CHAPTER 1: INTRODUCTION

Dorstfontein Coal Mine is situated at the northern limb of the Highveld Coalfield (Snyman, 1998). The close proximity of the Nebo Granite Suite (S.A.C.S., 1980), which outcrops near the box-cut, to the No. 2 Seam makes it a very difficult mine to operate. The coal seam mimics the granite paleo-topography and causes the seam conditions to vary extremely rapidly. Some of the related problems are floor rolls and the sudden change in the coal seam thickness. The mine has been in operation for four years during which time the best parts of the ore body were exploited. The seam heights were in the excess of 1.5 meters. In the north-western part of the mine the excessive rolling floor prohibited production. In some areas of the mine the seam is split into a thin (0.01 – 0.15m) upper and a thicker lower (1.2- 1.75m) seam by an upwards coarsening sandstone parting. Currently some mining is taking place below this seam-splitting parting where the seam height ranges between 1.5 and 1.75m. In other parts of the deposit very thin seam conditions prevail below the parting with heights ranging between 1.2 and 1.4 meters. Hopefully these very thin seam areas will be mined in the near future. In many countries these heights are not be regarded as thin as the definition for thin seams is any thickness between 0.6 and 1.0m (Clarke et al., 1982). In this treatise a thin seam will be regarded as a seam between 1.2 and 1.4m thick.

These thin seam areas were previously regarded as not mineable and omitted from reserves. These areas contain very high-grade coal and have the potential of adding another 6 years to the life of the mine. The aim of the study is to determine whether these areas can be mined economically and profitable.

1.1 Definitions and terms

Box-cut: A decline ramp intersecting the strata at an angle of ± 7° and ending in the mineable coal seam.

Thin seam: A seam with a thickness between 1.2 and 1.4m.

Parting: A competent layer of sandstone or siltstone in the coal seam and sometimes separating different seams.

Pre-Karoo: All rocks older than Karoo age, that is older than ±320 Ma.

Proximate analysis: The most basic analysis for a coal sample and done on an air dried basis: Moisture content, Ash content, Volatile matter, Fixed Carbon content (Karr, 1978 and Meyers, 1981).

Raw coal: Not beneficiated, as mined.

R.O.M.: Run of mine, the material coming out of the mine. ± 50 -60% of in situ reserve.

Seam: The coal horizon.

Strong roof: The horizon above the coal that forms a roof with strength in the access of 60 MPa. It normally consists of a fine to medium grained sandstone.

Wash fraction: The relative density or densities (R.D.) at which coal is beneficiated. Listed in a washtable (Table 1). Can be any R.D. between 1.0 and 2.7.

Table 1. Float fractions and qualities used in a washtable

Float	Yield	CV	Ash	H_2O	Vol	FC	S	Phos
1.35								
1.37								
1.40								
1.45								
1.50								
1.60								
1.70								
1.80								
2.20								

Washtable: The quantitative values of each coal quality analyzed for, at a specific R.D., listed in table form (Table 1).

Weak roof: any horizons that will break up or part during normal mining activities.

Yield: The resultant tonnage when 1 ton of coal is washed at a specific R.D., expressed as a percentage. For this study all yields quoted are theoretical yields i.e. no plant efficiency or other losses were factored into the yield.

1.2 The problem and its settings

The areas of the thin seam coal resources are normally associated with the seam-split parting. This parting divides the coal into a very thin upper coal and a lower thicker coal. It is this lower coal that is of economic importance and needs to be extracted. The following problems exist:

a.) The parting left to form the roof creates dangerous roof conditions and reduces the mining heights to between 1,2 and 1,4 m. If the parting is extracted, the heights increase but the yields of the thin seam coal drop to uneconomical proportions. Stowing the parting underground is an option but stone handling is costly and can cause injury.

b.) It is clear that the continuous miner (CM) mining method is the most efficient to extract thin seam coal. Drill and blast methods need reasonable heights and space and currently the equipment on the mine is too high for the thin seam areas. Drill and blasting below the parting causes it to break and separate which defeats the whole object of excluding the sandstone from the R.O.M. The CM operation would probably be more effective but the CM can not cut hard stone.

c.) Production rate. There is a production cutoff where the cost of the tonnage mined exceeds the revenue received for the product. What is the minimum tonnage that can be produced economically from thin seam areas?

d.) Yield cutoff. Hand-in-hand with production rates goes the yield of the extracted material. If the yield is to low, the production must be increased to make up for the lost product coal. The parting must remain up to increase the yield. What is the cutoff yield and how is it affected by inclusion of the parting?

e.) Health and Safety. What are the safety implications if the parting is kept up? How will personnel and machinery be able to work safely in the thin seam area? What are the new health and safety risks when mining thin seam coal?

f.) Costs. How much will it cost to undertake thin seam mining? New thin seam equipment will be introduced and tested below the parting. What is the break-even point in production rate and costs?

1.3 Hypothesis

Current thick seam mining operations in similar conditions as thin seam areas indicate that the theoretical yield falls from 85% to 65% when the parting is included. This means that for every hundred tons mined, only 65 tons can be sold but the company still has to pay for hundred tons mined. It is more economical to mine as much "clean" coal as possible. The feeling is that in the thin seam areas the parting will have to stay up and form the roof to increase the yields and to make this an economical area. This mining method creates numerous problems regarding health and safety and will lead to a decline in the production rate. The risks have to be quantified and weighed up against the necessity to mine these thin seam areas. In the end the decision to go ahead with thin seam mining will be based on economical as well as health and safety issues. It is postulated that mining the thin seam coal will be expensive but profitable. The working conditions will change and workers will have to become comfortable with their new working environment.

1.4 Delimitations

1.4.1 Only thin seam areas have been assessed and evaluated.

1.4.2 The mine will be in operation for at least the next ten years.

1.4.3 This is not a complete feasibility study and only focuses on one aspect of the geology namely the thin seam resource.

1.4.4 The current borehole spacing is 1 hole / 300m and all the geological conditions have been modeled based on this spacing.

1.4.5 Very little information exists about other thin seam operations.

1.5 Assumptions

1.5.1 It is assumed that the entire infrastructure exists on the mine surface and underground. This will just be an additional section at the mine.

1.5.2 This study assumes that the geology has been well defined and this is no attempt to revise the geological section of the feasibility report of Dorstfontein Mine. The geological insert merely acts as background for the reader with additional information about the thin seam added, as gathered through the lifetime of the mine.

1.5.3 The study intends to change the long-term planning and scheduling of the mine as it adds additional information and creates the possibility of extending the life of the mine.

1.5.4 This study assumes that the current policy of T.C.S.A., to use contractors for mining and to outsource all activities, will not change in the future.

1.6 Research methodology

1.6.1 Current history of Dorstfontein mine. The past and current mining problems and geological conditions will be reviewed.

1.6.2 Use of borehole information. Borehole core was used to study and analyze the parting strengths and properties. The information gathered from these reports and the analyses from coal sampling were used in this study.

1.6.3 Geological model simulations. Use was made of the geological data supplied by T.C.S.A. head office. The Minescape/Stratmodel software was used to model coal qualities and seam heights.

1.6.4 The same software was used to determine the in-situ thin seam coal resource.

1.6.5 The data gathered and analyzed was used to come to a conclusion regarding the feasibility of extracting coal from thin seam areas.

CHAPTER 2: REVIEW OF RELATED MATERIAL.

Very little information exists about thin seam coal mining. Contrary to this there exist great volumes regarding coal mining and coal as a rock. These publications are not relevant to the problem of thin seam mining, its methodology, products and cost. The only relevant publication found is that of Clarke et al, (1982): Thin Seam Coal Mining Technology. Another very interesting but old book by Smyth: Coal & Coal Mining was published in 1886. This book makes very interesting reading about the mining methods, problems and history of the old British collieries.

In the book of W. W. Smyth he refers to the startling observation made in 1860 that the British coal output had doubled in 20 years, from 65 million tons to 134.6 million tons per annum. The big concern of the day was the new technology of using explosives to liberate coal at the face, which led to many fatalities and injuries due to "blow-out" shots. One of the biggest concerns of the time was underground explosions caused by gases and poor ventilation. It seems that the greatest danger was the extinction of the miner's cap lamp flame during an explosion leaving the underground workers without light. This resulted in many miners being lost underground in the dark, as they could not find their way out. This seems to be one of the earliest health and safety problems due to bad lighting or no lights at all.

The relevant issues at the time (1885), which still hold for today's drill and blast mining and of which some can be applied to continuous miner operations, are the following: i.) adopting such methods that will produce the least dust, ii.) the removal of such dust and prevention of it being carried down the downcast ventilation system, iii.) watering where practical the places in which dust accumulates and the sprinkling of common salt or other deliquescent material, iv.) the avoidance of common concussions accompanied by much flame as caused by "blown-out" shots and the careful examination for gas and clearing of dust from the place where a shot is to be fired.

Smyth (1886) also describes the very primitive ways that were employed in the 1800s to liberate coal. The first procedure was to "hole" the coal by cutting a groove two to three feet deep in the lowest part of the coal with a pick. For this holing at the bottom of the seam the collier laid on his side and in an apparently constrained attitude swung the pick almost horizontally. Some coal seams had the advantage of being able to be holed in the middle, depending on the position of the in-seam partings. The sides were cut vertically, called shearing, to form a short block of coal that needed to be collapsed. The final breaking down or "collapsing" of the seam was done by applying taper wedges a few feet apart and driving them with heavy hammers. In some cases where the coal was more resistant to collapsing, use was made of gunpowder. Later developments made use of hand drills to drill holes into the coal seam and charged with gunpowder. This method led to many injuries as proper tamping of holes did not exist and gunpowder easily pre-ignites. It is also rendered useless when wet and waterproof packaging did not exist at the time.

Bord and pillar mining layouts were the most common but longwall-mining did exist, leaving nothing but goaf or gob behind. Support was installed by means of timber props to uphold the overlying strata and in many cases where the heaviest roof pressure was expected they used nogs and chocks instead of props. Coal was removed from the face by dragging sledges, loaded with coal, along the floor. In some of the more primitive mines the coal was loaded into baskets and carried by woman bearers. The Germans were the first people to introduce underground rails. The problems encountered with underground rails were their frequent sinuosity and unevenness, confined space and the tendency to disturb roof and floor. Special designed wagons were used to transport the coal up an incline shaft. The various trolleys and tubs were either pulled by Shetland ponies or pushed by boys. It is mentioned that where very thin seams were worked the cost of carting the coal becomes very onerous (Smyth, 1886). In thin seams the tubs or wagons must necessarily be low and the wheels small so that the total weight is low in order for the onsetter and banksmen to easily pull or push the trolley up the mostly incline shafts.

During the 1800's the fatality in British coal mines were between nine hundred (900) and one thousand two hundred (1,200) people per year. The most common cause of deaths and accidents were falls of roof, methane explosions due to poor ventilation, shaft accidents and holing into old workings where methane and other gases have accumulated as well as inrushes of water which were lying under pressure in the old areas. The most feared substance and cause of fatalities in the mines was so called firedamp better known today as methane.

A very interesting book and one used very extensively in this study is one on thin seam coal mining technology and by Clarke et al. (1982). This is the only book dealing exclusively with thin seam mining methods as most other publications and books deal with coal and mining methods in general. It can also be concluded that thin seam coal mining has become unfavourable due to its low production rate and high cost and that the focus is more on high output (economy of scales) from thicker coal seams. Clarke et al. (1982) highlights the occurrences of accidents in thin seams, various extraction methods and equipment, health and safety issues, mine design and layout, costs and thin seam resources, from mainly U.S.A. based mines. This book was published in 1982 and covers mainly the mining in the 1960's and 1970s when coal prices were high and costs exuberant. The mines sold low ash coal (12-16%) for $28.0 but mined that coal at $34.0-$40.0 per ton. They were and still are heavily subsidized and many tax incentives were introduced to keep these mines open so that small communities could survive.

Many lessons can be learned from the American thin seam collieries regarding their mining methods, health and safety issues and mining costs. Real issues and factual data was used from operating collieries within the U.S.A. and compared to other collieries in the former U.S.S.R., Colombia, Great Britain, and other European countries. Many of the issues raised in this publication can be directly implemented and applied to the Dorstfontein scenario. The risks involved are pertinent to our current mining as well as to the proposed thin seam mining areas. As very few mines are currently mining thin seam coal in the R.S.A., lessons must be learned from the past and be applied at Dorstfontein.

In Chapter 3 (Clarke et al., 1982) a comparison is made between the accident analysis of thick seam and thin seam mining. The various kinds of accidents mentioned are relevant to the current mining a Dorstfontein and will be used as risks for the thin seam mining. Chapter 12 deals with productivity and the factors affecting productivity. Although many of the statistics and data goes back to the 1960s and 1970s, it can be assumed that because of the mining conditions and productivity with modern-day machines will not be dissimilar from those eras. Many U.S.A. thin seam mines produced 20 000 tons per month per section from 24 inch (0.6m) high seams. In the conclusions it is quoted that there is a correlation between seam thickness and labour productivity. There are also countries where thin seam mines are very productive due to good geological conditions such as competent and strong roofs and flat seams.

Chapter 13 (Clarke et al., 1982) deals with costs and although costs in the 1960s and 1970s cannot be compared to today's cost, one can come to a conclusion about the exorbitant costs of thin seam mining. It is interesting however that the selling price of high quality coal in dollar terms in 1977 is the same as today but decreased in terms of inflation adjusted figures. The main reason for this is that the highest quality coal occurs in thin seams and is well sought after because of the low sulphur and ash content. This is the same quality coal produced at Dorstfontein Mine. Chapter 14 covers the health and safety environment and gives a very good insight into conditions that could be expected when entering the thin seam areas. Up to now at Dorstfontein seam heights (all above 1.5m) comparable to that mined in the U.S.A (between 0.6 and 0.75m) have not been encountered. In Chapter 15 the authors deal with the various mining systems and methods and give one insight into the various methods employed in thin seam coal winning. Chapter 19 discusses the output and productivity of various mining methods. At Dorstfontein the mining methods are fixed, in the sense that bord and pillar layout applies, continuous miner machines are being used and that the necessary equipment for thin seam extraction has already been bought or current equipment adapted. Chapter 20 deals with the costs involved in thin seam mining. It appears that labour cost forms the greatest component in the U.S.A. but in the R.S.A. the possibility exists that the capital costs will form the greatest component due to the volatile exchange rate. The financial sensitivities involved in thin seam mining and their effect on production and cost are discussed in Chapter 22. Extracts from this publication have been used to design the financial model, assess the risks and the sensitivities. It provides a general background on the various thin seam mining methods used in the U.S.A. and other parts of the world.

Very little information exists in the R.S.A. about previous mining of thin seams in KwaZulu-Natal. Spurr et al. (1986) published a few papers on the general geology of the Vryheid and Utrecht coalfields, its qualities and tonnages. Most of the mining problems, production rates and costs are kept in in-house reports and are not available to the public.

Jacobs (1989) identified the relationship between geological conditions and mining problems at Ermelo Mines, but the problems of the thin seam areas here differ distinctly from Dorstfontein as they encountered bad roof conditions, which do not occur at Dorstfontein as frequently as they did at Ermelo Mines.

This document would therefore appear to be one of the few documenting the potential mining of thin seam coal resources in South Africa. This is a radical opinion since thin seam coal mining has become unfavourable due to its high costs and low production rates. It is the opinion of the author however, that this view will change as thick coal seam resources are being depleted and the need for additional coal resources will necessitates the reinvestigation of thin seam deposits. The findings relevant to the Dorstfontein deposit may have far reaching consequences in other mining areas as it may result in substantial increases in available resourcess.

CHAPTER 3: GEOLOGY OF THE NO. 2 THIN SEAM.

3.1 Introduction

Extracts from a 1999 AngloVaal Minerals geological report by Stewardson and Saunderson have been used for this chapter. A few amendments have been made based on additional information that has become available from recent drilling programmes. Underground mapping and recording of mining problems have added to this information, which has been reconciled with the borehole data.

The term "reserve" used in this study complies with the SAMREC code (SAMREC, 2000) as this thin seam area has been included in the approved Environmental Management Programme Report (EMPR) and the mining permission area. The necessary extraction rates are known, the market exists and all the other elements of the definition have been met. The thin seam was not regarded as mineable due to practical reasons like the non-existence of modern high productive equipment.

3.1.1 General

Dorstfontein Coal Mine falls within the Highveld Coalfield and is situated 4 km east of the town of Kriel and 25 km northwest of Bethal. (Fig. 3.1) Adjacent collieries include the defunct Ingwe operated Transvaal Navigation Colliery (TNC), the current Xstrata Mines of Arthur Taylor Colliery (ATC) and Arthur Taylor Colliery Open Cast Mine (ATCOM) which are 15 km to the north, the Anglo Coal operated Kriel Mine and Eyesizwe operated Matla Colliery, about 10 km west (Snyman, 1998 and Baker, 1999). Only Matla and Kriel Collieries are also in the Highveld Coalfield while the other neighbours fall inside the Witbank Coalfield. Other mines in the Highveld Coalfield (Fig. 3.2.) are the SASOL owned Secunda Collieries (Brandspruit, Twistdraai, Syferfontein and Bosjesspruit) at Secunda, the Anglo Coal owned New

Denmark Colliery near Standerton and the Total Exploration SA owned Forzando Colliery near Hendrina (Jordaan, 1986 and Barker, 1999).

Various studies were conducted to determine the local and regional stratigraphy as well as the depositional environment of the Highveld Coalfield (Winter et al., 1987). The area studied by Winter et al. in 1987 was seen as part of the Highveld Coalfield at the time but is currently viewed as the western part of the Witbank Coalfield (Snyman, 1998). The seam correlations and depositional environment are similar to the Highveld Coalfield and may still be used for research. Other researchers have done some work in various parts of the Highveld Coalfield since 1928 and include names like Wybergh, W.J. in 1928, Venter, F.A. in 1934, Stanistreet, I.G. et al. in 1980, Smith, D.A.M. in 1970, Cadle, A.B. and Hobday, D.R. in 1977 (Jordaan, 1986).

T.C.S.A. owns all the coal rights over the farms Dorstfontein 71 IS, Welstand 55IS, Fentonia 54IS and Boschkrans 53IS (Fig. 3.3) (Stewardson and Saunderson, 1999). Mining is currently taking place on the farm Dorstfontein 71IS where a high-grade coal, suitable for export and metallurgical applications, is extracted. The study only deals with the very thin seam coal area (heights between 1.2 and 1.4m) at Dorstfontein 71IS, which was until recently been regarded as un-mineable and thus excluded from reserves.

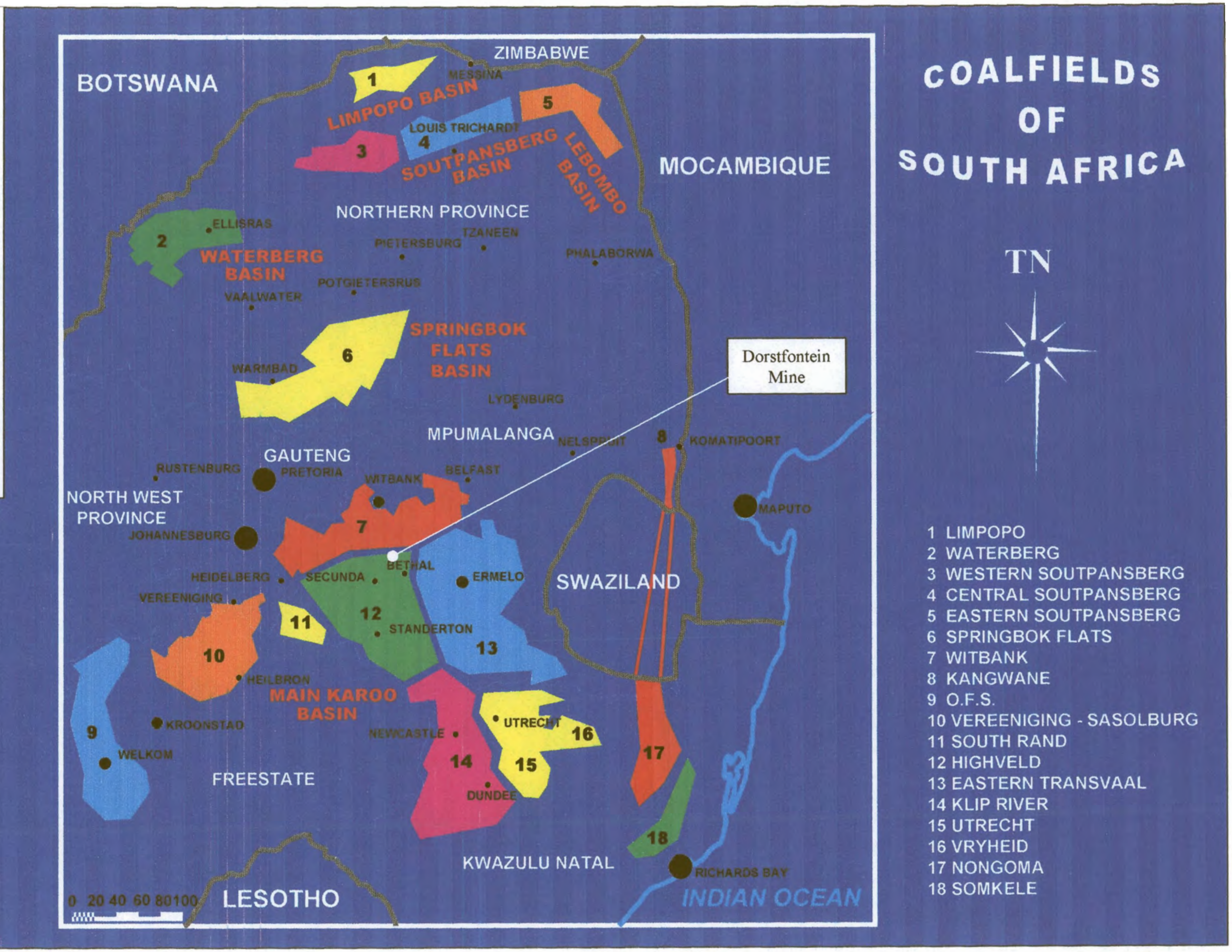

Fig. 3.1. Coalfields of South Africa. (Source unknown)

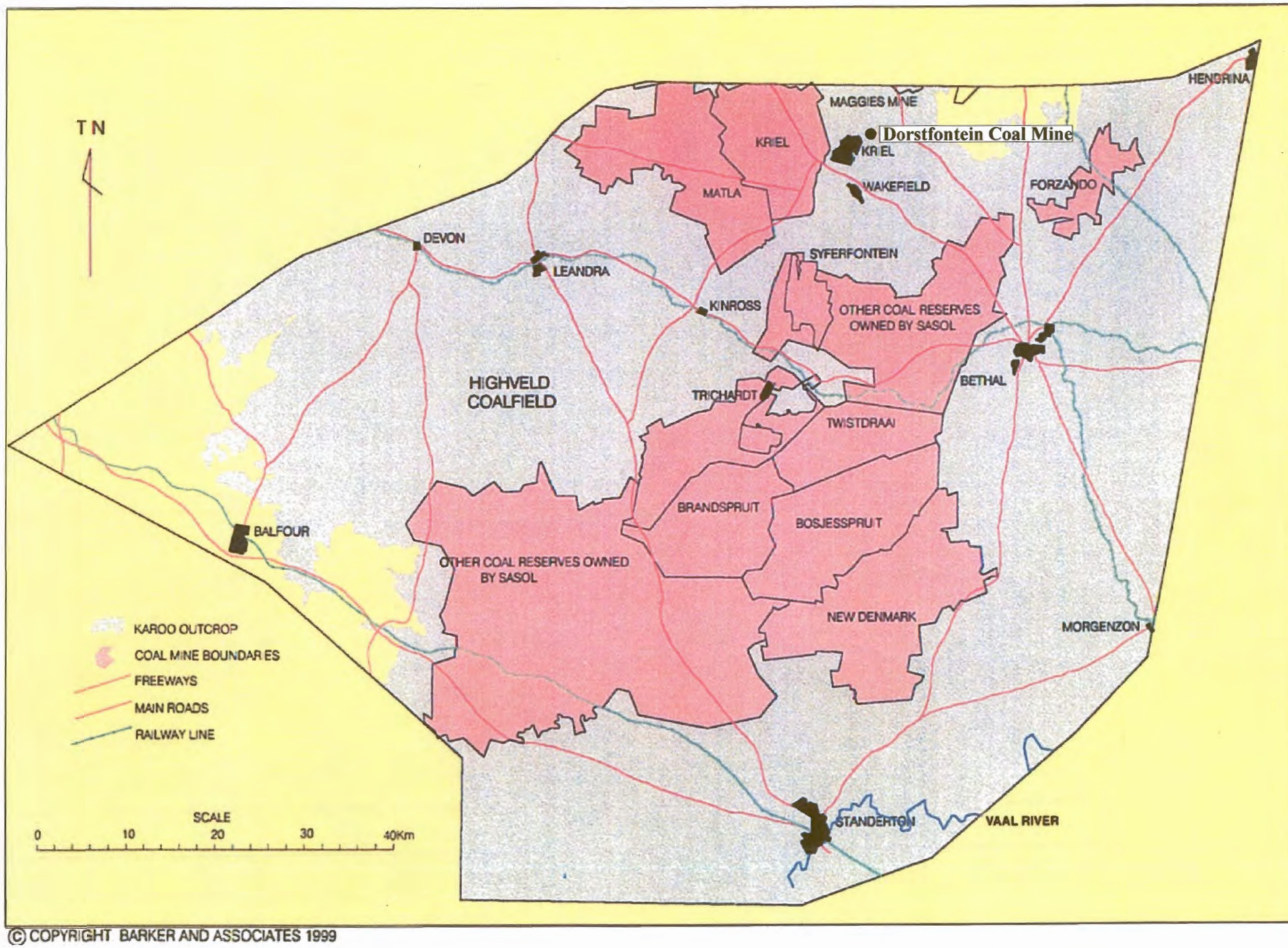

Fig. 3.2 Coalfield Boundaries and Coal Mines of the Highveld Coalfield (after Barker, 1999)

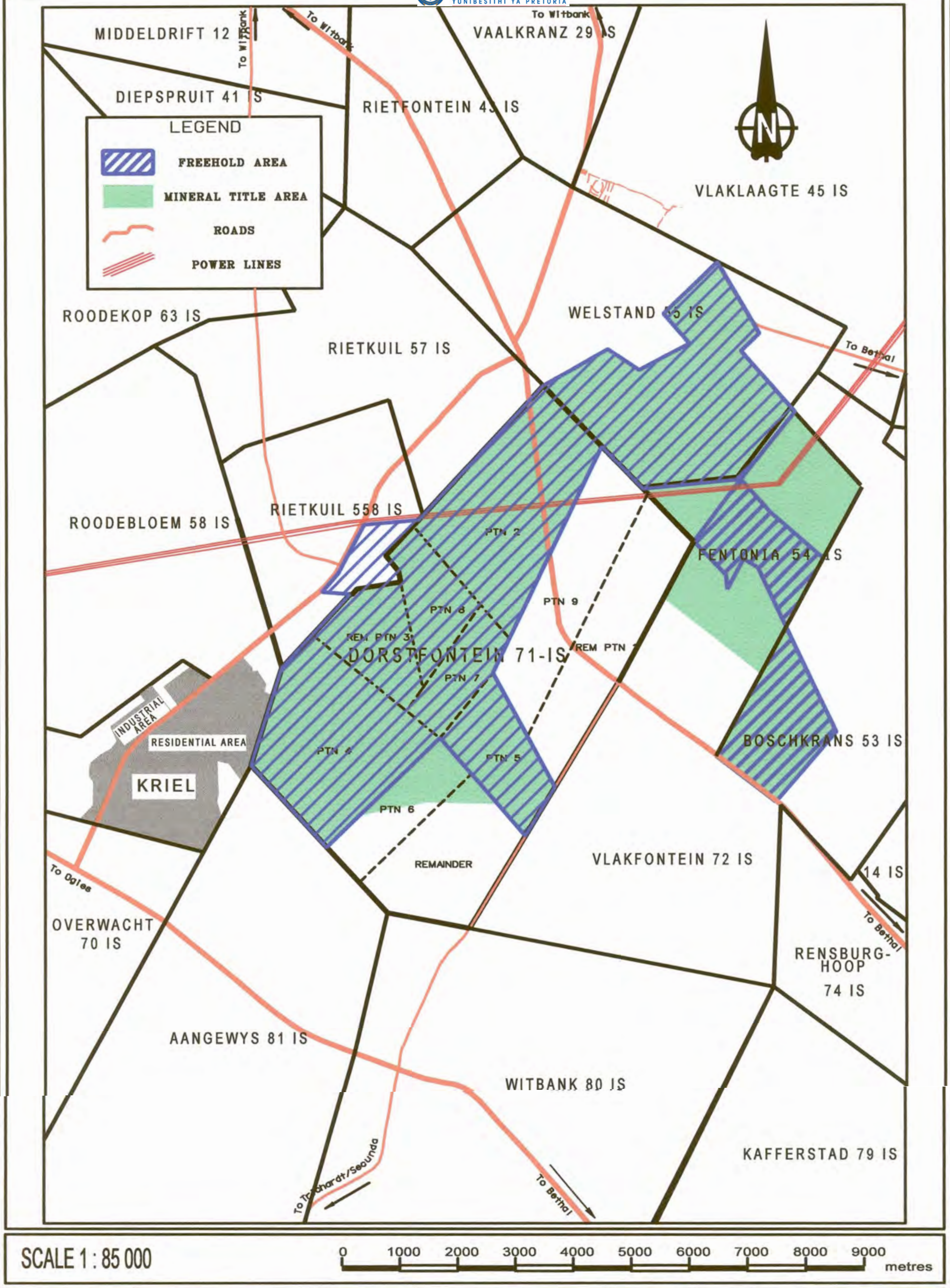

Fig. 3.3. Locality Plan and Mineral Rights. (after Stewardson and Saunderson, 1999)

3.1.2 Topography and land usage

The topography is gently undulating (Fig. 3.4) with a few small tributaries of the Steenkoolspruit draining the property. The previous farmer or owner constructed a few farm dams on the property. The T.C.S.A. owned surface is currently being rented out to farmers who use it for maize cultivation and grazing. The property is sparsely populated by a few farm workers staying in workers huts (Stewardson and Saunderson, 1999). The use of bord and pillar mining methods and the properly designed pillars, prevent surface subsidence. In terms of sustainable development objectives, the surface should be returned to its original use for agriculture as minimal negative impacts on the surface was done by mining.

3.1.3 Mineral Rights

T.C.S.A. owns all of the mineral rights in the mining lease area (Stewardson and Saunderson, 1999). These rights were acquired by AngloVaal Minerals in the 1980s and 1990s and transferred to T.C.S.A. with the selling of Dorstfontein in 1999. Adjacent mineral rights owners are:

- Anglo Coal Plc and
- Mr. N.E. Hirschowitz

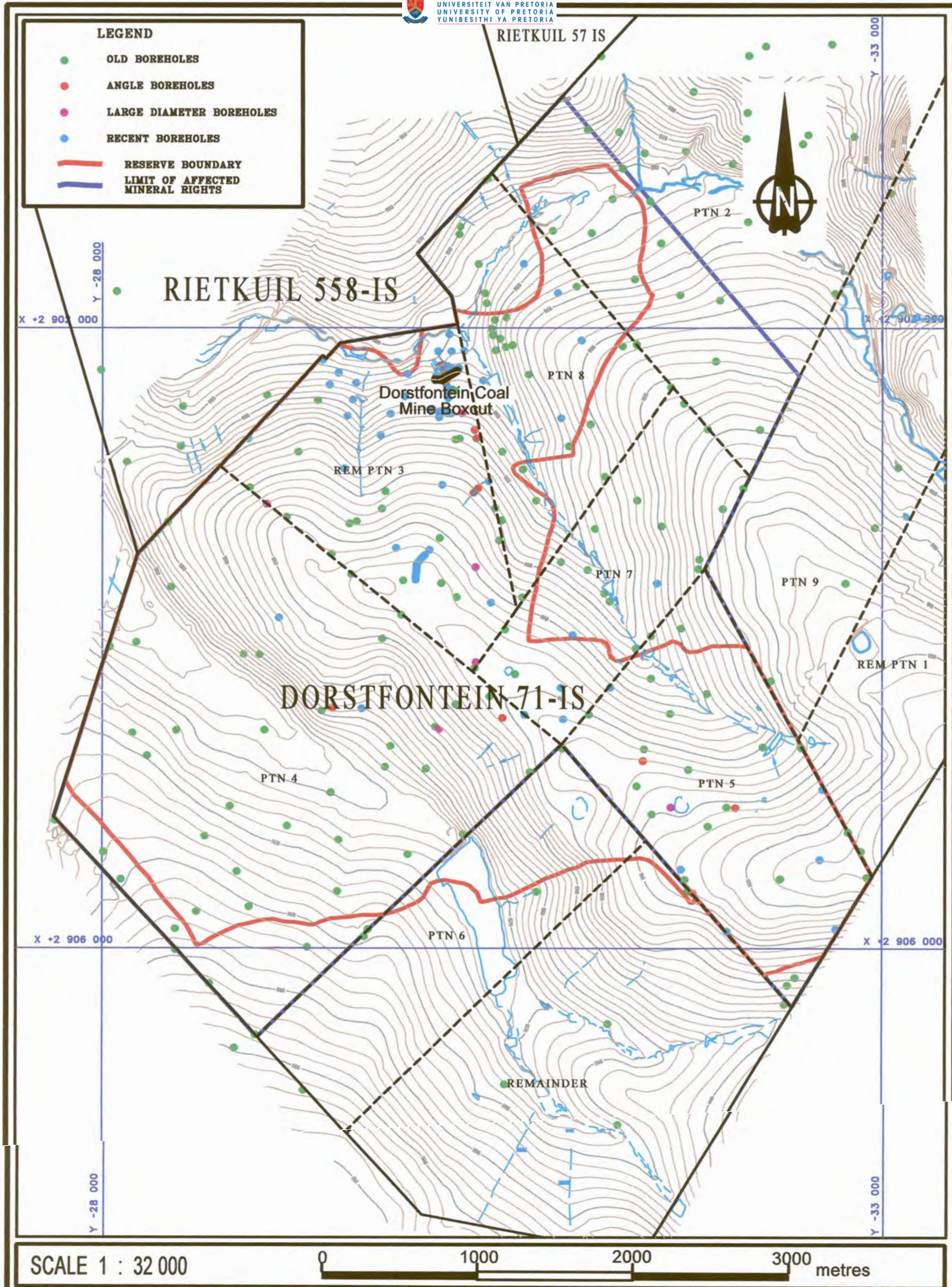

Fig. 3.4. Surface Topography and Borehole Plan.
(after Stewardson and Saunderson, 1999)

3.2 Exploration

Since the early 1960's up to 1999 a total of 174 holes were drilled in the then Dorstfontein resource area of which 19 holes were angled holes to confirm dolerite dyke positions (Fig. 3.4) (Stewardson and Saunderson, 1999). Subsequently another 64 holes were drilled in the reserve area since mining started in 1999.

Anglo American Corporation carried out the earliest exploration in the mid-1960s. Between 1974 and 1975, South Cape Exploration (Pty) Ltd drilled 47 holes on Dorstfontein. A further 43 holes were drilled by Sun Mining and Prospecting during the period 1975 to 1978 (Stewardson and Saunderson, 1999). These holes had limited washability data for the No. 2 Seam as only the No. 4 Seam was prospected for (see Stratigraphical Log, Fig. 3.5). In some cases only proximate analysis were performed on raw coal from the No. 2 Seam. All of the prospecting companies cancelled their optioning agreements and prospecting rights as the No. 4 Seam is of inferior quality and regarded as uneconomical. Options were taken out by AngloVaal Minerals when they considered the No. 2 Seam as mineable. This company drilled another 60 boreholes between 1980 and 1982 with a further 105 holes between 1996 and 1998. All AngloVaal Minerals' boreholes and subsequent T.C.S.A. holes were analyzed at 10 density fractions to get a better understanding of the washability of the coal.

In 1995 a helicopter-borne high resolution aeromagnetic survey was conducted to define magnetic dykes (Stewardson and Saunderson, 1999). Some anomalies were confirmed by drilling angled holes and by ground magnetometry. In 1997 a helicopter-borne EM survey was carried out to define some non-magnetic dykes. Anomalies were identified and angled boreholes drilled which confirmed some of these anomalies to be dolerite dykes (Stewardson and Saunderson, 1999). Most of the major dolerite dykes in the mining area were correctly predicted and very few surprises were encountered during mining. Only a few thin dolerite dykes/stringers were intersected during mining and a few situations the positions of the major dykes were out by not more than 25 meters.

3.3 Stratigraphy

The Pre-Karoo basement rocks consist of granite of the Nebo Granite Suite of the Bushveld Complex and in a few places Transvaal shales and sandstones (SACS, 1980). The granite outcrops close to the box-cut position and defines the northern mining reserve boundary. The basement is overlain unconformably by diamictites and associated glacial sediments of Dwyka age (Winter et al., 1987). These in turn are conformably overlain by sediments of the Vryheid Formation that comprise of a series of stacked upwards-coarsening sequences of siltstone and sandstone. Each sequence is capped by a coal seam (Fig. 3.5).

Five major seams are present and numbered from the base upwards as Seams No. 1 to 5 (Snyman, 1998 and De Jager, 1976). Thickness and distribution of the seams were controlled by paleotopography as well as pre- and syndepositional events (Winter et al., 1987). The best developed and most extensive seam is the No. 4 Seam which reaches maximum thicknesses of up to seven meters. Unfortunately this coal has a very low yield for export products and the calorific value and volatile matter of the seam renders it only suitable for use as steam coal. Currently an oversupply of this type of coal exists but there is always the possibility that some market might become available in the future. The No. 5 Seam is developed only in the topographically elevated areas and the negative experience of other No. 5 Seam producers discourages any mining of this seam. The No. 1 Seam is only locally developed in a small palaeo-valley in the northeast of the mining reserve. It is of inferior quality and uneconomical. The No. 3 Seam is very localized and thin and occurs only in a few places in the deposit. Currently the No. 2 Seam is the only economic viable seam in the deposit and a detailed description is to follow (Fig. 3.6).

Late Jurassic time dolerite intrusions, which coincided with the Gondwana breakup, have resulted in some areas of burnt and or devolatilised coal (Jordaan, 1986). The migration of dolerite sills to different stratigraphical levels had resulted in seam displacement but had only a limited effect on the No. 2 Seam reserve area. The eastern mining reserve boundary has been defined using such a migrating sill as reserve limit (Stewardson and Saunderson, 1999).

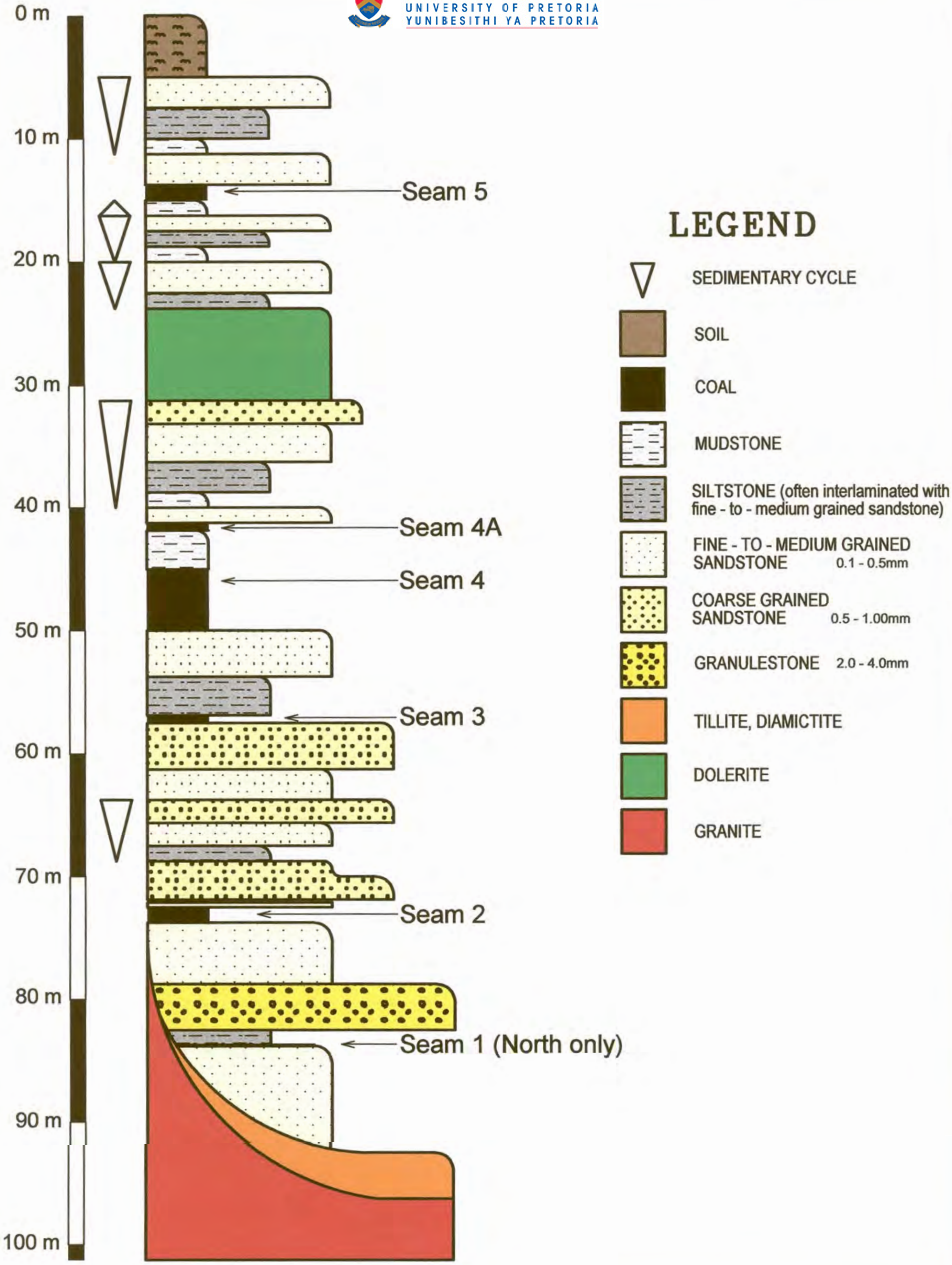

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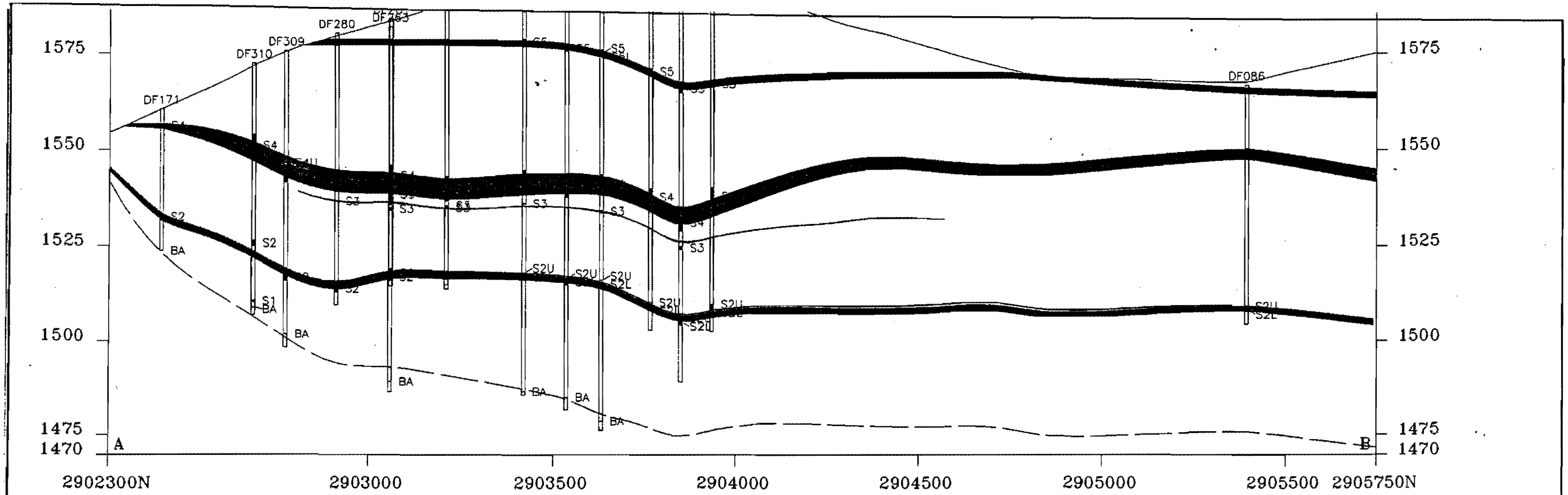
Fig. 3.5. General Stratigraphic Log. (after Stewardson and Saunderson, 1999)



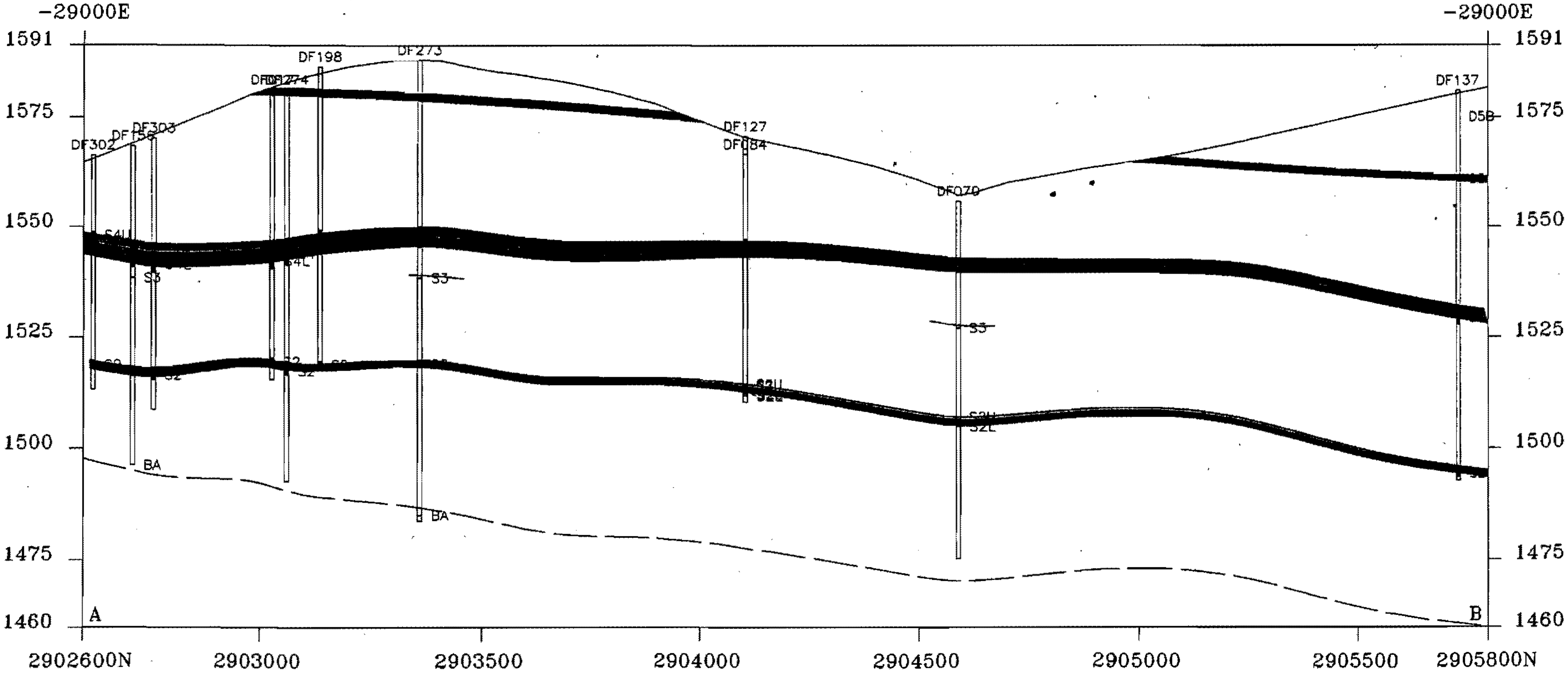


Fig. 3.6. North-South cross-section of the Dorstfontein Deposit (after Bartkowiak, 2001).

3.4 No. 2 Seam and No. 2 Lower Seam

The palaeo-basement geometry determined the geometry and thickness of the No. 2 Seam (Fig. 3.6 and 3.7). The rate at which the surface subsided during peat accumulation controlled the thickness and character of the coal. Height variations can be attributed to pre- and syndepositional geological events (Stewardson and Saunderson, 1999).

3.4.1 Seam splitting

The single coal seam in the north is split into an upper and lower seam in the south by a persistent sandstone parting (Fig. 3.7 & 3.8). The parting is positioned towards the top of the seam and ranges from 0.0 to 0.75m in thickness. The No. 2 Upper Seam is thin (0.01 to 0.35m thick) and only the No. 2 Lower Seam forms an economic unit. In the No. 2 Thin Seam area the parting is thick and as only 0.3m is enough to form a safe beam, this parting will form a proper roof for the lower, mineable part of the No. 2 Seam (Spengler, pers. comm., 2002).

3.4.2 Seam Elevation

The elevation of the base of the No. 2 Thin Seam ranges from the 1511 to 1518m AMSL (Fig. 3.9). The seam topography reflects the Pre-Karoo relief with the seam dipping gently from east to west towards a north-south trending paleovalley. The overall regional dip of the seam is from north to south, that is from the granite outcrop towards the depositional basin. In the study area the coal seam is flat with a barely noticeable dip towards the south.

3.4.3 Seam Thickness

The total thickness of the No. 2 Seam, including the parting, is illustrated in Fig. 3.10. The central area of maximum thickness reflects the zone of maximum parting thickness. In the study area the seam thickness below the parting ranges from 1.2 to 1.4m (Fig. 3.11).

In the area where the seam splitting occurs, the No. 2 Upper Seam is developed and ranges in thickness from 0.01 to 0.35m. There is no correlation between the No. 2 Upper Seam thickness and the underlying parting thickness. The clean, well-sorted sandstone that overlies the No. 2 Upper Seam has generally a thin, silty zone at its base. This suggests disturbance of the peat surface during transgression. The absence of rip-up clasts indicates little or no erosion of the seam (Stewardson and Saunderson, 1999).

3.4.4 Main Parting

The parting thickness ranges from 0.0 to 0.75m with its maximum thickness in an east-west linear zone (Fig. 3.8). The parting consists of an upwards-coarsening sequence grading from lenticular-laminated siltstone through interlaminated sandstone-siltstone to cross-laminated sandstone at the top. The lithology and geometry suggested a crevasse splay deposit, which emanated from a channel system in the east of the reserve area (Stewardson and Saunderson, 1999).

Mechanical strength tests were done on core from the 2002-drilling programme (Spengler, 2002). The results indicated that the parting is competent and will not collapse during mining and that it will form a safe beam if bolted with full column resin roofbolts. The only provision is that the mining method below the parting should not be the conventional drill and blast methods but preferably mechanical continuous mining methods. Mechanical mining methods cause the least disturbance and possible separation of the laminated strata, which could result in the beam thinning to dangerous proportions. In Chapter 7 there is a detailed discussion on the testing of the parting and instructed support pattern.

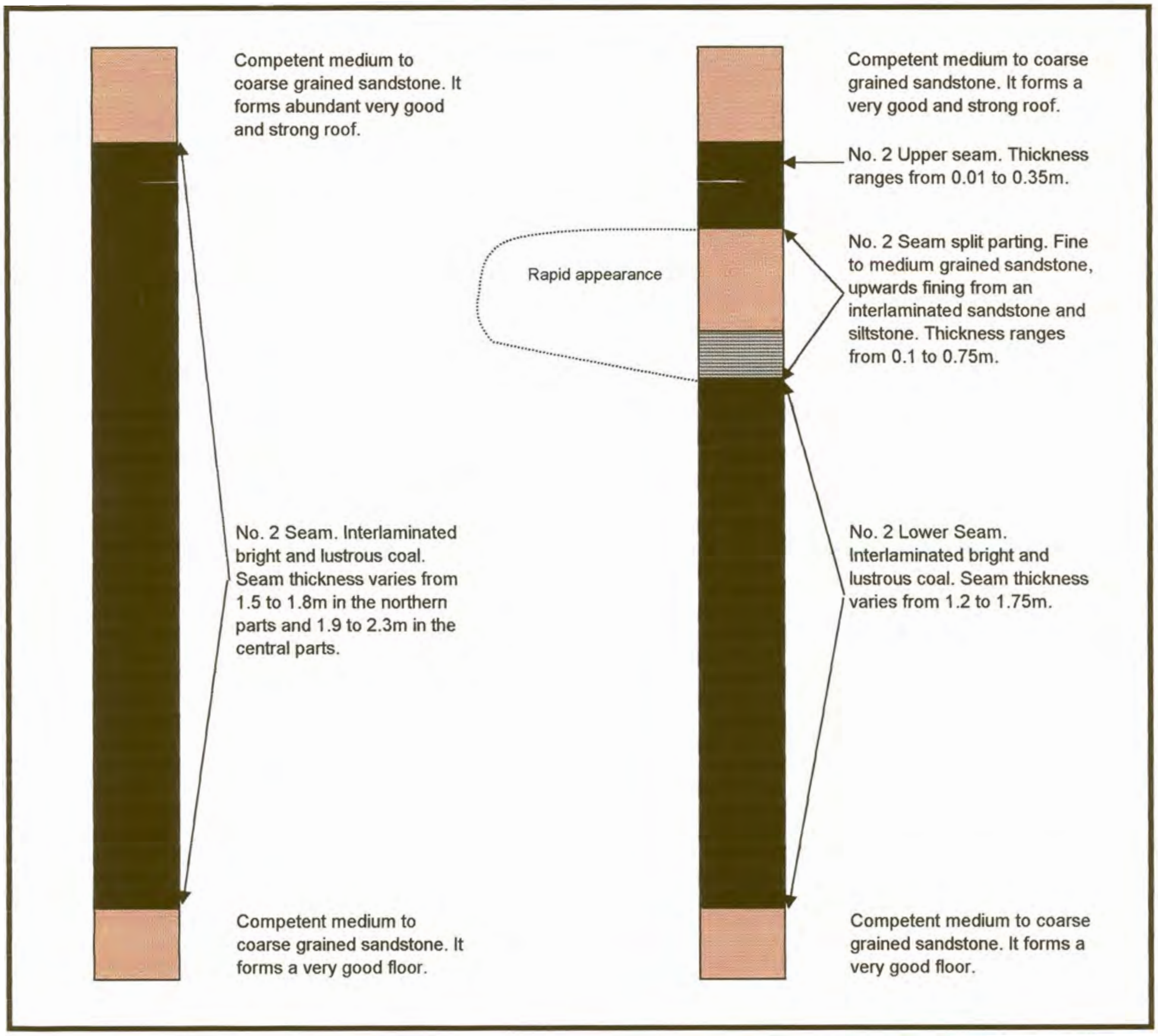


Fig. 3.7. No. 2 Seam and No. 2 Seam Seam-Split Parting.

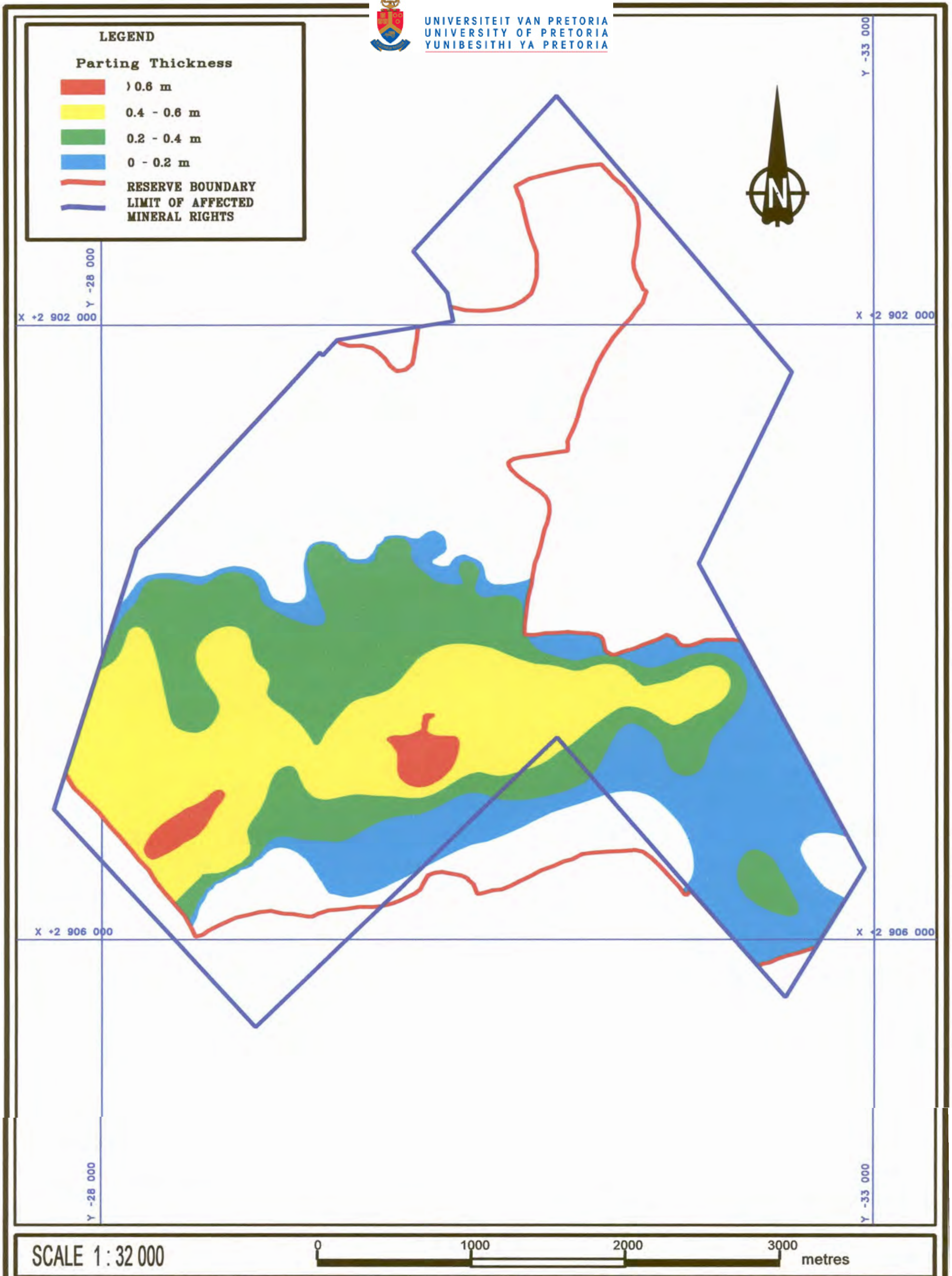


Fig. 3.8. Seam-Split Parting Thickness and Position.
(after Stewardson and Saunderson, 1999)

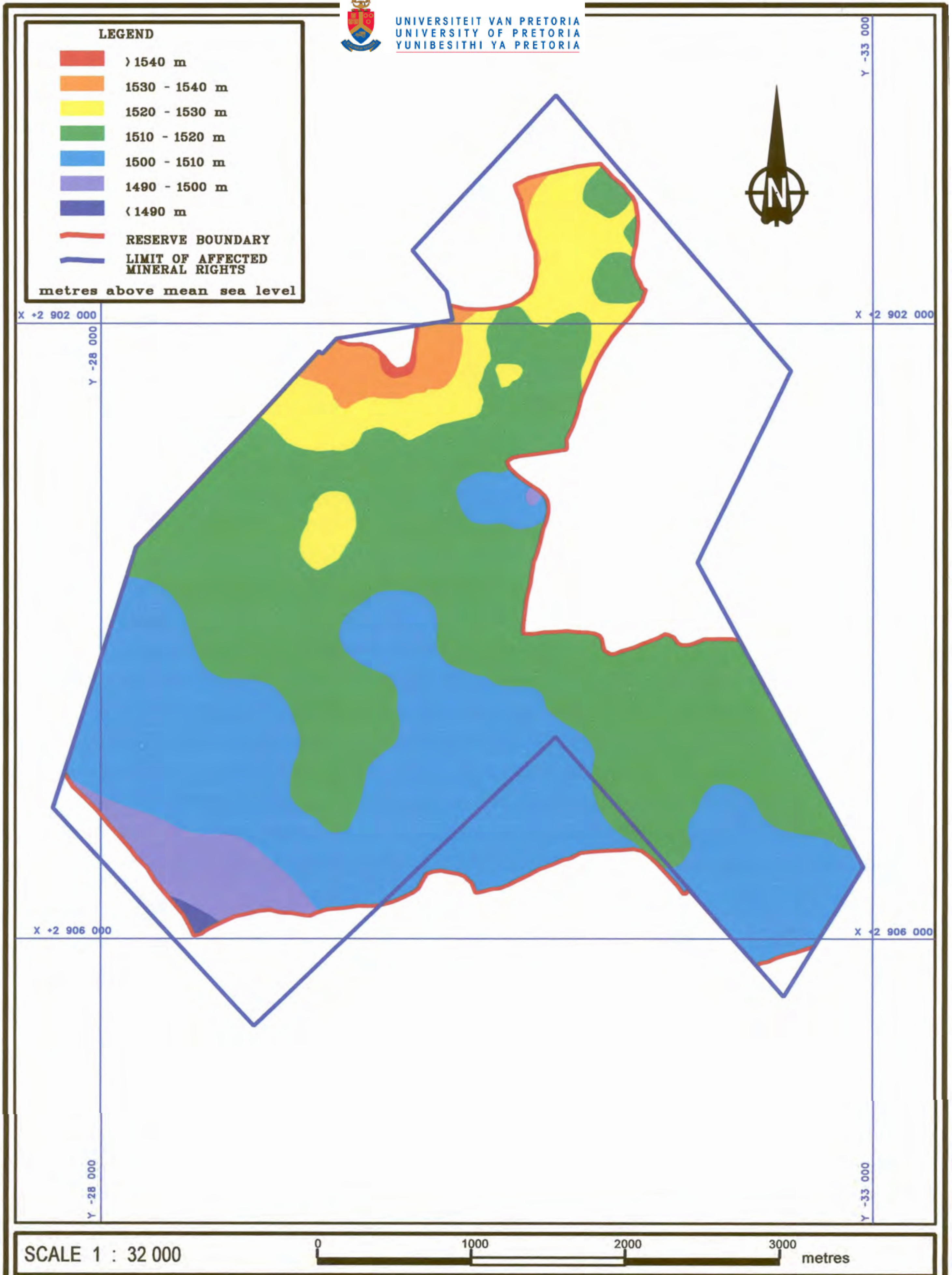


Fig. 3.9. Base elevation of the No. 2 Seam. (after Stewardson and Saunderson, 1999)

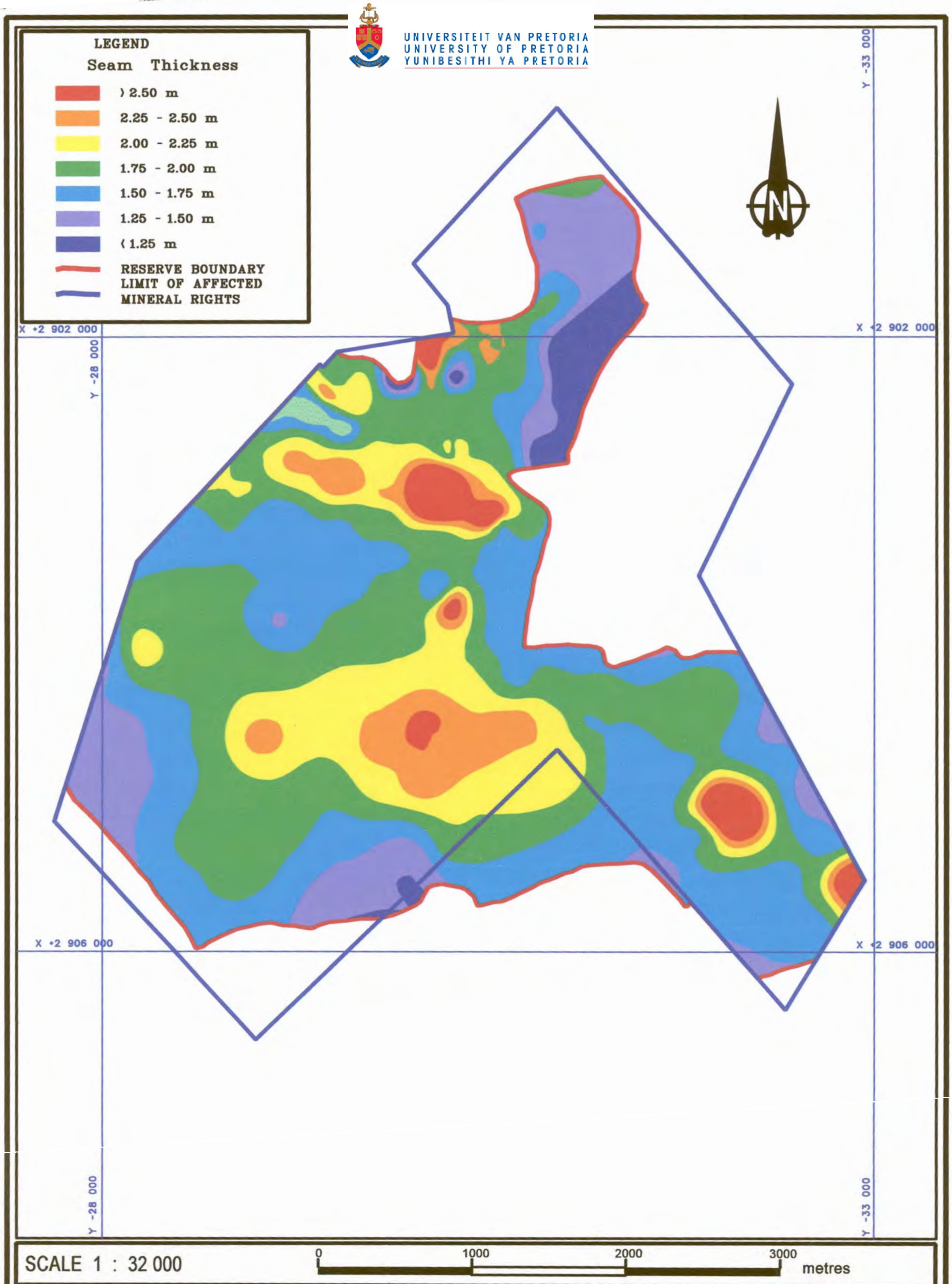


Fig. 3.10. Total Thickness of the No. 2 Seam, including Seam-Split Parting.
(after Stewardson and Saunderson, 1999)

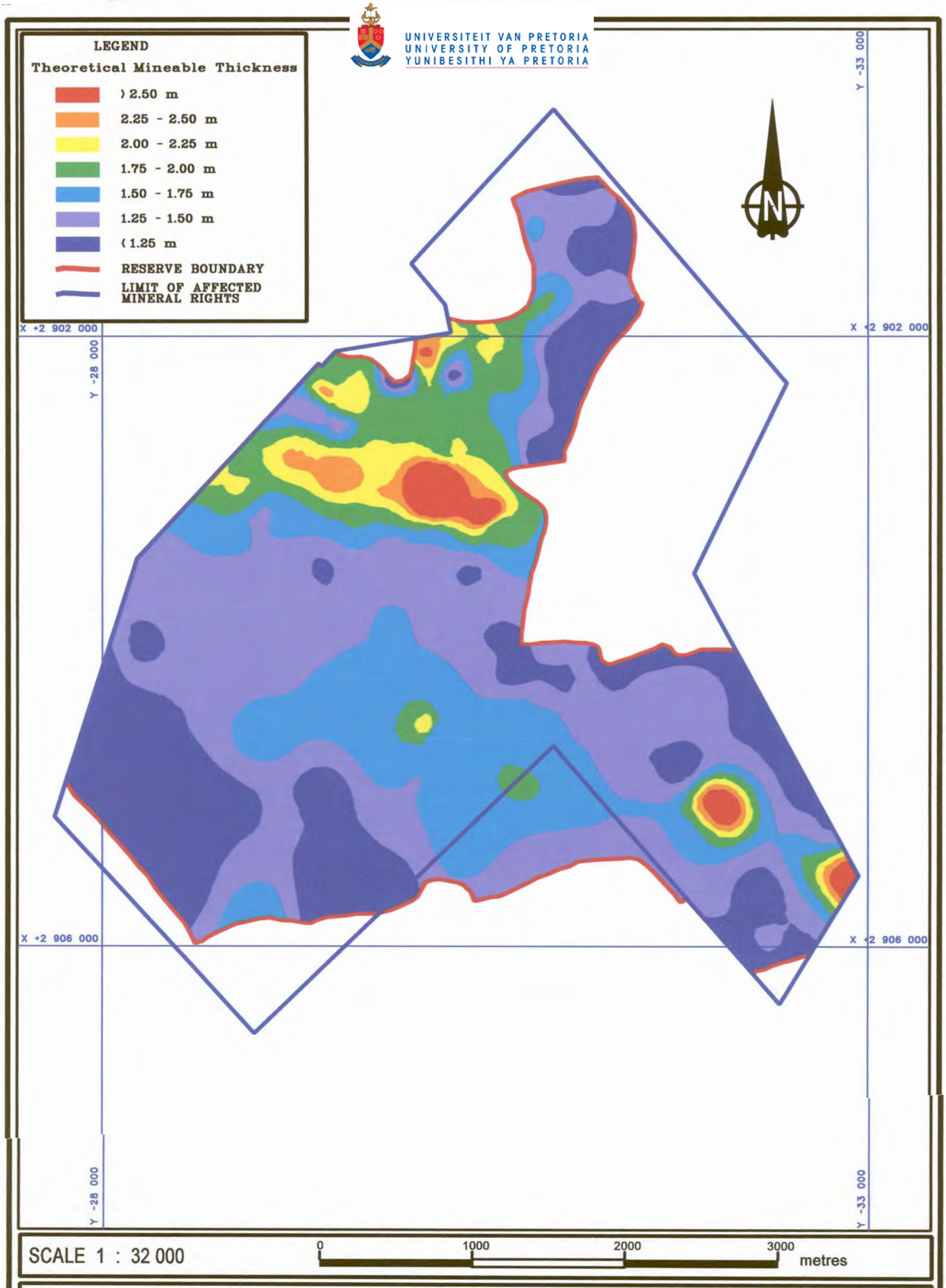


Fig. 3.11. Mineable Seam Thickness of the No. 2 Thin Seam.
(after Stewardson and Saunderson, 1999)

3.4.5 Seam Roof

The purpose of this study is to determine the result and affect if the seam-split parting forms the roof in the study area. However, it would be necessary to do roof stripping (parting) in the belt road and main travel roads to increase heights for the people and vehicles to move. The stripping, normally done to a height of 1.8m, will expose the overlying fine grained, homogeneous, clean and well-sorted sandstone unit, which currently forms the roof. This unit is mostly unbedded and lack silty laminae. Occasional occurrences of bioturbation and cross trough bedding are developed. These occurrences do not have any negative effects on overall rock strength (Stewardson and Saunderson, 1999). All roof rock (parting) will be mined as a second cut and be stowed underground to prevent contamination of the mined coal.

3.4.6 Seam Floor

Competent, medium grained sandstone underlies the seam. The sandstone floor forms the final depositional stage of a prograding delta platform upon which the coal seam developed (Stewardson and Saunderson, 1999). In currently mined areas and old workings, the floor is still competent and did not scale or break-up during vehicle movements. It is expected to behave the same in the thin seam areas.

3.5 Dolerite Intrusions

Magnetic and non-magnetic dykes as well as magnetic dolerite sills occur (Fig. 3.12). These were detected using both geophysical surveys and borehole intersections (Stewardson and Saunderson, 1999). In the study area and the current reserve, dolerite sills do not underlie the mineable seam. In the east of the current reserve a dolerite sill cuts vertically across the strata to outcrop on surface. It underlies the No. 2 Seam in the east, displaces the seam upwards the same distance as the dolerite thickness and thus renders the coal inaccessible and unmineable due to this discontinuity. This position of the sill transgression was used to define the eastern boundary of the current mineable reserve.

In the south of the study area a major magnetic dyke was identified using an aeromagnetic survey. It trends more or less east - west and is near vertical. Mining through this dyke has proved its thickness to be 2.8m at the locality it was intersected.

In the western part of the study area, 3 dykes occur. Mining confirmed their positions during a southern development towards higher seam areas, the so called South Main area. All of these dykes were relatively thin (< 2 m thick) and had no serious effect on the coal seam. It is concluded that these dykes should not pose any serious problem for mining the thin seam area.

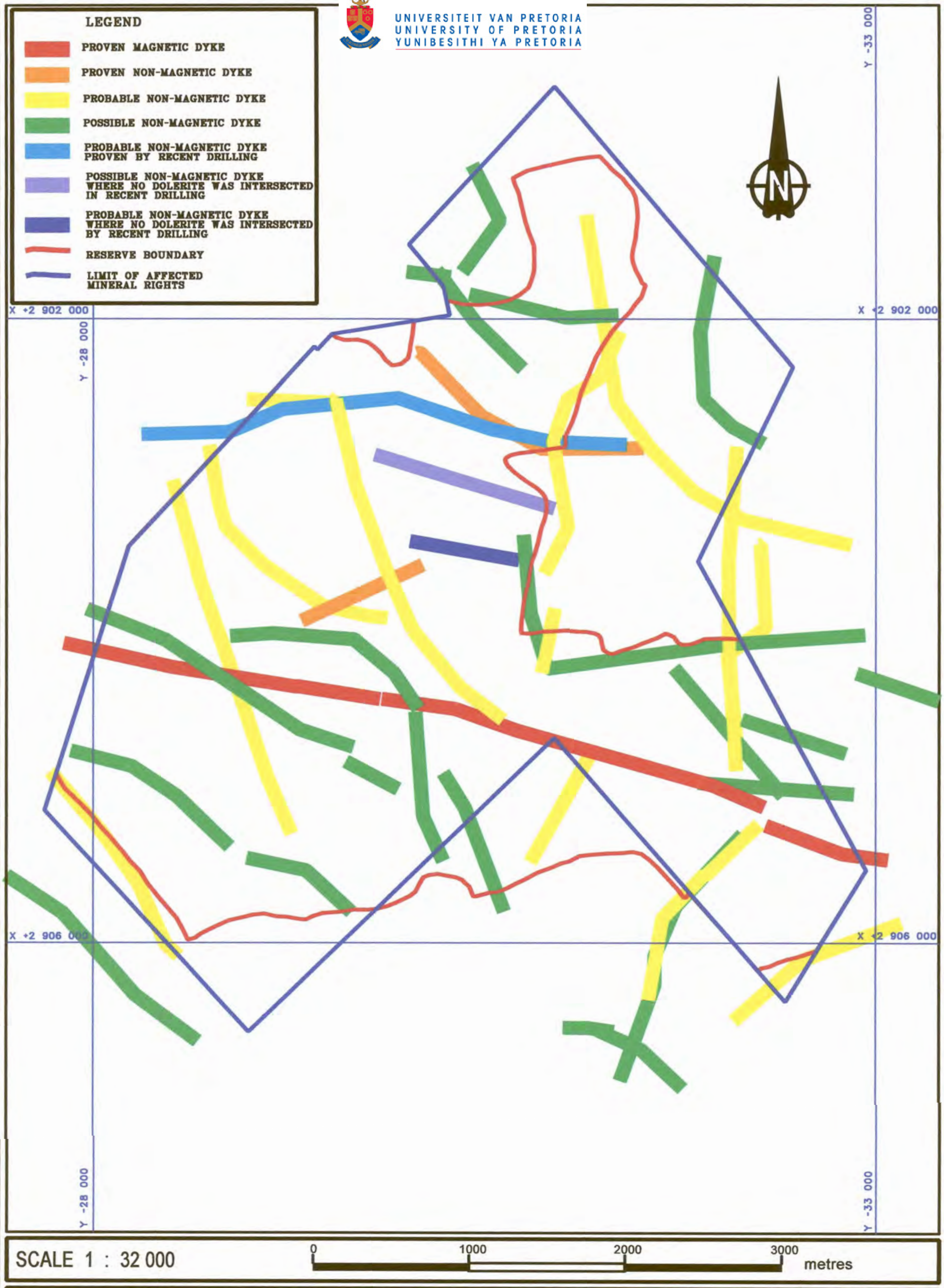


Fig. 3.12. Dolerite Positions. (after Stewardson and Saunderson, 1999)

3.6 Resource estimate and Grade

3.6.1 Summary of Resources and Grade

Tabulated below is the spread of the No. 2 Seam resource at various height intervals.

Table 2. Resources for the No. 2 Thin Seam area (Bartkowiak, 2002).

Thickness Interval (m)	Thickness Cut-Off (m)	Mass per Interval (kt)	Cumulated Mass (kt)	Percentage of Total (%)	Cumulative Percentage
< 1.0	1.0	335.21	335.21	1.17	1.17
1.0 to 1.1	1.1	233.16	568.37	0.82	1.99
1.1 to 1.2	1.2	1513.29	2081.66	5.30	7.29
1.2 to 1.3	1.3	2960.82	5042.48	10.37	17.66
1.3 to 1.4	1.4	4100.36	9142.84	14.36	32.02
1.4 to 1.5	1.5	3707.62	12850.46	12.99	45.01
1.5 to 1.6	1.6	4325.97	17176.43	15.15	60.16
1.6 to 1.7	1.7	5176.15	22352.58	18.13	78.29
1.7 to 1.8	1.8	2011.15	24363.73	7.04	85.33
1.8 to 1.9	1.9	774.86	25138.59	2.71	88.05
1.9 to 2.0	2.0	1007.57	26146.16	3.53	91.58
above 2.0	above 2.0	2405.01	28551.17	8.42	100.00

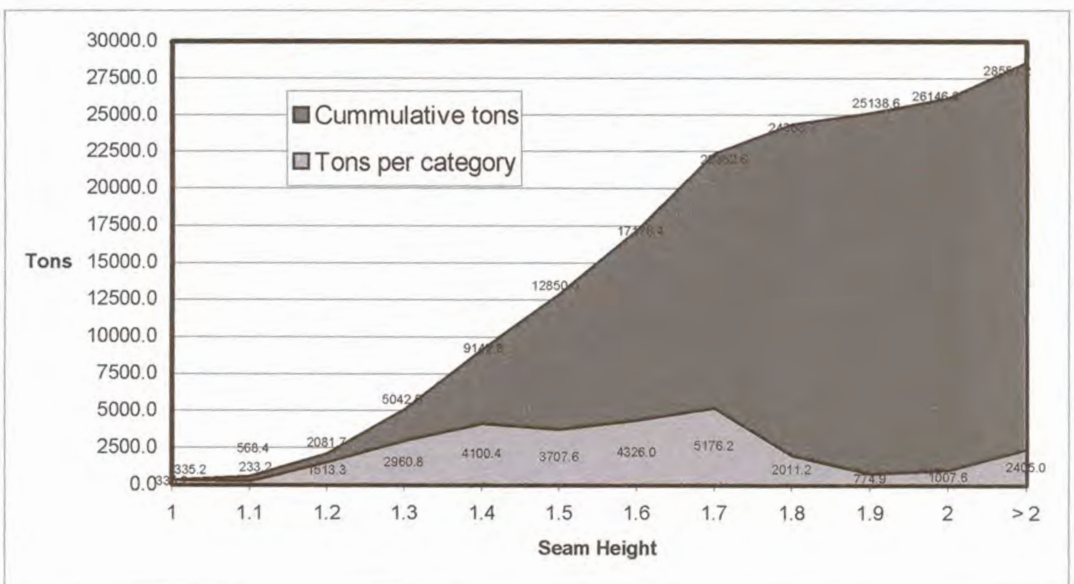


Fig. 3.13. Tonnage distribution against seam heights.

As can be seen, the 1.2 to 1.4m resource constitute 24.73% of the total No. 2 Seam resources. The 1.2 to 1.4m intervals will form 26.68% of the mineable resource if the tonnages below 1.2m are omitted. The estimated mineable resource of the No. 2 Thin Seam coal is 7.06 mt in situ.

Tabulated below is the theoretical washtable for the thin seam resources in the study area. Detailed descriptions of the coal qualities and product parameters will follow in the next paragraphs. Currently Dorstfontein targets the metallurgical market that specifies a minimum calorific value of 26.0 MJ/kg, volatile matter above 26.5%, sulphur content below 1.0%, low ash content and very low phosphorous content (< 0.010%).

Table 3. Average washtable for the No. 2 Thin Seam area (Air dried) (Bartkowiak, 2002)

Float	Yield	CV	Ash	H_2O	Vol	FC	S	Phos
1.35	22.49	30.07	7.21	3.12	32.18	57.49	0.49	0.007
1.37	33.27	32.17	7.57	3.17	32.32	57.95	0.46	0.007
1.40	46.00	29.65	8.14	3.15	30.16	58.56	0.43	0.007
1.45	65.95	29.15	9.23	3.18	28.33	59.27	0.40	0.006
1.50	80.32	28.72	10.25	3.17	27.18	59.41	0.40	0.007
1.60	89.22	28.31	11.25	3.15	26.52	59.08	0.42	0.007
1.70	91.65	28.18	11.59	3.14	26.42	58.86	0.44	0.007
1.80	92.97	27.93	12.20	3.12	26.27	58.42	0.49	0.007
2.20	100.00	26.65	15.54	3.00	25.72	55.75	1.26	0.007

Product	Yield	CV	Ash	H_2O	Vol	FC	S
13.5	95.7	26.1	13.5	3.1	27.4	57.38	0.79
1.6	89.2	28.3	11.3	3.2	26.5	59.08	0.42

From the washtable and product extraction it is clear that the thin seam resource meets the specifications of the established markets. Further more it can be seen that the product yield is high in the regions of the product specifications.

To conclude: the thin seam resource consists of 7.06 mil. tons in-situ coal of the same quality as the current mining reserve. By factoring in an extraction rate of 70% and a geological and mining loss of 10% each, the recoverable (run of mine) tons comes to 3.56 mil. tons. By applying the product yield at a 13.5% ash content (yield = 95.7%) the product tons are 3.41 mil. tons and by applying the yield at RD=1.6 (yield = 89.2%), the product tons are 3.18 mil. tons.

3.6.2 Thin seam resource limits

The main study area is defined by the 1.2 to 1.4 m seam height contour line (Fig. 3.14). A mined-out area forms the northern boundary, while a sill transgression line defines the eastern boundary. There will no other restrictions placed on defining the resource area.

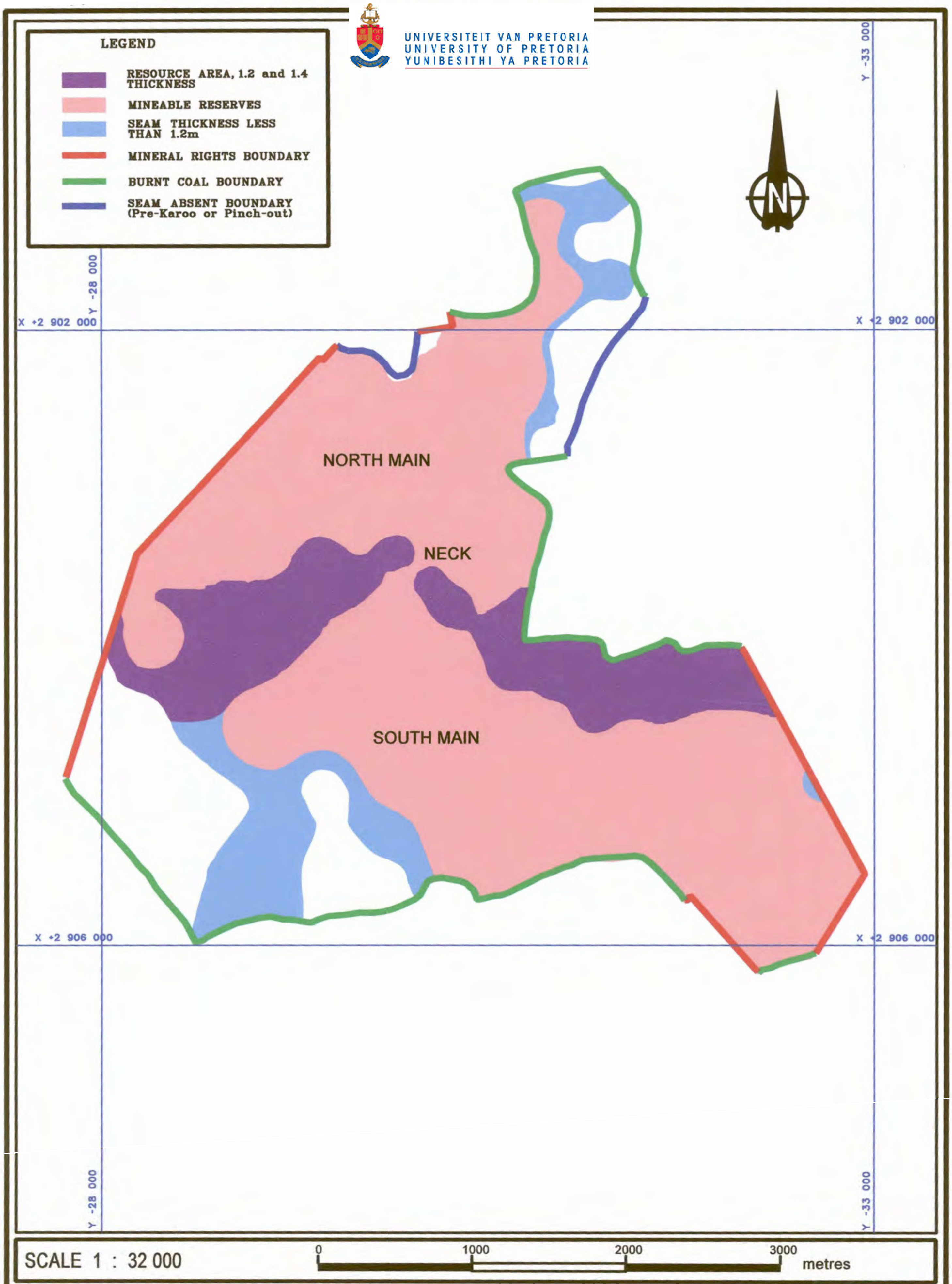


Fig. 3.14. Resource Limits (after Stewardson and Saunderson, 1999)

3.7 Seam Quality

3.7.1 General

For the geological study of 1999, coal quality values were quoted as at R.D.=1.6 on an air-dried basis (Stewardson and Saunderson, 1999). At this wash fraction the mine was viable and the coal could be economically exploited. The quality parameters normally quoted are: Yield, Calorific Value (CV), Ash %, Moisture Content %, Volatile Matter % (Vols), Fixed Carbon % (FC), Sulphur % (S) and Phosphorous % (P). In practice it has been found that it is more practical to wash the coal to achieve 13.5% ash content (Air dry). The market also readily accepted this quality as little change was brought upon the volatile matter and calorific value. Therefore all current qualities are quoted as for an ash content of 13.5%. In the study area the ash content is 11.6% at a R.D. = 1.6. The direct effect of an increase in ash content is an increase in yield. Therefore, in the study area the average yield of 89.2% at R.D. = 1.6 has gone up by 6.5 percentage points to 95.7% at an ash content of 13.5%. This relates to an increase of approximately 2100 tons per month more of saleable coal from the thin seam area alone.

3.7.2 Qualities

Coal and Mineral Technologies, a subsidiary of the SABS, did all resent analysis according to the ISO 1928 standards (The South African Coal Processing Society, 2002). Various other laboratories were used in the past but most of them have closed. Analysis from some of the older borehole data could be used but many of the older holes did not intersect the No. 2 Seam. Since AngloVaal Minerals drilled a 500m grid and T.C.S.A. closed the grid to 250m, enough borehole information exists to confidently predict the coal qualities and tonnage for the thin seam area.

Some of the more important qualities for the thin seam coal are briefly discussed. For Fixed Carbon and Moisture Content, see the details tabulated in Table 4.

3.7.2.1 Yield

The theoretical yield for the thin seam area is 95.7% at an ash content of 13.5% (R.D. = 1.99) and 89.2% at a R.D. = 1.6 (air dry).

3.7.2.2 Calorific Value

The CV in the study area is 28.31 MJ/kg at a R.D. = 1.6 and 27.21 MJ/kg at an ash content of 13.5% (air dry).

3.7.2.3 Volatile Matter

The volatile matter at R.D. = 1.6 is 26.52% and 26.15% at an ash value of 13.5% (air dry), showing very little difference between the two products.

3.7.2.4 Sulphur

It was initially perceived that Dorstfontein had a sulphur problem but the markets steadily accepted slightly higher sulphur values so that the mine is currently meeting all the product specifications. Most of the resource area has an average sulphur content of 0.42% at the R.D. = 1.6 float fraction. At an ash of 13.5% the average sulphur content is 0.79% and in some mining blocks it can go as high as 1.25% because of the free pyrite occupying the cleats. Because of this, the current beneficiation practice to wash to an ash content of 13.5% will not be suitable to produce low sulphur coal. The wash density will have to be reduced to a suitable fraction of between 1.6 and 1.8 to make a low ash and low sulphur product.

3.7.2.5 Phosphorus

The phosphorus content of the entire deposit is below 0.010%. This low value makes the Dorstfontein coal well sought after as a product used in the metallurgical industry.

3.7.3 Additional Analysis

No additional analyses were done on core from boreholes in the study area. It is recommended that the following additional analysis be done for future market requirements (The South African Coal Processing Society, 2002):

- Ultimate Analysis: Carbon, Hydrogen, Nitrogen, and Oxygen.
- Full Ash Analysis: SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, K_2O, SO_3, P_2O_5, MgO, Na_2O.
- Ash Fusion Temperatures.
- Hardgrove Grindability and Abrasiveness
- Forms of Silica.
- Forms of Sulphur.
- Swell and Coking Properties.

It should therefore be concluded that based on the continuity of the No. 2 Seam and the consistency of the seam quality, that a product meeting the market specifications could be produced from the No. 2 Seam thin area.