

Calorific value of the Main Seam is lower than that of other two seams because eight samples out of twenty-four of the Main Seam are classified as anthracite so that the mean calorific value relatively decreases.

Based on the classification of A.S.T.M. (American Society for Testing and Materials), the Intermediate Marker Seam is classified as semianthracite except that of DD 7 classified as anthracite. The Main Seam in DD 1, DD 2, DD 4, DD 7, DD 13, and lower parts of this seam in DD 29 and DD 11 holes are classified as anthracite, and the others are classified as semianthracite. The Footwall 3 Seam in DD 6 is classified as low volatile bituminous coal and the others are as semianthracite except upper part of DD 1, DD 2 and DD 4 holes where the seam is classified as anthracite.

Where the intrusion of dolerite is found in the roof and floor of the Main Seam, the quality of the coal seams is often graded up to anthracite.

The content of total sulfur of the three major seams is generally lower than 1% except the Intermediate Marker in DD 6 (1.67%) and the Footwall 3 in DD 8 (1.37%).

Drawing 13a to 13c show the iso-ash and iso-volatile matter for the Intermediate Marker, Main Seam and Footwall 3 occurring in the northern part of the Lubhuku area. These maps indicate that ash content of the Intermediate Marker and Main Seam tends to increase towards the south and/or the southeast of this area, and that of the Footwall 3 tends to increase towards the southwest. On the other hand, volatile matter content of the Intermediate Marker, Main Seam and Footwall 3 tends to increase towards the west or southwest.

Almost all samples of the major coal seams show swelling number of 0 and have no caking property.

6.3 Float and Sink Tests

These tests were executed in Swaziland on five samples of the Intermediate Marker, twenty-one of the Main Seam and five of the Footwall 3.

Coal samples were crushed into +½ mm to -25 mm size and tested for the washability at SG 1.5, 1.6 and 1.8. Table 10a shows the yield and ash content in case of testing at the fractions of F1.5, S1.5-F1.6 and F1.6.

Table 10a. Results of Sink and Float Analysis

Coal Seam	Fraction Sample No.	Fl.5		Sl.5-Fl.6		Fl.6	
		Weight (%)	Ash (%)	Weight (%)	Ash (%)	Weight (%)	Ash (%)
Intermediate Marker	DD4-1	37.5	14.0	53.2	21.1	90.7	18.2
	DD25-1	42.2	12.3	47.6	20.9	89.8	16.9
	DD5-1	65.9	14.8	28.3	22.4	94.2	17.1
	DD49-1	66.9	13.5	28.3	22.2	95.2	16.1
	DD6-1	54.8	12.2	27.7	22.3	82.5	15.6
Main Seam	DD2-2	0		0		0	
	DD3-1	91.7	10.2	6.6	—		—
	DD4-2	60.4	9.4	23.7	17.2	84.1	11.6
	DD25-2	71.9	9.6	17.9	19.8	89.8	11.6
	DD5-2A	66.4	11.2	17.6	22.3	84.0	13.5
	DD5-2B	90.2	10.9	4.4	23.7	94.6	11.5
	DD49-2	77.2	10.3	11.6	24.1	88.8	12.1
	DD50-2A	32.3	12.6	52.1	22.1	84.4	18.5
	DD50-2B	71.3	10.4	16.7	22.3	88.0	12.7
	DD6-2A	75.7	10.2	9.7	22.9	85.4	11.6
	DD7-2	0		0		0	
	DD8-2	0.1	—	0		0.1	—
	DD28-2	29.6	13.0	27.7	21.3	57.3	17.0
	DD29-2A	33.8	11.5	42.7	20.5	76.5	16.5
	DD29-2B	78.4	9.7	18.0	20.7	96.4	11.8
	DD51-2A	0		0		0	
	DD51-2B	12.0	9.4	12.3	17.1	24.3	13.3
	DD11-2	0		0		0	
	DD13-2A	0		0		0	
	DD13-2B	0		0		0	
DD38-2	51.9	11.5	29.1	21.2	81.0	15.0	
Footwall 3	DD1-2A	0.2	—	10.7	—	10.9	12.5
	DD1-2B	2.0	—	36.9	—	38.9	16.2
	DD3-3	86.7	7.9	4.7	—	91.4	—
	DD5-3	81.6	12.9	11.8	23.8	93.4	14.3
	DD6-3	48.5	11.4	17.1	23.5	65.6	14.6

* Size of coal washed $\frac{1}{2}$ mm ~ 25 mm.

* Tested by Fuel Research Institute of South Africa.

Table 10b Results of Sink and Float Analysis

Sample	Fraction	Weight (%)	Ash (%)
DD25-1	F1.5	73.8	8.6
	S1.5-F1.6	12.9	19.9
	S1.6	13.3	38.2
DD25-2	F1.5	59.4	9.4
	S1.5-F1.6	13.5	19.9
	S1.6	27.1	38.6
DD50-1	F1.5	52.0	10.3
	S1.5-F1.6	22.6	21.1
	S1.6	25.4	46.0
DD50-2	F1.5	63.2	8.6
	S1.5-F1.6	14.9	21.6
	S1.6	21.9	46.4
DD38	F1.5	46.2	11.2
	S1.5-F1.6	26.5	20.5
	S1.6	27.3	49.5
DD13	F1.5	0	—
	S1.5-F1.6	0	—
	S1.6	100	—

* Analyzed by Tokyo Coal and Mineral Research Institute.

* All samples are Main Seam.

Mean ash contents on a raw coal basis of the Intermediate Marker, Main Seam and Footwall 3 are 20.3%, 20.5% and 18.4% respectively. The yield at SG1.6 of the Intermediate Marker ranges from 82% to 95% with ash contents of 15% to 18%. That of the Main Seam in the northern part of the area ranges from 84% to 94% with ash contents of 11.5% to 18.5%. Especially in DD 3 and DD 5, the yield at SG 1.5 ranges from 90% to 92% with ash contents of about 10%. The yield of the Footwall 3 in DD 3 and DD 5 is 91.4% to 93.4% with ash contents of 14.3%.

These tests on six samples of the Main Seam were also executed in Japan for cross-check (See Table 10b).

6.4 Ultimate Analysis

This analysis was conducted on five samples of the Intermediate Marker, seven of the Main Seam, and four of the Footwall 3.

The assay results were plotted in relation to each carbonization degree, showing in Figure 20 and 21.

The distribution of these figures of the Intermediate Marker and Main Seam plotted is stable, however, that of Footwall 3 is slightly scattered.

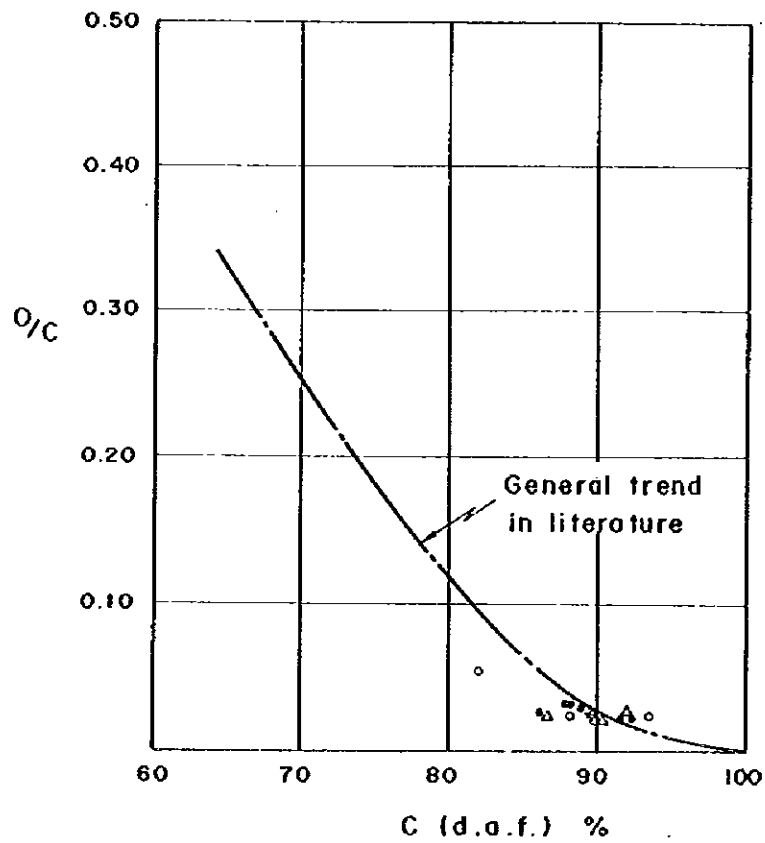
6.5 Ash Fusion Temperature and Ash Analysis

The ash analysis was carried out only in Japan.

Regarding ash fusion temperature, the hemisphere temperature of almost all seams except the Main Seam in DD 51 is over 1,350°C. Low hemisphere temperature of the Main Seam in DD 51 is due to the high contents of Fe_2O_3 and MgO in its ash.

Although the data on ash analysis are not enough to correlate to each seam, generally, it might be considered that the Main Seam has relatively high content of Na_2O compared with that of the Intermediate Marker and Footwall 3. Na_2O content of the Intermediate Marker and Footwall 3 is generally less than 1%, however, that of the Main Seam is sometimes more than 3%.

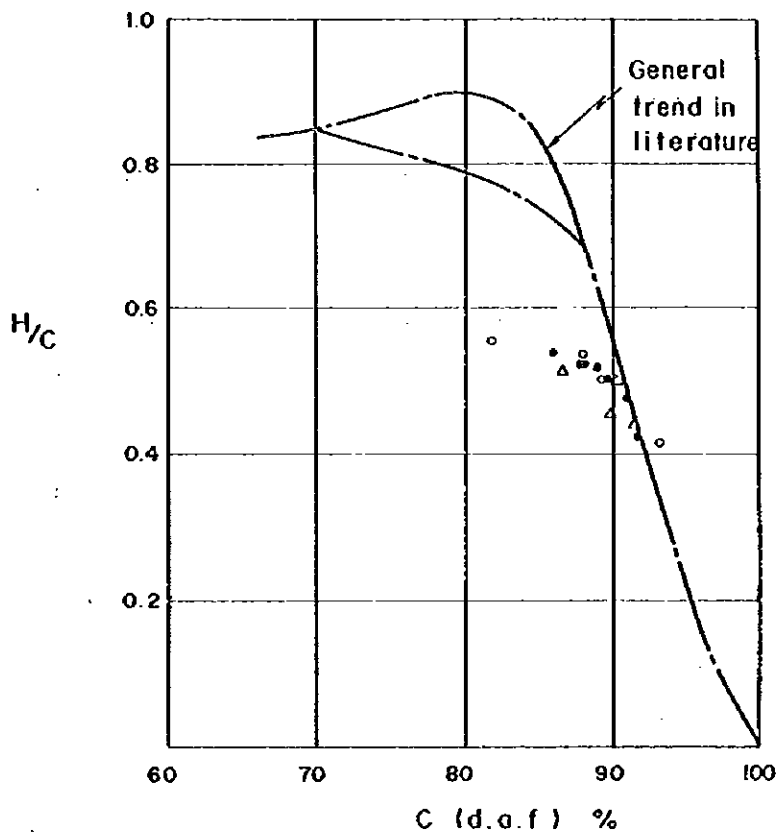
FIGURE 20. THE RELATION BETWEEN O/C RATIOS (In number of atoms) AND CARBON CONTENTS (d.a.f.)



[Remarks]

- △ Intermediate Marker
- Main Seam
- Footwall 3

FIGURE 21. THE RELATION BETWEEN H/C RATIOS (In number of atoms) AND CARBON CONTENTS (d.a.f.)



[Remarks]

- △ Intermediate Marker
- Main Seam
- Footwall 3

6.6 Petrographic Analysis

Exinite group was rarely observed in all analyzed coal seams. Instead inertinite group, especially semifusinite, is predominant in all seams (Table 11).

Mean reflectance of the major coal seams is high at 2.0 to 3.4 and this indicates that carbonization degree is progressed in these coals. Generally, mean maximum reflectance of vitrinite of three major seams tends to increase towards the eastern part of the Lubhuku area. This coincides with the fact that the depth of the coal seams deepens towards the eastern part of the area.

6.7 Evaluation of Coal Quality

Mean coal quality of the Main Seam from the Lubhuku area and Mpaka mine which is now in operation is shown below.

		Lubhuku Area	Mpaka Mine
Moisture	(%)	1.4	1.3
Ash	(%)	13.6	14.0
Fixed carbon	(%)	77.3	72.0
Volatile Matter	(%)	7.7	12.7
Total Sulfur	(%)	0.42	0.35
Calorific value	(kcal/kg)	7,147	6,745
Calorific Value	(MJ/kg)	29.9	28.2
Yield	(%)	79.6	75.0

(Washed at 1.6 S.G.)

Quality of the coal in the Lubhuku area compares favorably with that from the Mpaka mine. Volatile matter of the Lubhuku coal is less than 10% and calorific value and yield of washed coal are slightly higher than those of the Mpaka coal. Quality of this coal is also similar to that of anthracite in Natal, the Republic of South Africa.

Therefore, it is considered that the coal in the Lubhuku area has the marketability in a wide range of uses such as lime burning, manufacture of carbide, reductant in the alloy industry, manufacture of briquette, cement kiln fuel, thermal power generation and smokeless fuel.

Table 11. Petrographic Analysis.

Coal Seam	Intermediate Marker				Main Seam				Footwall 1			Footwall 2			Footwall 4					
	DD4-1	DD25-1	DD5-1	DD49-1	DD6-1	DD3-2	DD4-2	DD25-2	DD5-2A	DD5-2B	DD49-2	DD6-2A	DD3-4	DD6-4	DD3-3	DD4-3	DD5-3	DD6-3	DD25-7	DD49-7
Maceral Analyses																				
Vitrinite	28.6	31.2	31.3	23.4	32.5	54.3	45.0	47.8	49.1	50.1	53.0	55.3	52.3	35.6	63.1	16.3	61.5	50.4	59.7	52.1
Exinite	0.2	0.9	1.0	1.3	0.4	0.9	0.7	1.1	0.5	0.6	1.2	0.7	0.6	0.4	1.0	0.4	0.8	1.0	1.0	0.8
RSF	24.0	21.3	17.1	18.4	23.8	12.5	20.9	16.2	14.1	15.7	12.5	14.2	8.2	24.4	10.4	20.5	8.9	13.0	10.1	13.5
Semifusinite	44.7	35.6	42.7	50.1	32.0	27.4	29.1	29.6	28.5	29.0	26.3	23.7	24.1	36.7	19.5	60.0	20.6	21.0	21.8	26.8
Fusinite	0.1	0.7	1.1	1.0	1.1	0.9	0.5	0.8	0.9	1.0	0.3	1.1	0.8	0.5	1.1	0.4	0.9	1.4	0.6	0.7
Macrinite	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.2
Micrinite	0.1	0.0	0.0	0.3	0.1	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Sclerotinite	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.6	0.4	0.2	0.5
Visible Minerals	2.3	9.8	6.7	5.5	9.9	4.0	3.6	4.5	6.7	3.2	6.7	4.9	13.6	2.2	4.5	2.2	6.5	12.8	6.4	5.4
Reflectance Measurements																				
% Ro (V) Maks.	2.758	2.688	2.253	2.603	2.127	2.391	3.064	2.822	2.056	2.040	2.311	2.148	2.337	2.126	2.359	3.379	2.029	2.063	2.764	3.315
V-Class:																				
V17																				
V18					6															
V19					26															
V20					49															
V21				1	4	4														
V22				3	15	8														
V23				6	4	36														
V24				12		38														
V25		3	8	25		14														
V26		13		21																
V27		39	33	20																
V28		26	10	10																
V29		8	2	2																
V30																				
V31																				
V32																				
V33		19	39	25																
V34		39	33	20																
V35		26	10	10																
V36		8	2	2																
V37		2																		
V38																				
V39																				

* Analyzed by Fuel Research Institute of South Africa.

CHAPTER 7. COAL RESERVES

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7.1 Standard of Coal Reserves Calculation

The scope of coal reserves calculation is delimited to the drilled area of about 14 km in the north-south direction and 5 to 6 km in the east-west in the Lubhuku area, and the western limit lies at the Lubhuku fault.

Only coal reserves are calculated in this study because the intervals of boreholes are 1 to 2 km apart and the factors affecting mining such as dolerites and faults are not accurately known.

1) Classification of Coal Reserves

The coal reserves are classified into the following categories on the basis of their degree of confidence with which the coal quantity has been determined.

(A) Measured Reserves

Reserves for which occurrence and extent of coal seam are defined as being within a distance of 125 m from the point of observation.

(B) Indicated Reserves

Reserves for which occurrence and continuity of the coal seam are geologically estimated to an appropriate extent as being within a distance of 250 m from the point of observation.

(C) Inferred Reserves

Reserves inferred by broad geologic information in the area, and the continuity of coal seam can be expected from the point of observation used in the calculation of the measured and indicated reserves.

2) Range of the Calculation

The coal reserves are calculated for those areas where the coal thickness is more than 1.0 m for the major three coal seams (Intermediate Marker Seam, Main Seam and Footwall 3 Seam) which are generally distributed over the whole investigated area. In case coal thickness is less than 1.0 m, those areas where coal thickness is over 0.8 m and seam thickness is over 1.0 m are included in the calculation. The reserves of the other coal seams are calculated in case the seams with the coal thickness of more

than 1.0 m were confirmed by more than two adjacent points of observation.

The weathered zone within 50 m under the surface is excluded from the calculation.

Those areas where no coal seams are considered to be distributed because of the dolerite intrusions are also excluded from the calculation.

3) Block

The block that represents the point of observation is determined by the polygonal method using each drilling point as a center.

In case no adjacent holes are available, the area of the block for the inferred reserves is delimited to within 1 km of the drilling site.

4) Level

For the three major coal seams, the level is divided into four of above +100 m (above the sea level), +100 m to ± 0 m, ± 0 m to -100 m and -100 m to -200 m.

No division by level is attempted for the other seams because the area for reserves calculation is small.

5) Area

The area is measured by planimeter on the coal reserves calculation map, 1/25,000 in scale.

6) Dip

The dip for each block is determined using structure contour of the coal seam. In case dip is more than 5 degrees, the inclined area is calculated by multiplying the plan area by dip conversion rate (secant).

7) Thickness of Coal Seam

The thickness of the coal seam is taken as that of the coal part excluding partings greater than 5 cm in thickness, and the coal thickness measured in each borehole represents that of each block. No conversion into true thickness is necessary because most of the dips are less than 5 degrees.

Regarding the block represented by the borehole which encountered no coal seams because of faults or dolerites, the thickness of the coal seam in the said block is determined from the isopach map based on the drilling data.

8) **Specific Gravity**

The average value of 1.55, the measured specific gravity of the coal specimens collected in this investigation, is uniformly adopted. Analytical results show that ash content is about 20% at the specific gravity of 1.55.

9) **Theoretical Coal Reserves**

Theoretical coal reserves

$$= \text{plan area} \times \text{dip conversion rate (secant)} \times \text{thickness of the coal seam} \\ \times \text{specific gravity (1.55)}$$

10) **Safety Factor**

The following geologic safety factor is determined on the basis of stability of the coal seams and geologic structure, and the accuracy of the investigation.

This safety factor includes a factor for dolerite.

Measured block	80%
Indicated block	70%
Inferred block	50%

11) **Coal Reserves**

Coal reserves

$$= \text{theoretical coal reserves} \times \text{safety factor}$$

7.2 **Coal Reserves**

The coal reserves calculated on the basis of the above-mentioned standard are summarized below. Details of the calculation are shown in Tables 12 and 13.

(10³M.T.)

Coal seam	Theoretical coal reserves	Coal reserves
Intermediate Marker	86,188	44,455
Main Seam	215,966	111,189
Footwall 2	11,126	5,790
Footwall 3	48,142	24,968
Total	361,422	186,402

The coal reserves (measured, indicated and inferred) in each level are shown below. About 70 percent of them exist between +100 and -100 m above sea level (about 200 to 400 m below the surface).

Coal seam \ Level	above +100m	+100 ~ ±0m	±0 ~ -100m	-100 ~ -200m	Total
Intermediate Marker	7,604	18,871	10,257	7,723	44,455
Main Seam	5,612	34,984	41,104	29,489	111,189
Footwall 3	436	9,295	11,741	3,496	24,968
Subtotal	13,652	63,150	63,102	40,708	180,612
Footwall 2	—	—	—	—	5,790
Total	—	—	—	—	186,402

The coal reserves of the Main Seam comprise 60% of the above coal reserves. The coal reserves of the Footwall 2 are not divided into each level because the calculated blocks of it are only those of DD 3, DD 8 and DD 48, and the amount of the reserves are small.

The major part of the calculated coal reserves of four seams, about 70% of them, occurs to the north of DD 51 - 52 line. These coal reserves in the northern part of the area are considered to be enough for the development of new coal mine in the future. In the south of DD 51 - 52 line, a large amount of coal reserves cannot be expected because of the intrusion of the dolerite on large scale.

Table 12. Coal Reserves (Summary)

($\times 10^3$ M.T.)

Level	Measured Block			Indicated Block			Inferred Block			Total		
	Theoretical Reserves	Safety factor (%)	Reserves	Theoretical Reserves	Safety factor (%)	Reserves	Theoretical Reserves	Safety factor (%)	Reserves	Theoretical Reserves	Safety factor (%)	Reserves
Intermediate Marker	>+100	391	80	313	1,054	70	737	13,109	50	6,554	14,554	7,604
	+100~±0	597	"	477	1,893	"	1,325	34,133	"	17,069	36,623	18,871
	±0~-100	176	"	141	599	"	419	19,385	"	9,697	20,160	10,257
	-100~-200	353	"	282	958	"	671	13,540	"	6,770	14,851	7,723
	(Sub-total)	(1,517)		(1,213)	(4,504)		(3,152)	(80,167)		(40,090)	(86,188)	(44,455)
Main Seam	>+100	347	80	278	938	70	657	9,350	50	4,677	10,635	5,612
	+100~±0	1,077	"	861	3,388	"	2,371	63,495	"	31,752	67,960	34,984
	±0~-100	1,595	"	1,276	4,329	"	3,031	73,584	"	36,797	79,508	41,104
	-100~-200	588	"	469	1,901	"	1,331	55,374	"	27,689	57,863	29,489
	(Sub-total)	(3,607)		(2,884)	(10,556)		(7,390)	(201,803)		(100,915)	(215,966)	(111,189)
Footwall 3	>+100	--		--	--		--	871	50	436	871	436
	+100~±0	411	80	329	1,184	70	829	16,271	"	8,137	17,866	9,295
	±0~-100	420	"	337	1,287	"	901	21,003	"	10,503	22,710	11,741
	-100~-200	171	"	136	487	"	341	6,037	"	3,019	6,695	3,496
	(Sub-total)	(1,002)		(802)	(2,958)		(2,071)	(44,182)		(22,095)	(48,142)	(24,968)
Footwall 2	>+100~-200	(251)	80	(201)	(756)	70	(529)	(10,119)	50	(5,060)	(11,126)	(5,790)
	Total	6,377		5,100	18,774		13,142	336,271		168,160	361,422	186,402

Table 13. Coal Reserves Calculation

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)	
Measured	Intermediate Marker	2	>+100	49	2	1	49	1.58	77	1.55	119	80	95	
		5		49	3	1	49	1.83	90	"	140	"	112	
		49-A		49	3	1	49	1.73	85	"	132	"	106	
									(Sub total)		(391)		(313)	
			3-B	+100~0	49	2	1	49	1.28	63	"	98	"	78
			4-A		49	4	1	49	1.54	75	"	116	"	93
			6-B		49	4	1	49	1.55	76	"	118	"	94
			7-A		24	6	1,006	24	1.25	30	"	47	"	38
			8-A		49	4	1	49	1.43	70	"	109	"	87
			11-B		49	5	1,004	49	1.43	70	"	109	"	87
									(Sub total)		(597)		(477)	
		25-A	±0~100	49	4	1	49	1.53	75	"	116	"	93	
		50-A		6	3	1	6	1.35	8	"	12	"	10	
		7-B		25	3	1	25	1.25	31	"	48	"	38	
								(Sub total)			(176)		(141)	
		26-B	-100~200	49	3	1	49	0.83	41	"	64	"	51	
		50-B		43	3	1	43	1.35	58	"	90	"	72	
		28-B		49	3	1	49	1.42	70	"	109	"	87	
		38-C		49	6	1,006	49	1.18	58	"	90	"	72	
								(Sub total)			(353)		(282)	
Total											1,517		1,213	

(11)

(2)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)	
Indicated	Intermediate Marker	2	>+100	147	2	1	147	1.58	232	1.55	360	70	252	
		5		138	3	1	138	1.83	253	"	392	"	274	
		49-A		113	3	1	113	1.73	195	"	302	"	211	
										(Sub total)		(1,054)		(737)
		3-B	+100±0	147	2	1	147	1.28	188	"	291	"	204	
		4-A		147	4	1	147	1.54	226	"	350	"	245	
		49-B		34	3	1	34	1.73	59	"	91	"	64	
		6-B		147	4	1	147	1.55	228	"	353	"	247	
		7-A		79	4	1	79	1.25	99	"	153	"	107	
		8-A		147	4	1	147	1.43	210	"	326	"	228	
		11-B		147	5	1,004	148	1.43	212	"	329	"	230	
								(Sub total)		(1,893)		(1,325)		
Total		25-A	±0~100	147	3	1	147	1.53	225	"	349	"	244	
		50-A		56	3	1	56	1.35	76	"	118	"	83	
		7-B		68	3	1	68	1.25	85	"	132	"	92	
										(Sub total)		(599)		(419)
		26-B	-100~200	147	3	1	147	0.83	122	"	189	"	132	
		50-B		91	3	1	91	1.35	123	"	191	"	134	
		28-B		147	3	1	147	1.42	209	"	324	"	227	
		38-C		138	6	1,006	139	1.18	164	"	254	"	178	
								(Sub total)		(958)		(671)		
													4,504	3,152

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)
Inferred	Intermediate Marker	2	>+100	1,960	2	1	1,960	1.58	3,097	1.55	4,800	50	2,400
		3-A		606	4	1	606	1.28	776	"	1,203	"	602
		5		1,269	3	1	1,269	1.83	2,322	"	3,599	"	1,800
		49-A		963	3	1	963	1.73	1,666	"	2,582	"	1,291
		6-A		113	4	1	113	1.55	175	"	271	"	134
		11-A		294	5	1,004	295	1.43	422	"	654	"	327
							(Sub total)				(13,109)		(6,554)
		3-B	+100~0	1,319	4	1	1,319	1.28	1,688	"	2,616	"	1,308
		4-A		1,341	4	1	1,341	1.54	2,065	"	3,201	"	1,601
		49-B		1,263	4	1	1,263	1.73	2,185	"	3,387	"	1,694
		48-A		1,038	4	1	1,038	1.50	1,557	"	2,413	"	1,207
		48-B		738	4	1	738	1.50	1,107	"	1,716	"	858
		6-B		1,616	3	1	1,616	1.55	2,505	"	3,883	"	1,941
		7-A		613	6	1,006	617	1.25	771	"	1,195	"	598
		8-A		1,685	4	1	1,685	1.43	2,410	"	3,736	"	1,868
		10-A		2,156	2	1	2,156	1.30	2,803	"	4,345	"	2,173
		51-A		313	3	1	313	1.00	313	"	485	"	243
		11-B		3,216	5	1,004	3,229	1.43	4,617	"	7,156	"	3,578
							(Sub total)				(34,133)		(17,069)
		4-B	0~100	197	4	1	197	1.54	303	"	470	"	235
		25-A		1,741	4	1	1,741	1.53	2,664	"	4,129	"	2,065
		48-C		400	4	1	400	1.50	600	"	930	"	465
		49-D		550	8	1,010	556	1.50	834	"	1,293	"	647
		50-A		1,206	4	1	1,206	1.35	1,628	"	2,523	"	1,262
		7-B		638	3	1	638	1.25	798	"	1,237	"	619
		9-B		88	4	1	88	1.43	126	"	195	"	98
		23-A		594	5	1,004	596	1.42	846	"	1,311	"	656

(4)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)	
Inferred	Intermediate Marker	10-B	±0~-100	1,131	2	1	1,131	1.30	1,470	1.55	2,279	50	1,140	
		51-B		2,438	2	1	2,438	1.00	2,438	"	3,779	"	1,890	
		26-A		175	3	1	175	0.83	145	"	225	"	113	
		38-A		281	6	1,006	283	1.18	334	"	518	"	259	
		38-B		269	6	1,006	271	1.18	320	"	496	"	248	
									(Sub total)					(9,697)
		25-B	-100~-200	113	3	1	113	1.53	173	"	268	"	134	
		26-B		2,929	3	1	2,929	0.93	2,431	"	3,768	"	1,884	
		50-B		1,919	3	1	1,919	1.35	2,591	"	4,016	"	2,008	
		28-B		1,004	3	1	1,004	1.42	1,426	"	2,210	"	1,105	
38-C		1,781	6	1,006	1,792	1.18	2,115	"	3,278	"	1,639			
							(Sub total)					(13,540)	40,090	
Total														
Measured	Main Seam	5-A	>+100	49	3	1	49	4.57	224	1.55	347	80	278	
									(Sub total)		(347)		(278)	
		2-B	+100±0	49	2	1	49	1.03	50	"	78	"	62	
		3		49	2	1	49	2.42	119	"	194	"	147	
		4-A		6	4	1	6	3.72	22	"	34	"	27	
		49-B		49	3	1	49	4.30	211	"	327	"	262	
		6-A		24	4	1	24	3.81	91	"	141	"	113	
		11-A		49	5	1,004	49	2.96	145	"	225	"	180	
		43-B		49	4	1	49	1.16	57	"	88	"	70	
									(Sub total)					(1,077)

(5)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)		
Measured	Main Seam	4-B	±0~100	43	7	1,008	43	3.72	160	1.55	248	80	198		
		25-A		49	4	1	49	3.36	165	"	256	"	205		
		48-B		49	4	1	49	1.07	52	"	81	"	65		
		6-B		25	2	1	25	3.81	95	"	147	"	118		
		7-B		49	3	1	49	2.34	115	"	178	"	142		
		8-B		49	4	1	49	2.11	103	"	160	"	128		
		10-B		49	2	1	49	2.20	108	"	167	"	134		
		51		49	3	1	49	2.76	135	"	209	"	167		
		13-A		49	2	1	49	1.95	96	"	149	"	119		
									(Sub total)				(1,595)		(1,276)
										138			214		171
										92			143		114
										105			163		130
								44			68		54		
								(Sub total)			(588)		(469)		
Total											3,607		2,884		
Indicated	Main Seam	2-A	>+100	28	2	1	28	1.03	29	1.55	45	70	32		
		5-A		126	3	1	126	4.57	576	"	893	"	625		
									(Sub total)			(938)		(657)	
		2-B	+100~±0	120	2	1	120	1.03	124	"	192	"	124		
		3		147	2	1	147	2.42	356	"	552	"	386		
		4-A		50	4	1	50	3.72	166	"	288	"	202		
		49-B		147	3	1	147	4.30	632	"	980	"	686		
		6-A		73	4	1	73	3.81	278	"	431	"	301		

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000 m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)	
Indicated	Main Seam	11-A	+100±0	147	5	1,004	148	2.96	438	1.55	680	70	476	
		43-B		147	4	1	147	1.16	171	"	265	"	186	
			4-B	±0~100	97	7	1,008	98	3.72	365	"	566	"	396
			25-A		120	4	1	120	3.36	403	"	625	"	438
			48-B		147	4	1	147	1.07	157	"	243	"	170
			6-B		74	2	1	74	3.81	282	"	437	"	306
			7-B		147	3	1	147	2.34	344	"	533	"	373
			8-B		107	4	1	107	2.11	226	"	350	"	245
			10-B		147	2	1	147	2.20	323	"	501	"	351
			51		147	3	1	147	2.76	406	"	629	"	440
			13-A		147	2	1	147	1.95	287	"	445	"	312
										(Sub total)		(4,329)		(3,031)
	Total		25-B	-100~200	27	4	1	27	3.36	91	"	141	"	99
		50-B		147	3	1	147	2.81	413	"	640	"	448	
		28-B		147	3	1	147	1.88	276	"	428	"	300	
		29		147	4	1	147	2.15	316	"	490	"	343	
		38-B		74	6	1,006	74	1.75	130	"	202	"	141	
									(Sub total)		(1,901)		(1,331)	
											10,556		7,390	
Inferred	Main Seam	2-A	>+100	956	2	1	956	1.03	985	"	1,527	50	764	
		5-A		756	3	1	756	4.57	3,455	"	5,355	"	2,678	
		11-A		181	6	1,006	182	2.96	539	"	835	"	418	
		43-A		488	5	1,004	490	1.16	568	"	880	"	440	

(7)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)
Inferred	Main Seam	49-A	±100	113	3	1	113	4.30	486 (Sub total)	1.55	753 (9,350)	50	377 (4,677)
		2-B	+100±0	925	2	1	925	1.03	953	"	1,477	"	739
		3		1,885	2	1	1,885	2.42	4,562	"	7,071	"	3,536
		4-A		744	4	1	744	3.72	2,768	"	4,290	"	2,145
		49-B		2,166	3	1	2,166	4.30	9,314	"	14,437	"	7,219
		48-A		850	4	1	850	1.07	910	"	1,411	"	706
		6-A		1,213	4	1	1,213	3.81	4,622	"	7,164	"	3,582
		7-A		375	4	1	375	2.34	878	"	1,361	"	681
		8-A		88	4	1	88	2.11	186	"	288	"	144
		10-A		700	4	1	700	2.20	1,540	"	2,387	"	1,194
		11-B		2,510	5	1,004	2,520	2.96	7,459	"	11,561	"	5,781
		34-A		1,356	4	1	1,356	1.50	2,034	"	3,153	"	1,577
		36-A		375	5	1,004	377	1.50	566	"	877	"	439
		43-B		2,635	4	1	2,635	1.16	3,057	"	4,738	"	2,369
		5-B		463	4	1	463	4.57	2,116	"	3,280	"	1,640
									(Sub total)		(63,495)		(31,752)
		4-B	±0~100	831	7	1,008	838	3.72	3,117	"	4,831	"	2,416
		25-A		888	4	1	888	3.36	2,984	"	4,625	"	2,313
		48-B		1,325	4	1	1,325	1.07	1,418	"	2,198	"	1,099
		50-A		288	4	1	288	2.81	809	"	1,254	"	627
		6-B		556	2	1	556	3.81	2,118	"	3,283	"	1,642
		7-B		860	3	1	860	2.34	2,012	"	3,119	"	1,560
		8-B		1,350	4	1	1,350	2.11	2,849	"	4,416	"	2,208
		28-A		94	3	1	94	1.88	177	"	274	"	137
		10-B		2,372	2	1	2,372	2.20	5,218	"	8,088	"	4,044

(8)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)		
Inferred	Main Seam	51	±0~100	2,404	3	1	2,404	2.76	6,635	1.55	10,284	50	5,142		
		52-A		1,888	3	1	1,888	1.80	3,398	"	5,267	"	2,634		
		11-C		806	4	1	806	2.96	2,386	"	3,698	"	1,849		
		13-A		3,247	2	1	3,247	1.95	6,332	"	9,815	"	4,908		
		34-B		1,625	4	1	1,625	1.50	2,438	"	3,779	"	1,890		
		36-B		2,938	4	1	2,938	1.50	4,407	"	6,831	"	3,416		
		38-A		250	6	1,006	252	1.75	441	"	684	"	342		
		43-C		450	4	1	450	1.16	522	"	809	"	405		
		31-A		163	2	1	163	1.30	212	"	329	"	165		
									(Sub total)		(73,584)				(36,797)
		Total				969	3	1	969	3.36	3,256	"	5,047	"	2,524
					-100~200	2,675	3	1	2,675	2.50	6,688	"	10,366	"	5,183
						2,804	3	1	2,804	2.81	7,879	"	12,212	"	6,106
						1,497	3	1	1,497	1.88	2,814	"	4,362	"	2,181
				1,347	4	1	1,347	2.15	2,896	"	4,489	"	2,245		
				1,606	4	1	1,606	1.80	2,891	"	4,481	"	2,241		
				431	2	1	431	1.95	840	"	1,302	"	651		
				3,675	2	1	3,675	1.30	4,778	"	7,406	"	3,703		
Measured				144	4	1	144	1.50	216	"	335	"	168		
				1,969	6	1,006	1,981	1.75	3,467	"	5,374	"	2,687		
							(Sub total)				(55,374)		(27,689)		
										201,803		100,915			
Measured	Footwall 3	2-B	+100~±0	49	2	1	49	1.10	54	"	84	80	67		
		3-A		49	2	1	49	1.83	90	"	140	"	112		
		5-B		49	2	1	49	1.38	68	"	105	"	94		

(9)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)		
Measured	Footwall 3	49-A	+100±0	49	3	1	49	1.08	53 (Sub total)	1.55	82 (411)	80	66 (329)		
		4-B	±0~100	49	5	1,004	49	0.97	48	"	"	74	"	59	
		48-B		49	5	1,004	49	1.08	53	"	"	82	"	67	
		6-B		49	2	1	49	0.96	47	"	"	73	"	58	
		8		49	3	1	49	1.05	51	"	"	79	"	63	
		10		49	2	1	49	1.47	72 (Sub total)	"	"	112 (420)	"	90 (337)	
		51-B	+100~200	49	3	1	49	1.29	63	"	"	98	"	78	
		13-B		49	3	1	49	0.95	47 (Sub total)	"	"	73 (171)	"	58 (136)	
		Total											1,002		802
		Indicated	Footwall 3	2-B	+100±0	147	2	1	147	1.10	162	"	251	70	176
3-A				147	2	1	147	1.83	269	"	417	"	292		
5-B				126	2	1	126	1.38	174	"	270	"	189		
49-A				147	3	1	147	1.08	159 (Sub total)	"	"	246 (1,184)	"	172 (829)	
4-B	±0~100			147	5	1,004	148	0.97	144	"	"	223	"	156	
48-B				147	5	1,004	148	1.08	160	"	"	248	"	174	
6-B				147	2	1	147	0.96	141	"	"	219	"	153	
8				147	3	1	147	1.05	154	"	"	239	"	167	
10				147	2	1	147	1.47	216	"	"	335	"	235	
51-A				12	2	1	12	1.29	15 (Sub total)	"	"	23 (1,287)	"	16 (901)	

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)
Indicated	Footwall 3	51-B	-100~200	135	3	1	135	1.29	174	1.55	270	70	189
		13-B		147	3	1	147	0.95	140	"	217	"	152
Total									(Sub total)		(487)		(341)
Inferred	Footwall 3	2-A	>+100	275	2	1	275	1.10	303	"	470	50	235
		5-A		188	2	1	188	1.38	259	"	401	"	201
									(Sub total)		(871)		(436)
	2-B	+100~0	1,666	2	1	1,666	1.10	1,832	"	2,840	"	1,420	
	3-A		1,835	2	1	1,835	1.83	3,358	"	5,205	"	2,603	
	4-A		219	5	1,004	220	0.97	213	"	330	"	165	
	5-B		1,031	3	1	1,031	1.38	1,423	"	2,206	"	1,103	
	49-A		2,160	3	1	2,160	1.08	2,333	"	3,616	"	1,808	
	48-A		450	3	1	450	1.08	486	"	753	"	377	
	6-A		880	3	1	888	0.96	852	"	1,321	"	661	
									(Sub total)		(16,271)		(8,137)
	4-B	±0~100	1,358	5	1,004	1,363	0.97	1,322	"	2,049	"	1,025	
48-B		1,841	5	1,004	1,848	1.08	1,996	"	3,094	"	1,547		
8		1,779	3	1	1,779	1.05	1,868	"	2,895	"	1,448		
6-B		878	2	1	878	0.96	843	"	1,307	"	654		
10		3,072	2	1	3,072	1.47	4,516	"	7,000	"	3,500		
13-A		1,244	3	1	1,244	0.95	1,182	"	1,832	"	916		
51-A		1,413	3	1	1,413	1.29	1,823	"	2,826	"	1,413		
								(Sub total)		(21,003)		(10,503)	

(11)

Classification	Coal Seam	Block No.	Level	Reserves Area (1,000m ²)	Inclination (degree)	Correct. of Incl. (sec.)	Reserves Area Calculated (1,000m ²)	Coal Thickness (meter)	Volume Calculated (1,000m ³)	Specific Gravity	Theoretical Reserves (1,000 tons)	Safety Factor (%)	Reserves (1,000 tons)
Inferred	Footwall 3	51-B	100-200	1,263	3	1	1,263	1.29	1,629	1.55	2,525	50	1,263
		13-B		2,385	3	1	2,385	0.95	2,266 (Sub total)	"	3,512 (6,037)	"	1,756 (3,019)
Total											44,182		22,095
Measured	Footwall 2	3		49	2	1	49	1.07	52	"	81	80	65
		48		49	5	1,004	49	1.08	53	"	82	"	66
		8		45	3	1	49	1.17	57 (Sub total)	"	88 (251)	"	70 (201)
Indicated		3		147	2	1	147	1.07	157	"	243	70	170
		48		147	5	1,004	147	1.08	159	"	246	"	172
		8		147	3	1	147	1.17	172 (Sub total)	"	267 (756)	"	187 (529)
Inferred		3		1,835	2	1	1,835	1.07	1,963	"	3,043	50	1,522
		48		2,291	5	1,004	2,300	1.08	2,484	"	3,850	"	1,925
		8		1,779	3	1	1,779	1.17	2,081 (Sub total)	"	3,226 (10,119)	"	1,613 (5,060)
Total											11,126		5,790

CHAPTER 8. CONCLUSION

CHAPTER 8. CONCLUSION

The items clarified in this investigation were described in each chapter, and the main items are summarized below.

(1) Modes of Occurrence of the Coal Seams

More than twenty coal seams were found in the Lower Coal Zone of the Eccra Series during this drilling investigation, whilst three coal seams, Intermediate Marker Seam, Main Seam and Footwall 3 Seam, are considered to be minable. General modes of occurrence of the coal seams show that the seams in the northern part bordered by the DD 51 – DD 52 line occur predominantly than those in the southern part.

The Main Seam occurs most predominantly in this area and has a coal thickness of more than 1.0 m over the whole area. In the northern part, this seam has a maximum thickness in DD 5 (coal thickness is 4.57 m) and the thickness gradually decreases towards the surrounding area. The seam tends to split near DD 28 and DD 29 in the eastern part. In the southern part, the seam has a maximum thickness in DD 11 (coal thickness is 2.96 m) and the thickness also gradually decreases towards the surrounding area.

The Intermediate Marker Seam is distributed fairly extensively in the northern part and has a coal thickness of 1.0 to 1.8 m, but it becomes thin with a coal thickness of less than 1.0 m except in some places in the southern part.

The Footwall 3 Seam is also distributed fairly extensively in the northern part (coal thickness is from 1.0 to 1.9 m), but it becomes thin in the southern part with a coal thickness of less than 1.0 m.

These three coal seams occur from 100 to 450 m below the surface in the area.

(2) Correlation of Horizon

It is difficult to correlate the horizon in this area because of no characteristic key or marker beds and extensive intrusion of the dolerite and faulting.

This investigation reveals that heavy minerals in the sandstone and the pollen analysis are not useful for the correlation of the horizon.

However, the geophysical logging indicates a useful method for the correlation as this shows characteristic log response at the specific horizon (shale formation in the lower part of the Upper Transition Beds and some parts of the coarse-grained sand-

stone of the Lower Coal Zone). The lithostratigraphic correlation also indicates the useful method in case the correlation is carried out to subdivide the coal seams into several groups and these groups can be compared in combination with the general change in the rock facies.

(3) Dolerite

The sills and dykes of the Karoo dolerite extensively intrude into this area, especially in the southern part. Four thick dolerite sills were found from the central of the northern part to the southern part. The intrusion frequency of dolerite (dolerite ratio in the whole strata) is generally high in the southern part at 25 to 40 percent, on the contrary, it is low ratio in the northern part at 1 to 25 percent except the area adjacent to the southern part. These intrusions show complex occurrence and affect coal seams by replacement, burned-out and coked, but the thermal effects of the dyke appears to be more common than those of the sill.

(4) Sedimentary Environment

Considering the sedimentary environment of the Ecca Series based on the variation in the lithology, grain size and sand-shale ratio, it shows deltaic and alluvial sedimentary facies. The sediments were supplied from the Swaziland Highland, west of sedimentary basin, into the Lebombo Graben elongated in the north-south direction. The Lower Coal Zone shows delta plain to alluvial plain facies with upward-fining sedimentary cycles. An appropriate environment for the deposition of the coal seams was provided in the basin. Stable sedimentary basin is found both in the northern and southern parts, and the major coal seams extensively deposited in these basins during the early sedimentation period of the Lower Coal Zone. The sedimentary basins became somewhat unstable and the coal seams occur less extensively in the later period.

The sedimentary basin in the northern part during early period shows high coal ratio. It is expected that this basin extends farther north of the investigated area.

(5) Coal Quality

As proceeding of the degree of coalification of the Intermediate Marker, Main Seam and Footwall 3, almost all of them are classified as semianthracite and some of them as anthracite base on the standard of A.S.T.M.

Recent analyses are not enough to consider the overall quality of the coal in the area,

however, the followings can be pointed out at the present time.

- Ash content of the three major seams tends to increase towards the south and east.
- Content of volatile matter in the three major seams tends to decrease towards the east and south.

(6) Coal Reserves

In this coal reserves calculation, geologic safety factor based on the stability of geologic structure, dolerite intrusion and accuracy of investigation is determined as 80%, 70% and 50% for measured, indicated and inferred blocks respectively.

Based on the above, the theoretical coal reserves calculated are 360 million tons, and coal reserves, taking into consideration the safety factor, are 186 million tons. About 60 percent of the reserves are in the Main Seam and of those about 70 percent are in the northern part of the area.

The increase in coal reserves is expected in the inferred blocks in the northern part after further exploration has been completed.

As described above, this study reveals that;

1. Coal bearing horizon of the Lower Coal Zone extends into the uppermost part of the Basal Sandstone which has previously been considered to contain no coal seams.
2. The western boundary of the Upper Coal Zone occurs further to the west that previously reported.
3. The known coal seams occur in the shallow part have been ascertained to continue to the depth of 450 meters and more below the surface in a virgin area of the Swaziland coalfield.
4. Quality of the coal in the Lubhuku area compares favorably with that of the Mpaka mine and anthracite from Natal which are in operation at present. This indicates that the Lubhuku coal has the same marketability as those coals.
5. Total coal reserves of 180 million tons are expected in the investigated area and of those about 70 percent are in the northern part. These reserves in the northern part

are considered to be enough for the development of a new coal mine in the future.

6. Coal seams in the northern part of the area are promising judging from their modes of occurrence, sedimentary environment, dolerite intrusions and coal reserves. These promising coal seams extend to farther north of the area.

CHAPTER 9. RECOMMENDATION

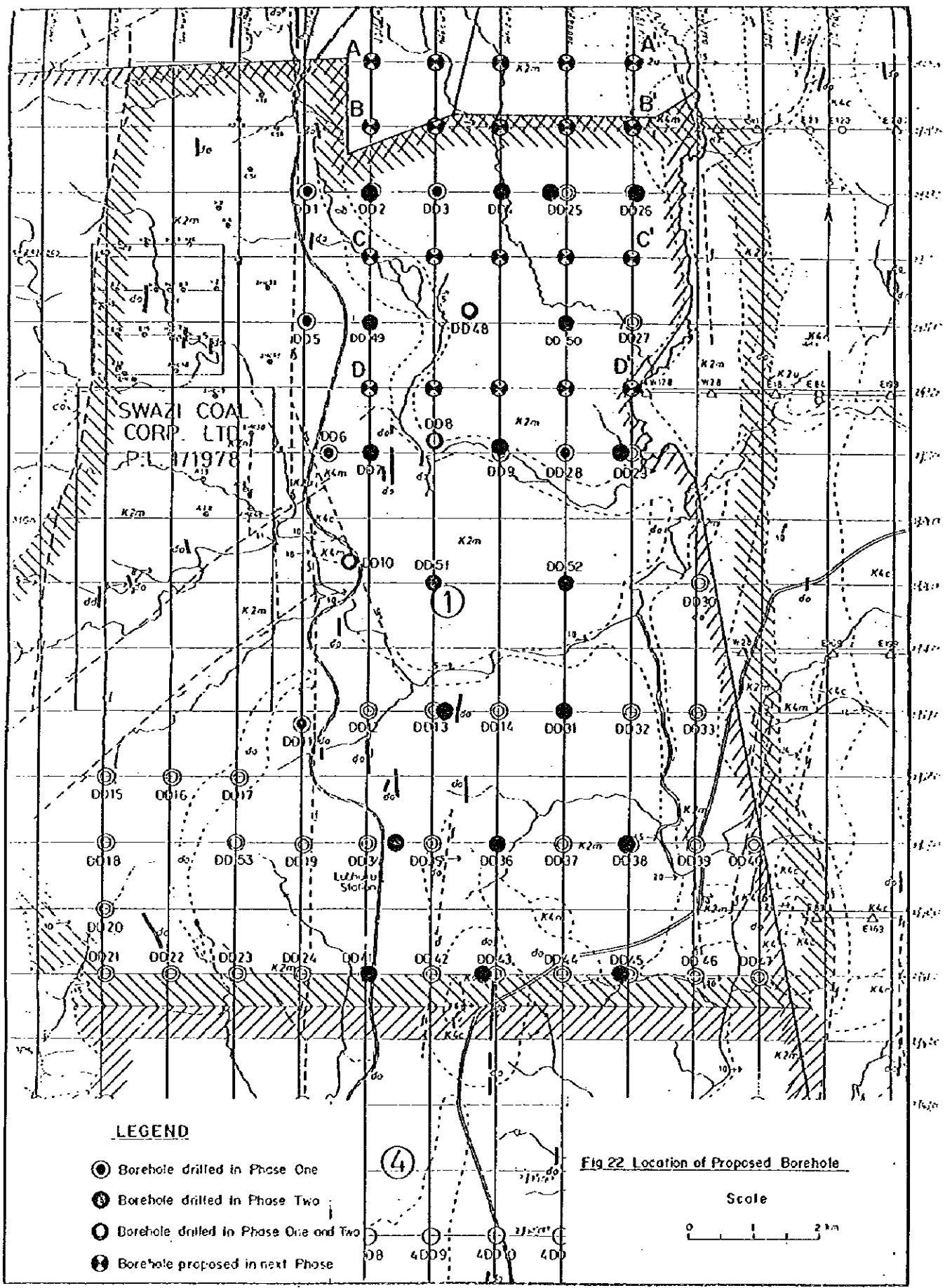
CHAPTER 9. RECOMMENDATION

The results of this investigation show that coal reserves (measured, indicated and inferred) of about 186 million tons are expected in the three major coal seams in the Lubhuku area. Especially, the northern part is considered to be promising for development of new coal mine because the coal seams stably occur judging from the sedimentary environment and about 70 percent of the reserves calculated in this study are contained in this part. In addition, only small amounts of dolerite intrusions affected on the coal seams are found in the northern part.

However, considering large intervals of the boreholes in this investigation and geologic characteristics in this area, it is clear that available data are not enough to select the area for future detailed exploration and exploitation.

Therefore, it is strongly recommended to perform further drilling investigation of total length of about 7,400 meters in 20 boreholes at 1 km intervals in the northern part of the area and its northern adjacent part. Proposed drilling sites of 20 boreholes are shown in Fig. 22 on the lines of A-A', B-B', C-C' and D-D'.

From this exploration, useful geological information will be obtained in the northern part of about 24 km² where the occurrence of coal seams is considered to be promising. This information will contribute to select the area for future detailed drilling exploration at 500 m or less intervals in the most hopeful part of the area, for the promotion of the development of new coal mine in order to attaining of self sufficiency in energy resources which is one of the main targets of the Kingdom of Swaziland.

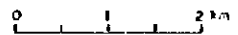


LEGEND

- Borehole drilled in Phase One
- Borehole drilled in Phase Two
- Borehole drilled in Phase One and Two
- Borehole proposed in next Phase

Fig 22 Location of Proposed Borehole

Scale



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REFERENCES

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