



DPRU

WORKING PAPERS

**An Overview of Producer
Services in the Mining Industry in
South Africa**

Thomas E. Pogue

No 00/35

February 2000

Development Policy Research Unit
University of Cape Town

INTRODUCTION

This working paper forms part of a broader research programme undertaken by the DPRU and the Christian Michelsen Institute (CMI), Norway, on the interrelationship between producer services and the mineral sector. The focus of this particular paper is the role of producer services in the mining sector of South Africa. The objective is to understand what producer services are spawned by the mining sector, what role they play in determining the performance of mining firms, how the firms have chosen to organise their provision and what broader impact have they had on the economy.

The first chapter of the paper is an examination of the mining sector in South Africa. It begins with a brief discussion of the sector's historical development since the discovery of diamonds 130 years ago. This is followed by a close look at the historical structure and performance of mining in South Africa where different minerals have come to the fore at different times. Finally, the chapter examines the impact of mining on the greater South African economy through its contribution to GDP, employment and trade.

The second chapter of the paper examines the mining firm and its production processes. It begins with a description of the emergence of mining finance houses - a peculiar feature of the South African mining sector. The production process is then detailed from the project tasks of exploration and feasibility studies, through to commissioning, operations and lastly decommissioning. The final component of this chapter looks at which producer services are used in each step of the production process and how they impact on the performance of the mining firm.

The final chapter of the paper takes a close look at how a typical mining firm organises the producer services it uses in the production process. The firm used as a case study is the Anglo American Corporation, the dominant mining finance house in South Africa. The chapter begins with a brief history of the corporation from its beginnings in 1917. The second section of the chapter examines how and why Anglo American has organised its producer services between provision by the Chamber of Mines, the Group, the individual mines and outside contractors. It then continues to look at how these services have performed and how their organisation has changed over time in response to changing circumstances. Finally, the last section concludes by asking whether these services have had an impact on the broader economy.

1. THE MINING SECTOR

1.1 Introduction

Identification is a common problem in many empirical exercises. In our study of South African producer services, the recurring difficulty of aggregation and disaggregation of economic sectors has further complexity because of an inter-relationship between the various sectors. In South Africa, a cluster of inter-related economic sectors form a coherent entity, the minerals/energy complex (MEC). An important criticism of much of the political economic analysis done in South Africa to date has been their neglect of the MEC¹. Our focus on producer services is not a comprehensive analysis of the MEC, but an analysis of two of the MEC's major components, petrochemicals and mining.

In this chapter, we take an overview of the historic development and contemporary characteristics of the mining sector. The mining sector has undergone considerable qualitative change and has a transformed relation to the MEC from that of 100 years ago. Importantly, mining continues to be a force in South Africa's economy, but the role which mining plays in economic development has progressively become less direct. Section one provides an introductory overview and is then followed by brief historic and contemporary sketches of South Africa's principal mineral sub-sectors. Sections three and four then present, respectively, domestic and international economic statistics on South Africa's mining sector, followed by a brief summary and conclusion. This chapter's overview of the principal characteristics of the South African mining sector sets the stage for our analysis of producer services, which occurs in chapters two and three, with analyses of firm structure and operational organisation.

1.2 A Brief History of the Sector

In South Africa, Western mining practices began in the copper mines of Springbok and the Northern Cape in 1852². A few discoveries of large diamonds in the Northern Cape led to a diamond rush in 1869. This inflow of European fortune seekers, then in 'remote' Africa, was subsequently rationalised into mining operations that lay the foundation for South Africa's modern mining sector. Even then, it took the discovery of gold and the development of the Witwatersrand in the last decade of the 19th century and the first decade of the 20th century to give substance to the earlier foundations. When the South African Union was formed in 1910, the early mining finance houses had been created and the nascent operational structure of the minerals sector, the group system, both formal and informal, had been established.

The growth of South Africa's mineral sector for large part mirrors that of the development of the mining finance houses discussed in chapter two. Amalgamation of diamond interests and development of the Witwatersrand goldfields required an inflow of international capital. Early on, the important players in South African mining were large, financially well connected firms. This condition arose because at the turn of the 20th century, South African gold mining required an unprecedented scale of operations. The large mining firms that developed found themselves in a nourishing environment. This was because South Africa and the surrounding nations of Southern Africa are endowed with most major types of economically important mineral deposits.

¹ Fine and Rustonjee (1996) provide an overview of the problem and discuss shortfalls of some of the previous political economic analyses.

² A map of mining deposits in South Africa is available in the appendix for those unfamiliar with SA geography.

Gold's pre-eminence, until recently, hedged South African mineral firms from volatile fluctuations in international mineral prices. It is probable that this is an important factor in explaining why, compared to other developing nations with similar dependence on mineral resources, South Africa has achieved an advanced (although skewed) level of economic development. While it is not the only significant characteristic in contemporary South African mining, the historic stability and predominately upside which gold provided, stands in important contrast to the current gold market.

The development, more than a century ago, of gold mining on the Witwatersrand generated unprecedented direct and indirect demand in South Africa's economy. The development of large-scale coal mining is an example, as despite previous knowledge of coal deposits their exploitation was not an economic proposition until the gold mining boom on the Witwatersrand. With the building of railroad infrastructure to transport large mining equipment to the rand, a further impetus to the coal mining industry and general economic development was created. Perhaps the most important influence though, was the electrification of the gold mines that began in 1906 and became the foundation for coal demand. This was further boosted when the state-owned Electricity Supply Corporation (ESCOM) was established in 1922. When the state-owned Iron and Steel Corporation (ISCOR) was founded in 1929 yet another major economic sector became intricately linked to South Africa's coal resources. South Africa's coal resources led to the formation of still another major industrial sector, when under pressure from fuel shortages in 1950, the government established the South African Coal, Oil and Gas Corporation (Sasol)³. The large coal deposits have been a major force in the economic development of South Africa and intimately complimented gold in the building of South Africa's mineral energy complex.

It should be noted that while diamonds, gold and coal were the major mineral industries, South Africa has increasingly diversified its mineral operations. Currently South Africa is largely self-sufficient in mineral resources. In 1995, less than 0.05 percent of South African local mineral sales was imported. As will be discussed below, over the last few years platinum and its family of metals, platinum group metals (PGMs), have significantly expanded in importance for South African mineral production. We will now turn to a brief analysis of important historic development in South Africa's major mineral sectors.

Table 1.1: Composition of South Africa's Mineral Output

Year	Gold	Diamonds	Coal	PGM	Other
1920	73.8%	16.7%	7.3%	0.0%	2.2%
1930	80.3%	10.4%	6.2%	0.6%	2.6%
1940	91.1%	1.9%	4.1%	0.3%	2.6%
1950	73.6%	7.2%	7.4%	1.1%	10.7%
1960	62.6%	4.0%	6.4%	N/A	27.0%
1970	53.2%	4.8%	7.0%	N/A	35.0%
1980	67.0%	3.6%	9.7%	5.5%	14.2%
1985	56.1%	2.6%	18.7%	7.3%	15.3%
1990	45.7%	N/A	19.6%	12.4%	22.2%
1994	49.2%	N/A	20.4%	11.5%	18.9%
1995	43.1%	N/A	23.7%	N/A	33.3%

(Note: information N/A - not available – is part of the Other category.)
Source: CSS SA Statistics 1979-1995.

1.3 Structure and Performance

1.3.1 Diamonds

³ Sasol is the second case study in this project.

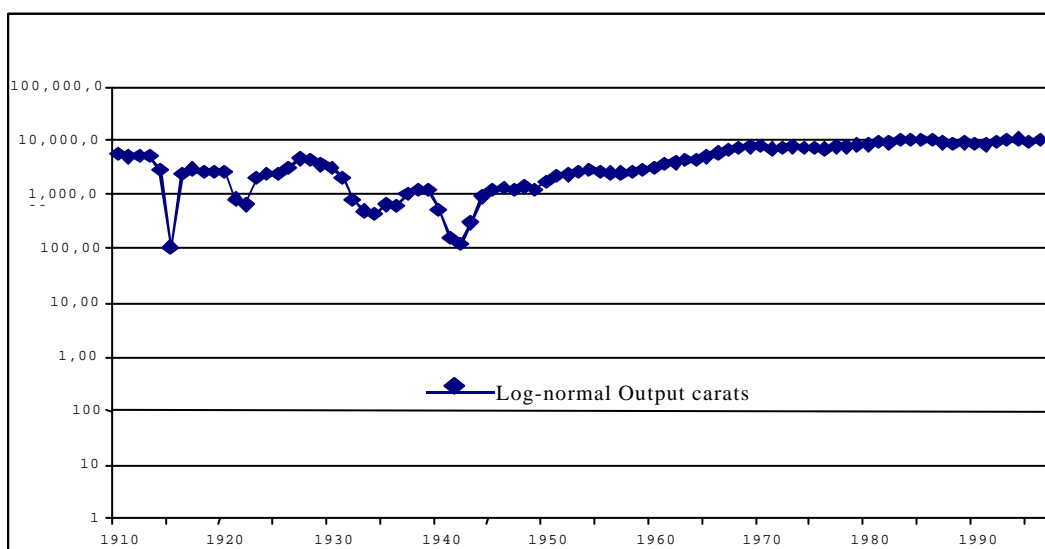
While diamonds were first discovered in the area near what is today Kimberley in 1871, it was not until 1880 that production began to be consolidated in more capital intensive mining corporations. Mining of the three big pits (de Beers, Dutoitspruit and Bultfontein) in the most efficient manner required systematic extraction through a comprehensive plan. Numerous small mining operations were created by the small size of the original diamond claims leading to a quilt of small claims that were dangerous at the increasing depths. This web of complex claims prevented the best mining methods from being used until 1889 when control of the three diamond deposits was secured and comprehensive mining began (Williams, G. 1904). By 1891, a diamond alliance was completed giving three men and their respective companies control of 90% of the world output. These three men and their companies united a disparate industry into an enduring icon of diamond production, de Beers. The alliance that formed De Beers became an important source of funding in the later 19th century for British Imperial ambitions, particularly the personal one's of Cecil John Rhodes (Walker, E.A. 1957).

This control was not enduring however, as new deposits in the first decade of the 20th century in South Africa, Namibia, and the Belgium Congo eroded the market stability they had secured. Feeding on income from its lucrative gold operations in the Far East Rand, the Anglo American corporation secured a crucial market position in diamonds with its purchase of diamond concessions owned by Germans in Namibia (Innes, D. 1984). Overproduction from these new deposits hurt de Beer's income and after being outmanouvered in securing control of them, de Beers was taken over by Anglo American corporation in 1929. By that point the Great Depression had shattered demand, production was cut back, and stocks accumulated to preserve the price as much as possible (See Figure 1.1).

Following World War II, the market improved, but in the 1950's General Electric corporation began production of synthetic diamonds, which were a major threat to de Beers. De Beers met this challenge by entering the field as well. Currently, synthetic industrial diamonds account for 90% of the world's industrial diamond supply (Damarapurshad, A.K., 1997). With the improvement in market conditions after World War II, de Beers used this money to invest in other mining and industrial ventures in order to protect it from the volatility and inevitable downturns in the diamond market.

As can be seen in Figure 1.1, diamond production has continued to increase, but its importance in South Africa's economy has decreased. de Beers remains pre-eminent in its position in the diamond market, but the contribution of diamonds to the national economy has decreased. This decrease can be seen in Table 1.1.

Figure 1.1: Annual South African Diamond Output



Source: Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

1.3.2 Gold

The first recorded discovery of gold by Europeans in South Africa was that of Carl Mauch in 1868 near the Olifants River in the Transvaal. Then, once the diamond mines near Kimberley had been discovered in 1871, the sanctity of the Afrikaner's rural existence was interrupted by increasing numbers of fortune seekers⁴. When gold was discovered near Barberton (1883) in what is now Mpumalanga, the Afrikaner government of the Transvaal Republic attempted to limit prospectors. The numerous small and scattered deposits plus a lack of governmental experience impeded these policies, and by 1886 Barberton was in the midst of a temporary boom. In February of the same year, gold on the Witwatersrand was first discovered, an event of infinitely greater significance for what eventually became South Africa. The Witwatersrand gold deposits were geologically unprecedented. Previously, gold had only been found in relatively small deposits in veins or as surface flakes. In the Witwatersrand however, gold was intermixed with other minerals at relatively low levels, but on a huge scale. This meant that radically different mining methods would be necessary.

Open-cast mining on the Witwatersrand was short lived and within a year of its discovery underground, extraction of gold-bearing ore had commenced. Proximity to the Kimberley Diamond Fields would have a terrific influence on the mining of the Witwatersand, particularly in establishing industrial and labour structures. Near perfect inelasticity of demand for gold, caused by the gold standard and the relatively small size of annual gold mining output with respect to the stock of world gold, was also a crucial influence. Early cooperation in provision of the necessary factors of production and pooling of information on a variety of technical challenges faced by the mines laid the foundations for an industrial structure that would eventually expand beyond gold mining to other types of mining. The demand faced by the gold firms was Intra-industry cooperation in gold, and later coal mining, was institutionally embodied in the Transvaal Chamber of Mines, which is today known as the Chamber of Mines of South Africa.

A few early bugbears added question to the significance of the Witwatersrand gold deposits, namely the continuation of gold at depth and the economic extraction of gold from pyritic soils encountered at deeper levels. By the early to mid 1890's these problems had been solved, but it was not until after political security had been gained and labour supply secured that large-scale deep level mines on the Witwatersrand gained an unquestionable permanence. Predating this was the emergence before the Anglo-Boer War of large gold mining houses. Their economies of scale, particularly in the provision of expensive consultative services, became an important driving force in the viability of gold mining on the Witwatersrand.

The first three decades of the 20th century saw the South African gold mining industry become an increasingly modern industrial organisation. The industry worked through difficulties with industrial relations and the geographic shift of majority gold production from the Central Rand to the East Rand. The world depression circa 1930 should have permitted South African gold producers to benefit from international economic uncertainty. However, as the price of gold was pegged to the British pound at that time, it was not until the British suspended gold convertibility in September 1932 that South African gold mines could have benefited. Domestic insistence at keeping convertibility of the South African rand postponed yet longer a clear boost to the industry, but in late December 1933 South African gold production benefitted from suspension of conversion to gold for the rand.

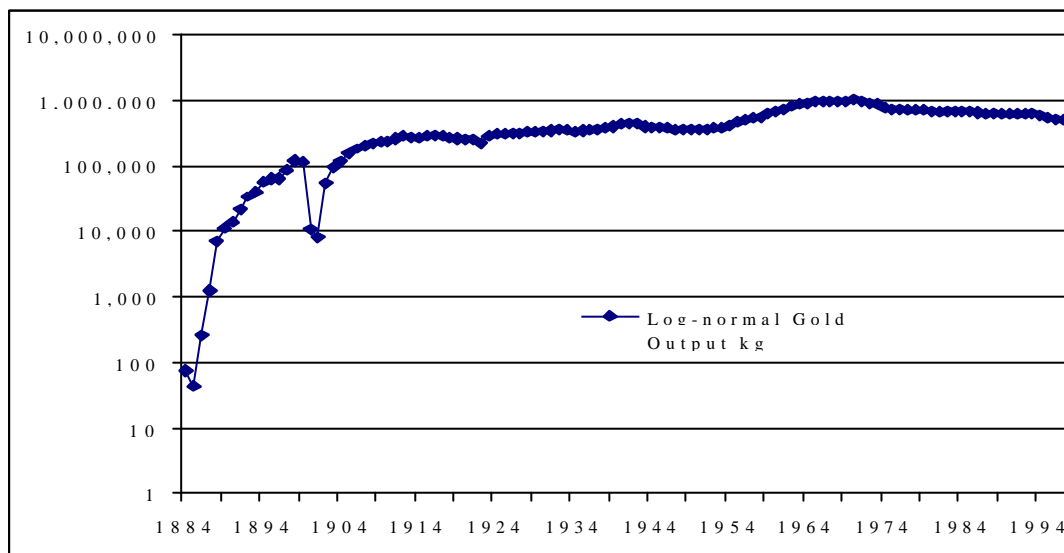
New survey technology in the 1930's led to the discovery of significant new gold deposits in the Far Western Rand (approximately 60km west of Johannesburg), in the region near Klerksdorp (approximately 160 km west-southwest of Johannesburg), and in the Orange Free State (approximately 280km southwest of Johannesburg). Development of these new resources was delayed by World War II. Existing gold production, however, continued in the war as it had in the First World War, to support the war effort. When the war was over, South African mining finance houses went in search of the large sums of financial capital needed to develop the gold deposits they had identified before the war. Their success in raising capital came at a particularly important period in South Africa's economic development. World War II had given a large boost to domestic industries. Thereby, the financial resources of the large mining finance houses came to play an important role in the industrial development of South Africa by continuing the domestic demand generated during the war.

⁴ Morrell (1940) gives an excellent overview of the international fortune hunters of this era.

Inflation in the years after World War II caused a constant real decrease in the sale price of gold because of the fix at \$35/oz under the Bretton Woods Agreement in 1948. Thus, despite increased output (see figure 1.2), an increasing pinch on South African gold producers was felt as inflation raised costs. The government provided some assistance to the industry beginning in the mid-1960's, but it was not until the Bretton Woods agreement began to unravel in 1968 that inflationary pressures on gold producers began to ease as the price of gold began to rise⁵.

Even with the rising price of gold, difficulties plagued South African gold mining throughout the 1970s. Foreign labour sources were decreasing and domestic labour was sought in an increasingly hostile climate. With price pressure easing, the mines began to pay higher wages. By the early 1980s, gold reached all-time high prices. The price of gold had added volatility to an industry that was built on a relatively stable price. Perhaps more important for South African gold mining in the 1980s and into the 1990s has been the increasing depth of the gold reserves. This, along with the difficulty of mining at these depths, have forced a large R&D effort to be undertaken to develop new technology to permit continued economically viable gold mining in South Africa. A decreasing gold price throughout much of the 1990s has added further importance to this endeavour.

Figure 1.2: Annual South African Gold Output



Source: Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

1.3.3 Coal

The importance of coal resources to the South African economy is demonstrated in the role they played in the development of several of the most important industries, i.e. gold mining, ESCOM, ISCOR and SASOL. Indirectly through these industries, as well as directly through exports, coal has been fundamental to South Africa's economic growth and development⁶. In 1995 four large mining groups produced 87% of saleable coals, they were Ingwe 36%, Amcoal (a division of Anglo American Corporation) 23%, Sasol 20% and Iscor 8% (Prevost, X.M, p. 41, 1997).

Figure 1.3 gives an historic overview of South African coal production. In 1890, South African coal production was 500 000 tonnes by 1900 it was two billion tonnes. The Transvaal-Victoria Falls Power

⁵ Although the Gold Standard was officially abolished in 1971, it began to unravel much earlier when a significant black market for SA gold developed in 1968.

⁶ Lang (1995) provides an excellent overview of the role that coal has played in South Africa.

Company began developing power stations on the coalfields around 1910. In the 1930s and 1940s, ESCOM established a captive colliery policy, causing coal demand and production to grow rapidly (Ibid. 1997, p. 49). The first small exports of coal, principally from Natal, began around 1910. However, in 1951 when the railways were unable to meet the demands of both local and foreign buyers, an embargo was placed on exports. This put doubt on South African supplies and was a lingering cloud over the export market until the oil crisis in the 1970's gave life to exports again.

South African coal is inexpensive to produce, but it is high in ash, which made it impractical as a coking coal in the production of steel. In the 1960s, Amcoal developed a washing technique that made South African coal viable as a coking coal. This processed coal gained acceptance internationally as a steam and metallurgical coal and revived the export market. The demand for South African coal required an improved shipping infrastructure and coupled with higher international demand led to the establishment of the Richards Bay Coal Terminal in 1976. There is a significant price difference between the coal sold domestically and that which is exported, as can be seen in Table 1.2. This is because most of the domestic coal sales, with high ash content, go straight from the mine to electricity generation. A premium is received on exported coal, which is beneficiated by first crushing and then washing to improve the quality.

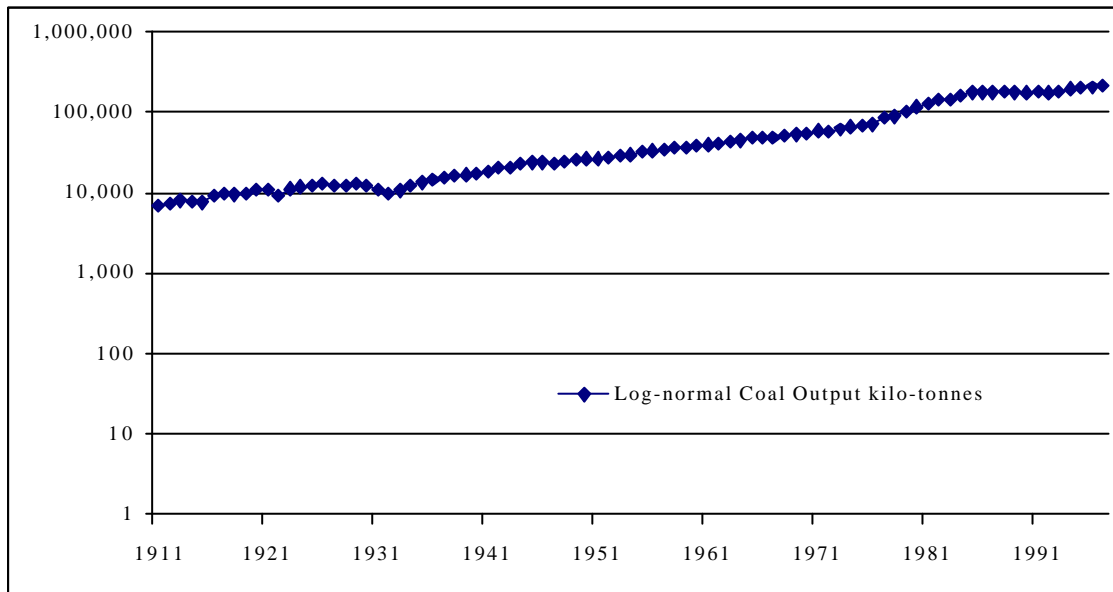
Table 1.2: Coal Sales, real Rands per ton

Year	Local Sales (R/t)	Export Sales (R/t)
1985	33	136
1990	31	81
1995	25	64

Source: Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

The majority of South African coal mining is done using open-pit methods (53.3%). Another third is done underground using largely mechanised bord and pillar methods, the remainder being longwalling and pillar recovery. Currently, the principal coalfields are Witbank, Highveld, Waterburg, Vereeniging-Sasolburg, Eastern Transvaal, Kliprivier, Utrecht, Vryheid, Nongoma, and Soutpansberg. Because of increasingly large mechanised open-pits and mechanisation underground, employment on the mines has been decreasing while output has increased.

Figure 1.3: Annual South African Coal Output



Source: Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

1.3.4 Platinum-Group Metals

Platinum and the five other metals (iridium, osmium, palladium, rhodium and ruthenium) that make up the platinum group of metals (PGMs) have become an increasingly important part of South Africa's mining activities. In 1992, PGMs became the second most valuable of South Africa's mineral exports. South Africa has the largest known PGM reserves in the world and produces nearly 50% of the world's PGM annual output. Jewellery, investment and automobile emissions control have been the major sources of demand over the last 25 years. Development of fuel cell technology and other industrial applications are likely to ensure the continued significance of PGM mining.

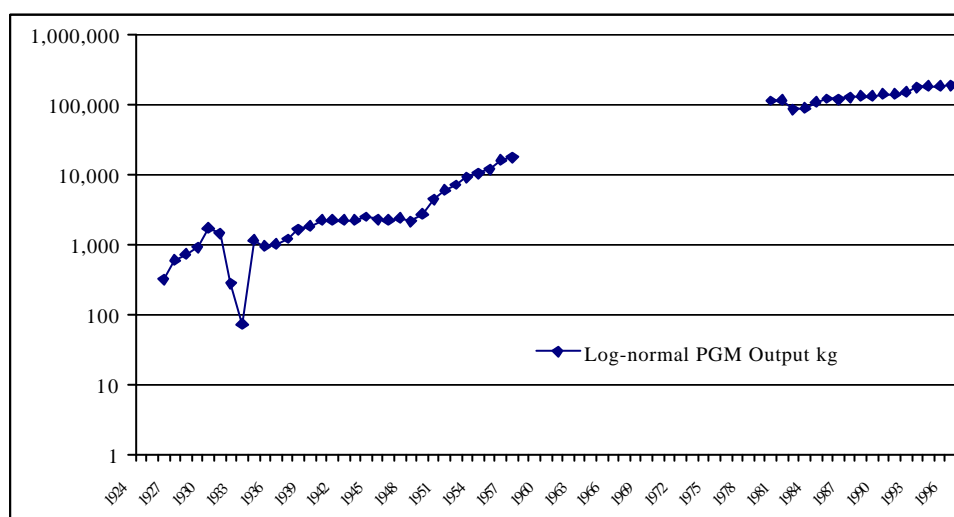
Platinum was originally discovered in the 1890s in South Africa, but it was not until the mid 1920s that production began. In 1931, after a collapse in the market, several of the small platinum mines

merged and formed Rustenburg Platinum Mines Ltd (RPM). The great depression forced a halt in production from April 1932 until August 1933 (see Figure 1.4). RPM has today become part of Anglo American Platinum (AMPLATS), a division of Anglo American Corporation and continues to be the largest producer of platinum in South Africa. In 1958, demand for platinum at oil refineries collapsed and a major fall in South African production followed. In the mid 1960s, U.S.-based Englehard and U.K.-based Johnson Matthey, began research in the development of an autocatalyst to deal with increasing automobile emissions. Demonstrating the effectiveness of their designs, the United States adopted emission standards that required platinum-based autocatalysts in the early 1970s (Crankshaw, P. 1994, pp. 40-41). This has become a major source of platinum demand, particularly since the European Union followed in the 1980s.

As mentioned, AMPLATS is the largest producer of platinum in South Africa. They, together with three others, namely Lonrho, Goldfields South Africa (GfSA), and Gencor's Impala platinum mines account for all of the Bushveld Complex PGM mining. Some PGM production occurs in Phalaborwa copper mining and on the Witwatersrand goldfields, but these account for only 0.5% of South Africa's annual production. All other output is from the Bushveld Complex (Macleod, D.B. 1996, pg. 37). The Bushveld operations are unique in the world for they are the only mines where PGMs are the principal minerals being mined. Most other PGM production is a by-product of chromium or copper mining.

Only one of the ten major platinum mines, Potgieterust Platinums Ltd, is open-cast which is in the north of the Bushveld Complex. Eight of the other nine underground mines are in the western section of the Bushveld complex, near Rustenburg. These mines have only recently begun to go to significant depths, but have had difficulties as the ore is much more fractured and therefore more difficult to mine than in the gold mines. Another problem of increasing depths with platinum mines has been an increase in rock temperatures at depth about twice that experienced on the Witwatersrand gold mines (Ibid. 1994, pg. 31).

Figure 1.4: Annual South African PGM Output



Source: Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

1.3.5 Other Minerals

Gold, Coal and PGMs alone have accounted for over three-quarters of the South African mineral sales over the past ten years. In 1985, the last time reported, the total value including diamonds was slightly more than 85% of total mineral sales. Many other minerals are mined in South Africa, enabling it to be self-sufficient in most of its mineral requirements. A few of the other more significant minerals mined are:

chrome ore, copper, iron ore, manganese ore, and nickel. Through beneficiation, many of these other minerals have a magnified impact on the economy, which is often not found in precious metals or stones.

1.4 Economic Linkages

Keeping in mind the incomplete picture one gets from a definition of the operation of the mine alone, we will now look at some of the major economic characteristics of mining and quarrying as a sector. In Table 1.2, the variability of mining activities and its importance in South Africa's economy can be seen. Despite the increase in the gold price in the early 1980s, mining and quarrying has been on a downward trend. Demonitisation of gold, coupled with increasingly volatile markets has generated increased instability in the minerals sector. Given the proportionately large share of GDP that they account for, this has created difficulty for both the government and the private sector (Jones and Muller, 1992).

Table 1.3: Economic Significance of Mining in South Africa's Economy

Year	Mining & Quarrying (% of GDP)	Other Primary (% of GDP)	Secondary (% of GDP)	Tertiary (% of GDP)	Mining production: Non gold (Unit: Index 1990=100)	Mining Revenue as a % of Total Government Revenue
1967	9.7%	11.5%	29.2%	49.6%	43.2	13%
1970	9.0%	7.9%	30.8%	52.3%	55	10%
1975	11.4%	8.5%	31.4%	48.8%	62.2	17%
1980	21.1%	6.8%	28.9%	43.2%	90.1	19%
1985	14.8%	5.8%	31.0%	48.3%	104.4	9%
1990	9.7%	5.3%	33.3%	51.7%	100	4%
1991	9.2%	5.1%	32.5%	53.2%	98.9	4%
1992	8.6%	4.2%	31.5%	55.8%	98	2%
1993	8.8%	4.5%	30.8%	55.9%	102.6	1%
1994	8.6%	5.1%	30.6%	55.6%	105.3	1%
1995	7.8%	4.4%	31.4%	56.4%	110.6	2%
1996	8.1%	4.8%	30.7%	56.4%	112.8	1%
1997	7.8%	4.5%	30.7%	56.9%	116.9	2%

Source: South African Reserve Bank Quarterly Bulletin 98(3) S-131

One of the most notable changes in mining with respect to the national government has been its decreasing importance in revenue for the state. While unsteady throughout the 1990s, the contribution that mining has directly made to national revenue has declined. Declining employment has accompanied the general increase in mechanised mining methods in South Africa (see Table 1.4).

Table 1.4: Mining Employment in South Africa

Year	Total Mining Employment	Gold (% of Mining Employ)	Diamonds (% of Mining Employ)	Coal (% of Mining Employ)	Other Mines (% of Mining Employ)	Quarries (% of Mining Employ)	Mining Employ (% of Econ. Active Pop)
1967	619,043	68.1%	3.4%	12.1%	13.3%	3.1%	
1970	655,346	64.7%	3.3%	11.4%	17.8%	2.8%	
1975	639,473	60.7%	3.1%	12.2%	20.7%	3.3%	
1980	709,042	66.8%	3.3%	12.4%	15.4%	2.1%	
1985	724,587	71.2%		13.6%	13.1%	2.1%	
1990	692,900	70.7%	3.3%	12.3%	11.5%	2.2%	6.2%
1991	653,134	67.2%	3.3%	11.9%	15.4%	2.2%	5.6%
1992	607,950	67.7%	3.2%	12.5%	14.3%	2.2%	5.0%
1993	561,655	70.4%	2.6%	10.6%	14.2%	2.2%	4.5%
1994	613,584	63.9%	2.6%	9.9%	21.5%	2.1%	4.3%

1995	595,384	N/A	N/A	N/A	N/A	N/A	4.1%
------	----------------	-----	-----	-----	-----	-----	------

Source: Central Statistical Services of South Africa Statistics - Editions from 1979 - 1995

1.5 International Trade and Investment

Gold is the primary export revenue earner in South Africa and has been since the Union was formed in 1910. Lately, gold has been losing its relative importance as a generator of export revenue. Notably though, while variable, other minerals have maintained nearly the same contribution to exports.

Table 1.5: South African Mining and the Foreign Sector

Year	Minerals' (Non-gold) contribution to South Africa's Total Exports	Gold's contribution to South Africa's Total Exports	Mineral Exports as a Percentage of South Africa's Total Exports
1986	0.235	0.425	66%
1987	0.197	0.403	60%
1988	0.197	0.38	58%
1989	0.233	0.338	57%
1990	0.23	0.312	54%
1991	0.232	0.300	53%
1992	0.201	0.290	49%
1993	0.217	0.295	51%

Source: South African Reserve Bank Quarterly Bulletin 98(3) S-131

1.6 Conclusion

The mining sector has been decreasing in economic importance during the past decade. This has been caused by the decrease in gold output and a generally poor market for minerals. However, it still constitutes a large component of South Africa's economy, particularly with respect to export earnings. Historically, the mineral sector has played a very important role in the economic development of South Africa. Understanding the current economic landscape of South Africa requires at least cursory knowledge of its mineral heritage. Perhaps one of the most important influences has been the industrial organisation of the mining industry which is analysed in the next chapter.

2. THE MINING FIRM

“Mining is a branch of industry occupied with the search for, exploitation, dressing and sale of economic minerals and rocks...The miner has two main tasks: To break out, and to transport to the surface the economic mineral. Everything else which the miner does is only a necessary evil, work which is done to make these two fundamental activities possible.” - Bohuslav Stošes, Introduction to Mining, pg. 17, 1954.

2.1 Introduction

This chapter gives a stylised overview of what a mining firm is and what production for a mining firm involves. While large mining firms around the world are very similar, South African mining firms have some important differences. These have been loosely pooled under the title of the mining finance house and are discussed in the next section of this chapter. Following that background, a simplified overview of the production process follows. This third section of the chapter gives a general description of the major activities that the mining firm is involved in during the various phases of resource extraction. The fourth section of the chapter focuses more explicitly on the role that producer services play in production, with concentration on development and day-to-day operations at a mineral deposit. A summary follows in the last section that will prepare the reader for the analysis of the organisational structure of producer services within the firm in chapter three.

2.2 The Mining Finance House

Mining firms commonly need to provide infrastructure in order to extract a mineral deposit. Typically, this infrastructure is developed in conjunction with the government. In many less economically developed nations, this leads to ‘enclaves’ of development with little interaction between them and the local communities. In more economically developed nations, the remoteness of the mineral deposit and dearth of other viable economic activity often leads to the pooling of local economic benefits from the mining to existing nearby urban centres. In South Africa, the size and richness of its gold and diamond deposits created a fostering environment for development of local infrastructure that was important to future national economic development.

The geographic remoteness of the Witwatersrand goldfields was significant, as many industries were only created with the assistance of the mining firms. This got South African mining firms involved on a large scale in economic activities that are not typical of a mining firm. The relative underdevelopment of South Africa’s economy at the time meant that the South African mining firms became conglomerates better described as mining finance houses. These mining finance houses became important forces in national economic development across diverse sectors. This condition persisted for the better part of a century and significantly influenced the economic development of South Africa. In analysing its economic development, South Africa’s experience because of this persistent influence of its mining sector is analogous to the phenomena of corporate dominance in a company town. During the 1990s, political and market changes have caused a significant change in the activities of the mining finance houses. Today most of the major mining finance houses are refocusing on mining and divesting of other holdings.

When the Union of South Africa was formed in 1910, the early mining finance houses existed and their nascent operational structure, both formal and informal, established. Development of the

Witwatersrand goldfields necessitated an inflow of international capital. The riches won by leading firms on the diamond fields in Kimberly were large, but even for these firms development of the underground gold operations required finance beyond their resources. The formalisation of the structure of the mining finance houses was then significantly tied with the role of raising foreign capital. The mining finance houses facilitated the raising of large sums of capital because they established a competent reputation for financial stability and technical knowledge to bring otherwise prohibitively risky mining ventures into operation (Oppenheimer, H., pg. 325, 1954). An example of the externalities generated by the mining finance houses in so doing occurred when, with the development of the Orange Free State goldfields, an influx of capital for the gold mines' development facilitated the formation of South Africa's money market in the mid-1950's. During the more than 100 years of mining in South Africa, the system has undergone substantial change. These changes have been caused by a variety of forces and interactions from internal, domestic, and international sources.

The geologic nature of the Witwatersrand gold reef has been another important source of growth in the mining finance house system. As mentioned in Section 1.3.2, the structure of gold on the Witwatersrand was unique and from early on required different mining techniques from those used elsewhere. Because of this, a second function of the mining finance houses early on was provision of expert services that would have been prohibitively expensive for an individual mine to incur. Economies of scale then were a crucial influence in building the mining finance house structure in South Africa. Under this system, a sort of apprenticeship scheme was established, individual mines being run by less experienced managers with expertise being brought in from headquarters or subcontracted through headquarters when required. Originally, focus was on engineering services, but once the benefits of this structure became clear it was extended to other professions, and the mining finance houses began providing experts in metallurgy, geology, mechanical engineering, law, health, and administration (Limebeer, A.J., pg.27, 1951). The mining finance house became an in-house provider of services for large finance requirements and major technical problems in a mines operation.

The mining finance house offered a reasonably flexible foundation upon which quality services could be provided in an economical way. It was not just within the mining finance houses that provision of services in South African mining took advantage of increasing returns to scale, but they also worked between firms. The nature of the gold market and the gold deposits of South Africa were important influences in inter-firm cooperation. The nearly perfect elasticity of gold demand meant that producers gained no price influence over other producers. Again the demand characteristics for gold came from the monetary gold standard and the small size of annual gold production with respect to the world market stock of gold. Given the uncertainty of international investors in the Witwatersrand deposits (see Chapter One), if a mining firm developed a technological improvement in gold extraction, it paid them to share it with the other gold mining companies. The advantage from sharing was derived because it meant a likely increase in total gold production from the Witwatersrand. This brought in more investment, increased liquidity, decreased perceived risks, and helped to spread infrastructure costs. Therefore, technology as such was not a strategic variable for the mining finance house, but it was rather the securing of the rights to the geologic deposit that was crucial to the firm's competitiveness. While proprietary technology is important, to this day in many mining firms around the world it is their superior ability to identify and secure an economic mineral deposit that differentiates them from others.

Having identified a common interest in working together, South African mining finance houses developed an institution under which to pool these activities. Today that body survives and is known as the Chamber of Mines of South Africa. The Chamber of Mines of South Africa became a supra-mining service provider. As with the development of the mining finance houses themselves, the Chamber was originally rather modest in scope. It provided a concentration of political force in lobbying for the interests of South African gold mining and provided a labour recruitment service for the labour-intensive mines. As the major product, i.e. gold, which the Chamber and group system was built upon, did not foster competition in output, price, knowledge and technical resources within the groups ensured resolution of problems quicker, and with the large capital investments at stake this meant at an increasingly profitable rate. The Chamber facilitated this by developing a research structure to focus resources. Later, as South Africa increased its independence from Great Britain, the Chamber also established a refinery for the final stages of gold production. With respect to labour, the common

requirements and scale of employment meant that the Chamber was particularly useful in providing industrial relations services to the gold mining industry.

Mining by small to medium sized firms, which can not even loosely be considered mining finance houses, does occur in South Africa but the majority and most important force in South Africa's mineral sector are the mining finance houses. A mining firm could be a single entity established to extract the mineral wealth of a deposit, or a portion of a deposit. In South Africa, and many other nations, it has been and is typically uneconomical to be so micro-focused. The structure of the various mines in South Africa, particularly in gold mining, is such that there is particular independence given to the individual mine which is largely a self-operating entity in day-to-day operations and with considerable freedom to choose in-house or the market for services. Local conditions and opportunities are thereby more flexibly dealt with. The system in the more competitive mining finance houses also serves to insure a certain level of quality in the services provided to their subsidiaries. This structure also allows some needed market flexibility, since today a principal mining finance house in South Africa is likely to have operations in most of the main mineral sectors and several minor ones and they are highly likely to be actively involved in a variety of mines internationally.

There has been a notable change in the structure of the mining finance houses during the last five years, as many of the conglomerates break-off non-core and operationally distinct aspects of their operations. A few notable examples of this have occurred at Anglo American Corporation, now Anglo American Plc. (see Chapter Three for more detail), Gencor, Goldfields and Anglovaal. Many of these companies (or their subsidiaries) are listing on London and New York stock exchanges to gain access to larger financial resources than are available in South Africa. As maturity and refocus has spread through South African mining finance houses, this large realignment has also brought change in what has been the formal embodiment of inter-firm cooperation, the Chamber of Mines of South Africa.

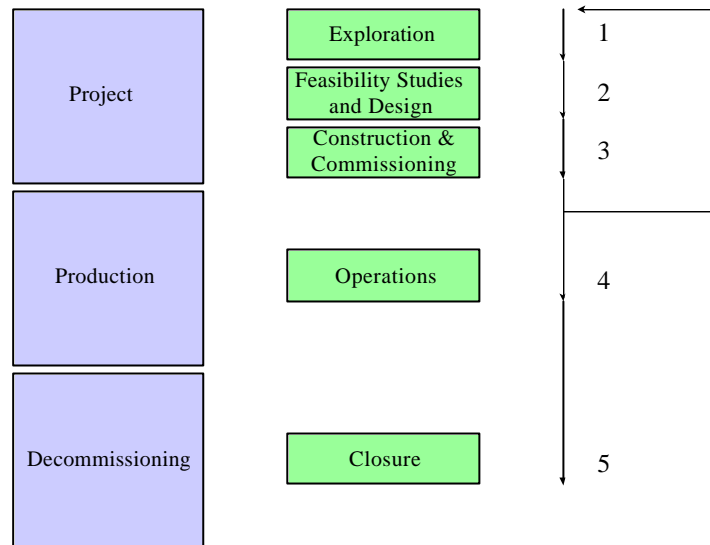
2.3 The Production Process

The geologic specifics of a mineral deposit and its geographical location are fundamental forces that influence if and how mining takes place. As with farming methods that are only suitable to a particular area, so too various mining methods are suitable to specific types of mineral deposits. Often mining operations occur in underdeveloped regions which require substantial infrastructure development. This will mean that a mining company is importantly involved in such areas as town planning and transportation, which are not directly related to the extraction of the mineral. Mining companies might also have important vertical links, either upstream such as in production of mining equipment, or downstream in an activity like steel production. The present analysis is concerned with the operations involved at or very near the mineral resource, the infrastructure necessary to directly support those activities, and the management resources needed to run the mine.

The production process that concerns us is that directly related to the extraction of a mineral deposit, but these activities will occur both on-site and off-site. What follows is a simplified description of the production process involved in the extraction of a mineral deposit. In section four, we discuss how this process and producer services are related. The organisation within the firm of these production processes and services are analysed in a case study in Chapter three.

Simplifying the process considerably, three groups of procedures can be identified in a mine's life (see Figure 2.1): (1) Project, (2) Production and (3) Decommissioning. In this examination, the first two groups of procedures are of primary interest. Project procedures include the exploration and identification of the mineral deposit, feasibility studies, design, construction and commissioning of the operations. Production procedures are day to day operations, but because of the nature of geology, this might better be described as minor adjustments in the operating procedures to extract the mineral resource. Lastly, decommissioning is the closure of the mine site after completing the warranted degree of mineral extraction. It is rare that alterations do not occur in the extraction of the mineral deposit. Below is a simplified schematic of the production process in a mining operation.

Figure 2.1: Primary Production Phases of a Mining Firm



2.3.1 Project Phase

Exploration

Exploration is a fundamental activity in mining. It ensures that the mining firm has future deposit to extract, which given the non-renewable nature of mineral deposits, is their *raison d'être*. Exploration is also critical in identifying the specific structure of the mineral deposit and is thereby a critical input in the design and operation of a mine. The critical nature of exploration means that for most mining firms, the majority of exploration is done in-house, or at least coordinated in-house. Satellite imagery, aerial surveying, seismic and drill samples are the principal methods of exploration. Obviously, all sampling is a site-specific exercise, while in the early project phase it is unlikely that much processing or interpretation will occur on-site. If it is a brown-field project, i.e., a project involving the expansion or rehabilitation of an existing mine, there will likely be some analysis of exploration samples done on-site as prospecting and sampling on a continuous basis is an important activity in a modern mine.

The geologic interpretation of the results will provide early information on the economic viability of a mineral deposit. If encouraging results are obtained, more detailed exploration will commence. Depending on the mineral, the company, and market sentiments, the financing of exploration may be out of operating income, internal capital provision or via external financing. Identified mineral resources form the basis for the valuation of a mine. Exploration is an expensive and often very speculative endeavour undertaken by a mining company. In an operating mine, exploration is ongoing at a very detailed level to determine maximum extraction techniques based on the current value of the mineral. In a sense then, exploration can be considered an operating activity.

Feasibility Studies and Design

Once a mineral deposit has been identified through exploration, there is the difficulty of whether that mineral deposit can be economically extracted. There is a variety in detail amongst feasibility studies. As promise of economic viability of the mineral resource increases, so does the level of detail in the feasibility study. Mineral rights, infrastructure support, market evaluation, estimated extraction costs, processing costs, and the potential variability of all these must be considered to determine whether mining the mineral deposit is an economically viable proposition. Three distinct stages comprise this phase:

1. *Preliminary investigations* - initial cost estimates, R&D to derive scope, and front-end engineering.
2. *Preliminary options evaluations/Feasibility study* - initial engineering complete, final scope development, detailed estimating.

3. *Project scope and cost defined/Preliminary project execution* - detail design, drafting and project management. During this phase financial resources are pulled together to fund the project.

While a much more intensive sampling program is undertaken on-site for most of the feasibility studies, the design stages are performed at the mining firm's international or regional headquarters and by independent contractors. Based on analysis of the mineral deposit and its location during this phase of operations, many crucial estimates are made, the accuracy of which will have important influence on whether the estimated viability of the project occurs. The main technical and related aspects that need to be considered in a project's viability are:

1. Location, access, and climate
2. Ownership, mining leases, and other permits
3. Geology
4. Mineral resources and reserves
5. Mining methods and production levels
6. Beneficiation and metallurgical processing methods
7. Infrastructure
8. Health and safety
9. Environmental impact and management
10. Capital costs
11. Operating costs
12. Revenues
13. Cash flows and net present value
14. Management and staffing
15. Legal aspects of the company
16. Financial structure

(Source: Cole-Baker, J.R. and G.J. Bowyer, 1998, pg. 2).

Construction and Commissioning

Detailed plans and revisions occur during the early stages of this phase, but the large scale of capital expenditures typically means that the mining method and mine plan are locked in. As construction progresses it will be necessary to begin ensuring adequate staff and management are employed and that they have the required skill to run the mine. Procurement, timely execution, and cost containment are some major aspects of this phase of mine development.

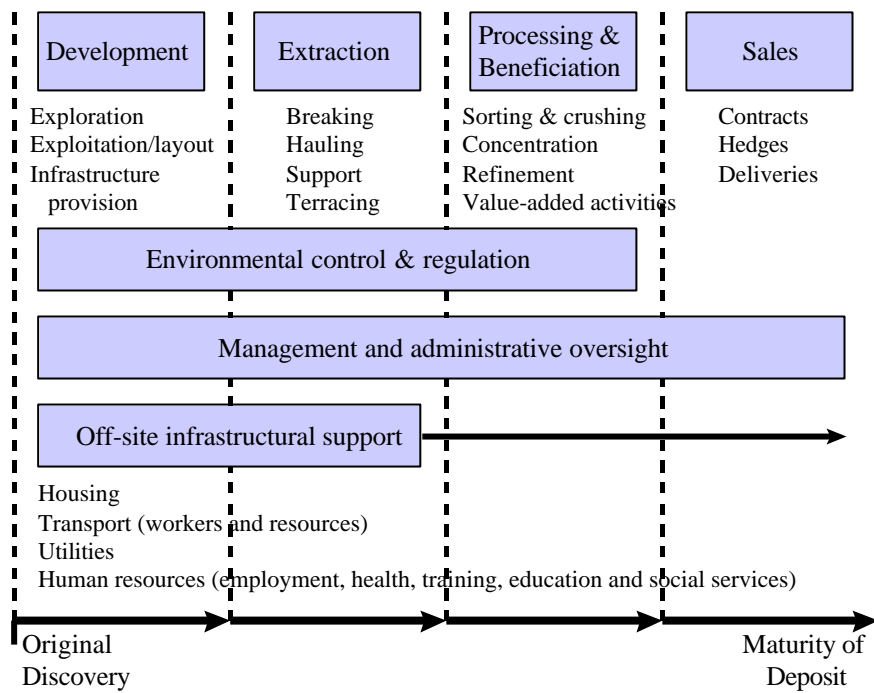
As construction nearly finishes, the mine will move into project execution (procurement, construction and commissioning) – specifications and procurement, construction management, commissioning and training, establishing operating procedures, capital and cost control. Preliminary operations will begin and basic operating procedures will be established as the mines then move into the operations phase.

2.3.2 Operations Phase

Mining involves continuously adjusting procedures slightly as different geological characteristics of the ore body are encountered. While many of these adjustments can be foreseen and planned for early on, some of the necessary adjustments will only become apparent as actual mining operations encounter the different conditions. The majority of day-to-day activity in this phase is run on-site, with higher-level management investment and technical decisions being done at the corporate level. Much of the operations work is sub-contracted. When additional assistance is needed, it is often also purchased from the market.

There are four distinct elements in operation: development, extraction, processing & beneficiation, and sales. These are represented in figure 2.2 below. It is important to remember that during operations some minor adjustments will be required in operating procedures. If new significant changes evolve in the mine's operations, it will be necessary to return to the feasibility and design stage (see feedback loop in figure 2.1).

Figure 2.2: Elements of the Operations Phase



2.3.3 Decommissioning

This final phase of a mine's life involves the dismemberment of mining equipment and the processing plant and salvage of possible capital equipment. It also involves the environmental rehabilitation and stabilisation of the mine site - mine dump rehabilitation. In a mine that produces precious metals, the closure stage would involve the melting down of most of the plant and equipment to get residual accumulations of the precious metals. Increasingly there are specialised firms that just close down mining operations, they have been used on some South African gold mines, but overall their use has not been widespread.

2.4 Producer Services and the Production Process

Producer services used by these diversified conglomerates are tremendously varied. We are only concerned with the mining activities of the firm. This requires a somewhat arbitrary definition of what are mining-related producer services. Regrettably, to maintain manageability, the current investigation does not include financial services used by the mining firm. The scale and structure of capital resources are critical dimensions in a mine, but will have to await further investigation. Our current concern is with those activities most directly linked to the mining process itself and not ancillary activities, despite their potential importance in the viability of a mine. Focus is on the mining firm and its activities in exploration, development of greenfield (a new mine) and brownfield (an existing mine) projects, running its mines' daily operations and the decommissioning of a mine or part of a mine. Downstream activities after the sale of the mineral or rock, even if undertaken by the mining firm, are not within the scope of this analysis.

Producer services are used in every phase of the mine production process. As noted at the outset the current investigation is primarily concerned with technical services used by the mining firm, but in this section other services which are not analysed in detail elsewhere are noted. Many producer services are used in multiple stages of the production process and are therefore repeated in each descriptive section.

2.4.1 Project Procedures

Exploration

Exploration is highly dependent on the services of the geologist. Because of strategic interests, most large mining firms will retain their own geologist to perform their exploration programmes. Some mining firms do not have the resources for a geological team, in such instances the firm will have to hire outside geologists to perform the analysis. A good deal of the actual drilling and field work is contracted out by all mining firms whose geologists then coordinate the sampling and exploration plan. Because special skills and computer modelling techniques are necessary to get maximum value from field-samples, data may be sent to special consultants for further analysis and modelling. Some of the services used in the exploration phase are:

1. *Ore-body evaluations* - geostatistical studies, geology and ore reserves mapping, geographical information systems, consulting geophysical information specialists, chemical analysis;
2. *Exploration and identification of mineral resources* - design & management of surface exploration programs, management of deep drilling programs, geochemical exploration, a variety airborne prospecting techniques, geological structural mapping via 3-D seismic reflection surveys, remote sensing, geological surveys, environmental monitoring surveys, and hydrologic surveys;
3. *Sundry exploratory services* - geological training, consulting geophysicists, mathematicians, engineers, and computer software specialists.

Feasibility Studies and Design

Mine design is significantly influenced by information from geological and mineral resource data gathered in the exploratory phase. If data from the exploratory stage is promising, as described above, the project will proceed to a pre-feasibility and feasibility stage before detail mine planning commences. Based on the economic assessment of each stage, project finance will need to be mobilised to get the increasingly detailed and expensive information necessary to get the mine to a point where construction can begin. Financial services are very important in this stage of a mine's production process. A large quantity and variety of specialists are often needed at this stage, but depending on the novelty of the development, the actual number of specialists and consultants can vary considerably. Some of the services used in the feasibility study and design phase are:

1. *Financial Services* – financial risk estimation, corporate financial consultation, cash-flow & dividend forecasts, financial administration, commodity price forecasts, market studies, sensitivity analyses, alternative business model evaluations, national fiscal regime analyses, and financial audits;
2. *Legal Services* – title searches, reviews and reports on national mining and exploration licensing systems, analyses of legal system and enforcement capacity, legal consultants, and legal audits;
3. *Mining design and planning* – mine optimisation and design for both open-pit and underground operations, soil mechanics, geotechnical risk analysis and assessment, mining method selection, blastability assessment, geotechnical engineering, mining engineering, ventilation and refrigeration engineering, mining equipment engineering, rock mechanics engineering, dragline engineering, mine shaft & winding plant design, mine shaft conveyance design, and railway design & audits;
4. *Metallurgical process analysis and design* - metallurgical engineering, process plant simulation & design, hydrometallurgy consulting, comminution consulting;
5. *Waste product handling* – tailings engineering, tailings management systems specifications & design, contaminated site assessment and remediation, waste engineering, water quality management, slimes filling, slimes backfilling, and slimes process & systems design;
6. *Project feasibility analysis* - desk studies of mineral potential, prospect evaluation, database validation, due diligence reviews, ore reserve/resource estimation, ore body modeling, project valuation, geostatistical studies, mining costs estimation, operating costs estimation, capital costs estimation, environmental impact assessments, and technical audits;
7. *Sundry feasibility and design services* – Industrial engineering, process engineering, civil engineering structural design, mechanical engineering, fuels and lubricants engineers, structural engineering, materials engineering & corrosion protection, electrical power systems design, energy audits, communication systems specification & design, grade control, pumping and conveyor system analysis & design, process research & development laboratories, geographical information systems, surveying services, hydrologic consultation, on-site water management, water treatment services, architectural services, urban design, town planning, landscape architecture, power generation & transmission design, mine and project management, tender management, staffing, management staffing, project generation, socio-economic analysis, social and development management, environmental management, and technical training.

Construction and Commissioning

A modern mining firm contracts out much of the actual construction activity involved in a mine's development. It is at this stage that the new mine management and staff begin operations. It is typically the responsibility of the head office of the mining firm to manage these initial operations. If they lack the resources or ability to manage these activities, some sort of management sub-contracting must occur. This management responsibility is often undertaken by the mining finance house in South Africa, but if it is a small mine, a contractual arrangement may be entered into. If the favourable feasibility study is to come to fruition, it is crucial to ensure that the development of the mine meets quality, schedule, and

budget parameters. Particularly owing to the large sunk capital costs, it is critical that the mine begins operation as soon as it is feasible in order to begin generating a return on the investment.

Some of the services used in the construction and commissioning phase are: Quantity surveying, contract administration, contract negotiations, civil and structural engineering, safety, construction management, quality control, operational procedures, site material management, commissioning services, maintenance, trial operation, shaft sinking, staffing, and training of operating personnel.

2.4.2 *Operating Procedures*

A terrific number of contractors are used in operations as they can perform the needed work more economically than a typical in-house unit. Some of the services used in the operations phase are: health services, social services, education & training, security services, transportation services, administrative services, secretarial services, accounting services, financial services, hedging activities, derivative trading, equipment monitoring & assessment, equipment repairs & work control, management consultation, marketing management, operational problem solving, due diligence reviews, data integration, environmental management, plant process audits, process risk assessment, mine surveys & volumetric audits, engineering surveys, process control evaluation, systems simulation & analysis, power supply contract negotiations, technical audits, environmental monitoring & reports, mining share valuation & analysis, machine condition assessment, materials testing, tribology consultation & analysis, and infrastructural support.

2.5 Conclusion

The operation and production processes of a mine are varied. Extraction of a mineral deposit may be run by several different mining firms during its life, particularly when there are very large deposits such as those of gold in South Africa. Although brief, the description of production above gives a general image of what is involved in the mining of any type of mineral, anywhere in the world. In order to understand how the various elements of production are interrelated, it is necessary to analyse the operations of the mining firm itself. The next chapter focuses on a study of a major South African mining finance house.

3. PRODUCER SERVICES IN A MINING FIRM

3.1 Introduction

This chapter is a case study of a major South African mining finance house, Anglo American Plc. (hereafter referred to as Anglo American). It is built upon background research of the company, correspondence with service providers to the firm, as well as discussions and interviews with senior management at Anglo American. The focus in this case study is at the highest corporate level - that of Anglo American. A complete picture of the use and provision of producer services requires that a majority of the operating subdivisions also be included. Due to the rapid and numerous changes that these divisions have undergone during the course of this investigation, that was not possible. Descriptions and data that follow are then of Anglo American as a whole and not of any of its particular divisions (Amplats, AngloGold, etc.) or mines. Costs of services, internally and externally provided, are estimates given by experienced senior management at Anglo American.

The next section of this chapter provides a brief historical sketch of Anglo American and some of its principal operating divisions. Section three examines the role which producer services play in the production process. In an effort to limit the scope, this investigation only examines three groups of services: 1. Research and development, 2. Engineering & technical services, and 3. Information technology (IT) services. Section three begins with an overview of the role that these three play in production and then looks more specifically at their importance to the project and operating phases of production. The relationship between production and our selected services is followed by an overview of how these services are provided both internally and externally within the operational structure of the firm.

After this general overview, section four looks specifically at the project and operating phases of production as well as some of the geographic aspects of production and their possible trade impacts. The next section, section five, identifies historic and current forces that have pushed the firm to change the operational structure of service provision. Section six attempts to provide a rough guide of the impact of producer services on the industry and from the industry as a whole on South Africa's economy. This section looks at direction and comparative advantage of the firm and the industry. As incomplete evidence, estimates of productivity changes in the mining sector over time are analysed. That is followed by a conclusion in section seven.

3.2 A Brief History of the Mining Firm⁷

Introduction

The Anglo American Corporation of South Africa was formed in September 1917 from strategic holdings in the Far East Rand owned by the Oppenheimer family. As mentioned in chapter one, the main gold mining activity up to that point on the Witwatersrand had been around the Central Rand. Through superior geological advice and cooperation, the Corner House and Gold Fields had secured all the major mines in that region. Given their dominance of the Central Rand, if Witwatersrand gold was to be used in formation of a new mining company, mine development was required outside the Central Rand. The

⁷ There have been several books written about Anglo American, most of them are not concerned with the firm. Focus is usually on individuals or the South African political economic context in which Anglo American operates. A few such examples are: T. Gregory (1962), D. Innes (1984), C. Newbury (1989), D. Pallister et al (1987).

Oppenheimer family had some resources from its diamond interests and used them to purchase a speculative mining company named Consolidated Mines Selection Company (CMSC) in 1905. CMSC had widespread mining rights, but with greatest concentration in what would become the Far East Rand. When prospects for the Far East Rand began to look increasingly promising, the Oppenheimer family found themselves well positioned in the region. By 1916, through gradual accumulation they had taken over the other major mining rights holder in the Far East Rand, the Transvaal Coal Trust (a legacy of the region's previous importance in coal supply). The Transvaal Coal Trust was placed under the control of CMSC and in June of 1916 the expanded CMSC was renamed Rand Selection Corporation (RSC).

As with others who had made their fortune in South African diamonds, the Oppenheimer family did not have enough financial resources themselves to float the type of large-scale gold mines needed on their Far East Rand properties, despite substantial wealth. With the First World War diverting European financial resources, the United States capital market was drawn upon for the start-up capital necessary to transform the properties into producing mines. Thus in 1917, the Anglo American Corporation of South Africa was formed, its headquarters being in Johannesburg rather than London.

Anglo American was never intended to be a solely gold mining company, but a mining finance house with geographical concentration on the mineral resources of Southern Africa. Within 15 years of its formation, Anglo American had consolidated diamond purchasing, sales and production under two related companies and it had also embarked on large-scale copper mining in Zambia. A major statement of self-confidence by Anglo American came after the Second World War, when it began development of the Orange Free State Goldfields, and the continued development of the Klerksdorp and Far West Rand Goldfields. These areas required Anglo American to yet again secure development capital at an unprecedented scale, not only for the corporation, but also for South Africa. With establishment of these three goldfields, Anglo American further secured its position as the leading mining finance house in South Africa, a position which it still holds today.

Early Anglo American 1917 to 1929

Anglo American was formed in September of 1917, with the financial assistance of the American bank, J.P. Morgan and the American mining firm, Newmont. Notably at odds with the practice of other South African mining corporations at the time, Anglo American's headquarters were in Johannesburg rather than London. From the start, Anglo American was interested in other minerals besides gold.

In October 1919 as post-First World War disinvestment of German colonial holdings began, Anglo American gained control of the diamond mines in South-West Africa (now Namibia) forming Consolidated Diamond Mines of South West Africa Ltd. (Consolidated Diamond Mines) to exploit them. By 1924, with Consolidated Diamond Mines and additional interests in other non-South African diamond mines, Anglo American was admitted to the Diamond Syndicate (the cartel that regulated the price of diamonds). After wrestling with the Diamonds Syndicate's unfavorable structure to their holdings and with South African government intervention in the wind, Anglo American formed a new diamond syndicate, which, with the assistance of another major diamond producer (B. Barnato who led what became Johannesburg Consolidated Investment, JCI.), replaced the old diamond syndicate in 1925. These two important diamond producers, Anglo American and JCI, then gained strategic power within the De Beers Diamond Mining Company (De Beers). Anglo American increased its holdings and control of De Beers so that when the opportunity presented itself in late 1929 in a depressed diamond market, Anglo American took over De Beers.

Besides diamonds and gold, Anglo American expanded its mining activities into copper during this period. This expansion is telling in that it illustrates the early regional focus and desire to unlock the mineral potential of Southern Africa by the company. With a threat of American copper producers securing the vast copper resources of Zambia, Anglo American moved quickly to secure the mining rights themselves. They largely succeeded, creating in 1929 Anglo American Rhodesia. Anglo American Rhodesia, a holding company, was an important additional division as its structure would be copied many more times in the future. As a holding company, it provided a useful performance monitor on a

distinct operating division of Anglo American, a firm that already had by the late 1920s diverse mining interests.

Anglo Expansion 1930 to 1948

With control of De Beers secured in association with Anglo American, they moved to change the role of the syndicate into two separate organisations of buyers & sellers and producers, both of which to be organised under De Beers. This was accomplished in 1934 with the establishment of the Diamond Corporation. In 1935, A. Dunkelsbuhler & Co., the company under which the Oppenheims built their early Kimberly diamond interests, was dissolved and transferred to the proprietary firm E. Oppenheimer & Sons. During this inter-war period the diamond became a strategic mineral as its use in industrial applications expanded. Drilling and grinding were two primary uses of diamonds that were important in the war effort. As industrial uses for diamonds expanded, a special division was created for industrial sales and a Diamond Research Laboratory was founded in 1936 to explore additional industrial applications.

During this period the government significantly expanded its industrial development initiatives. This gave a significant boom to domestic demand for many minerals. It was during this period that the next wave of more distant gold deposits were discovered away from the main reef. Anglo American exploration was not part of the original discoverers of these deposits, but their significance quickly became apparent to the firm and by the time the Second World War had started it had secured substantial holdings in all three of the new gold bearing regions. While expanding in South Africa, Anglo American also continued to expand abroad. Of particular note was the progression to standard operations at the copper fields in Zambia.

Anglo Development 1949 to 1968

With cessation of hostilities in Europe, development of the newly discovered South African gold deposits became a priority for Anglo American. In raising finance, the firm was greatly assisted by its close association to De Beers, which was enjoying strong diamond sales as part of the post-war boom. Even with its by now large corporate resources, ventures put exceptional strain on these resources, particularly in the isolated Orange Free State. During this period, government intervention continued to expand into new areas. In the history of Anglo American, this change was important as the government worked closely with the firm in assisting it in developing the infrastructure necessary to make these new mines viable. Intra-firm co-operation was also very important in development of these new gold deposits. Again, while competition for mining rights remained cut-throat, once these rights were secured, it was generally mutually beneficial for the mining finance houses to cooperate.

Increasingly during this period, Anglo American developed a conglomerate structure with large property and industrial holdings coming under its structure. Anglo's dominance in mining gave it a firm footing in which to outmanoeuvre other mining finance houses. The mining finance houses, as large multinational firms, were well positioned to bring in foreign technology and as the mines in the new gold regions began operations, the firms had significant cash flow with which they looked to promising domestic ventures. Thus, throughout much of the 1960s, South Africa enjoyed a booming economy. Political unrest by the unrepresented black majority increased during this period, but it was not until the 1970s that this force would begin to play an important role in the fortunes of firms like Anglo American.

Anglo Transition 1969 to 1983

Problems with labor sources in the rest of southern Africa and increased domestic unrest created many difficulties for South African mining firms during this period despite some increased flexibility given them because of a rising gold price. By this period, Anglo American had secured significant industrial holdings and established itself in a position of terrific involvement in South Africa's economy, far beyond that typical of a mining firm. Increased international sanctions against South Africa caused the firm to develop a structure with distant firms, independent of the South African parent, in order to avoid

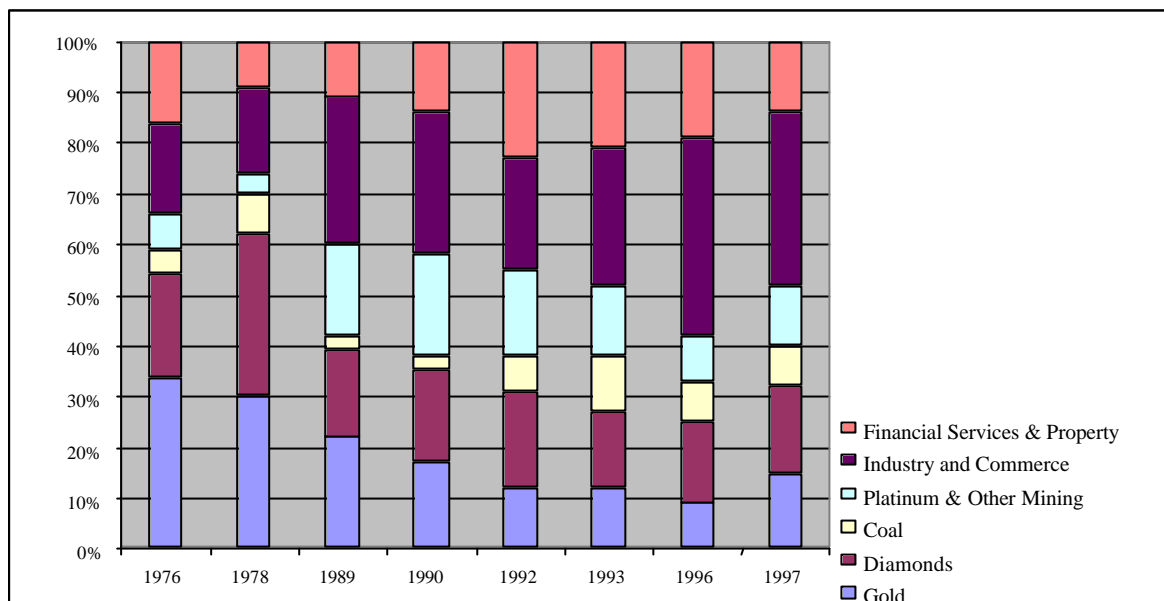
sanctions. The gold price surge in the early 1980s helped to reduce some of the difficulties of domestic political pressures. Increasingly transition and change became clear, but the path that change would take remained unclear during this period. Anglo American aggressively sought to increase its own position in South Africa's mineral structure. Working in strategic alliance with upstart Afrikaner mining house Gencor, Anglo secured important coal contracts with the national power company ESKOM.

Recent Changes at Anglo American

South Africa has made a difficult political transition over the past decade and a half. Anglo American and the other major mining finance houses have played important roles in assuring this peaceful transition. As will be discussed below, with a reopening of South Africa to the international market and a general shift in market sentiments away from conglomerate holdings, Anglo American has refocused itself on mining and shed many of its commercial holdings.

Anglo American is one of the world's largest mining firms. With significant holdings in southern Africa and throughout the world, it is likely to remain so in to the near future. Table 3.1 and figure 3.1 provide overviews of Anglo American and its group of companies total income and their source.

Figure 3.1: Anglo American Group Income by Source



Source: Anglo American Corporation Annual Reports 1979 to 1997

Table 3.1: Anglo American Group Net Income 1979-1997

Year	Real Net Income After Taxation (millions of \$US)
1979	2,615.3
1981	4,521.9
1983	2,905.3
1985	1,339.7
1987	1,769.5
1989	1,321.9
1992	1,135.6
1993	782.9
1996	1,551.3
1997	2,013.5

Source: Anglo American Corporation Annual Reports 1979 to 1997

3.3 The Role of Producer Services in Production

3.3.1 Overview of Select Producer Services

Anglo American Corporation (AAC) produces a variety of services internally at the corporate level and at the sub-division level. It is extremely difficult to say that a given specific service is used in the production process without question. Depending on the type of mineral deposit, its geographic location,

and its history, these various producer services may or may not be required. A brief description of our selected services and their role in production follows.

Research and Development Services

Exploration involves the identification and definition of economically viable mineral deposits. Exploration is not just looking for new deposits, but is a continuing process in an operating mine. Accurate exploration is a major input in the operations phase. It is possible to classify some exploration as operations not R&D, but such specification is not done in this analysis. This is a core competency of Anglo American, and this service is a complete product internally provided. However, field labour may be contracted largely on a spot basis.

Exploration technology involves the development of new and improved methods of mineral identification for both existing and as yet undiscovered deposits. This is another central activity of the corporation. Increasingly, large data bases have meant that this element of R&D is integrally linked with Information Technology (IT) activities. The link with IT is natural since exploration technology is increasingly becoming part of other aspects of operations as systems management increasingly integrate all aspects of production. According to senior management, in the area of exploration evaluation, Anglo American is a recognised world leader.

Process technology research involves improving techniques to extract the minerals. Anglo American Research Laboratories (AARL) is the chief source of this activity. This seems to be a fundamental type of R&D as AARL will often cooperate with external research units at universities, with state research units such as Mintek, and with private corporations on a variety of metallurgical problems.

Mining equipment research, as its name suggests, is the search for new and improved machines for Anglo American's operating mines and for future mining operations. Currently, this is a changing division at Anglo American, with increasing independence. Its structure is similar to that of process technology R&D described above. It works cooperatively on research endeavours with universities, government research institutes, and private corporations.

Technological management is an analytic process through which the corporation is kept up to speed on new technology and application of technology that could be relevant for the firm. This R&D service is provided by both AARL and the Technical Director's Office (TDO). Technological management involves evaluation and testing of technology for application within the group or for its clients, as well as disseminating information about new technologies within the group.

Mining management systems are software and hardware systems which integrate the operations of a mine. These provide highly complicated operations integration linking the running of mining operation, including ventilation schemes and survey systems. As with exploration technology this activity has a strong link with IT services.

Engineering and Technical Services

Most of these services are provided by AARL or the TDO. For simplicity, general categories of these services are given and then a few more specific examples. *Mineral resource evaluation* is a major service. A few of the different types of studies are: geostatistical evaluation of ore reserve data, airborne electromagnetic surveys, airborne multi-spectral scanning surveys, and reflectional seismic surveys. Anglo American also has experts in spectral geology, geological modelling and verification, geostatistical estimation, terrestrial photogrammetry and spot image mapping.

Besides more or less geological services, Anglo American possesses a variety of resources in *mine engineering*. They include: pilot plant testing, assessment of operating costs & capital costs for process options, project evaluation by modelling from production to financing, mineral price sensitivity analysis, standardisation & valuation methodology analysis, mine optimisation and design for surface and underground mining.

These mining engineering services can include *business management services*. The following services fall under this category; project management, proposal management, project consulting, project reviews & audits, quantity surveying & cost control, procurement, planning & scheduling, expediting, extraction optimisation & risk analysis, mine equipment selection design & analysis, process & plant design, process flow sheets development design & equipment specification and plant commissioning and training of plant operating personnel.

Several more specific types of engineering and professional services are available within the corporation. They include structural engineering, conveyor-material handling equipment design & specifications, tailings & waste disposal engineering, electrical network design & analysis, plant control & communication systems, electrical equipment specification & tender negotiations, design of control & instrumentation systems, rail transport engineering, power generation & transmission design, mining architecture including landscape architecture, town planning, and urban design as well as interior design, independent due diligence, reconciliation of estimated, mined & recovery data, plant process audits, process risk assessment, mine surveys & volumetric audits, engineering surveys, mechanical engineering testing & analysis, technical auditing, environmental impact assessments, environmental management systems, materials testing, tribologic services, project management, feasibility studies, construction management and equipment optimisation.

Information Technology Services

While a distinct set of services, IT is pervasive in most all aspects of the production process and is a critical part of many of the various other services that Anglo American provides. Beside those mentioned above in the sections on R&D and Technical services, a couple of other IT services are provided by the corporation. These are:

1. *Business and technical systems* - IT systems which link projects and operations with all of the various R&D activities.
2. *Process control and data management systems* - other IT systems that integrate mine planning with GIS to generate comparative design simulations.

Not all of these services are provided by the highest level of the corporation alone. Sub-divisions have some or all of the above services, with varying levels of sophistication including some of greater complexity such as process security in diamond mines and seismic systems like finite element analysis used by the gold mines. In general, the sub-divisions have core expertise to support production, which is supplement as necessary from external, or group capabilities. These capabilities are significant though as every operation has sufficient internal capabilities to develop and manage projects with contractors.

3.3.2 Project Phase

Anglo American has strong resources in analysis of ore resources and exploration with ongoing international projects. In mining, AAC has comprehensive consultancy services to evaluate new projects and to upgrade or rehabilitate existing operations. Metallurgical research continues to progress in order to provide better methods of mineral extraction and to evaluate the most economical processing & beneficiation plant designs. Mine, plant and infrastructure requirements are reviewed in preparation of capital and operating costs. Input from all of the above are used to create a conceptual technical study that determines project feasibility. Once that has been done, further consultation with financial risk occurs. The TDO has developed a special competency in assessing the inter-dependence of internal variable like scope, quality, cost and timing, with exogenous forces such as socio-economic situation and environmental issues.

3.3.3 Operations Phase

After commissioning, the group continues to offer management engineering and other services. AATS and the TDO also provide continuing consulting services and project support for expansion and upgrading of facilities. Once the operations phase of production has been reached, most of the services

that would be needed are supported. Within the corporation, much of this is provided from the subdivision itself.

3.4 Organisation and Change of Producer Services in the Production Process

3.4.1 *Internal/External Provision*

As Anglo American has increasingly refocused on a group of core competencies in the mining sector it has increasingly sought to outsource, or find the most economical source, for the provision of a variety of services. This refocusing has meant increased concentration on services that have a high value added and in which they can develop an expertise. If it is not a high value-added service for the corporation, they are increasingly outsourcing it. Figures 3.2 and 3.3 provide an overview of the current Anglo American group business and organisational structure. This is the new look of Anglo as it returns to a concentration upon mining.

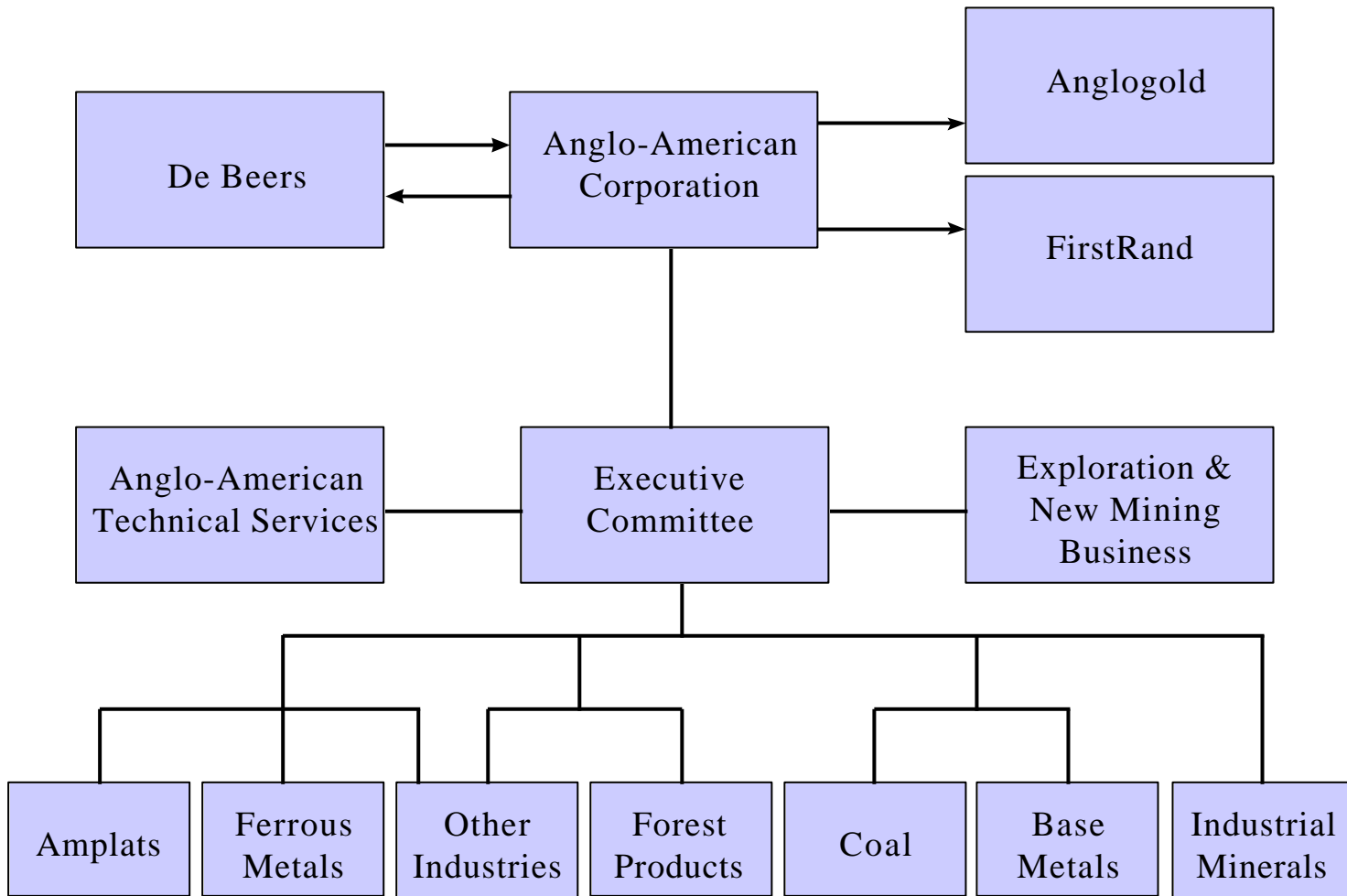
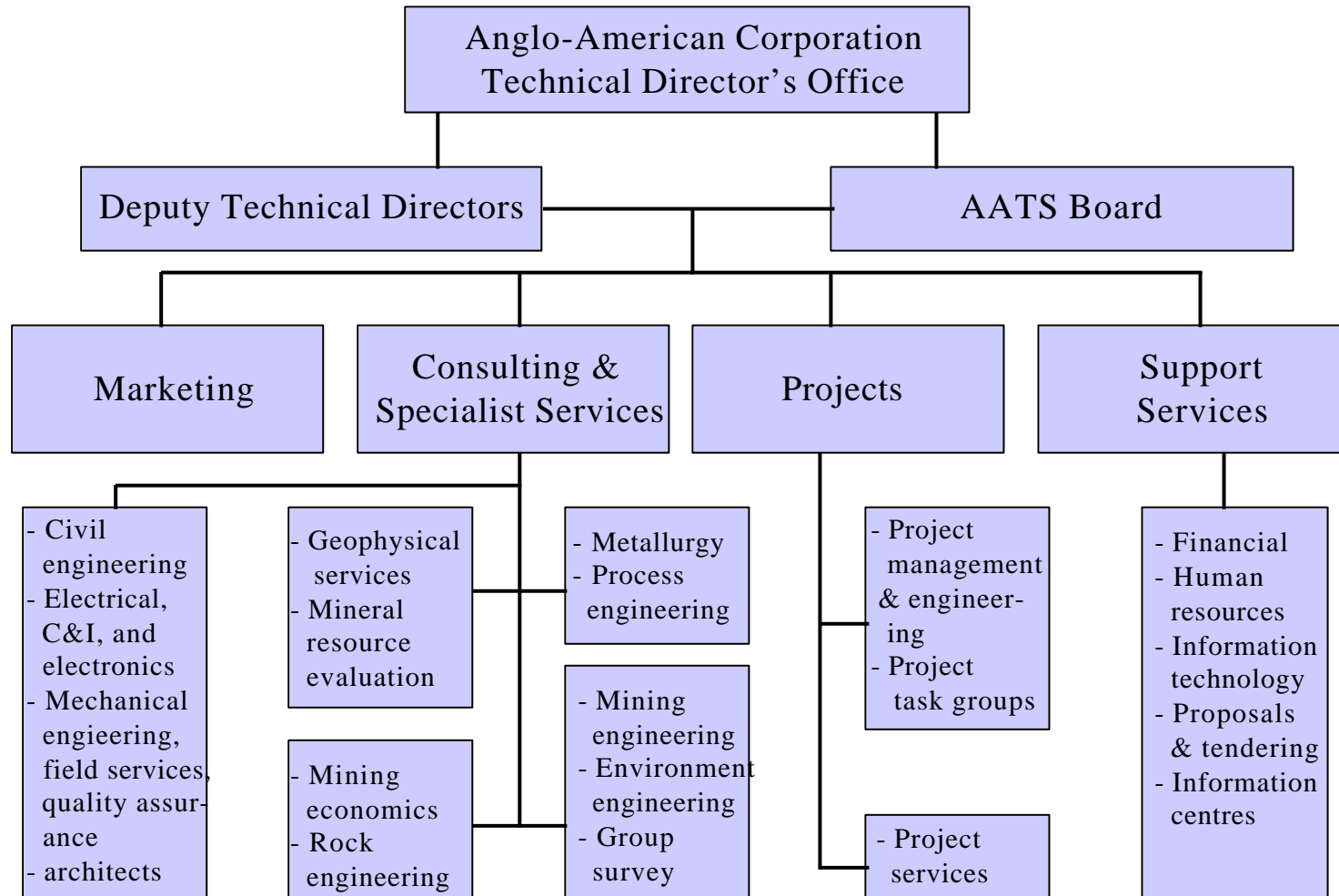


Figure 3.2: Anglo American Group Business Structure

Figure 3.3: Anglo American Group Organisational Structure



According to senior management at Anglo American, internal production of services occurs because that service, whether it be R&D or Engineering/Technical or IT, has one or more of the following characteristics:

1. The services cover core knowledge and expertise essential to the mining and beneficiation operations and projects that Anglo American is or could be invested in.
2. The TDO w/AATS is responsible for advising the corporation with regard to the development of new mines and beneficiation plants, evaluating new projects, providing technical consulting to existing operations and being ready to join project task teams to conduct technical or business investigations.
3. Anglo American's centres of excellence require that they maintain leading edge knowledge and expertise. This can be achieved by practicing the identification and implementation of break-through technology that improves existing operations, or allows the establishment of new operations. The focus is to look for opportunities to move down the cost curve or to increase opportunities for extraction.
4. It is important that the owners of operations have adequate in-house capability to moderate and critique the project and consulting inputs that are provided by external contracting parties. An investment in quality control.
5. In general, services provided internally are not routine but are of an expert nature and are not always readily available externally although experienced consultants are called upon to complement these capabilities. A lack of routine to justify entry.
6. The services are provided on arms-length commercial basis to AAC, its subsidiaries, and associates, but are also available to the open market at competitive rates.
7. Some services are available commercially, but in general, external providers do not have the insight into the background and context to meet the needs of Anglo American. Because of this the services are generally managed and overseen by in-house experts.
8. In-house service often deals with confidential information about mineral content, economic viability and proprietary technology that are critical competitive information.

In general relational contracts are often used because of economies of scale or a relatively long duration in provision of a service. Administrative costs of these contracts tend to decrease and establishing costs decrease over longer periods. Sometimes specificity issues arise and are reasons for relational contracts with services that are unique or rare. Another factor that may also lead towards relational contracts is the protection of intellectual property or to ensure confidentiality and security.

3.4.2 Project Phase⁸

These are the estimated cost composition for Anglo American Corporation of the various categories of services during the project phase of production.

R&D Services: + 7% of total costs; internal provision 20%, external provision 80%. The majority are spot purchases +/- 60%, but up to 90% with variation of +/- 20%.

IT Services: 2 to 4% of total costs; variable, purchases at established operations 50/50 internal/external, at new operations 70 to 80% external, 20 to 30% internal. With new systems 100% spot purchases, but potential for establishing relational agreements.

Technical Services: 2 to 14% of total costs; external purchases are typically 70 to 85%, but with new projects can be nearly 100%. More than 50% of these services are bought on the spot market with special consulting possible.

⁸ Excluding exploration because of its difficult characteristics, spending is highly variable and depends whether it is a Greenfield project or expansion of an existing operation, with numerous variants for strategic reasons.

3.4.3 Operations Phase⁹

These are the estimated cost composition for Anglo American corporation of the various categories of services during the project phase of production.

R&D Services: 1 to 2% of total costs; variable internal/external provision, some 100% internal while others + 85% external. Most external work is done on a spot contract basis.

IT Services: <1 to 2% of total costs; majority is external, but average 50/50, with a tendency of increasingly small operations to have higher percentage internal provision. Of the externally provided services nearly 100% on relational contracts.

Technical Services: 2 to 3% of total costs; 50 %external purchases. Of the external purchases 50/50 split between spot and relational contracting.

3.4.4 Location of Service Production

Services are purchased or produced internally for a variety of reasons. Likewise, the availability/cost of the service and transportation costs of consultants is important. Given its origins, many of Anglo American's internally produced services are from South African based employees. As was described above, several services are strategically important to the firm and so it is difficult to exactly quantify where a cost difference between a South African and another service provider becomes critical as the strategic context and inherent knowledge associated with that service could add considerable variability to otherwise similar services.

It makes sense for a company to involve as many local employees as possible so long as they are able to do so in an efficient cost effective manner. Trade in services has been a common practice in most mining firms as they expand beyond their original borders. Currently some of the main difficulties a South African mining finance house has come with regional trade agreements such as the Lomé - European Union agreement that has given disproportional advantage to former colonies who signed the trade agreement. In the course of discussions with senior management at several large South African mining finance houses, none of them identified increased liberalisation of trade in services as a particularly high corporate priority.

3.5 Service Performance and Sources of Change

3.5.1 Direction and Focus

As mentioned above, Anglo American has focused its production of producer services on special, highly technical services which it can best put its advanced technical resources to work. Services, which are competitively available in the market, are outsourced. During the restructuring process of the last few years AATS and Anglo American in general, have worked to outsource routine operations on the external market. An example of this process at Anglo American of internal disengagement is their black empowerment enterprise created out of Anglo American's Civil Engineering Department. This department has become an independent consulting firm that Anglo American is helping to get established on the market by a guaranteed continuation of its business with them for the near term.

In general, Anglo American has been closing internal services as part of their process of centralising non-core activities. Outsourcing has been undertaken and is being pursued where possible in the presence of an adequate-to-good market for the service. Again, the goal of the company has been to maintain existing core service expertise while it works to shift the majority of services it provides towards higher quality and greater value added services.

⁹ Also excluding exploration for the same reasons as in note one.

3.5.2 *Going Concerns*

Overall, the corporation has entered into an increasing number of relational contracts with service providers. This has been part of the strategic shift in the redirection of the corporation's own internal service provision. The general trend of this increasing use of relational contracts has been in very specialist areas such as R&D and IT services. Those relational contracts that have been terminated recently do not reflect a general tendency in the corporation, but rather, are the result of normal turnover.

Over the past ten years, the corporation has seen a substantial increase in the size and its use of the spot market for service suppliers. This general trend has been caused by the breaking-up of many larger firms into focused entities, particularly pronounced with IT service providers. Anglo American and its changes have been similar to the general industry trend, which has been the decrease of large internal capabilities and thereby an expansion in demand for specialist services providers.

3.6 Impact of Services

3.6.1 *External Effect of Internally Produced Services*

As has been mentioned in the section review on coal exports, a critical development for the economy of South Africa was the development of a coal washing technique that increased quality opened up the export market for South African coal producers. This process was developed by AARL. Again, because of the need for a market, both upstream and down stream for mining products, it often made sense to share less strategically important technical knowledge with other South African mining finance houses to spread risk and reach a certain critical mass of operations.

It would be difficult to precisely separate those benefits exclusive to the firm and the industry as a whole. Particularly with mining of gold, sharing technical knowledge is an accepted industry practice. The operations and knowledge have spill over into other activities as well, for a South African mining finance house particularly with ability in financial services. A large mining company like Anglo American can use its areas of competitive advantage for a comprehensive packaging of producer services.

3.6.2 *Producer Services and Strategic Importance in Business Expansion*

The new refocusing on high value added producer services and activities more directly linked to mineral extraction should give a firm like Anglo American significant benefits in efficiency as it can outsource those activities that are not key to the production process and hopefully used those resources to further benefit areas of more strategic importance to the firm. Margins continue to decrease in mining and to maintain a market leading position it is important that a firm like Anglo American constantly finds more efficient means to extract minerals and discover more cost effective mineral deposits.

When a firm such as Anglo American looks for long term growth it must look abroad as well as domestically. Strategically given the importance of accurate exploration information upon which to finance and design appropriate mines it seems that Anglo American and its considerable ability in exploratory activities should be well positioned to continue expanding and giving good returns on investment. Its spectrum of producer services and their integration in the cycle of mining production would also suggest that as Anglo American competes internationally it will be able to provide new mines at a markedly more efficient level of operations than its competitors.

3.6.3 *Producer Services and South Africa's Comparative Advantage*

Declining grades, particularly in gold, as well as market fluctuations makes determining a measure of better mining practices difficult. Particularly when looking at an industry level where new and old mines are present, efficiency can be misleading. Nonetheless, South African mining firms have often seemed to be near the end of their productive lives only to reform and increase efficiency. Lately, low gold prices seem likely to further pressure and seriously threaten a major section of South Africa's mineral sector, increased efficiency is crucial to these mines continuation, but despite surprising historic improvement there are undoubted limits to the improvements possible by South Africa's mining sector.

Below is some evidence of South Africa's mining sector productivity improvement. This is a crude national measure of overall productivity change in the South African mining sector. Data availability is a major hindrance in deriving a measure of efficiency of this sort. In order to get a historic comparison total employment in the mining sector has been divided by the real value of total output in the sector.

Table 3.2: South Africa's Mineral Sector Productivity 1920-1994

Year	Efficiency	Year	Efficiency	Year	Efficiency
1920	8.96	1981	67.56	1988	65.40
1930	10.15	1982	63.94	1989	66.20
1940	16.12	1983	64.20	1990	59.97
1950	15.63	1984	66.78	1991	57.54
1960	20.42	1985	76.62	1992	52.88
1970	25.93	1986	70.84	1993	57.92
1980	85.75	1987	59.98	1994	52.64

Source: Central Statistical Services of South Africa Statistics - Editions from 1979 - 1995; Department of Minerals and Energy Affairs Annual Reports 1976 to 1997

There has been a general trend toward increased efficiency in the mining sector as Table 3.2 shows. The large portion of gold mining in South Africa's mineral sector has distorted efficiency during price booms (early to mid 1980s) and price drops (1990s). Ability of South African mining firms to improve and increase their efficiency seems likely, but a relatively static operating environment has up until the last ten years or so meant a focus on different aspects of efficiency than are required now as they refocus on mineral extraction.

However, past experience and technical skills can play a significant role in the extraction of minerals in other countries which have not reached the depths of South African mines. It is here that South African mineral companies may hold a comparative advantage in development of these deposits. Greater technical efficiency makes it more likely that deposits will be profitable to mine once the rights have been secured. This offers a new source of demand for the internal and external producer services in South African mining now that the domestic market has moved to other challenges.

3.7 Conclusion

Anglo American is a large and important corporation in South Africa. Its resources, size and new direction seem likely to ensure its importance as one of the large multinational mining firms. There is an incredible variety of services that it uses and produces to support its mining operations. As the service market is established, Anglo American, like many other mining firms are increasingly using the market to provide its support services.

The trade of services, based on the evidence of this case study, is increasingly important. A significant deterrent had previously been the corporate structure itself. As competition for efficient mineral wealth extraction continues, a greater degree of standardisation in various elements of the production process seems to be arriving. This has allowed increased use of independent service providers.

BIBLIOGRAPHY

Anglo American Corporation *Annual Reports 1979 to 1997*

Central Statistical Services of South Africa *Statistics 1979 to 1995*

Cole-Baker, J.R. and G.J. Bowyer (1998) 'The Role of the Independent Technical Audit in Raising Finance', *Mining in Africa '98* published by the South African Institute of Mining and Metallurgy, 1998, pp. 1-10.

Crankshaw, P. (1994) 'Platinum Group Metals', *South Africa's Mineral Industry* published by the Department of Mineral and Energy Affairs, 1992/1993, pp. 22-27.

Damarupurshad, A.K. (1997) 'Diamonds', *South Africa's Mineral Industry* published by the Department of Mineral and Energy Affairs, 1995/1996, pp. 22-27.

Department of Minerals and Energy Affairs *Annual Reports 1976 to 1997*

Fine, B. and Z. Rustomjee. (1996) *The Political Economy of South Africa: From Minerals-Energy Complex to Industrialisation* (Johannesburg: Witwatersrand University).

Gregory, T. (1962) *Ernest Oppenheimer and the Economic Development of Southern Africa* (London: Oxford University).

Innes, D. (1984) *ANGLO: Anglo American and the Rise of Modern South Africa* (Johannesburg: Raven).

Jones, S. and A. Müller (1992) *The South African Economy, 1910-1990* (New York: St. Martin's).

Lang, J. (1995) *Power Base: Coal Mining in the Life of South Africa* (Johannesburg: Jonathan Ball).

Limebeer, A.J. (1951) 'The Group System of Administration in the Gold Mining Industry', *Optima*, 1(1), pp.26-30.

McCleod, D.B. (1996) 'Platinum Group Metals', *South Africa's Mineral Industry* published by the Department of Mineral and Energy Affairs, 1994/1995, pp. 40-41.

Morrel, W.P. (1940) *The Gold Rushes* (London: Adam & Charles Black).

Newbury, C. (1989) *The Diamond Ring: Business, Politics, and Precious Stones in South Africa; 1867-1947* (Oxford: Clarendon).

Oppenheimer, H.F. (1954) 'Union's Group Mining System', *The Mining and Industrial Magazine of Southern Africa*, 44(9), pp.323-327.

Pallister, D., S. Stewart and I. Lepper (1987) *South Africa Inc.: The Oppenheimer Empire* (Sandton, South Africa: Media House).

Prevost, X.M. (1997) 'Coal', *South Africa's Mineral Industry* published by the Department of Mineral and Energy Affairs, 1995/1996, pp. 49-55.

South African Reserve Bank *Quarterly Bulletin* 98(3) S-131

Stošes, Bohuslav. (1954) *Introduction to Mining* (London: Lange, Maxwell & Springer).

Walker, E.A. (1959) *A History of Southern Africa* (3rd edn) (London: Longman, Green & Co.).

Williams, G.F. (1905) *The Diamond Mines of South Africa* (New York: B.F. Buck & Co.).

Appendix