is of great importance to the economy of the Democratic People's Republic of Korea (DPRK), accounting for about 15.2% of its exports in 2005. (Chung, Woo Jin 2007, p. 3). In particular, the iron and coal mining industries have been priority industries for DPRK economic development since the 1970s (Korea Mining Promotional Corporation report, 2005). Minerals industries in the DPRK have been played prominent roles in North Korean National exports as shown in Table 1, below. The DPRK holds the great bulk of the total known minerals deposits on the Korean peninsula. It is estimated that some 200 of the minerals found in the DPRK have economic values. The value of North Korea's known minerals deposits was estimated to be nearly thirty times of that of South Korea's as of 2005 (Kim, Young Yoon, 2007, p. 13).

Mining industries are very important to the DPRK. The mining subsector of the DPRK's industry accounted 8.3% of the North Korean GDP and about 15.9% of total export revenues in 2005. The minerals production sector in North Korea has, however, been struggling because of poor central planning and a lack of modern technology and equipment, as well as a shortage of electricity. For these reasons, North Korea needs to rebuild its production lines by obtaining proper equipment and technology (ibid, p.14). As a result of the problems noted, minerals production in the DPRK has declined sharply in the past two decades. It is estimated that production in 2002 was between one third and one half in comparison with output data obtained during 1989 (ibid, p. 12, and private source, 2010). In the decade from 1997 to 2007, DPRK authorities have allowed foreign investors to participate in selected mining projects. The Government plans to continue its effort to consolidate heavy industries, and at the same time to develop light industries.

Based on a study conducted by Chung, Woo Jin (Korea (South) Energy Economics Institute, 2007), exploitation of the DPRK's mineral resources through linkages with South Korean and overseas consumer markets is likely to be the most profitable way for the DPRK to develop its minerals sector. Strong markets for the DPRK's gold, silver, lead, iron ore, zinc, Tungsten, copper, and other metallic minerals are likely. In additions, among the DPRK's non-metallic minerals, magnetite, flaky graphite, and limestone are valuable products.

The DPRK's mineral resources are of considerable interest to the Chinese market, as moving North Korean minerals to China is less expensive in comparison with the transportation costs involved in acquiring Australian and Brazilian mineral resources (Chinese Source and Private source, 2010).

Table 1: Importance of the Mineral Sector in the DPRK Economy

Year	Total export US$ 100m.	Mineral Export US$ 100m.	Comparison (%)
1998	6.4	0.8	12.3
1999	6.5	0.6	9.3
2000	7.1	0.6	8.5
2001	8.2	0.8	9.8
2002	10	1.1	11
2003	10.7	1.7	15.9
2004	6.6	0.6	9.1
2005	6.6	1	15.2

Source: Korea (ROK) Trading-Investment Agent <http://www.globalwindow.org>

This paper describes and evaluates the DPRK's mineral sources in terms of importance, where they are found, and how they might be developed with financial input by overseas investors. This study will propose various ways of effectively engaging in businesses in mineral resources development and investment in the DPRK by analyzing the mineral industries of the DPRK and exploring possible investment projects in the DPRK mineral industry. The difficulties typically encountered in trading between the DPRK and foreign investors, possible solutions to those difficulties, and the economic effects of trade in minerals on the DPRK are also studied.

1.1. Sources and Methods Used in this Paper

In order to prepare this paper, various methods have been used to gather facts and sources from the DPRK, China and South Korea. First, DPRK internal documents related to natural resources in the DPRK and their exploration were collected from contacts in the border region of the DPRK and China. Second, some sources providing trade data and other documents were collected from representatives of Chinese state-owned corporations and medium-sized businesses, as well as North Korea-related economic research institutes in China. Thirdly, statistical data and in-depth research papers were collected from South Korean energy-related institutes and government-owned research institutes in order to analyze and to assess DPRK natural resources from an objective view point.

In addition, the author interviewed 11 North Korean defectors living in Seoul and Australia who have work experience in the minerals and coal mining industries in the DPRK (5 were in mines in Ham-Gyung province, 2 were in the coal industry in Pyong-An province, and 4 were from Pyong-an and Chong-Jin Ion manufacturing companies and the Nam-Po and Moon-chon refinery) as a key method to collect information on latest current situation in the DPRK mining industry. Cooperating with South Korean institutes such as the Korea Energy Economics Institute The ROK National Institute for Unification is another source of ideas as to how to

produce effective outcomes and feasible solutions for potential overseas investors and DPRK-related policymakers**.**

Data on trade experiences between North and South Korea and between the DPRK and China in the North Korea natural resources development and export area also were used to assemble data to help inform potential overseas investors. To analyze DPRK mineral industry development and investment from overseas including from China and South Korea, newspapers (South Korean, Chinese, and English-language newspapers), broadcast sources, and internet sources were collected during the period from 1998 to 2010 via the internet and through KOTRA (the South Korean Trading and Investment Agency), and were analyzed by annual periods. Finally, the author's experience and knowledge (as a former North Korean assistant researcher in the DPRK Agricultural Research Center, with education including majoring in the Earth Physics Geological Exploration course at Chong-Jin Mineral and Metal University), were used to compile this paper. As a geology student, the author traveled and was involved in minerals exploration projects throughout the DPRK for 3 years. The author's experiences and the book "Geologic travel in North Korea", published in 1995, were also used in preparing this paper, in part to make up for a lack of academic articles and papers in the literature focusing on the DPRK mineral production and related educational and organizational systems, and to compensate for the lack of realistic documents on the mining and coal industries in the DPRK.

1.2. Current Status of the DPRK Minerals Sector

Table 2 summarizes the known reserves of major natural resources in the DPRK, along with their value, if extracted, assuming 2005 resource prices**.** .

Table 2: Major Natural Resources in the DPRK

Classification	Grade (%)	Unit	Deposit	Value (US$, million)
Gold	Metal (Au,100)	1,000 tons	1.5	19,171
Silver	Metal (Ag, 100)	1,000 tons	4	745
Copper	Metal (Cu 100)	1,000 tons	2155	2,044.9
Pb	Metal (Pb 100)	1,000 tons	6000	1,178.4
Zn	Metal (Zn 100)	10 million tons	1.5	6,709.1
Iron	Fe 50	100 million. tons	30	71,866.3
Tungsten	WO_3 65	1,000 tons	250	219.4
Molybdenite	Mose 90	1,000 tons	2	8.2
Manganese	Mn 40	1,000 tons	200	6.5
Nickel	Ni 3	1,000 tons	15	3.6
Black lead	Various classes	1,000 tons	6000	3,316.5
Limestone	Various classes	100 million Tons	1000	996,230.7
Kaolin	Various classes	1,000 tons	2000	30.2
Talc	Various classes	1,000 tons	600	75
Asbestos	Various classes	1,000 tons	13	0.9
Fluorspar	Various classes	1,000 tons	500	12.5
Barite	Various classes	1,000 tons	2100	163.6
Magnesite	MgO 45	100 million tons	35	126,000
Anthracitic	Various classes	100 million tons	117	767,138.9
Bituminous coal	Various classes	100 million tons	30	168,000
Total				**2,162,927**

Source: Korea Mining Improvement Corporation Report (ROK), 2004

1.3. Key Regional Mines and Capacity of Extractive Infrastructure

There are more than 360 types of natural resources in DPRK, which are for the most part evenly spread out across North Korean regions. 220 types of resources among them are useful for economic purposes. The DPRK's reserves of tungsten, molybdenite, black lead, barite, and Fluorite, for example, place the DPRK among the world's top 10 countries in terms of reserves (Korean Mining Improvement Corp. (ROK) report, 2008).

The DPRK has not only vast mineral resources, but also abundant energy resources such as coal and Uranium, which play major roles in supplying power and industrial materials in North Korea.

Table 3 summarizes ROK estimates of mineral resources in the DPRK by major mines in DPRK. In this table, production data for North Korean mineral resource in 1990 have likely been understated, with production somewhat overstated after 1990. A reason for this is that North Korean natural resource production capacity reached its highest level in 1990, based on the author's experience and knowledge, but declined dramatically through 1999. This decrease in DPRK mining capacity was not well known to ROK analysts. As a result, the numbers in Table 3 are inaccurate reflections of true DPRK minerals production. According to the testimony of former North Korean miners (Mr. Kim, 57 years old with 30 years of mining experience, and 6 other interviewees) mining production in the DPRK declined dramatically from the early 1990s (from about 1993-1994) through 1999 (Interviews with Mr. Kim, Mr. Lee, Mr. Koh, Mr. Young, Mr. Shi, Ms, Han, and Private Source, 2010).

Discussions of key mines and output trends for each of several different key minerals are provided below.

Table 3: Output of Major Metallic Ores in the DPRK

	Gold (tons)	Silver (tons)	Copper (1,000 tons)	Tungsten (ton)	Pb (1,000 tons)	Zinc (1,000 tons)	Iron ore (1,000 tons)
1990	5	50	15	1000	80	230	8430
1992	5	50	16	1000	75	200	5747
1994	5	50	16	900	80	210	4586
1996	4,5	50	16	900	80	210	3440
1998	4.5	50	14	500	70	100	2890
2000	2	40	13	500	60	100	3793
2001	2	40	13	500	60	100	4208
2002	2	40	12	600	60	100	4078
2003	2	20	12	600	60	100	4579
2004	2	20	12	600	12	100	4580
2005	2	20	12	600	13	100	5000
2006	2	20	12	600	13	100	5000

Source: Korea Mining Improvement Corporation Report, 2008

(1) Gold Mining

Gold ore is producing with Silver ore and also with Copper ore in the DPRK (private source, 2010). Gold and silver ore reserves total a few million tons of raw ore, according to a Korea

Mining Corporation source, with Gold ore reserves estimated at 2,000 tons (Korea Mining Improvement Corporation report, 2005, p.8) as Au 100% and Silver reserves at 3,000-5,000 tons as Silver 100%.

Major gold mines in the DPRK are the Soo-An Mine (Soo-an-gun, Hwang Buk province), the Hol-dong mine (Yonsan-gun, Hwang Buk province), the Dae-yoo-dong mine(Dongchang –gun, Pyungbuk province), the Woon-san mine (Woonsan-gun, Pyong-Buk province), the Sung-hong mine (Hoi Chang-gun, Pyongnam province), the Sang-nong mine (Huh-chon-gun, Hamnam province), the Ong-Jin Gold mine (Hwang-Hae province) and the Kum-kang mine (Kumkang-gun, Kangwon province) (ibid, p.9 & private source, 2010). The total production from these 7 major gold mines has not been officially reported, however it is clear that the annual gold production capacity is approximately 5 tons in these major mines, and annual silver production is approximately 40 tons (ibid, p. 9, and private source, 2010). In particular, the annual production capacity of the Woon-San gold mine is about 1.5-1.8 tons according to private sources (2010). This mine's capacity is estimated to amount to over 40% of the DPRK's gold production capacity. The Woon-san mine's deposits of gold ore are estimated as 1,500 tons alone, which is almost 50% of North Korean gold reserves (private source, 2010).

In terms of production technology in the gold mining industry, the DPRK has been experiencing a shortage of technology and infrastructure. For example, the large mines described above generally have 30-40 year-old (or older) production equipment, including some equipment inherited from the 1940s Japanese colonial period. As a result, these mines' production capacity is likely similar to their 1940s era production capacity (Private source 2010). As is widely known, the DPRK authorities have declared that all gold production in the country should belong to the Labor Party's assets (which are controlled by the "39" Department, which is Kim Jong Il's private assets manager), and as a result no other organization has the authority to deal with and to produce gold in the DPRK (private sources, 2010). Deeper and deeper strata in the gold mines described above have been worked due to the mines having been operated for more than 50 years, and the increasing depth of pit (tunnel depth) is making it more complicated and difficult to extract gold ore from these mines (private source, 2010).

Due to a decline of gold ore production, DPRK authorities have contacted Chinese businessmen and Japanese business contacts in an attempt to attract funds to invest in those major gold mines (Korea (ROK) Energy Economics Institute, 2005, and private sources, 2010). That means that the Labor Party (39 Department) wishes to produce more gold ore to earn more hard currency to support the newly-announced military leader, Kim, Jong Eun, by providing precious gifts such as Mercedes Benz cars, Swiss-made watches, and whisky for his followers (Private source, 2010).

The investment proposal made to overseas investors by DPRK authorities is as follows: (1), investors should invest at least 1 million US dollars in cash to produce gold ore (Hol-dong gold mine, Kum-Kang, and Woon-san gold mine), (2), the North Korean government will be the guarantor to protect the investor's funds, (3), investors will have the authority to bring out gold ore from the mine they invested in, and export it to overseas locations for refining into gold metal (Private source, 2010).

Transportations infrastructure in gold mining regions use trucks and freight trains as major carriers of ore from mines to refineries, with heavily-armed guards to protect shipments against potential robberies (Private source, 2010).

(2) Iron Ore

Table 4 summarizes the major iron ore mines in the DPRK, including their location, the reported size of their deposits, and the reported grade of their ore bodies, as well as estimates of their output as of 2001.

Table 4: Major Iron Ore Mines of DPRK

Area	Mine name	Location	Deposit	Grade	Others
East	Moo-san	Moo-san, Ham-kyung province	1.5 billion tons	25-35 %	8 million tons. (30%), 3 million tons (60%)
	Lee-Won	Lee-won Ham-Nam, prov.	20 years operation	49%	
	Poong-San	Poong-San Ran-gang prov.	120 million tons	45%	
	Hur-Chon	Hur-chon Ham-nam	150 million tons	48%	
	Dan-chon	Dan-chon Hamnam	100 million tons	45%	
	Jang-Gang	Ja-Gang province	unknown	50%	
West	Eun-Ryul	Hwang-nam province	100 million tons	48%	Open mine 1.6 million tons
	Jae-Ryung	Hwang-nam province	100 million tons	50%	Open mine 500,000 ton
	Chon-Dong	Gae-chon Pyong-Nam province	50 million tons	50%	1 million tons
	Suh-hae-ri	Eun-Ryul Hwang-Nam province	unknown	55%	Under development
	Hah-Sung	Shin-Won Ham-Nam province	15 million tons	45%	Open mine 500,000 ton
	Duck-Hyun	Eui-Joo Pyong-Buk, province	unknown	50%	Iron & copper 500,000 tons
	An-Ark	Hwang-nam province	unknown	50%	Newly developed
	Song-rim	Hwang-buk province	unknown	55%	Newly developed
	Hwang-Joo	Hwang-buk province	unknown	55%	Newly developed
	Yon-San	Hwang-buk province	unknown	55%	Newly developed
	Tae-Tan	Hwang-nam province	unknown	55%	Newly developed
	Gae-chon	Pyong-Nam province	17.5 million tons	45-55%	Developed 1976

Source: "DPRK's Industry", Korea Industrial Bank (ROK), 2001

The overall size of deposits of iron ore in the DPRK is estimated at 3.5 – 4.0 billion tons (including ores of quality in the 22-50% Fe range) according to a Korea Mining Corporation (ROK) report (2008). Major iron ore regions are the Moo-san, Lee-won, Buk-Chong, Hur-chon

areas (Ham-Kyung province), and Eun-Ryul, Shin-Won, and Jae-Ryong (in Hwang-Hea province) (Ibid, p. 16). Details of key mines and factories using iron ore are provided below.

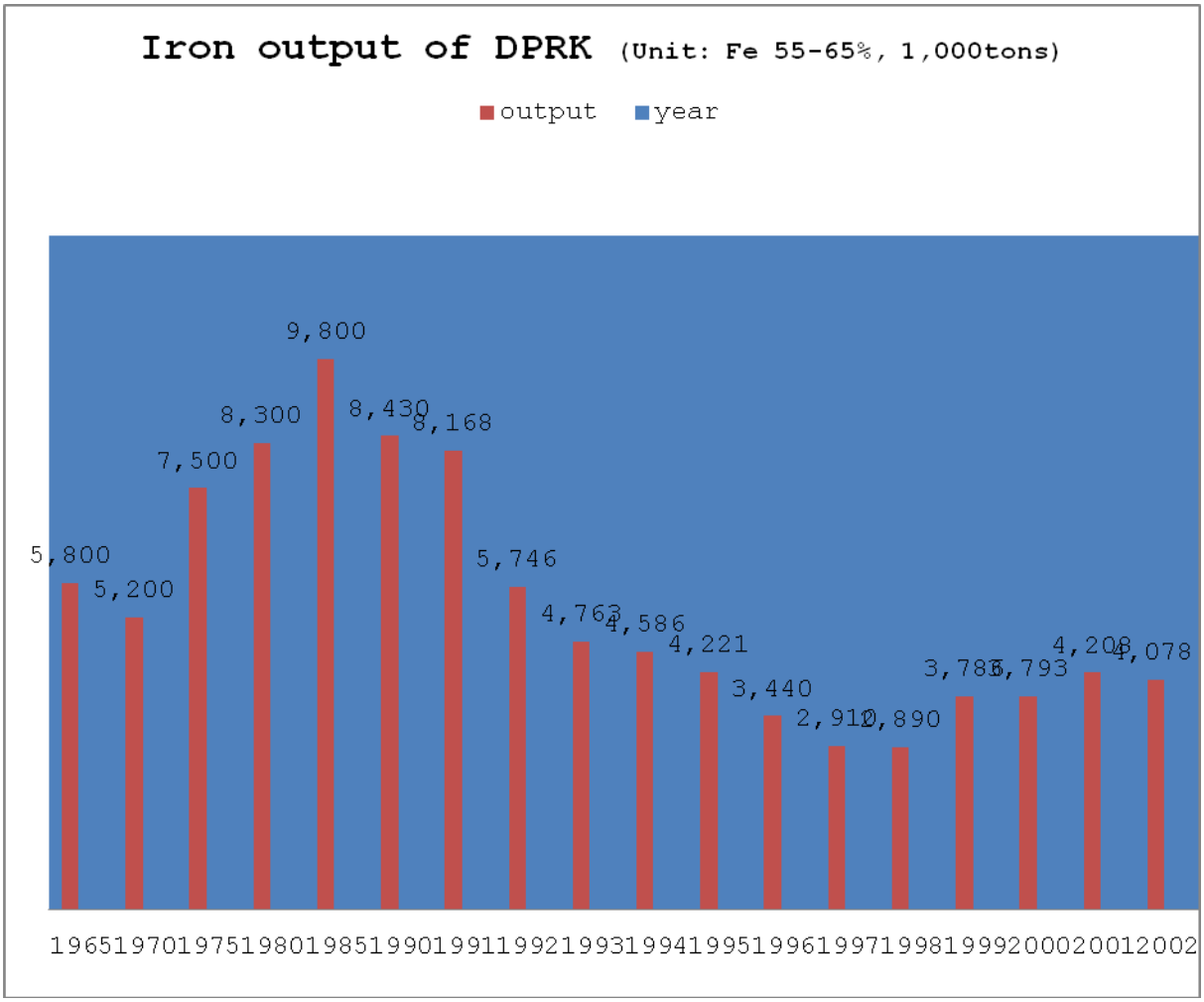
As can be seen from Figure 1, iron ore production in the DPRK peaked in 1985 (at 9.8 million tons, Fe 65%) but sharply declined to 2.89 million tons as of 1998.

Moo-san Iron Ore Mine

The reserves of the Moo-san mine are estimated at 1.5-2.0 billion tons as Magnetite ($FeOFe_2O_3$) containing Fe at 23-30% (ibid, p. 16). The mines reserves are considered low-grade ore (average 25%), but as it is a strip mine (an open pit mine), it is a well-known mine in the worldwide and offers iron ore production at low cost. There are 3-4 mineral veins in the Moo-san mine. The first vein is 400 meters in width, 3,000 meters in length, and 1,000 meters deep. Another 3 veins are known to be similar in structure to the first, but further details on those veins are not available (Korea Mining Improvement Corporation report, p.17, 2008).

In the mine, 28-30% iron ore is refined to an iron content of 60%-65% through a dressing (separation of higher grade ore products) procedure in the mine area. Ore produced from an open surface is sent to 6 ore separators in 25-ton and 50-ton heavy trucks (which were mostly imported from Sweden) then, the ore is sent to dressing plants (for selecting out) by gravity separation methods at a location near the ore separator (private source, 2010).

Figure 1: Estimated Iron Ore Output in the DPRK by Year through 2002



Source: "DPRK's Industry", Korea Industrial Bank (ROK), 2001

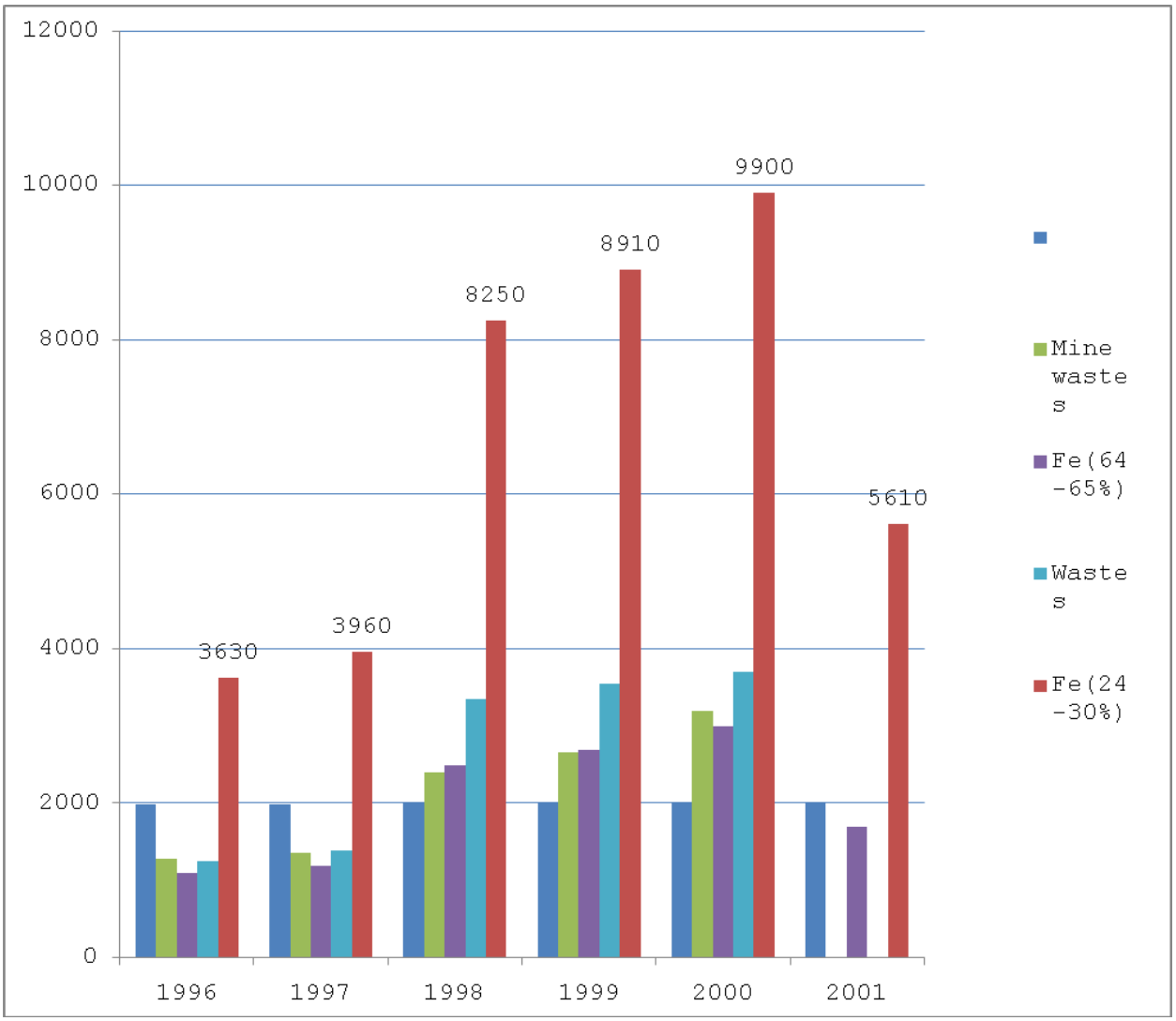
Using this refining method, the ore is produced as 60-65% powdered ore then, sent to the Kim-Cheack Iron-manufacturing plant in Chong-Jin city, 97 km from the Moo-san mine via freight train and via a steel pipe line that is 2 meters in diameter (private source, 2010). Unlike mostr regional one-way railway systems in the DPRK, the railway from the mine is a double line so that powdered ore can be carried out without any delay via freight train if the mine produces at its maximum capacity. In fact, the capacity to carry out powdered ore via the railway and pipe lines (which go the 97 km distance from the Moo-San mine to the Chong-Jin iron manufacturer) was 6 millon tons per year (Kim, 2007, and Private source, 2010).

The mine's production capacity is 3 million tons of 65% powdered ore. As shown in Figure 2, the mine produced 9.9 million tons of raw ore in 1985, but after that production sharply declined to 2.89 million tons, or 30% of 1985's production, though iron ore production at the mine has reportedly been slowly increasing between late 2002 and 2009 (Ibid, p. 17).

As an iron ore provider, the mine has been supplying its production to the Kim-Chaek Iron-Manufacturing Company. This iron-manufacturer's production capacity is 2.17 million tons,

accounting for about 40% of the DPRK's iron production (5.42 million tons) (Korean (ROK) Central Bank report, 2005). This manufacturer employed 20,000 workers when operating at peak output, and its annual capacity is reported to be 2.4 million tons of pig iron, 2 million tons of steel, and 1.4 million tons of steel materials (rolled steel) (Han GyeRe, Newspaper, 3rd Mar. 2002).

Figure 2: Output of iron ore of Moo-san mine (unit: 1,000 tons)



Source, Korea Energy Economics Institute, 2002-2003).

Eun-Ryul Mine

This mine has iron ore in the form of limonite ($Fe(OH)_n H_2O$) and is located in Eun-Ryul-Gun, Hwang-Hae province. Deposits in this mine are estimated to total 200 million tons. Due to their high grade of iron ore (Fe 44%) and the convenience of transporting ore in ships (the Eun-Ryul mine is within 20 kms of Hae-Joo port) the Eun-Ryul mine and the nearby Jae-Ryong mine

descibed below are likely possible destinations for overseas' investment funds (Kim, 2007 and private source, 2010).

Jae-Ryong Mine

This mine is located in Jae-Ryong-Gun, Hwang-Hae province. The mine vein is similar to that in the Eun-Ryul mine. Both mines provide their production to the Hwang-Hae Iron-manufacturer.

Hwang-Hae Iron-Manufacturer

The two mines above provide their production to the Hwang-Hae Iron-manufacturer. This factory's capacity in to produce pig iron is approximately 1.14 million tons per year (Korea Mining Improvement Corporation report, 2005, p. 9). This iron-manufacturer has more modernized and sophisticated facilities relative to the Kim-Chaek Iron-Manufacturer, but it does not operate continuously due to a shortage of iron ore supplies from the Jae-Ryong and Eun-Ryul mines (Chung, 2007 and private source, 2010).

Hur-Chon iron ore mine

This mine is located in Hur-Chon Gun, Hwam-Kyung Nam province. The deposit is composed of reserves of hematite (Fe_2O_3), and the quality of iron ore is 44% (Kim, 2007 and Private source, 2010).

North Korea is reluctant to export iron ore, but it encourages iron ore manufacturers to export steel or pig iron production to China or South Korea (Chung, p. 12, and Private source 2010). Table 5 provides a summary of the production capacity (in units of ten thousand tons per year). Table 6 shows the supply chains—sources of ore and electricity—for major iron manufacturers in the DPRK.

Table 5: Production Capacity of Major DPRK Iron Manufacturers (10,000 tons per year, and fraction of total national capacity)

Name	Iron making (10,000tons)	Steel making (10,000tons)	Rolling (10,000tons)
Kim-Chaek Iron Manufacturer	216.7 (40%)	240 (40%)	147 (36.4%)
Hwang Hae Iron Manufacturer	114.2 (21%)	144.5 (24.1%)	75 (18.6%)
Sung Jin Iron Manufacturer	48 (8.9%)	72.6 (12.1%)	41.5 (10.3%)
Chong Jin steel manufacturer	96 (17.7%)		
4.13 Iron manufacturer	51.6 (9.5%)		
September Iron manufacturer	9.6 (1.8%)	9 (1.5%)	55 (13.6%)
others	6 (1.1%)		
Total	542.1	600.2	403.7

Source: "DPRK's Industries", Korea (ROK) Industrial Bank, 2002

Table 6: Supply chains for Major Iron & Steel Manufacturers in the DPRK

Name	Major Products	Iron Ore	Power Plant	Supplies Products for
Kim-Chack Iron Manufacturer	pig iron, steels, rolled steel	Moo-san Iron mine	Chong-Jin Thermal power plant	Sung-Jin, Chunrima steel maker
Hwanog-Hae Iron Manufacturer	Pig iron, steels, secondary metal products	Eun-Ryul, Jaer-yong mine	Pyong-Yang Thermal power plant	steel sheet, Rail, shape steel
Chunrima steel Manufacturer	general rolled steel steel rope, secondary steel products	Chon-dong, Gea-chon mines	Pyong-Yang Thermal power plant	construction, building materials
Chong-jin steel manufacturer	secondary steel products alloy steel products structural steel		Chong-Jin Thermal power plant	machinery factories, exporting

(3) Copper Mines

North Korean authorities have been deliberately reluctant to reveal information about North Korea's copper mines and copper production capacity to outsiders, including China and South Korea, due to the fact that copper has been a significant material for producing military equipment, for including copper cable, bullets, shells and missile-related materials (Private source, 2010). Thus it is not easy to gather data related to copper mines and copper production in North Korea. There are 3 major copper mines in Northern part of the DPRK: Hur-Chon Copper Mine, Hye-San copper mine and Yong-Heong Copper Mine. Those mines are owned by the People's Army Department as they provide strategic war industry supplies, and are controlled and operated by the PAD (Private source, 2010). The information available on these mines follows.

Hye-San Youth Copper Mine

This mine is located in the Hye-San region in Ryang-Gang province. The copper ore deposit for this mine is known to be 20 million tons, the mine's annual production capacity is 30,000 tons (of Copper 30%) and its employees number about 2,500. Copper ore from the mne is processed in a concentrator unit at the mine, and the concentrated ore is carried by freight train to Dan-Chon refinery (DPRK published document, 2010 and private source, 2010). There are two copper mines in this region: Gap-San copper mine and Shin-Pa copper mine in Ran-gang province.

Hur-Chon Copper Mine

This mine is located in the Hur-Chon region of Ham-Kyung province. The known copper ore deposit for the mine as 15 million tons, and Gold and other rare minerals are also found in the deposit. The annual production capacity of the mine is 20,000 tons (Copper 40%) and it employs 5,500 personnel. Copper ore is processed in a concentrator at the mine and is carried by trucks and freight trains to the Dan-Chon refinery (private source, 2010).

Yong-Heong Copper Mine

This mine is located in the Yong-Heong region in Ham-gyung province. The known copper ore deposit is 12 million tons, and is associated with Gold and rare minerals. The annual production capacity of the mine is 10,000 tons (Copper 40%), it employs 1,500 workers. Copper ore is concentrated in concentrator units at the mine, and is carried by trucks and freight trains to the Dan-chon refinery (Kim, 2007, and Chung, 2007).

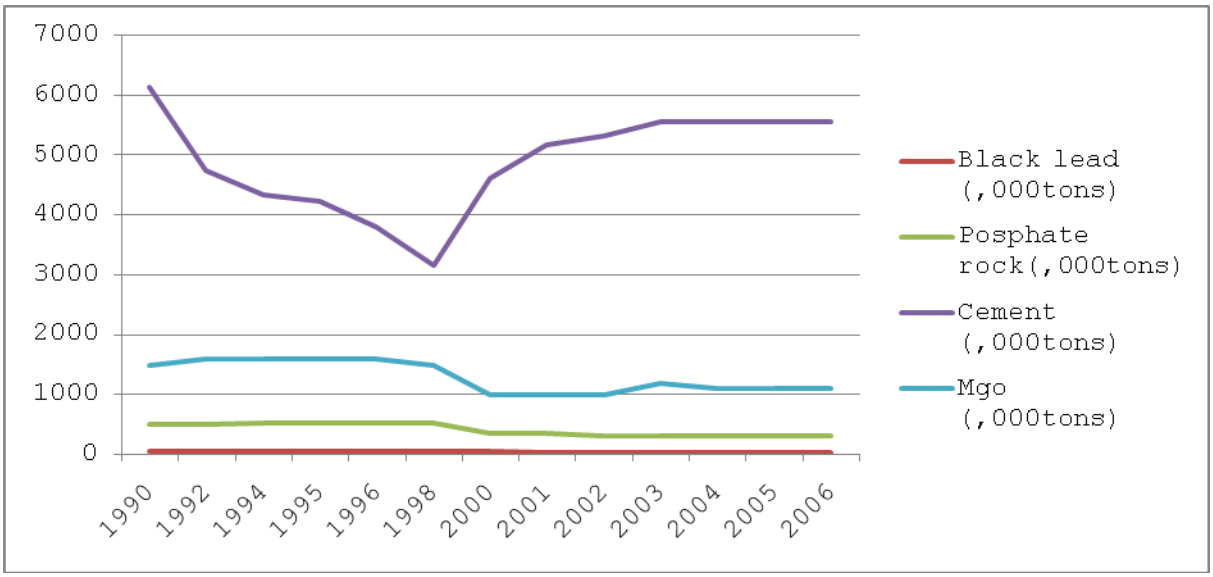
(4) Man-Nyun Mine (Tungsten and Molybdenite)

This mine is located in Shin-Pyong –Gun, Hwang-Hae province. Tungsten reserves in this area are approximately 20 million tons (WO_3 65%), accounting for half of North Korea's total reserves (Ibid, p. 13). There are 10 veins of Tungsten in the deposit, of 3-6 meter width and

1,800 meter length, in this mine. This mine also produces Manganese ore and Copper pyrite ore. The mine's ore separator's capacity is 1000 tons/day, and the mine produces 500,000 tons of ore annually (measured as WO_3 65%). The mine employs 3,500 workers, and has 8 work tunnels for mining (Ibid, p. 15).

Figure 3 shows the output of major non-metallic minerals in the DPRK over the period 1990 thorugh 2006. Major non-metallic mineral products include black lead (graphite), phosphate rock (mainly used as fertilizer), limestone used for cement, and magnesium oxide, from magnesite. Major mines for each of these are discussed below.

Figure 3: Output of Major Non-metallic Ores in the DPRK



Source: Korea Mine promotion Corporation Report, 2005. Note that in this graph, "Cement" denotes tonnes of cement clinker

(5) Magnesium oxide (ore)

The DPRK's reserves of the nonmetallic mineral magnesite are estimated at 3.5 - 4 billion tons (Mg 45%), and are mostly located in the Dan-Chun area, Ham-Kyung province, which is largest deposit in the world. In particular, as a strip mine and large scale mine, the deposit in the Baekgumsan area is approximately 3.6 billion tons and is 7,660 meters length, and 7-100 meters in depth. North Korean production of Magnesite as of 2005 was estimated at 1 million tons as concentrated ore (Kim, 2007 & private source, 2010).

<u>Ryong-Yang Mine</u>

This mine is located in Don-san dong, Dan-Chun city and is a subsidiary of the Dan-Chon Regional Mining Group. The Magnesite ore grade is MgO 30%, and the mine's capacity to produce Magnesium ore is 8 million tons per year, which after concentration of the ore (to 55-

60% Mg) is 3 million tons. Mining operations use two methods, terraced strip mining and underground mining. Heavy trucks operate from inside the mine to transfer points outside of the mine tunnels, and freight trains are used as major carrier to move ore from the mine area (Ibid, p. 15, 2005). A major ore separator was built within the mine in 1988, and the capacity of the separator is 8 million tons of ore per year.

This mine is operating as a subsidiary of the Korea Magnesia Clinker Industry Group (KMCIG), and this parent company has three mines and three clinker manufacturers with 30,000 employees. In addition, the KMCIG operates four kilns for CCM (caustic calcined magnesia) and dead burned magnesia, and its capacity of production is 750,000 tons per year (Kim, 2007, p. 18).

Double railways were built early in the 1990s as infrastructure for this mine. Freight railways operating from the seaside (Dun-chon City) to the mining sites are, however, on steep slopes, and alternative freight methods need to be considered to serve the mine (Private source, 2010).

(6) Lead and Zinc Mines

Most lead and zinc deposits are found in Ham-Kyung, Pyong-An and Hwang-Hea provinces, and the total and total reserve are approximately 600,000 tons (Pb 100%) and 15 - 20 million tons (Zn 100%), respectively. The National total output of lead and zinc are approximately 60,000 tons and 100,000 tons per year respectively (Kim, 2007, p. 12, 2005). Most zinc and lead ore are smelted at the Moon-Pyong Refinery (located in Moon-Chon City, Kang-Won province).

Gum-Dock Mine

This mine is located in Dan-Chon area in Ham-Kyung province. As the largest zinc mine in the DPRK, this mine has rich vein of ore 9 km in extent, and its deposit is estimated at 8 million tons (Zn 100%), half of the DPRK's total deposits (ibid).

(7) Energy resources: Coal

Table 7 list the major coalfields in the DPRK, providing the type of coal mined and the estimated size of coal deposits for each.

Table 7: Deposits in Major Coalfields of the DPRK (unit: million tons)

Type of Coals	Name of coalfields	Deposits of coals
Anthracitic	Northern Pyong-An coalfield	3,670
	Southern Pyong -An coalfield	1,260
	Ko-Won coalfield (Kang-won province)	320
	others	6,490
	Sub-total	11,740
Brown coal	Northern Ham-buk province	1,910
	Southern Ham-buk province	570
	others	520
	sub-total	3,000
Total		14,740

Source: Korean Central Bank, 2008

Coal in the DPRK's economy has been recognized as a major strategic energy resource as an economic development engine, as well as an industrial material for thermal power plants and factories, railway operations and even household (Chung, 2005, and Private source, 2010). Approximately 70% of North Korea's energy is provided by coal, thus coal mines have been recognized as having a significant position in resource development plans for the DPRK's economy (Chung and Kim, 2007 and Private source 2010). The DPRK has exported approximately 2 million tons of coal annually to China in exchange for strategic materials needed by North Korea or for US dollars (or other hard currencies) since 2004. For instance, coal produced in the Pyong-An Regional Mines has been exported to Tien-jin, Dalian and Ching-dao Cities in China from Nam-po port in the Western DPRK (Private source, 2010).

Coal reserves in the DPRK include the coal types Anthracite and Brown coal, but reserves of bituminous coal are not found in the DPRK, according to the Korea Mining Improvement Corporation report, 2004.

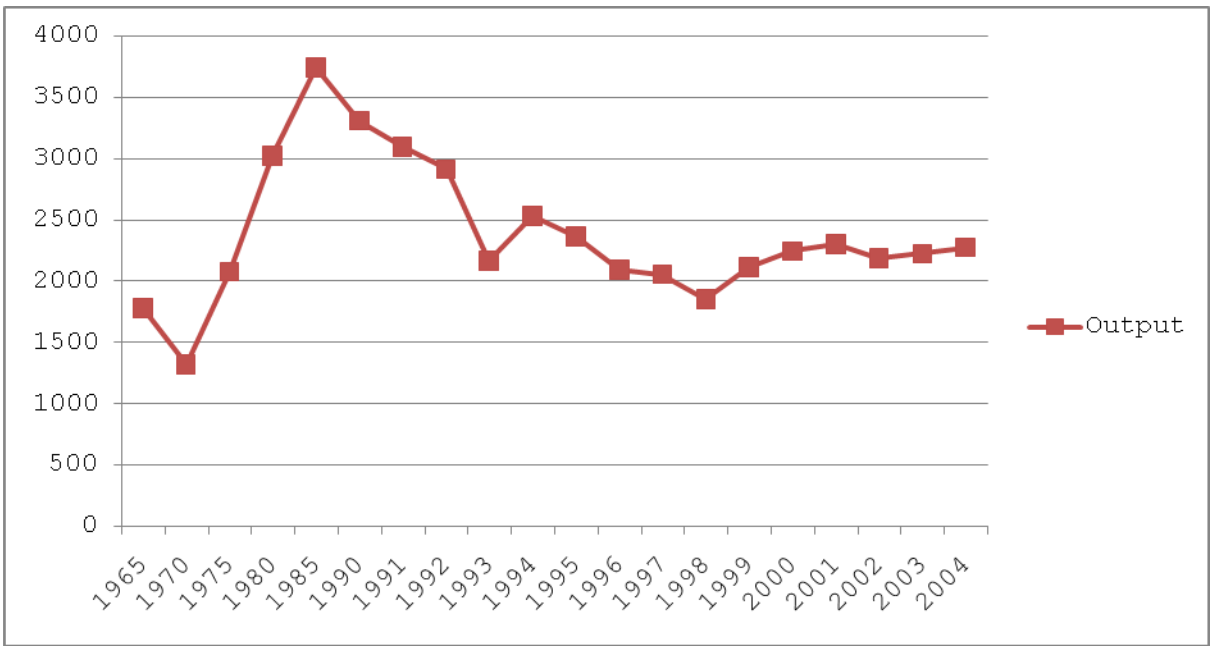
The total of DPRK's coal deposits sum to approximately 14.7 billion tons, including 3 billion tons of lignite coal (soft coal) and 11.7 billion tons of Anthracite coal, mostly in Pyong-an province and Ham-Gyung province.

In terms of antracite coal reserves in North Korea, major coal production areas are classified into two areas: the North Pyong-An coalfield (deposits of 3.7 billion tons) and the South Pyong-an coalfield (deposits of 1.23 billion tons).

In terms of lignite coal reserves, major coalfields are divided into 3 areas: North Ham-gyung province coalfield, South Ham-gyung coalfield, and An-Joo coalfield (Pyong-An province). Coal deposits in those major coalfields are 1.88 billion tons, 480 million tons and 117 million tons respectively (Jung, 2007, p. 5 and Kim, 2007, p. 18).

Figure 4 shows ROK estimates of overall DPRK coal production from the 1960s through 2004.

Figure 4: Output of Coal (units: 10,000 tons)



Source: (Korea Mining Improvement Corporation report, 2005)

It has been reported that the An-Joo coalfield has produced coking coal (high heat content coal used as coking coal), which was exported to China in 2008. By contrast, South Korean research papers on the topic have so far denied the existence of coking-quality coal production at An-Joo (ibid, p.17, Private source, 2010). Annual nationwide coal production was 38.3 million tons in 1989 but production of coal declined sharply after 1990 such that annual coal production was 18.6 million tons in 1999. Estimanted nationalwide coal production capacity, however, is said to have been 53.50 million tons in 1986. (Jung, 2007, p.18).

With regard to coal quality, DPRK-produced anthracite coal from the Duck-Chon coal mine is reported by Chinese importing authorities and Shipping business sources to have the following characteristics. Coal of this type has recently been exported to Chinese thermal power plants in Tien-jin and Dai-lian (private source, 2010). This coal is of much better quality from a caloric value standpoint than normal coal produced by the DPRK.

Coal Specifications:

- Caloric value: 6,480 kcal/kg (min.)
- Fixed Carbon: 80.3% (max.)
- Ash contents: 12.2% (max.)
- Volatile material: 6.1% (max.)
- Sulfur: 0.2% (max.)

- Moisture (max): 6.0% (max.)
- Size: 0-30 mm (100%. min.)

(Source: Invoice from DRPK exporting company, 2009).

Urgent Problems in the DPRK Coal Industry

There are currently several urgent problems that the DPRK coal industry must overcome. First, the depth of mining at existing sites which means that the expense and difficulty of draining underground water has increased, and the operational effectiveness of the mines has decreased, on average. Second, a lack of power, transport equipment, mining technology and funding has held down production. Third, there is a lack of attention to mine development, as opposed to enforcement of impractical plans to promote coal production in the short term when new general managers or Labor party executive are sent to oversee the mines**.** Fourth, deterioration of mining equipment and equipment parts, as well as lack of mine support posts, limits production. Fifth, a high rate of industrial accidents and the lack of new investments in the coal mining industry reduces output. And sixth, that lack of electricity for mine operation is a cause of lack of power production due to the fact that most power plants rely on coal supplied by coal mines as energy sources, resulting in a vicious circle connecting the problems of lack of power and the energy sources used to produce power in the DPRK (Jung, 2007, and Private source, 2010).

(8) Energy Source: Uranium Ore

DPRK has been highly reluctant to reveal the extent of its deposits of Uranium ore and its annual production capacity to the outside world. According to private sources in China and DPRK business contacts, however, the DPRK's deposits of Uranium ore amount to approximately 26 million tons. In fact, there are 2 major Uranium ore mines in the DPRK: the Pyong-San mine, and the Woong-Gi mine, as described below (Private source, 2010).

Pyong-San Uranium Mine

This mine is located in Pyong-San–Gun, Hwang-Hae province and has been operating for 30 years under the control of the People's Army Department. The deposit in this mine area was estimated at 1.5 million tons (as Uranium ore), and the mine's annual production capacity is 10,000 tons (private source). The mine has own separator for concentration of ore. All products are sent to the Nyung-Byun (Yongbyon) Nuclear power station under armed guards. Recently, a new facility for Uranium extraction has been built in the Pyong-Won area (private source, 2010).

Woong-gi Uranium Mine

This mine is located in Woong-gi, Ham-Kyung province and has been operating for 35 years under the control of the People's Army Department. The deposit in this mine area was estimated at 10 million tons (as Uranium ore), and its annual production capacity is 19,000 tons (Private source). The mine has its own separator for concentration of ore. All products are sent to the Nyung-Byun Nuclear power station under armed guards (Private source, 2010). The mine's

operation has been kept from outsiders, and even from North Koreans, due to the fact that output from the mine is known to have been used for nuclear weapon development purposes. As a result, the workers and engineers in the mine have been restricted within the mine facilities even if they suffered from nuclear radiation-related disease (Private source, 2010).

Educational Institute for Uranium Mines

In the fields of geological exploration and engineering , the Kim-Chaek Engineering University, the Chong Jing Mining and Metal University, and the Sariwon Geology University have been playing major roles in staffing exploration activities to find additional Uranium ore deposits. Nyung-Byun Physics University and Lee-Gwa University have been playing major roles in the areas of mining and ore separator operation within mines, as well as logistics, for security reasons (Private source, 2010).

Infrastructure and Facilities for the Mines

Unlike other mining industries in the DPRK, Uranium mines have been targets of heavy investment, and its high grade engineers and skilled workers receive preferential treatment in terms of food, salary and social status. Funds have invested in the mines have been used for mining equipments and facilities,. In particular, instead of freight railway shipping of ore, sophisticated trucks, imported from Sweden and Japan, are operating to support production activities (DPRK published documents, 2010, and Private source).

(9) Energy Source: Oil

Ascertaining the truth as to whether or not North Korea has petroleum deposits has not only been one of the critical issues in the geological exploration community in the DPRK, but also is a factor for central economy planning authorities. In fact, North Korean geologists and foreign engineers have found oil deposits during East Sea seabed area exploration (near Tong-Chon, Kang-won) and in West seabed area exploration (near Nam-Po) in 1985 (Private source). North Korean authorities have established a self-reliance policy for oil exploration and production since the 1960s. The DPRK set up an Oil Exploration Institute in Sook-Chon (near the West Sea) in 1968, with advanced exploration equipment imported from Russia and Sweden, in order to accelerate oil exploration within the West seabed area. In 1978, North Korea signed an agreement with China on oil exploration, under which the DPRK would receive support in the form of Chinese technology and equipment (oil drilling machines and oil prospecting ships) in the Bal-Hae-man area (the Yellow Sea) (Chinese documents, Private source, 2010).

In addition, North Korea sent experts in oil exploration to Russia in 1991 in order to gain expertise and experience from Caspian Seabed oil exploration activities. The North Korean Physical Exploration Department drilled 13 exploratory holes in the East seabed and West seabed with assistance from Sweden engineers, and found significant results in 1993. As a consequence, 350 barrels of oil were produced in 1998 at the “406” location, located 66 km from Cho-Do Island of Pyong-An province in the West Sea. Also, 450 barrels of oil were produced from an exploration well at the Nam-Po offshore drilling point, also in 1998. The Canadian oil exploring company Cantexa reported that the oil deposit in the 406 drilling area could hold 5 - 40

billion barrels (Korea Marine Institute, www.kordi.re.kr). The Microleptonics Research Laboratory of the Russian Exploration Institute has reported that massive oil deposits have been found in the West seabed and Yellow seabed (ITAR NEWs, 4/9/1999). Analysis of oil samples from these explorations revealed specific gravity of 0.854-0.887, paraffin content of 8-9%, hydrocarbon content of 70-80%, and asphaltic content of 0.2-1%, suggesting that these finds are commercially valuable oil deposits (ibid, and Private source).

The latest activities related to oil exploitation in the DPRK in partnership with overseas investors include an agreement between KOREX and KOEC (Korean Oil Exploration Company) on a PSC (production sharing contract) in the East-sea, based on a report by Channel Asia News, 2 June, 2006. KOREX was established as a subsidiary of the Irish company Aminex and the North Korean firm Cho-sun Energy (as a 50:50 shared company).

2. Environmental and Work Conditions in the DPRK Mining Sector

Brief descriptions of environmental and workplace issues encountered at several important DPRK mines follow.

Moo-San Mine Development and Environmental Issues

A fact finding mission was undertaken as a joint investigation by Australian (Clough Engineering Co, Ltd) and Japanese (Mitsui Metal Development) mining experts had been implemented in order to identify problems and solutions related to mining operations and their environmental effects on the Doo-Man River area, with the support of the UN Office of Project Services (UNOPS) in 2001 (KOTRA, report, 2005). According to the report of the mission, the Moo-San mine has been divided into six mining areas; three of which are open sites, and three of which are designated as future areas for underground mining. Mined ore including wastes ore are sent to the separator directly. About 33% of the total mined ore were waste rocks to be disposed of, 1/3 is usable ore, and another 1/3 is fine tailings. The mine discharges these fine tailings as wastes into the Sung-chon River, which flows into the Doo-man River. As a consequence, the river is polluted by the mining wastes (fine tailings). As a result, downstream farmers could not use the river water and two Chinese hydroelectric power generators had to have their turbines replaced every year due to the water pollution (ibid, and Private source, 2010).

Sang-Nong Mine's Environmental Issues

This mine produces Copper and Gold ore. It has approximately 5,000 employees working as miners and in mining-related positions. Due to the age and poor condition of the facilities in use, including separator and concentration equipment (the facilities were mostly built in the 1960s with assistance from Russia; some have been in use since the Japanese colonial period), the Hu-chong River is heavily polluted, and fish cannot be found in its waters. In addition, as a result of the use of strong mining-related chemicals, the 200,000 local residents of the area has serious coughs and other respiratory ailments, and some have lung-related occupational diseases (Private source, 2010).

Pyong-San Uranium Mines

Miners working at these two mines have been suffering occupational diseases since development of these mines began. The most serious situation was that mine workers were diagnosed to be infertile for lack of sperm (Private source, 2010). DPRK authorities provide preferential treatment to miners, includng regular supplies of meat, sugar, alcohol and housing, as compensation for those suffering from diseases related to their mining activities (Private source, 2010). Workers were told to keep their disease problem as a secret to outsiders, even including relatives. Most mining engineers, as university graduates and people who know about this occupational disease problem, wish to avoid this occupation, but workers and graduates must follow the Labor Party's dictates, reinforced by considerable social pressures (North Korean students study for free at university, thus University graduates are obliged to follow government instructions).

Another significant issue in these mines is that residents around the mining sites are also suffering similar symptoms, but as yet the authorities have not provided any alternative residential solution such as moving to a reasonably safe area (private source, 2010).

3. Infrastructure

Infrastructure in mine areas can be classified into 3 categories: 1) transportation facilities including trucks roads and railways, 2) power facilities for mining and related industrial operations, and 3) metal refining industries including refineries and iron manufacturers. Each of these is discussed below.

3.1. Transportation Facilities

Railway systems

Most mines are linked with freight railways. The railways are single lines in most areas in the DPRK, although, double track railways have been built over the 97 km between Moo-San (iron mine area) and the Choing-Jin refining facilities (private source, & Kim 2005). Open freight cars have been used for carrying iron ore and other ore materials. The DPRK's railway system is experiencing deterioration in its technology and operational system. For instance, most locomotives are electric-powered, and thus rely on consistent supplies of electricity. Most mining operations cease when sufficient supplies of electricity, typically generated by thermal power plants, are unavailable (Kim, 2007, p. 5, and Private source, 2010).

With regard to the condition of railroads, the tracks are so old (built in the 1940s and partially replaced in the 1970s) that fatal accidents have occurred annually (Private source, 2010). The system and operating conditions should be improved or replaced within 3 years if transporting of products from mines is to be sustained (Private source, 2010). As a result of the generally poor condition of the road system, freight trains have become the major means of transportation for iron ore and coal. Most open cars of freight trains are 60 tons capacity for heavyweight cargoes, but some 30 tons cars are also used as coal carriers (Chung, 2007, p. 4, and Private source, 2010).

Road Transport Systems

With regard to facilities for truck transport of mine products, the North Korean roads system identifies roads linking provinces as 1st class roads. Second class roads link counties within a province, and 3rd class road link towns within a county (Private source, 2010). Most roads covered in this paper fall into the 2nd or 3rd road classes. Ore products are sent typically via railway facilities, as previously noted, but some products are not sent via freight trains due to safety concerns. Gold and other rare metal ores are therefore carried using heavy trucks, made in the DPRK or imported from Russia, Sweden and more rarely China (Private source, 2010). Thus 2nd, 3rd class roads should be considered as important infrastructure serving mines. In fact, however, although1st class roads have been paved with asphalt since the1990s, 2nd class roads are not paved with asphalt due to a shortage of asphalt, which must typically be imported from China or Russia. Most 3rd class roads also are not paved with asphalt, so that operation of trucks on those roads entails higher costs for repair, tires and fuel. For instance, trucks operating on unpaved roads have more than 20% higher maintenance, fuel, and tires expenses according to a DPRKs research centre (Private source, 2010). In recent years, due to a lack of dollars for operation of heavy truck (for tires and oil and truck components/parts), heavy trucks are experiencing inappropriate operation (ibid). On the other hand, China and Russia are keen to participate in road construction projects in the DPRK For example, Russian authorities wish to participate in a DPRK railway development and improvement construction business, and are willing to invest 200 million dollars, according to an article in the Vladivostok News, 17th July, 2008.

3.2. Power Facilities

Major Thermal Power Plants

Table 8 presents key specifications of major thermal power plants in the DPRK. "Combined type" denotes that the plant produces both electric power and heat for industrial and/or residential/institutional use.

Table 8: Major Thermal Power Plants in the DPRK

Name	Capacity of production (MW)	Specifications
Pyong-yang Plant	500	Anthracite, combined type
Dong-Pyong-yang Plant	50	Anthracite, combined type
Book-Chang Plant	1,600	Anthracite, combined type
Chong-Cheon Gang Plant	200	Anthracite
Chong-Jin Plant	150	Anthracite, combined type
Soon-Chon Plant	20	Anthracite, combined type
12wol Plant (Kang-sun)	50	Anthracite, combined type
Sun-Bong Plant	200	Heavy oil, combined type

Source: Korea (ROK)Energy Economy Institute, 2002

The connection between power plants and the minerals and coal mining industries is crucial for mining operations in the DPRK. All industries rely on power plants that were built in major cities or major industrial areas (private source, 2010). More than 60% of the DPRK's electricity needs for the mining and minerals industries in recent years have been supplied by five major thermal power plants fueled with coal and heavy oil. These are the Chong-Jin and Dan-chon thermal power plants (Ham-Kyung province), the Buk(or Book, or Puk)-Chang and Ham-huong thermal power plants, the Pyong-Yang thermal power plant, the Chong-Cheon Gang thermal power plant, and the Nam-po thermoelectric power plant (Pyong-An province) (Kim. 2007, Private source, 2010). For example, Chong-Jin power plant supplies electricity to the Moo-San mine and the Kim-Chaek Iron manufacturer group, and the Buk-Chang power plant supplies electricity to the Pyong-An coalfields and to major Pyong-An metals refineries. The annual electricity production capacities of each power plant are sufficient to supply its client companies, but the power plants often fail to produce enough power due to a shortage of coal and heavy oil (Private source, 2010).

3.3. Refining Facilities

Moon-Pyong Metals/Minerals Refinery

Most of the DPRK's Zinc and Lead ore is smelted at Moon-Pyong Smelting Factory, which is located in Moon-Chon City, Kang-Won province. The annual production capacity of this Smelter is: Pb: 35,000 tons, Zinc:110,000 tons, Gold: 600 kg, Silver: 40 tons, Tin: 115 tons, Antimony: 100 tons, Cadmium: 450 tons, Sulfuric Acid: 240,000 tons, and Superphosphate of Lime: 200,000tons (Kim 2007, Chung, 2007, and Private source, 2010).

Nam-Po Metals/Minerals Refinery

The Nam-Po refinery is one of the major gold refineries in the DPRK, but the use of the refinery facilities fpr Gold production is hidden from the public. The capacity of the refinery is Gold, 2 tons annually, and Silver 15 tons per year (private source, 2010). The Refinery at Nam-Po is also quite old, having been built in the 1940s and modified in the 1970s, thus, its infrastructure and production systems are not only inefficient, they are also not environmentally friendly (Kim, 2007, and Private source, 2010). The area where the facilites are located (Nam-po City) is polluted by heavy metal wastes from the refinery, and an unknown number of patients have reported health problems, in particular dental problem and skin diseases.

As one of the largest smelters in the DPRK, the Nam-Po Refinery Group also produce Non-ferrous metal products. The annual production capacity is: electrolytic copper: 414,000 tons (99.97%), electronic Zinc: 45,000 tons, Tin: 200 tons, Gold :500 kg, Copper cable: 10,000 tons, Copper cable: 10,000 tons, Superphosphate of Lime: 200,000 tons.

In order to operate its electric furnaces, the power requierments of this refinery are supplied by the Buk-Chang and Pyong-Yang thermal Power plants, for which the refinery is a major consumer (Private source, 2010).

Heong-Nam Refinery:

This refinery is located in near Ham-Heong City and produces copper, gold, and rare earth materials using mineral ores supplied from the Hye-San and Dan-chon mines.

Hae-Joo Refinery

This is plant us located in Hae-Joo. Its main products are gold, copper, tungsten, and rare earth materials using ore mined in Hwang-Hea province. These facilities have the potential to be used to extract gold and copper for export via Hae-Joo port as a part of a foreign investment.in the DPRK mining sector.

The 7.27 Gold Refinery

A third major gold ore refinery in North Korea is the 7.27 Refinery (Heong-Nam 2 refinery). The 7.27 Refinery is located in Ham-Heong city, and was established in 1983 as a subsidiary of the People's Army Department. Its annual production capacities are gold, 1 ton, and silver 10 tons, respectively (Kim, 2007, p. 13, and Private source, 2010).

3.4. Mining Machinery Manufacturers

Another key category of infrastructure related to the DPRK mining industry is the supply chain for equipment used in mining. Table 9 provides information about manufacturers of key mining machinery, and Table 10 lists key manufacturers of equipment specific to coal mining and transport.

Table 9: Major Mining Machinery Manufacturers in the DPRK

Name	Size	Products	Notes
Nack-Won Machine Manufacturer	Site: 93,000 m^2 employees: 4,500 1st class firm	Oil pressure (hydraulic) excavators	Specialized in Excavator production
Koo-Sung Mining Machinery Manufacturer	Site: 27,000 m^2: employees: 5,000	Drillers, lorries, crushers, pumps	Built in 1957
Dan-chon Mining Machinery manufacturer	Site: 10,000 m^2 employees: 2,000	Lorries, crushers, polishers, pumps	Also called the 4.28 factory
Sariwon Mining Machinery Manufacturer	Site: 43,000 m^2 employees: 2,500	pumps, conveyors, belts, compressors, winches	
Shin-Ui Joo Mining Machinery Manufacturer	Employees: 1,500	High-speed excavators, rock drillers	Also called the 8.9 factory

Table 10: Coal Mining Machinery Manufacturers in the DPRK

Province	Name of Manufacturer	Products	Size
Ham-Gyung Buk province	Hei-Ryong Coal mining Machinery Manufacturer	Coal carrier car production, iron supports, compressors, cranes, machinery parts, crushers, comprehensive drillers	29,000 m^2 2,500 employees 1st class company
Ham-Buk Province	Na-Nam Coal-mining machinery Manufacturer	Various coal mining drills, carrier cars, cranes, safety equipment production	1st class enterprise (3,000 employees)
Pyong-Yang City	Pyong-Yang coal mining machinery manufacturer	Supports, hydraulic machinery, hydraulic coal mining machines, pumps, conveyors, rock drills	1st class company 64,000 m^2 35,000 employees
Pyong-An province	Duck-Chon Coal mining machinery Manufacturer	Coal lorries, coal drills, pressure horse winches, belts, reduction gears	1st class firm 50,000 m^2 4,000 employees
Hwang-Hea province	Jae-Ryong coal mining machinery manufacturer	coal lorries, coal drills, pressure hoses winches, belts, reduction gears, air chargers, mine buses	2nd class firm, 1,600 employees, 31,000 m^2

Source: "DPRK's industries, Korea Industry Bank (ROK), 2002

3.5. Major Ports and Related Facilities

Key to the export of minerals and mineral products from the DPRK are the port facilities available to handle these materials. Brief summaries of the specifications of the major North Korean ports used to handle minerals and mining products are provided below.

Na-Jin Port:

Na-Jin port is located in the Na-Jin Sun-bong (also known as Rajin-Sonbong) Free Trade area. The port is specialized in importing and exporting bulk oil and mineral ores. Approximately

100,000-ton capacity cargo ships can be handled at this port. The port was modernized in 1998 with support from Chinese and Russian enterprises. According to the China News (KBC, Gaung-Zhou, China), KOTRA Report, 2008, the Jangil development district plan has been approved by the Jillin province (China) authorities for development of this port to expand Jilin province's exports to Japan and the USA. Also China is planning to invest more than 10 million dollars to expand a 54 km highway to link Hoon-Choon and Na-Jin city, and will also support construction to expand Na-Jin port to build the port's third and fourth docking areas .

Chong-Jin Eastern & Western Port:

The Chong-Jin Port is one of the 3 major ports in the DPRK and is located in Chon-Jin, Shin-am district and Po-hang district. The port is important for iron ore and iron-related products exports. Approximately.three 100,000-ton cargo ships can be handled by this port at the same time. The port was modernized in 1984 with support by Russian enterprises (Kwon, Hyuk Soo, 2000, and Private source, 2010)

Heong-Nam Port

This port is a major port and is located in Ham-Huong City. Mineral products produced in the Hur-Chon and Ham-Nam region are expored via this port. The port is well modernized in 1992. Loading facilities such as dock cranes and warehouses are well prepared for use (private source, 2010).

Dan-chon Port

This port is located in Dan-Chon city, and is used for exporting Magnesite ore and Zinc ore to overseas and domestic locations. Its capacity to load goods is 300.000 tons/month, expressed as the capacity of the ships that this port can handle (Private source, 2010).

Nam-Po Port

This port is the largest of the three major ports in the DPRK, and is located in Nam-Po City. The port plays the role of exporting mineral ores and coal produced from Pyong-an coalfields, as well as metallic materials refined in the Nam-Po refinery, to China and South Korea (Private source, 2010).

Hae-Joo Port

This port is located in Hea-joo, Hwang-Hae province. The port plays a significant role in exporting iron ore and steel produced at the Hwang-Hea Iron manufacturer and the Eun-Ryul and Jae-Ryong Iron mines. Its loading facilities were modernized in 1999 with imported dock cranes from Russia and Japan (Kwon, Hyuk Soo, 2000, and Private source, 2010).

4. Policies, Organizations and Human Resources Involved in the DPRK Minerals Sector

Brief summaries are provided below for North Korean mining industry policies and mining-related organizations, as well as the organizations in charge of minerals exploitation in the DPRK, development of technology related to geological exploration, and the educational system for mining and minerals-related occupations.

4.1. North Korean Mining Industry Policy and Related Organizations

Mining Policy

The mining industry has been a top priority industry since the 1970s, exceeding other industries in importance because of its key role in providing sufficient materials and energy sources for the DPRK. For successful development of the mining industry, the DPRK has established three major policies: first, strengthening geological exploration to promote new coal and minerals mine development; second, promoting technological development in the excavating of underground tunnels and in ore collection procedures; and finally, scientific research in digging equipment and exploration (Private source, 2010, & "DPRK's Mineral Industry", 2003). Another major principle in the DPRK mining industry is the self-supporting and self-sufficiency policy. This policy has been interpreted such that most mineral resources produced domestically are to be used for domestic purposes. As a result, the domestic supply rate for minerals resources in the DPRK is very high compared to the DPRK's historical imports of mineral resources. For example, North Korea is 100% self-sufficient in iron ore, pig iron, partially-finished steel products, copper, cement and graphite (private source, 2010).

Despite of this self-sufficiency policy, North Korean authorities have since the 1990s been pursuing opportunities for minerals exports to earn hard currency, according to KORTRA data (see Table 4). In fact, resource development in DPRK has been closely related to North Korea's munitions industry; for example, copper, uranium and iron mines exploitation have been developed substantially to meet military equipment and weaopns needs (Private source, 2010).

Natural Resource Law in the DPRK

According to this law (Section, 21, DPRK Published Laws, 2003), the North Korean cabinet is in charge of the exploration, exploitation, and use of minerals, with several organs of consultation involved in the approval of exploration, development and standards for minerals deposit estimation by geologic exploration institutions (ibid, p. 159). Section 40 of the law indicates that an organization or individual company should acquire a permit from a government body when the organiations plans to export precious metals or iron ore overseas, and section 51 indicates that in case of any breach in the law, the company or organization should be punished. Section 46 indicates that any skilled labor or engineer, equipment, materials, or funds related to the mineral exploration industry may not be used for other industrial purposes. In particular, section 17 emphasizes that any existing mine or coal mine cannot be closed (abandoned mine issue) without permission from the government consulting body.

Mining Industry-related Organizations

The DPRK mining industry is essentially under the control of the Labor Party and the Cabinet at the same time, but the Party's power dominates the Cabinet's role in the DPRK. As part of the Geological Exploration Institute system, the DPRK established in 1995 the Central Mineral Resource Institute in Pyong-Sung, which is a scientific city and part of the Pyong-Yang capital city. This Central Institute controls all geological organizations and institutes of the DPRK, including the Ham-Huong and Pyong-Yang Exploration Institutes (Chosun News, 26th Jan. 2002 and Private source, 2010).

DPRK commercial organizations involved in trading and development of mineral resources include the Cho-sun General Mining Trading group, the Chosun Magnesite Clinker trading group, the Myong-Ji group, the Dae-Sung Trading Company, the Chosun Baek-Gumsan Trading Company, and the Chosun Maebong-san Trading Company, as well as others (Private source, 2010). These organizations are described briefly below.

- Cho-sun General Mining Trading Group

The company is located in Joong District, Pyong-Yang City. Its primary business is to trade nonmetallic minerals. It has 10 subsidiaries in 10 major cities throughout the DRPK, and two branch offices. Zinc, copper-related products, and silver are the major export items handled by the company, in addition to nonmetallic refinery-related equipment and facilities, tin, antimony, aluminum cable and bar, coated wire, and other products.(ibid).

- Magnesite Clinker Trading Enterprise

Major trading items of this company are magnesite clinker, magnesite ore, magnesite brick and diatomite for export. The company also imports coking coal, chrome steel, mining equipment and machinery (ibid).

- Myong-Ji Corporation

This company was called Samchonri Group, but changed its name. Zinc and heating coils are its major export items.

- Cho-Sun DaiJin Trading Company

This company is located in Pyong-Yang and is controlled by the 39 Room (Department) of the Labor Party. Its focus is on trading to obtain hard currency, and it specializes in exporting coal and mineral ore overseas and in importing commodities and electric goods from Hong-Kong, Macau and China for Kim Jong Il's family and others (private source, 2010).

- Other Companies

The Chosun-Daesung Group, the Chosun DongHeong Trading Company, the Chosun Baekgumsan Trading Company, and the Chosun Maebong Company are major and exporters

raw mineral resources to overseas buyers, and importers of machinery and equipment from overseas (Lee, Hea-Jung 2008, p. 39).

4.2. Mineral Resource Exploitation System

In cases of independent development of mineral resources, the National Underground Resource Development Committee is in charge of providing permission for mining activities through the Ministry of Gathering Industry and the Ministry of Electricity & Coal Industry. Once permission is granted, an individual mine or company would be able to commence the development process. In this step, foreign investors could be involved in the process by contracting with an individual mine or company. In other words, once overseas investors invest by purchasing facilities and equipment for mining, the investors can bring out of the country a contracted amount of produced ore or refined products, which they can offer for sale (DPRK published documents, 2010, and Private source, 2010).

With regard to mining operations and development, skilled workers and engineers are responsible for management and engineering affairs in mines and minerals-related companies, and military service men and skilled workers are responsible for the required labor (Private source, 2010). The mineral ores produced would be sold by the independent mining company to overseas buyers for dollars, or to domestic clients (ibid).

4.3. The DPRK's Geological Technology Development

For minerals exploration, geological technologies have been developed in the DPRK since the 1990s. There are two major issues related to geological exploration. The first is geological technology, and the second is earth physics exploration technology. According to a technical and geological magazine published in the DPRK, there are 10 major technology development issues: (1), new explorathon methods to look deep into the earth's crust, (2), computer controlled drilling under GPS (global positioning system) guidance, (3), development of new earth physical exploration methods for depths up on 2,500 meters, such as 3dimensional elastic wave exploration, (4), satellite-controlled exploration methods development (for coal, gold, geothermal heat, natural gas, and underground water, for example), (5), far-infrared radiation controlled exploration, (6), bio-earth physics exploration, (7), electrical exploration development, (8), tomography technology for finding coal and colored metals (such as gold or copper), and (9), advanced chemical exploration methods development. These technologies are related to Earth Physics exploration methods (Private source, 2010, and "DPRK 's Mineral Industry", 2003).

4.4. An Analysis of the Educational System for Mining-related Occupations

The DPRK maintains a three-level higher-educational system for mining-related occupations. The first level is central government-controlled universities, the second level is local government-controlled colleges, and the third level is enterprise- or company group-controlled colleges used as occupational skill schools. The Mining and Metals and Nonmetallic engineering-related educational system in North Korea has been well established for development of the industries in comparison with the treatment of these discriplines in the South

Korean and Chinese educational systems—for example, there is only one Earth Physics Exploration course in South Korean Universities (ibid).

University Curricula

With regard to the curricula and quality of education in fields related to mining and minerals, the technology and equipment used in the Universities are mostly from Russia or China, and more rarely from Japan. In the author's view, the quality of education on these topics in the DPRK is competitive with that offered South Korean students**,** but needs additional support to reach USA or European standards (private sources, 2010). The situation in each of the three levels of education in mining-related topics is described below.

Universities Controlled by the Central Government

There are five major Universities with courses in the mining and metals, geological exploration, and Earth physics exploration: Kim Il Sung University, Kim-Chaek Engineering University, Chong-Jin Mine and Metal University, Pyong-Sung Coal mining engineering University and Sari-won Geology University (private source, 2010).

- **Kim-ll-Sung University** is located in Pyong-Yang. It has 12,000 students, including 600 students in the geology exploration course. The university has three courses, Geology Exploration, Earth Physics Exploration and Earth Chemical Exploration. In order to graduate from the university, students must attend five years of courses including at least one year spent doing a practicum in their field . Students in these courses learn English and Russian (most students learn English since about 2000). Graduates of this university are dispatched by the University to geology-related exploration companies and research institutes throughout the DPRK. The graduates have no opportunity try to find jobs that they favor as individuals, rather they are obliged to follow the orders of authorities because their university have studieswere supported by the government, which paid for their school fees and dormitory costs, including clothes and food. The graduates are classified into three categories: those destined to work as Labor Party officials, those who will work as government cabinet officials (in Ministries, for example), and those who will work as exploration company experts or in research institutes. The classification of the graduates is done by the Education Department of the Central Labor Party. Graduates are granted Bachelor degrees in their mining or minerals course and become official experts of their industry. For example. If a student graduates from the Geology Engineering course in this university, she/he will be entitled as a Geology Expert with a Bachelor's degree of Geology Exploration (Private source).
- **Kim-Chaek University** is located in Pyong-Yang. It has 10,000 students including 1,800 students of Geology Exploration, Mining Engineering, Metal and Nonmetallic Engineering courses. The university has six related courses, Geology Exploration, Earth Physics Exploration, Earth Chemical Exploration, Metal and Nonmetallic Engineering and Colored Metal Engineering, Refinery Engineering and Iron engineering, and Material Analytics courses. In order to graduate from the university, students must attend a five-year course including one year at least for practicum. Students at Kim-Chaek also learn English and Russian, with English the language of choice since about 2000. Graduates of

this university are dispatched to geology related exploration companies and research institutes, mines, Iron manufacturing companies, and refineries throughout the DPRK. The graduates are classified into three categories by Central Labor Party officials as described above. If a student graduates from the mining engineering course in this university, she/he will be entitled as a mining engineer with a Bachelor's degree in Mining Engineering (Private source, 2010).

- **The Chong-Jing Mines and Metals University** is located in Chong-Jin, Ham-gyung province. This university was established in 1959 to support the Moo-san mine, the Kim-Chaek iron manufacturing group, and other coal mines with personnel trained in engineering, management, and exploration work. This university has 6,000 students. There are 20 courses related to mining, iron making and management of refinery companies. A selection of these are as follows. The geological exploration courses are the Underground Water Exploration Course, the Drilling Engineering Course, and the Earth Physics Exploration Course. In Geology Engineering School, mining-related courses are:Mining Engineering, Coal Mining Engineering, the Mine Management Course, and the Mining Analytics Course. With regard to mining mechanical equipment course, there are two courses: Mining Mechanic Engineering, and Coal Mechanic Engineering. In order to graduate from the university, students must fulfill the same requirements listed for the universities above, and are similarly dispatched to geology-related exploration companies and research institutes, mines, iron manufacturing companies and metals refineries throughout the DPRK by decisions made by the Education Department of the Central Labor Party.

- **Sariwon Geology University** is located in Sariwon (Hwang Hae province) to support minerals and coal mining in the province. The University has five exploration courses including Earth Chemical Exploration, Earth Physics Exploration, Drilling, Underwater Exploration, and Analytics. Graduates become geology engineers and are sent to exploration companies and to be university teachers for colleges. Other situations are similar with the universities described above. This university has 3,000 students.

- **Pyong-Sung Coal Mining University** is located in Pyong-Sung city and supports coal mining engineering in Pyongan and Hwang-hae provinces. The University offers 10 major coal mining-related courses, including: Coal Mining Engineering, Coal Exploration, Coal Mining Mechanics and Analytics, and Management courses. Most graduates are dispatched to coal mining and exploration companies as engineers. Other conditions for graduation from theUniversity are similar to those of Chong-Jin Mines and Metals University. This university has 4,000 students (Private sources, 2010, "DPRK's Mineral Industry", 2010).

Colleges Controlled by Local Governments

Each province has a mining engineering college and a exploration engineering college. College students take 3-year courses in their majors. All financial support for school fees, dormitory costs, food, and clothes are provided by the government. Graduating students are dispatched to local mines, coal mines, and exploration companies as junior engineers. Students must finish a university course of two years or more, following their training at the provincial level, if they

wish to be engineers in their industry. The dispatching of graduates to their positions is carried out by the local government department for human resources. Each college has 700-800 students in every province. For example, the Dan-chon Exploration College has 800 students and has three courses: Geologic Exploration, Drilling, and Underground Water Exploration. After graduation from this college, graduates are granted positions as junior engineers and are dispatched to exploration companies in Ham-gyung province. Their wages are typically 70-80% of those of engineers graduating from universities (Private source, 2010).

Colleges Controlled by Enterprise Groups

The college system controlled by enterprise groups is built upon an educational scheme first established during the 1970s. Large enterprise groups such as the Kim-Chaek Iron manufacturing group or the Moo-san mining group operate colleges called "Factory Colleges". College students study after work from 7 pm to 9 pm twice or three times per week in these colleges to obtain more advanced skills and knowledge. Education in these colleges provides good opportunities for promotion or professional development within the company or organization, but the courses taken in these colleges are not recognized by other companies or organizations. These college's curicula are different than those of other universities and colleges, but are worthwhile students in that they provide applicable work skills for their jobs (private source, 2010). For example, if a worker in mining company studies in a factory college, she/he would be granted an increase in job level from 3 to 4, and the nextyear, would receive an increase from level 4 to 5, accompanied by a promotion and an increase in wages. It is estimated that there are 100 "factory colleges" throughout the DPRK, with an estimated current enrollment of more than 100,000 students (private source, 2010).

5. Conclusions and Alternative Strategies for Overseas Investors

5.1. The Most Fruitful Areas for Foreign Investment in the DPRK Minerals Sectors

The most fruitful areas for foreign investment in the DPRK minerals sector are as described below.

(1) The iron mines in the Moo-San and Eun-Ryul areas have great potential to produce significant benefits for overseas investors due to the fact that the DPRK's biggest iron manufacturers, the Kim-Chaek and Hwang-Hae corporations, could be used to process iron from those mines, and the steel and pig iron products could be exported to provide return on investment with low costs for transportation.

(2) Gold and copper mines could be beneficial investment projects offering low transportation expenses. In recent years, DPRK authorities have proposed that overseas funds be provided to invest in Gold mines and Copper mines as stated above. In fact, newly explored and developed mines such as the Sang-Nong, Gap-San and Shin-pa copper mines may be great opportunities for overseas investors (Hwang, 1999, p. 19, and Private source, 2010).

(3) Another possible mine for investment is the Dan-Chon Magnesite mine, which could be developed to export product to China and the USA. In this case, it should be possible to

cooperate with the authorities for a "win-win" strategic investment. According to private sources (Chinese source, 2010), a DPRK company has made a deal with a Chinese trading company for the export of Caustic calcined Magnesia (MgO 90%, CaO 2.5%, SiO_2 2.5%, Fe_2O 1.05 %, LOI 3.5%, Size; 200 mesh 95%). In this deal, the selling price of the material FOB Heong-Nam port was US$ 88.0 per metric tonne.

(4) Mining of limestone ore is another possible application of overseas investments, coupled with construction of cement factories in the DPRK and export of cement product to China and S. Korea. In addition, with investments in the cement industry, overseas funds could be involved in SOC (State-owned Corporations) in the DPRK, as well as North Korean calcium fertilizer industries, which can provide products key to helping DPRK agriculture to be more productive (Private source, 2010).

(5) The coal mining industry could be an alternative investment for foreign investors, as the DPRK needs to increase production of coal as a required energy source to drive the country's economic engine. In this industry, exploration and development of new coal mines would bring significant benefits to overseas investors

(6) Investing in zinc ore mines such as the Gum-dok, Hye-san and Ruck-Yon mines has potential for investors due to the fact that the DPRK has sufficient existing capacity to refine the zinc ore, and thus zinc metal could be exported, providing a good return to investors (private source, 2010).

(7) Tungsten mines could be alternative destination for investment due to the high price tungsten fetches in the international market, its low transportation expenses, and the huge deposits of tungsten ore at the Man-Nyun mine, which is currently being further developed and expanded (private source, 2010).

(8) New exploitation of deposits of rare-earth elements such as titanium, indium, and cerium are another area in which the DPRK's natural resources could be developed. Rare–earth element production has in recent years been dominated by Chinese mines, which have accounted for 30% of global deposits, but 97% of global production (Cho-sun news, 22th Oct. 2010). North Korea is known to have reserves of these materials in the Gyung-Sung and Hur-Chon areas. In particular, the Saen-gi-ryong area in Kyung-sung country is not only abundant in Kaolin, the raw material for ceramics, but also has some Indium and Cerium elements in abundant wastes rocks from Kaolinte mining process (Private source, 2010). Due to the DPRK's competitive labor costs relative to costs of Chinese labor, development of DPRK rare-earth resources for export would yield significant benefits (ibid).

5.2. Obstacles to Effective Minerals Sector Development through Foreign Investment, and Solutions to Overcome Obstacles

Key obstacles to effective minerals development in the DPRK with funds from overseas investors include 1) the shortage or lack of adequate and consistent constant supplies of oil and coal as energy in DPRK; 2) the fact that the DPRK lags behind other nations in technologies and operational methods for minerals (due to reliance on old methods), as well as in the use of modern equipment in mining and other minerals sector operational activities; and 3) a shortage of funds for education of engineers and for investment in technologies (Private source, 2010).

Key solutions to the obstacles above are as follows: 1), stabilizing coal mining operations to supply adequate coal for power plants; 2) attract overseas funds for investment in modernization of mining equipment and related technologies; and 3) balancing in mining business management between production and exporting operations (ibid).

5.3. Infrastructure Investments for Stable Operation of Mining Industries

With the above obstacles and solutions in mind, key infrastructure investments to allow stable operation of mining industries in the DPRK will be:

- Thermal power plants should be stabilized in order to provide reliable sources of power for mining and minerals refining facilities, thus investments in the DPRK's coal mining industry should be carried out as soon as possible as a short-term solution.
- Modernizing minerals processing facilities such as metals refineries and iron manufacturers is necessary for the DPRK to be able to export secondary goods derived from mineral resources, steel, or refined metals at higher prices (relative to raw ores) so that the DPRK can increase its foreign exchange earnings.
- In the longer term, a self-supporting accounting system for the management of mining and minerals refinery industries should be applied and implemented (adopted) in the DPRK. Capacity-building will be needed to train DPRK workers and officials in management techniques for self-supporting businesses (Private source, 2010).

5.4. Feasible Strategies for Overseas Investors

Co-operating with South Korean firms would be beneficial for overseas investors in order to assist with security of investment in the DPRK minerals sector, and to build relationships with future consumers of mineral products. South Korean firms investment in the mining industry in the DPRK, and Chinese firm's experience in the DPRK in investment in mining trading and mineral resource development represent valuable experience that overseas investors can learn from (private source, 2010). South Korean firms are also likely to be willing buyers of minerals products from the DPRK.

Building sustainable relationships with DPRK authorities in mining departments and other officials is significant for hedging risks in the uncertain business environments that prevail in the DPRK. First, using the Korean-Chinese business network, for instance, by trading between the DPRK and China via Chinese-Korean community channel, would be beneficial. These Chinese live in the DPRK and have been playing major roles to in the trading business between the two countries since the 1980s. According to private sources, approximately 5,000 Chinese live in the DPRK (with Pyong-yang home to about 2,000, and Ham-Nam, Buk province, and Ryan-gan province homes to another 3,000). These Chinese have knowledge of outside news and skills for trading between the two countries, and could play major roles to promote international business for overseas investors (private source, 2010). Second, contributing towards North Korea's social and humanitarian needs (for example, by providing free supplies of basic medicines, milk, childrens clothes, and food) is an alternative strategy to deal with those focused targets. In fact, DPRK authorities wish to build partner relationship in developing the country's mining sectors. As an example, during a visit by Tony Nam-Kung, an advisor to the governor of the US state of

New Mexico, to Pyong-Yang, DPRK officials suggested foreign investment in DPRK mineral resource development by the USA, in particular, in the Dan-Chon Magnesite mine for mine development and exporting of ore (Bloomberg, Asia Times, April, 2002).

5.5. Alternative Strategies and Issues for Overseas Investors

Alternative strategies and special issues relating to investment by foreign companies in the DPRK's minerals sector are described below, incluidng possible funding approaches for development of the minerals sector, issues to consider when reviewing investment possibilities, approaches to making investments in the sector, and mining rights issues for foreign investors, A case study of an investment possibility in a Molybdenite mine concludes this section.

Establishing Special purpose Enterprises (SPEs) for Funding Development of the DPRK Mineral Sector

Due to the large amount of funds needed for investment in this sector, one approach for developing mining businesses would be to establish SPEs and then issue company debentures or bonds to attract large amounts of investment funding. In fact, individual and institutional investors would be interested in this business opportunity due to the fact that the DPRK's mineral sector could generate significant benefits (return on investment) if the US or South Korean government could provide assurance for those investments as, for example, the ROK government has been providing assistance and assurance to Korean companies investing in Kaesong and other joint ventures (Private source, 2010). According to the South Korean government policy for investing in the DPRK, funding for ventures could be subsidized by the South Korean government on the basis of its contrbution to North-South Korea economic cooperation. This means that more than 50% of investment funds could be provided in the form of government assistance. The USA and other governments can also provide such assistance for overseas mineral exploration businesses (Korean Central Bank report, 2008).

Factors to Be Considered When Evaluating Potential Investments

There are five major issues that should be considered when overseas investors are making decisions regarding investment in DPRK's mineral sector: (1) the attributes of the deposit of mineral resource with repespect to its possible development; (2) the quality and cost of available labor; (3) the availability and status of infrastructure needed for mining, such as power plants , railways, roads, and ports; (4) the status of environmental regulations; and (5) the political and economic stability of the country. In the case of the DPRK, in its current situation, the author believes that (5), (1), and (3) should be improved to allow safe investment in the mineral sector. Based on the; experience of South Korean companies, DPRK authorities seem to have principally been considering three factors when overseas investors offer investment possibilities: (1) the scale of the investment, (2) whether the investment will result in the transfer of mining technologies to DPRK, and (3) whether the investmetn will support infrastructure development.

Possible Scenarios for Investment

Contracting for equipment supply in exchange for mineral products is an option that avoids the possible failure of large investments in the DPRK. Due to environmental concerns in developed nations that result in mine closures and a surplus of mining infrastructure, second-hand mining equipment and facilities could be assembled at low cost and exchanged for minerals resources in initial deals with the DPRK then, if the deals proceed as expected, small amounts of funds could be invested in DPRK mining operations in a step-by-step fashion.

In addition, investing in mines already operating and drawing on economic deposits of mineral resources reduces risk. Investing in new mine development requiring an initial exploitation step is a significantly more risky business when compared with investing in existing mines. Investing in existing mines would be an appropriate strategy to reduce the possibility of failure of investments in the DPRK. With regard to difficulties in the DPRK energy sector as they might affect the more than 20 mine development projects for overseas investors that have been identified by DPRK authorities (according to private sources and South Korean sources), energy supplies can be provided if investments in mining projects require energy supply upgrades.

The DPRK has been experiencing a lack of technology and equipment in the mining sector. Thus, overseas investors or companies could offer exploration systems and equipment and engineers as an in-kind investment in the DPRK minerals sector, and new minerals finds or production could be shared between the DPRK and the company providing the technology and expertise.

Mining Rights Issues for Foreign Investors

In cases of cooperation between foreign investors or overseas companies in development or exploitation of DPRK minerals resources, it is very rare that mining rights will be transferred to foreigners who invest in mining technology, equipment, and facilities such as dump trucks and drills. Rather, foreign companies would likely gain only the rights to sell the products produced by the mining operation (Private source, 2010).

There are a number of reasons why the DPRK has been reluctant to transfer its mining development rights to foreign companies and investors thus far: The first reason is political concern that the authority's power would be reduced in terms of its power/ability to mobilize workers, that is to control its people, therefore resulting in political risk. Second, the authorities believe that mineral resource development could be a significantly beneficial business in the future, and thus are reluctant to offer rights to outsiders. Third, the DPRK expects that it could make enormous profits in this industry if funds, facilities and mining engineering technologies one day become available, despite the current shortage and lack of those resources for mine development (private source, 2010). This means that DPRK authorities have been overstating the potential profits from their mining development businesses, and are less willing, as a result, to part with mining rights (Private source, 2010).

Case Study of Investment in a Molybdenite Mine

According to the Pyong-Yang IP Centre, in a research paper for estimating the potential economic benefits from expanding the Yon-San Molybdenite ore production and exporting

venture, US$ 397,307 should be invested in equipment and an electricity generating plant, materials, labor costs, and freight costs in order to increase annual production capacity of the mine from 10,000 tons to 40,000 tons (Pyong-Yang IP centre, 2009). The authors of the research paper estimated that it would take 6 months to return the whole amount invested (US$397,307). However, it was incorrectly estimated that the investment could produce 17.2 million dollars as profit within 5 years ($3.94 million per year). In fact, it should be considered that production capability per DPRK worker should not be higher than a South Korean worker's production capacity, given the South Korean workers will have generally superior tools and conditions to work with, but the per capita production capacity of Molybdenite ore by N. Korean workers was estimated to be higher than that of South Korean workers in the research paper (ibid). This is clear evidence that DPRK authorities have been overstating the economic benefits from mining businesses relative to more reasonable estimates. This tendency to overstate potential benefits suggests that DPRK authorities would likely suspect, in reviewing estimates prepared using standard procedures and provided by Western companies, that foreign investors or companies are underestimating its mineral resources.

The DPRK lacks experience in attracting foreign investors to participate in its minerals sector development. This example shows that negotiations between foreign investors and DPRK authorities should be implemented carefully, and based on reasonable estimation procedures and international benchmarks in the industry, with supervision and participation by DPRK experts who have some experiences in the industry (Private source, 2010).

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Vladivostok News 17th July, 2008

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