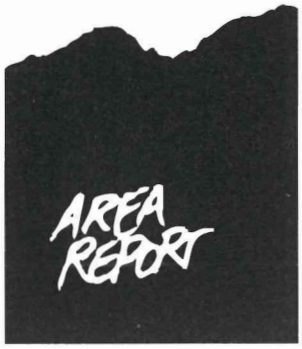

Adding value to South Africa's minerals

by Paul Jourdan

Although the South African mineral beneficiation industries generally are internationally competitive the downstream metal fabrication industries generally are not. This is principally due to high feedstock (mineral/metal) prices in the domestic market (import parity pricing). The main reason for this is the lack of domestic competition combined with South Africa's geographic isolation from the main alternative suppliers.

In this article the strategies of the new government to reduce feedstock prices and eliminate import parity pricing is discussed.

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South Africa's exceptional mineral resource endowment is well-known and it is widely documented. For six major minerals South Africa has the world's largest reserves, namely, manganese, the platinum group metals (PGMs), chromium, vanadium, gold and alumino-silicates. For another six minerals, South African reserves rank in the top four. In addition, South Africa has vast reserves for many other minerals such as iron ore, coal and base metals. In general the mineral potential has been realised and mineral production reflects mineral reserves. By far the most important mineral in terms of value is gold. This is followed by coal, platinum, diamonds, iron ore and copper. However many of these minerals are beneficiated before export in which case the order would be gold, iron and steel, PGMs (and byproducts), coal and ferro-alloys. In terms of global output the minerals for which South Africa's share is greater than one-fifth are: platinum (67 per cent), rhodium (63 per cent), vanadium (50 per cent), chromium (38 per cent), palladium (31 per cent), gold (28 per cent) and titanium (22 per cent).

The mineral beneficiation sector comprises all the processes carried out on a mineral ore, from mineral dressing, to concentration, to smelting, to refining and finally to the production of semi-finished dimensional products, such as sheet, bar or rod. Clearly a wider definition of beneficiation would also include the production of the finished mineral-based manufactured product. However, in this paper the two processes for convenience the two processes are separated and are termed beneficiation, till the pure metal or alloy, and fabriction, till the final manufactured product.

Table 1. South African mineral reserves

Mineral	South African mineral reserves			
	Reserves	Share of western world reserves (per cent)	Share of world reserves (per cent)	World rank
Manganese (metal)	4.0 Gt	90	82	1
Platinum group metals	30.2 kt	85	78	1
Chromium (ore)	2.4 Gt	58	56	1
Vanadium (metal)	7.8 Mt	64	47	1
Gold (metal)	20.0 kt	53	44	1
Alumino-silicates (ore)	51.6 Mt	47	37	1
Diamonds	360.0 Mcts	27	24	2
Zirconium (metal)	6.9 Mt	16	14	2
Uranium (metal)	317.0 kt	13	n.a.	3 or 4
Fluorspar (CaF_2)	32.0 Mt	30	11	3
Titanium (metal)	31.1 Mt	12	11	4
Coal (recoverable)	58.4 Gt	20	10	4
Nickel (metal)	11.4 Mt	12	10	6
Vermiculite (ore)	73.0 Mt	40	n.a.	n.a.

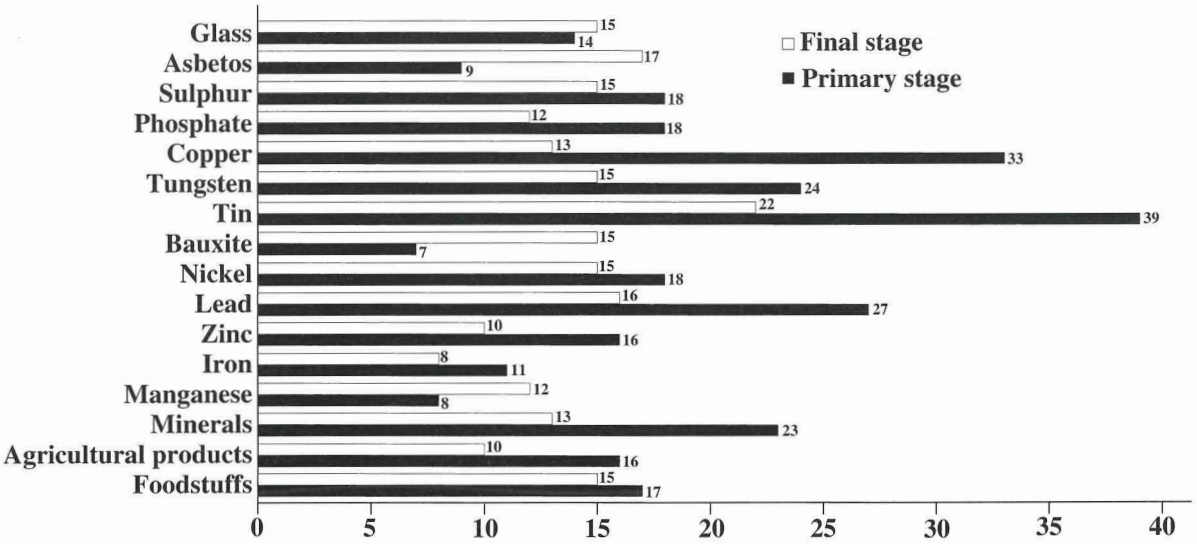
Note: n.a. not available.
Source: CMSA 1992, MB 1992.

Table 2. South African mineral production and per cent of global production 1991

Mineral	1970	1975	1980	1985	1990	1993	Share of world production	MUSD
Gold (t)	1002	713	673	671	603	614	27.9%	7114
Coal (mt)	54.6	69.4	116.1	173.3	174.8	183.4	5.0%	2961
Platinum (t)	29.0	52.0	60.0	72.8	86.5	104.5	66.6%	1422 [2]
Diamonds (mcts)	7.0	7.3	8.5	10.2	8.7	8.4	14.0%	1588
Iron ore (mt)	7.4	12.3	26.3	24.4	30.3	29.6	3.1%	392
Copper (kt)	149.2	178.6	200.7	195.4	178.7	168.6	2.1%	317
Manganese ore	3053	5881	5788	5263	4402	2507	14.3%	168
Rhodium (t)	2.1	3.9	4.4	5.4	6.4	8.6	63.2%	[2]
Nickel (kt)	11.6	20.8	24.0	29.4	28.2	29.0	2.9%	140
Chromite ore (kt)	1427	2075	3600	3698	4600	2827	38.4%	108
Titanium (TiO_2)	0.0	0.0	272.0	255.0	710.0	758.0 [1]	21.5%	152 [1]
Palladium (t)	3.1	3.2	3.7	4.5	38.4	43.4	31.4%	[2]
Vanadium (V_2O_5)	12.2	19.0	26.6	25.0	30.5	27.6 [1]	50.2%	91 [1]

Notes: 1. 1991 data. 2. value for all PGMs.

Diagram 1. Average annual price changes 1965 – 1987



Source: Yeats 1991, table 5.

Why beneficiate?

It can be argued that if there are greater returns to capital from just selling the raw minerals (ores) than through beneficiating them, then this activity represents the optimum activity in terms of the country's factor endowments and will maximise the generation of surplus for overall economic development. Therefore, why should any government encourage the further beneficiation of its mineral resources?

Mining is different to other sectors of the economy in that it exploits a wasting resource and thus the production of any mineral has a limited life. This can be clearly seen in the case of gold mining in South Africa where two-thirds of the original resource base has been removed and what is left is generally low grade and/or extremely deep. Thus an industrial strategy based on gold exports would be unsustainable in the long term. Therefore, the national benefits of a mineral resource need to be maximised over the life of that resource. By beneficiating the mineral greater value is added through the employment of capital and labour thereby, inter alia, generating greater forex earnings, greater government revenue and greater employment.

In general, mineral beneficiation in South Africa is internationally competitive due to the transport advantage of carrying it out close to the source of the ore thereby reducing the mass/volume of the final product before export. However, due to subsidies to beneficiation industries and tariffs on beneficiated products in the developed countries, it is sometimes more profitable to export unprocessed ores (which seldom attract tariffs).

In addition, due to the limited nature of mineral deposits, the indefinite expansion of a mining industry is impossible: a point is reached when almost all economic mineral deposits are under exploitation, as is broadly the case in South Africa, and new areas of productive investment need to be identified. In overall volume terms (and in terms of contribution to GDP), mining has basically been stagnant over the last 20 years and most new growth has come from deepening (beneficiation) the industry, rather than broadening (more mining) investment. However, it can be argued that once the major mineral deposits have been taken up, new investment should not necessarily go into the further beneficiation of minerals, but might be better employed in other sectors of the economy where returns might be higher and employment generation greater. Not all minerals should *per force* be beneficiated, but that the long term *dynamic* comparative advantage of the beneficiation industry should be determined, and if considered to be strong, a degree of privileging that industry in terms of the cost of capital or other incentives might be appropriate. However, any other industry that appears to have a strong long term dynamic comparative advantage might also so be privileged.

Given that several beneficiation industries, particularly ferrous metallurgy, have been regarded as "strategic" in the past by the industrialised countries, which led to a variety of state interventions (such as subsidies and protection) resulting in noticeable market imperfections, it might be reasonable to postulate a long term dynamic comparative advantage for these industries on the assumption that, now that the Cold War is over, these imperfections will diminish and South Africa's inherent comparative advantages will come to the fore in the form of increasing international competitiveness.

A characteristic that mining shares with other primary product industries is that of falling terms of trade. In the long term, the price of primary commodities is constantly falling in relation to manufactured products. Thus by beneficiating, a nation will gradually change its trade profile to products with greater value added and a lower terms of trade disadvantage. In addition, the prices of primary commodities tend to fluctuate wildly and to be cyclical in the short to medium term. A recent study concluded that natural resource-based industrialisation strategies conveyed important price benefits

Table 3. South Africas mineral beneficiation ratios 1993

Beneficiation in South Africa	Production ratio (PBR)	Export ratio (EBR)
Antimony concentrate to antimony trioxide	95%	97%
Chromite ore to chromium alloys	87%	84%
Copper concentrate to copper metal	89%	87%
Iron ore to iron and steel	31%	22%
Manganese ore to manganese alloy and metal	56%	48%
Nickel matte to nickel metal and sulphate	100%	100%
Phosphate concentrate to phosphoric acid	56%	25%
Zinc concentrate to zinc metal	87%	44%
Titanium slag to titanium dioxide	5%	1%
Vanadium slag to vanadium pentoxide	5%	1%

Source: MB 1994 and own data.

Table 4. Exports of mineral and mineral-related products (real 1981 MZAR)

	Export sales value				Ratios	
	Phase 1	Phase 2	Phase 3	Total PT	P1/P2	P1+2/P3
1981	12 013	1 176	599	13 788	10.22	22.02
1982	10 874	1 043	598	12 515	10.43	19.93
1983	11 034	1 074	546	12 654	10.27	22.18
1984	11 669	1 373	641	13 683	8.50	20.35
1985	13 786	1 771	966	16 523	7.78	16.10
1986	13 341	1 842	985	16 168	7.24	15.41
1987	11 139	1 610	821	13 570	6.92	15.53
1988	11 165	2 138	901	14 204	5.22	14.76
1989	10 596	2 515	966	14 077	4.21	13.57
1990	9 399	1 915	1 116	12 430	4.91	10.14
1991	8 457	2 007	1 080	11 544	4.21	9.69

Note: Phases 1, 2 & 3 refer to the GEIS beneficiation categories, namely, primary products, beneficiated primary products and material-intensive products, but only for selected minerals.
Source: MB bulletin feb/mar 1993.

for commodity exporting countries in that price instability decreased with increasing processing (beneficiation), except where the ore has some form of producer organisation, which stabilised the price, and the processed product was freely traded.[1] The study of minerals, agricultural materials and foodstuffs all displayed greater stability with increasing beneficiation, but the change was the most marked for minerals (figure 1), which decreased as a group by almost half.

Thus it would appear that while there may sometimes not be an immediate profit incentive to beneficiate for a private company, there are numerous compelling advantages to beneficiation for a nation.

South Africa's degree of mineral beneficiation

South Africa still exports much of its mineral production as ores, concentrates, intermediate compounds and slags, with the degree of beneficiation being determined by the mining company on profitability, rather than by the nation on overall welfare. In 1993, only one-third of the the 29 Mt of iron ore mined was destined for domestic iron and steel plants and one half of the 2.5 Mt of manganese ore mined was beneficiated into ferromanganese and manganese metal (table 3).

Although almost all vanadium ore (vanadiferous magnetite) was converted to either vanadium pentoxide or slag, only about 1 per cent was converted into ferrovanadium, nitrovan[2] or carvan[3] for the steel industry. Almost all slag is exported but Highveld Steel and Vanadium have, however, announced that they intend to convert up to 20 per cent of the slag output into vanadium pentoxide.

The production beneficiation ratio is the ratio of the beneficiated form over the total mass of the commodity produced (PBR) and the export beneficiation ratio (EBR) is the amount of the exported beneficiated form over the total exports of both the unbeneficiated and beneficiated form. In general, the EBR is higher than the PBR due to the transport disadvantage for exporting the unbeneficiated form, although there are exceptions (such as iron ore and zinc) caused by the high local consumption of the beneficiated product.

However, it should be borne in mind that table 3 only gives the beneficiation ratio for a particular step, which varies from mineral to mineral. A better representation would be to display the ratio for each step, such as under the GEIS[4] system (below) which categorises the beneficiation stages into: 1. Primary Products (eg ores); 2. Beneficiated Primary Products (eg alloys/metals); 3. Material-intensive Products (eg semis); and, 4. Manufactured Products (i.e. finished products).

An analysis of selected mineral-based and mineral exports from 1981 to 1991 shows a clear tendency towards greater mineral beneficiation, despite sanctions over this period. The ratio of category 2 over 1 declined by more than half from 10.2 to 4.21 and that of categories 1 plus 2 over 3 by 56 per cent from 22.0 to 9.7 (table 4).

Nevertheless, the first obvious question to be posed regarding a mineral beneficiation strategy is, why has South Africa not beneficiated its minerals further up to now? Only a small proportion of its huge mineral output is transformed for the production of items for the local market, sometimes with some export capacity. An example is stainless steel, where a tiny proportion of South Africa's ferrochrome, nickel and iron production is transformed into stainless steel by Columbus Stainless (ex-Middleburg Steel and Alloys), to supply local stainless steel fabricators with the raw material to make stainless finished products and for export.

Another example is titanium, where a small plant belonging to Tioxide (ICI)

transforms about 5 per cent of titanium slag output from Richards Bay Minerals (RTZ) into titanium dioxide for the local paint and paper industry and a small amount for export. The apparent paradox, that although South Africa has the technological and financial capacity for minerals beneficiation, yet it continues to sell huge quantities of unprocessed ores, concentrates and ferroalloys could have several possible explanations:

i. Generally, beneficiation means going into **competition** with your customers, thus, given apartheid, South Africa's international pariah status and need to please, beneficiation was difficult. In some cases, such as the conversion of titanium slag to dioxide, expansion of exports would be in direct competition with other plants belonging to the mother company and was therefore not undertaken.

ii. Sanctions were generally not applied against South Africa's raw mineral exports by the industrialised countries, as they were lowly or cheap priced and in some cases alternative sources were of a lower quality and/or more expensive. However, **sanctions** were applied against beneficiated mineral products (particularly steel and stainless steel) as these were competing against producers in their own countries.

iii. For high value minerals (gold, PGMs, diamonds) there is no insurance, handling and freight **cost advantage** to a local beneficiator who will source his mineral raw materials at the same price as his overseas competitors.

iv. It has been argued that in some cases, South Africa has such a **large share** of world production that it would be impossible for it to beneficiate all of its ore production because it would increase the customer's perceived vulnerability (thus a notional market share "ceiling" exists for several beneficiated mineral products, such as ferroalloys).

v. Related to the above, several countries maintain a **minimum capacity** for the production of strategic mineral products for perceived national security reasons. This capacity is sometimes significant and cannot readily be penetrated by a foreign producer. In some cases, consuming countries keep a minimum capacity (in terms of total imports) as a bargaining machanism, when purchasing from foreign producers.

vi. As value is added to minerals, the further beneficiated products usually attract increasing **import tariffs**. Thus ores are generally duty free, ferroalloys have low import duties (6 per cent to 10 per cent) and the import duties on special steels are often significant (10 per cent to 20 per cent). This often neutralises the cost advantages that a beneficiator, with its own mineral sources, might have.

vii. Finally, it can be argued that the apartheid regime in fact has invested billions of Rand in minerals beneficiation projects over the past 20 years, but these have been uneconomic strategic investments aimed at self-sufficiency at all costs, such as the SASOL plants (over 30 000 MZAR/Rand) and the Mossgas project (15 000 MZAR). These two projects could have alternatively financed about eight stainless steel plants the size of the Columbus project, which would have given South Africa nearly half the world capacity and earned over twice as much forex as current gold exports.

Given the current gold crisis and the exhaustion of most high grade or shallow gold reserves over the last 100 years, South Africa will soon be desperately in need of alternative exports if a major balance of payments crisis is to be averted in the medium term. The easiest and most obvious alternative is to value-add minerals by beneficiation before export. If only 10 per cent of South Africa's chromite ore output was beneficiated to produce 1.5 Mt of stainless steel (about 14 per cent of the world market), about 3.75 GUSD would be earned, equivalent to half the country's gold exports. However, if the stainless steel was further transformed into finished stainless steel products before export, all gold production could be replaced in terms of forex earnings, but only a fraction of the employment in gold mining would be replaced.

Advantages to further mineral beneficiation

1. The transport advantage. A South African operation can generally source the raw materials (minerals) to be beneficiated at a lower cost than a competitor in the industrialised countries. This discount is generally equivalent to the FOR – CIF differential from the mine (smelter) to the main markets (eg Rotterdam) and thus is proportionally greater, the lower the unit value of the mineral. For the high value minerals (gold, PGMs, diamonds), there is virtually no transport advantage (an Italian jeweller can source precious metals at the same cost as a South African one). The transport advantage does not only apply for the mineral being beneficiated, but also for all other minerals (and mineral-based consumables) used in the beneficiation process, such as fluxes, reductants, electrodes, acids, conditioners, refractories and other minerals/metals used in the fabrication of the product/item. These are significant for the production of titanium dioxide and vanadium products.

2. The weight loss advantage. This is closely related to the transport advantage, and refers to the fact that the first stages of beneficiation usually involve a significant weight loss when the ore is reduced to the metal. This can vary from 70 per cent for a concentrate to 30–70 per cent for an ore, such as iron ore or chromite ore. However, from the alloy to a special steel or semi, there is no weight loss.

Thus there are obvious transport costs advantages to reducing the ore as close to the deposit as possible and there has been

Table 5. Weight loss through beneficiation for South Africa

Conversion	Per cent metal or compound	Per cent weight loss
Chromite ore to ferrochrome	45	55
Ferrochrome to stainless steel	100	0
Manganese ore to ferromanganese	40 to 68	32 to 60
Ferromanganese to steel	100	0
Iron ore to liquid iron	60 to 70	30 to 40
Liquid iron to steel	100	0
Ilmenite to titanium slag (85 per cent TiO_2)	50	35
Titanium slag to pigment (TiO_2)	85	15
Gold metal to jewellery	100	0
Vanadium ore to slag (25 per cent V_2O_5)	1.5	23.5
Vanadium slag to oxide (V_2O_5)	25	75
Vanadium oxide to ferrovanadium	56	44

Source: Coetzee (ed) 1975 and own data.

a worldwide tendency for mineral reduction to move to the producer countries, except in the case of iron ore, which is still mainly reduced to iron and steel in the industrialised countries (possibly due to the perceived "strategic" nature of this industry). For a weighted basket of fourteen minerals, from 1965 to 1987, the share of developing countries in the total imports of the processed stage (beneficiated) by developed countries, increased by one-third.[5] However, downstream transportation can also be a disadvantage, in that beneficiated products often attract higher freight and insurance rates due to their greater value and, often, fragility.

This was effectively demonstrated in a study done in 1989 on the beneficiation of chromite ore[6] where the following transport and handling costs were computed going from chromite ore to ferrochrome to stainless steel to tubes to European customer (1989 Rand, Table 6).

From this it is immediately apparent that the greatest weight loss (ore to alloy) correlates to the greatest transport cost saving (Route II), which was but one-third of the cost of transporting finished stainless steel tube to a European customer. The "SA" side of these figures refers to all process taking place inland near the ore source. These figures are, however, distorted by the then South African railways policy of charging a freight cost relative to the value of the product, thus severely biasing beneficiation.[7] The railways are apparently moving away from this value related pricing policy to that of the real costs of the operation, irrespective of the value of the goods. The costs from Gauteng (ex-PWV) to the port are roughly equal to the costs from the port to the main markets (Europe, North America and the Far East). The figures also include EU duties which escalate with greater beneficiation. Therefore it would appear that the optimum transport configuration for beneficiation in South Africa would be to reduce the ore to alloy or metal at the mine site, and then to locate the transformation plant (steel works) and semi-fabrication (tube plant) plant on the coast. The energy advantage in terms of transferring hot liquid metal/alloy straight into the refinery would, however, be lost (see below).

3. The energy advantage. Most beneficiation processes are energy-intensive (particularly the reduction of oxides) and thus a South African operation will benefit from the country's low electricity tariffs. This is clearly more important for the pyrometallurgical beneficiation processes (usually reduction) such as the production of ferroalloys (FeCr, FeSiCr, FeSi, FeMn, FeSiMn, FeV) and steels.

Almost all electricity in South Africa is generated by Eskom, almost entirely from coal-fired power stations, and due to the cheap price of local coal and the lenient enforcement of environmental legislation, bulk electricity prices to the beneficiation plants are amongst the cheapest in the world, so much so that South African ferroalloy producers are generally particularly inefficient users of energy in that the waste heat (producer gas) is not utilised as is done in most European plants. This situation was aggravated by the Power Rebate where 30 per cent of the electricity used for ferroalloy exports was repaid by government through energy subsidies like the power

Table 6. Beneficiation: Transport costs to Europe 1989

Route	Ore	FeCr	Stainless steel	Tube	Customer (ZAR/t)
I	SA	EU	EU	EU	477
II	SA	SA	EU	EU	174
III	SA	SA	SA	EU	435
IV	SA	SA	SA	SA	514

Note: SA South Africa. EU European Union.
Source: BTI 1989, p7–9.

sebate export incentive. However, this scheme will ceased at the end of 1992 and in response, some of the ferroalloy producers are already planning to use their energy more efficiently.

In terms of published industrial electricity prices, Eskom is in the lowest quartile worldwide. However, ferroalloy producers receive special electricity discounts in almost every country and thus accurate price comparisons are extremely difficult.

A new phenomenon is the linking of electricity costs to the price of the commodity. Eskom has already agreed to link the price of electricity to the LME aluminium price for the new Alusaf project (see below) and the ferroalloy smelters are currently considering negotiating similar deals.[8]

Other energy sources, such as coal, are also exceptionally cheap. This advantage could, in fact, improve further as South Africa is re-integrated into the subcontinent and the enormous regional hydroelectric potential becomes available. There is also an indirect energy advantage in pyrometallurgical beneficiation processes in that hot alloy can be transferred from one process to the next thereby conserving energy. A stainless steel producer without a ferrochrome industry must remelt the ferrochrome, while a South African producer can introduce hot liquid ferrochrome straight from the smelter.

4. The labour advantage. With unemployment standing at 7 to 8 million (40 to 50 per cent of the workforce), unskilled and semi-skilled labour is still relatively cheap in South Africa, compared with developed countries (though not compared to some developing competitors). This advantage clearly applies more to the labour-intensive beneficiation processes and less to the capital-intensive ones. As capital intensity tends to increase as the mineral is further processed, this is not generally an important factor in the establishment of beneficiation plants. They usually require relatively few workers, mainly in the skilled and professional categories. Nevertheless, there are certain beneficiation processes that could employ large numbers of people, such as the fabrication of jewellery and the transformation of stainless steel into finished products (eg cutlery, holloware and construction fittings).

South Africa's labour to physical output ratios are in general much higher than comparative industries elsewhere. For example, in 1981 in South Africa about 123,300 workers produced some 9 Mt of steel (73 t per worker), while in the EU[9] about 621 800 workers produced some 140 Mt of steel (225 t per worker), giving three times more output per worker.[10] By 1990, this situation had deteriorated even further when South Africa produced 77 t per worker and the EU produced 362 t per worker, or 4.7 times more. Labour productivity comparisons are difficult as more or less work is subcontracted out by different plants[11] and, also, each plant has a discrete product mix that might require more or less labour. Nevertheless, it is clear that for most beneficiation industries, South Africa is more labour-intensive than its First World competitors and NICs.[12]

In terms of labour costs, South Africa is generally low and in December 1991, labour costs per t of steel at the Vanderbijlpark Works was 111 USD compared to 152 USD in the USA, 179 USD in Germany and 145 USD in Japan, but 67 USD in South Korea and 82 USD in Brazil. However, the new highly mechanised Nucor Thin Slab Plant in the USA had labour costs of only 46 USD/t of steel shipped[13], due principally to the capital-intensive technology used.

5. The technological advantage. Most mineral beneficiation processes are pyrometallurgical and over the last twenty years South Africa has become a world leader in furnace operation and design (particularly plasma smelting) and has even supplied state-of-the-art furnaces to industrialised countries. However, for some minerals, such as the conversion of titanium slag to pigment, South Africa has no experience and the acquisition of technology is retarding beneficiation.

When a beneficiation process is first embarked upon, the technology is usually completely imported, often on a turnkey basis. Thus there are significant extra running costs in terms of imported spares, maintenance contracts and payments for technology. However, in general, in South Africa the technology has slowly been unpackaged and a local technological capacity has been built up so that later plants often use local technology and the older, imported plants, are upgraded and improved using local know-how. An example would be for ferrochrome and ferromanganese, where the first generation of plants were imported, the next generation were locally supplied and the current domestic pyrometallurgical capacity is state-of-the-art to the extent that furnaces are now exported to industrialised countries. However, the plant for the next stage, Columbus Stainless Steel, is mostly imported. Overall, a significant local prowess has been created in minerals beneficiation technology, meaning that costs for technology are generally low.

In general, there appears to be a positive correlation between local technological prowess and world market share. In the areas where South Africa has a significant world market share of the beneficiated product, such as ferrochrome, ferromanganese, vanadium pentoxide and precious metals, the technological competence is high and where the market share is small, it is low. Also, some forms of technological competence came about because the available international technology was not suited to South African conditions and therefore had to be adapted which sometimes resulted in a better process being developed, such as for a variety of technologies associated with very deep level mining, the smelting of fines using plasma technology[14] and, to a certain extent, the development of the Corex

iron making technology, together with Voest Alpine.

6. Other inputs. In general, other inputs to the beneficiation process also come from South African raw materials (eg reductants, fluxes, refractories, chemicals) and are in, the main, cost competitive. However, spares and maintenance for imported capital goods can be more expensive than for First World competitors. Furthermore, each beneficiation process has its own discrete inputs, thus it is difficult to make generalisations across the industry.

7. Working capital. Due to the long time lags between each beneficiation stage, when the processes are carried out in different countries (transport delays) there is clearly a major advantage in beneficiating at the resource in terms of reducing working capital. The average time from chromite ore mined to the sale of ferrochrome for one company is about one year.[15] Thus the time from chromite ore to final stainless steel article sold must be in the order of two years. The cost of this long time in process is generally not appreciated because different companies are doing different beneficiation stages and for each the time in process it not inordinate. However, the overall cost of materials in process must finally be reflected in the final selling price of the fabricated product. Thus, if the whole process from ore to alloy to stainless steel to finished article were to be undertaken in the same area, the time for materials in process could most probably be reduced to a few months, or about 20 per cent of the current transglobal situation[16] which should have a significant effect on the competitiveness of the final product. A true JIT[17] situation can only be achieved if all processes are undertaken in close proximity to one another. However, finally the end product must be conveyed to distant markets (in the case of South Africa) and the transport costs for the value-added products are usually higher than for the raw materials.

8. Transfer pricing. Ores and concentrates tend to be specific to the deposit in terms of their composition and value. Thus, it is difficult to have benchmark prices for comparison to monitor under invoicing (transfer pricing). However, the beneficiated metal or alloy generally has an internationally quoted price (such as the LME or NYMEX), which can be used for comparison to control transfer pricing.[18]

9. Pollution abatement laws. Due to past practices and high population densities, the industrialised countries are constantly adding to the cost of beneficiating minerals through environmental legislation. Thus beneficiation industries are relocating to the ore producing countries that are often more sparsely populated and generally have less strict environmental legislation, such as South Africa.[19]

Constraints to further mineral beneficiation

1. The high cost of capital. As beneficiation plants tend to be extremely capital-intensive the high interests rates in South Africa put a local project at a disadvantage to a similar plant located in a country where the cost of capital is lower. Sacob[20] have argued that the cost of capital in South Africa varies from twice to nine times that of our major competitors, but their calculation appears to double the effect of South Africa's high inflation rate.[21] Nevertheless, due to the high inflation rate relative to major competitors, the cost of capital is high, especially in terms of capital write-offs against tax over time for new projects. To get around this, until the end of 1994, the government had a new system for new projects (Section 37E) whereby capex was written off over five years starting in the year after expenditure, against tax in other parts of the group or using negotiable tax certificates. This ameliorated but did not eliminate the effect of high inflation. This system expired at the end of 1994 and consideration is currently being given to a new system to replace it.

In general beneficiation projects tend to be capital-intensive, thus the cost of capital is usually an important cost item for international competitiveness, particularly during the early period (the first five to ten years) when financial charges are generally high. Notwithstanding this, financial charges per t of steel for Iscor's Vanderbijlpark Works are amongst the lowest in the world, though this could be due to the fact that the capital was invested some time ago. The newer plants tend to have the highest financial costs (eg Nippon Steel and Posco).

2. The high rate of taxation. The company tax rate in South Africa (45 per cent) is significantly higher than in most countries that are our competitors in mineral beneficiation. This can be ameliorated through various incentives that allow for tax write offs resulting in an *effective* tax that is much lower. The Sacob study referred to above puts South African tax rates in 1989 in the upper quartile of a selection of 32 countries.[22] Another study displayed a marked international trend from 1980 to 1990 to reduce taxes, a period in which South Africa was second highest in a group of seven countries that actually raised taxes.[23] All the other countries either remained unchanged or lowered taxes. Between 1980 and 1990 South Africa moved from having the 39th highest corporate tax rate of a group of 60 countries, to fourth.[24] However, comparisons of *effective* corporate tax rates are unavailable.

3. The lack of investment incentives. South African industrialists generally complain that the overall package of investment incentives for major investments for beneficiation projects, is inferior to those offered by many of our competitors. The validity of this argument is difficult to ascertain (the issue is however extensively discussed in the Sacob study referred to above).

4. The lack of skilled, professional and managerial personnel. Due to centuries of racist education and training, South Africa has shortage of qualified

personnel, particularly technical personnel, which impacts particularly on mineral beneficiation projects as they tend to be medium to high tech and skill-intensive. The racist barriers to skilled grades have created a false shortage in these professions which has escalated remuneration and caused a drop in efficiency, increasing overall costs and decreasing the competitiveness of industry.[25]

5. Distance from consuming markets. The main markets for South Africa's beneficiated minerals are the Far East, Europe and North America which all require long transport distances and for each there is generally a competitor situated closer. However, in one sense this can also be an advantage in that by being equidistant from the three main markets, the world market can effectively be played to take advantage of any price differentials between them. This is more of an advantage for higher value to weight products.[26]

The long distances can be an increasing disadvantage as products are further beneficiated, both in terms of the beneficiated products attracting higher transport costs than ores or metal due to their higher value and fragility, but also because of the difficulty of responding rapidly to markets for highly differentiated beneficiated products when there are long transport lead times from producer to customer. Conversely though, for the more beneficiated products, the distance from competition could be seen as a sort of non-tariff barrier, where the transport advantage (above) works in reverse.

The consuming (industrialised) countries are also usually the source of capital goods and equipment for South African beneficiation operations. In 1989 it was estimated that a South African plant would pay three times more for the transport and installation of a piece of equipment from Europe than a European competitor.[27]

6. Domestic input prices. The first stage of mineral beneficiation benefits from having the ore locally available below the international price and as the next stage is usually carried out by the same company it also benefits from a lower in-house price. However for the final stage (fabrication) the refined mineral is often sold domestically at *import parity prices* which are the prices that the refiner calculates that the customer would have to pay if the metal or alloy were to be imported and thus includes the international price (LME)[28] plus the cost of transporting it to South Africa, plus any protective tariffs that South Africa might have imposed. This method of pricing has been practiced for aluminium, copper, steel and stainless steel and basically amounts to exploiting the domestic market to subsidise exports. It is probably an important factor in the failure of local metal fabricating industries to move from the small domestic market to the huge export market. Their principal input is thus only available at a price well above that paid by their international competitors. In effect their are five possible prices that a local fabricator could pay for beneficiated mineral inputs: 1. *import parity with tariff* (worst case); 2. *import parity without tariff* (eg LME plus transport); 3. *international price* (eg LME); 4. *export parity* (eg LME less transport); and, 5. *local metal cost* (best case) .

In general the only way that a fabricator can get the metal/alloy at the local cost, which would include the full advantage of having the high grade resource, is if it is part of an integrated industry that would prefer to declare its profit at the final stage. Unfortunately the types of processes used in refining (beneficiating) are generally quite different from those used in fabrication (manufacturing) meaning that the two are usually done by separate companies. Thus the normal best case would be the export parity price. The new government is committed to finding ways of reducing input costs to the manufacturing industry and eliminating import parity pricing.

7. Technology acquisition. For some beneficiation processes world production is highly concentrated in the hands of a few companies that have developed the technology. A new operation could thus encounter difficulties in acquiring the technology, while developing it in-house would be too expensive. A case in point would be the technology for pigment manufacture from titanium slag, which is held by a small group of companies who are not willing to either locate a major plant in South Africa or to license the use of their technology.[29]

8. Trade barriers. A major disadvantage to beneficiating minerals at source is that protective tariffs barriers and non-tariff barriers tend to increase in the main markets as value is added. Thus there are almost no import tariffs for ores and concentrates in the industrialised countries, very low tariffs for metals and alloys, higher tariffs for semi-finished products and significant tariffs for finished items. However, they are typically only in the 0 per cent to 10 per cent range for most beneficiated products and are generally falling or progressively being done away with as through the GATT negotiations.[30] In addition, they are very dependent on bilateral and multilateral trade agreements (such as Lomé and GATT) and thus, as South Africa normalises and re-negotiates its trade relations with its main trading partners and is given the status of a *developing* country, overall barriers to beneficiated exports may fall in the next few years. Nevertheless, even low tariffs can be important for certain beneficiated products such as steels. For each step in the first stages of beneficiation (ore to unwrought metal to refined metal) the developed countries show increasing tariff levels. However, the tariffs escalate rapidly for semis and elaborate goods. In addition, for some metals, such as iron and steel, non-tariff barriers (such as quotas) are more important than tariff barriers.

In addition, domestic tariffs can have a significant impact on the competitiveness of the product in the local market. However, this has the effect of raising

domestic prices above international prices which severely compromises the ability of local downstream fabrication industries to export onto the world market, though tariff exemption for exporters is often given. Overall, a recent study on South African trade showed that tariffs on "mining" products (metals) were very low,[31] with a weighted mean of 3 per cent. There are however exceptions such as aluminium (20 per cent) and steel (formula tariff) and stainless steel. The coefficient of variation (standard deviation as percent of mean) is very high (187)[32] indicating a wide range of tariffs, albeit low.

Domestic tariffs also have the effect of raising the cost of vital imported inputs such as capital goods. A 1989 a comparison[33] of the cost of a piece of capital equipment, made in Europe, in Germany and in South Africa, concluded that the South African operation would have to pay 63 per cent more than the German competitor due to extra transport and installation cost (3 times higher), extra tariffs and taxes[34] (44 per cent of the original purchase price) and interest for the extra delivery time (3.3 per cent of the original purchase price).

9. The concentration of capital. Capital is highly concentrated in South Africa and it is estimated that the four main groups control as much as 80 per cent of the value of shares on the JSE.[35] This can be an advantage for mobilising the large amounts of capital necessary for large scale beneficiation projects and the Columbus Joint Venture (stainless steel), which brought together the Anglo group (through HS&V) and the Gencor group (through Samancor), is cited as an example in this regard. However this can also be a disadvantage as it can also have the effect of keeping other players (competition) out. A prospective foreign investor was recently looking for a possible local partner for a second large stainless steel plant, but was finding it difficult to find one with the requisite resources that was not part of the two groups involved in Columbus.[36] JCI[37] with its ferrochrome subsidiary, CMI[38], is a possibility, but their mother company, Anglo, might not want it to go into competition with Columbus Stainless.

The concentration of capital and the existence of monopolies is a more severe constraint on down stream fabrication. A recent major study of the South African economy[39] displayed that for diverse sectors feedstock prices were much higher than for international comparisons. One reason for this is the concentration of capital in South Africa where certain mineral feedstocks are dominated by one or two companies (e.g. aluminium, copper, steel, stainless steel), which are then in a position to set import parity prices.

Conclusion

Due to a variety of factors, South African mineral beneficiation industries are generally internationally competitive. The factors include the country's resource endowment, low cost energy, good infrastructure and specific areas of technological prowess. This is borne out by the stream of major beneficiation projects underway (Alusaf, Columbus, Namakwa, Saldanha steel) or under consideration (Iscor stainless steel, Phalaborwa iron carbide and phlogopite, IDC zinc smelter and Comodinox stainless steel). The first batch received an important capex support (37E) which will need to be replaced by another mechanism to increase the viability of the second batch.

However, South Africa's downstream metal fabrication industries are generally not internationally competitive, principally due to high feedstock (mineral/metal) prices in the domestic market (import parity pricing). The main reason for this is the lack of domestic competition (rivalry) combined with South Africa's geographic isolation from the main alternative suppliers.

Due to the high employment potential of the metal/mineral-based fabrication industries, the new government has focused on ways of reducing feedstock prices and eliminating import parity pricing. Strategies under consideration include, the removal of all tariffs on metals to allow potential competition from imports; the encouragement of domestic competition by supporting the establishment of more than one plant; the strengthening of competition policy with anti-collusion legislation; the encouragement of world class/scale plants that do not "need" to fleece the domestic market; the use of state equity (IDC) and incentives to encourage export parity pricing; the enactment of "non-discriminatory pricing" legislation and the possible use of energy costs to influence the domestic prices of the feedstocks produced.

A combination of appropriate strategies will hopefully lead to the extension of South Africa's international competitiveness in basic mineral beneficiation industries to mineral/metal-based fabrication industries, with resultant employment creation.

Notes

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1. Yeats 1991.
2. nitrovan: nitrogen-vanadium compound.
3. carvan: carbon-vanadium compound.
4. GEIS: General Export Incentive Scheme.
5. Yeats 1991, Table 2.
6. BTI 1989, p7–8.
7. This policy led to the inefficient transport of stainless steel by road from Middleburg to the coast. The truckers would set their rates slightly below the escalated rail rates (Hully, M, MS&A, pers. comm.).
8. Ferroalloys Producers Association, personal communication, 10/92.
9. EC: European community.
10. Steel labour and production data from the IISI in Brussels. However, the South African figures are inflated by the inclusion of mining labour.
11. In general, in the industrialised countries, there appears to be a tendency to subcontract out all jobs except for the core activity, giving artificially low labour force figures.
12. NIC: Newly Industrialised Country (eg Taiwan, S. Korea, Singapore and Brazil).

13. Labour costs from the IISI and Iscor, 10/92.
14. This technology, originally developed by MS&A for chromite fines, has now been adapted for the smelting of ilmenite sand.
15. Samancor 10/92, personal communication.
16. At the Outokumpo plant in Tornio ore is converted to alloy, to stainless steel, to tube all at the same location thereby drastically reducing working capital.
17. JIT: Just in Time.
18. see von Bellow 1990, p129.
19. von Bellow 1990, argues that SA's pollution laws applying to mineral beneficiation are not much less strict than developed countries, but the enforcement of the laws is much more lenient (p132).
20. Sacob: SA Chamber of Business.
21. See for example Sacob 1991.
22. Sacob 1991, fig. 4.1.1.2.2.
23. van Blerck 1991.
24. van Blerck 1991.
25. Skilled (white) workers can always find another job. See BTI 1989, p6–14.
26. SA's geographic position is seen as an advantage for the location of a new large scale stainless steel plant by foreign investors, due to its equidistance from the markets (see section on stainless steel).
27. BTI 1989, figure 7.2.1.5.
28. LME: London Metals Exchange
29. Du Pont, Kerr McGee, SCM and Tioxide.
30. GATT: General Agreement on Trade and Tariffs.
31. Belli et al 1993.
32. Belli et al 1993, table 3.
33. BTI 1989, Figure 7.2.1.5.
34. Import duty + import surcharge + GST.
35. JSE: Johannesburg Stock Exchange.
36. Heinz Pariser, personal communication, February 1993.
37. JCI: Johannesburg Consolidated Investment Company.
38. CMI: Consolidated Metallurgical Industries.
39. Monitor Company, 1994.

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