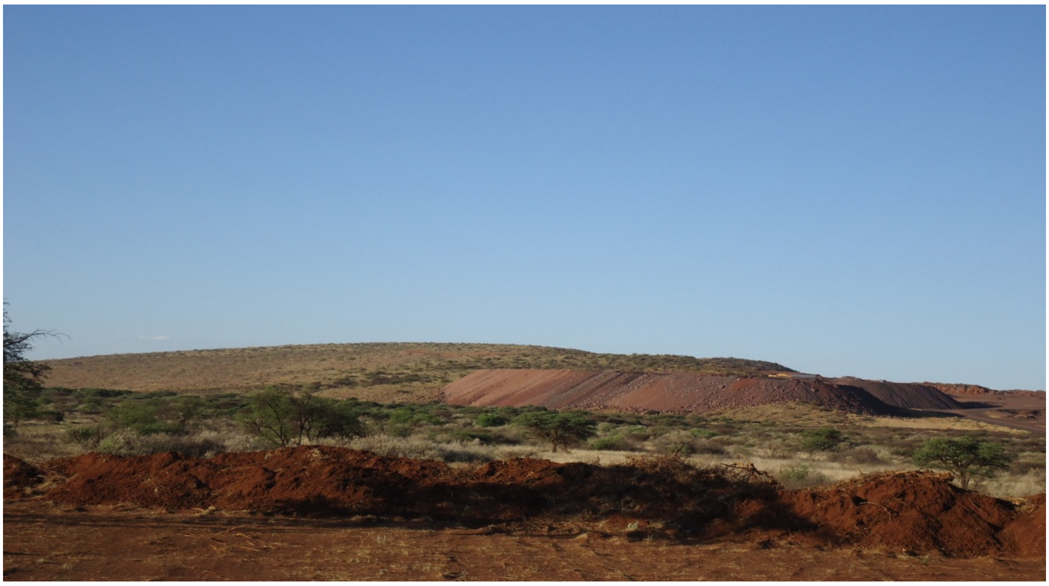
LOMOTENG MINE

Geological Report

of the PIN2 Section
of the Lomoteng Iron and Manganese Mine,
Postmasburg District, Northern Cape Province, South Africa



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Feburary, 2012

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OVERVIEW:

Lomoteng Mine, mining area is located in the Northern Cape Province, northwest of South Africa, under the jurisdiction of Postmasburg District, which covers an area of 8.5652 km^2. Its geographic coordinates are between 27°59′59″-28°03′38″ S and 22°59′33″-23°01′53″ E. The mining area is easy to access.

The consigning Institution is SUPER MAYER INVESTMENT LTD. We, No.409 Geology Team of Bureau of Geology and Mineral Exploration and Development of Hunan Province, RPC, have conducted a prospecting project which started from May to November, 2011.

It includes 2761.29m drilling and 2530m^3 trenching, totaling R 27.98 million. Six (6) layers of deposits have been investigated, with lengths ranging from 2400m to 3600m, widths 265m to 1110m, thicknesses 3.84m to 6.03m. In average, these deposits contain Mn 25.80%, TFe (total iron) 25.36%, and Mn+TFe 51.11%. It's been calculated that there are 133.904 million tons of high-iron manganese ore and iron ore resources, which include 97.39 million tons of indicated mineral resource (UNFC Code 332) and 36.514 million tons of inferred mineral resource (UNFC Code 333).

In referring to iron ore resources, there are 17.623 million tons, which involve 9.765 million tons of indicated mineral resource (UNFC Code 332) and 785.8 million tons of inferred mineral resource (UNFC Code 333). In contrast, there are 116.281 million tons of high-iron manganese ore resources, which include 87.625 million tons of indicated mineral resource (UNFC Code 332) and 28.656 million tons of inferred mineral resource (UNFC Code 333). It is noticed that there are 97.39 million tons of indicated mineral resources (UNFC Code 332) for both high-iron manganese ore and iron ore, which account for 71% of the total high-iron manganese ore and iron ore resources.

In addition, the stripping ratio is 5.83:1. The hydro geological conditions of the abovementioned deposits are simple, while their engineering and environmental geological conditions are rated as medium. After general studies, the technical conditions of deposit mining can be considered as medium, whilst the technical conditions of ore processing are simple. This Lomoteng Iron and Manganese Mine are expected to serve 128 years.

The potential economic value of these deposits is considered to be R 690.934 billion, which is expected to bring considerable economic benefits.

This report contains 27,005 words. 56 maps, 19 tables and 4 other documents are attached.

Keywords: Iron and Manganese ore + Geological report + LOMOTENG + The PIN2 section of the Lomoteng mine

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LIST OF ATTACHMENTS

Attachment 1：

A copy of Class A certificates of geological exploration qualifications in solid minerals prospecting and geophysical exploration.

Attachment 2：

Technical summary of the surveying and mapping project at the PIN2 section of the Lomoteng Iron and Manganese Mine, Northern Cape, South Africa.

Attachment 3：

The Qualification Certificates of Professional and Positions of five geological engineers.

Attachment 4：

Mining Right NC 30/5/1/2 240 MR (Copy attached)

CHAPTER 1

Introduction

1.1 Objectives

Super Mayer Investment Ltd has invested the Lomoteng Iron and Manganese Mine, which is situated in Postmasburg District, Northern cape Province, South Africa. For the purpose of geological prospecting, Geology Team No.409 of Bureau of Geology and Mineral Exploration and Development of Hunan Province, are assigned to undertake geological survey and other surveys on hydrogeology, engineering geology, environmental geology, in this mining area. To complete such project, drilling, trenching and other methods are utilized. As a result, the occurrence of high-iron manganese ore, its quality features, mining technical conditions, concentration and metallurgy conditions, and act. are gradually determined, based on the results from the abovementioned surveys. The main results are described as follows:

1. The geological survey has been completed for the PIN2 section of the Lomoteng mine in Postmasburg District, which covers an area of 8.5652km^2. Detailed survey has been conducted for favorable mineralized sections, whilst general survey has been done for the rest.

2. The surveying and mapping project for the mining area has been done in map scale 1:5000 and 1:10000. Then investigations on the open-pit mining section and trenching, middle-deep drilling, sampling and other geological work were undertaken. Lithology, structure and other geological features, and ore characteristics as well as types, have been discovered with certainty. In addition, the technical conditions of processing, concentration and metallurgy for such ore have been generally studied. In the meantime, basic studies on hydrogeology, engineering geology, environmental geology have been done. Technical and economic conditions for deposit exploitation have been researched as well.

3. Trenching, drilling and other prospecting projects were undertaken under the supervision of Behre Dolbear Group Inc. (BDB). Such job has been completed strictly following BDB's technical requirements. Meanwhile, based on the national standards of the Republic of China, field work has conducted, and the "Geological report of the PIN2 section of the Lomoteng Iron and Manganese Mine, Postmasburg District, Northern cape Province, South Africa" has been compiled.

1.2 Location of the area and accessibility

The PIN2 section of the Lomoteng mining area is located in the south-east region of the South Africa, which is under the jurisdiction of Postmasburg District, Northern cape Province, South Africa. The area is 50km north of Kathu, a famous mining town, and 30km south of Postmasburg. It covers an area of 8.5652km^2. Its geographic coordinates are between 27°59′58.63″-28°03′38.13″ S and 22°59′32.83″-23°01′52.54″ E (see Table 1).

Table 1 Coordinates of PIN2 section of the Lomoteng mining area

No.	UTM coordinates system				
	Longitude and latitude			Square grid	
	East longitude	South latitude		X	Y
1	22°59′35.315″	27°59′57.186″		-3098355.290	08499325.625
2	23°00′51.452″	27°59′55.926″		-3098315.911	08501405.913
3	23°00′43.066″	28°02′14.601″		-3102085.412	08501175.770
4	22°59′26.845″	28°02′01.703″		-3102190.849	08499100.137
Area	8.5652km^2				

The transportation is very convenient in the Lomoteng mining area. Its eastern area is accessible by an international railway from Hotazel to Lesotho. Meanwhile, another international highway runs through its northern margin, connecting Gaborone, the capital of Botswana, to Namibia. From the mining area, it needs to travel north-east for 700km to Johannesburg and Pretoria, 250km north to Gaborone, the capital of Botswana, 280km west to Namibia, and 180km south to Kimberley, the world's renowned diamond origin (see Map 1-1). It normally takes an hour from Kimberley to Johannesburg by flight.

1.3 Natural geography and economy overview

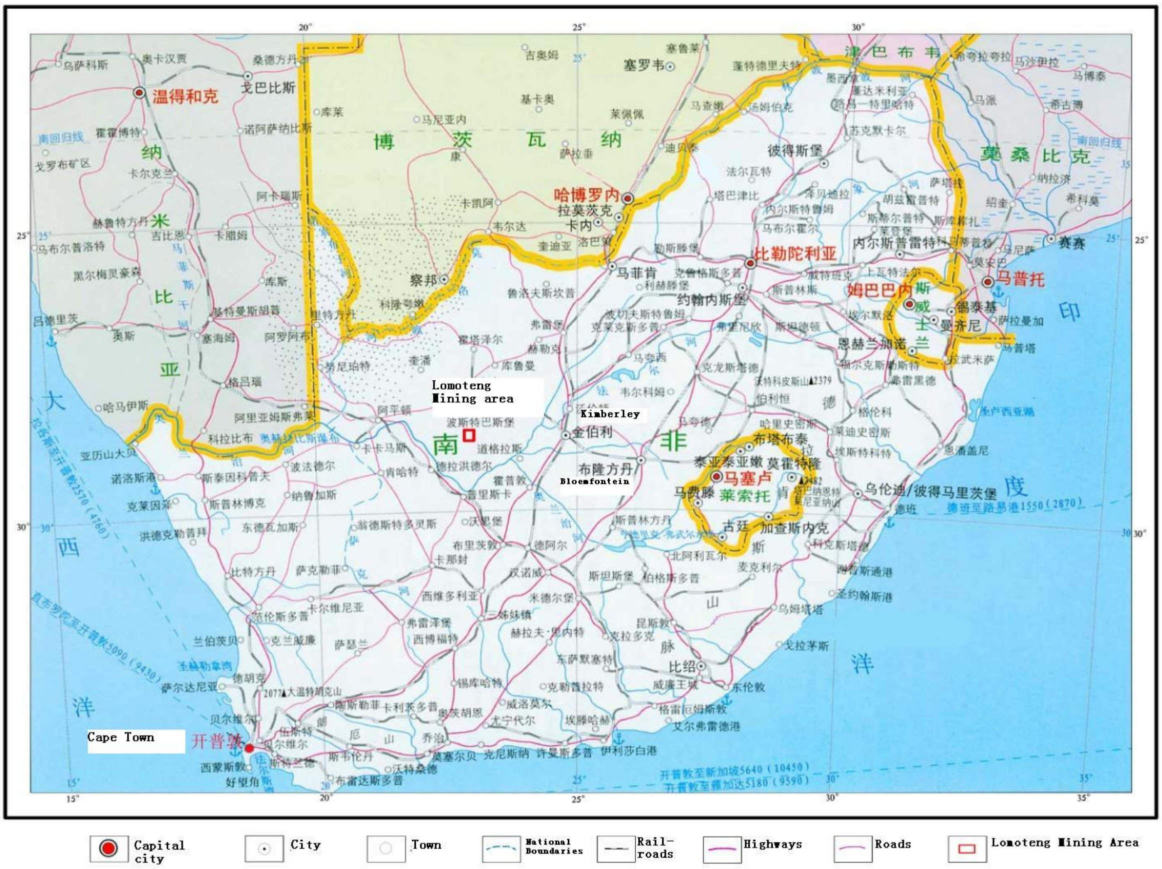
1.3.1 Natural geography

The mining area is situated in the southern area of the Kalahari basin, which is in the northwest part of South Africa. However, this area is mainly covered by a plateau with an elevation between 1200 to 1600m, which is flat. South Africa has a generally savanna climate with four distinct seasons. The summer begins December and ends the next February, with the highest temperature of 32 to 38 ℃. It winter, however, starts from June to August, with the lowest temperature of -10 to -12 ℃. The annual rainfall is 60-1000mm, and the average is 450mm. There is no river source exists in this area, but one of the tributaries of Limpopo river runs through this area.

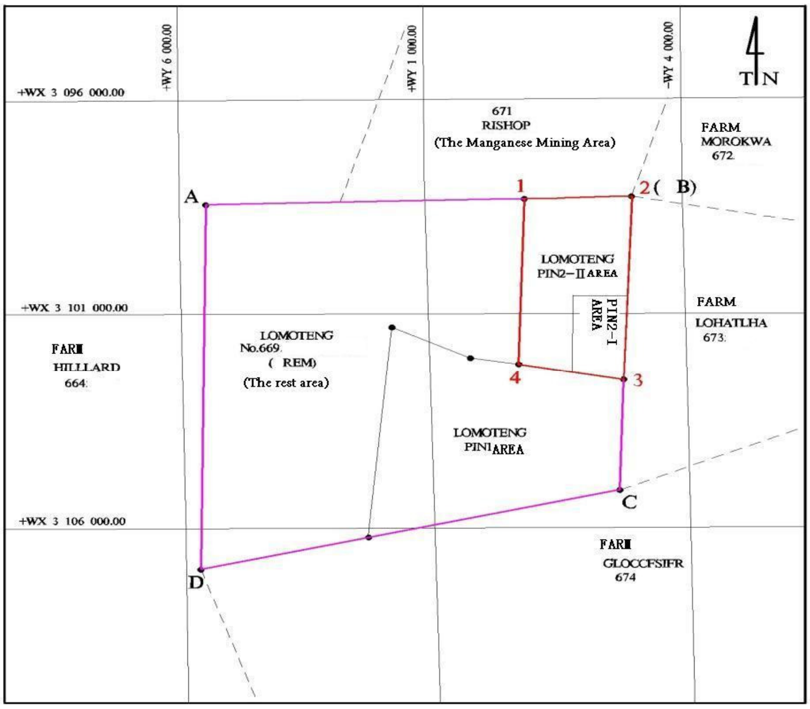
1.3.2 Economy overview

The mining industry contributes the most to the local economy, followed by agriculture and husbandry. There are considerable amount of large Iron and Manganese Mining corporations established in or nearby the Lomoteng mining area. Dominant population groups in South Africa are black Africans and white Africans. There is a huge gap between the annual incomes of black Africans and white Africans, which makes the white South Africans on the top of the income pyramid. The labor resources in South Africa are still relatively abundant. This Lomoteng mining area is famous for its iron ore resources, while its manganese resources are less well-known. Owing to the mining industry, its local economy is comparatively more developed. There is a ground-water well 2km away in the south of the mining area, which can produce 400 m^3 of water per day，is sufficient for the demand mining operation and living water. The electricity supply for the mining area is supported by the South African electricity public utility. Both water and electricity supplies are sufficient to meet the mine's demands.

1.4 Mining Rights



Map 1-1 Traffic map of Lomoteng Mining area



LOMOTENG 669 FARM CO-ORDINATES		
No.	EAST	SOUTH
A	22° 56′ 43.05″	27° 59′ 59.19″
B	23° 1′ 52.54″	27° 59′ 58.63″
C	23° 1′ 37.55″	28° 3′ 38.13″
D	22° 56′ 32.83″	28° 4′ 34.51″

LOMOTENG PIN2 CO-ORDINATES		
No.	X	Y
1	−3085961.869	08495925.895
2	−3097076.585	08498005.351
3	−3100844.578	08497775.300
4	−3100949.973	08495700.497

Map 1-2 The area covered by Mining right in Lomoteng Iron-manganese mining area

Adistra 11 CC (Registration Number 2005/067236/23) has obtained the Mining Right (NC 30/5/1/2/2 240 MR) of the Farm Lomoteng No.669 on 11th of August, 2010. The Primary mining area covers an area of 6404.460 hectares. On June 8, 2011, Adistra 11 CC has assigned the Mining Right to Super Mayer Investment Ltd , and it holds 74% of the shares. The Mining Right is 15 years and can be renewed. The prospecting area consists of 4 sections, namely PIN2-1, PIN2-2I, PIN1 and the REM, which covers an area of 37214.3232 hectare.

Super Mayer Investment Ltd has commissioned our team to complete the exploration project for the abovementioned PIN2 section which covers 8.5652km^2 (see Map 1-2). No other person holds A Prospecting Right, Mining Right, Mining Permit or Retention Permit for the same mineral and land. Related coordinates of the PIN2 section can be found in Table 1.

Map 1-1 the traffic and location of the Lomoteng mining area

Map 1-2 the distribution of mining right of the Lomoteng mining area

1.5 Previous Work

A few geological researches have been done, listed as follows:

I. The Council for Geosciences (CGS), South Africa, conducted a regional geological survey in scale 1:250000 in 1983.

II. The CGS then completed a thematic map in scale 1:50000 for Postmasburg District, which can provide some detailed information on the surface and near-surface geology, strata, rocks, minerals and structures, in 1997.

III. During the same year, it undertook an aeromagnetic survey in Northern cape Province, then 4 aeromagnetic anomalies were identified which have been proved to be Iron and Manganese ore deposits. These former researches have become reliable sources for our project.

The Iron and Manganese deposits near Postmasburg were discovered in 1922, and have been exploited since 1929. Only few private mining companies conducted some geological exploration, and even fewer data have been preserved for almost a century. Before the operation of Super Mayer Investment, some basic exploration projects were undertaken by local drilling companies. A number of percussion drilling (22 holes, +1000m) was done. However, no original data were collected, due to that the time of drilling cannot be traced.

To purchase the Mining Right of Lomoteng mining area, in June 2010, Guangxi N & H Metallurgy Development Co, Ltd commissioned Nanning Land Reserves and Resources Consulting Ltd to compile the Guangxi Zhuang Autonomous Region Land Reserves Committee's Review No. 82, [2010] on *Manganese Ore Project Report for Lomoteng Mining Area in Kuruman*. Guangxi N & H Metallurgy Development Co, Ltd had conducted a pilot mining activity on a chosen outcrop area, and till June 2011, about 0.4 million tons of Iron and Manganese had produced during the pilot mining activity.

1.6 Brief of the Project

This detailed exploration was started from the middle of June, 2011. The field work was completed by the start of November, 2011. Based on the thematic map in scale 1:50000 for Postmasburg District, this project were initially organized according to Exploration Type II.

Trenching was done on the surface, while drilling was completed underground. The programmes of this project have been completed with good quality, see Table 1-2. It is proved that in the mining area, there is host strata at the bottom of the Asbes heuwels Subgroup (Vg). The geological structure of the mining area is simple, mainly composed by a west-dipping monocline. Some layered or lenticular outcrops of the ore body can be seen on the surface of the ground. The ore body dips 10-24 °to the northwest, extends for around 3600m with width between 550 to 950m.

There are 3 layers of iron ore deposits investigated. The second and the third are extremely irregularly distributed. In contrast, the first layer has thickness ranging from 0.57m to 8.26m, with an average of 3.50m. The thickness variation co-efficient of this layer is 126%.

Meanwhile, there are 3 layers of high-iron manganese ore bodies, and the I and II are comparatively regularly distributed. The total thickness is ranging from 1.53m to 20.51m, with an average of 8.97m. The thickness variation co-efficient is 264%.

The III layer is in lenticular shape which is very irregularly distributed. In addition, there are 4 intercalated layers existing, which are slates. Three of them are irregularly distributed, while the left one is relatively regular. Their thicknesses are ranging from 0.32 to 1.09m, and the average thickness is 0.92m. Such slates contain 3.98% Mn, and 15.72% TFe, in average.

Table 1-2 Programmes and workload

Programmes		Units	Workload		
			Designed	Done	Done（%）
Topographic Survey in Map Scale 1/2000		km^2	8	8.6	107
Geological Survey in Map Scale 1/5000		km^2	4.6	4.6	100
Geological Survey in Map Scale 1/10000		km^2	4	4	100
Hydrologic, Engineering, and Environmental Geology Survey in Map Scale 1/10000		km^2	8	8.6	107
Survey for Geological Section of Exploration Line in Map Scale 1/1000		m	15000	15924	106
GPS Surveying		Spot	100	60	60
Drilling		m	3300	2761.29	83.67
Drill Logging		m	3300	2761.29	83.67
Trenching		m^3	4000	2530	63
Trench Logging		m	4000	2530	63
Chemical analysis		Slice	2400	669	27.88
Sampling	Trench Samples	Slice	1000	105	10.5
	Core Samples	Slice	1400	564	40.29
Rock Samples		Slice	100	9	9
Samples for Particle Density Test		Piece	60	102	170
Samples for Rock Mechanics Experiments			30	17	56.67
Samples for Bacteriological Water Analysis			3	1	33

The exploration area is between the exploration line 18 (in the north) and the exploration line 17 (in the south); with a breadth of 1110 m and a length of 3600 m. High-quality deposits are discovered in this area. High-iron manganese (or iron-manganese) ore deposits contain Mn 25.80%, TFe (total iron) 25.39%, and Mn+TFe 51.24%. Whereas, iron ore deposits contain Mn 3.80%, TFe (total iron) 42.04%.

There are 6 layers of ore bodies/ore beds and 4 intercalated layers/interbeds discovered in such area, covered by the roof (Vg) which consists of sericite slate and slates contains iron. The total thickness of such slates is between 3.41 m - 54.49 m. The hydro geological conditions of the abovementioned deposits are simple, while their engineering and environmental geological conditions are rated as medium. This area is suitable for open-pit mining. After calculation, the stripping ratio is 5.83:1.

This report, "Geological report of the PIN2 section of the Lomoteng Iron and Manganese Mine, Postmasburg District, Northern cape Province, South Africa", was compiled in December, 2011. It's been proved that there are 135.578 million tons of high-iron manganese ore and iron ore resources, which include 96.602 million tons of indicated mineral resource (UNFC Code 332) and 38.976 million tons of inferred mineral resource (UNFC Code 333).

Refer to iron ore resources; there are 17.623 million tons, which involve 9.765 million tons of indicated mineral resource (UNFC Code 332) and 785.8 million tons of inferred mineral resource (UNFC Code 333). In contrast, there are 117.955 million tons of high-iron manganese (or iron-manganese) ore resources, which include 86.837 million tons of indicated mineral resource (UNFC Code 332) and 31.118 million tons of inferred mineral resource (UNFC Code 333) (See Table 1-4). This Lomoteng Iron and Manganese Mine is expected to serve 128 years. The potential economic value of these deposits is considered to be RMB 69.584 billion, which is expected to bring considerable economic benefits. The results are promising, while the objects of the project have been met.

Table 1-4 The Statistical table of mineral reserves

Ore		Codes	Amount (million t)	Average grades (%) Mn	TFe	Mn+TFe	Mn/TFe
Iron Ore	1	332	976.5	3.82	42.74	/	
		333	785.8	3.78	41.16	/	
		332+333	1762.3	3.8	42.04	/	
Iron-Manganese Ore	I	332	7275.7	26.07	25.15	51.22	
		333	2128.3	25.28	25.77	51.05	
		332+333	9404	25.89	25.29	51.18	
	II	332	1408	24.84	26.56	51.40	
		333	983.5	26.62	25.01	51.63	
		332+333	2391.5	25.65	25.86	51.51	
	I + II	332	8683.7	25.9	25.34	51.24	
		333	3111.8	25.7	25.53	51.23	
		332+333	11795.5	25.85	25.39	51.24	
Total		332	9660.2	/	/	/	/
		333	3897.6				
		332+333	13557.8				

This exploration project has been firmly supported by Super Mayer Investment Ltd, and Behre Dolbear Group Inc, with full co-operation. All the geological work has been completed smoothly and successfully.

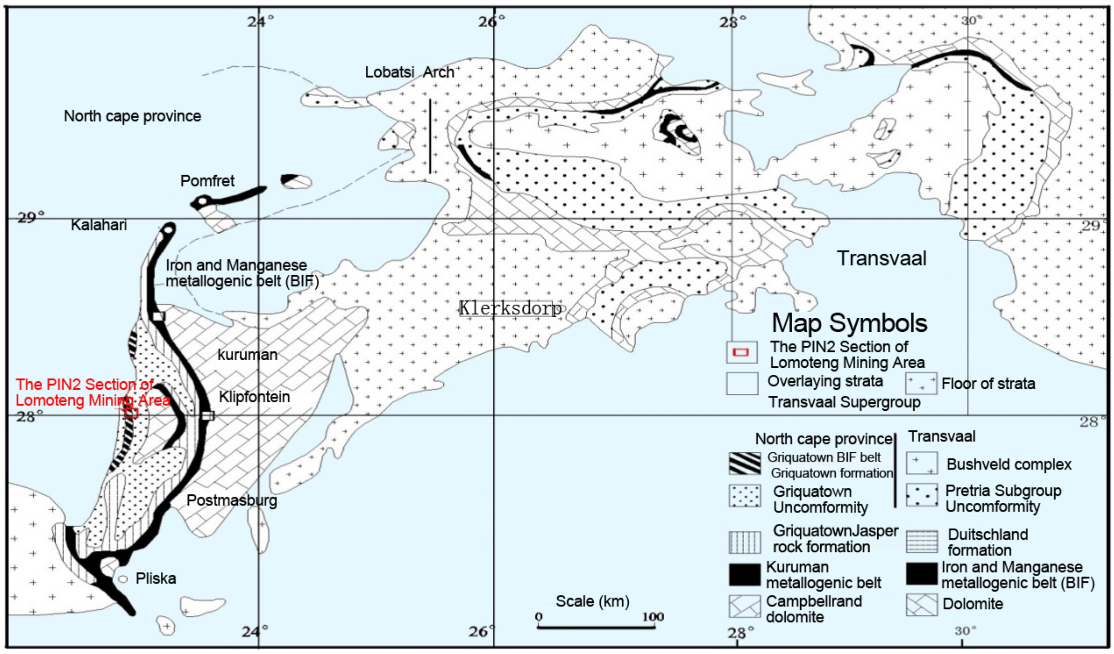
CHAPTER 2

Regional Geology

2.1 Regional geological background

Lomoteng mining area is located in the west limb of the mid-Postmasburg anticline, which is in the southbound Postmasburg manganese metallogenic belt of the world famous Kalahari Iron and Manganese metallogenic belt (BIF), South Africa. The Postmasburg manganese metallogenic belt starts from Sishen in the north ends at the Postmasburg city. It extends from south to north for 55km long, and is about 5 -10km in width from east to west. The Postmasburg manganese metallogenic belt is divided into three ore belts--the east ore belt, west ore belt and south-west ore belt in the Wolhaarkop mining area. Lomoteng mining area is in the middle of the west ore belt (see Map. 2-1).

2.2 Geological Strata



Map 2-1 Reginal geolgical map

The regional strata mainly consist of Naragas formation (Vgl)of Campbellrand subgroup of Proterozoic Transvaal Supergroup ghaap group, Asbesberge formation of Asbestos subgroup (Vg), Gamagara formation of Gamagara subgroup of Postmasburg group, Makganyane Formation, Ongeluk Formation, Fairfield formation

(Vf), Lorteri formation(Vm), Groep formation(Vo), Carboniferous Lucknow formation and quaternary system.

3. Quaternary -tertiary system：sandstone, limestone.

2. Carboniferous system: Lucknow Formation, classic rocks bedded with lava.

----Unconformity ----

1. Proterozoic erathem, Precambrian system (Transvaal Group)

(8)<u>Group Formation</u>: quartzite, greywacke, shales, conglomerate bedded with Mafic lavas, thickness > 5000m

(7) Lorteri Formation: andesitic lava, about 1200m thick.

(6) Fairfield Formation: banded manganiferous itabirite which is contains manganese and bedded with dolomite layer, 450m(±)thick.

(5) Ongeluk Formation: andesitic lava, breccia, and marl, about 1000m thick

(4) Makganyane Formation: Glacial deposit (Glacier Marine deposits), about 500m thick.

(3) Gamagara Formation: phyllite, shales, quartzite, basal conglomerate in part of the layers, iron or manganese layers, about 300m thick.

----Unconformity ----

(2) Asbesheuwels-koegas Formation: sand, shales(phyllite, slate), banded

Iron-manganese itabirite formation, jasper rocks, and silicon breccia as the bottom bed forming the manganese ore deposit, iron/ manganese ore deposit, manganese/iron ore deposit and iron (hematite) ore deposit, are considered the main part of Lomoteng mining area's ore bed.

----Unconformity ----

(1) Campbellrand Dolomite Formation: mainly formed by dolomite layer, bedded with grey rocks, chert and phyllite in part.

See Table 2-1 for the formation of regional strata and its characteristics of lithology.

Table 2-1 Regional strata characteristics of the Lomoteng Iron and Manganese Mining area

System	Super -group	Group	Sub-group	Formation	Lithology	Thickness (m)	Remarks
Quaternary -tertiary system					Sandstone, limestone.	Unclear	Unconformable Contact
Carboniferous system				Lucknow formation	Classic rock embedded with lava	Unclear	Unconformable Contact
Proterozoic erathem	Transvaal super group	Postmasburg	Voelwater subgroup	(Vo) Groep formation	quartzite, greywacke, shales, conglomerate bedded with Mafic lavas	>5000	Unconformable Contact
				(Vm) Lorteri formation	Andesitic lava	1200	
				(Vf) Fairfield formation	Banded manganiferous itabirite bedded with dolomite layer	450±	
				Ongeluk Formation	Andesitic lava, breccia, and marl	1000	
				Makganyane Formation	Glacial deposit	500	
			Gamagara subgroup	Gamagara Formation	phyllite, shales, quartzite, basal conglomerate in part of the layers, iron contain ore or manganese layers	300	

		Ghaapgroup	Asbestos subgroup	(Vg) Asbesberge formation	sand, shales(phyllite, slate), banded Iron-manganese quartzite formation, jasper rocks, silicon breccia as the bottom bed, forming the manganese ore deposit, iron/ manganese ore deposit, manganese/iron ore deposit and iron (hematite) ore deposit, are considered the main part of Lomoteng mining area's ore bed.	150-750	Unconformable Contact
			Campbellrand subgroup	Naragas Formation	Mid-thick bedded dolomite, quartzite, manganese ore bed	1500-1700	

2.3 Structure

The geological structure is simple in the region. According to other regional geological reports, the west north Koegas-Kuruman Rupture tilted across the working area from south to north. Fracture crosses the western part of the working area from south to north in an oblique direction. The region is about 500m in length, and has about 10km long outcrops, no signs of fault were found through surface geological and drilling work. The fold in the region is an asymmetric anticline, and strikes to north and south with its two limbs dip into east and west. The Campbellrand dolomite formation is exposed in the core, and the fold is surrounded by Asbesheuwels-koegas iron-manganese formation. The anticline is open and flat, with a medium dipped east limb, steeps on the west limb, and cut through by a longitudinal fault. Its axis represents an arc with the convexity facing the east and the concavity facing the west. The anticline is also called Maremane cove.

2.4 Magmatic Rock

Magmatic Rocks in the region are developed mainly to be volcanic rocks. The lithology of magmatic rock in the region is basalt and andesite. Magmatic rocks are not found in the mining area.

2.5 The Abnormality of Geophysical Prospecting

There are 30 -100km^2 delineated as the area of aeromagnetic anomaly, presenting in an oval shape or egg shape. The field work area is located right in the center of the aeromagnetic anomaly.

2.6 Regional Mineral Products

The minerals are primarily iron/manganese ore in the region. The manganese ore which used for metallurgical purpose are associated with hematite, mainly produced in the world famous super-scale Postmasburg manganese mine. Alongside the anticline of Postmasburg from east to west, the manganese ore belts can be divided in western, middle, and eastern for three parts which are separately distributed at the west limb, the core, and the east limb. The mineralization presents a gradually changed pattern from west to east. The western belt contains mainly manganese ore, associated with iron ore; the middle belt presents a mix of manganese ore and iron ore; and the eastern belt mainly contains iron ore, associated with manganese ore. The ore deposit is sedimentary metamorphic of deposit type. The region is located in the middle of the western ore belt. The ore are mainly Iron and Manganese ore with a certain amount of iron ore on the top.

CHAPTER 3
Geology of Mining Area

3.1 Strata

The strata in the ore block outcropped mainly are Naragas Formation (Vgl)of Campbellrand Subgroup of Proterozoic Transvaal Supergroup ghaap Group, Asbesberge Formation of Asbestos Subgroup, Gamagara Formation of Gamagara Subgroup of Postmasburg Group, and Quaternary System. The abovementioned strata can be summarized as below from the youngest to the oldest:

3.1.1 Naragas Formation (Vgl)of Campbellrand Subgroup of Transvaal Supergroup

Naragas Formation (Vgl): purplish gray to black ferrous dolomite with part developed into a small scale of iron ore body, there are karsts grow on the roof of the exploration line 5, 6 etc. The dolomites consist of the iron ore body or the floor of Iron and Manganese ore body. The outcrops thickness ranges from 2.55m to 61.73m and distributed in the whole mining area.

3.1.2 Asbesberge Subgroup of Transvaal Supergroup

Asbesberge Formation: this formation is ore body occurrence horizon and it is distributed in the entire mining area. It can be divided into 5 layers from bottom to the top. Their lithology is described in the following order:

⑤ off-white, fine-grained, crystalloblastic texture, mid-thick bedded ferrous-manganese metacryst quartzine with thickness ranges from 3.68m to 27.81m, is distributed in the mid west of mining area.

④ purplish red mid-thick and fine-grained metamorphic ferrous- feldspar & quartz sandstone with thickness ranges from 4.53m to 47.42m, is distributed in the hole mining area.

③ purplish-red & light yellowish grey, sandy slaty structure, contains of a small amount of iron-manganese, some sericite slates ,with its thickness ranges from 3.41-54.49m, distributed in the hole mining area.

② grayish black and steel gray, mid-thick Iron ore body and Iron/manganese ore body bedded with 1-4 interlayer's of purplish red thin bedded slates with its thickness ranges from 1.64m to 29.14m, distributed in the most of the mining area, only missed in a small part of the west end of the exploration line.

① purplish red sandy slate, contains a small amount of Iron and Manganese which consists of the floor of iron ore body or Iron/manganese ore body, distributed unstable, thickness ranges from 0.64m to 27.30m.

3.1.3 Gamagara Subgroup of Postmasburg Group, Transvaal Supergroup

Gamagara Formation (G): light yellow-grey thin sandy slate, outcrops thickness ranges from 15.18m to 44.55m, is distributed in the western mining area, partly covered by Quaternary System, presenting an unconformable contact with strata underneath.

3.1.4 Quaternary System

Quaternary System is a set of residual slope accretion, with red and brownish yellow sandy soil bedded with chunk of quartzite. It is consists of rock block, partly developed into thin bedded Iron and Manganese ore body with thickness ranges from 8.00m to 17.89m.

3.2 Structure

The ore block is located in the west limb of the anticline of Postmasburg. It shows a uniclinal structure which is westward extended. Its direction of dip is 220-315°and the dip angle is 15-35°.

The geological structure is simple for its fault is not developed and only two relatively small scale anticlines (coded as No.1 and 2).

The No.2 anticline is relatively small in scale, extended into the north-south direction for 105m with little impact on the mining area. The No.1 anticline is in a large scale and its impact on mining area created corrugations in part of the eastern strata. It is summarized as below:

No.1 anticline is a wide and gradual plunging anticline, distributed in the eastern mining area. The axial is near to north-south with axis plunges to the north near the Line 18, and extends to the south outside of the mining area for about 250m to the north of the Exploration Line 11. The axial extends for 2700m. In the middle of the axis, the old mining pits which are 200m to the south of Exploration Line 5 and 6 are filled with mud. The axial surface dips to the west, and the dip angle is almost perpendicular. There are outcrops of ferrous-dolomite of the block ④ of Naragas formation (Vgl)and mid-thick bedded Iron/manganese ore body of Asbesberge Formation in the core of anticline, and outcrops in the two limbs of the anticline expose the medium crystal texture ferrous-dolomite of the block ④ of Naragas formation，the block ③ of slate, the block ② of metamorphic feldspar & quartz sandstone and the block ① of quartzite. The strata are generally folded, the two limbs of strata orientation are flat and smooth, and the dip angle is generally 15-25 °with part reach to 52°. In general, the strata are wide, flat and opened.

The syncline is poor developed. There only appears a small scale syncline extends toward west east at the neighboring area of the Exploration Line 18 in northern mining area. The involved stratum is mainly Asbesberge Formation. The stratum has a rather smooth dip angel, generally at 10-35°, representing an open and undulant feature. Part of the stratum shows a turn-over orientation with small folds particularly developed in some geological section. The orientation of mangani-ferrous rock system varies a lot, but has little impact on the ore body of the mining area.

3.3 Magmatic Rocks

There are not outcrops of magmatic rocks in the ore block. According to previous researches, there are basalts andesite developed in the western mining area which is covered by Quaternary Period. No magmatic rocks were reached for the exploration depth was rather shallow.

CHAPTER 4

Geology of Ore Beds

4.1 Characteristics of Ore Beds

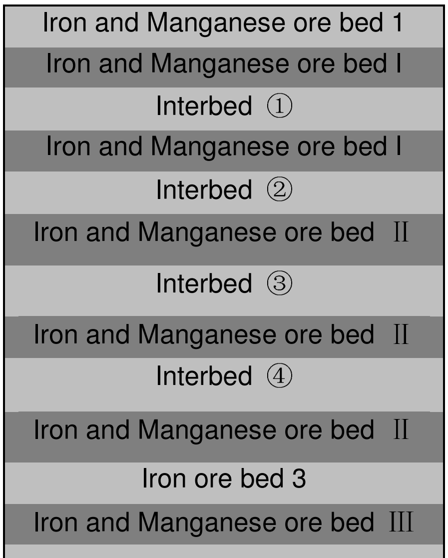
Lomoteng Iron and Manganese ore deposit occurs in Asbesberge formation of Asbestos subgroup (Vg) of Transvaal Supergroup, and is banded or massive sedimentary-metamorphic Iron and Manganese ore deposit.

The ore bed as a hole occurs as monocline, undulating along the direction of dip, striking north-east, the general direction of dip is west – south-west with dip angle of 13-20° in general.

The outcrop of ore beds in the low hill area which is high in the east and low in the west. The highest and lowest elevations/level are 1442m and 1347m respectively. Continuity of ore beds in the mining area is good, length of extending is about 3600m, and width of outcrop is 15-205m (Table 4-1).

Table 4-1 Outcrop Width of Ore beds

Line No.	Line 18	Line 12	6	0	5	11
Outcrop width of ore bed(m)	15	205	170	35	145	60
Remarks	control	control	Control	control	control	control



Map 4-1 Orientation of Iron ore beds & interbeds

Map 4-1 Diagram of output of iron ore bed and other interbeds

According to the differences of Fe and Mn content, ore bed can be classified as iron ore bed and Iron and Manganese ore bed, in the meantime, stable intercalated silty slates in the layer can be divided from top to bottom into 6 beds: Iron ore bed 1, Iron and Manganese ore bed I, Iron ore bed 2, Iron and Manganese ore bed II, Iron ore bed 3, Iron and Manganese ore bed III, numbers: (1,I,2,II,3,III). There are 4 interbeds in the ore beds, numbered ①,②,③, ④ and they are almost paralleled with abovementioned ore beds. Ore bed 1, I and II are main layers, the 2, 3 and III are extremely unstable. Characters of the 6 ore beds are shown as below:

(1) Iron Ore bed 1

This ore bed is the main layer of the mining area and it is the only iron ore bed with commercial production value. It starts from the north by line 18 to the south of line 5, striking length 3000m, width 265-930m, control level 1186m - 1433m, striking almost south to north, dipping to the east, with dip angle of 13 -16°, the orientation of such ore beds is stable, along the strike, there are thinning-out and recurrence, whilst along the dip it is a little undulating.

This ore bed occurs under Asbesberge formation of Asbestos subgroup (Vg), and surrounding rocks of top slate are purplish red and grey-yellow sandy slate. Ore beds made up of massive or banded hematite with thin purplish red sericite slate, conformably contacting with Ore bed me underneath.

The structure of ore beds are simple, mainly made up of hematite, generally with no interlayer occurs in the layer, only some parts contain 0.02-0.10m thick purplish red sericite slates with a small amount of iron. Main ore type is banded or blocky hematite, with some patchy hematite which lies on the upper of the ore bed sizing 2-30cm, and purplish red hematite and clay mineral are filled between the patchy ore.

The thickness of ore bed 1 ranges from 0.57m to 5.87m, 3.84m on average, variation co-efficient is 126%, and along the strike thickness varies significantly. Mn content of single sample from ore bed is 0.09-12.38% , TFe content 26.22-62.93%, average Mn content of layer 3.80%, with TFe content 42.04%, and content varies significantly with variation co-efficient of 247.06%.

(2) Iron and Manganese ore bed I

Iron and Manganese ore bed I is the most important layer of the mining area, extending stably along the strike and the direction of dip. Its control level ranges from 1184m to 1442m. Among the surveyed area, the layer starts from Line 18 in the north to Line 17 in the south with total length of 3600m and width of 280-1110m，tending from the south to the north, dipping to the east, obliquity is 15-22°.

Ore bed occurs in the same layer as Ore bed 1, surrounding rocks of the top slate is purplish red and lark silty slate, or contact conformable directly with Ore bed 1, with lark silty slate as the symbol layer. Divided by Interbed ② and Ore bed II, if Ore bed II disappear in some parts, then the bottom surrounding rocks is silty slate or Naragas formation (Vgl)of Campbellrand subgroup of dolomite.

The structure of the ore bed is relatively simple, mainly made up of iron manganese ore, scattered within Interbed ①，and the interbred is thin purplish red sericite slates with iron.

The ore types are mainly banded or blocky Iron and Manganese ore, and as secondary which occurs on the upper part of ore bed. Blocky and patchy ore are mainly hard manganese ore and hematite, sizing from 2-2.8cm in general. Between the patchy slates are filled with purplish red hematite and clay mineral. From the microscope, we can see that metallic minerals of blocky or banded iron manganese ore mainly are: hard manganese ore, hematite, soft manganese ore, a few bixbyite ore, and black manganese ore; gangue minerals mainly are clay minerals, little opal and barite.

Thickness of trench and drilling is 3.76-10.18m，average thickness is 6.03m，co-efficient of thickness variation is 72%，along the trend thickness changes significantly. Mn content of simple sample from the layer is 10.3-50.00%，average of the layer is 25.89%，co-efficient of content variation is 296.36%，varies quite hugely; TFe content is 7.10-55.8%，average is 25.29%，co-efficient of content variation is 398.71%，Mn+TFe is 51.18%.

(3) Iron Ore bed 2

This layer is unstable scattering on the surface, and only located at trench TC001,TC1601 and TC1801, with control level ranges from 1375m to 1433m, disappears along the strike and dip, conformably contacting Ore bed I, strike from the south to the north, dipping to the east with obliquity to be 24°, thickness to be 0.42-3.88m, average 2.31m，Mn content of simple sample from the layer is 0.19-29.6%，TFe content:15.8-67.0%；average Mn content: 3.86%，average TFe content is 46.83%, P content is 0.01-0.06%，average: 0.03%，SiO_2 content 7.91-33.2%，average:12.49%，S content 0.1%。Quality of this layer is poor, thickness is thin, and only scatter at some limited areas, the resource volume has not been estimated as it has no commercial value higher than UNFC Code 333., but still can be mined for other purpose.

(4) Iron and Manganese ore bed II

Ore bed II is the main layer of the mining area, extending stably along the strike and dip. among the surveyed area, the layer starts from Line 12 in the north to Line11 in the south with total length of 2400m and width of 460-850m, with its control level ranges from 1160m to 1428m, dipping to the east, obliquity is 11-20°.

Ore bed occurs in the same layer as Layer 1, divided by Interbed ② from Ore bed 1, surrounding rocks of the bottom are slate silty slate, or dolomite of Naragas formation (Vgl)of Campbellrand subgroup of, only contact with Fe^3 Layer at some areas of ZK501,TC1601 and TC1801.

The structure of the subgroup of is relatively simple, mainly made up of iron manganese ore, middle and upper parts include Interbed ③, only lower part of ZK001 hole includes Interbed ④, character of rock of the interlayer is the same as Ore bed I, thickness of Interbed ③ is 0.32-0.95m, average thickness is 0.88m, mainly located at exploration line No. 3, 5 and 6 thickness of Interbed ④ is 0.77m, only exposes at the bottom of hole ZK001. Types of ore are the same as Ore bed I, mainly are banded or massive Iron and Manganese ore, spotted Iron and Manganese ore as secondary with the same quality as Iron and Manganese ore bed I.

Thickness of section of ore bed is 4.05-6.85m average thickness is 4.77m, co-efficient of thickness variation is 23%, along the trend thickness changes mildly. Mn content of simple sample from the layer is 10.8-49.8%, average of the layer is 26.65%, co-efficient of content variation is 369.35%, varies quite significantly; TFe content is 7.90-50.4%, average is 25.86%, co-efficient of content variation is 414.92%, Mn+TFe content is 51.51%.

(5) Iron Ore bed 3

This layer is extremely unstable scattering at ZK501 in the central east of the mining area, disappears along the strike and dip, with its control level ranges from 1311m to 1367m, conformably contacting Ore bed II, striking from the south to the north, dipping to the east with obliquity to be 28°, thickness to be 4.06m. Mn content of simple sample from the layer is 0.08-1.04%, TFe content: 45.8-63.8%; average Mn content: 0.03%, average TFe content is 54.45%, P content is 0.01%, SiO_2 content 4.30-23.2%, average: 18.80%, S content

4.30-23.2%, average 0.1%. Quality of this layer is good, but the thickness is thin, and only scatters at some limited areas, the resource volume has not been estimated as it has no commercial value higher than UNFC Code 333, but can be mined for other purpose.

(6) Iron and Manganese ore bed III

This ore bed is extremely unstable scattering at some area of borehole ZK603 in the central west of the mining area, with its control level range from 1340m to 1360m, disappears along the strike and dip, conformably contacting sandy slate, striking from the south to the north, inclining to the east with obliquity to be 25°, thickness to be 1.63m. Mn content of simple sample from the layer is 14.85-50.00%, TFe content: 2.6-2.7%; average Mn content: 29.3%, average TFe content is 2.7%, P content is 0.01%, SiO_2 content 0.4-0.7%, average: 0.58%, S content 0.1%, Quality of this layer is good, but the thickness is thin, and only scatter at some limited areas, the resource volume has not been estimated as it has no commercial value higher than UNFC Code 333.

Characters of the ore beds are seen as Table 4-2

Table 4-2 Main characteristics of iron (manganese) ore beds

Ore bed No.	Orientation(°)			Length (m)	Control depth(m)	Thickness(m)			Grade(10^{-2})	Remarks
	Strike	Direction of dip	Dip angel			Min	Max	Avg.	Min - Max / Avg.	
1	5	w	14	3000	1115	0.57	5.87	3.84	26.22-62.93 / 42.04	Iron content
2	158	w	24	1800	10	0.42	3.88	2.31	15.8-67.0 / 46.87	
3	20	w	28	300	50	/	/	4.06	45.8-63.8 / 54.52	
I	162	w	19	3600	1115	3.76	10.18	6.03	10.3-50.00 / 25.89	Manganese content
II	177	w	15	2400	1115	4.05	6.85	4.77	10.8-49.8 / 25.65	
III	175	w	25	300	30	/	/	1.63	14.85-50.00 / 29.41	

Inside the ore deposit, the average of thickness for the iron ore beds and the Iron and Manganese ore beds is 10.33 m, the thickness variation co-efficient is 123.68%, see table 4-3 for the variation co-efficient for ore bed and interlayer.

Inside the ore deposit, the average TFe of ore bed is 42.04%, grade variation co-efficient is 247.06%, Iron and Manganese average TFe 25.85%, grade variation co-efficient is 402.85%, Man: 25.39%, and grade variation co-efficient is 315.39% (see table 4-4)

Table 4-3 statistics table for thickness of main ore bed and interbred of various section

Unit: m

Section number	Line 18	Line 12	Line 6	Line 0	Line 5	Line 11	Line 17	Average	Variation co-efficient
Ore bed Fe I	0.57		5.87	1.84	5.27	5.67		3.84	126
Ore bed I	4.57	4.33		6.85	4.05	4.05		4.77	23
Ore bed II	6.19	6.52	10.18	4.91	4.61	3.76		6.03	72
Total	11.33	10.85	16.05	13.6	13.93	13.48		4.88	23
Interbed①	d	0.85		0.66	1	0.84		0.84	
Interbed②	0.58	1.14		1.1	1.68	1.43		1.19	
Interbed③			1.37	1.07	0.88	0.87		1.05	
Interbed④				0.77				0.77	
Total	0.58	1.99	1.37	3.6	3.56	3.14		3.84	

Table 4-4 Maximum and Minimum Contents of Other Components in Iron and Manganese(Iron) Ore beds for single-project engineering

Ore bed No.	Components	Minimum×10^{-2}	Maximum×10^{-2}	Average×10^{-2}	Remarks
Fe 1	Mn	2.72	4.97	3.92	
	TFe	34.36	48.39	41.82	
The Fe I layer TFe grade variation co-efficient 247.06×10^{-2}					
I	Mn	18.36	29.95	25.26	
	TFe	26.31	26.31	25.84	
Ore bed I Mn grade variation co-efficient 296.36×10^{-2}, TFe grade variation co-efficient 398.71×10^{-2}					
II	Mn	18.98	37.66	25.65	
	Tfe	16.62	28.94	25.86	
The II layer Mn grade variation co-efficient 369.35×10^{-2}, TFe grade variation co-efficient 414.92×10^{-2}					

4.2 Ore quality

Inside the ore block, the ore divide into iron ore and Iron and Manganese ore, according to the ground engineering and drilling rock microscopic identification result, iron ore shows steel gray and gray in black color, patchy, banded and blocky in size, ore type mainly is hematite, Main metal mineral element is hematite (28-80%) and a small amount of hard manganese (20-35%), main gangue mineral is clay mineral(20-35%), micro mineral opal (1-4%), barite (micro-2%). The ore is hard, mostly is cryptocrystalline texture, banded and lumpy shape, edge fracture. Iron and Manganese ore is gray black color, banded, plaque and lumpy size, ore type is mostly iron-manganese. Main metal mineral element is psilomelane (35-75%), hematite (4-28%), bixbyite (4-20%), hausmannite (1-5%), pyrolusite (micro-10%), main gangue clay mineral (9-35%), micro mineral opal (micro-4%), barite (mirco-2%) . The ore is strong and hard, mostly is cryptocrystalline texture, banded and blocky shape, edge fracture.

Map 4-2 Slices of Iron-manganese Ore

According to the analyst result of the 412 samples taken from the main layer surface and drilling in the ore block, the ore type is mainly iron-manganese, and then is iron ore. In those 351 Iron and Manganese layer samples, 45 samples the main component Mn grade are 10-15%, 44 samples the grade are 15-20%, 157 samples the grade are 20-30%, 72 samples the grade are 30-40%, 33 samples the grade are 40-50%, the samples which grade are ＞20% take 74.64% of all the samples, the ore deposit average grade is 25.85%, there're 7 samples the iron–manganese grade are ＜30%, 28samples the Iron and Manganese grade are 30-40%, 100 samples the grade are 40-50, 206 samples the grade are ≥50, and the samples which Iron and Manganese grade ＞50% take 61.54% of all the samples, the ore deposit average grade is 51.24%, the average grade for 332 type is 51.24%, the average grade for 333 type is 51.23%. (table 4-3, 4-4).

There're 67 samples taken from iron ore bed, 10 samples the Fe grade are 20-30%, 14 samples the grade are 30-40%, 23 samples the grade are 40-50%, 20 samples the grade are 50-70%, the samples which grade are ＞30%, take 85.07% of all the samples, the layer average grade is 43.58%，the layer Mn average grade is 4.68%，the Fe grade is 36.52%，and it took 2 drilling boreholes(zk1101 and zk1801) from south and north mining area to analyst the element of Cu, pb, Zn, Ni and Co, basis on the above information, the summary is, the ore is in good quality, the quality of the iron ore meets the general industrial index requirement of beneficiation, the quality of Iron and Manganese reach the II grade of Iron and Manganese industrial index . The variation of the secondary component content of the iron ore and Iron and Manganese ore see table 4-5. And hereby state the ore quality and variation characteristic of different layer as following:

Table 4-5 Variation table for ore bed impurity content Unit:×10^{-2}

Components	SiO_2	S	P	Cu	Pb	Zn	Ni	Co
Min	0	1.10	0.16	0.01	0.01	0.01	0.01	0.005
Max	5. 9	9.26	1.92	0.02	0.07	0.03	0.06	0.027
Avg.	4.89	4.71	0.52	0.01	0.02	0.01	0.01	0.007

Figure 4-3 Bar Chart Showing Mn contents in Iron and Manganese ore bed

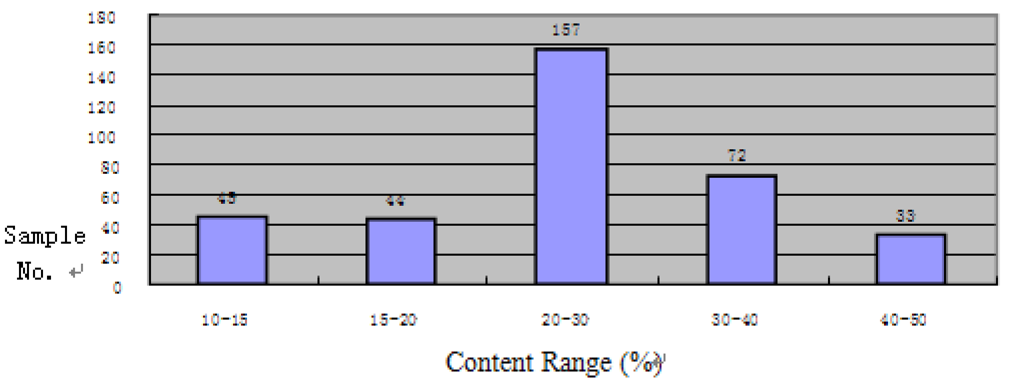
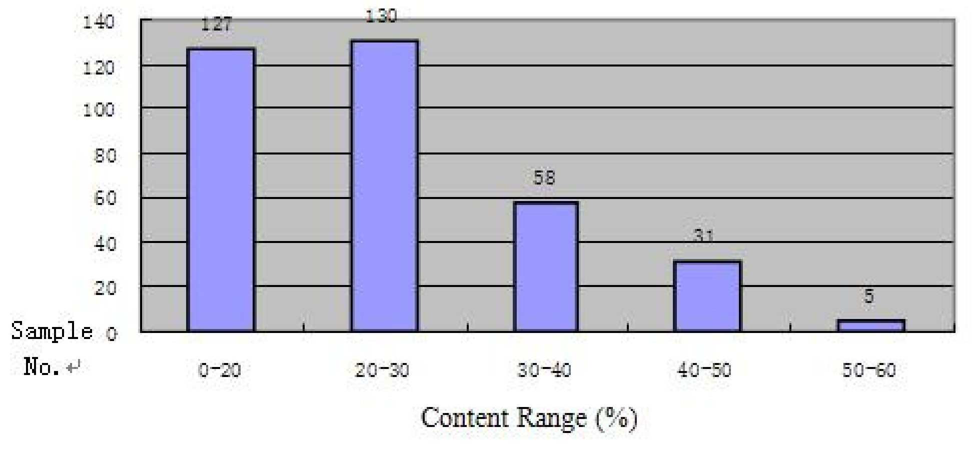


Figure 4-4 Bar Chart Showing Mn+TFe contents in Iron and Manganese ore bed



4.2.1 Iron ore bed 1

There're 67 samples are taken from the said ore bed, and after chemical analyst , 10 samples are the Fe grade 20-30% , 14 samples are the Fe grade 30-40%, 23 samples are the Fe grade 40-50% , and 20 samples are the Fe grade 50-70% . Its limit value between 23.49-62.93% , and its biggest variation range is 39.44%. The average grade of this layer is 36.52% .There're 60 samples with the Mn grade ＜10% , 7 samples grade 10-30% , its limit value between 0.09-26.00%，the biggest variation range is 25.01%. The content fluctuate range of the harmful component SiO_2 is 1.80-5.3%，the average content is 13.19%；the S content fluctuate range is 0.1-0.2%，the layer average content is 0.1%。The P content fluctuate range is 0.01-0.38%，the layer average content is 0.06%；Cu layer content is 0.01%； pb ore bed average content is 0.01%；Zn ore bed average content is 0.01%；Ni content fluctuate range is 0.01-0.05%，ore bed average content is 0.01%；Co content fluctuate range is 0.005-0.021%，the ore bed average content is 0.06%

In conclusion, the beneficial and harmful content of the layer sample in Iron ore bed 1 mostly vary between the industrial index range, and during the producing and sales practice, the S, P content are both very low, totally meet the requirement of the ore quality. According to the average component, the main beneficial content of the ore has a big variation along the strike and the tipping, but all above the minimum industrial grade.

4.2.2 Iron and Manganese ore bed I

There're 260 samples taken from the said ore bed, after chemical analyst, 34 samples the Mn grade is 10-15% ,take 13% of all the samples, 27 samples the Mn grade is 15-20% ,take 10%, 125 samples the grade is 20-30% , take 48%, 51 samples the grade is 30-40% , take 20%, 23 samples the grade is 40-50% , take 9%; and 199 samples the grade are ＞20%,take 77%. Its limit value between 10.30-50.00%，the biggest variation ranges is 37.71%, the ore bed average grade is 25.89%。

There're 29 samples the Fe grade are10-20% , take 32% of all the samples, 30 samples the grade are 20-30% , take 33%, 19 samples the grade are 30-40% , take 21%, 13 samples the grade are 40-55% ,take 14%, the ore bed average grade is 25.29%，its limit value between 10.43-52.48%，the biggest variation range is 42.05%.

There're 5 samples the Mn + Fe grade are 20-30% , take 2% of all the samples, 20 samples the grade are 30-40% , take 8%, 81 samples the grade are 40-50% ,take 31%, 119 samples the grade are 50-60% ,take 46%, 35 samples the grade are ＞60% ,take 13%, and 154 samples the grade ＞50%, take 60%. Its limit value between 24.54-63.75%，the biggest variation ranges is 39.21%, ore bed average grade is 51.18%.

The average grade of 332 types is 51.22%，the average content for 333 types is 51.05%。The harmful component SiO2 content fluctuate range is 0.5-26.3%，the layer average content is 10.51%；P content fluctuate range is 0.01-0.72%，the ore bed average content is 0.44%，the associated component Cu content fluctuate range is 0.01-0.02%，the ore bed average content is 0.01%；pb content fluctuate range is 0.01-0.07%，the ore bed content average is 0.03%；Zn content fluctuate range is 0.01-0.03%，the ore bed average content is 0.01%；Ni content fluctuate range is 0.01-0.06%，the ore bed average content is 0.01-0.06%，the ore bed average content is 0.02%；Co content average fluctuate range is 0.005-0.027%，the ore bed average content is 0.008%；S average content is 0.1-0.4%，the ore bed average content is 0.1%

In conclusion, the beneficial and harmful component of layer samples in Iron and Manganese ore bed I are mostly vary in between industrial index range, and during the producing and sales practice, the S, P content is very low, totally meet the requirement of ore quality. According to the average component, the main beneficial component has a big variation along the strike and tipping, the Mn and Mn + Fe grade are mostly vary in between the I - II grade In conclusion, the beneficial and harmful component of layer samples in Iron and Manganese ore bed I are mostly vary in between industrial index range, and during the producing and sales practice, the S, P content is very low, totally meet the requirement of ore quality. According to the average component, the main beneficial component has a big variation along the strike and tipping, the Mn and Mn+Fe grade are mostly vary in between the I - II grade (see Map 4-6 and 4-8).

4.2.3 Iron and Manganese ore bed II

There're 86 samples taken from the said ore bed, after chemical analyst, 7 samples the Mn grade are 10-15% , take 8% of all the samples, 17 samples the Mn grade are 15-20% ,take 20%, 31 samples the grade are 20-30% , take 36%, 21 samples the grade are 30-40% , take 24%, 10 samples the grade are 40-50%' take 12%, and there're 62 samples the grade ＞20%, take 72% of all the samples. Its limit value between 10.80-50.22%，the biggest variation ranges is 38.13%, the layer average grade is 25.65%。

There're 96 samples the Fe grade are 10-20%' take 40% of all the samples, 95 samples the grade are 20-30%' take 39%, 31 samples the grade are 30-40%' take 13%, 19 samples the grade are 40-55% ,take 8%. The ore bed average grade is 25.86%，its limit value between 9.33-53.54%，the biggest variation ranges is 44.21%.

There're 9 samples the Mn+Fe grade are ＜30%' , take 4% of all the samples, 16 samples the grade are 30-40% , take 6%, 84 samples the grade are 40-50%' take 34%, 124 samples the grade are 50-60%' take 50%, 16 samples the grade are ＞60%' take 6%, 224 samples the grade are ＞40%, take 90% of all the samples. Its limit value between 11.44-64.69%，the biggest variation ranges is 53.25%. the ore bed average grade is 51.51%，the average grade for 332 type is 51.40%，the average grade for 333 type is 51.63%，the content fluctuate range of the harmful component SiO2 is 0.2-34.2%，the ore bed average content is 5.36%；The P content fluctuate range is 0.01-0.53%，the ore bed average content is 0.38%；the associated component Cu ore bed average content is 0.01%；the pb content fluctuate range is 0.01-0.04%，the ore bed average content is 0.02%；the Zn ore bed average content is 0.01%；the Ni ore bed average content is 0.01%；the Co content fluctuate average is 0.005-0.01%，the ore bed average content is 0.005%；the S content fluctuate range is 0.1-0.4%，the ore bed average content is 0.1%。

To sum up, most of the useful and harmful components in Iron and Manganese ore bed II are within the range of industrial requirements. According to the average components, main useful components in ore are stably distributed along the strike and dip (see Figure 4-7) with small variations. The industrial qualities of Mn and Mn + TFe are ranked between Grade I and Grade II (Figure 4-7, Figure 4-9). The maximum and minimum contents of other components are illustrated in the Table 4-6.

Table 4-6 Maximum and Minimum Contents of Other Components in Iron and Manganese(Iron) Ore beds Unit: ×10^{-2}

Ore bed No.	Components	SiO_2	S	P	Cu	Pb	Zn	Ni	Co
1	Minimum	4.65	7.57	1.05	0.44	0.32	0.06	0.34	0.03
	Maximum	5.90	9.79	1.92	0.91	0.80	0.07	0.36	0.04
	Average	5.36	8.53	1.43	0.64	0.53	0.06	0.35	0.04
I	Minimum	3.68	3.26	0.41	0.26	0.17	0.06	0.05	0.02
	Maximum	1.99	6.18	1.03	0.43	0.28	0.07	0.07	0.04
	Average	3.26	4.61	0.68	0.34	0.24	0.064	0.06	0.03
II	Minimum	4.10	2.22	0.35	0.18	0.18	0.06	0.07	0.02
	Maximum	5.65	10.31	1.50	0.52	0.29	0.07	0.31	0.06
	Average	5.08	4.60	0.70	0.32	0.27	0.07	0.20	0.04

Figure 4-5 Bar Chart Showing TFe contents in Iron Ore bed 1

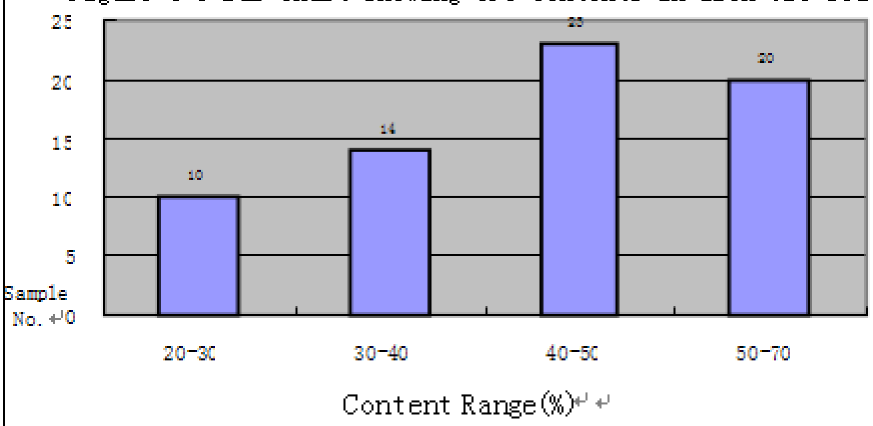


Figure 4-6 Bar Chart Showing Mn contents in Iron-mamnganese Ore bed I

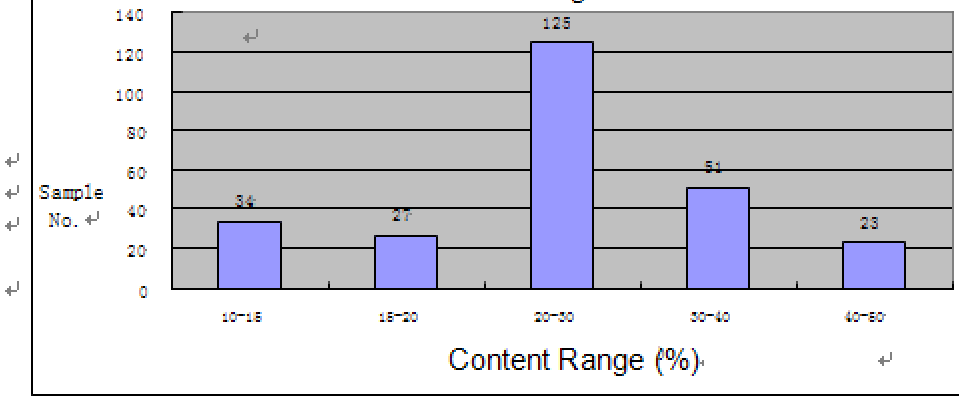


Figure 4-7 Bar Chart Showing Mn contents in Iron and Manganese ore bed II

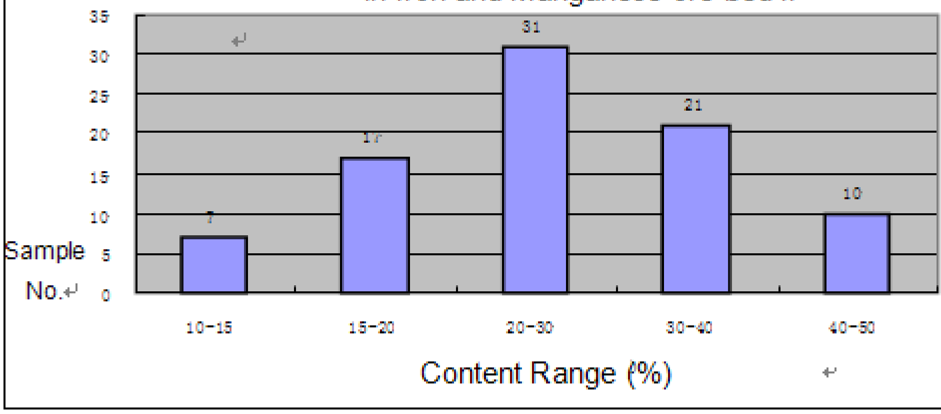


Figure 4-8 Bar Chart Showing Mn+TFe contents in Iron and Manganese ore bed I

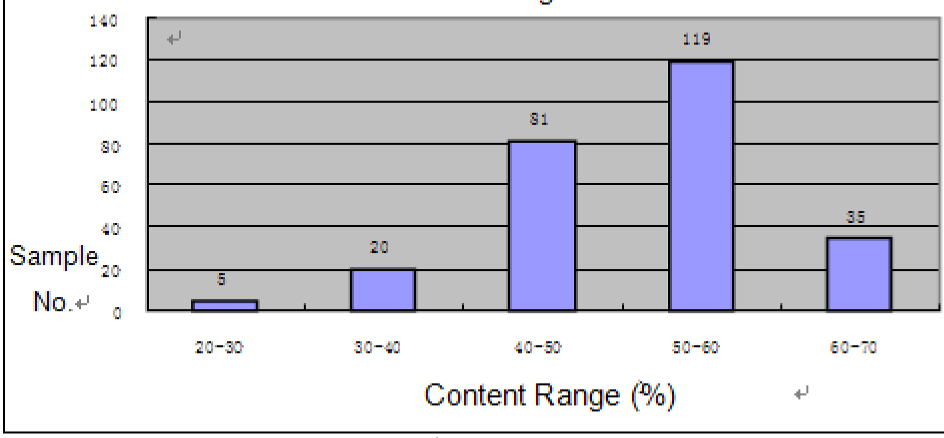
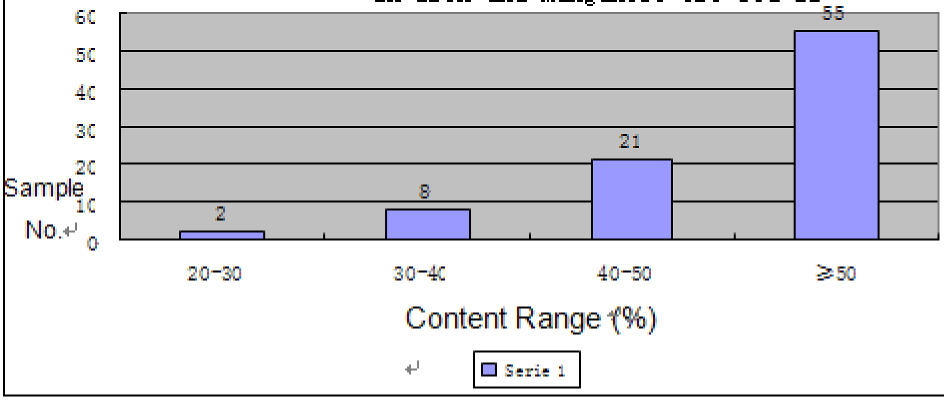


Figure 4-9 Bar Chart Showing Mn+TFe contents in Iron and Manganese ore bed II



4.3 Ore Types and Grades

4.3.1 Iron ore

According to the composition, structure and appearance characteristics, the types of the ore can be identified as patchy/ banded, blocky and dense hematite ore.

Most of the iron ore are hematite ore, which are gray or grayish-black, banded or blocky, followed by patchy hematite ore, which are med-thick bedded. The main mineral component is TFe (6.5% to 64.3%). Components affecting the quality of the ore are mainly SiO_2, S and P, mixed with some minor ones like Cu and As.

As categorized according to the industrial usage of the ore, they are processing-needed iron ore.

4.3.2 Iron and Manganese ore

According to the composition, structure and appearance characteristics, the types of the ore can be identified as patchy/ banded, blocky and dense oxidized Mn ore.

Iron and Manganese ore are mainly grayish-black, banded or blocky, then patchy and med-thick bedded. The main mineral components are Mn (7.8% to 50%, with an average of 25.8%), TFe (7.1% to 55.8%, with an average of 25.39%), Mn + TFe (51.24%), Mn/Fe(1.02), impurities P (0.35% to 1.50%, with an average of 0.57%) and SiO_2 (1.99 % to 5.65%, an average of 9.63%). Mn + TFe is 51.24%, while Mn/Fe is 1.02.

As categorized according to the industrial usage of ore, they are high-iron manganese ore. In this area, Iron and Manganese ore vary greatly in the quality and generally they are Grade I Iron and Manganese ore.

4.4 Country Rocks of the Ore body and Interbeds

4.4.1 Country Rocks of the Ore body

The floor ore body is comprised of the purplish-red thin-bedded silty slates which belong to the Member ⑤ of Asbesberge formation of Asbestos subgroup of Transvaal super group, and the purplish-gray medium-grained ferruginous dolomite which belong to the Naragas formation (Vgl)of Campbellrand subgroup of Ghaap group of Transvaal super group. The main minerals of the silty slates are clays, a little silts (quartz), and little white mica, tourmaline, zircon, sphene and leucoxene. The mineral compositions of dolomite are dolomite (> 96%), calcite (1%) and pelitic materials (<3%).

The direct roof of the ore body is comprised of grayish-yellow / purplish-yellow thin-bedded silty slates or sericite slates which belong to the Member ③ of Asbesberge formation of Asbestos subgroup of Transvaal super group, purple and yellowish gray thin-bedded silty slate or sericite slate. Its mineral compositions are: sericite (80%), quartz (< 20%), and little white mica, tourmaline, zircon, sphene and leucoxene. Its chemical compositions are: Mn (0.01% to 9.64%), TFe (0.4% to 41%), SiO2 (0.4% to 69.5%), P (0.01% to 0.13%) and S (0.1% to 0.3%).

4.4.2 Interbeds

According to sample results, there are 4 intercalated layers: Interbed② is comparatively stable, but the Interbed ① and ③ are relatively unstable, and the Interbed ④ is unstable. Their features are as follows:

It occurs in Ore bed I, and is mainly distributed under the Exploration Line 0, 5, 11 and 12. The length of the strike is measured to be 1,200m, and the occurrence is identical with that of the Iron and Manganese ore bed I, with irregular distribution. It is discontinued along the strike and dip and occurs in lenticular shapes. In terms of lithology, the ore are purplish-red thin-bedded sericite slates of blastopelitic texture and slaty structure, containing iron-manganese. Regarding its mineral compositions, there are mainly clays, followed by a little manganese, iron and little white mica, tourmaline, zircon, sphene and leucoxene. The chemical compositions are: Mn (0.63 to 8.89%, with an average of 3.84%), TFe (5.4% to 37%, with an average of 4.4%), SiO_2 (9.8% to 36.8%, with an average of 26.41%), P (0.01% to 0.04%, with an average of 0.02%), S (0.1% to 0.17%, with an average of 0.84%). The thickness is 0.66 to 1.00m, with an average thickness of 0.80m.

Interbed ②:

As the main interlayer within the mining area, it is located between Ore bed I and the II ore bed. The distribution is fairly regular along the strike and it is disconnected only along Line17 and 6. Along the dip, it is discontinued and the occurrence is consistent with that of the Iron and Manganese ore bed I and II. Its lithology and mineral compositions are the same as those of Interbed ①. Its chemical compositions are: Mn (0.1% to 9.67%, with an average of 5.01%), TFe (1.7% to 45.8%, with an average of 15.51%), SiO_2 (6.6% to 72.4%, with an average of 33.27%), P (0.01% to 0.17%, with an average of 0.03%), S (0.1% to 0.2%, with an average of 0.1%). The thickness is 0.64 to 2.52m, with an average thickness of 1.22m.

Interbed ③:

It is located on the upper part of Iron and Manganese ore bed II in a discontinued distribution along the strike and dip. It is discontinuously distributed along Exploration Line 0, 5, 11 and 12 and the occurrence is the same as that of Ore bed II. The lithology and mineral compositions are the same as those of Interbed ①. Its chemical compositions are: Mn (1.98% to 9.6%, with an average of 5.75%), TFe (8.3 to 54.8%, with an average of 4.51%), SiO_2 (2.1 to 36.2%, with an average of 22.7%), P (0.01 to 0.13%, with an average of 0.04%), S (0.1 to 0.2%, with an average of 0.1%). The thickness is 0.32 to 0.95m, with an average thickness of 0.88m.

Interbed ④ :

It is located in the lower part of Ore bed II. It is in a lenticular shape and distributed only under the Borehole ZK001, with the occurrence the same as that of Ore bed II. The lithology and mineral compositions are the same as those of Interbed ①. Chemical components are: Mn：4.62%，TFe：10.4%， SiO_2：33.2%， P：0.03%， S：0.1%,0.77m thick.

The average thickness of each interbred in the deposit ranges generally from 0.77 to 1.16m, with an average thickness of 0.92m. The chemical compositions: Mn (0.10 to 9.67%, with an average of 4.85%), TFe (1.7 to 54.8%, with an average of 9.39%); other components in the interlayer's: SiO_2 (2.1 to 72.4%, with an average of 28.7×10^{-2}), P (0.01 to 0.13%, with an average of 0.03%), S (0.1 to 0.2%, with an average of 0.1%). (see Table 4-7 and 4-8).

Table 4-8 Maximum and Minimum Contents of Other Components in Interbeds Unit: %

Components	SiO_2	P	S
Minimum	2.1	0.01	0.1
Maximum	72.4	0.17	0.2
Average	28.7	0.03	0.1

Table 4-7 Interbed thickness and Main components of ore deposit

Exploration line No.	Interbed No.	True thickness	Avg. grade(%)	
		(m)	Mn	TFe
0	①	0.36	2.46	51.60
		0.96	8.08	40.50
	②	0.57	8.30	14.20
		1.62	4.24	25.35
	③	0.32	1.98	8.30
		1.62	3.41	15.09
		0.75	9.60	18.70
	④	0.77	4.62	10.40
5	①	1	2.01	22.1
	②	0.93	9.67	45.80
		0.71	3.10	8.00
		1.96	0.94	14.93
		2.47	2.48	8.07
	③	0.95	8.42	47.70
		0.80	6.46	12.44
6	③	0.87	4.14	33.00
	②	2.25	1.61	8.51
		1.00	1.14	6.18
11	①	0.47	3.11	5.40
		1.20	0.63	6.60
	②	0.33	2.41	7.90
		0.63	2.99	10.20
		2.52	3.70	14.06
	③	0.87	6.92	54.80
12	①	0.85	5.98	18.40
		0.53	8.45	37.00
	②	1.64	0.11	2.11
		1.25	7.36	13.90
3	②	0.64	6.94	9.00
Avg. grade of interbred	①	0.80	3.84	4.40
	②	1.22	5.01	15.51
	③	0.88	5.75	4.51
	④	0.77	4.62	10.4
Avg. grade of ore deposit		0.92	4.85	9.39

4.5 Ore Genesis and Prospecting Criteria

4.5.1 Ore Genesis

The mining area is located at the middle section of the world-famous Postmasburg- Kalahari Iron and Manganese ore belt (BIF), at the southern part of Kalahari Basin. The mineralization belt possesses a huge amount of resources. Within this remote and isolated Kalahari basin, metamorphism develops due to strong volcanic activities.

Banded structures containing Iron and Manganese are widely distributed. The ore bed belongs to a sedimentary exhalative deposit, caused by the release of ore-bearing hydrothermal fluids in the bottom of the ocean, and it has the related characteristics of such release. It is rich in carbonatite quartzite, volcanic rocks and other sedimentary exhalative structures across multiple phases, which contain iron-manganese. During each release, a large amount of Fe, Si and other minerals and acidic and reducing gas are emitted, providing the material basis for the formation of a giant Iron and Manganese deposit. The deposit occurred in Asbesberge formation of Asbestos subgroup of Transvaal super group, and in genetic type it belongs to the metamorphosed sedimentary Fe/Mn (Fe) deposit.

4.5.2 Prospecting Criteria

(1) The Asbesberge formation of Asbestos subgroup of Transvaal Supergroup is the place where the Iron and Manganese ore occur, and it covers a huge region, which are the criteria for prospecting.

(2) The outcrops of the iron-manganese ore, boulders stones and mining pits are direct prospecting criteria.

CHAPTER 5
Technical Performance of Ore Processing

A small-scale trial production has been carried out. According to Iron and Manganese ore which have been identified in the mining operations and exploration, the ore have a simple mineral composition and relatively simple chemical composition. According to the portfolio analysis made in the exploration phase, no other useful components are found.

It is estimated that there is a small amount of associated harmful impurities in the resource reserves. For manganese ore from Lomoteng mining area, no separation test has been made. But as the Lomoteng mine is adjacent to the Bishop Manganese mining area which is operating. In 2009, eight ore samples from Bishop Manganese deposit were collected and sent to Chang Sha Research Institute of Mining and Metallurgy for separation tests, using high-intensity dry permanent-magnetic separators.

Fairly satisfactory results were achieved. These 8 ore samples are mixed into 5 samples and then crushed to-30mm. The 30-15mm size sample tests are then made and the results are as follows: the raw ore contains Mn 22.66-29.34%; after separation, the manganese ore have a production rate of 61.75 to 76.51%, with Mn grade of 32.58 to 38.25%, and recovery rate is 61.75 to 76.51%; the tailings rate is 23.49 to 38.25%, the tailings grade is 6.65 to 14.88, and the tailings recovery rate is 9.95 to 17.14% (see Table 5-1).

Table 5-1 One roughing and one scavenging, using high-intensity dry permanent-magnetic separator, on manganese ore from Bishop

<table>
<tr><th>Granularity</th><th>Testing times</th><th>Name</th><th colspan="2">Productivity (%)</th><th colspan="2">Mn grade (%)</th><th colspan="2">Recovery (%)</th></tr>
<tr><td></td><td></td><td>Tailings</td><td colspan="2">32.88</td><td colspan="2">13.57</td><td colspan="2">17.14</td></tr>
<tr><td></td><td></td><td>Raw Ore</td><td colspan="2">100.00</td><td colspan="2">26.05</td><td colspan="2">100.00</td></tr>
<tr><td rowspan="8">Sample No.6+7 are crushed to 30-15mm
Dry concentration</td><td rowspan="4">1</td><td>Concentrate</td><td>45.62</td><td rowspan="2">71.72</td><td>35.88</td><td rowspan="2">33.91</td><td>57.37</td><td rowspan="2">85.24</td></tr>
<tr><td>Middling’s</td><td>26.10</td><td>30.46</td><td>27.87</td></tr>
<tr><td>Tailings</td><td colspan="2">28.28</td><td colspan="2">14.88</td><td colspan="2">14.76</td></tr>
<tr><td>Raw Ore</td><td colspan="2">100.00</td><td colspan="2">28.53</td><td colspan="2">100.00</td></tr>
<tr><td rowspan="4">2</td><td>Concentrate</td><td>22.33</td><td rowspan="2">71.72</td><td>38.76</td><td rowspan="2">33.91</td><td>30.34</td><td rowspan="2">85.24</td></tr>
<tr><td>Middling’s</td><td>49.39</td><td>31.72</td><td>54.90</td></tr>
<tr><td>Tailings</td><td colspan="2">28.28</td><td colspan="2">14.88</td><td colspan="2">14.76</td></tr>
<tr><td>Raw Ore</td><td colspan="2">100.00</td><td colspan="2">28.53</td><td colspan="2">100.00</td></tr>
<tr><td rowspan="2">All mixed samples are crushed to 30-15mm</td><td rowspan="2">1</td><td>Concentrate</td><td>25.84</td><td rowspan="2">67.41</td><td>40.35</td><td rowspan="2">36.00</td><td>36.88</td><td rowspan="2">85.83</td></tr>
<tr><td>Middling’s</td><td>41.57</td><td>33.29</td><td>48.95</td></tr>
</table>

Granularity	Testing times	Name	Productivity (%)	Mn grade (%)	Recovery (%)
dry concentration		Tailings	32.59	12.29	14.17
		Raw Ore	100.00	28.27	100.00

Mixed samples	Raw ore	Concentrate	Middling's	Tailings
TFe	22.39	15.27	20.86	30.00
SiO2	6.25	5.50	5.54	7.75

According to the separation indexes of Table 5-1, it is not only the Mn grade is improved by 5.19-9.92%, but also the content of Fe is decreased.

Lomoteng 669 manganese ore and Bishop manganese ore are located in the same ore zone. They are neighboring to each other. Their conditions of mineralization and occurrence are basically similar. The types and properties of such manganese ore are similar as well. Thus, some relevant indexes and information of the mineral concentrating test can be learned from Bishop's. The ore concentration results of Bishop, Paling and Lomoteng 669 ore are good. The prep arability of such ore is excellent, and the technical conditions of mineral processing are simple.

CHAPTER 6

Technical Conditions of Ore Mining

6.1 Hydrogeology

6.1.1 Physical Geography

The Lomoteng Iron and Manganese Mining area is located on a flat plateau. Its terrain is generally higher in the east than in the west. Its western part consists of low and smooth mountain slopes, and the eastern part is great flat grassland. The ridge line heads to NNW which is consistent with the trend of the rock stratum. The terrain slope is ranging from 6-22°. Its highest point, which is 1454.27m in elevation, is located in the north-east part of the mining area; while the lowest point, which is 1310m in elevation, is in the western part. The biggest height difference is 144.27m.

The mine area has a generally savanna climate with four distinct seasons. In the monsoon climate, vegetation on the surface is rare. Basic rocks are exposed in the eastern part of the mining area, while the western part is covered with Quaternary sandy soil. Here the summer begins December and ends the next February, with the highest temperature of 32-38℃. Its winter, however, starts from June to August, with the lowest temperature of -10--12℃. Precipitation is rare, and the annual rainfall is ranging from 60 to 1000mm, with an average of 450mm. There is little surface water, which cannot be found in or nearby the mining area.

6.1.2 Aquosity of Stratum

1. Quaternary system (Q),

   Q, which belongs to eluvium, is situated in the western part of the mining area, on top of the basic rock. The soil appears to be sandy and yellowish-red, which contains little clay. Its pore connectivity is poor and its water retention is low. The thickness of the soil is 8.00-17.98m. There is no spring water can be found in Q stratum in this area. This system, which is pore aquitard or permeable layer, Q contains little stagnant water and appears to be weak-pore aquifer or permeable layer.

2. Gamagara formation of Gamagara subgroup of Postmasburg group of Transvaal Supergroup

   Vgm is exposed in the west part of the mining area, which is covered by the Q zone. It is composed of yellowish-grey thin-bedded silty slates. The discovered thickness is between 15.18-44.55m. Features like few discontinuous fractures and low water retention are identified. Only little fracture water exists. Vgm shall be taken as a relative aquifuge.

3. Member ① of Asbesberge formation of Asbestos subgroup of Transvaal Supergroup

   Member ① is exposed in the middle-west part of the area. It consists of quartzites which can be characterized as grey-white colored, med-thick bedded and fine-grained. Its thickness is between 3.68-27.81m. Weathering fissures are developed in member ① with poor connectivity. Thus, its water retention is low, and its fracture water is little.

4. Member ② of Asbesberge formation of Asbestos subgroup of Transvaal Supergroup

Member ② is exposed in the whole mining area. It consists of metamorphic feldspar sandstones which can be characterized as purplish-red, small-grained and thin- to med-thick bedded. Its thickness is between 4.53-47.42m. The rock is comparatively integrated, with poor fracture connectivity and low water retention, which only contains little fracture water.

5. Member ③ of Asbesberge formation of Asbestos subgroup of Transvaal Supergroup

Member ③ is exposed in the whole mining area. It is formed by silty slates and sericite slates, which can be characterized as purplish-red/grayish-yellow and thin-bedded. Its thickness is between 3.41-54.49m. The rock is integrated with no fracture and low water retention, which shall be taken as a relative aquifuge.

6. Member ④ of Asbesberge formation of Asbestos subgroup of Transvaal Supergroup

Member ④ is exposed in the most parts of the area. It is formed by grey-black Iron and Manganese ore, with a thickness between 1.64-29.14m. Such rocks are hard and compact, with fractures generally developed. Such fractures are filled up with slates and shales. Member ④, with low water retention, contains little fracture water.

7. Member ⑤of Asbesberge formation of Asbestos subgroup of Transvaal Supergroup

Member ⑤ is exposing in some parts of the area, which is irregularly distributed. It is formed by silty slates and sericite slates, which can be characterized as purplish-red/grayish-yellow and thin-bedded. Its thickness is between 1.64-29.14m. Such rocks are hard and compact, with fractures generally developed. Such fractures are filled up with shales. Member ⑤, with low water retention, contains little fracture water.

8. Naragas formation (Vgl)of Campbellrand subgroup of Ghaap Group of Transvaal Supergroup Vgl is exposed in the whole mining zone, which is widespread. It is formed by purplish-gray dolomites which can be characterized as blocky, medium-grained and ferruginous. There are karst caves developed at the top of the stratum which is located in the middle of the mining area. Such caves are filled up with shales. Some fractures are developed in certain areas. Vgl is comparatively rich in fracture karst water, with high water

retention. Since the fracture karst water exists under the ore beds, the mining process will only be slightly affected.

6.1.3 General evaluation of Hydrogeology

The hydrogeology conditions of this ore zone are simple. Surface water is found, which the underground fracture water is low. The ground water level is between 1283-1291m. At present, the early stage mining is undertaken above the ground water level. Thus, water in mining pits will mainly come from raining. As it rains rarely in the mining area, the dewatering processing can depend on gravity drainage, taking advantage of the geography conditions. Such method has little influence on the mining operation. For the later stage mining if it is deep open pit mining, the mechanical dewatering can be used and drainage ditch can be built according to the actual situation.

6.2 Engineering Geology of Mining Area

6.2.1 Evaluation of Ore Deposit Lithology, Physical Mechanical Property and Rock Mass Quality

The rock types of mining area mainly are grey-white med-thick bedded quartzite, metamorphic feldspar-quartz sandstone and sericite slate. The upper parts of the country rock consist of quartzites which are med-thick bedded. Such sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 132.8-152.3MPa. The effective angle of internal friction (represents the shear strength) is 43°. The cohesion of such rocks is 16MPa, which can be considered as hard rocks.

The majority of the country rock consists of metamorphic feldspar-quartz sandstones texture which are med-thick bedded. Such sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 68MPa. The effective angle of internal friction (represents the shear strength) is 40.9-41.0°. The cohesion of such rocks is 1.98-2.65MPa, which can be considered as hard rocks.

The roof country rock is formed by sericite slates which are thin-bedded. Such sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 50.0-51.2MPa. The effective angle of internal friction (represents the shear strength) is 41.6-42.3°. The cohesion of such rocks is 4.06-4.52MPa, which can be considered as soft rocks.

The floor country rock is formed by dolomites which are blocky. Such sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 105-120.3MPa. The effective angle of internal friction (represents the shear strength) is 45.3°. The cohesion of such rocks is 12.6MPa, which can be considered as hard rocks.
The ore bodies are med-thick bedded. Such sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 135.1-159.5MPa. The effective angle of internal friction (represents the shear strength) is 44.2°-46.1°. The cohesion of such rocks is 10.7-16.2MPa, which can be considered as hard rocks.

Iron ore sample is studied using thin sections oriented parallel to the drill-core axis, and its uniaxial compressive strength is 132.7-142.3MPa. The effective angle of internal friction (represents the shear strength) is 45°. The cohesion of such rocks is 10.2MPa, which can be considered as hard rocks.

The ore body strikes to the north-east, and dips to the south-west with a dipping angle of 8-23°. Thus, the ore body belongs to a gentle dip slope. The direct wall rocks of both the roof and floor are soft rocks, which can easily be weathered. Such rocks can be characterized as low strength and less stable, which may negatively influence the mining process. However, due to the fact that the dipping angle is merely 8-23°, and the occurrence of the ore body is gentle, then a big landslip will not happen.

According to the 29 drill holes this time, the average RQD (rock-quality designation)of the roof country rock (metamorphic feldspar-quartz sandstones) is 39%, that of the direct roof slates is 44%, that of the ore body is 50%, that of the direct floor slates is 59%, and that of the direct floor or floor dolomites is 71%.

It is preliminarily judged that the Iron and Manganese ore are mid-thick bedded. The quality of such is considered to be favorable — Grade II. In the stratum, there are 1-4 slate intercalated layers with thicknesses of 0.32-2.52m. Such layers are thin, narrowly distributed and occurred gently. Also based on the previous observation on existing mining pits, such layers have little influence on the mining process.

6.2.2 Features of the Structure Planes

There are two mainly two kinds of structure planes in the mining area: the primary structure plan and secondary structure plane.

The primary structure plane consists of several layers of the rock stratum. According to the survey on the mining pit the results of engineering exposure, these layers are flat and straight, and the intercalated layers between such layers are soft and thin. Such layers are on top of the ground water level. The occurrence of such layers is gentle which will not easily cause the interlayer gliding.

The secondary fracture majorly consists of weathering fissures.

Weathering fissures , which generally are 19-33m, are developed on the top of the rock stratum. Due other the weathering fissures, the rocks become fragmented and their engineering mechanics properties become worse, which will have certain effect on the stability of ore-deposit mining.

In conclusion, the rock stratum of the mine area belongs to a blocky-bedded structure. The occurrence of the stratum is gentle. The intercalated layers are soft and thin. The stratum belongs to hard rock's with high physics mechanics strength. Weathering fissures are developed on the top of the rock stratum, which will have certain effect on the stability of ore-deposit mining. Weathering fracture of the top part is developed which will have certain effect on the ore deposit mining. The engineering geological condition of the ore deposit is medium.

6.2.3 The Evaluation on the Stability of the Side Slopes of the Mining Pits

The side slopes of the mining pits are rocky and single-layered.

There is one trial mining pit in eastern part of the mining area. Its side slopes are facing east, which are contracted with the dipping direction of the rock stratum. They can be taken as scarp slopes. The heights of such slopes are generally between 8-22m, with a maximum of 50m. The angles of side slopes are between 70-80°, with a maximum of 83° (see Picture 9). Currently, these side slopes are stable, with no appearances of collapse or landslide.

Based on the abovementioned data, it can be predicted that the quality of the side slopes will remain to be good, and such slopes will stay stable. Thus, the height of the bench and the angle of side slopes can be designed according to the specifications of the Grade II rock.

However, there are fissures developed in some parts of the Iron and Manganese ore bodies, which may considerably influence the stability of the side slopes. Hence, during the mining process, measures, such as monitoring the stability of the side slopes, lowering the bench height of certain parts, and removing loose rocks, shall be undertaken.

6.3 Environmental geology

6.3.1 Stability of the Region

The neo-tectonic movements of the region, in which the mining area is located, appear to be gently ascending. No earthquake activity has been recorded in such region. Thus, it belongs to an inactive earthquake zone, with its Liedu intensity less than Level VI (see the China Seismic Intensity Scale). With such high stability, the mining area is suitable for large-scale mining operation.

6.3.2 Influences of the Mining Operation on the Water Resources and the Environment

Open-pit mining is applied for this mining area. Thus, little ground water is discharged from the mining pit at the initial mining stage. Generally, no influence will be caused on the water sources around the mining area. No dry out of the sources shall be occurred.

6.3.3 Geological Hazards of the Mining Area

No collapse, landslide, mudslide, ground collapse caused by karst effect or any other geological hazards have ever happened in the mining area or its surrounding areas. Thus, it is an area of low vulnerability to geological hazards.

1. Collapse and landslide

Open-pit mining is considered as the main mining method for this mining area. Weathering fissures are developed in both roof and floor of the ore bodies, which will lower the stability of the rock stratum. Nevertheless, due the fact that the occurrence of the stratum is plain and gentle, there is little possibility that large-scale collapse or landslide may occur in the mining area. Such risk is minor.

2. Mudslide

The catchment area, which is located in the upper part of the mining area, is relatively small. Few loose types of sediment exist on the surface of the mining area. Moreover, the precipitation is small. Thus, there is low chance that any mudslide can be triggered by natural causes.

There are considerable amount of waste rocks near the mining area, which is suitable for dumping waste rocks and residue soil. Such waste rocks are hard and big, and the dump sites are quite stable. Thus, it is unlikely that severe mudslides will be caused by the waste rocks and residue soil from the dump sites. Nevertheless, necessary measures, such as drain ditches and stonewalls, shall be built to prevent any possible geological hazards and to protect the geological environment of the mining area.

6.4 Chapter Summary

6.4.1 Hydrogeology

Most of the ore bodies in the mining area are above the erosion base level, and the dewatering processing can depend on gravity drainage. The water in mining pits will mainly come from raining. Other conditions, like deep groundwater, rare precipitation and gravity drainage, have limited influence on the mining process. The hydro geological conditions of such area are simple.

6.4.2 Engineering geology

The engineering geological conditions of the mining area are rated as medium.

6.4.3 Environmental geology

The environmental geological conditions of the mining area are rated as medium.
In summary, the technical conditions of this mining operation are rated as medium.

6.5 Studies on the Hydro-, Engineering, and Environmental Geology, and Comments

6.5.1 Study methods

To generally understand the technical conditions of mining in such deposit, studies on the hydro-, engineering and environmental geology haven been conducted. Such studies are undertaken according to the "Exploration specification of hydrogeology and engineering geology in mining areas" (GB12719－91) and, other prescribed protocols and standards.

Since the mining area is relatively small and survey period is short, the following methods are mainly utilized for this general exploration:
Drillings have been done for the basic hydrological observation. The dynamic observation of the groundwater is conducted as well. Water samples are collected from the wells in the mining area. Drill holes are logged, and the physical Mechanics properties of rocks are tested.

6.5.2 Comments on Quality

The abovementioned studies are undertaken according to the prescribed protocols and standards. It has been proven that small amount of water-filled fissures are developed in such deposit. Fissure water is originated from the rain. Moreover, the surface water has little influence on the mining process. It is generally ascertained that the ore bodies of the mining area are med-thick bedded, with thin and soft intercalated layers. The occurrence of the ore bodies is flat and gentle. The physical mechanics strength of such rocks is high, while the side slope is stable. Thus the engineering geological conditions of the mining area are good.

After the collection of regional data and the geological study of the mining area, the stability of the mining area has been proven. It also has been proven that no geological hazards have ever happened in this area. Then an evaluation on possible geological hazards for the future mining process has been conducted, and suggestions have been provided. Based on all the previous materials obtained from the abovementioned work, the conclusion, that the technical conditions of this mining operation are rated as medium, is correct and trustworthy. The quality of the conducted work can satisfy the prescribed requirements.

CHAPTER 7

Geological Survey and Quality Control

7.1 Exploration Methods and Project Management

7.1.1 Exploration Type

The major layer of the ore body appears to be in bedded and stratified structures. It occurs along the dip direction, with the length of 3600m, width 1100m and thickness 6.03m. Such layer is regularly distributed with excellent continuity. The internal structure of the layer is quite simple, which only contains few discontinuous intercalated layers. Its geological structure is quite simple. It is considered to be a very large sedimentary Iron and Manganese ore deposit. According to the "Specifications for iron, manganese and chromium mineral exploration" (DZ/T02000—2002) and "Classification for resources / reserves of solid fuels and mineral commodities" (GB/T17766-1999), such deposit can be classified as Exploration Type Ⅰ (complicated).

7.1.2 Exploration Methods

Based on the objects of this project, the characteristics of the terrain and ground objects, trenching was done on the surface, while drilling was completed underground. Other programs, such topographic survey, geologic survey and others have been undertaken as well.

7.1.3 Exploration Plan

It has been proven that the Iron and Manganese deposits are monoclinic layered, which can be characterized as regularly distributed, and gently dipping. Then, generally, parallel exploration lines which are perpendicular (at 270 degrees) to the strike of the ore body, are established. Since the Iron and Manganese deposits are classified as Exploration Type I with considerable lengths, and topographic features are quite simple, survey grids of the exploration are set up to 600 x 300 meters, to investigate the indicated mineral resources (UNFC Code 332) within the survey area.

The inferred mineral resources (333) are extra-polated according to the strike and dip directions. There are 7 exploration lines arranging from the north to the south, namely 18, 12, 6, 0, 5, 11, and 17. Along the survey grids, trenching combined with surface sampling have been undertaken. Meanwhile, There are 27 holes drilled along the survey girds, as follows, 3 holes on the Exploration Line 3, 6 holes on the Exploration Line 12, 6 holes on the Exploration Line 6, 3 holes on the Exploration Line 0, 3 holes on the Exploration Line 11, and 3 holes on the Exploration Line 17. The distance between drill holes is not allowed to exceed 300m. The results of indicated mineral resources (UNFC Code 332) and inferred mineral resources (333) turn out to be reasonable and satisfying. Thus, such plan has been reasonably designed.

7.2 Quality Control

7.2.1 Drilling Project

All drill holes are along the survey grids. All locations of the holes have been observed and recorded after the drilling. It is designed that straight-hole drilling shall be applied for this project. To accelerate the drilling process, some percussion drilling has been used to deal with surrounding rocks. Both 600 and 1000m drilling rigs have been used to spud 29 holes, with total footage of 2761.29m. 1677.29m were done by percussion drilling. The average depth of the drilling hole is less than 200m, with a starting diameter of 110mm and ending diameter of 75mm, which can meet the requirements for sampling.

(1) Core Recovery

The majority of ore bodies outcrops, while the others are covered by Quaternary fine silt deposits. Hence, the ore bodies can be easily exposed during the drilling process. It is under the requirements of BDB and "Specifications for cement-materials mineral exploration"

(GF95-01) that the core recovery for surrounding rocks can be ignored, while the core recovery shall not be less than 80% for the ore bodies, their intercalated layers, and their roof and floor rocks (3-5m). The summary for core recovery rates is illustrated as Table 7-1.

Table 7-1 Core Recovery Rate

Hole No.	Core Recovery(%)				Remarks
	Total	Roof	Ore bodies	Floor	
ZK001	100	100	100	80	Met standard
ZK501	72	100	64	82	Below standard
ZK502	73	96	64	86	Below standard
ZK503	82	79	57	78	Below standard
ZK602	90	90	80	80	Met standard
ZK603	56	30	67	74	Below standard
ZK605	84	82	88	84	Met standard
ZK1101	93	89	98	90	Met standard
ZK1102	97	93	74	83	pass muster
ZK1103	99	98	100	92	Met standard
ZK1201	63	81	70	84	pass muster
ZK1202	66	91	40	77	Below standard
ZK1204	83	/	78	86	pass muster
ZK1701	97	/	100	94	Met standard
ZK1702	97	/	No ore discovered	/	Met standard
ZK1703	100	/	No ore discovered	/	Met standard
ZK1203	84	92	72	92	pass muster
ZK601	66	/	86	59	Met standard
ZK002	96	99	93	94	Met standard
ZK1206	100	100	100	100	Met standard
ZK301	100	100	100	100	Met standard
ZK504	98	99	99	99	Met standard
ZK003	98	99	97	84	Met standard
ZK1802	94	100	91	100	Met standard
ZK1801	95	100	90	73	Met standard
ZK1205	59	/	No ore discovered	/	Met standard
ZK606	98	99	99	100	Met standard
ZK604	82	93	59	83	Below standard
ZK1803	100	/	No ore discovered	/	Met standard
Average	87	91	83	86	Below standard

According to table 7-1, there are 6 holes below standards, 19 holes met the standards, which gives a 66% passing rate; and there are 4 holes pass muster, the passing rate is 14%, gives a total passing rate at above 80%. Combine the results of prospecting works and the exchanges opinions between the right holder and BDB, the recovery rate is considered satisfying which meets the requirements.

(2) Hole Deviation

Since all holes are less than 200m, the CX-5c inclinometer can be utilized to measure the whole deviation. It has been tested that the deviation is less than 2° per 100m, and the Azimuth Angle of finished hole is not beyond 1/4 of the exploration interval of distance, which meet the requirements (see Table 7-2).

Table 7-2 Hole Deviation

Hole No.	Hole Deviation			Remarks
	Depth (m)	Zenith Angle (°)	Azimuth Angle (°)	
ZK001	90	2°	146°	
ZK501	40	2°	261°	
ZK502	60	2°	146°	
ZK503	80.28	/	/	Failure in hole. End drilling, but met standards
ZK602	60	-2°	/	
ZK603	80	2°	261°	
ZK605	92	0°	/	
ZK1101	60	0°	/	
ZK1102	116	2°	166° /	
ZK1103	110	2°	/	
ZK1201	60	2°	261°	
ZK1202	35	2°	261°	
ZK1204	60	2°	146°	
ZK1701	26	0°	102°	
ZK1702	170	3°	311°	
ZK1703	64	/	/	Percussion Drill, end drilling for too much underground water and unsuited location in the office and living areas.
ZK1203	101	1°	201.7°	
ZK601	35	1°	201.7°	
ZK002	100	0.6°	130°	
ZK1206	100	1.1°	349.4°	
ZK301	120	1.2°	58.5°	
ZK504	146.85	2°	191.7°	
ZK003	150	2°	261°	
ZK1802	95	0.6°	130°	
ZK1801	100	1.1°	254.1°	
ZK1205	90	1°	200.7°	
ZK606	150	1.3°	112.9°	
ZK604	92	3.1°	51.1°	
ZK1803	150	/	/	Percussion Drill

(3) Depth Correction

After the depth correction, the depth deviation has been reduced to 0.00-0.05cm, which meets the requirements (≤0.1%). See Table 7-3.

Table 7-3 Depth correction

Hole No.	Depth Correction			Remarks
	Before Correction	After Correction	Deviation	
	(m)	(m)	(m)	
ZK001	95.95	95.93	-0.02	
ZK501	50.85	50.80	-0.05	
ZK502	67.74	67.74	0.00	
ZK503	80.28	80.28	0	Failure in hole. End drilling.
ZK602	60.94	60.94	0.00	
ZK603	83.68	83.68	0.00	
ZK605	101.38	101.38	0.00	
ZK1101	62.68	62.68	0.00	
ZK1102	119.67	119.67	0.00	
ZK1103	116.95	116.95	0.00	
ZK1201	60.68	60.68	0.00	
ZK1202	38.48	38.48	0.00	
ZK1204	68.68	68.64	0.00	
ZK1701	26.48	26.48	0.00	
ZK1702	173.78	173.78	0.00	
ZK1703	64.00	64.00	0.00	Underground water over the big end hole
ZK1203	107.95	107.95	0.00	
ZK601	36.28	36.28	0.00	
ZK002	104.98	104.98	0.00	
ZK1206	102.00	102.00	0.00	
ZK301	122.68	122.68	0.00	
ZK504	146.85	146.85	0.00	
ZK003	171.62	171.57	0.05	
ZK1802	95.71	95.71	0.00	
ZK1801	100.21	100.21	0.00	
ZK1205	101.73	101.75	0.00	
ZK606	159.03	159.03	0.00	
ZK604	92.88	92.88	0.00	
ZK1803	150.00	150.00	0.00	

(4) Hole Sealing

Although open-pit mining is designed for this survey area, ore sections of all drill holes are sealed with cement slurry (water-cement ration is 1:0.4). Other sections are filled with fine sand. Steel bars are set up as marks. Such process can meet the requirements.

(5) Basic Hydrological Observation

During the drilling process, accidents like leaking, collapsing, sloughing and act. are recorded. By the end, stable water level observation on each drill hole has been done. Such process has been done according to the requirements.

(6) Original Data and Summary

All original records of the drilling process and original data of other geologic surveys can meet the requirements.

All core samples have been handed over to Super Mayer Investment Ltd

In all, 29 holes have been drilled, with the maximum depth of 173.78m, and minimum of 38.48m, which all belong to shallow holes. Thus, the core recovery is considered to the most significant figure for the quality control. Combining all six criteria, all bole holes are considered to be qualified. The quality of the drilling process meets the requirements of this exploration.

7.2.2 Topographic Survey and Quality Control

GPS

(1) Since there is no previous data have been provided, this topographic survey therefor has introduced the free station positioning by GPS-RTK, then related date can be directly observed by the receivers as long as GPS-RTK satellite signals can be received. An independent coordinate system, which similar to the WGS-84 coordinate system, was utilized for this project. Then 3 first-order control points are established as initial points. To facilitate this survey project and provide coordinate references to the follow-up programs, 14 other second-order control points are established. 3 sets of Hi-Target V9 GNSS GPS-RTK are utilized as receivers for the field observation, while Hi-Target corresponding software is applied to adjust the differences of the field data.

a. Data Observation

The free station positioning is established using GPS-RTK. Then, 2 groups of data from each observing spot are obtained at different hours, 2 times in a group and at least 4 times in total. The data from each second-order are obtained at least twice.

Detail requirements see tables below:

Orders	Horizontal accuracy	Distance from the base station(km)	Observation Times
First-order	≤3cm between times (same group) ≤7cm between groups	≤5	2 times each, for 2 mobile stations
Second-order	≤5cm between times (same group)	≤7	2 times

Main technical requirements of horizontal survey by GPS-RTK

Orders	Vertical accuracy	Distance from the base station (km)	Observation Times
First-order	≤3cm between times (same group) Less than 4cm between groups	≤5	2 times each, for 2 mobile stations
Second-order	≤5cm between times (same group)	≤7	2 times

Main technical requirements of vertical survey by GPS-RTK

All data obtained meet the above accuracy requirements.

b. Accuracy Test

Total stations are introduced to measure the height difference and side length between two control points which could be seen directly from each other. The maximum error of the horizontal distance is 0.048m, while the maximum error of the height difference is 0.046m, which meet the requirements.

(2) Topographic Survey in Map Scale 1:2000

The topographic survey in map scale 1:2000 is completed by No.409 Geology Team of Bureau of Geology and Mineral Exploration and Development of Hunan Province, PRC, which starts from May 2011, and ends by July 2011. Such topographic sheet covers an area of 8.50Km^2.

Methods:

3 SET2110 total stations have been used for the field data collection, and the draft of the topographic sheet has been completed accordingly in field.

Requirements: The whole survey area is divided into different survey zones by roads, channels and other linear ground objects. Then the data collection is conducted in each zone. The draft is drawn based on the existence of ground objects, topographic elements and their features. Survey points have also been marked on the draft which must be consistent with the original records. All collected data are saved and secured in the laptop. Certain data have been frequently observed to accurately reflect all ground objects and topographic features.

Data processing: Using the CREAD RDMS software, field data are converted into a topographic map. Then, according to the draft drawn in field, the topographic map is edited. During the mapping process, all data have been saved and secured periodically. The methods of demonstrating ground objects and topographic features are strictly based on China's National Standards of 98's. All survey results have been checked and approved by qualified technicians. Accuracy requirements have been met.

7.2.3 Engineering Survey

GPS-RTK has been utilized to measure all the drill holes, end points of survey lines and significant engineering points. The control points established by us are taken as the initial points. There are 56 points surveyed, which include all the drill holes. The maximum error of the horizontal distance of end points is +0.289, while the minimum error is 0.012m. The maximum error of the height difference is 0.166m (See Annexed Table 1). Such results meet the requirements of "Specifications for iron, manganese and chromium mineral exploration" (DZ/T02000—2002).

7.2.4 Topographic Survey on the Sections of Exploration Lines

All the geological sections of exploration lines are perpendicular to the main strike of the ore bodies. The map scale is set up to 1:1000. The survey for such sections is undertaken by GPS-RTK. The end points of survey lines are identified, and cement columns are erected at the positions of end points. Control points buried by us are chosen to be the initial points for the survey. Each survey point on the geological section is no far than 2Km away from the base station. The maximum distance between nearby control points is 100m. The errors of heights, observing distances, horizontal distances, which are measured from each survey points and stations, must not exceed 0.001m.

To sum up, this survey has been completed based on the current technical standard. All data have been fully recorded with the right method. All data have been check twice and all calculations have been done by two technicians. Such results are trustworthy and can satisfy the needs of this exploration project.

7.2.5 Geological Survey on the Sections of Exploration Lines

All the geological sections of exploration lines are perpendicular to the main strike of the ore bodies. The map scale is set up to 1:1000. Topographic profiles along these sections and geological surveys on the sections are constructed at the same time. All formations are identified as the basic the litho stratigraphic units for this survey. In addition, based on the adjacent geological boundaries, which are exposed by the surface engineering method, stereographic projection is made to estimate the occurrence and location of ore bodies and intercalated layers. A survey including 15000m has been completed.

7.2.6 Geological mapping in 1:10000

This simple geological survey is undertaken in the western part of the mining area, which is mostly covered with overburden, in the map scale of 1:10000. For this survey, both tracing methods and observation in field are undertaken, using GIS GPS. The whole survey covers an area of 4km^2, involving 60 geological dots. The base map for the mapping program of this survey is the Topographic sheet in 1:5000. All geological dots are marked on the base map, and then, geological boundaries are identified accordingly. All geological dots are marked and assorted, according to the "People's Republic of Geology and Mineral Resources of solid mineral exploration industry standard geological record, the original provisions of (DZ / T 0078-93)". The density of geological dots is medium. The abovementioned method is accurate and reliable, which meet the geological survey standards.

7.2.7 Geological mapping in 1:5000

This simple geological survey is undertaken in the eastern part of the mining area with a long mining history, which is mostly covered by outcrops, in the map scale of 1:5000. Both traverse method and tracing method are utilized, but it mainly depends on traverse method. GIS hand-held GPS is used for this project. The whole survey covers an area of 4.6km^2, involving 377 geological dots. The base map for the mapping program of this survey is the Topographic sheet in 1:5000. All formations are identified as the basic the litho stratigraphic units for this mapping program. All geological dots are marked on the base map, and then, geological boundaries are identified accordingly. All geological dots are marked and assorted, according to the "People's Republic of Geology and Mineral Resources of solid mineral exploration industry standard geological record, the original provisions of (DZ / T 0078-93)". The abovementioned method is accurate and reliable, which meet the geological survey standards.

7.2.8 Sample Collection, Sample Analysis, and Rock Identification

1. Sample Collection

(1) Basic sampling

a. General Principles

Rock samples are obtained from both drill core and outcrop. Both stratified sampling and block sampling are utilized. During the sampling process for Iron and Manganese ore, the minimum exploitable thickness and the stable quality of the ore are recognized. Thus, extracted samples are cut into standard length which shall not exceed 1m, but few ones exceeding 1m are allowed. Intercalated layers which can be seen with bare eyes are sampled separately.

b. Sampling method

Samples of outcrops are extracted by trenching along the survey lines and the thickness direction of deposit, using trenching machine. Trenches (10 x 3cm) are digged and 105 trench samples are collected. During the trenching process, the trenching machine is cover by canvas to prevent sample loss. All samples are collected from fresh rocks, which meet the quality control requirements. Meanwhile, core samples are cut into two longitudinally. One set of samples is sent to the laboratory, while the other is kept for further uses. There are 564 core samples obtained. Specifications, namely Mn, TFe, SiO_2, S, P, are tested for these Iron and Manganese samples.

(2) Composite sampling

Composite samples are collected from two drill holes, ZK1801 and ZK1101. 46 composite samples are prepared. Elements Cu, Pb, Zn Ni and Co are analyzed, to investigate the contents of impurities in ore body (intercalated) layers.

Rock Samples, and samples for particle density test and rock mechanics experiments, are collected according to different layers and different types of ore. The sizes of samples and collecting methods are based on the requirements.

(3) Sample Preparation

Rock samples are crushed into 0.5cm particles, using jaw crusher, and then grinded into 0.1mm particles, using disc refiner. Based on the formula $Q=Kd^2$, when K equals to 0.1, the quantity of samples is ranging from 150g to 200g. The process of preparation is reliable.

2. Sample Testing and Evaluation

The chemical analysis of all samples is undertaken by the ALS Minerals - ALS Chemex (Guangzhou). This company is famous for its technical strength, honored with all necessary qualifications. This time the monitoring measures were taken for testing the standard samples, blank samples and repeat samples. The analysis components are Mn,TFe,SiO_2,S,P etc. five components.

Originally, the samples were tested by alkali fusion—quantitative measurement of Plasma Emission Spectrum and the test results show there is big deviation between standard samples and repeat samples. After exchanging of opinions by all parties of the contract, ALS Minerals had studied the testing methods and tested for several times, finally, had chosen a better method called acid fusion—quantitative measurement of Plasma Emission Spectrum to test the samples which Mn≥15% , and combined X-fluorecence spectrum and titrimetry for selective examination and monitoring. In general, the testing methods are correct for testing samples.

ALS Minerals repeat their tests on samples which show a large deviation, and come to a result that the deviation had been controlled well. The statistics show the absolute deviation of Mn content is usually within 1%, a small amount of samples are within 2%, and only one sample is beyond 2% but within 3%. After consulted with BDB engineers, with ALS Minerals applied the international quality control standards, the analysis results are basically meet the requirements. The results show the statistics can be used and has little impact on the estimation on amount of reserves.

(1) Testing of blank samples

There are 669 samples, including 36 blank samples, monitoring rate 5.38%, minimum value of Mn absolute deviation 0.01%, average value 0.05%, maximum value 0.12%, and the abovementioned statistics has met the international quality control of testing requirements asked by BDB.

(2) Testing of standard samples

There are 669 samples, including 36 standard samples, monitoring rate 5.38%, minimum value of Mn absolute deviation 0, average value 0.24%, maximum value 1.05%, minimum value of Mn relative deviation 0, average value 0.24%, maximum value 1.05%, minimum value of TFe absolute deviation 0, average value 2.84%, maximum value 0.51%, and minimum value of TFe relative deviation 0, average value 2.11%, maximum value 22.77%. The abovementioned statistics has met the international quality control of testing requirements asked by BDB.

(3) Testing of repeat samples

There are 669 samples, including 23 repeat samples, monitoring rate 3.43%, (among samples there was a possibility the two sets of samples of ZK1204,TC0011-H18 had put on wrong test numbers when making them, naturally there were excluded from all samples), minimum value of Mn absolute deviation 0.04%, average value 0.66%, maximum value 2.63%, minimum value of TFe absolute deviation 0, average value 0.64%, maximum value 2.17%, and minimum value of TFe relative deviation 0, average value 2.67%, maximum value 6.08%. The abovementioned statistics has met the international quality control of testing requirements asked by BDB.

3. Rock Samples

Rock samples are collected to study the chemical composition, structure, formation and nomenclature of ore, roof and floor rocks in the survey area. 9 Rock specimens, who can fully represent rock types in the mining area, are collected. Then the types of rocks are identified.

CHAPTER 8

Estimation of Resource Reserve

8.1 Industrial Index and Estimation Range of the Reserve Estimation

8.1.1 Industrial Index of the Reserve Estimation

Based on the commission contract, the general industrial requirements for iron manganese (iron) ore of the Geological Exploration Criterion of The Iron, Manganese and Chrome Deposits(DZ/T0200-2002)were adopted for estimating resources and reserves. Quality requirements see Table8-1, 8-2.

Table 8-1 Industrial Index of Iron-Manganese Ore

Natural Types	Industrial Classification	Grade	ω(Mn)％		ω(Mn+Fe) ％	ω(Mn)/ ω(Fe)	Allowed phosphor content % of every 1% manganese	$\omega(SiO_2)$ %
			Boundary Grade	Average Grade of Single Project				
Manganese oxide ore	Iron-manganese ore	I			≥50		≤0.2	≤25
		II			≥40		≤0.2	≤25
		III	10	15	≥30		≤0.2	≤25

Mining technical conditions:

Minimum mining thickness of ore: 0.50 m;

Admissible maximum thickness of interlayer barren: 0.20m.

Table 8-2 Industrial Index of Iron Ore

Ore Types	ω(TFe)	
	Boundary Grade	Industrial Grade
Hematite	≥25	≥30

Note：ω(TFe) means Omaga, content of TFe in percentage

Mining technical conditions:

Ore minimum mining thickness: 2m, the thickness of few ore body is less than 2m. Since the iron ore body is connected to Iron and Manganese ore are mined together, is also considered to be the ore body.

Admissible maximum thickness of interlayer barren: 2 meters .

8.1.2 Range of Reserves Estimation

Range of reserve estimation: range of exploration in mining area (see table 1-1)

8.2 Determination of Method for Reserves Estimate

This exploration project of the mining area is evenly distributed, and its layer is banded output. The orientation is flat, smooth and stable, the continuity of the ore body is good, and grade variety is well distributed. The geological block method of horizontal projection is applied for reserve estimation.

The formula:

$Qore=(S \div Cos\alpha) \times M \times D$.

Where:

Q-Ore reserves (ten thousand tons);

S-Projected area;

α- Average dip angle of block (°);
M—Average thickness of block(m);
D—Volumetric weigh of Ore(t/m^3)。

8.3 Determination of Main Parameters for Reserves Estimate

8.3.1 Determination of block area

The mapping software MapGis is used to calculate the projected area of each block. The arithmetic mean of three calculated projected area values is used and then the oblique area is obtained by using the average dip angle of the block.

Note: MapGis is a mapping software which developed by a Chinese software company—Zondy

Cyber. MapGis is the new generation of GIS basic software platform with network-oriented and super large distributed architecture. MapGIS has integrated more than 20 years' functional resources which were accumulated by Zondy Cyber, experts and our customers in various fields when implementing GIS solutions. The integration of 2D-3D in Dynamic Management and seamless integration of GIS and MapGIS-RSP makes MapGIS K9 as an integrated development platform of GIS, RS, and GNSS. For more information, please visit its website at http://www.mapgis.com.cn/EN/index.aspx

8.3.2 Determination of the average block thickness

True thickness of ore body may be calculated by using the formula below:

$$L_{true\ thickness} = l \cdot \cos(\beta - \alpha)$$

$$L_{true\ thickness} = l \cdot \cos\ (\beta - \alpha)$$

Where, $L_{true\ thickness}$—the true thickness of the ore body in the section along the prospecting line;

l—The thickness of the drill hole penetrating the ore (m);

α—The zenith angle of the drill hole cut throughing the ore body;

β—The dip angle of the ore body;

Since the drilling work needs to penetrate the ore body, which has a small deviation from the section, it has a little effect on the calculation of the true thickness of the ore body in the section and therefore, for the calculation of the true thickness, the oblique angle between azimuth angle when drilling though the ore body and the section azimuth is not considered in the calculation of true thickness. The arithmetic average method is used to estimate the average thickness of the block.

8.3.3 Determination of ore density

In this work, 102 small density samples have been collected, including 75 Iron and Manganese ore samples and 27 iron ore samples. Refer to the table for the results. The samples have a low humidity, which can be dismissed. Since the ore cracks are uneven and there are different types of ore shapes, e.g. patchy, banded and blocky, analysis of the samples revealed that the weight of Fe-Mn (iron) ore is in non-linear correlation with the grade (Figure 8-1, Figure 8-2, Figure 8-3). Therefore, the arithmetic average method is adopted. The Fe-Mn ore has a body density D of $4.23t/m^3$ and the iron ore has a body density D of $4.21t/m^3$. Refer to Fig. 13.

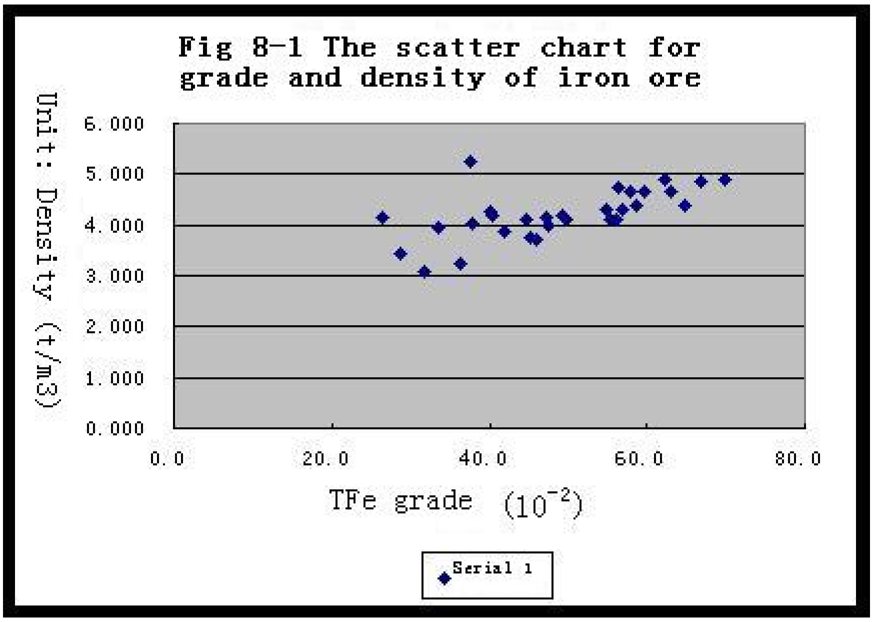


Fig 8-1 The scatter chart for grade and density of iron ore

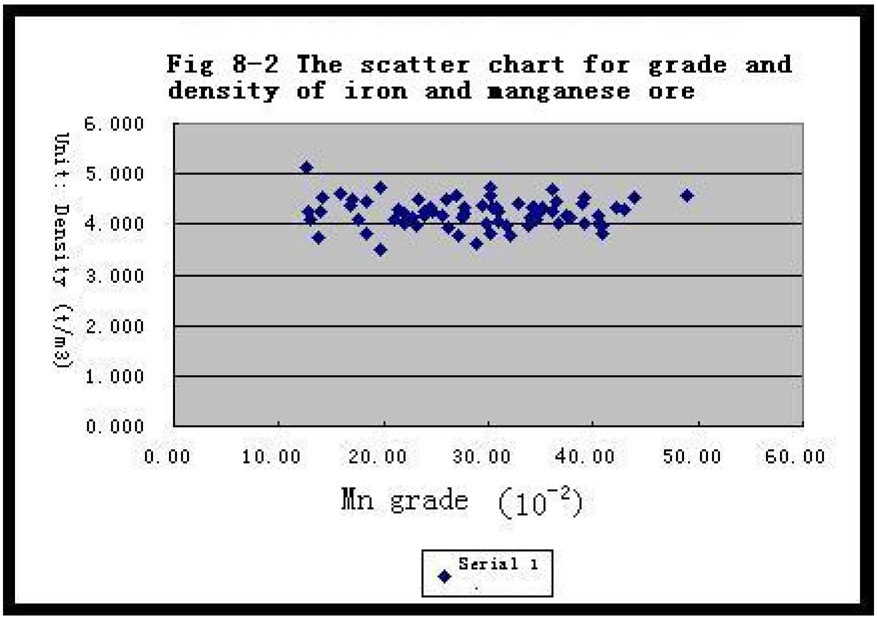
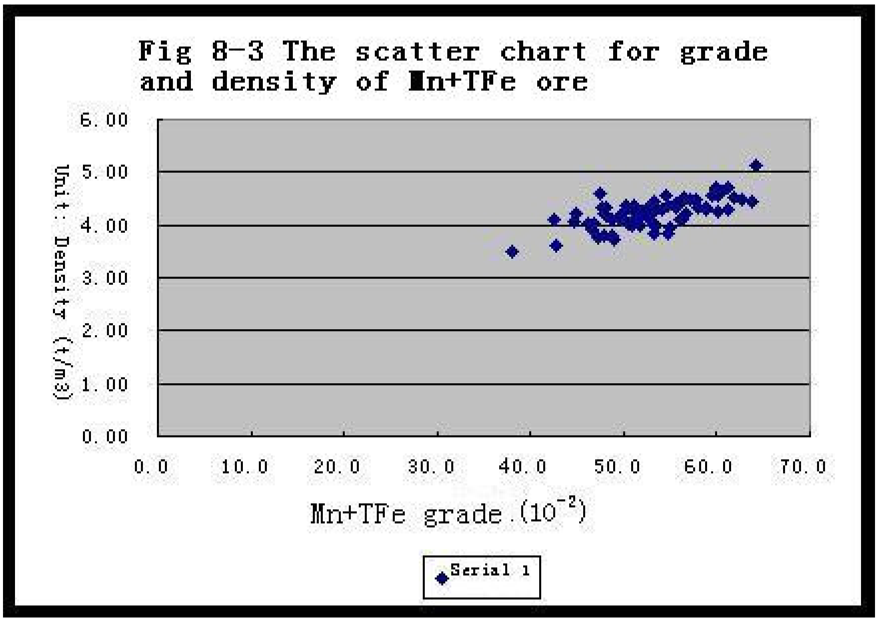


Fig 8-2 The scatter chart for grade and density of iron and manganese ore



8.3.4 Average grade

Iron and Manganese (iron) deposit may not be subject to estimation of metal amount and the ore body grade shall act as the basis for ore body delineation.

Average grade of single project engineering: The single project (drilling, trenching) method is adopted. The individual sample grade of the ore bed is obtained using the weighted mean thickness.

Average grade of a block: Refers to the weighted mean thickness of relevant single project of block.

Average grade of the ore bed: Refers to the average grade of a block obtained using the weighted mean volume.

Average grade of deposit: Refers to the average grade of each ore bed, as obtained using the weighted average total volume.

8.4 Ore body Delineation Principles

8.4.1 Ore body delineation principle

In single project engineering, samples with the grade greater than or equal to the cut-off grade will be included in the ore body. In general, straight lines are used to connect the ore body shape. The thickness of the ore body between two project engineering's is not greater than the maximum thickness of the ore body of adjacent project engineering under actual control.

If the continuous cumulative thickness of samples with the grade inferior to the cut-off grade is greater than the band rejected thickness, the band should be delineated and those less than the band rejected thickness should be incorporated into the ore body, but it should be ensured that the grade is not lower than the cut-off grade.

8.4.2 Industrial ore body delineation principle

On the basis of the ore body delineation for single project engineering, separated ore body comes into being when the boundary points of adjacent works are connected in the plans and profile maps in accordance with the industrial indexes and mineralization principles. In the connection of ore bodies, the inferred ore body thickness between works should not be greater than the maximum thickness under engineering control and the engineering extrapolated ore body thickness should be less than the thickness under engineering control.

8.4.3 Band delimitation and extrapolation principles

According to the industrial index requirements, if the interbred thickness is greater than or equal to the interbred rejected thickness, it should be rejected and if it is less than the rejected thickness, it should be considered in the calculation of the average grade of single project engineering. After that, the ore body average grade should not be less than the required boundary grade.

The principle of extrapolation of interbred should accord with the extrapolation principle of ore body.

8.4.4 Delineation of ore body in geologic profile map and plan

If corresponding ore bodies are discovered in two adjacent works, the corresponding basis point of them should be connected, which should therefore be the ore body boundary line.

<u>Ore body extrapolation principles</u>:

If ore are discovered in any works but not in the adjacent works, generally the extrapolation should be such that it is made from the works where ore are discovered to the adjacent works along ore body strike and tendency for 1/2 exploration engineering spacing as the ore body boundaries and for 1/4 as the resources boundary (works along the strike for 150m, works along the directing of dip for 75m). However, under special circumstances, the ore body should be connected according to mineralization principle and extrapolated distance should be less than the distance of the former.

If, along the strike and tendency of the works where ore are discovered, no works control exists, the extrapolation should be such that it is made outwards from the boundary works where ore are discovered along the ore body strike and tendency for 1/2 exploration engineering spacing as the ore body boundaries and for 1/4 as the resources boundary.

8.5 Classification of Reserves and Block Division Principles

8.5.1 Classification of Reserves

This deposit is a metamorphosed sedimentary ferromanganese (iron) deposit. It is of an oversized deposit scale, with the main ore bed layered and stratiform. With simple geological structure, the ore bed is stable and performs well in continuity. For this survey, only a scoping study is made. Therefore, the estimated amount of resources is of intrinsic economic resources. *According to the Code for Geological Prospecting of Iron, Manganese and Chromium* (DZ/T02000-2002) and the *Classification of Solid Mineral Resources/Reserves* (GB/T17766-1999) as well as the geological features of the deposits, the exploration type of this deposit is classified into the type I fairly complex type.

Through foregoing work done, the stratum, structure and deposit geological characteristics within the work area have been basically identified. In accordance with the exploration type I and relevant regulatory requirements, for the specified estimation range of reserves, the drilling control is made at the spacing of 600m × 300m and according to the actual geological conditions of the mining area, surface engineering is arranged.

A systematic sampling is made, ensuring that the control depth and study extent of ore body, intermediate layer and overlay meet the conditions of the reserves and that the goal of basic identification extent is achieved.

According to the type of survey, it is determined that the 600m × 300m grid exploring mode be employed for the control of the intrinsic economic resources amount (332). According to the extrapolated amount of resources, it is of the inferred intrinsic economic resources (333). In this survey, for the finally determined exploration engineering spacing, (UNFC Code 332) is 600m × 300m, which meets regulatory requirements.

8.5.2 Block division principles

According to the ore bed occurrence and engineering control degree, blocks are estimated basing upon ore beds and comprising adjacent exploration works. From the top of ore body to the bottom and left to right, the blocks are number. According to the above principles, for each ore bed, there are 6 blocks of UNFC Code 332 and 7 blocks of UNFC Code 333. For Iron and Manganese ore bed I, there are 22 blocks of UNFC Code 332 and 13 blocks of UNFC Code 333. For Iron and Manganese ore bed II, there are 7 blocks of UNFC Code 332, and 11 blocks of UNFC Code 333. The whole mining area is divided into 66 blocks including 35 UNFC Code 332 blocks and 31 UNFC Code 333 blocks.

8.6 The Estimation Results of Reserves

Through resources reserve estimation, within the mining area there are 135.578 million tons of Iron and Manganese ore + iron ore resources UNFC Code 332 +333, including 96.602 million tons of UNFC Code 332 ore and 38.976 million tons of UNFC Code 333 ore. For iron manganese + iron ore, there are 97.39 million tons of UNFC Code 332 ore, accounting for 71% of the total reserves. The deposit stripping ratio is 5.83:1. Refer to Table 8-3 and Table 8-4 for details.

For iron ore resources, there are 17.623 million tons of UNFC Code 332 + UNFC Code 333 ore: the Mn grade is 3.80% and the TFe grade is 42.04%. The UNFC Code 332 ore have 9.765 million tons: the Mn grade is 3.82% and TFe grade is 42.74%. The UNFC Code 333 ore have 7.858 million tons: the Mn grade is 3.78% and the TFe grade is 41.16%.

For Iron and Manganese ore resources, there are 117.955 million tons of UNFC Code 332 + UNFC Code 333: the Mn grade is 25.85%, the TFe grade is 25.39%, and the Mn + TFe grade is 51.24%. There are 86.837 million tons of UNFC Code 332 reserves: the Mn grade is 29.50%, the TFe grade is 25.34% and the Mn + TFe grade is 51.24%. There are 31.119 million tons of UNFC Code 333 ore: the Mn grade is 25.70%, the TFe grade is 25.53% and the Mn + TFe grade is 51.23%.

For Iron and Manganese ore bed I resources, there are 94.04 million tons of UNFC Code 332 + UNFC Code 333: the Mn grade is 25.89%, the TFe grade is 25.29%, and the Mn + TFe grade is 51.18%. There are 72.757 million tons of UNFC Code 332 reserves: the Mn grade is 26.07%, the TFe grade is 25.15% and the Mn + TFe grade is 51.22%. There are 21.283 million tons of UNFC Code 333 ore: the Mn grade is 25.28%, the TFe grade is 25.77% and the Mn + TFe grade is 51.05%.

For Iron and Manganese ore bed II resources, there are 23.915 million tons of UNFC Code 332 + UNFC Code 333 ore: the Mn grade is 25.65%, the TFe grade is 25.86%, and the Mn + TFe grade is 51.51%. There are 14.08 million tons of UNFC Code 332 reserves: the Mn grade is 24.84%, the TFe grade is 26.56% and the Mn + TFe grade is 51.40%. There are 9.835 million tons of UNFC Code 333 ore: the Mn grade is 26.62%, the TFe grade is 25.01% and the Mn + TFe grade is 51.63%.

Table 8-3 Reserves Estimation

Ore Body No.	Code No.	Block No.	Projected area(m^2)	Avg. dip angle(°)	Slope aea(m^2)	Avg. thickness(m)	Volume(m^3)	Density(t/m^3)	Avg. grade (%)		Amount	Remarks
									Mn	TFe	(10,000t)	
1	333	1-1	89200	11	90870	4.68	425269	4.21	2.92	40.46	179	
	333	1-2	150649	14	155261	3.25	504598	4.21	3.41	38.85	212.4	
	333	1-3	39900	17	41723	2.92	121831	4.21	3.74	45	51.3	
	332	1-4	141050	16	146734	1.79	262654	4.21	3.89	44.73	110.6	
	332	1-5	160025	13	164234	2.74	450002	4.21	2.72	44.69	189.5	
	332	1-6	137175	16	142703	4.47	637883	4.21	3.38	39.72	268.5	
	332	1-7	62225	13	63862	3	191585	4.21	4.27	34.36	80.7	
	333	1-8	23000	14	23704	1.21	28682	4.21	4.57	42.13	12.1	
	333	1-9	38650	17	40416	5.75	232392	4.21	4.97	48.39	97.8	
	332	1-10	160050	14	164950	3.53	582272	4.21	4.84	47.38	245.1	
	332	1-11	82250	12	84088	2.32	195083	4.21	4.26	39.84	82.1	
	333	1-12	74425	16	77424	2.23	172656	4.21	3.39	36.24	72.7	
	333	1-13	86350	13	88621	4.3	381072	4.21	4.64	41.54	160.4	
I	333	I-1	58675	15	60745	11.75	713752	4.23	24.77	28.57	301.9	
	333	I-2	31125	25	34343	10.59	363692	4.23	25.18	25.91	153.8	
	332	I-3	131850	14	135886	12.12	1646943	4.23	26.40	25.46	696.7	
	332	I-4	83575	14	86134	9.65	831189	4.23	27.35	24.77	351.6	
	332	I-5	83200	8	84018	7.29	612489	4.23	24.28	22.60	259.1	
	333	I-6	38600	17	40364	10.87	438753	4.23	25.71	23.52	185.6	
	332	I-7	166100	16	172794	5.67	979740	4.23	24.86	19.92	414.4	
	333	I-8	18725	46	26956	3.55	95693	4.23	24.71	20.96	40.5	
	333	I-9	34375	22	37075	8.82	327002	4.23	25.15	21.51	174.5	
	332	I-10	108100	20	115038	10.45	1202143	4.23	27.34	22.79	508.5	
	332	I-11	160225	14	165130	7.65	1263245	4.23	29.71	23.89	534.4	
	332	I-12	156700	10	159117	4.89	778084	4.23	24.57	26.56	329.1	
	332	I-13	65150	13	66864	10.14	677998	4.23	26.03	22.01	286.8	
	332	I-14	101325	15	104899	8.54	895841	4.23	28.23	18.18	378.9	

Table 8-3 Reserves Estimation (continued)

Ore body No.	Code No.	Block No.	Projected area(m^2)	Avg. dip angle (°)	Slope area(m^2)	Avg. thickness(m)	Volume (m^3)	Density (t/m^3)	Avg. grade (%)		Amount	Remarks
									Mn	TFe	(10,000t)	
I	333	I-15	37325	40	48724	5.55	270420	4.23	30.54	17.77	114.4	
	333	I-16	45175	17	47239	10.1	477115	4.23	26.03	25.23	201.8	
	332	I-17	140600	17	147024	7.78	1143849	4.23	26.49	24.15	483.8	
	332	I-18	159250	13	163439	5.46	892377	4.23	26.76	26.62	377.5	
	332	I-19	137375	16	142911	4.98	711697	4.23	24.11	33.15	301	
	332	I-20	65375	17	68362	8.77	599536	4.23	27.20	23.89	253.6	
	332	I-21	47750	17	49932	9.21	459872	4.23	30.41	18.94	194.5	
	333	I-22	37500	18	39430	5.17	203852	4.23	30.84	20.84	86.2	
I	333	I-23	46625	18	49024	7.7	377488	4.23	25.34	28.90	159.7	
	332	I-24	160700	15	166369	5.01	833508	4.23	26.09	26.32	352.6	
	332	I-25	172075	12	175919	3.99	701918	4.23	24.94	28.07	296.9	
	332	I-26	144900	15	150012	4.44	666051	4.23	21.16	32.24	281.7	
	333	I-27	52375	16	54486	1.98	107882	4.23	18.55	40.09	45.6	
	332	I-28	158255	14	163100	2.54	414273	4.23	21.19	32.72	175.2	
	332	I-29	145020	9	146828	4.25	624311	4.23	26.78	28.03	264.1	
	332	I-30	81725	12	83551	5.57	465378	4.23	23.97	28.34	196.9	
	333	I-31	112350	18	118132	6	708791	4.23	24.28	28.85	299.8	
	333	I-32	58350	18	61353	7.04	431924	4.23	22.81	24.68	182.7	
	332	I-33	52929	17	553477	5.34	295555	4.23	22.35	26.74	125	
	332	I-34	68815	13	70625	7.14	504263	4.23	24.40	27.60	213.3	
	333	I-35	29200	22	31493	9.74	306744	4.23	24.94	26.20	129.8	
II	333	II-1	69100	32	81481	5.39	439184	4.23	33.25	15.56	185.8	
	333	II-2	13300	16	13836	1.51	20892	4.23	19.79	20.19	8.8	
	333	II-3	10950	11	11155	4.07	45401	4.23	36.55	21.34	19.2	
	333	II-4	76775	18	80726	4.88	393943	4.23	21.41	28.38	166.6	
	333	II-5	33975	13	34869	5.34	186199	4.23	25.34	28.11	78.8	
	332	II-6	64025	16	66605	5.68	378317	4.23	28.77	23.60	160.0	

Table 8-3 Reserves Estimation (continued)

Ore body No.	Code No.	Block No.	Projected area(m^2)	Avg. dip angel(°)	Slope area (m^2)	Avg. thickness(m)	Volume (m^3)	Density (t/m^3)	Avg. grade (%)		Amount (10,000t)	Remarks
									Mn	TFe		
II	333	II -7	43425	15	44957	5.22	234675	4.23	35.38	18.09	99.3	
	333	II -8	40575	18	42663	5.35	228247	4.23	23.08	29.03	96.5	
	332	II -9	80525	16	83770	4.91	411311	4.23	23.10	28.23	174	
	333	II -10	67675	15	70062	5.94	416170	4.23	21.32	29.61	176.0	
	332	II -11	152450	15	157828	4.35	686551	4.23	26.06	24.66	290.4	
	332	II -12	80775	14	83248	6.78	564420	4.23	29.38	24.41	238.7	
	333	II -13	45000	16	46813	1.62	75838	4.23	25.35	26.49	32.1	
	332	II -14	137920	14	142142	1.42	201842	4.23	22.60	25.75	85.4	
	332	II -15	167065	9	169147	2.96	500677	4.23	26.97	28.07	211.8	
	332	II -16	82350	11	83891	6.98	585561	4.23	20.62	28.70	247.7	
	333	II -17	8150	18	8569	9.26	79353	4.23	27.06	28.91	33.6	
	333	II -18	72575	15	75135	2.73	205119	4.23	27.06	29.32	86.8	

Table 8-4 **Estimation results of Lomoteng mining area** **Unit: 10,000 t**

Ore bed No.	Code No.	Amount	Grade (%)			Mn/TFe	Remarks
			Mn	TFe	Mn+TFe		
1	332	976.5	3.82	42.74			1.total stripping ratio of ore deposit is 5.83:1
	333	785.8	3.78	41.16			2. Code 333 reserves accounts for 71% of total reserves amount
	332+333	1762.3	3.8	42.04			
I	332	7275.7	26.07	25.15	51.22	1.04	
	333	2128.3	25.28	25.77	51.05	0.98	
	332+333	9404	25.89	25.29	51.18	1.02	
II	332	1408	24.84	26.56	51.40	0.94	
	333	983.5	26.62	25.01	51.63	1.06	
	332+333	2391.5	25.65	25.86	51.51	0.99	
I+II	332	8683.7	25.9	25.34	51.24	1.02	
	333	3111.8	25.7	25.53	51.23	1.01	
	332+333	11795.5	25.85	25.39	51.24	1.02	
Total	332	9660.2	The grade of total reserves amount has not calculated for iron and Iron and Manganese ore are two different types of ore.				
	333	3897.6					
	332+333	13557.8					

8.7 Issues of reserves estimation

If the sampling rate of certain holes like ZK1201 and ZK604 is low, when judged in combination with drilling rock core, it should be categorized as floor of country rocks or slate interbeds.

1 If the minimum mining thickness of iron ore is 2m but the thickness in certain place of the ore body is less than 2m, and the iron ore body is connected with the ferromanganese ore, they may be mined together and should also be considered as ore body.

2 Pursuant to provisions of the contract, in this estimation only the UNFC Code 332 and UNFC Code 333 resources are estimated while the UNFC Code 334 is not included. As the Iron ore bed 2, 3 and Iron and Manganese ore bed II are in discontinued distribution and occur sporadically, they should be categorized into the UNFC Code 334 resources and thus are not estimated.

3 As iron ore and Iron and Manganese ore are in non-positive correlation in terms of ore grade and the weight, the arithmetic mean method is employed for the ore body weight.

4 As iron ores and iron and manganese ores are in non-positive correlation in terms of ore grade and the weight, the arithmetic mean method is employed for the ore body weight.

8.8 Stripping Volume Estimation

8.8.1 Estimation for the Stripping Volume of Overburden

The stripping volume of overburden refers to the Quaternary overlays and other overlays like the slate, metamorphic feldspar and quartz sandstone and quartzite. The volume is calculated using the average thickness and the distribution area. According to the orientation of ore bed, the physical properties of ore and mining methods, the slope is determined as 55°.

(1) Average overburden thickness: it is determined using the arithmetic average method through the actual control thickness of drilling and trenching.

(2) The distribution area: the mapping software MapGis is employed and it is directly measured from the stripping volume of overburden plane drawing at the scale of 1:5000.

(3) The western external stripping amount along the dip slope line: in principle, it should be carried out in the sectional line and at the lowest position of the ore bed with 55° slope angle, and the crossing point at the surface should be the Stripping Volume of Overburden slope point. The folded line come into being as the ground surface slope points of the exploration lines are correspondingly connected should as the as the slope line for the estimation of western stripping volume of overburden.

(4) The slope line of the stripping volume of overburden at the north and south along the trend: In principle, it should be carried out in the sectional line and at the lowest position of the ore bed with 55° slope angle, and the crossing point at the surface should be the slope point of the stripping volume of overburden.

(5) The stripping volume: the product of slope area multiplied by the average thickness.

8.8.2 The Stripping Volume of Tailings

Within the estimated range of reserves and in accordance with the ore body delineation principle, it refers to the total amount of all slate or silty slate tailings ore beds.

(1) The interbred area: it should be determined using the method for determining the resource reserves.

(2) The stripping volume: When the adjacent section interbeds are interconnected and compared, and are corresponded to each other, it is determined using the method for reserves estimation. If adjacent section interbeds cannot be connected to each other or compared, and are not corresponded to each other, the intermediate layer should be inferred using the natural distinguishing method along the tendency or 1/2 engineering spacing, and the delineated interbred area and speculated strike length should be used for the calculation.

8.8.3 Estimation results of stripping volume

As calculated, the total stripping volume of overburden and the stripping volume of tailings is 187,071,665m^3, including 183025174m^3 the stripping volume of overburden, and 4,046,491m^3 stripping volume of tailings. The total volume of ore bed of ore deposit is 32071345m^3 and the deposit stripping ratio is 5.83:1. (see Anaxed map 16, Table 8-5 and Table 8-6).

Table 8-5 Table on Stripping Volume of Overburden of Ore bed

Block No.	Projected area(m^2)	Avg. dip angle(°)	Slope area (m^2)	Avg. thickness(m)	Volume (m^3)
1	58675	15	60745	72.25	4388814
Slope 1	14313	15	14818	36.13	535371
2	41625	25	45928	72.25	3318306
Slope 2	44520	25	49122	36.13	1774792
3	131850	14	135886	64.78	8802721
4	83575	14	86134	49.67	4278253
5	83200	8	84018	27.46	2307125
6	38600	17	40364	35.08	1415959
7	166100	16	172794	5.70	984924
8	18725	46	26956	11.50	309991
9	43375	22	46781	97.21	4547624
Slope 3	59500	22	64173	48.61	3119441
10	108100	20	115038	76.70	8823385
11	160225	14	165130	50.85	8396864
12	156700	10	159117	34.31	5459316
13	65150	13	66864	20.89	1396783
14	101325	15	104899	11.24	1179069
15	37325	40	48724	11.51	560817
16	45175	17	47239	127.92	6042829
Slope 4	63315	17	66208	63.96	4234662
17	140600	17	147024	98.35	14459836
18	159250	13	163439	64.80	10590843
19	137375	16	142911	40.89	5843636
20	65375	17	68362	19.46	1330326
21	47750	17	49932	5.88	293599
22	37500	18	39430	0.60	23658
23	46625	18	49024	117.08	5739780
Slope 5	57020	18	59954	58.54	3509729
24	160700	15	166369	88.94	14796848
25	172075	12	175919	88.94	15646259
26	144900	15	150012	25.66	3849296
27	52375	16	54486	97.15	5293284
Slope 6	39015	16	40587	48.58	1971730
28	158255	14	163100	70.39	11480592
29	145020	9	146828	37.62	5523658
30	81725	12	83551	21.39	1787151
31	112350	18	118132	9.82	1160054
32	52400	18	55097	45.76	2521221
Slope 7	21728	18	22846	22.88	522720
33	52929	17	55347	42.35	2343963
34	68815	13	70625	21.03	1485246
35	29525	22	31844	13.79	434288
Total					183025174

Table 8-6 Table on the Stripping Volume of Tailings of ore bed

Block No.	Projected area(m^2)	Avg. dip angle(°)	Slope area(m^2)	Avg. thickness(m)	Volume (m^3)
(4)	83575	14	86134	0.18	15504
(5)	83200	8	84018	0.53	44529
(7)	166100	16	172794	0.75	129595
(8)	18725	46	26956	0.82	22104
(9)	43375	22	46781	1.00	46781
(10)	108100	20	115038	0.38	43714
(11)	160225	14	165130	0.70	115591
(12)	156700	10	159117	1.31	208444
(13)	65150	13	66864	0.99	66195
(14)	101325	15	104899	0.94	98605
(16)	45175	17	47239	1.47	69442
(17)	140600	17	147024	0.74	108798
(18)	159250	13	163439	1.54	251696
(19)	137375	16	142911	2.04	291539
(20)	65375	17	68362	0.38	25978
(23)	46625	18	49024	2.71	132856
(24)	160700	15	166369	2.20	366012
(25)	172075	12	175919	1.85	325451
(26)	144900	15	150012	1.91	286522
(27)	52375	16	54486	3.60	196148
(28)	158255	14	163100	2.65	432214
(29)	145020	9	146828	1.44	211432
(30)	81725	12	83551	1.42	118642
(31)	112350	18	118132	1.48	174835
(32)	52400	18	55097	1.86	102480
(33)	52929	17	55347	1.45	80254
(34)	68815	13	70625	0.77	504263
(35)	29525	22	31844	0.84	26749
					4046491

CHAPTER 9

Economic significance of the Lomoteng Mine

9.1 Situation Analysis for Manganese Resources

Manganese (iron) ore is an important mineral resource for the modern industry. Manganese (iron) ore and related products have been broadly used in all sectors of the national economy. The steel industry heavily depends on manganese alloys as deoxidizer and desulfurizer, which takes up 90 to 95% of manganese usage. The rest 10 to 5% are utilized in other industrial sectors, such as chemistry industry (like manganese salt), light industry (like batteries, matches, paints, soaps and act.), building material industry(like colorants and deodorants for manufacturing glasses and ceramics), national defense industry, electronics industry, environment protection industry, farming and animal husbandry, etc.. Overall, manganese (iron) ore has been taking a significantly important strategic position in the national economy.

China is rich in manganese resources, however, its high-grade manganese resources are scarce which merely accounts for 6.4% of recoverable deposits in China. Manganese deposits can be characterized as "lean, thin, impure, and fine". "Lean" means that the grade of manganese is comparatively low. The average grade of manganese deposits in China is merely around 22%. "Thin" underlines the thinness of the manganese deposit, which is only between 1-1.5m. "Impure" shows the high content of phosphorus and sulfur impurities. Most of manganese carbonate ore in China has a high content of phosphorus, which cannot be used to produce manganese alloys. "Fine" that manganese mineral are considerably fine in dissemination size. For instance, the general dissemination size of manganese carbonate ore in China is around 10-40u, so that they can hardly be concentrated by the mechanical processing. Due to the fact that the manganese ore production in China cannot be largely increased, the supply cannot meet the demand. Hence, China has to increasingly import manganese ore to satisfy the demand of metallurgical industries.

In addition, iron deposits in China are normally developed in groups and belts. Although geographically concentrated, they are considerably lean. It has been estimated that there are only 1.48 billion tons of high-grade iron ore, which merely account for 2.8% of proved reserves in China, could be smelted directly. Within these high-grade ore, only 1.24 billion tons are recoverable, which account for 2.47% of recoverable deposits of iron ore in China.

The PIN2 section of the Lomoteng Mine is abundant in Iron and Manganese ore, which is suitable for open-pit mining. Such ore is comparatively in good quality with low contents of SiO_2, phosphorus, sulfur and other impurities. This area has convenient road network and sufficient power resources, which has advantages to undertake large-scale mining.

9.2 Market Prospect for Manganese-iron Ore

Due to the current situation on manganese (iron) ore deposits, Chinese manufacturers have to heavily depend on imports. It is also predictable that the imports will be increasing, since the Chinese steel industry has been under rapid development, and the growing demand for raw materials can hardly be satisfied by local production. Although the demand has been affected by the last GFC, this demand still exceeds the supply.

Manganese is a metal with important industrial metal alloy uses, particularly in steel production. Above 90% of world's manganese ore are used in steel industry. The booming Chinese steel industry requires a growing amount of manganese ore every year. Meanwhile, the world's iron ore production is about 1.8 billion tons, and it remains growing due to the increasing demand, especially from the Chinese steel industry. Since the Chinese iron ore resource is limited, the import of iron ore in China is expanding which results in the continuously rising prices of the worlds' iron ore. Under the encouragement of the Chinese government, more Chinese companies intend to explore mineral resources abroad to meet the needs of home market. This manganese deposit in South Africa can be characterized by large-scale reserves and high grades. Thus, this project has a very promising market potential.

9.3 Water supply, Power Supply and Transportation

9.3.1 Water supply

This is an open-pit mining project, which requires small water usage. In the mining area, surface water is rare, but there is a ground-water well in the south of the mining area, which is sufficient for the mining demands and living supplies.

9.3.2 Power supply

The power supply in South Africa is adequate. Referring to the Lomoteng mining area, it has equipped with transformers and other power supply equipments, which can support mining and living needs.

9.3.3 Transportation

The Lomoteng mining area is around 50Km away from Postmasburg. Its eastern area is accessible by an international railway from Hotazel to Lesotho. Meanwhile, another international highway runs through its northern margin, connecting Gaborone, the capital of Botswana, to Namibia. There are other roads and tracks which extends to villages, providing very good accesses to the mining area.

9.4 Production Capacity, Mine Life and Product Plan

9.4.1 Production capacity

According to the feasibility study report on Lomoteng manganese mining project, the product capacity of the Lomoteng mine is expected to be 1 million tons per annum, which shall be considered as middle-scale mining.

9.4.2 Mine life

It has been proven that there are 135.578 million tons of high-iron manganese ore and iron ore resources in the PIN2 section of the Lomoteng mining area. If assume the mining recovery rate is 95% and the annual production is 1 million tons, then the mining life is expected to be 128 years.

9.4.3 Product plan

Products are Iron and Manganese ore and iron ore.

9.5 Development plan for Lomoteng mine

The main layer of the deposit extends along the same direction, which is around 3600m long and 10.65m thick. The stripping ratio is calculated to be 5.79:1. The first phase of Iron and Manganese ore outcrops on the top of the hill, or the hillside. It occurs along the dip direction and its length extends between 0-880m, with an average of 200m. The thickness of its overburden is between 0-87.06m, with an average of 40.15m. It suggests that the mine is suitable for large-scale open-pit mining.

Then, a bench mining method shall be applied which will require haul roads and conveying belts. Dumps need to be well managed to minimize degradation, and the following rehabilitation shall be preceded properly without interrupting the mining progress. The second phase of Iron and Manganese ore outcrops in the area covered by Quaternary fine silt deposits. It occurs along the dip direction and its length extends between 270-1115m, with an average of 650m. The thickness of its overburden is between 42.36-155m, with an average of 94.95m. Both open-pit mining and pit mining can be considered.

9.6 Techno-economic Assessment and Potential Economy Benefits

9.6.1 Main Technological and Economic Indicators

It's been calculated that there are 135.578 million tons of Iron and Manganese ore and iron ore resources (UNCF Code 332+333). Refer to iron ore resources, there are 17.623 million tons in total. These resources include 9.765 million tons of indicated mineral resource (UNFC Code 332), which contain an average of TFe 42.74%. These ore are expected to be sold at RMB 128 per ton in China as projected in the "Investment Feasibility Report of Lomoteng Iron and Manganese Mine".

In the meantime, consider Iron and Manganese ore resources, there are 117.955 million tons in total (UNFC Code 332+333). These resources include 86.837million tons of indicated mineral resource (UNFC Code 332), which averagely contain Mn25.90%, Mn+TFe51.24%, the mining recovery rate is 95%. These are expected to be sold at RMB 830 per ton in China as projected in the "Investment Feasibility Report of Lomoteng Iron and Manganese Mine".

9.6.2 Potential Economy Benefits

Assuming the recovery rate is 95%,, only indicated mineral resources (UNCF Code 332) of both iron- manganese ore and iron ore are estimated as below:

$$9.765\text{mt}\times95\%\times120\text{RMB/t}+86.837\text{mt}\times95\%\times830\text{RMB/t}=69.584 \text{ billion RMB}$$

The economic value of inferred mineral resources (UNCF 333) has not been calculated.

CHAPTER 10
Conclusions

10.1 Work Results

Judging by the literature of previous geological work, there has been little work done on the region, and the scope of work was limited to survey on surface only. This project is the first time that systematic data of on-depth drilling has been provided which proves that it should take further exploration since it has great potential on developing of the Lomoteng mining area.

1. It has been investigated that the ore deposit is controlled by Transvaal Super group Asbesberge formation of Asbestos subgroup which is characterized so sedimentary metamorphic ore deposits.

2. There are 6 ore beds delineated after the primary geological works and engineering control, which are identified as Iron ore bed 1, Iron and Manganese ore bed I, Iron ore bed 2 and Iron and Manganese ore bed II, Iron ore bed 3 and Iron and Manganese ore bed III respectively. The ore body represents in a stratiform, striking to the west-north, dip to the east-south, and with the avg. dip angle at 17°. The Iron/manganese ore bed I is the host layer of ore deposit, which is 3600m in control length, 280-1110m in controlled width，3.76-10.18m in thickness，6.03m in average thickness, 1115m at maximum extension, 10.3-50.00% at Mn grade，25.89% at avg. grade, 7.1-55.8% at TFe grade，25.29% at avg. grade，and 51.18% for Mn+TFe grade。The Iron ore bed 1 is 3000m in control length, 280-1110m in control width. It ranges from 3.76 to 10.18m in thickness，6.03m in average thickness；1115m at maximum extension； Mn grade 0.09-12.38% %，avg. grade 3.80%, TFe grade26.22-62.93%，avg. grade of Mn+Tfe 42.04%. The control length of Iron and Manganese ore bed II is 2400m, and its control width ranges from 460m to 850m. The thickness of the layer is range from 4.05m to 6.85m, and its average thickness is 4.77m. Its maximum extension is 1115m long. Its Mn grade ranging from 10.8% to 49.8%, average grade 25.65%, and its grade ranges from 7.90% to 50.4%，with average grade 25.86%，Mn+TFe grade 51.51%. The rest four Iron and Manganese (iron) ore beds are relatively in low thickness and they are scattered distributed in the region. The ore resources have not been calculated because they are not inferred mineral resource (UNFC Code 333) and they do not appear to have mining values.

3. Through the study on the quality of ore, the manganese ore can be classified according to its composition and structure, which are classified as oxidize patchy Iron/manganese ore, oxidize banded Iron/manganese ore, and oxidize dense patchy Iron/manganese ore. Manganese ore can also be classified for industrial purpose which they are identified as oxidize Iron/manganese ore (high Iron and Manganese ore) and needed-to-be-selected hematite ore.

4. The basic conditions of distribution, orientation and water retention of aquifer and aquiclude in the mining area are investigated, and the water retention of the strata is determined as well. It is concluded that water in mining pits mainly comes from raining. Thus, the hydrogeology conditions of the ore deposits are classified as simple. We suggest that the water source of industrial and household can be satisfied with the supplying of local water for its quality and amount can meet the both abovementioned needs.

5. The nature of the rock mechanics in mining area is investigated and the engineering and environmental geological conditions are rated as medium.

6. This geological work has studied geological disasters such as earthquakes, collapse, slide, and debris flow, etc. of the slopes and its environmental geological impact on the future mining activities.

7. By estimation, there are 135.578 million tons of UNFC Code 332 + UNFC Code 333 mineral resources of Iron and Manganese ore and iron ore, including 96.602 million tons of UNFC Code 332 iron ore, 38.976 million tons of UNFC Code 333 iron ore. The UNFC Code 332 ore resources accounts for 71% of the total resources estimation. The stripping ratio of ore deposit is 5.83:1.

There are estimated 17.623 million tons of UNFC Code 332 + UNFC Code 333 iron resources with Mn grade 3.80%, TFe grade 42.04%, including estimated 9.765 million tons of UNFC Code 332 iron resources with Mn grade 3.82%, TFe grade 42.74%, and estimated 7.858 million tons of UNFC Code 333 iron resources with Mn grade 3.78%, TFe grade 41.16%.

There are estimated 117.955 million tons of UNFC Code 332 + UNFC Code 333 Iron and Manganese ore resources with Mn grade 25.85%, TFe grade 25.39%, Mn+ TFe grade 51.24%, including estimated 86.837 million tons of UNFC Code 332 Iron and Manganese resources with Mn grade 25.90%, TFe grade 25.34%, Mn+ TFe grade 51.24%, and estimated 31.118 million tons of UNFC Code 333 Iron and Manganese resources with Mn grade at 25.70%, TFe grade 25.53%, Mn+ TFe grade 51.23%.

There are estimated 94.04 million tons of UNFC Code 332 + UNFC Code 333 of Iron and Manganese ore bed I resources with Mn grade 25.89%, TFe grade 25.29%, Mn+ TFe grade 51.18%, including estimated 72.757 million tons of UNFC Code 332 Iron and Manganese resources with Mn grade 26.07%, TFe grade 25.15%, Mn+ TFe grade 51.22%, and estimated 21.283 million tons of UNFC Code 333 Iron and Manganese resources with Mn grade 25.28%, TFe grade 25.77%, Mn+ TFe grade 51.05%.

There are estimated 23.915 million tons of UNFC Code 332 + UNFC Code 333 of the Iron and Manganese ore bed II resources with Mn grade 25.65%, TFe grade 25.86%, Mn+ TF grade 51.51%, including estimated 14.08 million tons of UNFC Code 332 Iron and Manganese resources with Mn grade24.84%, TFe grade 26.56%, Mn+ TFe grade 51.40%，and estimated 983.5 million tons of UNFC Code 333 Iron and Manganese resources with Mn grade 26.62%, TFe grade 25.01%, Mn+ TFe grade 51.63%.

All the scheduled geological work has been completed, and the goal of prospecting has achieved.

10.2 The control level of ore deposit and quality of geological report

10.2.1 The control level of ore deposit

Due to the major geological factors that the deposit is super huge in scale, simple in formation and strata structure, and with its stable and continuous strata, the exploration type of the deposit is determined to be such deposit can be classified as Exploration Type I (complicated). The hosting layer strikes for 3600km. For the specified estimation range of reserves, the drilling control is made at the spacing of 600m × 300m for exploring the inferred intrinsic economic resources (333), and seven exploration lines were set. Along the direction of dip, in according with the control principles of surface and underground double engineering drilling at less than 300m's slope distance for 3-6 holes for each exploration section, by using the horizontal distance and dip direction working along 1/4 for prospecting the UNFC Code 333 resources. The control level basically meets drilling control requirements for exploration UNFC Code 332+333 resources.

10.2.2 Quality of geological report

This geological report is strictly compiled to meet the requirements of DZ/T0033-2002 The Specification for Compilation of Geological Report of Solid-mineral Exploration / Mine-closing. All the adoptive materials are examined abide by the three level rule of quality management that the materials should be complete, authentic and reliable.

After the compilation and comprehensive study, the report is done by a form of integrating writings, figures and tables which summarizes the whole geological work.

The chapters of the report are arranged in an order which the writings are concise and the major points are stood out. The annexes figures and tables are complete and easy to read which corresponds to each other. In sum, the report is of fine quality.

10.3 The evaluation on the prospect of the iron and manganese (iron) ore deposit

10.3.1 The regularity of ore formation

This ore deposit is a sedimentary exhalative ore deposit which is strictly controlled by the stratum of the Asbesberge formation of Asbestos subgroup of Transvaal Supergroup. It is indicated in chapter 4 that banded structures containing Iron and Manganese are widely distributed.

The ore bed belongs to a sedimentary exhalative deposit, caused by the release of ore-bearing hydrothermal fluids in the bottom of the ocean, and it has the related characteristics of such release. It is rich in carbonatite quartzite, volcanic rocks and other sedimentary exhalative structures across multiple phases, which contain iron-manganese. During each release, a large amount of Fe, Si and other minerals and acidic and reducing gas are emitted, providing the material basis for the formation of a giant Iron and Manganese deposit. The deposit occurred in Asbesberge formation of Asbestos subgroup of Transvaal super group, and in genetic type it belongs to the metamorphosed sedimentary Fe/Mn (Fe) deposit with characteristics of multi-phase air injection in the sea bed.

10.3.2 The evaluation on the prospect of the Mining deposit (area)

Through the prospecting work, it is estimated there are 135.578 million tons of UNFC Code 332 + UNFC Code 333 mineral resources of Iron and Manganese ore and iron ore, including 17.623 million tons of UNFC Code 332 iron ore, 93.79 million tons of UNFC Code 333 iron ore. The rest are 117.955 million tons of UNFC Code 332 + UNFC Code 333 mineral resources of Iron and Manganese ore and iron ore, including 86.837 million tons of UNFC Code 332 Iron and Manganese ore, 31.118 million tons of UNFC Code 333 Iron and Manganese ore. This is a super huge scale Iron and Manganese (iron) ore deposit.

Through the regularity of ore formation, it is concluded the Asbesberge formation of Asbestos subgroup of Transvaal Supergroup is the prospect area for prospecting of the same type of Iron and Manganese ore deposits. Outside the prospecting area, there are Iron and Manganese outcrops appear in the south of mining block of the mining right area. Outside the mining area, there are 55.4742km^2 area has the same regularity of ore formation conditions as the prospecting block does. By conducting a simple comparison with the area of prospecting blocks and the thickness of Iron and Manganese ore beds, it is estimated the area within the mining right but excluded for the prospecting area is about 90 million tons of Iron and Manganese ore. There are particularly rich Iron and Manganese (iron) ore resources are vastly distributed in such stratum which can be the focal point of the future exploration.

10.4 Evaluation of mining technology conditions and environmental geology

In the early mining stage, the reserves in the mining block is fit to opencast mining for it is above the underground water level and outcrops appear on the surface or near surface. The water source for mining pits is mainly from atmospheric precipitation. In the later mining stage, impacted by or graphic factors, waterway must be built to eliminate the water when mining in a lower position. The ore beds and surrounding rocks have greater composite strength, better stability, with a stripping ratio at 5.83:1. The mining technical condition of ore deposit is rated at medium.

The investigated ore deposit is located in the slope at the lower part of the hill. The ground of the slope is basically stable in nature. The quart nary system coverage is characterized with little distributed fine sand layers, less thickness of layers, and small possibility of occurrences of geological disasters such as collapse, slide, and debris flow, etc. of the slopes. There were not significant breakage events in the mining area, and there are not literature found of records of earth quarks. The mining activity shall not have significant impact on geological environment, and the degree of impact is rated at small.

10.5 The economic value of the mining of ore deposit

There are 135.578 million tons of UNFC Code 332 and UNFC Code 333 mineral resources, including 17.623 million tons of UNFC Code 332 and 333 iron ore, 9.765 million tons of UNFC Code 332 iron ore, 117.955 million tons of UNFC Code 332 and 333 Iron and Manganese ore resources, and 8.837 million tons of UNFC Code 332 iron-manganese. The average grade of UNFC Code 332 ore is TFe at 42.74%, Mn at 25.90%, and Mn+ TFe at 51.24%. After calculated by taking the factors of 5% open-pit mining losses, one million tons annual production capacity, and 128 years of mine life, the potential economic value of UNFC Code 332 ore resources in the ore deposit is 69.584 billion Yuan.

10.6 Main lessons and problems

10.6.1 Main lessons

The geological work is a commissioned by Super Mayer Investment Ltd. The contact parties agree to corporate on undertaking the minimum work for achieving a fruitful results on the project design, project execution and compilation of the geological report. BDB engineers have come to the site and gave directions which reduced many errors for conducting the exploration work, and we are beneficial from their professional opinions and also improve our work so it will meet the standards. We appreciate the professional work and knowledge they brought to us.

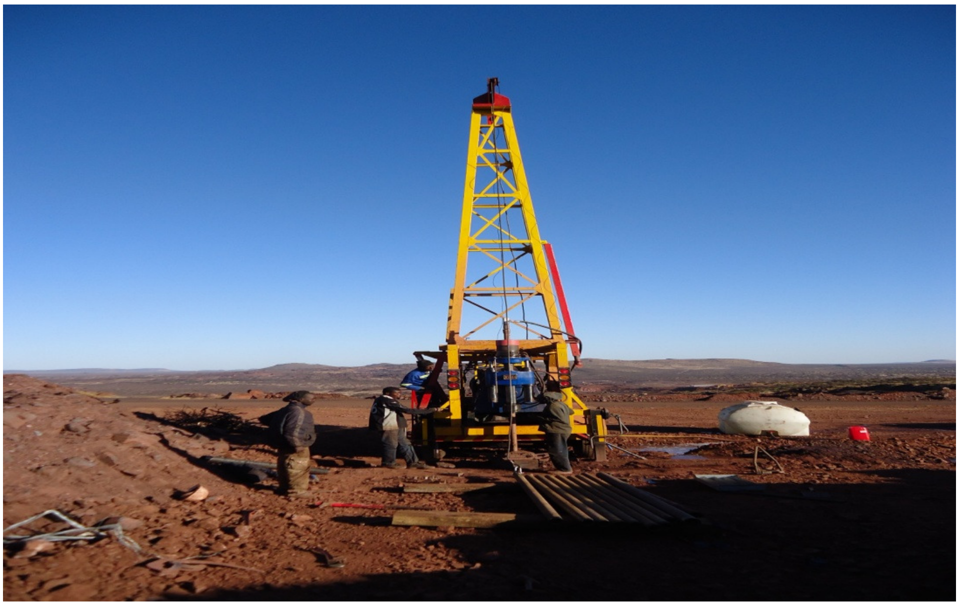
10.6.2 Problems

There are smashed ore in individual mining blocks, and individual drill holes such as ZK501,ZK602 and some other holes produces relatively low recovery rate of ore core, and the samples . However, there is not big difference on the testing result for few samples with low recovery rate would not make a difference on the whole ore stratum.

10.7 Recommendations on future mining

1 Suggest taking further exploration on hydrogeology, engineering geology and environmental geology for more detailed data so as to take future mining.
2 The environmental condition is good and it is opencast working at the early stage of mining. Suggest taking necessary measures to reduce the damage on original landform and ecological environment during the mining process. Tree planting, grass covering and rehabilitation should be taken to avoid the water losses and soil erosion.
3 Suggest keeping undertaking productive prospecting work whilst making a constant observation on the change or ore deposit for the western ore deposit is concealed in nature.
4 Suggest to further study ore selection and smelting for improving the grade of manganese ore.

Picture No.1 The landform of the mining area



Picture No.2 The drilling site

Picture No.3 The outcrops in the northern area of the mining area

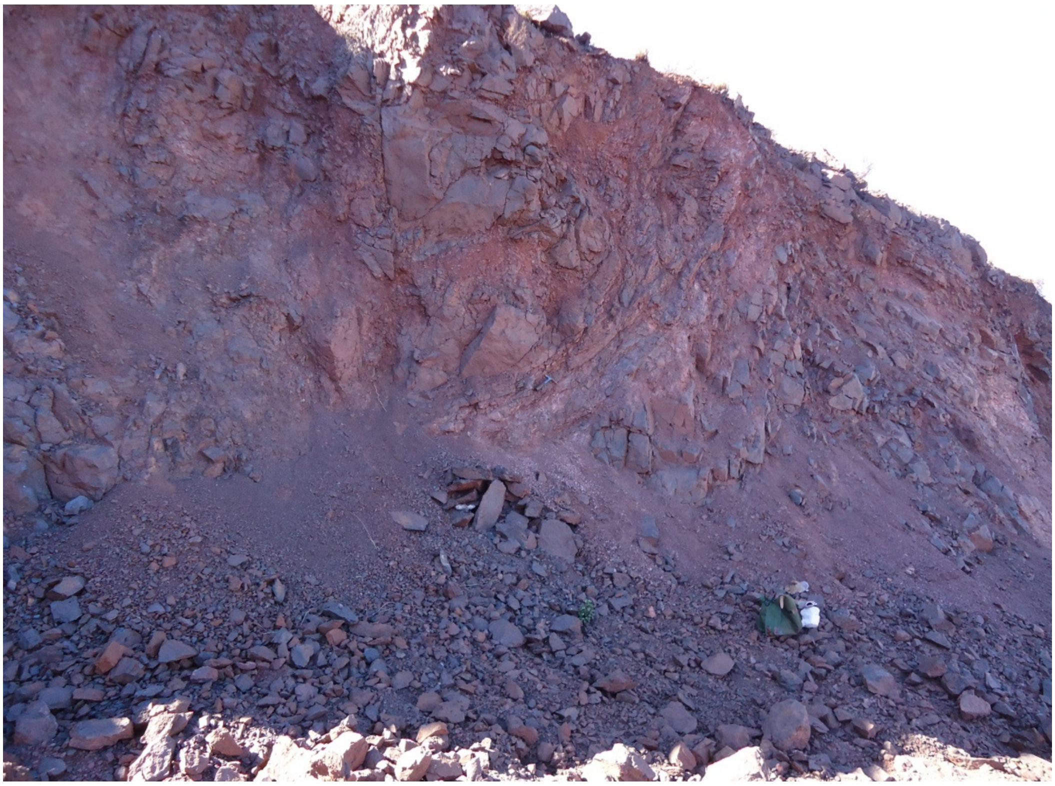
Picture No.4 Patchy Iron and Manganese ore

Picture No.5 Blocky Iron and Manganese ore

Picture No.6 Massive Iron and Manganese ore

Picture No.7 Silty slates

Picture No.8 Weathering denudation of the top of dolomite



Picture No.9 The stability characteristics of mining pit in the eastern mining area