

A Perspective on the South African Mining Industry in the 21st Century

An independent report prepared for the Chamber of Mines of South Africa by the Graduate School of Business of the University of Cape Town in association with Genesis Analytics. The bulk of the work was completed in February 2000.

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The discovery of world-class diamond and gold deposits in the latter half of the 19th century laid the foundations for transformation of South Africa from an essentially agricultural to a modern industrial economy. Mining – embracing numerous other minerals too, in which South Africa has an exceptional geological endowment – remained at the heart of the economy in the 20th century.

Nevertheless, the political transition that commenced in 1990 posed huge challenges to the industry. The corporate and governance structures that had evolved over many decades were unacceptable to the international investment community who re-entered South Africa and who were important to the companies for raising capital not only for South African but also for off-shore projects. Further, management and workplace practices – the latter a product of the colonial and apartheid eras – were way behind international standards. The pressure was intense to shed the image of association with an exploitative and racially discriminatory regime, and concomitantly also to identify with the objectives and processes of forging a new South Africa. The need to modernise the industry was profound.

The story of the 1990s is the story of the start of this modernisation. Restructuring has taken place and/or is underway at several levels: mining house, mining company and workplace. What has emerged is a leaner, more focused, more competitive and internationally active industry. There are world-class mining companies in gold, platinum, diamonds, coal, ferrochrome and base metals. There are also world-class engineering and other companies that serve the industry. The industry provides the base for the country's competitive advantage in electricity, chemicals and related industries.

The contribution of mining to the economy must be seen as coming not only from mining operations but also from upstream and downstream activities. Indeed, mining constitutes what is surely the most successful 'cluster' in the country's economy.

This is not the common perception of the industry. The scale of contraction in gold mining – in output terms from 566 t in 1990 to 420 t in 1998 – has tended to create the impression that mining in South Africa is a sunset industry heading for marginal status in the economy. This impression is reinforced by the decline in the weight of the industry on the JSE Board, the 'buzz' associated with the rise of sectors such as financial and Internet-based services and, rather differently, the adverse social implications of massive job loss in the gold industry (from 474,000 employees in 1990 to 217,000 in 1998).

But this perception is simply wrong. With the exception of gold and of manganese, all of the country's major minerals have experienced long-term growth. Large-scale investment projects are at varying stages of design and implementation across all commodities. At the start of the new century, the South African mining cluster is making a rich and varied contribution to the national economy and is well advanced in making a substantial impact principally but not only in Africa. The industry is positioned to be a significant contributor to the government's objectives of employment creation, rural upliftment and regional (SADC) development and, more broadly, to giving an economic underpinning to the vision of an African renaissance.

Six perspectives on the industry bear out these statements.

One

Hidden inside SA's aggregate mining statistics are large, expanding industries

The decline in gold production has masked significant growth in other mining sectors in South Africa. Measured in terms of production, three sectors (coal, platinum group metals (PGM) and chrome) have **doubled** in size since 1980, while iron ore production has increased by more than half. During this period, mining other than gold grew faster than the rest of the economy. These industries are larger than most manufacturing subsectors: South African coal sales in 1997 were R16 billion, PGM R8.5 billion and chrome R4 billion. Some of the largest current investment projects in South Africa are in these industries.

Platinum and related metals are in a growth phase, with South Africa boasting around half or more of world production and reserves. Existing mines are being expanded, a new R1.35 billion mine is being built, and several other mining projects are being seriously considered. Refining capacity is being expanded, and sales of branded platinum, which is value-added, increasing rapidly.

Zinc, iron ore and nickel. South Africa may develop a large zinc industry over the next five years. A R4 billion mine, concentrator and smelter are being planned at Gamsberg in the Northern Cape, while a R2 billion zinc smelter at Coega in the Eastern Cape is under consideration. In iron ore, R850 million is being spent to upgrade the Sishen mine and rail line to Saldanha, with significant beneficiation taking place at Saldanha Steel. Nickel prospects are being investigated.

Chrome. Almost a quarter of the value of stainless steel resides in the ferrochrome added to the iron ore during production, making the chrome value chain one of the most desirable elements of this global industry. South Africa has two-thirds of the world's chrome reserves, and is steadily increasing its share of the world market in the beneficiated product ferrochrome, meeting 40 per cent of world demand in 1998. Investment activity in new mines and smelters is ensuring that South Africa is capturing a large proportion of the growth in world demand, currently expanding at a rate of 5-7 per cent per year.

During the period of heavy job losses in the gold industry, the non-gold mining sector chalked up a more positive employment performance. During the period 1990-96 the non-gold mining industry increased employment by ten per cent, employing 217,000 people by 1996. And between 1993 and 1996, a period during which 35,000 jobs were lost in manufacturing and 45,000 jobs in construction, more than 40,000 workers were added to payrolls in the mining sector outside of gold.

Two

Mining and related beneficiation account for half of South Africa's exports

Mining continues to be the single most important earner of foreign exchange in the economy. During the 1990s, mining directly generated 41 per cent of total exports, around the same as the fast-growing manufactured exports sector. In 1997 the value of mineral exports was R51 billion. In that year, for the first time possibly since the start of the 20th century, non-gold mineral exports (at R27 billion) exceeded the value of gold exports, testimony to the resilience and growth of the non-gold sector. Gold, with exports valued at R25 billion, was by itself responsible for one-sixth of South Africa's export earnings. These statistics undervalue the contribution of the mining sector to export earnings. Upon closer inspection, the handsome growth in South Africa's manufacturing exports turns out to be based in large part on metals processing built on our mining activities. Once one includes processed mineral products, such as ferroalloys and aluminium, the mining sector's contribution to exports is half of all exports.

Three

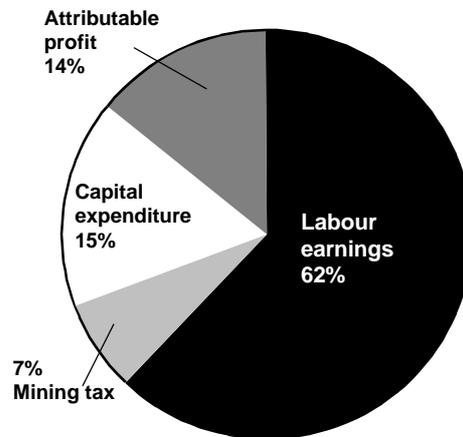
For a community of 5 million South Africans, mining remains a principal ally against poverty

The latest population census shows that one in seven African men with a formal sector job in 1996 was employed in the mining industry. Through this, the mining industry remains a conduit of money and opportunity to some of the poorest areas in South Africa.

Mining's contribution. Analysis of the 1996 population census identifies 56 magisterial districts in which a sixth or more of the aggregate earnings of African men derives from mining. The list includes the most important mining areas, but is dominated by poor rural districts from which miners are recruited. We can speak of the 56 districts collectively as South Africa's 'mining nation': The total population of these areas is 5.7 million, and on average more than a quarter of all income earned by African men is earned in mining. The Eastern Cape has a particularly strong presence: 14 Eastern Cape districts with a total population of 1.6 million, are part of this mining nation, with more than 20 per cent of all earnings of African men coming from mining. The 'mining nation' includes some of the poorest areas in the country, commonly with very high dependency ratios (number of dependants per economically active person).

The 'mining nation' areas have borne most of the social costs of the relentless fall in gold mining employment as more than 300,000 jobs were lost between 1986 and 1998.

Where the money goes. The pie chart below deals with the gold mining industry, which remains by far the largest employer in mining. It shows how the value generated in gold mining – that is, the value of the gold produced less the value of inputs other than labour – is divided between employees, shareholders and government.



Distribution of gold mining value added: 1990-1998
Source: Chamber of Mines

Labour is the most important beneficiary of gold mining activity, capturing 62 per cent of all value generated. Rising real wages and falling margins have contributed to labour's share rising by half from historical levels of 40 per cent of value-added in 1970 to the 60 per cent plus levels seen today. It overshadows the portion of value added captured by shareholders (14 per cent) and by direct government taxation (7 per cent). Conversely, it means that labour suffers the most heavily from the shutting down of capacity. Considering that the unskilled share of total labour earnings has been above 60 per cent for most of the 1990s, much of the brunt of restructuring is borne by the communities identified above.

Four

Mining potentially offers the key to economic development in Africa

During the last two decades, two macroeconomic shortcomings have repeatedly pushed African economies back into dependence on the multilateral aid agencies:

African countries have saved at less than half the rate of other developing countries, mainly due to an **inability of governments to generate tax revenues** to cover fairly low government expenses.

With limited exports, countries have had **too little foreign exchange** to purchase the machines and computers required for export-led growth.

The root causes of these maladies – political instability, weak institutions and poor policies – are being addressed, and yet the lack of government revenues and foreign exchange perpetuate a cycle of economic underperformance that is difficult to break.

This is where mining can play a critical role in Africa's economic renaissance. It offers the continent's best opportunity for international competitive advantage, all the more so because of the rich but still relatively unexplored minerals endowment. Mining operators, often the pioneer foreign investors in African countries, generate large amounts of foreign exchange and provide a large revenue boost to governments.

Why are mining operators willing to lead the way for other foreign investors? Unlike large infrastructure operations, the foreign exchange earnings of mines means that they operate with virtually no currency risk, one of the main bugbears of investment in Africa. Secondly, although a competitive industry, mining does not face the same level of competition of other low-wage countries as applies in manufacturing.

Mining is already transforming the economies of some African countries. **Botswana's** stellar economic performance built on diamond mining is well documented. Foreign direct investment (FDI) of more than \$800 million in **Zambia's** copper mines seems set to revive a stagnant sector and economy. By far the largest contributor to FDI in an otherwise struggling **Zimbabwe** in 1998 was mining investment totalling \$544 million. **Mozambique's** economic restoration has been heralded by a \$1 billion plus aluminium smelter, and the country is enjoying renewed exploration interest. **Tanzania's** mining FDI receipts of \$297 million during 1995-1999 are likely to be exceeded in coming years following the discovery of promising gold ore bodies.

Five

South Africa is well positioned to be the driving force of mining development in Africa

South African mining companies are leading the resurgence of mining activity in the region, sometimes in partnership with foreign mining operations. Anglo American, Randgold, Gencor and JCI have each invested sums in excess of US\$12 million in African exploration. Billiton is building an aluminium smelter in Mozambique, Anglo American and Gold Fields are heavily involved in gold projects in West Africa, and Anglo American and Anglovaal Mining are investing in copper/cobalt in Zambia.

Johannesburg may reclaim its position as a global centre of mining technology, specialist services and supplies. If it does so, it will be the continent's sourcing centre for supplies and services. It is estimated that more than half of the investment made in certain very large-scale projects in Southern Africa has returned to South Africa through the purchase of services and supplies. South African firms also benefit from the on-going operating expenditures of the mines. In the case of one giant project, the Konkola copper deposit, it is calculated that more than R10 billion will be spent on South African services, technology and supplies over the 30-year course of the project.

Six

South African firms are at the centre of global mining operations, services and technology

Using its mining activities as a base, South Africa has nurtured strongly competitive sectors providing sophisticated inputs and services to the global mining industry. In particular, South African firms have become globally prominent in three areas:

- **Technology providers** to the global mining industry
- Providers of **knowledge-based mining services**
- **Specialist mining contractors.**

South African firms are among world leaders in mining explosives, drilling equipment and abrasives, metallurgical processes and plants, and delivering knowledge-based services to mines everywhere. It is also one of the few fast-moving technology spheres where a significant number of South African companies are at the frontier of innovation. South African firms are active in the specialised mining supply industry. For instance, AECI and Sasol are leading suppliers of mining **explosives**; Boart International is a world leader in **abrasives**; and two South African firms, SRK and Bateman, are among the most important **mining consultancies** in the world.

South Africa also has a strong regional franchise in specialist contract mining. South African firms like LTA and Cementation Mining play a major role in **specialist contract mining** in Africa.

To appreciate the opportunities in these fields, consider that, at value added of as much as \$1 trillion, the global mining industry is ten times the size of South Africa's economy. That implies that the global mining supplies and services business is several times larger than South Africa's entire mining sector. Among other things, these activities are the basis for a strong South African presence in a key 21st century growth industry: management services and systems applied to environmental protection, not only in mining but also in other sectors.

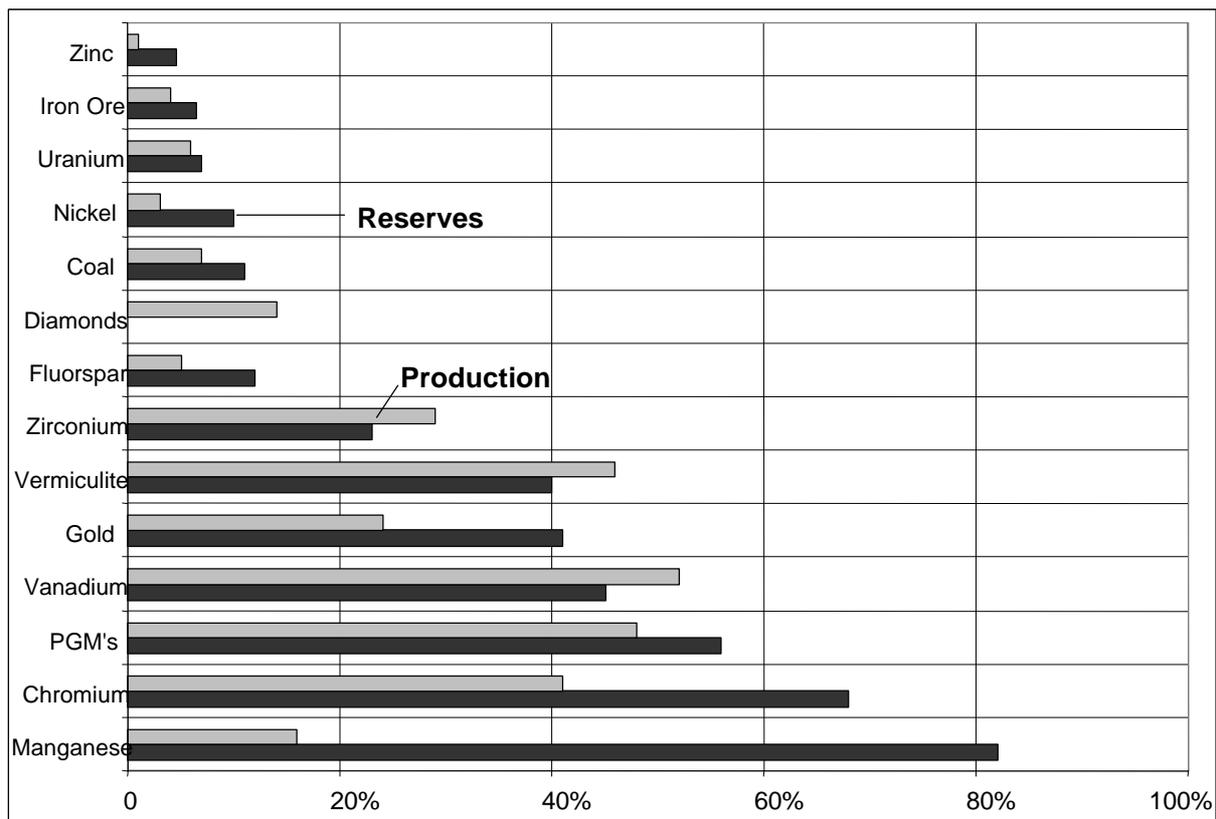
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1 An overview of the mining industry in South Africa and the region

Mining in South Africa

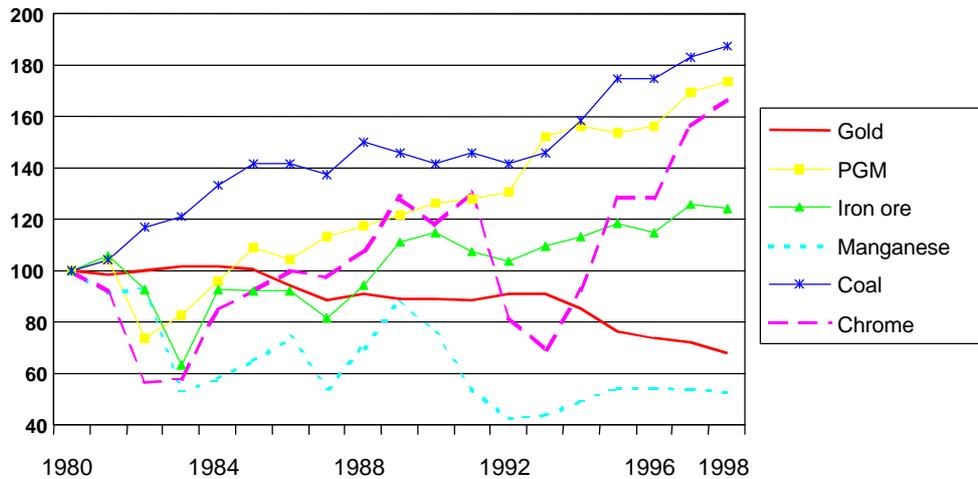
After a century of mining activity in South Africa, the country remains one of the most geologically blessed regions in the world. South Africa has more than half of the world's reserves of manganese, chromium and platinum group metals. It has 40 per cent or more of the world's vanadium, gold and vermiculite reserves. The country's mineral legacy is reflected in robust production statistics, a full roster of new mining investments, a dynamic mining supplies and services sector, and globally prominent firms. It has also made an imprint on the macroeconomy. We briefly turn to each of these topics.

Production. Apart from being the world's largest producer of gold, platinum, manganese, chromium and vanadium, South Africa is one of the world's biggest producers and exporters of steam coal, the feedstock for 34 per cent of the world's electricity.



South African reserves and production in key minerals, 1998 (% of world)

Source: Chamber of Mines

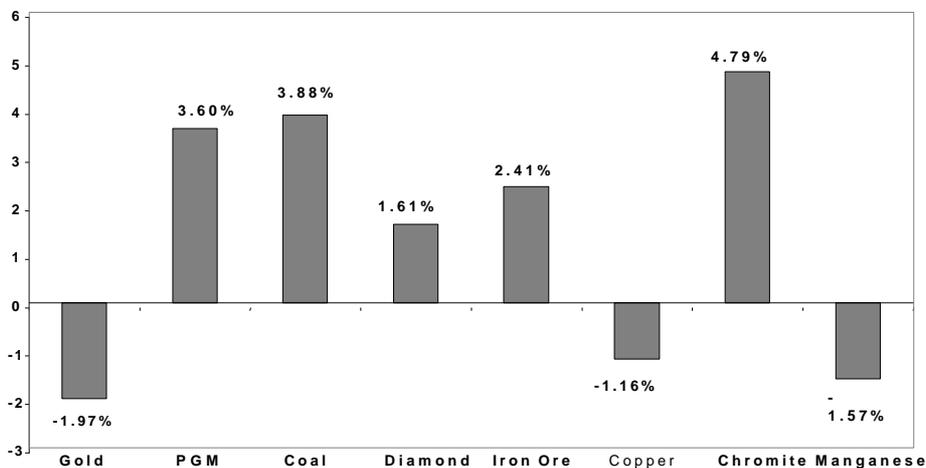


South African production trends for six key minerals (1980=100)

Source: Minerals Bureau

Two trends, two industries. Gold mining has, with a brief exception in the early 1980s, for three decades displayed a downward trend in production as the industry has reached maturity. At 464 tonnes 1998 production was around half the historic peak of production in 1970. Gold mining shows a pattern of development that is relatively distinct from the other principal ores mined in the South African economy. With the exception of manganese, production of other minerals has increased handsomely since 1980.

Coal production almost doubled in the 1980 to 1998 period and reached 224 580 thousand tons in 1998. Similarly, mining of platinum group metals has increased steadily and significantly since 1983, moving production levels up from below 100 tons in 1982/83 to 200.1 tons in 1998. Increasing levels of production are also reported for **iron ore** and **chrome**. Finally, **diamond** production increased by one-fifth over the period.



Average annual change in production: 1980-1998

Source: Minerals Bureau

As the chart above shows, large increases in production have occurred in platinum group metals (PGM), coal, diamonds, iron ore and chrome. Coal and chrome production has doubled, while platinum production has increased by 89 per cent since 1980. For a smaller group of minerals, gold, copper and manganese, production has reduced, losing between 20 and 30 per cent of output. Capital expenditure to expand production is occurring at a high level, as the following examples show.

Planned expansion in South African mining: a selection

Iron Ore. Expansion in this industry is centred on an increase in production of ore by both Iscor and Associated Manganese Mines of South Africa (Assmang). In addition rail and port capacity are also being upgraded. Spoornet has long-term plans to expand the railway link capacity (from Sishen to Saldanha) to 38m tpy by 2010. In the short term it is making a R170m investment in the line to increase the line's capacity from about 22m tpy to 27m tpy over the period 1998-2000.

At the beginning of 1999 Iscor embarked on a R670m upgrade project at Sishen. The upgrades are scheduled to occur over a four year period to maintain the mine's long term production capacity and enable it to produce various products according to market demand.

Platinum. In the platinum arena expansion is also imminent. Outlook for the growth in demand of platinum group metals is positive. The two largest platinum producers in South Africa, Amplats and Implats, are both looking to expand. Amplats is currently (late 1999) adding 400 000ozs of annual production capacity from current projects. The company also announced in December 1999 that a new platinum group metals mine would be developed on the eastern limb of the Bushveld Igneous complex. The feasibility study indicates a capital investment of R1.35 billion, with an annual production of about 162,000 ounces of platinum.

According to Implats production of its branded platinum will increase by an average of 10 per cent per year over the next five years. The final phase of Implats refinery upgrade was commissioned in July 1999 and this raises annual capacity to 1.4 million ounces of platinum. An associate company Aquarius is currently developing the Marikana UG2 project, which has been estimated to have resources of 18 million tons. In addition Implats are investigating Everest South which has resources estimated at between 15 and 20 million tons.

Gold. The most important new gold project in South Africa is South Deeps, a joint venture of Western Areas and Canada's Placer Dome, and involving investment exceeding R3 billion and full production of 700,000 ounces per annum. Avgold's Target Mine near Bothaville is another important development: by using new technology, Target will be able to mine below 2,200m at a cash cost well below \$200/ounce. AngloGold are currently involved in exploration of the Western Ultra Deeps Level Property (WUDLS), which is the down-dip extension to the Western Deep Levels, Elandsrand and Deelkraal mining leases. Exploration at this site commenced in mid-1998 and is expected to last until mid-2002 and to cost about R130 million.

Diamonds. De Beers has recently announced the go-ahead for a new R610 million combined treatment plant that will extend the life of the Kimberley mines by approximately 14 years. De Beers is also examining the feasibility of extending the life of its Premier mine by 20 years in a R1.5 billion extension. Should the project be completed output at the mine will be about 3.4 Mct/y, which is equal to about a third of the current annual output from De Beers' South African diamond mines. To go ahead, the project will require a halving of working costs from current levels.

Ferroalloys and vanadium. South Africa's ferrochrome capacity is in an historic expansion phase, as is described in Chapter 5.

Zinc. Anglo American are planning to develop a R4 billion zinc mine, concentrator and smelter over the next four years, based on the Gamsberg deposit. This mine will produce about 200 000 t/year of refined zinc. In addition, Billiton has plans for a R2 billion zinc smelter at Coega, although these plans are still to be finalised.

Aluminium. Billiton is South Africa's only primary aluminium producer. Hulett, who are active in the downstream aluminium industry in South Africa, are currently implementing a R2.4 billion expansion, which is projected to raise sales to more than 175 000 t by the end of 2002 (an increase of 250 per cent). Early in 1999 the company began work on the R800 million hot-line at its new plant in Camp's Drift.

Nickel. Implats is involved, in conjunction with Falconbridge of Canada, in the exploration of the Insiswa nickel project in the Eastern Cape. This is primarily a nickel project but it could also produce significant amounts of platinum group metal concentrates.

Industry structure

Majors. Apart from geological resources and output, South Africa remains the nerve- centre of some of the largest mining companies in the world:

- Anglo American is a world leader in gold and platinum, and has significant interests in copper, steam coal and a number of other minerals.
- De Beers is the most important diamond company in the world.
- Billiton is a major participant in the world's base metals and aluminium smelting industries.

South African 'juniors' emerge. In recent years, a number of smaller entrepreneurial South African companies have emerged out of the restructuring of the local industry. These and other already established smaller companies, typically using more flexible and nimble management methods, have been instrumental in saving a large number of marginal operations and making them feasible entities.

A world-class mining services and supplies industry. South Africa has, as befits a country with a strong minerals cluster, a very strong – and unsung – mining supplies and services industry operating worldwide. It is also one of the few fast-moving technology spheres where a significant number of South African companies are at the frontier of innovation. South African firms are active in the specialised mining supply industry. AECI and Sasol are leading suppliers of mining **explosives**. Boart International is a world leader in **abrasives**. Two South African firms, SRK and Bateman, are among the most important **mining consultancies** in the world. South African firms like LTA and Cementation Mining play a major role in **specialist contract mining** in Africa.

Mining and the economy

Mining remains the critical South African export

Mining continues to be South Africa's single most important earner of foreign exchange. During the 1990s, mining directly generated 41 per cent of total exports, around the same as the fast-growing manufactured exports sector. In 1997 the value of mineral exports was R51 billion. In that year, for the first time possibly since the start of the 20th century, non-gold mineral exports (at R27 billion) exceeded the value of gold exports, a testimony to the resilience and growth of the non-gold sector. Gold, with exports valued at R25 billion, was responsible for one-sixth of South Africa's export earnings. These statistics undervalue the contribution of the mining sector to export earnings. If processed mineral products, such as ferroalloys and aluminium were included, the mining sector's contribution to exports would be around half of all exports.

Sector	Average for decade		
	1970s	1980s	1990s
Agriculture & Forestry	6.9%	3.5%	4.2%
Mining	54.0%	61.3%	40.9%
Manufacturing	24.6%	23.6%	40.3%
Electricity, Gas & Water	0.1%	0.1%	0.1%
Construction	0.0%	0.0%	0.0%
Services	14.4%	11.5%	14.3%

Composition by sector of South African export earnings

Source: Statistics South Africa

Output

In 1998, mining contributed R44 billion to South Africa's GDP, or 8 per cent. Focusing on the sector's contribution to the private economy, over the 1975-98 period, the proportional contribution of the mining sector to total value added in the South African economy has declined from 13.9 per cent in 1975 to 9.9 per cent of the private sector's GDP in 1998.

Stages of development. The declining relative importance of mining to aggregate South African output is consistent with international patterns of economic development: it is what the mining houses themselves, the broader union movement and governments of the day had envisaged should happen as the country developed a manufacturing and services base. What emerges from comparative studies is that for countries with higher per capita GDP the share of primary activities (agriculture and mining) in the economy becomes lower and the share of manufacturing and services higher. In this light, a declining

Sector	1975	1980	1985	1990	1995	1998
Agriculture, Forestry & Fishing	5.4	5.7	5.4	6.1	5.3	6.4
Total Mining	13.9	13.3	13.0	11.3	10.5	9.9
Total Manufacturing	30.1	32.8	29.4	29.6	29.3	28.3
Electricity, Gas & Water	3.1	3.6	4.6	5.1	5.6	5.9
Building & Construction	6.3	5.0	4.4	4.0	3.4	3.3
Services	41.1	39.6	43.2	43.9	45.9	46.3

Percentage contribution to GDP by sector: 1975–1998

Source: SA Reserve Bank

primary sector reflects a typical transformation of an economy in the course of economic development. In short, South Africa is no different from other countries in displaying a declining relative contribution of primary commodities to aggregate output.

The next table depicts the proportional contributions to GDP of the three principal mining sectors. This exercise reveals that mining's declining share in GDP is chiefly attributable to the falling output of gold and uranium. Between 1980 and 1998, the gold sector contribution to private sector GDP fell 4.3 per centage points, while the mining sector contribution as a whole fell only 3.4 per cent. This means that the non-gold mining sector grew faster than the rest of the economy between 1980 and 1998. The contribution of the gold and uranium subsector to total mining output stood at 80.9 per cent in 1970, and while having declined to 46.5 per cent by 1997, it still represents the single largest sector in the South African mining industry.

Mining subsector	1980	1985	1990	1993	1998
Coal mining	1.5	2.7	2.0	1.5	1.9
Gold & Uranium Ore Mining	8.4	7.1	5.7	7.3	4.1
Diamond mining			0.4	0.5	0.6
Platinum & Other Mining	3.3	3.2	3.2	2.5	2.5
Total mining	13.3	13	11.3	11.8	9.9

Percentage contribution to private sector GDP

Source: SA Reserve Bank

Mining and employment

Even after a decade of downsizing, mining still employed 551 677 people in 1997. Of that group, 62 per cent, or 343 922 people, were employed on gold mines, and a still large 207 755 on the rest. Trends in employment are discussed in more detail in Chapter three.

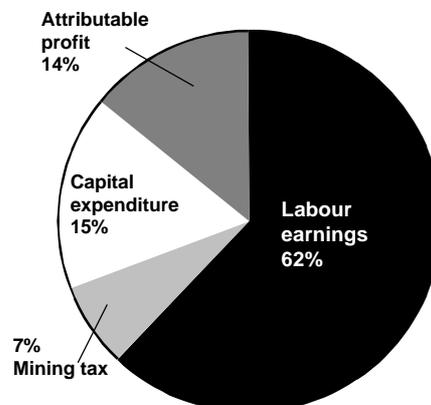
How the proceeds of mining are distributed

A key question for understanding the social impact of mining is to assess to whom the proceeds of mining are distributed. Because of the social relevance of the sector – and because data are available – this section focuses on gold mining. There are two types of ‘proceeds’ that can be measured, **overall revenues** and **value added**, and we report on both. What is meant by the latter is the value added by the industry to the physical inputs it has used, calculated as the difference between the value of the gold produced and the cost of the purchased inputs. What makes ‘value added’ such an interesting measure is:

Firstly, value added is ultimately **distributed in full to three groups**: employees (in the form of salaries and wages), owners and other providers of capital (in the form of profits and interest payments), and the government (in the form of taxes). The breakdown of this distribution is obviously of great interest.

Secondly, value added, as the term suggests, is where economic value, or **well being**, is created. That is why GDP, our measure of economic output, is nothing more than the sum of all the value-addition that takes place in the economy.

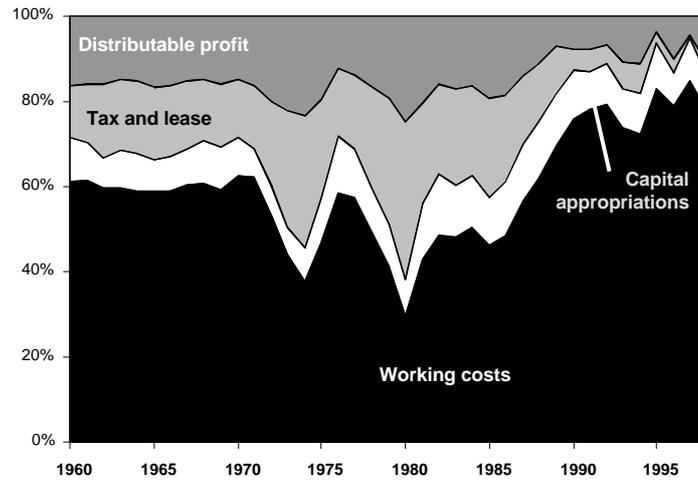
Distribution of overall revenues. As the chart on the next page shows, over the last three decades working costs have shot up from historic levels of around 40-60 per cent of total revenues to around 80 per cent. This dramatic margin squeeze is a combination of lower output prices (which depress revenues), higher real wage costs and less favourable geology (in the form of lower grade ore at deeper levels). The revenue distribution shows how both profits and taxes on profits have been relegated to minor components by the margin squeeze. Note also, how at times of high prices and profits, the tax take increases sharply to capture a large part of the additional revenues generated. This illustrates the working of South Africa’s graduated tax system for gold mines.



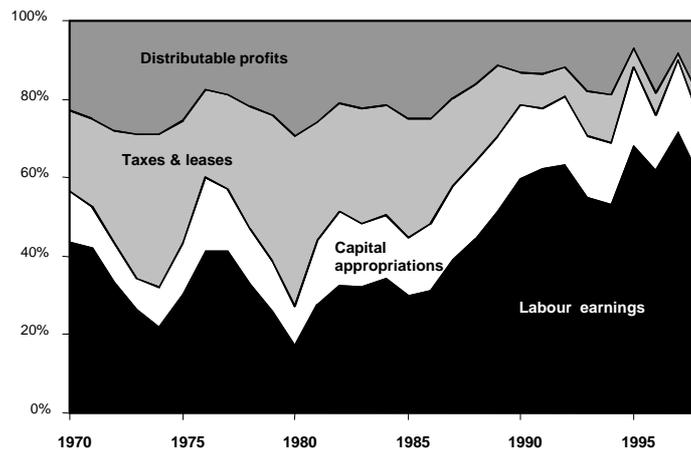
Distribution of gold mining value added: 1990-1998

Source: Chamber of Mines

When we turn to how gold mining’s value added is divided up between labour, government and owners, the structural nature of the industry is revealed. Firstly, the chart shows how labour has increased its share of value added since 1970 from historical levels of around 40 per cent to current levels of around 60 per cent. This trend reflects the increases in real wages. It is also due to the fact that profit is a residual item: with a price downturn, much of the reduction in revenue



Gold revenue distribution: 1960-1998
Source: Chamber of Mines



Distribution of gold mining value added: 1970-1998
Source: Chamber of Mines

is borne by the owner (and government), until such time as restructuring takes place, which reduces the wage take. Profits, on the other hand, captured 14 per cent of value added, and mining taxes 7 per cent. It is difficult not to conclude that the main losers of further downscaling of gold mining would be labour, as they have become, comparatively speaking, the largest beneficiaries.

Taxation

Because the mining industry's tax obligations are leveraged more dramatically to profit levels than the rest of the economy, its direct contribution to government revenue has declined from the 1970 and 1980s. During those decades the industry contributed around one-eighth of total government revenue. Most of these revenues came from the gold mines, whose effective tax rate during the 1970s-80s hovered around 55 per cent. Due to the sliding scale of gold mine taxation, the effective tax rate of gold mines fell precipitously during the 1990s: as a result, the industry's direct contribution to total tax revenues of government has fallen to one tenth of previous levels in proportional terms. Revenues from diamond mining decreased as a result of a decade of over supply and falling demand in international diamond markets triggered by Japanese recession and worsened by Asian financial market instability.

<i>Per cent</i>	1970s Average	1980s Average	1990s Average
Coal	0.29	0.52	N/A
Gold & Uranium	10.02	12.51	1.13
Diamonds	1.45	0.56	0.09

Contribution of direct taxes to government revenue (per cent of total revenue)

Source: SA Reserve Bank

However, these measures understate the total contribution that the mining sector makes to state coffers. As the analyses of the distribution of value-added and of revenues show, most of the output of the gold sector, for example, is expended on working costs, particularly wages. These expenditures generate large tax revenues for the government. For example, by making certain assumptions, it can be conservatively estimated that in 1998, gold mining employees contributed a further R1.8 billion in the form of income and value added taxes, all using income generated by the gold mining.

Investment and savings

Over the last three decades the mining industry has significantly increased its share of total capital stock. Moreover, buoyancy in investment in particularly gold and uranium mining during the course of the 1980s helped to prevent the slump in the investment rate of the economy from being even worse than it proved to be. During the course of the 1990s investment rates in the three aggregate mining sectors decreased from the high levels of the 1980s. Yet, at 17 per cent of total fixed capital stock (here defined as plant and machinery) the mining sector occupies an important part of South Africa's productive capacity.

<i>Per cent</i>	1970	1975	1980	1985	1990	1995
Total Capital Stock	6	6	6	7	9	8
Fixed Capital Stock	12	11	15	15	18	17

Proportion of capital stock dedicated to mining

Source: SA Reserve Bank

Coal mining has maintained far stronger growth in investment in machinery and equipment than the other two mining sectors. Moreover, through the 1970s and 1980s gold mines also maintained a healthy growth in fixed capital stock (the gold mining sector was ranked tenth and fourth respectively in the two decades amongst the 40 sectors for which data is available). Diamond and other mining came to prominence in terms of growth in fixed capital stock only during the course of the 1990s, and its rank of 19 out of 40 economic sectors suggests that the growth in fixed capital maintained by the sector was not spectacular by economy-wide standards.

<i>Per cent</i>	Build & Cons	Machinery		Equipment	
	1970-97	1970s	1980s	1990s	1970-97
Coal	9.61	15.51	6.33	1.48	8.05
Gold & uranium	3.49	8.04	8.94	-5.39	4.41
Diamonds	2.59	10.00	2.48	5.55	5.92

Average growth rate in capital stock by mining subsector

Source: SA Reserve Bank

The purchasing power of the mining sector

Input-output tables, which were last updated in 1993, give an indication of the purchasing power of the mining industry. Table 1 attached at the end of this chapter provides an initial impression of how important mining industry purchases

are for the rest of the economy. This gives the amounts spent by the mining industry in 1988 and 1993 for selected industries (from which one of the mining sectors purchased at least 5 per cent of its inputs in one of the years). The amounts spent on intermediate goods in 1993 came to a total of R 18.5 billion, with an additional R 15.2 billion spent on remuneration of employees¹. This represents a direct cash injection of over R30 billion.

It is clear that the sectors from which the mining industry draws the bulk of its supplies are all heavy industries - chemicals, metal fabrication, "special industrial machinery" and so on. This has obviously been one of the impacts of the mining industry. It has enabled the creation of a heavy engineering and industrial chemicals sector which otherwise would not have been viable. The only other sector which accounts for a significant proportion of input costs is wood² for the gold mining sector. Again these purchases have led to the creation of an entire industry - the forestry sector.

In Table 2 we have taken a different cut at the same flow statistics. We have shown the purchases by the mining industry as a percentage of total domestic output for various sectors. The mining industry is a large client of the industrial chemicals sector, purchasing 8.5 per cent of total output. It is also a large consumer of electricity. There are a number of additional linkages in evidence. Interestingly enough the mining industry is a very large client of railway equipment suppliers - purchasing over 40 per cent of domestic output in 1993.

Mining in Africa

Africa is the last continent waiting for the full force of modern mining techniques to uncover its mining potential. Mining, exploration and beneficiation increased during the 1990s. This is partly due to the international exploration boom of the early 1990s. At the same time some African countries opened their economies and modernised their mining codes, welcoming foreign investors who had been shunned since independence. For example, the Zambian government has recently sold certain copper mines to the same company from which it nationalised these assets in the 1960s.

With the entry of large mining operators, mining is again becoming what it used to be for some African countries: the driving economic force and major foreign exchange earner. Exploiting the continent's mineral wealth will help alleviate the two major constraints that have kept many African countries in the thrall of the multilateral aid agencies:

The lack, for many African governments, of sufficient **tax revenues** to cover (fairly low) government expenses.

A scarcity, in many African economies, of **foreign exchange earnings** for the purchase of foreign capital goods such as machinery and computers.

Mining is already transforming the economies of some African countries: **Botswana** has enjoyed a diamond mining boom, and investments in **Zambia's** copper mines seem set to revive a stagnant sector. In **Tanzania** gold exploration is taking off following the location of very promising ore bodies and a more stable economic and political climate. **Mozambique** and **Zimbabwe** have also enjoyed renewed exploration interest. While some traditional mineral exports like copper, zinc and lead have declined, there have been large increases in the production of diamonds and nickel. **Exploration and development.** Spending on exploration has increased markedly in the 1990s. Some estimates indicate that the African continents share of global exploration spending has risen from seven per cent in 1993 to 17.5 per cent in 1998. In Canada and Australia the most accessible and geologically prospective areas have undergone

Country	1993	1994	1995	1996	1997
Angola	NA	NA	0.9	1.5	2.3
Botswana	13.0	16.2	12.1	10.6	10.8
Lesotho			0.05	4.4	6.6
Mozambique	NA	NA	4.0	10.2	13.2

Namibia	3.7	3.7	9.1	11.3	9.3
Zambia	14.0	19.0	26	32.0	45.0
Zimbabwe	1.3	1.3	1.7	1.7	1.7
Total	31.9	40.2	52.9	68.5	86.6

Mining exploration expenditure 1993-1997 (US\$ millions)

Source: MCU 1998 Annual Report

successive stages of intensive exploration for the last 80 years and new discoveries are still made. Yet some geologically equivalent (though less accessible) areas in Africa have had no modern exploration completed on them at all. Projects to the value of \$6.7 billion are being developed (excluding South African projects and the expansion of existing mines).

There are three hindrances to the development of mining in Africa:

Political stability is a crucial and necessary requirement for significant long-term investment. The political unrest in Angola will act as a major deterrent to foreign investors in the future.

Geological information. Major mining companies are continuing to cut back on exploration spending leaving that activity to smaller exploration companies. Exploration companies often do not have the capital to carry out major regional surveys. Hence they concentrate their funds on targets identified from basic data. The lack of a comprehensive geological minerals database in Mozambique in an electronic format is a problem. The establishment of an African geological database would help stimulate investment and would reduce the risks and costs for many companies.

Infrastructure. As is shown elsewhere in the report, infrastructure for the running of a mine and the transport of minerals to foreign markets is a critical element of the feasibility of a mining operation. Countries will have to address these needs imaginatively.

South African mining benefits greatly. There is increasing evidence that South African mining houses are leading the resurgence of mining activity in the region, often in partnership with foreign specialist mining operations. De Beers, Anglo American, Randgold, Gencor and JCI have all invested sums in excess of US\$12 million in African exploration. Billiton is building an aluminium smelter in Mozambique and Anglo American is involved at the Sadiola gold project in Mali and in Zambian copper. The benefits that accrue to South Africa, and in particular to its dynamic mining services and supplies industries are enormous. It is estimated that more than half of the capital outlay made in certain very large-scale projects in Southern Africa has returned to South Africa through the purchase of services and supplies. South African firms also benefit from the on-going operating expenditures of the mines. In the case of one giant project, the Konkola copper deposit, it is calculated that South Africa will receive more than R10 billion over the 30-year course of the project.

Country	1998	1995-1999 Totals
Mozambique	8	20
Namibia	10	59
Tanzania	48	297
Zambia	162	405
Botswana	250	400
Zimbabwe	544	577
Totals	1,022	1,758

Recent Mining FDI* in selected SADC countries 1995-99 (US\$ millions)

Source: BusinessMap SADC-FDI database

Target Company	Target Country	Source Company	Source Country	US\$ m	Kind	Year
<i>Hartley Platinum Mines</i>	Zimbabwe	<i>BHP Minerals and Zimplats</i>	Australia	500	New	1998
<i>Chambisi Copper and Cobalt Mine</i>	Zambia	<i>Avmin</i>	South Africa	155	Privatisation & New	1998
<i>Kolwezi Tailings Project</i>	DRC	<i>Anglo American Corporation (AAC) and AMF</i>	SA & USA	130	Mergers & Acquisitions	1999
<i>ZCCM Copper Mines</i>	Zambia	<i>AAC</i>	SA	90	Privatisation	1999
<i>ZCCM Power Division</i>	Zambia	<i>Copperbelt Energy Corporation</i>	UK	50	Privatisation	1997
<i>Gecamines</i>	DRC	<i>Iscor</i>	SA	66.7	Expansion	1998
<i>Tsumeb Corporation</i>	Namibia	<i>Danae Resources</i>	Australia	49.2	Mergers & Acquisitions	1999
<i>Golden Pride Mine</i>	Tanzania	<i>Resolute Ltd & Samax Gold</i>	Australia	47	New	1997
<i>Turk Mine</i>	Zimbabwe	<i>Casmyn Corporation</i>	Canada	30	Mergers & Acquisitions	1995
<i>ZCCM/Kansanshi Mines</i>	Zambia	<i>Cyprus Amax Minerals</i>	USA	28	Privatisation	1997
<i>Bwana Mkubwa Copper Mine</i>	Zambia	<i>First Quantum Minerals</i>	Canada	26	Mergers & Acquisitions	1997
<i>Eureka Gold Mine</i>	Zimbabwe	<i>Delta Gold</i>	Australia	24	New	1998
<i>Williamson Diamond Mine</i>	Tanzania	<i>De Beers</i>	SA	22	Privatisation	1995-98
<i>Maamba Collieries</i>	Zambia	<i>Benicon</i>	SA	22	Privatisation	1997
<i>Phoenix Mine</i>	Botswana	<i>Tati Nickel Mining / AAC</i>	SA	20	New	1995
<i>ZCCM/Chibuluma</i>	Zambia	<i>Metorex Consortium</i>	SA	17.5	Privatisation	1997
<i>Indarama Gold Mine</i>	Zimbabwe	<i>Trillion Resources Ltd</i>	Canada	14.8	Mergers & Acquisitions	1998
<i>Rosh Pinah Zinc Corp</i>	Namibia	<i>Iscor</i>	SA	10	Mergers & Acquisitions	1998
<i>Geiba Gold mine</i>	Tanzania	<i>Ashanti</i>	Ghana	N/A	New	N/A
<i>Bulyanhula Gold Mine</i>	Tanzania	<i>Barrick</i>	Canada	N/A	New	N/A
<i>Rio Tinto Zinc Corp</i>	Zimbabwe	<i>Rio Tinto</i>	UK	5	New	1994
<i>Rio Tinto Zinc Corp</i>	Zimbabwe	<i>Rio Tinto</i>	UK	5	New	1994

Selected mining foreign direct investment in SADC 1995-1999 (US\$m)

Source: BusinessMap FDI-SADC database

Target Company	Target Country	Source Company	Project value US\$ m	Year
<i>Mozambican coal deposit</i>	Mozambique	<i>Ingwe Coal Corporation & Tavistock Collieries (SA)</i>	750	1998
<i>Namzinc</i>	Namibia	<i>Reunion Mining (UK) & Anglo American Corporation (SA)</i>	250	1997
<i>Mining exploration</i>	Tanzania	<i>AAC (SA)</i>	200	1996
<i>Kolwezi Tailings Project</i>	Congo (DRC)	<i>International Panorama Resource Corporation (Canada)</i>	190	1997
<i>Sengwa Coal Mine</i>	Zimbabwe	<i>Rio Tinto (UK)</i>	160	1998
<i>Nickel Cobalt Project</i>	Tanzania	<i>Sutton Resources Ltd (Canada)</i>	108	1997
<i>Gecamines</i>	Congo (DRC)	<i>JCI (SA)</i>	100	1998
<i>Ngezi Platinum Mine</i>	Zimbabwe	<i>Zimbabwe Platinum Mines (Zimplats)</i>	100	1998

Firm intentions and expressions of interest in larger mining projects in SADC

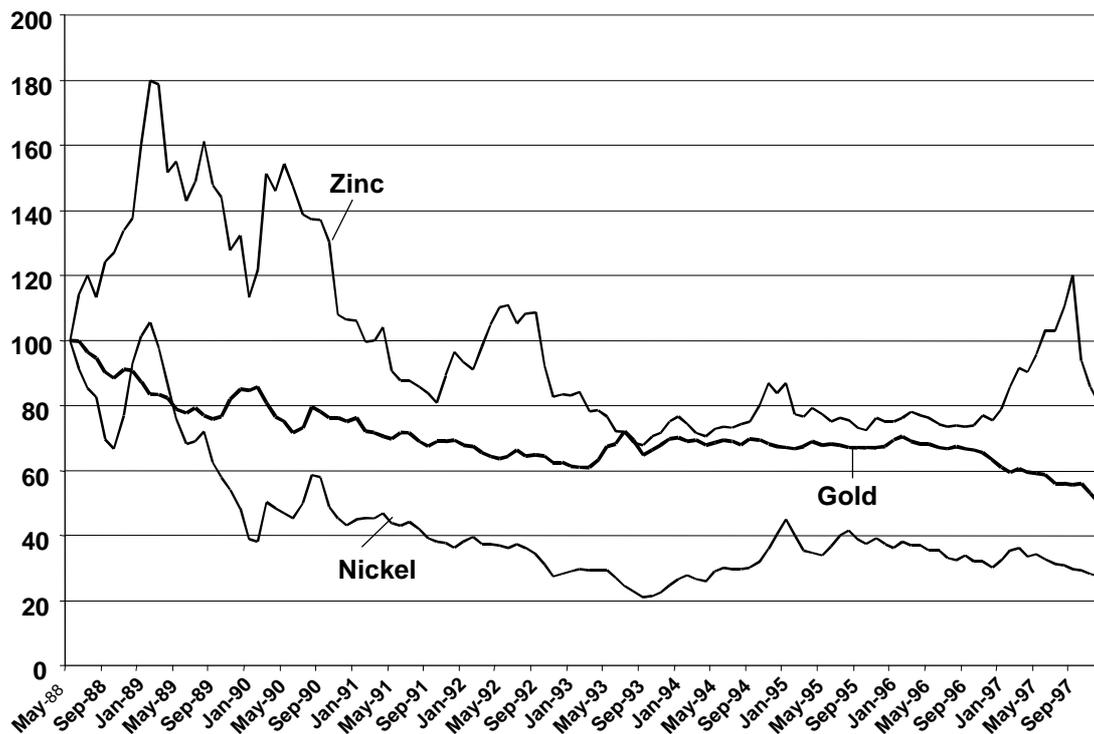
Source: BusinessMap FDI-SADC database

The global industry: mineral bounty and falling prices

A few decades ago, the Club of Rome, a group of concerned scholars, predicted a world in which natural resources would become prohibitively expensive before running out. This seemed a reasonable assumption for most minerals, as these are non-renewable. It is a tribute to the quiet revolution that occurred in the \$1 trillion global mining industry that they were dead wrong. In fact, for most minerals over the last three decades, the following hold:

- Production of most minerals has grown faster than the world population.
- Seen over the long term, prices of minerals have fallen relative to the cost of other goods in the world economy, and relative to the cost of labour.

The ever-increasing flow of metals, coal and other minerals, at prices trending lower over time, has extended amenities once limited to small elites – electricity, improved housing, cars and other goods – to hundreds of millions of citizens in developing countries. Lower commodity prices have also contributed to low inflation, so extending the long cycle of growth in the global economy that started in the mid-1980s. This remarkable record of ever-expanding production at lower prices is the signal and historic contribution of the global mining industry to high levels of growth in advanced and developing countries alike over the last twenty years.



Real dollar price trends of gold, nickel and zinc (May 1988=100)

This achievement has made mining an industry where survival and prosperity depend on a never-ending battle with cost, as output prices continue to fall in real terms. Long-term falling real prices have been a principal cause of the dramatic stresses and changes in mining in South Africa and around the world.

<i>Per cent</i>	May 88 – Dec 90	Jan 91 – Dec 95	Jan 96 – Oct 99
Platinum	-0.77	-0.02	-0.05
Copper	0.27	1.71	-0.45
Coal Steam	0.76	0.95	0.39
Coal Anthracite	1.65	2.67	2.58
Manganese	2.76	-1.05	-0.16
Nickel	-1.71	0.14	0.30
Zinc	0.98	-0.30	-0.10

Average annual percentage changes in prices of principal minerals

<i>Per cent</i>	1970-80	1980-85	1985-90	1990-95	1995-98
US \$ Gold Price	37.3	-11.5	4.6	0.2	-8.3
Rand Gold Price	36.7	9.6	7.1	7.4	5.8

Average annual percentage changes in gold prices in US Dollar and Rand

Modest returns on average, high returns for some. Lower prices also show up in the modest returns of the mining industry: over the past 20 years, the industry has achieved a real return on capital invested of only 5 per cent globally, and has destroyed value during long periods when capacity adjusted tardily to unfavourable price conditions. But companies that have adjusted swiftly to the nature of the industry have continued to do very well: the rates of return of individual companies in the mining industry vary enormously around the industry average; a few of the companies make most of the money.

The cyclical rebound in commodity prices only obscures a trend set to continue into the medium term. This chapter discusses the effects of 'mineral bounty' on global mining, and particularly on mining in South Africa.

Before continuing, it is worth noting that long-term falling real prices are increasingly observed in other sectors as well, including such varied instances as gas turbines, computer processing power and memory capacity, and cameras. Last year the CEO of the most valuable manufacturing company in the world, General Electric, pointed out that many of the firm's activities were in 'long-term deflationary markets', where prices fall by a few percentage points every year. The only way to maintain GE's stellar profit record in these markets, he suggested, was by increasing productivity and cutting costs faster still.

Falling prices

- Export coal prices have for decades now been subject to a slow and continuous fall in real dollar prices.
- Over the past thirty years, iron ore prices have declined by a little under 2% per cent per year in real terms. That means that today's prices are less than half in real terms of prices in 1970.
- Gold prices have fallen dramatically since the highs achieved during the first decade of market-determined prices.
- Once one considers cyclical peaks and troughs, it becomes clear that real dollar prices of aluminium, zinc, nickel and lead continued a secular downtrend during the 1990s.

The role of industry expansion

With some minerals, such as lead, substitution has dramatically diminished demand, making price falls inevitable. But in virtually all cases, production trends seem to have had a major effect on prices. The magnitude of new and potential production has significantly exceeded both expectations and capacity closure. Two base metals examples neatly illustrate the point. A third example, coal, shows that various types of competition can erode prices.

Nickel: industry expansion may cap future prices³

Nickel prices have been on a downward trend since mid 1995 before recovering some ground in 1999. The emerging market crisis was behind the cyclical downturn. Now the issue is: will the industry structure allow the price recovery to break the long-run downtrend? The Metals Economics Group points to the role of new and potential production.

Firstly, Western Australian laterite producers are now coming on-stream and continued high levels of Russian production may cut short the rally. Beyond the short term, a sustained price recovery may well be self-limiting, were it to prompt a second wave of low-cost laterite projects and the commissioning of the giant Voisey's Bay development in Labrador. Together, these projects would significantly lower nickel's cash cost curve.

³ Source: Metals Economics Group.

Zinc: an impressive array of new and potential mines⁴

As with other metals, zinc prices fell precipitously during the late 1990s. The project pipeline helps to assess the potential for more than a cyclical price recovery: *Recent projects to come onstream*, including those scheduled for late last year, will add 948,000 t/y of production, and *production increases at existing mines* will add 122,600 t/y production. *New projects yet to come onstream* during 2000-2003 total 953,000 t/y. This means that an additional 2 million t/y, 25 per cent of current annual production, will come onstream by 2003.

There are two further waves of potential projects, some of which will only be developed as prices improve. There are *45 projects that are in the reserves development stage*, potentially adding around ten per cent of current annual production. Also *under consideration* are 11 further projects each with more than one million tonnes of contained zinc, and crudely estimated annual production potential of 1 million t/y are under consideration. One of these is the Gamsberg deposit in the Northern Cape.

These figures do not account for reductions and mine closures; nor do they indicate an oversupply of zinc in the future: in a depressed market many of the projects will not come onstream. But the figures show that rising prices will be curtailed by the bringing onto the market of this production. The long-term market structure, in which new entrants place downward pressure on prices, will continue.

Coal: subject to competition at many levels

The secular fall in coal prices is a result of increased competition amongst producers, a loss of market share to other sources of energy, particularly in Europe and the former Soviet Union, and the deregulation of the power industry worldwide. The world's electrical utilities consumed 36% of the world's coal. In the new competitive regimes in electricity, input costs are all-important, and have led to pressure on coal prices.

Technology is behind ever-expanding capacity

Why have payable new mineral deposits not started to run out, as had been predicted? What drives the industry now is the relentless technological improvement of exploration, mining and mineral extraction: technology, along with the more receptive foreign investment climate has made it easier to prospect large and remote regions. At the same time, successive improvements in metallurgy have enabled the profitable extraction of minerals from hitherto uneconomical deposits.

A revolution in exploration

New technologies such as satellite imaging and information technology have revolutionised exploration. Electromagnetic spectrum analysis of the target landmass gathered from satellites is now the first stage of many exploration efforts, enabling geologists to home in on promising areas, which are then supplemented by geomagnetic information gathered from aircraft and, ultimately, exploratory drilling. Satellites now fully update spectral data every 16 days for the entire portion of the globe between the latitudes of 81 degrees north and 81 degrees south. Satellite sensors acquire spectral data on seven bands, two of which have direct application to mining.

Enter the exploration 'juniors'. The general availability of electromagnetic and geological data has removed a massive scale barrier to exploration. The exploration business was transformed by the entry of a myriad of small exploration companies, or 'juniors', often consisting only of a few geologists and a small budget, and competing by being nimble and technologically and geologically savvy. Although capital raised by these firms has plummeted after the Bre-X fraud, some majors still prefer to work through these entrepreneurial firms.

Recovery plant technologies render projects feasible

Advances in biotechnology, chemistry and mechanical engineering have cumulatively made reduction plants, where the mineral is extracted from the mineral-bearing rock, more efficient. These

⁴ Source: Metals Economics Group.

improvements have been large enough to change the financial viability of projects spanning many minerals. Two South African examples:

Bacteria are now used to assist in the extraction of gold from certain types of gold-bearing rock. This process, known as bioleaching, was pioneered in South Africa. Bioleaching is now used at mines around the world to raise gold yields and increase project feasibility. Advances like this lead to increased supply.

At the proposed \$970 million Gamsberg zinc project in the Northern Cape, new extraction technology developed in South Africa may render the project feasible. Gamsberg is expected to produce about 200,000 t of zinc annually at full capacity and provide an injection into the province's economy.

Non-technology factors added to the increase in capacity seen during the 1990s. The decade saw a striking change in ideology and policy among many developing countries. In many countries state-owned mining companies were privatised. Many countries became much more receptive to the notion of foreign investors 'exploiting' their mineral deposits. These shifts led to a higher degree of investment in new capacity as foreign mining companies, aided by the multilateral aid and investment guarantee agencies, came on board.

Price cycles are here to stay

Commodity price cycles are going to remain a fact of mining life. This is due to the deep-seated causes of the cycles:

- **General economic cycles have a disproportionate effect on mineral prices and profits.** Given the pervasive use of minerals in modern life, demand for minerals is closely tied to the rhythms of economic growth. Global market prices for immediate delivery ('spot' prices) tend to move with the cycle of economic growth. What is more, simple arithmetic shows that a modest shift in price has a far greater impact on profit levels, as the whole price increment falls to the bottom line.
- **Cyclical upturns cause exaggerated price rises, which in turn lead to overinvestment in capacity.** The early 1990s neatly illustrate this phenomenon. Because of the short-term inflexibility of mining output described above, output fails to keep up with increases in demand, and prices shoot up. Investors, who believe that the price increase is not cyclical but will endure, plan and commission new mines that will be profitable at the high prices. At this point the 'fallacy of composition' commonly occurs; investors do not consider the cumulative impact of their own and others' investment actions: that, the new capacity would likely cause prices to fall from the levels which had justified the projects in the first place. But once this capacity is in place, it tends to be operated at full capacity.
- **Mines are loath to cut production when prices fall.** An unprofitable mine would continue to maximise production, as long as the variable cash cost per unit of output does not exceed the price, and even if the operation is unprofitable. So price falls do not readily lead to a self-correcting fall in output. As Mining Journal commented last year at the bottom of the cycle, "each producer is waiting for a higher cost competitor to close down but many stubbornly continue to produce, regardless of short-term losses." Indeed, during this past cyclical downturn there was some evidence of increased production by certain mines, as they desperately attempted to cover as much of their fixed costs as possible. The pronounced trend in the industry towards increased scale, of both mines and processing plants, has aggravated the problem, as output is maintained to maximise the economies of scale intended.

The effects of cycles on the mining industry

- Price cycles offer a convenient 'alibi', to use David Humphreys' word, for poor management decisions. Ill-advised expansions or acquisitions are readily defended by invoking a future rise in prices. In short, the wide swings in prices greatly complicate the traditional monitoring function of capital markets over managerial efficiency. As a result of widespread underperformance compared to other equity classes, though, the entire mining sector has lost favour with investors.
- Cyclical recoveries are interpreted as a shift in the underlying economics of a mineral, which they rarely are. This may lead, as explained above, to overinvestment.

2 The world of work: restructuring and production

During the last three years the gold* mining industry has come to grips with a key challenge facing the South African economy: moving to a new model of work characterised by greater worker participation leading to increased responsibility and productivity. Two things have complicated an already difficult process. Firstly, the transition had to be made in the midst of a massive industry restructuring. Secondly, the industry is gradually jettisoning its previous model of production for not one but several new models. While this has strained the traditional collective bargaining processes, it is a time of experimentation and new thinking on all sides.

The old production model. The “old” model might be caricatured as the “Indian army” model of production. At the top were the English commissioned officers - the mining engineers, geologists and mine managers. In the middle were the non-commissioned officers - the artisans, miners and shift bosses. At the bottom were the ranks - the drillers and labourers. While there might be some advancement within these layers, the layers themselves were fairly rigid. Certainly the colour bar prevented anyone from the ranks ever advancing above that position.

Production was carried out in a quasi-military way, with instructions coming from the top and percolating down through the layers. Control was an important part of the system, with most aspects of the migrant worker's life organised by the mine from the time he arrived. In this model production workers were essentially expendable and exchangeable. They were not expected to think about how their activities contributed to the overall success of the enterprise. They did repetitive jobs that were easily supervisable. Responsibility, information and control were all vested in the higher layers. Turnover at the bottom did not matter, since very little information required for the success of this system was located there. Many workers worked only for the duration of one or two contracts and then returned to the rural areas.

During the past two decades this model, for reasons that will be explored below, has come under pressure. New models are emerging. The one perhaps most vigorously endorsed by the larger mining groups is the “managerial” model. In this model the mine withdraws from most of its non-core activities (such as hostel management) and focuses on its core business. Flexibility in adapting to circumstances (to changes, say, in the business climate or in the production process) is highly prized. This requires *distributing* responsibility, rather than centralising it, and providing with it the appropriate incentives. This approach only works if power shifts down the ranks. Impala Platinum Chairman Michael McMahon, for example, is quoted as saying⁵:

We let go many of the reins of control, though management did ensure it could monitor the situation. We said, for example, that there would be a reward structure for achieving productivity targets but that the workers would draw it up. There have been some weird side-effects. We allow the mining teams to decide what is the best way for them to work and determine the size and structure of their crews, their operating methods and bonus systems.

Each of the units or teams has to be aware of how it is embedded in the larger organisation. Clearly such a model can work only with a skilled and stable work force. Implicit also is that repetitive and dangerous work will be minimised, if need be by using machines.

This vision is guiding some of the major corporations, and promising results have been achieved at individual mines. Yet the reality in most mines is still a long way from there. Furthermore, some of the ore bodies cannot be profitably mined on the new model. In some marginal operations, a variant of the “managerial” model, with more radical incentivisation, is being used. In others both specialist and core activities are subcontracted out to ensure that staffing levels are fully flexible. These are the varied responses of mines to the gold crisis of the late 1990s. While this diversity of response has frustrated the desire for uniformity in the industry, it has also allowed shafts and operations that were slated for closure to survive. The challenge of the industry and its bargaining mechanisms will be to manage this complexity.

* This chapter deals principally with gold mining, where the bulk of workers in South African mining are employed.

⁵In the *Financial Mail* corporate report on Impala Platinum, September 17 1999, “Bosses bow to the workers”, page 6.

In the next section, we will discuss some of the key developments that led to the breakdown of the “old” model, before moving on to the new model.

The breakdown of the old model

Why did old ways of working suddenly change after persisting for the better part of a century? We do know that that the following contributed to the breakdown of the traditional model:

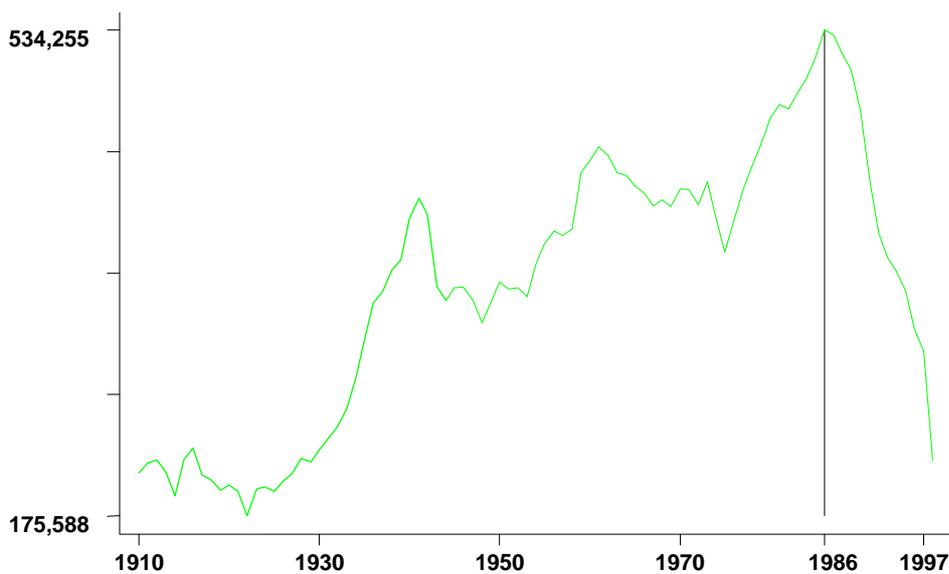
- The rise of **black unionism** (and the decline of white privilege in the mining workplace)
- **Political and legislative change**
- The **slump in the gold price**, and the lapse into losses for many operations.

The unusual combination of socio-political pressure for fairness and investor pressure for higher returns is shaping the new models of mine production. We tease out these influences in turn.

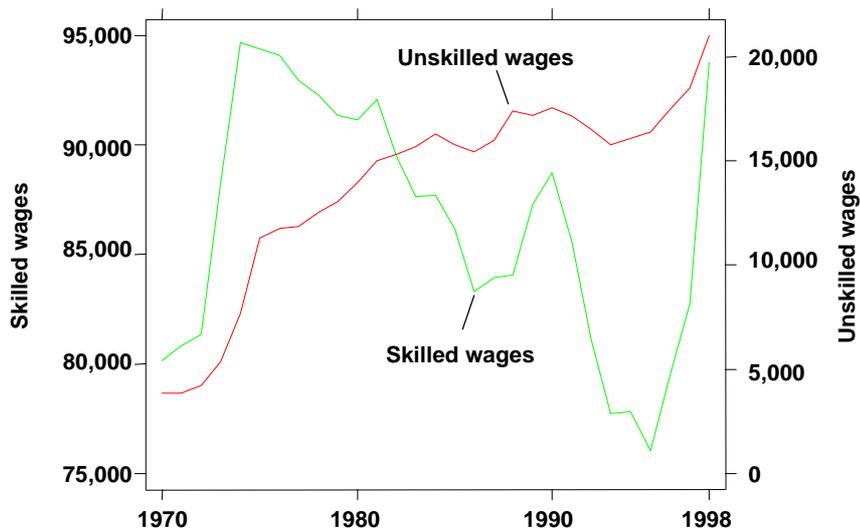
The rise of black unionism in the 1980s

In the early 1980s black unionism, in the form of the National Union of Mineworkers, became a recruiting force on the mines. In 1984 NUM embarked on its first legal strike. From that point on the level of conflict escalated, until it reached a climax in the big mineworkers strike of 1987. That strike led to mass dismissals which meant that 1986/87 also marked the peak in mine employment (see Figure 5). The numbers have dropped steeply since then. (The reader should note that this does not imply that job losses were a response to union power. Other factors – such as the changing gold price – have been important).

The lessons of 1987 have shaped subsequent developments. To at least some managers and union leaders, the strike confirmed that old methods of worker control would not work in the new dispensation. Unions and management would have to build structures of cooperation at mine and industry level if the industry were to restructure successfully. But another lesson was that the mines did not need the staff complements that they had. They could produce a similar output with a much smaller work force, provided that it was better utilised.



Employees on Chamber of Mines gold mines
Source: Chamber of Mines



Real average wages in gold mining

Source: Chamber of Mines

Union strategy has also been informed by the events of 1987. Although the union certainly did not abandon the strike as a weapon, it has increasingly focused on structures at mine and industry level through which it can influence the industry and working environments directly. Examples at a central level include the Mining Qualifications Authority and the Gold Crisis Committee, and at lower levels, hostel, safety and health and productivity committees. Although not without local competition, NUM has emerged in the 1990s as by far the most important force among organised labour. Numerically dominated by the lower-skill categories of employees, NUM has exercised a profoundly important influence on the industry.

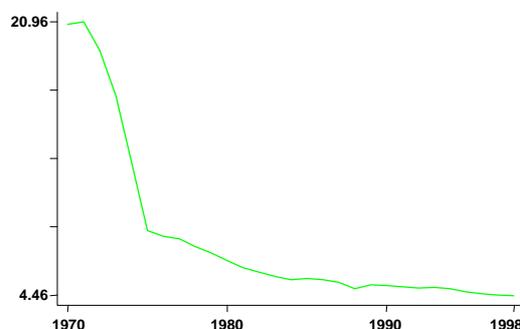
Long trend of increase in black bargaining power. **Unionisation was the culmination of a long process of growing bargaining power for black mine workers. During the pre-union era dramatic strides had been made in unskilled wage levels: between 1970 and 1982, real wages of unskilled workers increased four-fold. Union action certainly contributed to the further rise of a third in unskilled wages between 1982 and 1998.**

Possible causes of the increase in unskilled wages during the 1970s are:

The shift to South African employment documented elsewhere in the report. Mines now had to compete with wages paid by manufacturing.

Sharing the benefits of the higher gold price of the 1970s with workers.

Compensation for workers classified as “unskilled” increasingly performing a skilled function. The mining industry attempted to circumvent the colour bar by introducing “artisan aides” – people who received some training as boilermakers, electricians, fitters, riggers, plumbers and carpenters.



Ratio of average skilled to unskilled wages on gold mines

Source: Chamber of Mines

The upward trend in unskilled wages affected relative wages. In gold mines the ratio of skilled to unskilled wages had hit a high of 20 to one in the early 1970s. This huge gap could be due to one of two factors (or a combination of both): white miners and artisans were radically overpaid, or black miners were significantly underpaid. Given the way that apartheid distortions worked, it is probable that a combination of both was at play. This would now change. By the end of the 1970s, the ratio between skilled and unskilled wages had halved. This seems to have been a deliberate process: while unskilled wages were rising dramatically in real terms, skilled wages were falling. By the 1990s the ratio had halved again, to around five to one.

Political and legislative change

Union pressure ushered in a long process of legislative reform for black workers favouring worker representation, collective bargaining and the right to strike. Historic shifts in South African politics accompanied these trends. Political activism increased, with the union movement at the centre of the campaign for democracy. When the first democratically elected government took power in 1994, it was in an alliance with the Congress of South African Trade Unions. The new government embarked on an extensive legislative programme for the workplace, including new acts on the labour relations framework, minimum conditions of employment, training and affirmative action.

The changes in labour market regulation have had important consequences for mining as they have had for manufacturing and services. But in one area of change, health and safety in mining, the role of policy has been pivotal.

The impact of the health and safety campaign. Mining is an inherently risky activity and the industry world-wide has a record of recurring accidents (and occasional disasters) and a high incidence of occupational disease. South Africa with its very large, deep and labour-intensive mines, and with a workforce made up chiefly of people with a high degree of illiteracy, has been no exception to this record. Until the early 1990s South Africa's problems were compounded by a typically hierarchical and racial organisation of management on the mines, which hindered effective dialogue between management and workers around improvements in safety (and in productivity).

Around the start of the decade, against a background of concern about the industry's apparent inability to improve its safety record, NUM began to press for a commission of enquiry into health and safety. The new government strongly supported the concept, and the Leon commission was established with wide-ranging terms of reference.

The resulting report has had a lasting impact. Firstly, it has resulted in the establishment of a modern legal and regulatory environment governing health and safety, as well as of tripartite (government-labour-employer) structures and processes for implementation. Secondly, it sharpened the pressures on companies and management to improve the health and safety record. This has prompted the industry to seek to learn from international best practice.

Perhaps most importantly, the report identified entrenched production practices as a critical stumbling block to progress on underground safety citing low skill levels, illiteracy, poor communication and workers' lack of authority as problems. The report suggested that Fanagalo was wholly unsuited as a means of communication other than for the transmission of commands. The richer kind of communication about conditions at the work place and potential hazards could not occur through this medium. The Commission strongly endorsed the adoption of a uniform work place language and educational programmes for the lower skilled workers.

The commission concluded that the safety record would be improved only if some responsibility and the attendant skills to deal with this were devolved down to the production worker, and if new and safer technologies were adopted. Many of the proposals have become law:

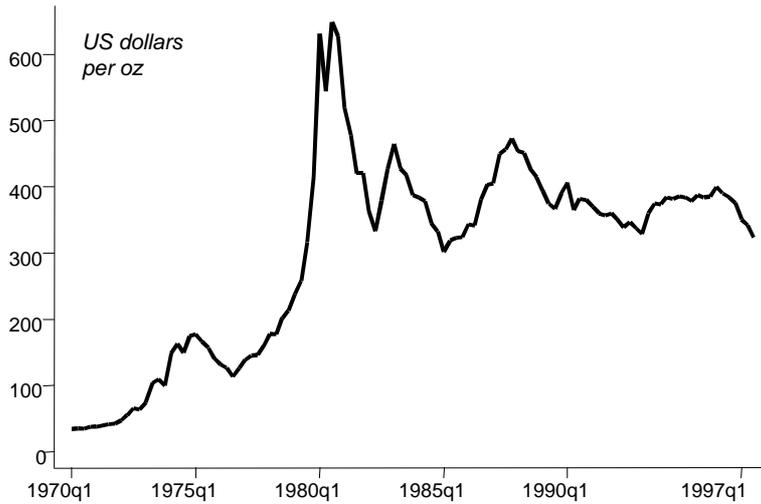
The involvement of labour representatives on **safety committees** on the mine and in the tripartite institutions created by the Act implies that the top-down command-driven model is no longer feasible.

The Act gives workers **the right to remove themselves** from dangerous working conditions and gives them **the right to various pieces of information**. These new rights again make the old model unworkable, provided of course, that they are exercised.

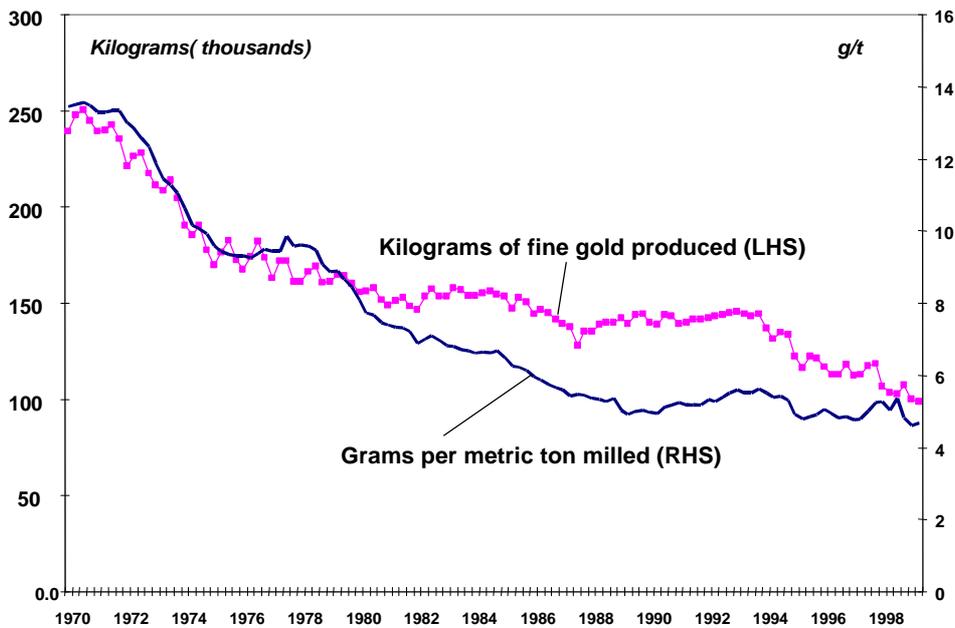
The shift towards tripartite industrial relations evidenced in the Leon Commission Report and the Mine Health and Safety Act is mirrored in other laws and institutions created in this period. Institutions such as NEDLAC and the Gold Crisis Committee reflect this approach.

The 20-year slump in the gold price

A spike in the gold price above \$800 in 1980 ushered in a period of optimism in gold mining: With buoyant margins the industry saw a sharp increase in development work and employment. In the process lower ore grade bodies were being mined, so that when the price came down again, mines were faced with a cost squeeze. It was the start of a 20-year period of falling prices, and by 1999 prices fell below \$260/oz. The price slump destroyed the margins of an industry built on the assumption of far higher prices. By the early 1990s, fully half of the shafts in the South African gold were making a loss.



Gold price in quarterly averages 1970-1997
Source: Chamber of Mines



Gold yields and production
Source: Chamber of Mines

The 1990s also saw a resurgence in shareholder vigilance: shareholders, mostly institutions, put pressure on mines and mining houses to curtail loss-making operations and to improve efficiencies. This necessarily implied a decrease in production as mines refrained from mining loss-making areas. The chart above shows the two workplace challenges the industry had to deal with:

- The downscaling of production
- Increasing efficiencies in the light of poorer geological circumstances.

New models develop

It was at that time, the early 1990s, that productivity concerns started to influence the shape of wage agreements. A 1991 agreement at the Chamber of Mines stipulated a low wage increase supplemented by production-linked bonuses. This experiment was not repeated the following year: one problem was that mines were in varying degrees of difficulty. Workers were willing to sacrifice increases at marginal mines but not at healthy mines. In this way the industry pressures have led to a quiet trend of decentralised bargaining on some issues. In 1995, a two-tier agreement provided for a wage settlement at the centre, but for 'operational issues' – including productivity related matters such as different shift arrangements – to be negotiated at mine level.

This approach created negotiating capacity and confidence at mine level, and was taken further in 1997. In the centralised 1997 agreement, reached amidst a further gold price collapse, implementation of the full wage increase was made conditional on productivity agreements at mine level. Ultimately, such mine level productivity agreements were struck at most mines, and included some of these elements:

- Additional shifts or full calendar operations
- The introduction of productivity committees or monitoring forums
- Broad-banding and upgrading lower categories of employees
- Introduction of multi-skilling
- Changed incentives: a bonus system, on top of the centrally agreed salary, linked to production targets
- Training.

The most important legacy of the 1997 agreement is the now widespread practice of negotiating on productivity issues at mine level. That has allowed Chamber-affiliated operations to implement some parts of the production models required for improved safety and increased productivity. Many of the new elements of work organisation listed below have been agreed to in mine-level forums.

What the 1997 agreements did not do was staunch job losses: the gold price deteriorated further in the period after the agreement, and large sections of the industry lost money. The subsequent loss of jobs is described in the next chapter.

In the next round of negotiations, which occurred last year, NUM refused to again make the centrally agreed wage increases conditional on productivity agreements. On balance, though, the decentralisation trend continued: on the critical issue of wages the union reached a separate agreement with each of the various mining companies, 12 or 13 agreements in all. Secondly the mechanism of productivity talks at mine level was preserved.

This bargaining framework has not been flexible enough to accommodate all situations: some of the smaller mining companies, such as African Rainbow Minerals and the specialist contractors, while unionised, negotiate outside the Chamber structures. But the framework has allowed for important changes in some operations. These changes include:

- Flattening hierarchies
- Using the team as unit of production
- Performance-based incentives
- Skills upgrading.

We briefly look at these elements.

Flattening the hierarchy

South African gold mines have traditionally had at least nine (and sometimes 14) or more levels in the organisation: this was cumbersome and impeded upward and downward communication. Mines have dramatically flattened their hierarchies, and some now have as few as five levels.

One instance of this redesign has led to a new and pivotal position that can be described as the '**crew leader**': a combination of the position of the qualified "miner" of the past, and that of the team leader (the highest position that a black worker could attain in the old system). This combination of these roles changes completely the point at which control in the previous system was maintained. The pivotal post is no longer filled by a man representing the hierarchy above, but by a man from 'below'. It also opens, at least potentially, routes to further advancement on the part of these individuals. Note again the necessary correlation of responsibility and skill: to fill the position the worker needs a blasting certificate. The position is central to the movement towards "one panel one crew", which is discussed next.

The team as production unit

The productivity agreements struck at mine level have often been aimed at empowering and rewarding the team or 'crew' of workers. The team approach usually has four characteristics: individuals have multiple tasks, the team is rewarded on the basis of performance, it has some decision-making autonomy and the team members are trained to expand their skills.

The team is **multi-skilled**. This allows the team to share tasks so as to utilise their time underground better, allows team members to monitor each other, and enables the team to cope with absences for leave or study periods.

The team is **rewarded for performance**. The system of paying bonuses for performance above the agreed wage is the key to the new model. By this simple mechanism the interests of the team and management are aligned. This allows – at least to some extent – for discipline and motivation among the team members to replace the control and discipline previously exercised from above. Team members monitor one another.

Under these circumstances, the teams have considerable **decision-making autonomy** in deciding how to execute their tasks.

The multi-tasking and autonomy that characterise the team approach require the team members to have a wider set of **production and business skills** than they had needed under the old model. In the mines where the team approach has been the most successful, participating in adult basic education (ABET) programmes is actively encouraged. Training programmes of the kind described below have been put in place to equip teams for their expanded role.

The pivotal aspect of the team approach is the aligning of the interests of the team with that of management. This is only possible if the performance of the team, usually defined in terms of face advance, can be measured. This has motivated the movement to 'one panel one crew': by making one team responsible for a particular panel it is easier to tie incentive payments to progress (say face advance) on that panel.

Example: team building at Tshepong, a gold mine in the Free State

At Tshepong a lot of effort has gone into the creation of production teams. Team building occurs in a specialised facility during an initial intensive four week period. The process by which this occurs is *inter alia* through "adventure based experiential learning". Members of the team have to help each other negotiate various obstacles, including balancing on 15m high poles. By the end of the process team members ought to have learned to trust each other and work with each other.

A key component of the team building process is also the acquisition of basic business skills. Team members engage in simulations in which the impact of various decisions on the profitability or otherwise of the enterprise is indicated. Attention is also paid in particular to the way in which bonuses are calculated, so that this is not seen as some mysterious process. The aim is to enable the team to be able to calculate more or less precisely what they would be entitled to. By making the connection between the efficient functioning of the unit and the bonus payments the incentives for drilling/blasting correctly are made clear.

According to mine management productivity improvements at Tshepong have been of the order of 25 per cent per year for three years in a row.

Incentives and pay structure

Reward-for-performance, the key to the new approach, has two aspects to which unions have traditionally been hostile: it creates uncertainty about the level of wages that will ultimately be paid; and it results in workers being paid different amounts. No doubt this is why incentives have been offered only over and above the agreed wage (although this has its own problems). The practice is now very widespread in the industry.

The bonus formula varies from mine to mine as does the size of the bonus payments. In the case of one mine visited, Mponeng, the bonus payments are of the order of 30 per cent of the total wages. Guesstimates for the industry average range from 20 to 30 per cent. In some individual cases miners have been able to double their pay. The differences can be ascribed to differing preferences among worker groups as well as differing financial circumstances at mines.

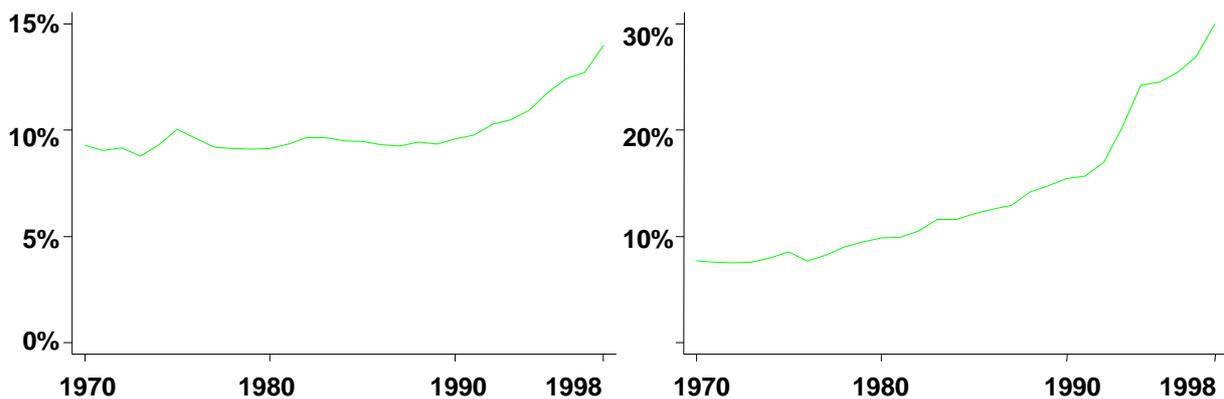
The structure of the incentive also varies. At Tshepong, for example, all members of the crew get an equal cut. Only the team leader, with his greater responsibility, gets a higher incentive payment. At Mponeng, by contrast, bonus payments vary with the roles played within the team. At Mponeng also, there are no bonus payments if the mine as a whole is not profitable.

The ratio of basic wage to bonus is restricted to an extent by the wages set at the centre, where possible bonuses are not taken into account. Mines and operations, such as marginal shafts, that require a more heavily incentivised package may be tempted to negotiate outside the Chamber for that reason, and a number do. It may be appropriate to have different packages in different parts of the industry.

Building skills for production and safety

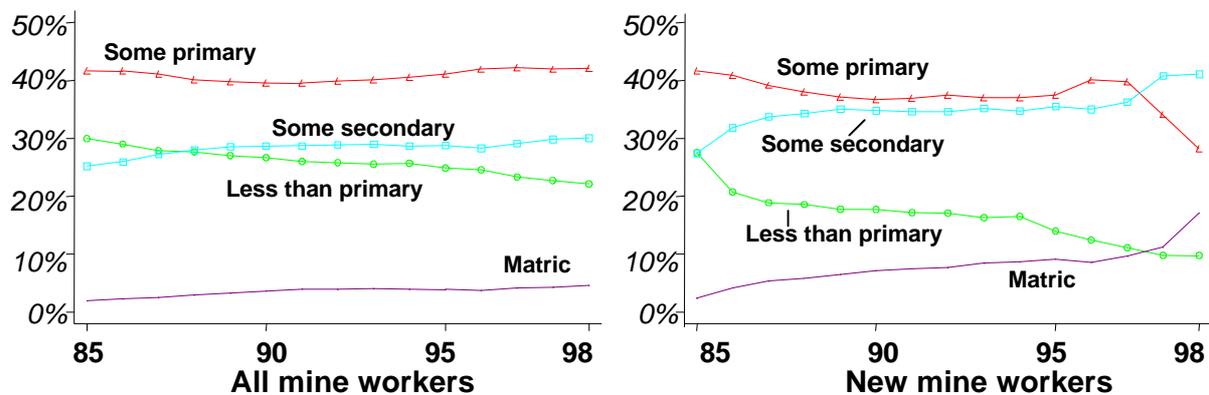
The new models of production are dependent on workers having good communications and problem-solving skills as well as varied production skills.

Mines have focused their hiring patterns on higher degrees of educational achievement and literacy. Mines have increased their educational requirements for novices. According to TEBA it is now routinely required of new recruits to have at least Standard 8. This means that the proportion of people that are literate will increase over time. This is indicated graphically below. The left hand graph depicts the educational profile of the entire work force in the TEBA data base over time, while the right hand graph focuses only on people who are in the data base for the very first time. Completion of primary education is often taken to be a sign of functional literacy, so it is clear that the functionally illiterate are a declining proportion of the overall work force. Nevertheless it is obvious that there is still some way to go before the aim of general literacy upon hiring will be reached.



Proportion of workers that are skilled in gold (left) and coal mining (right)

Source: Chamber of Mines



Proportion of workers that at various formal education levels

Source: Chamber of Mines

The educational profile of new hires has improved, with more than 60 per cent of recent new hires having matric or at least some secondary schooling: both of these are markers of literacy. In 1985 the figure was about 30 per cent. But worryingly, around 40 per cent of new employees in 1999 still had only some primary or less formal education: a large number of these workers may be illiterate, and therefore not suited to the demands of safe and productive mining.

The process of changing the skills profile of workers through different hiring criteria is a slow one, given the dramatic fall in the employment of new workers. In the case of gold mining, new workers hired averaged around 100,000 per year as late as the early 1990s, due to shorter-term employment at the time. By 1999 the number of new worker hired had fallen below 20,000. Therefore a higher educational profile among new hires will take time to work through to the workforce as a whole.

Large-scale internal training programmes are aimed at increasing literacy and safety and production skills among the existing work-force. Changing hiring practices will not change the skills level in the short term. Consequently the mining corporations are devoting large resources to adult basic education and training. At Tshepong, for example, the objective is that everyone should reach ABET level 3 (standard five equivalent) by 2004. The mining is now spending R50 million per year on training. Functional literacy is vital in ensuring that people are able to understand safety instructions and other communications. Attaining the initial literacy qualifications can, in the new system, lead to additional ones. Unlike the previous system, the emerging system is intended to allow for mobility:

A new education and training philosophy. In terms of the South African Qualifications Authority (SAQA) Act each industry is required to specify the skills and competencies required for particular tasks. Once these competencies are clearly defined, institutions can teach these competencies, while other institutions certify that individuals have these skills. A key aspect of this approach is that the various skills should be generally recognised within the industry (and where appropriate wider than that), and hence be “portable”.

The key institution for the mining sector in this regard is the Mining Qualifications Authority, a tripartite body. For reasons given above, the mining sector has gone further down the SAQA process than any other industry. One of the first qualifications to be restructured in line with this approach has been the blasting certificate. Until 1987 only whites could get a blasting certificate, and it was a major barrier to black advancement. Now it has become a bridge to positions of authority for underground workers.

With the imposition of the skills development levy the mining sector will be taxed in order to pay for training. Mining houses are estimated to spend between 5 and 10 per cent of payroll on skills and training programmes. In the past mining houses have run extensive in-house apprenticeship schemes. Given the demands of policy and the industry, these programmes have been focused on the precise needs of mining.

Sub-contracting

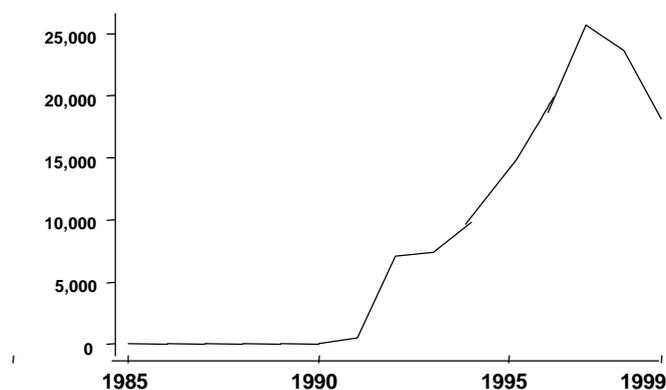
Industry interviews and the data available suggest a sharp increase in the use of subcontractors during the 1990s. The mining census suggests that in 1996 contracted labour constituted roughly 5.3 per cent of total labour in all mining, while it was 8.2 per cent in the coal sector and 6.5 per cent in the gold sector. Current industry estimates put contract labour at about 10 per cent of total labour.

Another indicator is provided by the graph below, which shows the number of contract workers administered by TEBA. Between 1990 and 1997 the number increased from zero to around 25,000, before falling slightly as the industry continued to contract. Readers should note that not all – or not necessarily even most – contracting employees are recruited through TEBA, so the data is only indicative of the trend.

The rise of subcontracting is probably explained by the search for efficiency and lower costs in the face of falling gold prices. That bland explanation masks the controversy subcontracting has stirred up in union circles, where the practice is often characterised as an attempt to undermine the union and the agreements that have been struck. The nub of the question is: how much of the benefit is due to the efficiency of the contracting teams and how much of it simply reflects their lower wages? It turns out that subcontracting types and firms are quite varied:

Subcontracting of non-core activities. Many mines have now contracted out non-core activities, such as catering, hostel management or security services. These forms of subcontracting are driven by corporate focus.

Subcontracting of specialised mining activities. Certain specialised tasks, such as shaft sinking, cementation and certain types of development, have been the domain



Number of subcontracting workers administered through TEBA

Source: TEBA

of contractors for many decades. The efficiency of the subcontractor in this case arises from scale economies rather than lower wages: the specialist can move from mine to mine performing the specialist task more cheaply, safely and competently than could general workers inexperienced in the particular activity.

Subcontracting of normal production activities. This has turned out to be the most controversial form of sub-contracting as the sub-contracting workers compete directly with the regular work-force.

NUM has vigorously opposed the subcontracting of normal production activities, particularly at mines where regular workers were recently retrenched. In response certain mines have committed to not increasing the use of contract workers for normal production activities. Other producers have pointed out that there are legitimate reasons for sometimes using contractors for normal production. One such reason mentioned is the need for a floating group of workers to help out at unusually busy times. It has also been pointed out that subcontractors may, rather than paying workers less, be paying them in a more highly incentivising way or may have improved work organisation and efficiency in another way. On the other hand, recent studies also show that at least some subcontract workers are paid less than regularly employed mine workers, have fewer benefits and receive less training. However, these studies do not yet provide a comprehensive picture of the subcontracting industry.^{6, 7 and 8}

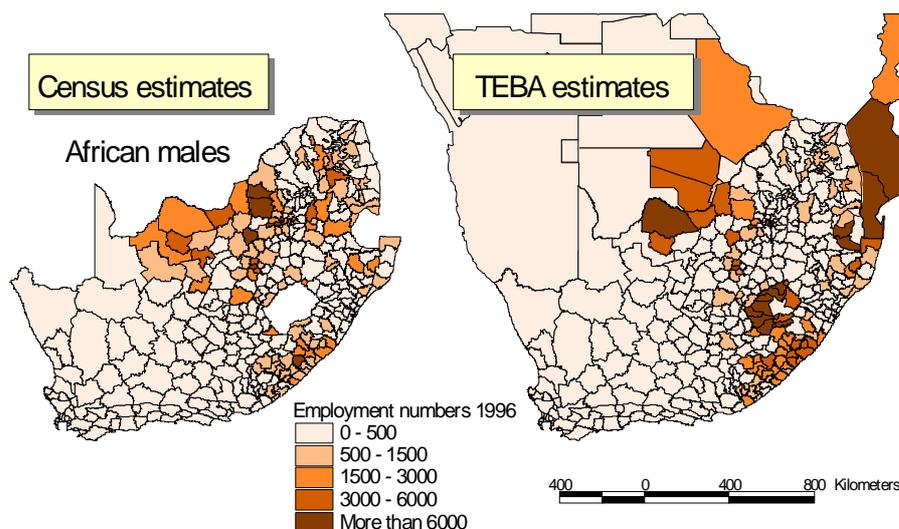
⁶ Crush, J. *et al* (1999), *Undermining Labour: Migrancy and Sub-contracting in the South African Gold Mining Industry*, South African Migration Project, Migration Policy Series No.15, Idasa, Cape Town.

3 The workers' world: communities and restructuring

Mining has traditionally been the primary source of non-agricultural employment in rural South Africa and parts of rural Southern Africa. A stream of remittances from the mines to these areas is only one of the links tying the well-being of families in these communities to the mines. In this chapter we start off by exploring these links to home and community. Then we move on the effects the dramatic downsizing of the industry has had on miners and the communities they come from. Finally we look at efforts to manage and to attempt to soften the blow of the downsizing of the industry.

Where the miners come from

The historical recruitment areas of the mines have been the deep rural areas, initially from outside of South Africa, and from the mid-1970s (for reasons explained below) increasingly from within South Africa. Despite the increase in recruitment from *within* mining communities (also discussed below), the communities of mine workers remain mainly rural, poor and isolated from other economic opportunities. The map of Southern Africa below shows what two different data sources indicate about the origin of mine labour. The map on the left was constructed from a large sample of the 1996 population census. The second map is based on data from TEBA, the recruitment operation of the Chamber of Mines, and includes data on surrounding countries. Both maps use magisterial districts as the base, and figures mapped are for African men only.



Mining employment by district of origin, 1996
Source: 1996 Census and TEBA data

⁷ The evidence is actually extremely hard to evaluate, since the size of the comparison sample is not revealed in this study. However a fourteen percentage point difference on a sample size of 93 (the size of the sample of subcontracted workers) will probably not prove all that significant, particularly not if the other sample is of similar size.

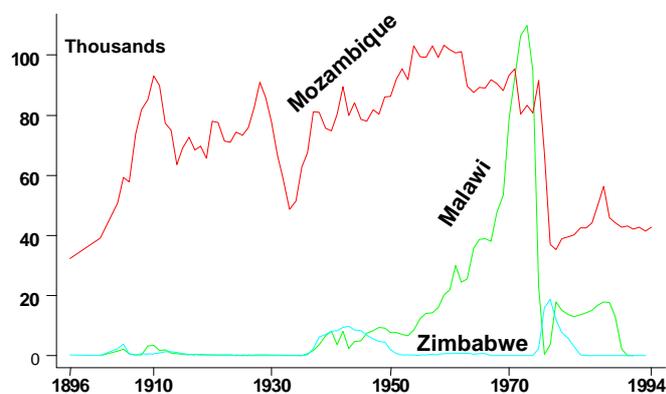
⁸ Readers should note that mine owners cannot through subcontracting delegate away responsibility for safety on their mines. Even if contract labour is used final responsibility for safety lies with the owner of the mine.

The darker the shade of the district, the more workers from there. The maps indicate where workers are from, not where they are working. Both maps paint similar pictures. Most South African workers come from ex-homeland areas, particularly in the Eastern Cape and the North West Province. These areas are among the poorest – and in some case among the most remote – in the country. The TEBA data show that many workers are still recruited from Lesotho and Mozambique, with some from Botswana and Swaziland. In these areas too, other opportunities are limited.

The shift to South African workers in the 1970s

The main source of mining labour had traditionally been Southern Africa outside of South Africa. Events during 1973-1975 were the start of renewed focus on South African recruitment: In this period, recruitment from Malawi came to a complete standstill and recruitment from Mozambique plummeted precipitously, as the chart shows. The drop in **Malawi** recruitment was due to an aircraft accident in April 1974 in which 72 Malawi miners were killed. In the wake of the accident the government of Malawi banned recruitment for the South African gold mines.

The drop in **Mozambican** mine workers is related to the change in government in 1974/75, as workers could not obtain travel documents. The political developments in the frontline states also had spill-over effects on the attitudes of mine workers. A 1976 study directed by Professor Dunbar Moodie found that Mozambican miners were committed to Frelimo, listened eagerly to Radio Mozambique and criticised white management as “colonialist, capitalist and exploitative of workers”. The report, however, also found that they were hard-working and “submissive”, “well-behaved” and “eager to please”.



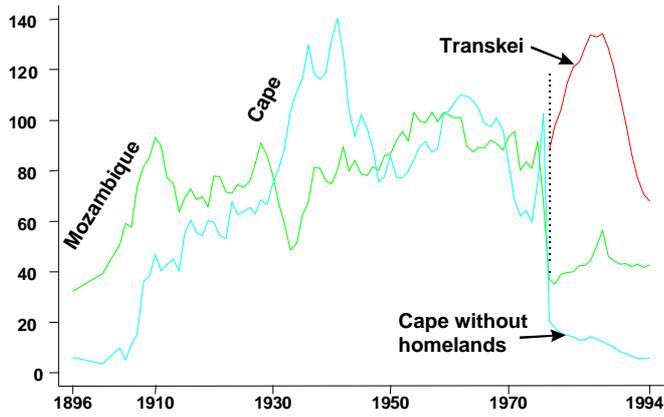
Foreign workers on South African gold mines: the long view
Source: Chamber of Mines data

Whatever the impact of the political developments in the frontline states might have been, there was definitely an increase in unrest, including some strikes, on a number of mines in 1975. In the wake of the unrest various groups of workers were dismissed, resulting in a further drop in the labour complement. Given these shortages, the mines had to look to other sources. As the graphic indicates, there was a marked increase in recruiting from **Zimbabwe**, but this proved short lived. After Zimbabwean independence recruitment fell back to zero.

In response the mines turned increasingly to South African sources. The graphic below shows how recruitment from the **Transkei** boomed in this period⁹. Whether it was the perceived need to make wages more competitive for South African workers, or whether there were other factors at play, real wages among Black mine workers increased relatively rapidly during this period.

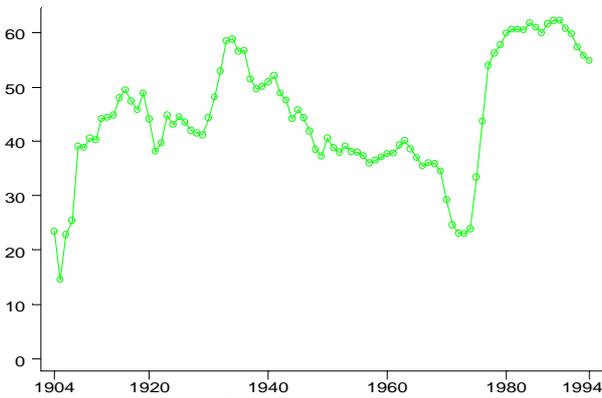
The effects of local recruitment were such that by 1978 the Chamber of Mines reported that the mining industry was receiving “an almost embarrassing flood” of African work-seekers. Despite this over-supply, the mining industry was careful not to drop foreign recruitment altogether. This was due to the experience of these migrants, and for strategic reasons: an over-reliance on a single area could leave the industry exposed if conditions in that area changed.

⁹Prior to 1977 no separate figures were provided for the Transkei. The discontinuity is indicated in the diagram by the vertical line.



Eastern Cape workers replace foreign workers on the gold mines

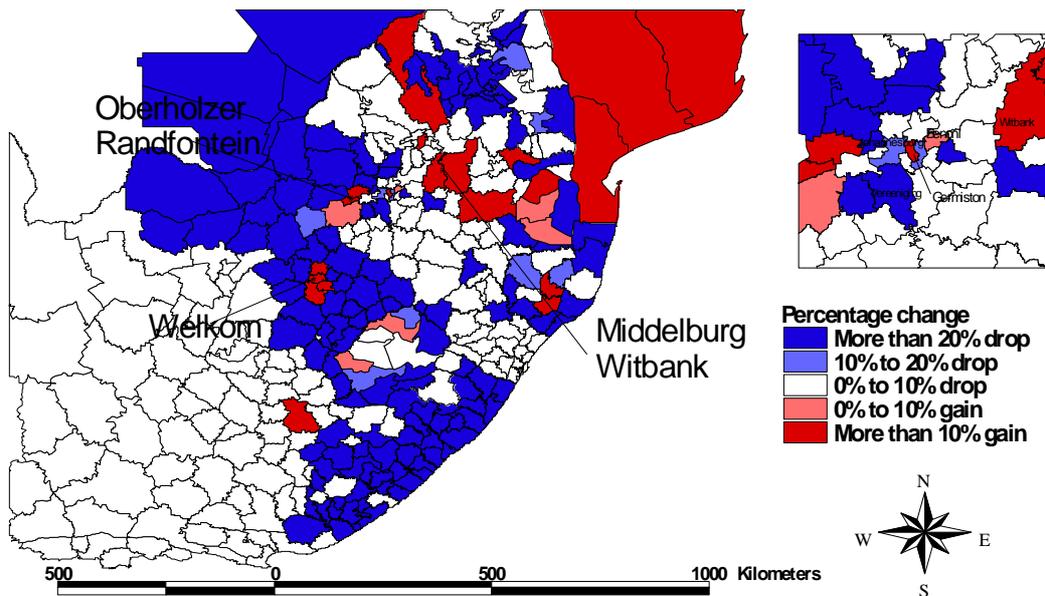
Source: Chamber of Mines data



Proportion of workers on Chamber-affiliated mines that are South African

Source: Chamber of Mines data

By the late 1970s more than half of all mineworkers were of South African origin, and by 1990 more than 60 per cent. During the mid-1990s a spurt of recruitment in Mozambique caused a small fall in the proportion of workers that are South African.



Changing origin of workers, from 1986 to 1998

Source: TEBA data

Recent recruitment patterns

Recent shifts in mining employment have not affected all sourcing areas equally. Consider the map above, which signifies a drop of 20 per cent or more in mining employment from a district (between 1986 and 1998) in a deep blue, while showing an increase of more than ten per cent in red. Readers will recall that overall mining employment between those two dates dropped by more than a third. Three trends can be discerned.

Traditional deep rural recruitment areas have suffered great losses. The classic recruitment areas of the Eastern Cape, northern KwaZuluNatal and the North West Province have virtually without exception reduced mining employment by 20 per cent or more.

Employment from within mining areas is increasing. In contrast, the number of employees from communities around mines has soared. As far as gold mine communities are concerned, the number of employees who stipulated Welkom, Randfontein or Carltonville (in the Oberholzer magisterial district called) as their place of origin increased by more than ten per cent, despite the overall deluge of job losses.

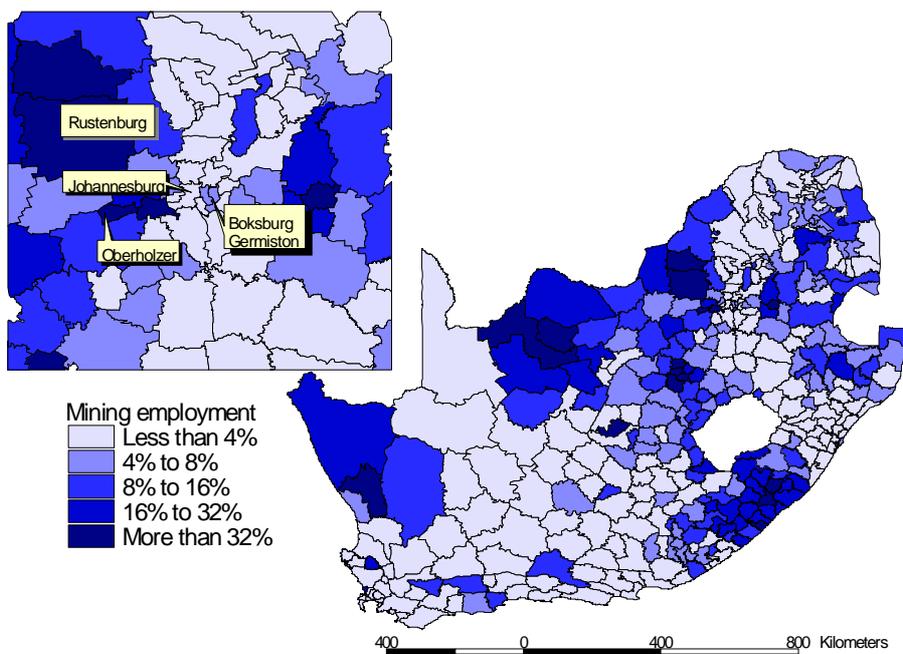
This trend is significant, as it is a departure from the migrant labour model that has dominated the industry for more than a century. Industry sources confirm that mines increasingly recruit locally from the unemployed in the surrounding communities.

A new mine like Target, with a novel extraction category, plans on having no migrant labour component at all. Some of the workers classified as local may, however, have been retrenched miners 'waiting' in these areas to see if any new jobs were to arise.

Thirdly, **recruitment from neighbouring countries** has been less adversely affected than recruitment from South Africa's rural areas. Lesotho districts have mostly showed fairly modest falls in employment numbers, while Mozambique exhibits a strong increase in employment numbers, in the southern districts of that country by more than ten per cent. This is not necessarily the result of employer choice; differing age profiles and preferences regarding voluntary retrenchment among workers from different areas may also have contributed.

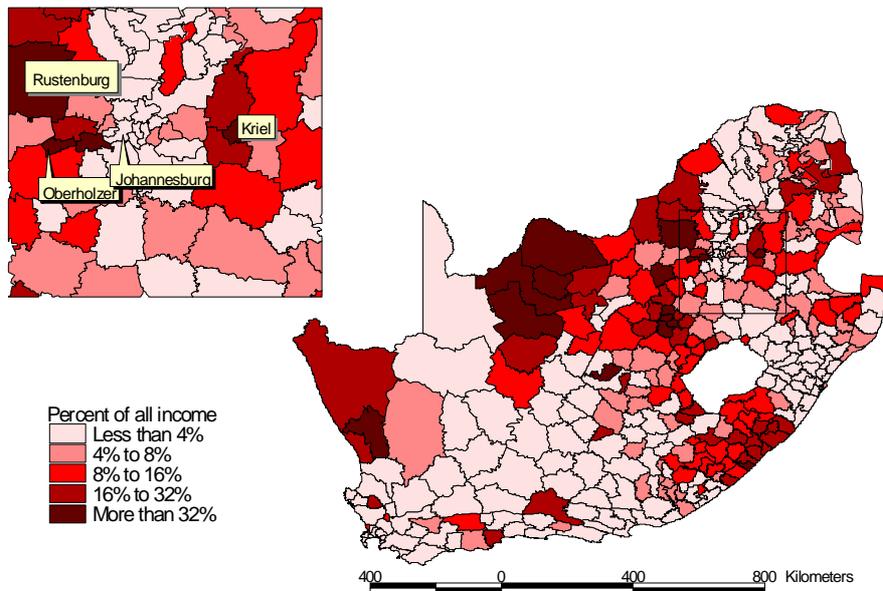
Rural communities continue to rely heavily on the mining industry

A large number of South African rural communities remain heavily dependent on mining as a primary source of jobs, income and financial security. Using the 1996 Census, the chart below shows mining employment of African men as a proportion of total employment of African men. In 15 districts one in three African males with a job



Reliance of African men on mining for employment

Source: 1996 Population Census



Proportion of total income of African men derived from mining

Source: 1996 Population Census

works in the mining industry; in another 38 districts, at least one in six African men with a job works in the mining industry. Virtually the whole Transkei falls into these two groups. It can be expected that large scale retrenchments in the mining sector would hit these communities, their breadwinners and their dependants particularly hard.

Districts dependent on mining for income. In 14 South African magisterial districts mining provides upwards of one third of the total income earned by African men. In a further 38 magisterial districts mining is responsible for one sixth or more of all income earned by African men, and in another 50 districts the contribution is significant, mostly around one tenth of the income of African men. These are some of the poorest areas in the country, commonly with very high dependency ratios (number of dependants per economically active person). Without the mines unemployment in these areas would be even more desperate than it already is.

The importance of mining among South African men. According to the 1996 population census, one in ten South African men with a job were employed in the mining sector. In the case of African men the ratio was higher still: in 1996, one in seven African men worked in mining. There have of course been further job losses since 1996, but these ratios are still remarkably high. The table containing the 1996 figures is on the next page.

#	Magisterial district	Province	Population	Mining % of total income
1	Westonaria	Gauteng	160 765	63%
2	Kriel	Gauteng	24 517	56%
3	Virginia	Free State	79 090	55%
4	Oberholzer	Gauteng	166 569	54%
5	Odendaalsrus	Free State	94 655	52%
6	Kuruman	Northern Cape	26 956	52%
7	Koffiefontein	Free State	11 640	49%
8	Theunissen	Free State	38 064	46%
9	Welkom	Free State	251 691	38%
10	Rustenburg	North West	370 915	38%
11	Kudumane	North West	143 865	37%
12	Elliotdale	Eastern Cape	74 162	36%
13	Postmasburg	Northern Cape	59 166	36%
14	Van Rhynsdorp	Western Cape	14 061	35%
15	Klerksdorp	North West	334 502	35%
16	Huhudi	North West	100 034	34%
17	Mankwe	North West	203 217	32%
18	Namakwaland	Northern Cape	72 707	32%
19	Libode	Eastern Cape	131 775	26%
20	Moorreesburg	Western Cape	13 883	26%
21	Ventersburg	Free State	13 597	25%
22	Highveld Ridge	Mpumalanga	159 135	24%
23	Thabazimbi	Northern Prov	55 417	22%
24	Madikwe	North West	132 895	22%
25	Mossel Bay	Western Cape	58 268	22%
26	Tabankulu	Eastern Cape	126 337	22%
27	Mqanduli	Eastern Cape	129 590	21%
28	Hennenman	Free State	26 854	21%
29	Jagersfontein	Free State	6 576	21%
30	Willowmore	Eastern Cape	11 733	20%
31	Wesselsbron	Free State	31 811	20%
32	Hay	Northern Cape	12 061	20%
33	Flagstaff	Eastern Cape	118 689	20%
34	Sekhukhuneland	Northern Prov	414 788	20%
35	Witbank	Mpumalanga	215 323	20%

Districts where 16 % or more of total income of African men derives from mining

Source: 1996 Population Census

#	Magisterial district	Province	Population	Mining % of income
36	Botshabelo	Free State	177 966	20%
37	Sterkspruit	Eastern Cape	112 061	19%
38	Ngqueleni	Eastern Cape	152 306	19%
39	Vredendal	Western Cape	31 027	19%
40	Phokwani	North West	201 272	19%
41	Namakgale	Northern Prov	48 718	19%
42	Vryburg	North West	60 527	19%
43	Randfontein	Gauteng	133 032	19%
44	Kentani	Eastern Cape	89 183	18%
45	Tsolo	Eastern Cape	103 792	18%
46	Winburg	Free State	15 254	18%
47	Bultfontein	Free State	29 590	18%
48	Bothaville	Free State	53 241	18%
49	Phalaborwa	Northern Prov	30 542	18%
50	Lady Grey	Eastern Cape	7 205	18%
51	Lusikisiki	Eastern Cape	247 422	18%
52	Elliot	Eastern Cape	16 386	17%
53	Noupoort	Northern Cape	7 754	17%
54	Ficksburg	Free State	47 063	17%
55	Port St Johns	Eastern Cape	68 141	17%
56	Bizana	Eastern Cape	196 383	16%
	Total		5 714 173	27%

Districts where 16 % or more of total income of African men derives from mining (continued)

Source: 1996 Population Census

The district level data presents a remarkable picture of 56 magisterial districts, geographically diverse and home to almost six million people, where mining continues to be a critical economic factor: in that very substantial part of South Africa, mining contributes more than one in every four rand of total income earned by African men. It is noticeable that these areas – which can be collectively described as the true ‘Mining South Africa’ – are among the poorest in South Africa, and often far removed from mining operations. Fifteen of these mining-reliant districts, with a total of 1.5 million people, are in the Eastern Cape, including Libode, Tabankulu, Nqanduli, Flagstaff, Ngqueleni, Tsolo, Lusikisiki and Bizana. Communities such as Sekhukhukeland (415,000 people) in the Northern Province and Botshabelo (178,000 people) in the Free State also rely heavily on mining income.

These numbers are, of course, no direct measure of remittance rates. Nevertheless figures given by Crush *et al* suggest that regular Lesotho migrants remit amounts of the order of R400 to R700 per month. This is certainly not the entire wage, but it is a remarkably large proportion of it.

The transfers through the TEBA Cash system are an indication of the size of remittances. For the past two years the annual transfers that have come through this system to Lesotho have been of the order of half a billion Rand. The total flows that went through TEBA Cash in the ten months January to October 1999 were around R 4.7 billion.

	African	Coloured	Indian	White	Unspecified	Total
Male						
Mining and quarrying	521 258	11 133	1 589	57 067	3 811	594 858
Other economic sectors	3 217 287	647 428	229 186	1 020 355	43 710	5 157 966

Female						
Mining and quarrying	9 749	1 266	278	9 955	117	21 365
Other economic sectors	2 135 093	518 433	133 901	827 141	35 374	3 649 942
Total	5 883 387	1 178	364 954	1 914 518	83 012	9 424 131

Sectoral employment by race and gender

Source: 1996 population census

Total employment in mining: calamity and hope

Various sources can be used to assess employment levels in the mining industry. Upon closer investigation they reveal a surprising trend, as well as confirming the enormity of the social crisis caused by falling gold prices.

The broadest dependable source on mining data is the mining census, which is performed every three years, the last published results being for 1996. The mining census shows that at that stage total employment in the mining industry was in fact still well above 500,000. Despite the move towards a smaller, more skilled work force, the mining industry still employs substantial numbers of workers.

According to the census, between 1990 and 1996, three out of every ten workers on the **gold mines** was either retrenched or retired without his job being filled. Chamber of Mines data going back thirteen years confirms the harrowing story of the downsizing of the gold industry. After employment peaked in 1986 at 534 000, the industry went into a trend of lower yields, falling production and falling employment.

Two restructuring episodes were particularly bad: during 1990-1992 a total of 120 000 jobs were lost, and during 1996-1998 another 125 000 jobs were lost. All in all, during the ten years following 1988, sixty per cent of the jobs in the industry were lost.

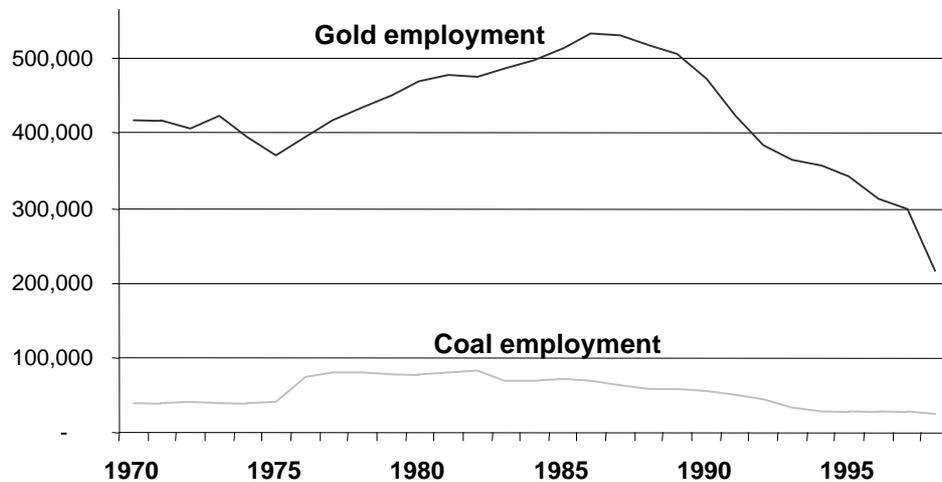
Type of mine	Employees			Annual Growth	Proportion of total
	1990	1993	1996		
Coal and lignite	76,324	61,718	62,956	-3.2%	11.2%
Gold and uranium	477,147	366,264	345,797	-5.2%	61.4%
Chrome	8,363	4,575	6,291	-4.6%	1.1%
Dimension stone	3,463	2,226	3,990	2.4%	0.7%
Limestone and lime works	2,874	2,810	3,255	2.1%	0.6%
Stone crushing	6,047	4,422	4,972	-3.2%	0.9%
Other stone, clay and sand	2,205	3,375	3,862	9.8%	0.7%
Salt and chemicals	4,496	3,245	2,915	-7.0%	0.5%
Diamonds	22,981	14,345	15,450	-6.6%	2.7%
Platinum and other	72,480	76,856	113,765	7.5%	20.2%
All mines	676,380	539,836	563,253	-3.0%	100.0%
All non-gold mines	199,233	173,572	217,456	1.5%	38.6%

Employment levels in South African mining, 1990-1996

Source: Mining Census and the Department of Mineral and Energy Affairs

Consider the vulnerable, mining dependent areas identified earlier: during the late 1980s, mining played a greater role in their economies than the still massive role they play today. Conservatively estimated, the 300 000 jobs lost since 1988 can be calculated to have had a negative impact on the lives of well more than one million dependants.

The rest of the mining sector added jobs. The gold crisis obscures a far more optimistic picture in the rest of South African mining. South African mining excluding gold mines increased employment by about ten per cent between 1990 and 1996, and became a very significant employer, employing 217 000 people in 1996. What makes the performance all the more remarkable is that the 'other than gold' mining industry added 40 000 jobs between 1993 and 1996, a period during which manufacturing, for example, lost 35 000 jobs and the construction industry lost 45 000 jobs.



Employment levels in South African gold and coal mining, 1970-1998
Source: Chamber of Mines

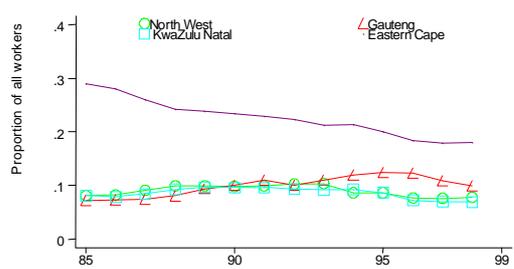
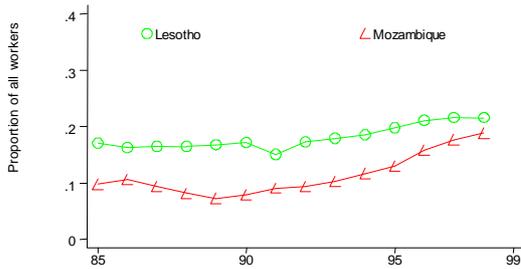
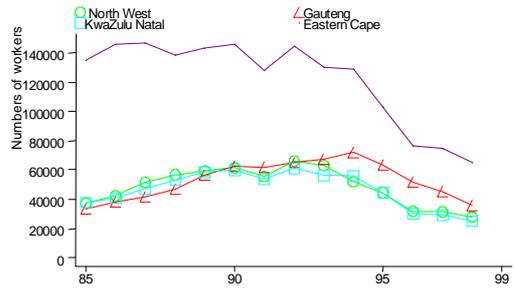
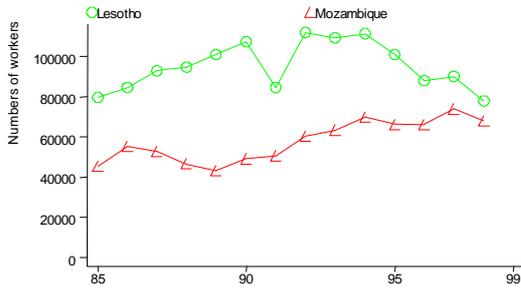
Wages and benefits

Wage levels. Wages among unskilled mine workers have risen more than four-fold in real terms through the last three decades, but from extremely low levels. In 1998, the average annual wage for grade 1 to 8 workers in gold mines was R26 063 or R2 172 per month. Both anecdote and data do suggest, however, that between mines and individual workers there is a lot of variation around this average. Given the increasing role of performance bonuses in the industry, the dispersion seems bound to increase further.

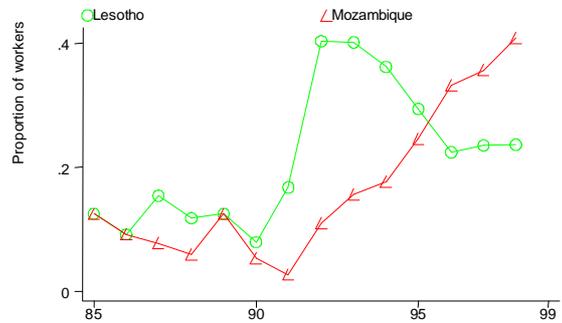
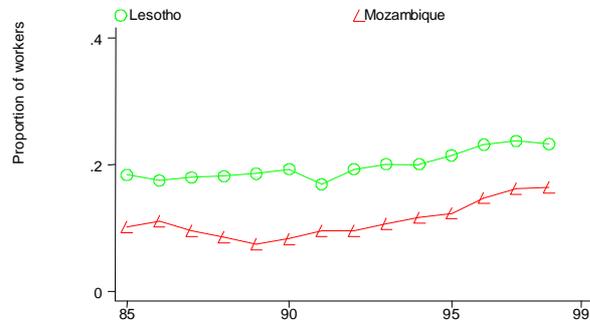
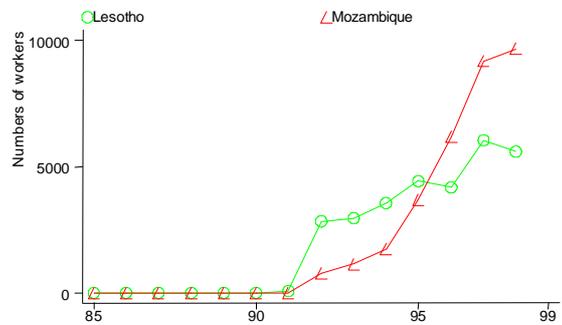
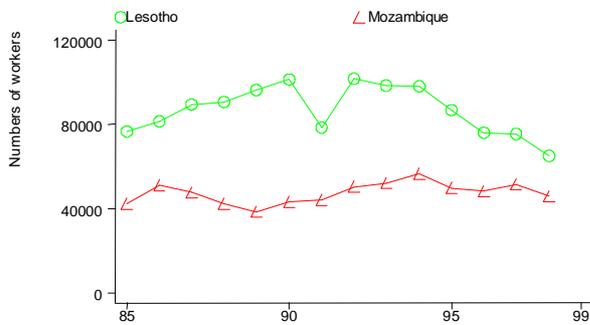
Other benefits. Besides the wage and bonuses, employees receive other kinds of benefits. One of the historically more contentious benefits was hostel accommodation and food. This enabled the mine worker to use the wage for remittances. At the same time, of course, the hostel system was part of the mechanisms of control of the previous form of production. With the break down of the migrant labour system a number of mines are offering accommodation subsidies to their workers. One indication of the magnitude of the costs involved is provided by the 1996 mining census. The census suggests that "payments in kind" added about another 6.8 per cent on to the direct salaries and wages in the gold mining sector and 6.2 per cent in the coal sector.

Another benefit is that of the pension or provident fund. Provident funds for black mine workers are a relatively new development and are claimed as a major victory by the National Union of Mineworkers. Employers and employees contribute to the fund.

The regional breakdown of falling employment



Demand for foreign labour



Dealing with downsizing in the gold industry

One of the key issues that the industry and rural communities have had to grapple with is how to deal with retrenchments. The responses can be divided broadly into two types: minimising the job losses and helping retrenched miners and the rural communities to cope with life after mine employment.

The retrenchment process and the Gold Crisis Committee

In terms of South African law employers are obliged to consult employee representatives on retrenchment programmes, not to negotiate them. However, since the first one was struck in 1990, many retrenchment exercises in the industry have been governed by agreements. The agreements would commonly specify a **retrenchment package** (usually two weeks wages per year of service, excluding payment for the notice month, which is usually not worked) and also have a **social plan** aspect. By this is meant assistance to the worker in making the transition to the non-mining sector. The assistance usually takes the form of retraining. Of course the workers provident fund savings are paid out at the time of his departure. Agreements may also have a **rehiring** clause, in terms of which retrenched workers have preference were the mine to increase staffing.

The Gold Crisis Committee

In the course of 1997-1998 around 96 000 jobs were lost in the gold industry. In February 1998, in the midst of this crisis, a tripartite Gold Mining Summit agreed to adapt the retrenchment process to ensure proper consideration of all possible alternatives to retrenchment. A moratorium was placed on retrenchments awaiting the formation of a tripartite Gold Crisis Committee (GCC) with representation from government, the Chamber of Mines and NUM. The GCC's major objectives were to revamp retrenchment procedures, search for alternatives to retrenchment, set up social programmes for retrenched employees, solicit state assistance for marginal mines and investigate gold beneficiation opportunities

The GCC process concerning retrenchments. The objective behind the Committee's involvement in the retrenchment process is to 'oblige the affected parties to seek alternatives to retrenchment.' The GCC does not have a veto right over retrenchments, but its process is designed to exert moral pressure and to ensure that retrenchments are minimised. The steps in the process are as follows:

The mine sends the GCC a first notification of the intention to retrench.

Upon receipt of the notification the GCC sends a verification team to the mine to assess the situation.

At mine level, management and employees then seek to reach agreement on the retrenchment programme. If they succeed, the retrenchment process starts as agreed.

If after six weeks no agreement has been reached, the GCC is notified of the lack of progress and the continued intention to retrench. At this point the various parties to the GCC – the industry, the government and the unions – may decide to use moral suasion to influence the course of events. Legally, the remainder of the process is subject to the legal rules governing retrenchment generally.

Is the GCC process succeeding? The GCC process has succeeded in drawing in all three parties into the restructuring process in gold mining. It has also improved access to information about retrenchment and the financial conditions of particular operations, so alleviating distrust. It has also forced mines to actively consider alternatives to retrenchment early in the restructuring process. In those terms the process may have saved a large number of jobs, but it is impossible to test this empirically. Indications are that the GCC has made a significant difference: between February and June 1998 the Committee considered 12 cases of retrenchment/restructuring involving 27 764 jobs at risk¹⁰. Total job losses eventually were 17 012. 16 628 of the jobs lost were not compulsory retrenchments, but voluntary separations or early retirements.

Other activities of the GCC. The GCC also set up task teams in the following areas:

State assistance to marginal mines.

Beneficiation.

Developing a market for gold.

Gold price stabilisation.

Mechanisation.

¹⁰Chamber of Mines Annual Report 1998, pages 14-15.

Retraining and reskilling

The massive scale of restructuring in the industry and the dynamics of the collective bargaining process have forced mining companies to assist retrenched workers in preparing for a life after mining employment. Many retrenchment contracts are now linked to **retraining schemes**. Workers are given training vouchers that they can exchange for training at various institutions for up to two years after retrenchment. The **severance packages** of course can also help mine workers to establish new lives for themselves back in their communities. Anecdotal evidence in this regard is rather mixed. In some cases it has made a huge difference, and examples were given of retrenched miners who set themselves up as successful taxi operators. Other anecdotes are less positive, with the severance pay being frittered away without building any lasting resources for the family concerned. The lack of financial skills is prompting TEBA Cash to set up a financial advice service for retrenched workers.

The **Mine Workers Development Agency** (MDA) has stepped in to assist retrenched workers during this perilous stage in their adjustment to post-mining life. The MDA has established, with financial support from mining firms, a number of development centres that offer skills to enable mineworkers to set up microenterprises. The courses on offer include building related skills¹¹, food production¹², farming skills¹³ and other micro-enterprise skills¹⁴. At present there are development centres in Maseru, Kokstad, Mhala and Welkom and two in Bophirima. The latter are supported by the North West government. Nine additional areas have been targeted for the establishment of such centres.

According to the MDA they are finding that most of the training is in fact being taken up by the wives of the mine workers. The mine workers themselves frequently gravitate back to the mining areas in the hope of finding employment again. This, of course, is leading to some unemployment problems in the mining towns. Consequently the MDA is also focusing some of its activities in areas such as Welkom.

Providing community resources

The provision of micro-enterprise and other skills would be of little help without the logistical and commercial resources to support such activities. Some attention has therefore been given to ways of building resources in the rural areas.

The MDA has started up a **central buying service** (Ethaleni) with funds secured from the Goldfields/NUM Social Plan Fund. The purpose of this service is to get inputs to users at much cheaper rates than would otherwise be possible. This service is intended to supply not only MDA projects, but also any other local enterprises. The MDA notes that it is frequently logistical problems that hamper micro-entrepreneurs. For example, getting steel rods for a local window frame manufacturer the 40km from Bushbuckridge to Mhala is a costly undertaking. These are now supplied from the MDA's development centre in Mhala, and are proving to be the fastest moving items. Ethaleni is hoping to facilitate the diversification of microenterprises by providing a range of inputs at competitive prices. According to the MDA, they have managed to achieve a 40% reduction in costs to the end user.

Some of the mining houses are investigating how their **procurement policies** might support rural entrepreneurs. Given the enormous resources pumped into the South African economy every year through mine purchases, even a marginal shift in procurement might make a major difference to these rural localities.

Availability of credit is also a major problem in many of these areas. TEBA Cash has applied for a banking licence. As soon as this is granted, some of these problems can be creatively addressed. TEBA Bank would be ideally placed to leverage real resources into the rural areas. It already has a network of over 70 centres located in the deep rural areas and administers significant funds. If it could take deposits and provide loans, it might serve to mobilise financial resources for rural development. For example, a rural community might be able to secure a loan for a rural water well against future earnings of some of their migrant workers.

¹¹Such as block and brick making, Roof and floor tile making, Prefabricated wall building, window frame production, concrete product manufacturing.

¹²Such as bread baking, fruit juice and ice-lolly manufacture, chip and peanut snack production, sunflower oil production, beer brewing, maize milling and atchar production.

¹³Vegetable and crop production, egg production, chicken production.

¹⁴Such as battery charging, polish and candle production, leather goods and shoe repair, key cutting, fence making, hairdressing kit, T-shirt printing, gravestone manufacture.

Providing rural health

Many people have left the mining industry disabled. These miners have drawn disability pensions from Rand Mutual, the industry's disability insurer, and have been periodically visited by people from TEBA, to ensure that their health needs are being adequately addressed. This health role is currently being expanded to the health needs of mining families more generally.

A project initiated by AngloGold Health Services but now taken over by TEBA is now specifying rural health needs much more precisely. The first step in the programme was a mapping exercise - **locating every mine worker family on a geographical information system (GIS)** by means of a global positioning system. The purpose of this exercise was to enable the researchers to determine access to various kinds of health care and facilities.

The second step was a **Participatory Rural Appraisal** exercise. Instead of the health professionals determining the appropriate health interventions on the basis of the map, they asked the families themselves what they thought their primary health care needs might be. In some cases it turned out that roads or water were more pressing needs than better clinics.

The next steps in this process will be to determine what kinds of **intervention** might be possible, and how different role players, including the mining industry, might be able to contribute.

The emergence of rural development agencies out of mining

The institutions that have grown up around the mining industry are repositioning themselves to serve rural communities. Consider TEBA, whose primary role, historically, was to funnel people from the rural areas to the mines and back. The recruitment role is currently at its lowest ebb ever. Instead, TEBA is starting to take on a much broader developmental role. For example, the information contained in the **TEBA Health mapping exercise** could be used as an input into government health programmes for the rural areas. Similarly, the **communications network** that TEBA Cash has put into rural areas might be used by communities to access global information. Indeed the TEBA Cash rural offices are currently linked by satellite to the Head Office, to facilitate online updating of information. There is, however, some spare capacity on the bandwidth at the moment and one idea being floated is to make this accessible to the families of mine workers, so that they can communicate with their husbands on the mines by means of e-mail¹⁵.

The Mineworkers Development Agency is also becoming a much more **broadly targeted rural development agency**, as the example of Ethaleni indicates. Indeed the original focus of the MDA on producer co-operatives is becoming submerged into the broader approach of facilitating the emergence of rural micro-enterprises and helping these producers access larger markets. Currently the MDA is experimenting with new products that might become profitable rural ventures, such as Marula beer and Marula Oil.

Many of the initiatives undertaken by the MDA, TEBA Social Services or TEBA Cash are also becoming dovetailed with each other. In many cases the MDA has moved into empty offices on TEBA properties. In places like Lesotho those offices are still operating as agents for TEBA Cash. These sort of linkages are of course important in ensuring that energies are concentrated and not dissipated.

The positioning of these institutions in relation to major players in the South African economy as well as their ability to provide an advocacy function for these communities, might be the best chance that these areas have of achieving sustained development.

¹⁵One of the services already provided by TEBA is a message service - allowing families to contact their migrants and vice versa.

Changing corporate structure and strategy in South African mining

For a century, the mining finance house dominated the private South African economy. These firms, formed to exploit the Johannesburg gold deposits, ultimately financed the entire gold mining industry in the country, ingested the diamond industry, pioneered coal and platinum mining, and funded South Africa's manufacturing base from the mid-century on. The houses were central to the development of South Africa's capital and money markets, and at times owned important stakes in South Africa's largest banks.

The houses were notable for their continuity. All seven major houses at the end of World War II still dominated mining, and much else, in 1990 (although two had joined forces, and one had merged with an industrial company).^{*} The corporate and industry structure among the houses in 1990 was virtually identical with that of 1946.

All this is now past. No traditional mining house remains. The industry is now home to diverse types of firms with diverse strategies: small mines dedicated to high productivity exploitation of marginal ore, single commodity companies mining long-life high-yielding deposits, mining venture capitalists and global mining concerns. Mining services and supplies, once internally provided by the mining house, are now commonly outsourced to a wide range of independent firms.

Why did this happen? What does it mean for mining in South Africa? This chapter will address these issues.

The logic of the mining house

The shape of the mining house structure reflects the industry's fundamentals during its first decades: massive capital demands driven by deep-level mining; vulnerability to rising labour costs; and the need for scarce skills. During the various bursts of development of South Africa's geological base - Johannesburg, the East Rand, Klerksdorp, the far East Rand, the Free State, Carltonville - the effective and rapid mobilisation of capital and skills was critical. The mining house was designed for that purpose. The industry structure that eventually emerged was also used to increase the supply of labour as a means of managing labour costs.

Capital. The geology of the Witwatersrand Basin meant that gold ventures had to mobilise very large amounts of capital. As the deposits were in a small agrarian country with virtually no financial system, the initial capital had to be raised abroad. Mining houses were a funnel through which large amounts of foreign capital were invested in the opportunities in South Africa. The mobilisation of capital allowed for a massive increase in production. Within four years after the first full year of Witwatersrand production, gold output had risen 18-fold, to 21 tons. Seven years later, in 1898, the last full year of production uninterrupted by the Anglo Boer War, 119 tonnes of fine gold were produced. In 1917, Anglo American was formed with the express purpose of raising American and British capital (hence the name) to develop the new East Rand gold fields. Each subsequent area of development required capital investment that dwarfed the resources of the mining houses, necessitating capital to be mobilised externally.

The reputation of the mining house was key to obtaining the capital, given the extreme information disadvantage of particularly the foreign investor with respect to the feasibility of a deposit. The only way money could be raised was if a mining house sponsored the mine by putting its reputation and significant equity capital behind the new venture. This process gave the mining house maximum exposure to the riskiest (and potentially lucrative) phase of mining, the development phase.

Skills. There were compelling reasons for the repository of skills to be centralised, and for the centre to provide services to the mines. As the mining house system of raising capital meant that mining operations were separate companies with their own shareholders, the mines had to pay a fee for centrally provided services. This system, which became less efficient over time, is discussed in the chapter dealing with the mining services and supplies industries.

^{*} The seven mining houses during the early post-war era were Anglo American, General Mining, Union Corporation, Gold Fields, Rand Mines/Central Mining, JCI and Anglovaal.

Fortune magazine describes the mining house in 1946

“In a way these corporations resemble investment banks: they finance and float new enterprises.”

The mining house maintains its own management, accounting, engineering, technical and legal staffs, generally including men of higher competence than any individual mine could afford to pay.”

The mining house purchases supplies for the entire group. It supervises all companies in its group in all large matters of finance, technology and capital expenditure, acts as head office secretary, consulting engineer, and technical advisor; handles stock registration, stock transfers, land transactions, taxation matters, mining claims, licenses, research, and cost accounting. General practice is to distribute among group members the approximate costs incurred by the mining house, plus a fee for the service.”

Share-premium financing: “a system whereby original paid-in gold mine capital is used to secure property and prove ore bodies, after which new stock is offered at a premium. The new capital is used to sink shafts and construct a reduction plant.”

Labour costs. The Witwatersrand Basin had an abundance of reef, at deep levels, and at low grades. These facts determined the operating cost structure of the mine: once the shaft had been sunk, labour costs were around 60 per cent of the costs of mining. The dramatic surge in the demand for labour on the Rand threatened to render the mines unprofitable and, at least in the early years, mine profitability was precariously balanced. The fear of being driven out of business by the market competition for labour led to a monopsonistic strategy on the part of the large mines, made feasible by the formation of the Witwatersrand Chamber of Mines in 1889. Its natural counterpart was a centralised drive to increase the supply of labour.

Considerations of capital-raising, rare skills and the importance of labour costs led to the familiar mining house and mining industry structure that dominated for most of the 20th century. To summarise, its key elements:

- Finding **new opportunities** through exploration or purchase of mining rights.
- **Mobilising capital** thorough sponsored listing of mines over which management control is retained.
- **Central provision of skills**: mining engineering for development of the mine, geology and metallurgy for the on-going running of the mine, accounting, legal and treasury services.
- **Central purchasing department** for material, to benefit from scale economies.
- Through the Chamber of Mines, **monopsonistic demand for labour**.
- Through the Chamber of Mines, and then through the groups, a **uniform approach** to both mining and to the government (the uniformity diminished over time).
- **Diversification**, which gained speed after 1960.

Financing the Free State gold fields. The mining house had been developed as a mechanism to build large capital-intensive businesses at a time of underdeveloped capital markets and a scarcity of technical skills. The apex of this model of capitalism probably occurred during the years 1946-1960, when it successfully developed the Free State gold fields. For South Africa the development of the Free State gold fields during 1946-1960 was critical. Equally critical was the role of the mining houses in mobilising the capital for that massive expansion. 88 per cent of all the funding raised by mining houses during this period came from abroad, and only 12 per cent from South African sources.

Of the foreign funding, most was in the form of debt on the London capital market. The London investors insisted on the sponsoring mining house committing large amounts of its own capital to the venture for which money was being raised. On average, mining houses committed their own resources equal to around 70 per cent of funding received from external sources to the new ventures.

In addition, the mining houses raised domestic capital on two fronts: firstly, on the Johannesburg Stock Exchange; secondly, on the South African money market, which had been started by the mining houses to avoid having to put and source cash off-shore. Between 1955 and 1961, total funds employed at call or short notice in South Africa grew by 81 per cent.

Changes and pressures

Four worrying long-term trends: 1960s-1980s

The Free State gold fields were perhaps the greatest industrial achievement of 20th century South Africa. It dwarfed any capital development before or since in terms of size, technical complexity and speed of execution. But, seen with hindsight, 1960 was probably a turning point for the mining house as a structure for organising business. In 1960, four trends that would last for the next 30 years took hold. Together, these trends would lessen capital markets discipline on the houses while at the same time causing their businesses to become more complex.

The mining houses became large net providers, rather than absorbers, of capital.

As the Free State gold fields were now developed, the capital needs of the gold mines slowed, and the surpluses of the industry increased. Now the mining house model was turned on its head. Designed to mobilise capital, it now became a source and allocator of capital, not only in mining activities, but also increasingly in the rest of the economy, as domestic mining proved unable to absorb all the capital it was now generating. The centralised structures of control that worked well for mobilising capital and skills for mines were less appropriate for allocating capital to unrelated ventures. And the very success of the mining activities allowed managers to become complacent and passive.

For the most part, the rest of the non-communist world practised another model of capitalism, where intermediation through capital markets and the banking system allowed for specialisation and for experimentation with variations in control structure, supervision and level of diversification. The South African mining house model of industrial investment and control tended to be static.

1960 started an era of isolation for South African firms, including the mining houses.

The events at Sharpeville in 1960 precipitated a long process of international opprobrium of apartheid South Africa, culminating in financial and investment sanctions. Government policies strengthened the isolation: one consequence of Sharpeville was exchange controls, which would ultimately trap the surplus capital generated by the mining houses in South Africa. High trade barriers, some in place since the 1920's, further distorted investment returns and hence decisions.

Isolation made it progressively more difficult for mining houses to evolve to global mining specialists rather than diversified regional champions . . .

The truncated access of South African firms to international capital markets and investment opportunities abroad precluded mining houses from pursuing the most natural path of expansion. This path would have been to do for the rest of the developing world what they had done for South Africa: be a conduit of capital from the international financial centres to mining opportunities in high-risk developing environments.

. . . . instead, industrial diversification became a strategic objective.

Perversely, the policy environment biased mining house investments away from mining. As already noted, exchange controls prohibited the investment of surplus South African capital in mining ventures abroad.; rules 'ring-fencing' mining activities for tax purposes discouraged mining investment in South Africa; and the trade barriers artificially raised returns on import-replacing manufacture.

Industrial companies, many of whom were expanding behind the tariff wall, eagerly absorbed the cash surpluses generated by the mining concerns. Among the latter were SA Breweries and Premier, both of whom raised cash through repeated rights offers. Ironically, these companies, too, diversified. During this era of diversification and distorted investment returns, the mining houses assumed the shape and investment approach that would characterise them at the end of the 1980s. The diversification was not good for managers. Because of protected markets, managers in these manufacturing markets could to an extent set their own margins, so they did not have to be cost managers. And company directors and managers at the highest levels were called upon to make decisions about businesses they were not expert in.

1980s: the lost decade. **The isolation had another, more subtle, effect. South Africa, as well as its mining houses, was now effectively cut off from the changes in how their international peers were managed and how they interacted with their shareholders. During the 1980s, foreign mining majors, continually under pressure from strong institutional shareholders, were adjusting painfully to circumstances. Global mining**

firm RTZ's response to investor demands in the 1980s – focus on mining, lean corporate structure, clear strategy – prefigured the reform of South Africa's mining houses by almost a decade. South Africa's pariah status insulated the countries businesses from similar scrutiny. By the end of the 1980s, the capital and managerial inefficiencies engendered and tolerated by the South African environment had become apparent. Gencor was the first mining house to start considering radical structural change following the appointment of Derek Keys as chief executive in 1986.

The 1990s: emergence and pressure

As South Africa emerged from its long slide into economic isolation, its capital markets were re-integrated with global capital markets. Foreign financial institutions were openly critical of the returns and management practices of the mining houses. Domestically, local institutions were shifting portfolios to the technology sector and foreign bourses. The pressure for change from shareholders focused on two related issues: poor returns on capital invested, and the mining house discount.

Poor returns on capital invested

During the early 1990s, two factors conspired to depress the returns from the traditional asset base of the mining houses. First, the maturity of South African gold mines in an unforgiving price environment: by 1990, many mines and shafts were operating at a loss. Cash margins in the gold industry reduced from 50 per cent to 20 per cent, at which levels one could no longer make money. One solution was to high-grade operations, but there were limits to this, as maturity reduced grade flexibility. The second factor depressed returns from industrial holdings: as various policy distortions were removed – through trade reform and increased integration with the global economy – the effects of the misallocation of capital showed up in corporate returns.

Senior mining executives now point out that management was also to blame. A top executive in the industry points out that “capital was appallingly misapplied. Real returns of seven per cent were considered acceptable, while the norm abroad was 15 per cent or higher, depending on the riskiness of the project. Risks were perceived to be low, but in fact they were not.” Another industry leader points to the lack of capital markets discipline in the capital-rich mining houses: “There was little sense of key measures of capital efficiency such as return on assets and return on equity. The companies were technically strong, but financially and commercially in the stone age.” By the mid-1990s, equity investors had dramatically devalued the traditional base of the industry.

The mining house discount

The most direct cause of restructuring was the discount of the value of mining houses relative to the market value of the underlying assets (in the mining house model, many of the assets of the mining house are also listed, and hence given a transparent market value). By the early 1990s the valuation of mining houses implied a significant discount relative to the value of assets. This was a simple and compelling indictment: it implied that investors considered that the house would not wisely invest the dividend flows and/or capital values of these assets. The discount also gave investors an easy rationale for encouraging restructuring: unbundling of the underlying assets, for example, would release the amount of the discount to investors.

The commodity price crisis of the 1990s. By the early 1990s, these pressures, together with the realisation that prices were in a long-term downtrend, concentrated the minds of mining house executives, and Gencor implemented an unbundling of non-core assets. For those mining houses that did not restructure, further margin pressure was on the way. Mineral prices fell sharply in the second half of the 1990s as financial crisis engulfed Asian countries, which are important buyers of commodities at the margin. Consider 1998, the key year. Copper prices for the year were 28 per cent below the 1997 average, and in the first quarter of 1999 fell to the lowest inflation adjusted price of the century. From their respective peaks in the mid 1990s, nickel and zinc prices almost halved, and lead prices fell by 40 per cent before 1998 was out. Aluminium prices fell throughout 1998, around twenty per cent from the peak on the first trading day. Precious metals were not spared. Platinum prices fell within 16 months by one sixth, before stabilising at around \$350 for most of 1998. Gold prices in 1998 were more than 20 per cent below the market levels of the mid-1990s, a painful fall given the high production costs of South African mines.

Industry responses

Geology and history conspired to put South Africa's mining houses under considerable pressure during the 1990s, but the global industry shared many of these pressures, particularly as prices turned down. Considering that mining is a global industry, it is not surprising that the responses of the South African and the foreign firms have the same objectives, and that the approaches often, and increasingly, converge. For the whole industry the main themes have been:

Reinforced cost focus. By decimating the profits of many operations, the sharp price falls of the late 1990s forced the industry into a survival mode, reinforcing the relentless focus on costs that has characterised the industry since the late 1980s. Around the world cuts in exploration budgets, corporate restructuring and mine closures were

accelerated. These were all attempts to salvage some returns for an investor community smitten with the massive returns achieved in the information technology and media industries.

Attention turned to industry structure. The downswing also illustrated the corrosive effects of investment and operating practices in the industry. Price increases and new investment opportunities in the early 1990s had led to a wave of expansion in the industry. As the new capacity came onstream, it added to the pressure of the Asian crisis. Clearly, there had been overinvestment as investors had not considered the aggregate effect of all the new projects on the price level. Unprofitable operations also did not shut down in response to prices, given the high fixed cost component: it was in their interest to continue operating as long as cash costs were covered. Both these practices were destabilising the industry and exaggerating the price cycles. Firms started considering whether it was possible to reduce these tendencies in the industry.

Corporate entities and operating units have transformed themselves to ensure survival and to generate acceptable returns for investors. The adjustment story of firms, South African and international, has two elements:

- a productivity drive in existing operations
- restructuring corporations for greater efficiency and to focus on distinctive capabilities.

A productivity drive in existing operations

Faced by falling prices and devastated profit margins, mining operations around the world responded by attacking cost per unit of output. The techniques most commonly used have been:

- right-sizing businesses (this includes refraining from mining unprofitable ore)
- applying cost-saving technology
- changing work organisation and employee incentives
- outsourcing
- merging contiguous properties to reduce operating costs.

In many cases the changes were implemented by **new owners** with a distinctive capability in management of a particular type of orebody. In South Africa for example, a number of smaller firms have distinguished themselves as superior managers of marginal orebodies. In other cases, existing management has implemented changes. Taken together, these measures have led to significant reductions in cash and overall costs of production in South African mines, as well as certain mines abroad. A number of South African operations would have been closed down as unviable had these changes, which are often difficult to implement, not taken place. Around the world, operations, which after such efforts have remained unviable, have been closed down.

Examples of the productivity drive around the world

The Australian coal mining industry responded to the low export coal prices of 1998 by focusing on higher productivity. The expansion of the Burton opencast mine to four Mt/y capacity and the use of longwall techniques buoyed production and reduced costs. At the same time, several older, higher-cost mines in New South Wales closed.

Also in Australia, Rio Tinto's Pilbara iron ore mine has maintained profits by designing operations 'more akin to a continuous manufacturing plant than a traditional mining operation.' Five years ago, the mine offered uniform conditions of employment and offered staff conditions to all employees. Since then, the Mining Journal reports, there has been greater motivation, more flexibility and opportunities for multi-skilling, and the work-force has been reduced by 25 per cent.

In South Africa, large parts of the gold industry adjusted work practices, employee incentives and staffing complements to deal with the price pressure. These changes are documented in the labour section of this report.

Cost savings in contiguous properties

Last year BHP and Rio Tinto, respectively the world's second and third largest iron-ore producers, seriously considered merging their giant iron ore operations in the Pilbara region of Western Australia. Although the agreement ultimately foundered on valuation differences, it is a striking

example of the potential of operational savings from mergers. Each producer currently runs its own railway system 400km to the north. The merger would have unlocked large gains from sharing rail facilities, power supplies and other infrastructure, as well as from production flexibility. Estimated annual savings: A\$250 million.

In South Africa, an agreement between Gencor and AngloGold to ensure the efficient extraction of the Driefontein orebody is one of a number of examples.

Corporate restructuring in South Africa and beyond

In mining, mergers and other corporate actions have been aimed at any of four things:

- Achieving **corporate cost savings**.
- Reducing **cost of capital**. This is achieved by corporate actions that reduce real or perceived risks.
- Promoting **rational market conduct**.
- Building on **distinctive capabilities**.

Virtually all mining corporate action – both in South Africa and globally – in the current wave has been justified on one or more of these grounds.

Distinctive capabilities

Amid the clamour of international institutional investors about eroding returns, mining firms have reassessed their business to identify those activities at which they excel, and at which they make superior returns. This activity has spawned virtually an epic poem of buzzwords such as ‘core competency’, ‘core activity’ and ‘competitive advantage’. These words all refer to the honing down of a business to its most profitable and accomplished parts.

Diversified mining firms have a well-established decision tree to work through in determining their focus:

Deciding on distinctive capabilities and corporate structure

Conglomerate structure or natural resources only?

If natural resources, forestry products, oil and so forth, or mining only?

If mining only, both precious metals and base metals (including coal), or only one category?

If only one of those categories, specialise in only one commodity, or in a number?

Further, how far into downstream activities? Only extraction, or also smelting, or also intermediate products, or final products?

Finally, in terms of operations and corporate activities, which capabilities should be retained in-house and which outsourced?

Decisions of this kind have been required of all diversified mining groups, South African and foreign, and global mining has seen a bout of restructuring. At the essence of the decisions: they are all taken by assessing across which activities the distinctive capability of the firm would hold.

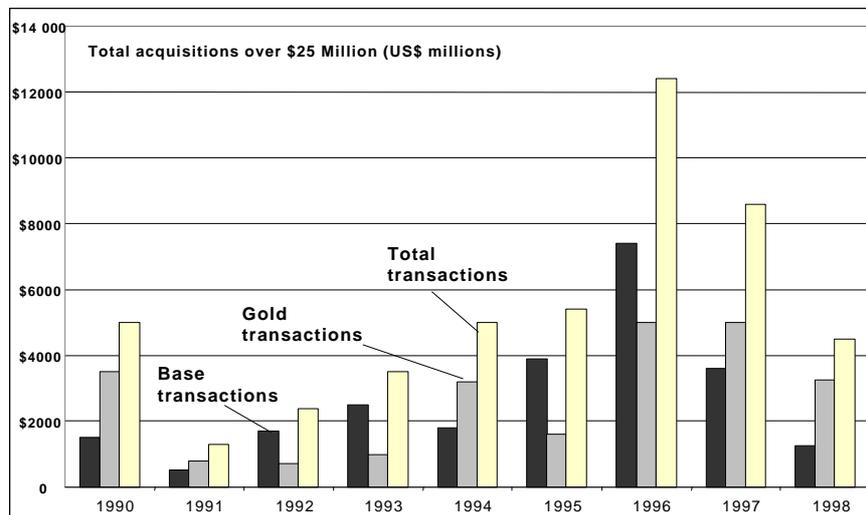
A vast international re-allocation of assets and activities

Once firms had identified their distinctive capabilities – for example, exploration, aluminium smelting, managing deep-level marginal mines – it was inevitable that there would be a round of divestitures and acquisitions, a reallocation of assets and activities to firms with the most appropriate capabilities. The reallocation of assets explains much of the merger activity of the 1990s; likewise the reallocation of activities explains much of the outsourcing activity of the recent decade. One result: the diversified mining house has disappeared. Other firm types, some large, some much smaller, have flourished in its place. Examples are: dedicated precious metal miners, giant global base metal players, integrated single-mineral concerns, specialist firms in managing marginal operations, small exploration firms, independent technical consultancies, and mining contractors. A following section shows how this played out

in South Africa. First we consider two types of corporation flourishing in the new era: the logic of the global mining major, and the opportunities for the small specialist firm.

The evidence: mergers in the 1990s

During 1990-1998, 253 companies and projects (only those deals individually worth more than \$25 million were counted) changed hands, roughly half in base metals and half in gold. The total dollar volume, as reported by the Metals Economics Group, was \$48.2 billion. The wave is not yet over: final figures for 1999 are not yet available, but indications are that merger and takeover activity has soared from the already



Corporate action in international mining: 1990-1998
Source: Metals Economics Group

feverish levels of the decade. What is motivating these mergers? The succinct answer: the search for returns in a low price environment.

Other factors have also encouraged corporate actions. In the 1990s, privatisation and better market access opened up a trove of investment opportunities for mining firms. At the same time, international capital markets, and the investment bankers that operate in them, have made available resources for take-overs on an unprecedented scale. Finally, the general business atmosphere has been thick with mergers and acquisitions; in part this reflects firm efforts to capture hitherto untapped (and untested) economies of scale and scope in global production and marketing.

The mining house restructures

As the 1990s unfolded, South Africa’s gold sector, with its focus on high-cost deep-level mines, restructured. It has effectively meant the end of the mining house as it originally existed.

Unbundling. Mining houses reduced - in some cases sharply - the diversity of their investments. Billiton, then Gencor, divested itself of its paper, oil, and consumer interests through an unbundling process. Anglovaal has split into three groups, focusing on mining, consumer goods and engineering/capital goods.

Full ownership of operating companies. The traditional mining house has been destroyed, and been replaced by holding companies - Billiton, Anglo American

Company	Location of Company Headquarters	Number of transactions	Total amount paid in cash and/or shares (US\$ Billions)
Inco	Canada	3	\$3.9
Anglo American	South Africa	7	\$2.6
Barrick Gold	Canada	3	\$2.5

BHP Minerals	Australia	2	\$2.5
Newmont Mining	United States	3	\$2.2
Placer Dome	Canada	9	\$2.1
Cyprus Minerals	United States	5	\$1.8
Battle Mountain	United States	3	\$1.6
Homestake Mining	United States	5	\$1.5

Corporate action by mining majors: 1990-1998

Source: Metals Economics Group

Gold Fields - with 100% ownership of their operating entities. This change is reflected in the number of listed mining companies on the JSE falling from 45 in 1992 to 14 in 1999, with entities such as Amcoal, Samancor, CMI, Western Deeps, Kloof, Driefontein and Ingwe delisting.

Outsourcing and lean corporate organisation. A combination of outsourcing and decentralisation has slashed head office functions and staff of these holding companies. Billiton, for example, spun off its technical division.

Down-sizing and portfolio shifts. Operations, particularly in gold, have down-sized, following the realisation that the \$400+ price levels seen in the 1980s were not going to reappear. The large mining groups closed unprofitable shafts and sold off marginal shafts better operated by smaller companies. Within many operations, a high-grading strategy was followed, with mines refraining from mining unprofitable areas.

The pioneer of mining house restructuring, Gencor/Billiton, is a good example of the process:

Six steps in transforming Gencor

First: The unbundling of Gencor

Management concluded that the centre 'provided no value enhancement' to a number of industrial and commercial holdings. These holdings were in activities removed from the core of mining and metals processing activities. For the non-core activities supervision by the centre was 'just another hurdle'. These interests were unbundled in 1992, the first process of its kind in South Africa. Companies unbundled included Sappi and Malbak. Subsequently, many other conglomerates unbundled, among them Barlow Rand, JCI and Anglovaal.

Second: Deciding on the core holdings

The remaining assets were grouped into five groupings. This begged another round of consideration about distinctive capabilities. Should a mining company be multi-commodity or single-commodity? The choice was a multi-commodity base metals and coal strategy, excluding precious metals. This choice was made on the basis that that would provide the company with critical mass, and that skills are transferable and similar across those commodities. It was also decided that forward integration would be limited to smelting.

Third: Accessing global capital markets

Billiton's fundamental strategy is to go where the deposits are; therefore it has to operate globally. Exchange control presents a problem. It means that foreign acquisitions can only be acquired in a very convoluted way. Essentially, therefore, to be a global mining company, Billiton needed an offshore balance sheet and to be a full participant in the global capital markets. The largest pools of capital in the world are New York and London. Hence the need for an off-shore listing on the best terms in a major capital market, which was achieved when Billiton shifted its primary listing to London and joined the FTSE index.

Fourth: Consolidating holdings

As a hold-over of the mining house structure, Gencor/Billiton 'looked like a unit trust', with large stakes in listed companies with minority shareholders. As a result, cash was trapped in various operating companies. So, during the bottom of the cycle, they took full control of coal and other interests.

Fifth: Enhancing the portfolio

Large opportunities are sought out and pursued. One example is the recent acquisition of nickel and manganese interests. Globalisation also plays a role here. For an acquisition to make a difference to Billiton it must make \$50-100 million per year in profits. Otherwise the transaction costs are too high. The important attributes in a metal are: scale, growth and the right opportunity.

Sixth: Splitting precious metals from the rest

Precious metals producers are rated differently. Therefore, it makes sense for these to be pursued separately. This was achieved with the separate listing of Gencor (the holder of gold and platinum assets) and its subsequent merger with GFSA.

Similar processes to the restructuring of South Africa's mining houses have been pursued by the foreign mining majors. Some preceded the South African restructuring by some years, others followed upon it:

Foreign majors home in on distinctive capabilities

RTZ prefigured the restructuring route of the South African mining houses by almost a decade: during the 1980s and early 1990s, it spun off non-core assets, including aluminium plants, chemical plants and oil and exploration assets. At the same time it reinvented the way it ran operations through a combination of decentralisation and outsourcing, leaving it with a very small head office. The restructuring boosted RTZ's share price, laying the groundwork for the 1995 merger with Australia's CRA, forming the world's most valuable mining group.

Similar parallels can be seen with Toronto-based **Noranda**. Founded in 1922, Noranda built up a diversified natural resources group with interests in mining and metals, forest products, and oil and gas. The company's vision was to be "one of the world's premier diversified natural resources companies". In 1997 the firm announced a major strategic shift. The firm would henceforth focus on being a mining and metallurgical operating company, focusing on its world class zinc and nickel assets, as well as interests in copper, aluminium, lead and precious metals. Together with associate company Falconbridge, Noranda plans to retain exploration as a core internal activity. During 1998, the group divested its oil and gas and forestry products businesses. The long-term goal of the group is to be focused on the production of base and light metals, comparable in scale to such groups as Billiton and Rio Tinto.

The effects of restructuring in South Africa and beyond

The effects of restructuring include the following:

- **Far more efficient mines able to survive at far lower prices than before.** This is the critical difference made by restructuring. Had South Africa's mines still been producing with the cost structures in the industry before the restructuring, the commodity price declines of the late 1990s would have forced significantly greater closures and job losses than has eventuated. The simultaneous impacts of better work organisation, better management and lower corporate overheads have transformed the industry. Some of the most remarkable advances have been made in marginal mines now under management of smaller companies. But established mines in the large groups have also performed well. As an industry journal commented recently, "who would have believed it possible to have cash costs in the June 1999 quarter of US\$ 158/oz for a 2000 m deep mine like Tau Tona (Anglogold's Western Deeps East Mine) two years ago?" The benefits of restructuring have also been felt in other commodities, like chromium.
- **The human costs of downsizing.** While the concerted action of firms, unions and the government has staved off even more radical downsizing, the human costs of the restructuring have been staggering. Between 1988 and 1998, 300 000 thousand people, with perhaps more than a million dependents, lost their jobs. The section on labour discusses this in more detail.
- **Global South African mining companies. South Africa has spawned two very large and a number of smaller specialist mining companies that are playing a central role in the development of the mining industry around the world. The knowledge and market access and power gained through these activities rebound favourably on South African and African mining operations. The majors are discussed below.**
- **Small companies have come to the fore.** The focus of the majors on the higher yielding mines and large-scale operations they can best manage has freed up other deposits for a number of smaller entrants, some of

which are pioneering black ownership and control in the mining sector. The rise of these 'junior' mining companies is discussed below.

- **Specialised outsourcing companies thrive internationally.** The restructuring has strengthened the independent South African firms that supply inputs, machinery, knowledge products and services to the industry. As mining houses have unbundled and outsourced technical capability, these companies have gained resources and custom domestically; the knowledge and experience built up here has enabled them to operate successfully around the globe.

The rise of the juniors

The forces that have transformed the industry – new technologies, the focus on cost and restructuring – have opened up opportunities in the industry for smaller companies. These companies are now a critical part of the industry.

In South Africa, restructuring by the mining houses created an opening for a number of new small firms specialising in managing troubled and marginal properties. These firms include Durban Roodepoort Deep, Harmony Gold Mining and African Rainbow Minerals. The actions of these firms have saved many of the marginal shafts on South African gold mines. The new industry structure has also opened the door to black economic empowerment ventures.

How industry changes have spawned legions of small firms

Exploration juniors. As technology has removed some of the scale requirements of exploration, small companies with technology and geology skills – and called 'exploration juniors' – have crowded into the field, their capital provided by individual investors or mining majors. The majors – with some significant exceptions – continue to draw back on grassroots exploration. Junior exploration companies have changed the economics of the industry. Even when an exceptional discovery is made, mining houses will compete to develop it, with the result that much of the perceived profit margin is lost at the bidding stage.

Smaller coal reserves. In coal, industry participants have predicted that large coal companies will increasingly consolidate reserves into larger blocks enabling operational scale economies. Smaller operators will also benefit as smaller reserves, which may be uneconomical in the hands of the bigger companies, are released to them. This has already started to occur in South Africa with the emergence of coal miners such as the empowerment group Kuyasa.

Marginal deep-level mining specialists. In gold, the largest companies, AngloGold and Gold Fields, have focused on the higher-grade shafts, releasing a large number of more marginal shafts to nimble operators such as Harmony, African Rainbow Minerals and Durban-Roodepoort Deep. These newcomers have displayed a greater flexibility in work reorganisation, worker incentivisation and mine planning, enabling them to mine shafts profitably which were unprofitable when mined by the mining houses.

African Rainbow Mining entered the gold industry by purchasing Vaal Reefs' 1,3,4,5,6 and 7 shafts from AngloGold in January 1998, and Western Holdings' 1,2,3,4,6 and 7 shafts from Freegold in August 1998. According to African Mining, productivity has been boosted at these shafts, with the labour efficiency of in-stope employees improving 60 per cent, and grams per employee by 11 per cent.

Mining contractors. Contract mining is now being used around the world. At Portman Mining's Burton Coal Mine in the Bowen Basin, Australia, a \$57 million expansion is carried out by contractors, who are paid for their mining activities per tonne of product coal shipped to the right specification. In South Africa, both specialist and production outsourcing has gained ground in recent years. Many of these companies are fairly small. In Africa, contract miners, often South African, are active on many open-cast mines.

Black economic empowerment in South African mining

Ownership of and executive management in the mining industry, for reasons flowing directly from the country's political history since the discovery of gold on the Witwatersrand in 1886, have been concentrated in white hands.

Given the economic power of the mining houses, as well as their significance as symbolic of the old order, it was inevitable that the political changes of the 1990s would put them under pressure to change and in particular to accelerate the introduction of black capitalists and managers into the industry. As discussed elsewhere, these pressures reinforced indirectly the demands for corporate restructuring made by the international investment community.

The mining houses and companies have responded in various ways to the challenge of black economic empowerment. Without exception all have given increased emphasis to their internal career advancement programmes for individuals from disadvantaged backgrounds, through a variety of special training, recruitment and mentoring programmes, both on the mines themselves and in head offices. Given the low starting base and the mostly highly technical nature of the industry, it is widely acknowledged that transformation of the racial profile of the industry's top professional and managerial cadres will be a long process. Non-executive appointments have also been made to company boards.

With respect to ownership, the picture was initially dominated by the decision by Anglo American in 1994 to break up JCI in such a way as to facilitate black control of the gold, coal, chrome and antimony assets. The spectacular collapse in 1997 of the structure initially formed undoubtedly did harm to the concept of black economic empowerment and reinforced a trend towards less ambitious and more realistically sustainable approaches. These have included the extensive support given by Ingwe to the 100% black-owned Kuyasa Mining for establishing and operating Kolwezi Colliery; the sale by AngloGold to African Rainbow Mining of a number of operations better suited to exploitation by a smaller company with lower overheads; a strategic financial and development partnership between Amplats and the Bafokeng tribe in bringing into operation the new Rasimone platinum mine; and a number of smaller initiatives. Recently a new black diamond mining group GEM has emerged.

The drive for black economic empowerment has inevitably included a focus on the potential for new small ventures. For reasons explained elsewhere, the South African industry moved, very quickly after its founding, towards very large operations; the emergent corporate structures, as well as the expertise developed in project management, financial planning and the like, naturally evolved in ways suited to very big mines.

The 1990s have seen attempts to change this situation. A number of public sector agencies, sometimes with private sector input, have collaborated in programmes and projects to promote the small-scale sector. There has also been an engagement with the informal or artisanal mining sector, to help make their operations safer and less environmentally harmful.

This study has regrettably been unable to get a full or quantified picture of black economic empowerment developments. Despite this it is probably safe to say that quantitatively the SME component is small and realistically will remain so. However, at the corporate level, the political and psychological significance of the emergence of successful black-led mining companies – as well as of prominent black individuals playing leadership roles in the industry – cannot be overstated.

The logic of the global majors

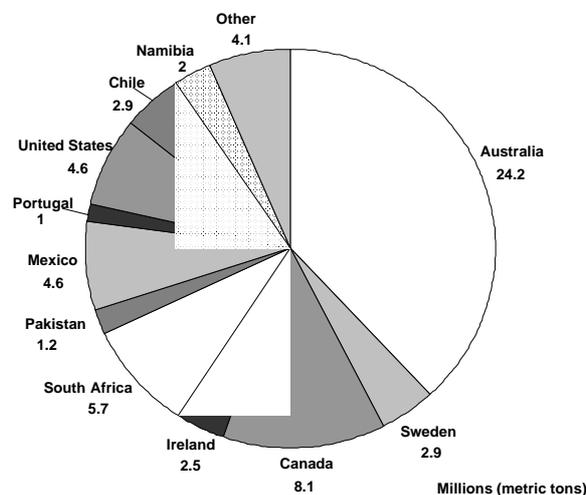
Two South African companies, Billiton and Anglo American, find themselves in the ranks of the global mining players. The world of the major is very different from the world of the small niche operator. It is an equally competitive world, one which sets a few clear prerequisites for success. Much of the restructuring the South African and foreign majors can be linked back to these requirements:

- **Global presence.** These firms gain from distinctive capabilities in finding, financing, running and marketing the output of very large deposits in their minerals of expertise. Geology determines where these deposits are. Hence the need for global operating capacity.
- **Large projects.** Given the size of these firms, they can only effectively expand their business by developing large projects. These projects may also be more profitable because they leverage infrastructure over a larger output (see below). Only firms that command very large resources can participate in such projects.
- **Living with the cycle.** The majors must be financially strong enough not only to survive the cycle, but to profit from it. Majors should ideally be in a position to purchase attractive properties at the bottom of the cycle.
- **Capital-raising prowess.** To do these things, the major is required to raise large amounts of capital. In a sense, the major is a specialist raiser of capital on the global capital markets, as these are the only mining pools of capital deep enough to fund the large projects. This is what motivated Billiton and Anglo American to shift their primary listings to the London Stock Exchange. Since its shift, Billiton has raised \$1.5 billion in equity and \$1.5 billion in debt on the global capital markets.

The need for global reach

Unlike manufacturing, miners cannot choose where to locate the production facilities; nature has made those choices. So firms that choose to exploit the economies and benefits of operating at a large scale have little choice but to go where the deposits are in which they have particular expertise. The graphic below shows the geographical dispersion of new projects (not yet producing) of the important base metal nickel. Clearly a large player would have no choice but to operate internationally, and to invest where deposits are.

Like most minerals, nickel prospects are scattered around the world



The role of infrastructure and other fixed costs

After more than two centuries of industrial age mining, new deposits are more likely to be in remote areas far from established transport routes and markets. Infrastructure to enable operations at the mine and to bring the product to market is an ever-more important fixed cost. The larger the deposit, the greater the output over which these large fixed costs can be spread, making giant deposits more profitable than smaller ones. But giant world-class deposits are few and far between. Very large companies that are in a position to take a large stake of such finds, are more effective and more profitable.

Example: Infrastructure for the Collahuasi copper mine

The Collahuasi copper mine, situated 4000 m above sea level in the Andes, has been one of the largest mining projects of the 1990s. The mine's production of more than 1,000 tonnes of copper per day will have to be transported to smelters in the Americas, Asia and Europe. At the same time the mine must be supplied with power, water, capital goods, people and supplies. The supporting infrastructure is staggering: a 150-MW generating station and 220-KV transmission line were built to power the mine. 14 wells were sunk to tap into the Coposa basin to supply the project with 600 litres of water each second. A paved road 220km long was built from the mine to the Panamerican highway. The copper concentrate is transported to the coast in slurry form via a 203km pipeline. A fibre optic cable continuously senses the internal pressure along the whole pipeline. If the pressure rises or drops, perhaps as a result of an earthquake rupture, the plant stops pumping slurry into the pipe within seconds. A port, and storage and ship loading facilities were also built for the project. Only very large companies can participate successfully in a project of this size. Anglo American has a 44 per cent stake in the mine.

Surviving the cycle: changes in steel

The steel industry increasingly relies on the electric-arc furnace (EAF), the use of which is growing at twice the rate of new blast furnace construction. The advantage of EAF production is that smaller plants can be economical and EAF plants can be operated efficiently at less than full capacity. This means that demand for iron will become more volatile, leaving iron ore miners exposed to larger price and volume fluctuations than before. Additionally, the beneficiation processes required to prepare iron ore for EAF require large capital intensive plants, further increasing the risk for suppliers of the prepared ore. Given the probable cyclical shocks, iron-ore producers supplying EAF feedstock will need to be large and have strong balance sheets.

Industry coordination and leadership

Mineral markets sometimes require industry leadership to stabilise and develop markets:

- Overinvestment and non-economic **overproduction**, which may cause large parts of the industry to run at a loss, are less likely to occur in an industry with more concentrated ownership. Such an industry would still be open to low cost start-ups, and there would be no collusion between firms.
- In metal markets where value is heavily influenced by **perception**, such as diamonds and gold, concerted industry action, involving large companies, unions and government, is required to stabilise markets to the benefit of the industry as a whole. An example is given below.
- The unbranded nature of a mineral puts it at a disadvantage relative to branded products. Advertising and other **marketing** for unbranded products tend to be too low, as much of the benefit of the marketing goes to firms who may not be paying for the advertising. This problem is alleviated in a more concentrated industry.

Industry leadership and the 1999 gold sales

Announcements of fairly modest gold sales by the IMF and the United Kingdom precipitated what seems to have been a reassessment of the future role and value of gold, and market prices plummeted from already low levels to below US\$260. Were this trend to continue to yet lower levels, vast parts of the gold industry would be rendered unprofitable, ultimately leading to closure.

The industry – in the form of some major producers, unions and the South African government – launched a campaign to support the gold market, among others by persuading central bank holders not to sell stocks, and to curtail lending activities. On 26 September 1999, the European Central Bank and the central banks of fourteen European countries announced that gold would remain an important reserve investment, that sales would be capped for the next four years, and that gold leasing would not be expanded. The immediate response was very helpful: the gold price shot up to above \$300, and gold lease rates increased markedly. Although prices have subsequently drifted lower, they seem to have stabilised at levels significantly higher than during the crisis.

Majors restructuring: the industry merger

The fundamental drivers of major profitability and success outlined above have led to a series of proposed and completed mergers among producers in the same commodities. Three of these provide instructive examples:

Proposed copper merger

In August 1999, US company Phelps Dodge launched unsolicited takeover bids for fellow copper producers Asarco and Cyprus Amax (who had previously announced a friendly merger). The merged company would annually produce 1.7 million tonnes of copper.

Corporate cost savings. Phelps Dodge estimates that the three-way merger would save cash costs of US\$200 million mainly through lower administrative costs, reduced overheads, and savings in materials and services purchasing. It is expected that these savings will be fully realised within two years after completing the merger.

Reducing cost of capital. Risks would be reduced by a geographically diversified portfolio of mines in the US, Chile and Peru.

Promoting rational market conduct. As a copper producer the company would be second in size only to Codelco, the state-owned copper producer of Chile. The company would be less prone to overinvest as a larger part of the adverse consequences would come onto its income statement.

Mooted aluminium mergers

Last August two mergers, which would dramatically increase concentration in the aluminium industry, were announced. The first proposed merger, between Alcan of Canada and European producers Pechiney and Alusuisse, would create a group, to be known as APA, with a 15.5 per cent share of Western primary aluminium production. 24 hours later, US giant Alcoa proposed a takeover of fellow US producer Reynolds. The Alcoa/Reynolds combination would achieve significant cost savings, and produce 25 per cent of Western primary aluminium output.

Corporate cost savings. The APA merger projects savings arising from the merger to be US\$600 million by 2002. Significant savings are expected from the Reynolds/Alcoa merger, given their concentration of activities in the United States.

Reducing cost of capital. The APA merger will reduce risks through geographical diversity. In the case of the Reynolds/Alcoa merger, this is absent. But notably, after the merger announcement all five stocks appreciated which directly reduced the cost of equity capital.

Promoting rational market conduct. Together, the two super-producers to come out of these mergers will have 40 per cent of Western primary aluminium production. The greater level of concentration may encourage the firms to be more rational in expansion and production level decisions, as a larger proportion of the effects of overinvestment by one of these firms would come back to depress its own margins. In both cases the firms involved have to overcome significant antitrust barriers.

Recent corporate actions in South Africa have followed the same logic as those just mentioned, and future corporate actions can be expected to do the same. We look briefly at a South African example in gold.

Goldfields/Gengold merger¹⁶

Gold Fields Ltd was formed in February 1998 by the merger of the gold interests of Gold Fields of South Africa (GFSA) and Gencor. The merged company is one of the largest gold producers in the world, with annual gold production of around 3 million oz a year from eight mines in South Africa and one in Ghana. Formed in the midst of a continuing gold price crisis, the overriding objective of the company has been cost reduction. The company aims to reduce average costs below US\$250/oz to ensure the survival and future prosperity of the company.

The merger has enabled the company to attack cost reduction on three fronts. Firstly, corporate efficiencies: The merger has enabled the companies to reduce head office costs dramatically: the pre-merger head office count of 700 has been reduced to a total head count of 125. Head office costs have now been reduced to around US\$1.70 per ounce of gold mined. Additional savings are being achieved by rationalising shared functions such as training, data processing, insurance and management. Further, certain services previously provided centrally will now be decentralised and others outsourced to specialist providers, instead of being carried as overhead. Secondly, portfolio restructuring: as of mid-1999, Gold Fields had specified four mines as non-core: Evander, St Helena, Leeudoom and Libanon. These mines would either be fixed, closed or sold off to smaller operators more suited to marginal operations. Thirdly, operational gains: the merger has brought sharper management focus on revenues and costs in operations. On the revenue side unprofitable mining will be reduced, and sweepings and mine call factors reduced. Cost reductions will focus on the better utilisation of labour. A key to reducing costs is increased blasting frequency, which can be achieved by higher education and training levels and flatter supervisory structures. In addition the merger has opened opportunities to exploit mineral rights around Beatrix and Oryx mines in the Free State, using existing shaft infrastructure.

Brave new world

Mining is a fundamentally international business, and since South Africa's re-entry into the world economy in 1994 its mining firms and operations have been subject to pressures that have been faced for a long time by foreign mining companies. The pace of adjustment has been punishing, but the prospects of the industry are much improved.

5 Mining and industrial development

The South African economy looks the way it does because of mining. Mining created the heavy engineering sector, generated the income that built South Africa's consumer industries, and financed the manufacturing sector. The needs of mining drove the development of South Africa's sophisticated capital markets and business law, and

¹⁶ Source: International Gold Mining Newsletter.

kindled an ability to handle massive and technologically complex projects. Johannesburg, one of the largest centres of production in the Southern Hemisphere, would not have existed without mining. This is of interest mostly to historians. But there is something of more immediate and pressing importance:

Using its mining activities as a base, South Africa has nurtured strongly competitive sectors providing sophisticated inputs and services to the global mining industry.

In particular, South African firms have become globally prominent in three areas:

- **Technology providers** to the global mining industry
- Providers of **knowledge-based mining services**
- **Specialist mining contractors.**

South African firms are world leaders in mining explosives, drilling equipment and abrasives, metallurgical processes and plants, and delivering intellectually based services to mines everywhere. It also has a strong regional franchise in specialist contract mining. To appreciate the opportunities in these fields, consider that, at value added of around \$1 trillion, the global mining industry is ten times the size of South Africa's economy. That implies that the global mining supplies and services business is several times larger than South Africa's entire mining sector. Among other things, these activities are the basis for a strong South African presence in a key 21st century growth industry: environment management services and systems.

Apart from scope, two factors make these industries particularly attractive to South Africa. Firstly, the knowledge and skills of these industries have made South African mining more viable, extending the lives of mining operations and rendering large projects feasible. The more dynamic the industry, the better it can support mining operations domestically and in the region.

The second attractive aspect of these industries is their source of competitive advantage: their success arises from an on-going process of improvement, adaptation and innovation that is very difficult to replicate. This allows firms to move up the value chain, increasing their value-added.

The mining industry, South Africa's most internationally vital and unsung 'cluster', has been curiously neglected by the country's industrial and educational policies. This neglect is undermining the sector's ability to grow and compete.

Before describing South Africa's presence in this field, a short excursion into how industries develop, to illuminate the growth of mining services and supplies.

The virtuous cycle of world-beating industries

Disk drives in Singapore. Memory chips in Korea. High-performance bicycles in Taiwan. High-speed printing presses in Bavaria. In all these examples a global industry is concentrated in one location, which is generally accepted as the world leader in product innovation and/or production efficiency. Often this dominance has been sustained over decades, even as technology and markets have changed, and initial factor cost advantages were eroded. In the right circumstances the advantages seem to be self-reinforcing, perpetuating and expanding the industry's dominance.

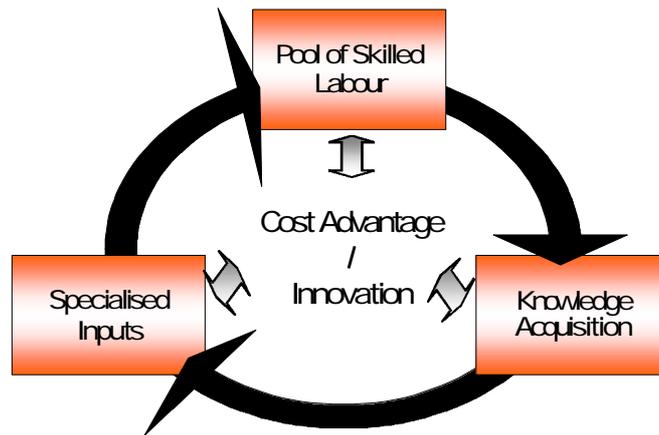
How does this dynamic work? Simply put, in the right environment, the proximity of firms creates valuable spin-offs for other firms, making a region with an existing industry a more attractive location. Chief among these spin-offs:

A deep pool of labour with the required skills

A ready, sophisticated supply of **specialised inputs** important to the industry that cannot be fully accessed remotely.

The need for **continuing knowledge acquisition by firms from other firms**. This is also known as 'technological spillover'.

The important insight is that as an industry in a certain location attracts more firms and custom, the effects themselves become stronger and more marked, benefiting and attracting yet more firms. Hence the virtuous cycle, which applies to industries whether driven by production efficiencies or product innovation.



The virtuous cycle of an industry's development

Source: Genesis Analytics

The competitive effect. All three elements – knowledge spillovers, specialised inputs and a pool of specialised skills – tend to increase the level of competition. Competition, in turn, promotes faster knowledge acquisition, a more attractive environment for labour, and demands more specialised inputs. The overall effect: increased efficiency and a higher rate of innovation.

If this sounds a bit abstract, note this description of Silicon Valley by Annalee Saxenian:

“As more firms located in the Valley they further enhanced the environment for start-ups by expanding the skilled labour pool, the capacity of shared services, and the intensity of localised communications and debate. That neatly explains why Silicon Valley has, despite its high costs, remained the preferred location for electronics start-ups.

The virtuous cycle in South African mining

Take the cluster of mining operations, technology products and knowledge services headquartered in Johannesburg. As this chapter will show, it has all the characteristics of a virtuous cycle industry. Johannesburg cannot be Silicon Valley, but it could be the Silicon Valley of mining.

Knowledge spillovers: Research at the cutting edge of technology and production advances tends to be both competitive and collaborative, making interaction and proximity an important ingredient. Firms tend to locate to a centre to tap into these networks. Relations between South Africa's mining-related firms are well suited to knowledge spillovers. For example, Johannesburg boasts a concentration of consultants, engineering companies, mining house technical departments and government bodies with deep expertise in certain areas, such as extractive metallurgy and recovery plants. Currently these communities have a critical mass: now they have to be enhanced and expanded. The dispersed industry structure in mining services described below promotes the diffusion of knowledge and technology. Increased outsourcing means that firms need to work together, learning all the while.

Specialised inputs. The larger the market for a particular specialised service, the easier it is for the suppliers of that service to specialise in it. As they become more effective, efficiencies are shared by their customers, who in turn create more demand, and so forth. Such specialisation should also make the provision of that service more effective globally. This has happened repeatedly in South African mining: note the mutually beneficial interaction between mines, on the one hand, and providers of technological inputs such as explosives, detonators, drills and mining props. There are many other examples. Note the close and repeated interaction between the providers of mining technology and services and their customers: this serves to speed the innovation process and to ensure that it addresses real needs

Deep pool of skills. South African universities have traditionally produced international quality mining engineers, geologists and metallurgists. In addition, the extent of mining activity in South Africa has offered ample experience for mining professionals, and the culture of technical excellence in mining houses further nurtured the talent pool, often bolstered by foreign talent. The break-up of the old system of employing these professionals was an important moment: will there be sufficient opportunity for them to remain based here, in a more effective industry setting, or will the talent be siphoned off to foreign countries?

From natural advantage, to virtuous cycle, to the globe

All countries wish to have virtuous cycle industries exist and flourish within their borders. South Africa's industrial policies, for example, are based on attracting this type of development, which has numerous advantages. Two are:

Firstly, virtuous cycle industries engender greater and greater value addition over time in the chosen location, which means higher economic growth, more tax revenues and higher salaries. The dramatic post-War rise (eight-fold or more) of living standards in Taiwan and Korea was the result of this process.

Secondly, due to the self-reinforcing dynamic of this process, the advantages of a existing well-functioning 'virtuous cycle' industry are difficult to replicate, far more difficult than, for example, factor cost advantages. This limits competition from rival locations.

The only problem with the development of virtuous cycle industries as a central policy objective is this: they are very difficult to start from scratch. This is so for an obvious reason: why would the pioneer industries locate to a place with no incumbent advantages? Therefore other advantages need to be in place. The classic approach in late 20th century developing country progress has been to offer irresistible factor cost advantages, mostly in the form of low labour costs and tax rates. South Africa has chosen to eschew this approach. That is what makes the greater mining cluster so valuable: it is already in full swing, having been created off the natural advantage of an extraordinary concentration of mineral deposits. Now that the limits to exploitation of some of these deposits are being reached, it is important to conserve and expand the vibrant and valuable industry that has been built around them. The solution is a prominent regional and global role for the three industries we describe below. If they do not succeed in that transition, they will slowly decline.

Technology providers to the mining industry

South Africa's mineral production base has led to technology providers that are internationally competitive in a number of areas. Some examples are discussed below, starting with: explosives, drills and abrasives, and extraction plants. A further example, the area of mine support devices, is an illustration of innovation by smaller companies. These examples show the scale and diversity of South Africa's technology skills; they also provide instances of how the technology providers have added to productivity and safety in South Africa's mines. While some of these examples are historic, the process they illustrate continues today.

Mining is now a technology-driven industry

Mining has become a high technology industry. The industry's on-going ability to produce more output at lower market prices in the face of geological difficulties has been due to relentless technological innovation. On-going technological advances have lowered the cost of finding, mining and extracting minerals.

Exploration. Exploration costs have fallen with the use of satellite images and information technology. Cost-effective and global exploration has led to deposits being found much more quickly. Once core samples are gathered and analyzed, the raw data is manipulated via computer. Geographical information systems allow a wide range of geological and other attributes to be mapped accurately at dramatically reduced cost.

Engineering design has been revolutionised through computer-aided design and engineering techniques. For example, Impala Platinum's \$60 million refinery in Springs was designed by Bateman using a novel 3D-computer model of the plant. The plant includes 1,200 pieces of mechanical equipment, 3,500 instrument loops and 5,000 individual pipelines. A further example: software now allows designers to 'enter' a planned mine in virtual reality. Users can stipulate a truck haul route, 'sit' in the cab of the truck and 'drive' it around the pit.

Day-to-day planning and rock mechanics. Computer modelling of a mine and its geological features should enable the mine planner to minimise ground instability and maximise ore recovery. In the past the equations were so complex, and calculations took so long, that this technique could not be used for daily mine planning. Advances in computer technology now make these techniques feasible for daily problem-solving. The techniques have led to reduced rockburst problems and increased ore recovery rates.

Excavation. The use of draglines has changed the face of coal mining. Abroad, technological innovation has also supported the adoption of longwall mining.

Reduction/recovery plants. Breakthroughs in biotechnology, chemistry and mechanical engineering have led to sharply more efficient extraction of minerals from the mineral-bearing rock. This in turn has changed the financial viability of projects.

Purchasing and inventory. Enterprise resource planning software allows mines to cut down on inventory and purchasing costs. Internet-based purchasing services increase the bargaining power of mines in purchasing a wide range of equipment.

Towards an integrated IT approach. Ideally, the total mining activity should be managed in an integrated way, using software that is sometimes referred to as an Integrated Resource Asset Management System. One such package "is designed to manage and optimise the quantification of the mineral resource, extraction planning and excavation – the main elements of any mining operation". The potential benefits: ready access to information, key performance indicators and a mineral balance sheet.

Explosives

The South African explosives industry has come a long way from the initial position where all technical expertise had to be imported. Nowadays South African global players like Sasol and AECI boast research laboratories that are globally competitive. They have the ability both to adapt technology and to generate new ones (such as the 'Dynagel' or 'Expan' type of explosives). Both AECI and Sasol are now global players, supplying proprietary technology explosives and detonators to mines around the globe, although Africa remains their biggest market. The history of AECI shows how a local technological capacity contributes to mining activity in South Africa.

AECI

One of the earliest supporting industries to be established on the Witwatersrand was the Nobel dynamite factory at Modderfontein, which started production in 1896. Production workers were recruited from all around Europe. This operation eventually became part of a larger South Africa explosives company, known today as AECI. With the development of the Free State gold fields, AECI became the largest manufacturing enterprise in the country. It was an industry pioneer on the equity market, and used it to raise capital for its expansion.

Product innovation. In the 1930s, AECI introduced ammonium nitrate based explosives as a substitute for nitro-glycerine. With these developments South African production moved to the forefront of explosive technology. These developments were driven by the production needs of South African gold mines. After World War II, the demands of mining at depth led to the innovative new explosive 'Dynagel' for use in damp conditions. In the 1960s the "PPAN" explosive was developed. This explosive had a better controlled blast, a longer shelf-life and better performance in damp conditions than its predecessors. AECI started fusehead production for electric detonators in 1971. It supplies detonators and initiation devices to South African mines. Like Sasol it is engaged in research on electronic detonation systems.

Although AECI was initially very dominant in the explosives sector, it currently faces stiff competition from Sasol and Omnia.

Sasol

Sasol started the production of explosives only in 1984. As an owner of various collieries, Sasol had direct experience of mining. Furthermore it was producing nitrates and was looking for ways of beneficiating these products. Since starting to produce explosives it has aggressively captured market share within South Africa, as well as expanding abroad. Sasol Mining Explosives (SMX) achieved turnover of R667 million in 1999.

SMX's strategy is based on technological innovation. Sasol has patented a process by which microspheres of gas can be incorporated into porous prill ammonium nitrates. This significantly improves the efficiency and performance of the explosives. On the basis of this technology Sasol is currently exporting explosives (more than 100 000 tons in 1997). It is also expanding its production offshore. It opened a plant in Manitoba, Canada, during 1999. Sasol also supplies detonators and initiation devices to the mining industry.

The history of mining explosives in South Africa illustrates the path followed by many mining support industries: physical proximity to South Africa's massive mining activities allowed profitable production of standard goods. Eventually the proximity translated into more knowledge and a closer working relationship, kicking off a cycle of innovation that was of great benefit to the industry. The virtuous effects of a pool of labour, closeness to the customer and technological spillovers led to innovation and global sales.

Drills and abrasives

Drills and drill bits are vital to the mining industry. The largest supplier of pneumatic drills in the world is Boart Longyear, a South African group. This group has also been at the forefront of drill bit technology, grinding and abrasives. It also provides services in the form of contract drilling or exploration drilling to the mining industry.

Boart Longyear

Boart is a truly global business, consisting of over 60 companies located in 38 countries on five continents, selling services to about 136 countries. It makes most of its revenue abroad and its South African companies have a significant export component. Turnover in 1997 was R3.6 billion with headline earnings of R161 million. It has a staff complement of over 8,500.

Boart Longyear is a story about how particular relationships within the mining industry can hone competencies on which an international market position can be built. In the early part of the century, boart – low-grade industrial diamonds – had no defined use. Once the company had devised a way in which these stones could be used for drilling, they replaced the larger, more expensive diamonds that had limited diamond drilling to rare specialist uses.

This innovation had a significant effect on mining. One of the first successful demonstrations of the efficacy of the diamond drills came with the development of the Free State gold fields. The development work could proceed much faster with the new drills than with the conventional ones. This technical advance made possible the unprecedented speed with which the great Free State mines came into production.

This placed Boart at the forefront of drilling operations right around the world, and Boart was established as a leading supplier of drill bits. The company developed an adjacent business as a supplier of drilling services. The experience gained through contract drilling allowed Boart to bring another innovation – tungsten carbide drill steels – to the market.

The key to Boart's emergence in this period lies in three interlocking features. Firstly, Boart's investment in research and development left it well placed to take advantage of the opportunity of global mining development. Secondly, its ability to prove its technology led to market demand. Finally, the particular nature of the client-supplier relationship paved the way for entry into foreign markets.

Recovery plants

In recovery plants mechanical chemical and biological methods are used to extract the desired mineral from the rock material and other minerals within which it is embedded. Recovery plant technology is a central driver of change in mining. More effective recovery of minerals has enabled a large number of projects, that would otherwise not have been feasible, to go ahead. It is important for mining in South Africa and Africa to be in close contact with this industry.

Innovation in this field is essentially a matter of technological change. South Africa continues to be a world leader in recovery technology. Our first example is of a technology developed in South Africa; the second example reports on a new technology, which was developed in Canada, but is being commercialised by a South African company.

Example: the BIOX process

Bacteria are now used to assist the extraction of gold from certain types of gold-bearing rock. This process, known as bioleaching, was pioneering by South African firm Gencor's BIOX process. South African firms Mintek and Bateman are leading consultants in this field. Bioleaching is now used at mines around the world to raise gold yields and increase project feasibility.

Microwave recovery techniques

In September 1999, South African mining engineering firm Bateman announced the commercial application of a “revolutionary new process” (Mining Journal) which uses microwaves to release gold, copper and other metals from refractory and hard-to-recover ores. The treatment is said to require less capital, have lower operating costs and be more effective than the BIOX bio-oxidation process. Bateman claims that “the microwave technology can make commercially viable those mineral resources which have previously been rejected as uneconomic because of the difficulties of extraction.”

There are numerous examples of the benefits to South African mining operations from progress in recovery technology. Many of the advances are incremental in nature. A recent example is state-sponsored Mintek’s Floatstar flotation system, which has been installed in platinum, gold and base metals operations, and is said to improve recoveries by 0.5% to 1.3%. An example of how technology can make large projects feasible is offered by Gamsberg, the proposed \$970 million zinc project in the Northern Cape province. A problem has been the high manganese content of ore in the deposit. New recovery technology developed by Anglo American and Mintek to deal with the high manganese content may help to render the project feasible. Gamsberg is expected to produce about 200,000 t of zinc annually at full capacity.

South African expertise in recovery plants extends beyond developing the technology. Firms such as Bateman and LTA design, build, commission and sometimes operate recovery plants. LTA is particularly active in Africa.

Bateman is a world leader in the provision of diamond processing plants and has designed, engineered, procured and managed the construction of processing plants on some of the world’s largest diamond mines. Bateman is also the leading supplier of modular diamond processes, and have delivered 230 such plants in the last 30 years.

Mining props

Mining supports are a critical safety, production and cost issue in underground mining. The closer to the stope-face, and hence the blast, the supports are, the higher the stakes. This example is interesting. It shows how a small company deeply linked into the rich mining environment can bring an innovative solution to market. It also illustrates Silicon Valley-like cooperation between small South African mining support firms to take advantage of an attractive opportunity. Above all, it shows the ‘virtuous cycle’ at work: the extent of underground mining operations in South Africa made such a specialised product feasible; in return, this product is making underground mining safer and more productive at a time when operations are under great pressure.

Example: the ‘disc prop’ mine support

Both conventional means of support close to the stope face have drawbacks: timber supports, the traditional approach, occasionally fail, and are particularly vulnerable when the blast occurs. Because of this, hydraulic props able to withstand the blast have been preferred at the stope face. But hydraulic props are expensive, which means that they have to be removed after each blast, a time-consuming and not entirely risk-free process.

The disc prop, an innovation from a consortium of small companies, solves these problems and brings with it surprisingly large efficiency gains. The prop, developed by Strocum and West Steel Engineering, prevents certain catastrophic failures and is not blown out of position by blasting. It is also much cheaper than the hydraulic props, so that it can be left in place. This allows the rate of face advance to increase significantly.

The prop now has about 20 per cent of the market. Three small firms are involved. Strocum, employing 54, manufactures the prop, West Steel Engineering, with 65 employees, makes an important component, and Johann Greyling Mining Consultancy, with 15 employees, supervises its installation on the mine, provides customer support and markets the product.

The key to the development of the prop was not a laboratory breakthrough, but an intimate knowledge of underground mining.

Knowledge-based mining services

Crisis has transformed delivery of specialist services to South African mines. In the past, mining houses delivered these services to their member companies, who were essentially captive clients of the centre. Today, the industry is decentralised and characterised by outsourcing, specialisation and, increasingly, globalisation.

Low metal prices, fewer new mines and investor criticism prompted mining houses to abolish captive client relationships and to review their internal technical capacity. The talent thus released has spawned a host of new providers of specialist services. For independent engineering and consulting firms, the changes brought a whole new client base. The changes have also benefited large South African specialist mining consultancies, which have emerged as global knowledge-based firms servicing mining operations around the world.

To understand these changes, one has to revisit the rationale for centralised services.

The mining house system of service delivery

The box below lists some of the specialist knowledge areas critical to the success of a mining enterprise. These services all share something: economies of scale. They are far cheaper to provide centrally to a large number of operations than have each operation provide its own. These were the options during the first 90 years of South African mining, and clearly centralised provision was the suitable option.

In fact, the mining house concept developed in part around the need to provide technology and expertise cheaply. The houses would bring out or develop the needed technology and capacity, and then apply it at all its operating mines. For most of the industry's history there were no outside providers. And it was natural that mining houses would charge a fee for providing expertise not to be found elsewhere. In time deep technological capacity developed within the mining houses.

Science	Engineering	Management
Geology	Geotechnical	Production systems
Metallurgy	Civil	Information systems
Bio/environmental	Mechanical	Finance
	Electrical	Risk management

Critical specialist knowledge areas in mining

As decades went by, weaknesses in this system became evident. The operating company was a captive client of the mining house, unable to source professional services freely. In addition, as the controlling shareholder, the mining house both specified the level of services required and then provided them at a profit. This contributed to a culture of overengineering: mining installations worked very well, but absorbed more capital than they needed. (At its core, the conflict of interest here occurred because the mining house and the mine did not have identical sets of shareholders. This was not just a South African phenomenon: large mining groups like BHP exhibited similar inefficiencies.)

By the early 1990s this system was under increasing pressure. Firstly, a decade of falling gold prices, together with the advanced phase of gold exploitation in South Africa, meant that there were few new projects. At the same time, growing investor disenchantment with poor returns of South African mines questioned the management fee and captive client structure. This was encouraged by the trend among some foreign mining companies of eliminating technical capabilities at the centre. By the late-1990s, the houses had abolished management fees and the captive provision of services. At the same time, the trend of taking full ownership of operating subsidiaries removed the conflict of interest of the old system. What has replaced it is something radically different.

The new approach

With management fees and captive client relationships gone, all the mining houses downscaled their central technical capacity. Some resources were reassigned to operations. Other services were bought in from external service providers, and surplus staff were let go. Within these outlines, the houses adopted quite different approaches. Billiton's surgery has been the most radical. In the belief that technology and specialist services can be bought in, most of its central technical capability was spun off. A 'honed-down service department' remains to interface with suppliers of technical services.

In contrast, **Anglo American** has decided to keep a strong technical capacity at the centre. It believes this capacity is needed for the proper evaluation of projects, as many of the risks in mining are technical. The company has also decided to locate its centre of global technical competence in Johannesburg. But it, too, has downscaled its technical capacity and has increased outsourcing. Anglo outsources routine work, and specialist services and/or technology.

Independent providers of knowledge-based services benefitted tremendously from the increase in outsourcing. Further, as the mining houses downsized, the freed technical capacity ended up in small consultancies, large international consultancies, and the growing South African consultancies with international activities. The main types of firms in the industry are:

The **global South African mining consulting firms**. One is Bateman, with offices in Africa, the Americas, Australia, Europe and the Middle East. SRK, profiled below, serves virtually all the large mining groups in the world from 22 offices on five continents.

Other **large South African providers** increasingly operate in Africa and beyond. Examples include BKS and LTA Process.

Smaller South African consulting firms with deep and narrow specialisations. These firms range from individuals selling their services back to their former employers, to medium-sized companies that operate internationally.

Foreign consultancies now active in South Africa. Canadian firm Hatch has absorbed a number of former Billiton staff, while Australian firm Snowden Associates have entered a joint venture with CSIR Miningtek.

State-supported research bodies, such as Mintek.

The remaining mining house technical departments and **laboratories** in Anglo American and Anglovaal.

Interestingly, the emerging structure of the specialised mining services industry closely matches the industry structure often seen in other highly innovative knowledge industries during the last 30 years, such as microprocessors, software and Internet businesses. The innovation-friendly structure looks like this: a mixture of large and very small firms, with numerous new entrants and foreign participants. Many of these firms specialise in only one link in the value chain, which means that they often work together with other firms in the industry. This results in an interesting industry culture combining competition with regular cooperation. Due to the nature of the service rendered, suppliers and future customers may also work closely together during product development. This allows for immediate feedback and interaction. This structure is effective at speeding innovation and the diffusion of knowledge.

Apart from heightened innovation, the new industry structure has three advantages:

- Instead of being limited to the one internal source of technical input, mining houses and operations **can now choose** from competing service providers. Choice commonly leads to lower prices and, over time, more suitable services. As one senior industry participant put it, “once the [mining houses] have moved to this model it is very unlikely that they would ever revert back to the old one.”
- The speed of diffusion and adoption of new technologies increases. Technological breakthroughs are **now available to the entire industry**. Consultants also build up a more diverse experience base.
- The general availability of capacities previously the preserve of the mining houses **lowers barriers to new entrants** into mining. Virtually every step of the mining process can now be outsourced.

Independent expertise lowers technical barriers to black empowerment entrants

A black empowerment company with no previous mining experience is successfully managing a number of deep-level shafts. Important geotechnical functions have been outsourced to an independent consulting firm with extensive experience in rock mechanics.

The same firm is providing technical expertise and services to small mining entrepreneurs in the Steelpoort area.

South Africa's global service providers

South African firms have flourished in the new industry environment, buoyed by the market opportunities offered by the restructured mining houses. The most prominent firms have in a short time become entirely global, which is the appropriate scale of operation for high-level intellectual services. SRK, which pioneered the global route for mining consultants based in South Africa, is profiled below.

SRK Consulting

SRK started as a three-man mining consultancy in Johannesburg over 25 years ago, specialising in soil/rock mechanics and tailings disposal. Today SRK is a pre-eminent global consulting company in exploration, mining, the environment, water and geomechanics. The firm has over 500 consulting engineers and scientists working on five continents. Clients include the world's major mining companies, governments and global banks. The firm has worked on projects in sixty countries. High-profile projects include the Lesotho Highlands Water Project, Chuquibambilla in Chile, the world's largest copper mine, Bodaibo in northern Siberia, possibly the largest unmined gold deposit on earth, and the privatisation of British Coal. The firm has a large and growing non-mining consulting portfolio in its areas of speciality like geotechnics and environmental management.

According to co-founder Dr Oskar Steffen, SRK's approach is characterised by (1) the belief that the most important stage of the development of a mining project is the conceptual stage; (2) a special focus on risk assessment; (3) a high hiring bar, necessitating offering employees global opportunities; and (4) offering to mines an end-to-end consultancy from exploration through to mine closure.

How it started. When SRK was started in January 1974, mining houses still relied almost exclusively on their internal expertise. SRK started off by exploiting niches considered non-core by the mining houses at the time, such as open-pit mining, rock mechanics and tailings disposal.

International expansion. As South African mining professionals and firms worked around the globe, their natural inclination was to retain the same firms they had experience of in South Africa. This factor was very important in the international acceptance and growth of SRK. Their large North American practice was kicked off by such an invitation in the mid-1970s. SRK benefited indirectly from the good international image of the SA technical mining fraternity. During the 1980s they expanded to Latin America and Australia, and later to Europe.

The logic of going global. According to senior SRK executives, a global profile is necessary to (1) attract the best talent in the international industry to work for the firm; (2) to access technology worldwide and spread it within the company; and (3) to have the capacity to field teams with the right experience and skills. South Africa still has the largest concentration of professionals: at any one time around one-third of the South African complement are on international assignment.

Specialised contractors

A similar process of internal restructuring and external focus has played itself out in South Africa's specialised contracting industry. Companies specialise in doing cementation, shaft sinking, development work, removing overburden and contract mining. In many cases, these processes are fairly standard, but best performed by teams and firms that specialise in them. This makes for a high degree of competition. Contractors have made impressive gains in the African mining market and beyond. In part they followed the expansion of the South African mining companies, but they have also gained contacts from other mine-owners. Areas of operation include shaft sinking, drilling and open-cast mining.

Shaft sinking and contract drilling: examples

Cementation Mining started by specialising in the cementation of shafts and tunnels, and later expanded to shaft sinking and development work. The processes involved are now fairly standard and hence there is fairly vigorous competition from other contractors. These include Shaft Sinkers, RUC and Boart Longyear. Some aspects of the process might be proprietary. Shaft Sinkers, for example, produce a particular kind of fibre which is added to the shotcrete and which they export. Otherwise competition tends to be mainly on the service provided in relation to the cost. Contractors often provide their own capital equipment, allowing the mine to avoid those expenditures.

Contracting firms have entered foreign markets to varying degrees. RUC markets itself aggressively as a global player, and has in the last six years undertaken projects in Australia, Indonesia, Philippines, Zambia, Zimbabwe, Lesotho and Ghana. Some of these are civil

engineering contracts, such as the tunnelling for the Katse Dam in Lesotho. Shaft Sinkers also has international operations. Its sphere of operations has included Laos, Indonesia, China and Tanzania. Recently it won a competitive tender for a contract in Switzerland. International business contributes roughly 15 per cent to Shaft Sinkers' turnover. Virtually all of it is of a civil engineering nature.

Open-cast contract mining: example

LTA is one of the largest open cast contract miners in Southern Africa, with contracts in South Africa, Zimbabwe, Ghana, Tanzania, Mali, Guinea and Namibia. The contract commonly works in the following way. The mine conducts the mine planning. The contractor removes the overburden, extracts the ore, stockpiles it and delivers it at a specified rate per hour to a beneficiation plant. The contracts extend for 2-5 years, and may require the contractor to provide equipment to the value of \$10-30 million. Management is usually South African. Training is provided to local personnel, in this way spreading mining know-how. The company has worked for South African, Canadian, Australian and Ghanaian mining companies. Its biggest competition is from other South African contractors and Australian contractors active in Africa. Significant benefits accrue to South Africa if the contractor is South African. The profits are repatriated to South Africa. Spares and consumables tend to be purchased from South Africa.

Africa: giant market, mutual benefit

South Africa's mining services and supplies firms are expanding rapidly into Africa and in certain areas hold dominant market shares. Mining support firms are particularly competitive in Southern Africa, for which Johannesburg has become an important supply sourcing centre. South African firms are also active in West and East Africa.

In this way much of the expenditure of South African mining companies on mining projects in Africa flows back to South Africa as services, goods and expertise are purchased from South African firms. Two examples, copper in Zambia and diamonds in Botswana, illustrate this dramatically:

Zambian copper: Konkola Deep will generate R13 billion of business for SA

Anglo American, having obtained control over the Konkola copper mine in Zambia's copper belt, has launched a project to expand Konkola to a large underground copper mine. The project is intended to produce copper for 30 years, and the development period is seven years. \$800 million will be spent on refurbishing and extending Konkola and adjacent properties. What are the benefits to South Africa?

Expansion investment at Konkola of \$523 million. The project managers have calculated that more than half of the project cost of \$523 million, or around \$300 million (**R1.87 billion**), will be spent in South Africa on *purely South African goods and services* such as mining equipment (imported equipment not included), engineering services, consumables, management services and design.

Refurbishment of \$277 million at Konkola and adjacent properties. Although an exercise has not been done to the same detail as for the expansion, the project managers' conservative estimate of the expenditure on South Africa goods and services during refurbishment is a further \$158 million (or **R971 million**).

Operating costs: Over the 30 years of operation, costs, including the payroll, will total \$7 billion. The project managers' conservative estimate is that 25 per cent of operating costs, or a total of \$1.75 billion, or **R10.7 billion** will be spent on South African goods and services. The money will be spent on consumables and capital equipment such as steel piping, crushers, pumps, electrical switching gear and electrical cabling.

Botswana Diamonds: \$400 million Orapa expansion

Orapa was the first major diamond mine in Botswana and at 117ha remains the second largest diamond mine in the world by surface area. A major expansion, called Orapa 2000, will double its capacity from six to twelve million carats a year, with an opencast life of 30 years, with another 25 years with subsequent underground expansion.

The expansion, which is nearing completion, will cost \$411 million. It will include the installation of a new primary crusher, the introduction of scrubbers, construction of a new, two-stage dense media plant, a completely automated recovery plant and major additions to the haulage fleet. The project has involved 550,000 m² of earthworks, 171km of pipework, 140,000 t concrete and 13,000 t steel. At the peak building phase, 3,250 contractors were working on site. The expansion may make Orapa the lowest-cost diamond producer in the world, will expand the mine's life and will save water, a precious resource in northern Botswana.

The benefits flow in both directions. Africa's mines have benefited enormously from technological inputs from South Africa and elsewhere. Technology has allowed some African projects to become feasible. There are advantages to having a centre of mining technology in the region: this ensures that technological expertise is applied to the region's problems. Some examples of this follow:

Technology is expanding diamond operations in Botswana

The consistent updating of technology and management techniques has been a feature of Jwaneng mine. Jwaneng is the largest diamond mine in Botswana, responsible for half the country's export earnings and with an annual production of 12,5 million carats a year. Technological and managerial improvements have borne dramatic results: between 1993 and 1998, the mine more than doubled its tonnage mined of diamond-bearing rock, with eight per cent fewer people and an almost halving of mine working costs per tonne. Carats recovered increased by 48 per cent.

Currently, the recovery plant and sorting facilities are being replaced at a cost of \$78 million, much of it spent on South African technology developed by De Beers. The mine is installing in its sorting house four single particle laser sorters that will examine every piece of rock and diamond individually and select the diamonds.

Example: a turnaround at Zimbabwe's Shamva Gold Mine

Zimbabwe's Shamva Gold Mine has experienced significantly increased efficiencies from the use of various software ore mapping and mine planning tools. These tools have enabled the mine to reduce its active mining area by half and have led to reduced operating costs and increased productivity. Mill feed grades have improved by 30 per cent, and the mine call factor from 78 per cent to 98 per cent.

Example: mobile gold processing plants for small-scale mines

South African firm Bateman Process Engineering has designed and now markets self-contained, fully operational, mobile gold processing plants. These robust and cost effective units are aimed at gold recovery from alluvial claims of small scale mining operators in East and West Africa.

Example: heap leach recovery make low grade gold deposits pay

The heap leach process specialises in the profitable recovery of gold at ultra low grades not economically recoverable by other processes. The process, which has been installed in a R65 million contract by South African firm Senet at the Siguiri Mine, can profitably recover gold with a grade as low as 0,7 g/t.

Example: turnaround at Tanzania's Williamson Mine

Two 100 tonnes per hour low-cost modular dense separating plants designed, built and installed by Johannesburg-based consulting firm Dowding Reynard and Associates, were installed in 1995 and have tripled production at the privatised mine.

Building on an existing base

The 'virtuous cycle' dynamic of industrial development is by no means inevitable. While it builds on existing strengths, the process requires very special circumstances in which to flourish. These circumstances depend on the behaviour of individual firms and industry bodies, but also on the contribution of government.

In particular, South Africa's knowledge-based mining concerns depend on access to the right kind of human capital. These sectors want to tap into particular knowledge pools. They need research and development facilities as well as the kind of flexible, highly skilled labour force that will enable them to produce high quality, novel goods on initially short production runs. This kind of production is most likely to exhibit strong increasing returns and will therefore be particularly valuable in building an internationally competitive mining and mining services and supplies sector in South Africa. Were a strong research base not maintained, and the supply of high-quality graduates to dry up, the competitiveness of the sector would drain away over time. As a senior industry leader said about the prognosis for technology exports in the mining sector:

"Technology exports are an opportunity, but it is less certain that South Africa has the support from the state in terms of university programmes, people and research to maintain its technological lead. In the absence of that it is very difficult to match the skills pools in the leading technological centres."

Industry views of the state of research and teaching are of concern: the view is that universities are "under great threat" in the mining-related disciplines. In the past there was a strong research element, but that has dwindled. South Africa's best academics in mining-related fields are being lured to Australia and Canada. In response, the industry has formed the Minerals Educational Trust Fund. The fund tries to cover, on average, about 30 per cent of the gap between salaries in academia and the private sector. There is a budget of R8 million, levied from the mining groups on a basis of R500 per qualified graduate in each group's employment. But it is feared that this will not be enough unless the state contributes more strongly.

State-supported research centres continue to play a critical role, such as Mintek and the CSIR. A senior research executive in the mining industry comments that "Mintek and the CSIR have contributed greatly to the fund of technical knowledge in the industry, and it would be very damaging if they were to reduce in stature." These centres have become all the more important given the abolition of research activities in many large mining companies abroad, and in some South African mining houses.

Private research laboratories continue to be important. Anglo American have decided to build up the internal research capability and that that capability will be in South Africa. They will also build substantial pilot plants to enable research to continue. For next year, the intended budget is R40 million, with a staff of 90 people. Half of the budget will be spent on research directed by the laboratory itself. After the operational splitting-off of Anglogold, the focus has turned to base metals. The main disciplines are analytical chemistry, mineralogy and extractive metallurgy.

Mining's downstream linkages

Our discussion of mining's downstream linkages – also sometimes referred to as beneficiation – focuses on three large and dynamic sectors:

The electricity generating sector. Transforming low-grade coal into electrical power that is among the cheapest in the world is the most important form of mineral beneficiation in South Africa. It enables the provision of electricity to a large and growing part of the population; it also creates a factor cost advantage that is important for large export industries such as smelting.

Metals smelting and processing. South Africa's competitiveness in these activities, helped by low power costs, has in turn made the country's considerable base metal deposits more attractive. The beneficiation of chrome, manganese and vanadium is important in this respect.

Petrochemicals and plastics. Sasol's fuel-from-coal activities also produce basic chemical feedstocks that are among the cheapest in the world. The feedstocks have, among other things, allowed internationally competitive polymer and alpha-olefins industries to be established in South Africa.

Mining and the electrical power industry

The development of the power sector and mining are intertwined: electrical power is not only a downstream product of mining, but it developed in scale and sophistication through the large power needs of the mining sector.

Mining as a pioneer of electrical power. The mines were responsible for some of the first power generation attempts. The Victoria Falls and Transvaal Power Company (VFP) pioneered the generation of electricity from the coal deposits of the Transvaal to supply the power-hungry mines. By 1915 four thermal power stations had a total capacity of more than 160 megawatts. In 1923 the Electricity Supply Commission (Escom/Eskom) was established. For the next twenty-five years, however, it coexisted and co-operated with the VFP. Several new power stations opened in this period were financed by Eskom but run by the VFP, before the organisation was absorbed into Eskom. The immediate post-war period saw a doubling of installed capacity as the new Free State gold fields made heavy demands on capacity. Today, mines consume 12.5 per cent of total electricity generated in South Africa.

Contribution to the economy. 92 per cent of South Africa's electrical power is generated using coal. The power generating process adds value of R13 billion to the coal and other inputs used. The value added accrues to the economy as a whole and contributes a hefty two per cent to GDP. As such one might consider electricity a major beneficiation exercise - taking low-grade coal and adding value to it.

SECTOR	R million	% of Output
Agriculture	15.73	0.1%
Coal Mining	1,488.70	6.2%
Manufacturing	1,166.30	4.9%
Electricity	5,398.26	22.7%
Civil Engineering and Other Construction	824.73	3.5%
Transport and Storage	712.94	3.0%
Total Intermediate Input	10,671.77	44.8%
Remuneration of Employees	3,589.05	15.1%
Gross Operating Surplus	9,405.03	39.5%
Net Indirect Taxes	156.17	0.7%
Total Input	23,822.01	

Inputs into the electricity sector

Source: Statistics South Africa

Cheap electricity as an industrial development tool. Eskom claims to be the lowest cost producer of electricity in the world. And according to international surveys (the latest one quoted was conducted in 1997) South Africans enjoy the cheapest electricity in the world. Given the general availability of generating technology, a part of the cost advantage must accrue from the good fortune of large coal deposits and the ability to place power plants right next to them.

Eskom has set up Industrelek, a service intended to help industries benefit from South Africa's low energy prices. The service includes flexible tariff options. According to Eskom the sectors most likely to benefit from Industrelek's services are mining, chemicals, timber, paper, textile and leather, metal, food and beverages, and non-metallic minerals.

The externalities that are attached to the coal based power system, particularly in the form of gas emissions, should also be noted.

Electricity as a social development tool. Eskom's RDP commitment was electrifying 1,750,000 homes by the end of 1999. At the end of 1998 a cumulative total of 1,451,503 homes had been electrified since January 1994, and the rate of connection was running at almost 300,000 homes per year. Eskom also undertook to contribute R50 million

per annum to the electrification of schools and clinics and other community resources. These activities are being funded from Eskom's balance sheet, an indication of the benefits of the particular minerals beneficiation process Eskom is engaged in.

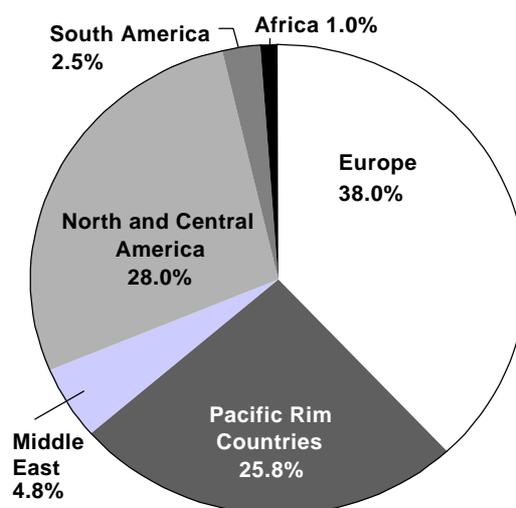
Mineral	1st stage	2nd stage
Diamonds	100%	52%
Iron ore	85%	29%
Manganese	51%	19%
Chrome	84%	5%
Platinum	100%	2%
Gold	100%	1%

Beneficiation levels in South Africa (proportion of mineral production)*

Source: Various companies

Metal processing

Helped by South Africa's cheap power, metals know-how and good base metals deposits, the metals processing industry is attracting large capital investments. Virtually all the additional capacity is for export purposes. In 1997, processed metal products to the value of R13 billion were exported, compared to R3 billion sold domestically. As the pie chart below shows, South Africa has an unusually diverse international market for these exports.



Export destinations for SA's processed minerals

Source: Minerals Bureau

Ferrochrome: SA's profitable share of the global stainless steel boom

Half of world chrome production is mined in South Africa. The country's chrome industry is becoming increasingly vertically integrated, as more chrome ore is converted into ferrochrome and chrome-based chemicals. Mining

* The definitions of the beneficiation stages (first and then second) are as follows: Chrome – inclusion of ore in ferrochrome and then inclusion in steel; Diamonds – sorting and valuing and then cutting and polishing; Gold – refining and then inclusion in jewellery; Iron ore – refining and then inclusion in steel; Manganese – inclusion of ore in ferromanganese and then inclusion in steel; Platinum – refining and then inclusion in jewellery or autocatalysts. The figures are for 1998 and in some cases for the 1998 financial year. For chrome, gold and iron ore 100% of the market was covered. For diamonds 98% of the market was covered, for manganese 99% and for platinum 90% of the market was covered.

Journal reports that out of almost 7 million t of chrome ore produced in South Africa in 1998, only 900,000 t of unbeneficiated ore was exported. Exports of the beneficiated product, ferrochrome, achieved a record level of 2.1 million t, satisfying 40 per cent of world demand.

What makes this trend particularly promising is that ferrochrome is a large and growing industry. Ferrochrome is used to make steel and, according to the Journal, makes up around 23 per cent of the value of stainless steel. Therefore the ferrochrome industry is about a quarter of the size of the world stainless steel industry. Stainless steel is in a long-term growth phase: it is called the 'prosperity metal' due to the inclination of societies to consume more of it as they grow wealthier. Worldwide consumption has grown by 5.9 per cent per year over the last six years.

But, while stainless steel is difficult to export profitably because of widespread trade protection and intense competition in the spot export market, South Africa has powerful competitive advantages in ferrochrome. More than 60 per cent of world chrome reserves are in South Africa. In addition, with electricity forming about a quarter of the cost of producing ferrochrome, South Africa's cheap power (see discussion of Eskom above) is very attractive. It is estimated that the world will require a further 150,000-200,000 t/y of ferrochrome capacity every year as stainless steel demand grows. The South African ferrochrome industry is well placed to benefit from this expansion.

South African activity and investment prospects

Both chrome ore mining and ferrochrome production in South Africa are dominated by two companies, Swiss-owned Xstrata and Samancor, a joint venture between Billiton and Anglo American. Xstrata has 14 furnaces and two retreatment plants, acquired since 1994, with additional capacity built at a cost of R400 million in 1997. The company's philosophy is to ensure that the ferrochrome plants are close to its mines, as transport costs are minimised in this way. As in mining generally, stringent cost control is the key to success in chrome. Samancor has 18 furnaces, and is currently carrying out a feasibility study of a new greenfields plant to be located close to one of the company's mines, again for transport cost reasons. Together the two companies produce around 2 million t of ferrochrome annually.

A third, smaller producer, Hernic (140,000 t/y), is adding 120,000 t/y ferrochrome capacity with advance smelting technology at a cost in excess of R800 million. A fourth company, Assmang, is spending R190 million on a 25,000t/y capacity expansion, while studying the feasibility of a further 100,000 t/y expansion.

Beneficiation of manganese and vanadium

Manganese. South Africa has more than 80 per cent of world manganese reserves and around 92 per cent of high-grade contained manganese resources in the world. Manganese alloys are used in making various kinds of steel, and manganese alloy production capacity to some extent reflects the geographical dispersion of steelmaking around the world.

As with steel internationally, the beneficiation of manganese has been marked by government interference, distorting the production locations and capacities of manganese smelters. This has been most pronounced in the ex-Soviet republics and in China, where uneconomic production continued throughout 1999. Moves to rationalise production in these countries, as well as the sobering effect of the Asian crisis on government sponsorship of investment, may put the industry on a rational basis. Were that to happen, South Africa would be well placed to expand its activities in this beneficiation phase of manganese. South Africa's ferrochrome production advantages also apply here: transport costs and competitive electricity prices.

Vanadium. A similar story, but on a smaller scale, can be told about vanadium. Xstrata South Africa's vanadium operation at Rhovan is to start converting oxide into ferro from 2000, according to the Metal Bulletin. The news is likely "to unnerve converters in the USA, Europe and Asia as South African producers continue to move downstream and as a result will have less vanadium pentoxide available to supply overseas operations". Xstrata plans to commission the 6,000 t/y ferro-vanadium plant at its Vantech plant at Rhovan in the first quarter of 2000. "The driving force for this is that there is no point converting anywhere else in the world," Piet Nienaber, chairman of Xstrata South Africa is quoted as saying.

Beneficiation process	% of production beneficiated	% of exports beneficiated
Antimony concentrate to antimony trioxide	65	80
Chrome ore to chromium alloys	57	71
Copper concentrate to copper metal	92	89
Iron ore to iron and steel	30	15
Manganese ore to manganese metal and alloys	49	43
Nickel matte to nickel metal and sulphate	100	100
Phosphate concentrate to phosphoric acid and phosphatic fertilisers	52	37
Zinc concentrate to zinc metal	100	100

Extent of beneficiation

Source: Minerals Bureau

How far to beneficiate?

Beneficiation activity is in an expansion phase in South Africa. Apart from electricity (Eskom), petrochemicals (Sasol) and steel (Iskor and Columbus), most beneficiation in South Africa takes the form of smelting, particularly for the production of ferro-alloys. But why is there not more? It turns out that beneficiation is not always an efficient use of South Africa's resources. A mine has a number of things to consider before deciding to beneficiate:

Firstly, by beneficiating some of its output, a mine competes with its customers.

Secondly, the marketing and distribution of a beneficiated product require new skills and knowledge. Commonly the beneficiated product needs to be sold to a large number of geographically dispersed firms new to the mine. These firms require small and frequent orders, and may need their orders customised or tailored. This is different from selling the mining output, which often has a central market and is a standard, commoditised product.

Thirdly, success in the new activity may require process expertise or factor endowments (cheap labour, say) not necessarily readily available to the mining company.

Matters of scale and transport costs are critical. A product with fairly high transport costs and/or a low ceiling of optimal scale can often profitably be beneficiated for the local market. An example of that is the manufacture of copper rods at Palaborwa. But competing for the export market is quite different: firstly, marketing becomes more difficult and expensive; secondly, cost and efficiency become critical and in particular labour costs, transport costs and tax rates. There is no direct reason for a producer of the mineral to have an overwhelming advantage in any of these, bar in some circumstances transport costs.

For example, in the proposed Gamsberg zinc project, the optimal place for the smelter might be right next to the mine. But equally favourable coastal settings may be found elsewhere. And South Africa's transport costs will not necessarily outweigh the other cost factors.

Fuel and chemicals

The role of the mining industry in developing a chemicals sector (in particular explosives) was noted above. The development of Sasol in that regard was touched upon. Nevertheless the role of Sasol in beneficiating coal deserves additional mention, since it has put a South African producer at the forefront of particular kinds of technology. The Fischer-Tropsch conversion process which underpins the oil from coal process has been adapted by Sasol to be applicable also in the conversion of gas to certain higher-grade fuels (in particular diesel). The "Sasol Slurry Phase Distillate Process" has been patented and is being marketed extensively abroad. Since natural gas is much more widespread than low-grade coal, this technology is attracting international interest. A number of international joint

ventures on the basis of this process have been launched. Sasol synthol technology allows the conversion of synthesis gas into gasoline and light olefins. Further, these processes have allowed one of the world's lowest cost polymer businesses, Polifin, to be established in South Africa. Polifin produces intermediate plastics.

The impact of all of this is notable. Sasol's turnover in 1999 was R19 billion, of which R9 billion were in chemicals. Exports in 1999 were R 5 000 million, making up roughly one quarter of total turnover. Sasol currently exports to 80 countries world wide, with a compounded growth rate in exports since 1993 of 62 per cent per annum. In 1998 it had 8 overseas production facilities and employed a total of 24 000 people world wide.

SELECTED SECTORS	COAL MINING			GOLD MINING			OTHER MINING			Diamonds
	1993	1988	% change	1993	1988	% change	1993	1988	% change	1988
Agriculture	15.97	19.95	-19.95	12.55	640.18	-98.04	3.15	42.05	-92.51	6.17
Manufacturing: Total	2,739.06	2,257.94	21.31	2,649.60	3,540.31	-25.16	3,885.37	4,520.89	-14.06	759.45
Wood and Wood Products	25.24	3.73	577.39	377.70	5.75	6471.15	51.12	8.59	495.39	2.09
Industrial Chemicals	82.19			290.63			336.64			
Petroleum Refineries and Products of Petroleum/coal (Industrial Chemicals Plus Petroleum)	355.08	437.27	292.71	49.39	402.77	439.93	-8.45	921.99	955.08	-3.46
Other Chemical Products	229.92	284.74	-19.25	186.46	637.63	-70.76	281.67	400.47	-29.66	61.97
Other Fabricated Metal Products	241.93	164.26	47.28	301.44	477.61	-36.89	242.54	310.32	-21.84	58.31
Special Industrial Machinery and Equipment	554.08	647.64	-14.45	319.41	647.28	-50.65	859.39	1,306.87	-34.24	231.65
Other Machinery and Equipment	264.02	155.36	69.94	253.40	316.65	-19.97	334.68	264.17	26.69	45.85
Electrical Industrial Machinery and Apparatus	206.86	136.44	51.61	56.35	71.20	-20.85	76.22	64.07	18.97	12.88
Electricity	449.74	434.30	3.56	1,436.58	1,762.70	-18.50	1,098.15	804.67	36.47	90.29
Wholesale and Retail Trade and Motor Trade	426.16	274.99	54.97	269.91	355.88	-24.16	584.97	554.89	5.42	88.72
Transport and Storage	367.36	91.31	302.30	89.01	194.36	-54.20	431.01	245.57	75.51	20.40
*Other	723.32	312.97	131.11	653.43	1,511.03	-56.76	1,678.27	2,327.33	-27.89	567.40
ALL SECTORS										
Total Intermediate Input	4,851.52	3,570.60	35.87	5,475.19	8,472.95	-35.38	8,183.05	8,973.68	-8.81	1,556.46
Remuneration of Employees	1,982.40	2,021.54	-1.94	9,241.58	11,704.6	-21.04	4,015.51	4,393.45	-8.60	594.35
Gross Operating Surplus	1,941.20	2,854.74	-32.00	7,899.64	15,964.3	-50.52	5,477.82	8,788.97	-37.67	1,150.52
Net Indirect Taxes	101.32	114.89	-11.81	1,111.74	243.67	356.26	158.07	526.70	-69.99	60.35
TOTAL (Output)	8,876.44	8,561.77	3.68	23,728.15	36,385.6	-34.79	17,834.45	22,682.80	-21.37	3,361.69

SECTOR	COAL MINING		GOLD MINING		OTHER MINING		MINING TOTAL	
	1993	1988	1993	1988	1993	1988	1993	1988
Manufacturing: Total	1.2	0.9	1.1	1.4	1.6	1.8	3.9	4.1
Cordage	1.1	0.5	13.1	26.1	3.1	1.8	17.3	28.4
Leather Products and Leather Substitutes	2.0	0.7	1.5	0.9	1.3	1.1	4.8	2.7
Wood and Wood Products	0.7	0.1	10.9	0.2	1.5	0.2	13.0	0.5
Industrial Chemicals	1.0		3.5		4.0		8.5	
Petroleum Refineries and Products of Petroleum/coal (Sum of Industrial Chemicals & Petroleum)	1.7		0.5		2.8		5.1	
Paints	0.9	0.7	1.2	1.7	2.7	1.7	4.8	4.1
Other Chemical Products	5.6	10.5	4.6	23.6	6.9	14.8	17.1	48.9
Tyres and Tubes	3.6	2.9	1.0	1.5	8.5	11.2	13.1	15.5
Other Rubber Products	8.8	7.8	3.8	6.5	8.1	10.6	20.7	24.9
Cutlery	6.2	4.6	4.8	7.2	5.2	4.8	16.2	16.6
Other Fabricated Metal Products	3.1	2.0	3.9	5.7	3.1	3.7	10.1	11.4
Engines and Turbines	0.1	0.2	1.7	1.0	5.7	1.9	7.5	3.0
Metal and Woodworking Machinery	0.7	1.2	0.3	1.2	3.4	4.5	4.5	6.9
Special Industrial Machinery and Equipment	13.1	19.7	7.5	19.7	20.3	39.7	41.0	79.1
Office	12.1	14.3	11.1	27.2	15.7	30.1	38.9	71.6
Other Machinery and Equipment	4.2	2.2	4.1	4.4	5.4	3.7	13.6	10.3
Electrical Industrial Machinery and Apparatus	8.1	2.7	2.2	1.4	3.0	1.2	13.2	5.3
Electrical Appliances and Housewares	0.6	0.7	0.6	1.6	1.2	4.2	2.4	6.5
Other Electrical Apparatus and Supplies	3.9	2.5	2.4	3.7	3.4	3.1	9.6	9.4
Motor Vehicle Parts and Accessories	3.9	2.5	0.4	0.7	4.3	4.8	8.6	8.1
Railway Equipment	4.5	1.4	27.8	24.0	10.1	2.9	42.4	28.3
Other Manufacturing Industries	0.9	1.0	1.0	2.5	0.9	2.3	2.8	5.8
Electricity	1.9	2.1	6.0	8.4	4.6	3.9	12.5	14.4
Water Supply	0.5	0.6	1.9	2.7	5.1	3.5	7.6	6.8
Machinery and Equipment Renting and Leasing	1.5	2.5	0.5	0.7	3.1	2.4	5.0	5.7
Other	5.2	2.0	4.7	9.6	12.0	14.8	21.9	26.3