SOUTH AFRICAN MINERALS
An Analysis of Western Dependence

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Preface

This issue in the series of Discussion Papers from the Scandinavian Institute of African Studies has been produced with the framework of the Southern Africa Programme, a joint initiative of the institute and the Swedish International Development Authority. The primary objectives of the programme is to strengthen Nordic research on southern Africa, to further links between researchers in the Nordic countries and in southern Africa, and, in addition, to provide information about southern Africa in the Nordic countries.

The present paper is a result of cooperation between the Scandinavian Institute of African Studies, the Raw Materials Group in Stockholm, and the Isolate South Africa Committee in Sweden. It has been particularly valuable to be able to use the unique and comprehensive data base of the Raw Materials Group for this analysis.

The Isolate South Africa Committee in Sweden publishes a condensed version of this paper in Swedish, in order to make the material available as widely as possible in the Nordic countries.

We hope that this Discussion Paper will stimulate discussion among non-governmental organisations, aid administrators, mass media, researchers, and others.

Bertil Odén
Coordinator for
the Southern Africa Programme
Abbreviations and measurements

Throughout the text, the SI unit system is used. The following abbreviations are used:

**Weight**
- kg, kilogram = 1,000 g
- t, metric tonne (ton) = 1,000 kg

**Prefixes**
- k, thousand (000)
- M, million (000,000)
- G, billion (000,000,000)

**Countries**
- UK, United Kingdom
- US/USA, United States of America
- USSR, Soviet Union
- FRG, Federal Republic of Germany
- SA, South Africa

**Currencies**
- SEK, Swedish crown
- DEM, West German mark
- GBP, UK pound
- USD, US dollar

**Other abbreviations**
- AAC, Anglo American Company
- BGS, British Geological Survey
- CSO, Central Selling Organization
- EIU, Economist Intelligence Unit
- GAO, (US) General Accounting Office
- GDP, Gross Domestic Product
- GNP, Gross National Product
- LDC, less developed countries
- MEC, market economy countries
- OECD, Organization for Economic Cooperation and Development (an organization for the Western market economies)
- OTA, Office of Technology Assessment, Congress of the United States
- RMG, Raw Materials Group (Stockholm)
- RTZ, Rio Tinto Zinc
- UNITA, União Nacional para a Independencia Total de Angola
- USBM, US Bureau of Mines
Introduction

One argument often used by opponents of sanctions against apartheid South Africa is that the market economy countries (MECs), particularly the industrialized MECs, are very dependent on imports of minerals from South Africa and that key industrial branches will grind to halt if the South African supply ceases. The argument is used both against sanctions on imports of the minerals as such and against sanctions in general, as the South African regime might counteract by prohibiting exports of strategic minerals.

Studies published during the 1980s, however, disagree on which minerals are to be considered critical, the degree of vulnerability, the concept of dependency, and other issues. While they use more or less the same statistics on production and trade, differing slightly over the years, their different conclusions are related to differing assumptions as regards e.g. price elasticity and its effects on substitution and recycling, use of strategic stocks, the South African control of transports in Southern Africa, the behaviour of the USSR, and the time perspective.

We therefore hope that a modest comparative analysis of some of the recent documents discussing the dependency of the outside world on South African minerals will also be of interest as an input in the ongoing discussion on sanctions against South Africa.

The outline of our study is as follows: The introduction containing a brief discussion on definitions and methodology is followed by a review of ten minerals claimed to be strategic. The chapter analyzes the world production and trade pattern and the position of South Africa, the main consumer countries and the role of South Africa in the present trade pattern.

The background material is used for a review in the following chapter of a number of recent reports on how dependent the industrialized market economies are. In this review we try to analyze what assumptions the conclusions of the reports are based on, as regards what minerals are critical, time perspective, demand and supply elasticity including recycling, substitution, alternative presently sub-economic sources and technological developments.

The following chapter briefly discusses the role of mineral exports for the South African economy after which we draw some tentative conclusions.
Mining and processing in the industrialized MECs are often carried out not by state organizations, but by private corporations. When we discuss South Africa in the field of world mining we are actually talking about a handful of large mining corporations.

Most of the statistics we use are taken from the data base of the Raw Materials Group (RMG) in Stockholm. This is one of the most comprehensive sources outside the mining companies themselves and we particularly hope that the information in the Appendixes will be of use to scholars and decision-makers specializing in the field of South African minerals.

To avoid misunderstanding and possible disappointment we should underline that, although the issue of mineral dependencies forms part of the international sanctions debate, we will not discuss the effects of sanctions on South Africa or the Front Line states. This is an analysis of its own, and is treated in a wide range of literature, which will not be dwelt upon in this study.

Our hypothesis is that studies commissioned by interests that are against sanctions are based on biased assumptions. These assumptions lead to the conclusion that industrialized market economies’ dependence on South African minerals is very strong. On the other hand, studies carried out by anti-apartheid, pro-sanctions organizations use different assumptions, leading to the conclusion that the dependence is weaker, and they concentrate on ways and means to counter it. Our own conclusion is that although the disruption of a few South African minerals, notably chrome and the platinum group metals, will create serious short- and medium-term problems, many of the documents on the issue tend to exaggerate the vulnerability of the industrialized market economies.

Two issues should be sorted out before we start the discussion. The first one is the different meanings of the concept of “dependence”, which sometimes confuse the debate, and the second one is the definition of strategic minerals, which varies considerably.

In the discussion of mineral dependency the distinction between what Keohane and Nye call sensitivity and vulnerability is essential (Keohane & Nye). Sensitivity, the short-term dependency without any changes in policy, is in this field closely related to the actual trade pattern. A large share of imports of a specific mineral equals a high degree of dependence.

In the medium- and long-term perspective, however, the important issue is not the share of total imports of a specific mineral at a given point of time, but the potential for responding to a major change in the pattern of supply. (KK 1981) In an extended perspective, the supply of many minerals from a specific country can be replaced in several ways. A mineral can be supplied from one or several other geographic sources, but also substituted by other minerals, and used more efficiently (e.g. recycled). As one US scholar said in a lecture on US dependency: “It is incorrect to identify import dependence per se as vulnerability. The real issue is how fast, how effectively, and at what cost can the US respond to import inter-
ruptions. Vulnerability is the residual damage incurred after you have done your damndest." (Shafer).

The term strategic minerals means different things to different people. Definitions vary and there are no hard and fast rules; at any one moment certain minerals can be classified as strategic, but classifications can change should substitutes become available or should technological change render particular uses obsolete. As a generalization, it can be said that strategic minerals are those essential for the continuance of modern industry and which come from supply sources that could possibly be restricted fairly suddenly for one reason or another. The combination of essential uses and vulnerable supplies decides whether a mineral is strategic or not.

A more narrow definition relates to minerals with specific application to military equipment, but in this report we use strategic in an economic rather than a military sense. Of course the time perspective is important in this definition. Today a country importing large quantities of a mineral from South Africa, and without strategic stocks, is very dependent in the short run, should disruption occur, but this is no indication of their capability to handle the situation in the medium- and long-term. With this terminology such a country is sensitive but not necessarily vulnerable.

Important factors when evaluating if a mineral produced in South Africa is strategic are i.a. the actions taken by the Soviet Union as this country in most cases is another important producer of the mineral; which countries are likely to introduce sanctions for a specific mineral; and if countries in the Southern African region such as Zaïre, Zambia and Zimbabwe are included in "South Africa" as most of their minerals are exported via South African harbours. Other important factors are the existence and possible use of stockpiles, recycling and substitution possibilities, price elasticity, and technological development.

A new concept launched by Jourdan is positive sanctions, by which is meant the conscious utilization and development of alternative supplies in the Southern Africa region.

The 10 minerals covered in this study are all exempted (=certified) in the US so-called Comprehensive Anti-Apartheid Act. This does not imply that we accept the concept of the South African supply of these minerals as being critical to the industry in the MECs. However, by including a greater number of minerals, we give the readers a chance to make their own assessments.

When defining "strategic minerals" we exclude both gold and uranium, although it could be argued that both of them are strategic. But gold is a very special case, strategic mainly in the sense that it generates around 40% of South Africa's export earnings. No one can argue that lack of South African gold output would force industries in the industrialized MECs to grind to a halt. (It would increase the price of gold on the market and create some turbulence in major financial spheres, but that is something
Uranium is highly strategic for the nuclear industry, but reports on strategic minerals still often exclude this mineral. The abandonment of construction plans for a large number of nuclear power plants during the 1980's has reduced world demand, which makes it easy to replace the South African supply, should it be cut off.
A Review of Ten "Strategic" Minerals

Chrome

The principal properties of chromium (Cr) are its ability to increase the hardness, strength, corrosion and wear resistance of steel and superalloys. Chromium is a vitally important material for the aerospace, chemical, power-generation and transportation industries. The most important application is stainless steel, which employs about 70% of all chromium metal.

Chrome supply

The main viable source of chromium metal (Cr) is chromite, which occurs in nature with varying percentages of chromium, iron, aluminium and magnesium oxides. The world reserves of chromite are estimated at 3,700 million tons (Mt), sufficient for 375 years of consumption at current levels. The known reserves are concentrated in southern Africa: South Africa has 75% and Zimbabwe 17%. (RMG)

South Africa is, along with the USSR, dominating the production scene, see table below. South Africa has strengthened its position from 26 to 36% of total world production between 1975 and 1988.

In 1987 2.2 Mt of the South African chromite production was consumed in South Africa, mainly by the ferrochrome industry, while about 1.5 Mt was exported.

All chromite for ferroalloy production is first converted into ferrochrome, which consists of iron, chrome and various grades of carbon, silicon, etc. This process requires large amounts of energy giving the advantage to countries with cheap electricity, such as South Africa, Norway and Sweden.

Based on the cheap electricity, suitable local coal and cheap labour, South African chromite producers could expand ferrochrome production in the 1970s. The expansion was a result of a conscious decision by the South African government including subsidies, tax concessions, low-cost loans and rebates. In the face of fierce competition and rising energy cost, many US, Japanese and European ferrochrome producers reduced capacity in the 1970s. This drastic change is visible in Table 1.
Table 1. *Major chromite and ferrochrome producing countries 1974–75 and 1988*

<table>
<thead>
<tr>
<th>Country</th>
<th>Per cent of total world production</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>9.4</td>
<td>6.4</td>
<td>-</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>2.1</td>
<td>5.3</td>
<td>2.6</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>-</td>
<td>-</td>
<td>6.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>6.4</td>
<td>6.5</td>
<td>0.8</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>-</td>
<td>-</td>
<td>29.1</td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>26.4</td>
<td>36.3</td>
<td>10.4</td>
<td>30.3</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>-</td>
<td>-</td>
<td>5.4</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>8.5</td>
<td>6.8</td>
<td>0.5</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>-</td>
<td>-</td>
<td>16.4</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td>26.6</td>
<td>27.7</td>
<td>9.9</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>7.5</td>
<td>4.8</td>
<td>9.7</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>13.0</td>
<td>6.4</td>
<td>9.5</td>
<td>21.0</td>
<td></td>
</tr>
<tr>
<td>Total, world</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Total (Mt)</td>
<td>7.84</td>
<td>11.70</td>
<td>1.86</td>
<td>3.30</td>
<td></td>
</tr>
</tbody>
</table>

Sources: BGS, RMG Data.

Three South African companies dominate the South African chromite and ferrochrome industry: Gencor, Barlow Rand and AAC. They all strengthened their positions in South Africa as well as on the world market, through acquisitions and expansions during the period. Only a minor share of the industry in South Africa is now controlled by foreign capital, since a US firm divested in 1988. Further expansions of chromite and ferrochrome production are planned, and the industry also has plans to integrate forward by building a stainless steel plant.

*Substitutes for chromium, and recycling*

Because of factors such as its relatively low cost and availability, chromium-containing steels, particularly stainless steels, are widely used, even in applications that do not require the superior performance provided by the high chromium content. There are many opportunities to use materials with reduced chromium or no chromium at all, but today there are few incentives for the private industry to replace stainless steel. (*OTA, 1985*)

According to a 1978 US National Materials Advisory Board Study, about 30% of chromium usage could be saved by functionally acceptable chromium-free substitutes currently available. An additional estimated 40% could be saved after 10 years of research and development. (*USBM, 1985; NMAB, 1978; OTA, 1985*)
About 15% of total US chromium consumption comes from secondary sources. Increased recycling is limited by a number of factors, mainly economic. (OTA, 1985)

**Dependence of the industrialized market economies**

The import dependence of chrome is high in all industrialized market economies, about 90%. Recent figures are difficult to obtain. South Africa’s share of chromite imports were 77% for the US (average 1983–86), 48% for the EEC (1983) and 47% for Japan (1983). South Africa’s share of ferrochrome imports were 55% for the US (average 1983–86), 50% for the EEC (1983) and 65% for Japan (1983).

No chromite is mined in the United States, and no domestic chromite production is viable over a 5-year period, the minimum time to start up a mine. Ferrochrome production in the US is currently only about 90 kt/year (see Table 1), but could be expanded to 270 kt if plants presently shut down could be reopened.

US Government stockpiles cover a 3-year supply of chromite and a 1.5-year supply of ferrochrome not including privately held inventories.

Apart from South Africa, other suppliers of chromite to the US include Finland, the Philippines and Turkey. Suppliers of ferrochrome include Brazil, Sweden, Turkey and Zimbabwe.

Other suppliers to the EEC are Zimbabwe 10%, Albania 13%, Turkey 5% and the USSR 2%.

All chromite consumed in Sweden is imported. From 1987, imports of chrome from South Africa are banned by the Swedish government. In 1986 imports came from Finland 40%, Albania 22%, the US 20%, Turkey 8% and South Africa 2%. In 1985 the South African share was 12%. However, as stated above, no chromite is mined in the US, consequently the US’ share must consist entirely of reexports, quite possibly of South African ore. The Swedish ferrochrome industry claims that it has to pay up to 100% more for Turkish and Albanian chromite than for South African. Sweden is a net exporter of ferrochrome. However, 46 kt was imported in 1984, 50% from SA.

**How sanctions hit**

In the event of a US embargo on South African chromium, a trade pattern adjustment could occur, permitting exports to the US to continue uninterrupted. It is estimated that a threefold increase in the price of chromium would occur in the event of a total worldwide cut-off of South African chromium. This would make many of the world’s subeconomic resources profitable to extract. It would only result in a 13 to 15 percent cost increase of stainless steel. The average cost to the US economy is estimated at 30
million USD/year. The US steel industry has strongly disagreed with the conclusions of USBM, emphasizing that any trade pattern adjustment would take 3–5 years. (US GAO, Sept 1988; South Africa: Time running out, 1981; USBM, 1988 pp 1–30)

As regards South African ferrochrome exports, the two authors of The Sanctions Handbook, Hanlon and Omond, argue that a sudden cut would create some disruption, particularly as stainless steel producers and users would have to modify the processes. The loss of South African exports would cause ferrochrome prices to jump, which would impose some costs on the MECs. “But the higher prices, combined with reasonable alternative supplies, would mean that market mechanisms should sort out ferrochrome and steel supplies. Thus sanctions against South African chrome would not cause a crisis in the West.” (Hanlon and Omond)

Only the USSR is considered to have the capacity to temporarily increase the supply in the case of an embargo, however, this is not sufficient to cover the shortfall from SA. A study made by the West German government concluded that the German GDP in the case of an embargo would fall by 20% resulting in the unemployment of 2 million. (Kääkönen et al 1984; CEE, 1985)

Positive sanctions

Zimbabwe possesses 17% of world chromite reserves, about 560 Mt. The reserve base is estimated a 3–10 Gt, corresponding to several hundred years of world consumption at current levels (Jourdan, 1988). The country’s chromite mining and ferrochrome production is entirely in the hands of two transnational companies, the US firm Union Carbide and the South African giant AAC. The ore is high grade chromite in narrow seams making it somewhat difficult to mine. This could provide an ideal opportunity for applying positive sanctions whereby the embargo on supplies from South Africa is compensated for by developing a mining method for the Zimbabwean chromite seams. A USBM report estimates the Zimbabwean chromite mining capacity to be about 1 Mt/year (0.59 Mt 1988). This is enough to replace the US’ current supplies from SA. (USBM 1981)

Presently a large percentage of chromium products from Zimbabwe is exported via South African railroads. USBM consequently does not consider chromium from Zimbabwe to be available for the US market in the case of an embargo. Upgrading of the railroads to the Mozambican and Angolan ports is therefore another opportunity to apply positive sanctions. (P Jourdan, Univ. of Zimbabwe, Nov. 1988)
Platinum metals

The platinum group metals include six noble metals with unparalleled physical and chemical properties. These metals, of which platinum, palladium and rhodium are the most important, normally occur in association. Their most important properties are resistance to high temperatures and chemical attack, extraordinary catalytic abilities, and high thermal and electrical conductivity.

Catalytic converters consumed about 37% of total platinum and about 75% of total rhodium in 1988, but only 8% of total palladium. Jewellery and investment consumed as much as 50% of total platinum, mostly due to the metal's popularity in Japan. Major uses for palladium in 1988 were electrical (51%) and dental (30%).

Supply of platinum

The world reserves of platinum group metals are estimated at 37 kt, sufficient for 175 years of mining at current levels. About 80% is concentrated in South Africa, the USSR possesses 17% and Zimbabwe 3%. In South Africa and the US platinum group metals are mined as primary minerals, while all other suppliers mine platinum group metals as by-products, mainly with nickel and copper. Thus, only the South African and US producers can plan the production of platinum group metals according to the market situation.

Table 2. Major platinum group metals producing countries 1975 and 1988

<table>
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<tbody>
<tr>
<td>Canada</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>6e</td>
<td>4e</td>
</tr>
<tr>
<td>South Africa</td>
<td>62</td>
<td>67</td>
<td>25</td>
<td>27</td>
<td>59e</td>
<td>46e</td>
</tr>
<tr>
<td>USSR</td>
<td>33</td>
<td>28</td>
<td>68</td>
<td>66</td>
<td>35e</td>
<td>50e</td>
</tr>
<tr>
<td>Others</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Total, world</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total (t)</td>
<td>88</td>
<td>117</td>
<td>83</td>
<td>123</td>
<td>5e</td>
<td>18e</td>
</tr>
</tbody>
</table>

e = estimate
Sources: BGS; USBM, 1985; RMG Data.

The distribution of platinum group metals in the South African ores is about 60% platinum and 25% palladium. In the Soviet and US ores, the relation is the opposite, while the Canadian ores hold approximately equal shares (45%) platinum and palladium. The rhodium content is about 4%
in all but the US ores. (SA Yearbook 1987; RMG 1983; Swedish Geological Survey 1989)

Platinum and palladium are mined in nearly equal amounts, about 120 t/year. Rhodium production has grown the fastest and was in 1988 about 18 t. As can be seen in the table above, South Africa and the USSR dominate world production almost entirely. South Africa’s position is strongest in platinum. The USSR exported 13 t of platinum and 55 t of palladium to the market economies in 1988.

The corporate concentration in the production of platinum group metals is among the highest of all minerals. Two South African companies, AAC and Gencor, controlled over 90% of South Africa’s platinum group metals production in 1988. (RMG) All South African producers are fully integrated and both the mining and the refining capacities are being increased. Mine production is projected to increase by more than 30% from 1989 to 1994.

In the market economies, the South African market shares of platinum and rhodium are both 80%. New environmental legislation is steadily increasing the use of catalytic converters and consequently also of platinum and rhodium. The US and Japan have put legislation into practice from the early 80s, Sweden and Switzerland from 1989. The EEC has recently decided on legislation. (Swedish Geological Survey 1989:1; Metals and Minerals Annual Review 1989; Engineering News, South Africa, Oct. 10, 1987; USBM 1988)

Substitutes and recycling

For catalysts in the automobile industry there is no substitute for platinum group metals. However, recycling is rapidly increasing, and a US report estimates that about 70% of the US consumption could be recycled. 40% of all platinum group metals are sold as jewellery or speculative stockholdings. These substantial reserves correspond to several years of South African production. In the situation of an embargo, a crucial point is whether they will be available to the industry.

US automobile manufacturers have recently reported on the development of a new catalyst utilizing palladium instead of platinum. If a palladium-based catalyst could replace the platinum-rhodium catalyst, the dependence on South Africa would be reduced, while the dependence on the USSR would increase. In 1987 the USSR supplied 48% of total palladium, South Africa 30% and Canada 4% to the market economies. The US domestic supply of palladium is relatively high, 12% of US demand from 1987. The current palladium price is about 30% of the platinum price and only about 10% of the rhodium price.
Dependence of the industrialized market economies

The United States' platinum consumption in 1986 was 30 t. The US automobile industry used about two-thirds of this. South Africa supplied 86%, USSR 3% and Canada 5%. The remaining 5% was provided from secondary recovery of catalytic converters. The share of secondary platinum has the potential for a rapid increase. The US government platinum stocks amount to about one year's consumption.

The US consumption of rhodium was about 3 t in 1986 or about half of the market economy consumption. Most of the rhodium came from South Africa.

Car manufacturers in Western Europe and Japan import all their needed platinum group metals mainly from SA. A total embargo on platinum group metals from South Africa would drastically reduce the production of three-way catalysts based on platinum and rhodium. However, many countries have stockpiles to cover a few months of embargo.

There is no mining of platinum group metals in Sweden. Imports are about 3 t/year of processed platinum, including imported auto catalysts. Only small quantities of other platinum group metals are imported. In 1988 the suppliers were Switzerland (46%), the US (15%) and West Germany (15%). The platinum probably originated from South Africa.

Effects of platinum sanctions

The US Bureau of Mines recently calculated the direct costs of a minerals embargo for the US economy amounting to 1.85 billion USD per year, the dominant part of which refers to two platinum group metals, namely platinum and rhodium. In case of a unilateral US embargo of South Africa platinum the USBM estimates a price increase of 466% over a five-year period, or 1,355 million USD/year. According to USBM there is insufficient non-SA rhodium to meet the US demand in the event of a US embargo. This would cause a 824% price increase on rhodium over a five-year period, or 384 million USD/year. The rhodium consumption in other industries than the automobile industry would have to be reduced. (USBM, 1988, p. 1–19) These figures are used by the General Accounting Office in its evaluation of the cost of an import ban of the minerals excluded from the Sanctions Act.

In another study by the Bureau of Mines the total impact (including secondary effects, etc.) on the GNP of an embargo on the platinum group metals is calculated to around 60 billion USD per annum. This report estimates a 25% shortfall of rhodium in the auto catalyst sector the two first years of the embargo causing a US production shortfall of 2.9 million catalysts/year. The report then goes on to make the surprising conclusion that this would somehow cause a drop in automobile production, which production of vehicles would decline by 2.3 million units causing a GPM
loss of 12 billion USD and the unemployment of 206,000. (USBM, 1988, p. 1–7)

Both of these studies are heavily criticized by Wright (1989). He points out that they assume that the sales of platinum group metals from the Soviet Union cannot be increased, and that neither study presents any justification for this assumption. Wright also argues that neither study considered the possibility of additions to supply resulting from domestic production incentives or technological changes.

Wright’s arguments to support his criticism are i.a. that the platinum group metals exports from the Soviet Union increased every year from 1982 to 1986 and that Soviet sales are determined more by a desire to obtain convertible currency than a response to market prices. He also argues that domestic production incentives can be introduced and the fact that the USA presently exports rhodium and catalytic converters, and that recent technologies have resulted in a new system for recovering precious metals from scrapped converters. A further argument is that converters containing rhodium (the main supply problem) have only been utilized in the USA since 1980 and since the average life of a car is about 9–10 years these converters will now be returning to the market. Still another argument of Wright is that Zimbabwean output could be increased.

Wright concludes that the Bureau of Mines’ calculations of the costs of a platinum group metals embargo are highly exaggerated, as they are based on unrealistic assumptions. He suggests an embargo on all of South Africa’s strategic minerals as soon as possible. By not excluding the platinum group metals he goes further than any other study in his recommendations.

Positive sanctions

According to USBM estimates, Zimbabwe possesses 3% of the world’s platinum group metals reserves. However, according to other estimates, the Zimbabwean share is much higher, about 20% (Jourdan 1988). The reserves are of lower grade than the South African reserves. Positive sanctions would include helping Zimbabwe exploit the reserves. Several feasibility studies have been carried out. One project which could produce 3 t platinum annually by the end of 1992.

Manganese

The principal use of manganese – about 90% – is in steelmaking and is used in virtually all steels and cast irons. The importance of manganese in the steel industry stems from the function it performs as a desulfurizing, deoxidizing and/or alloying element and from its chemical properties.
Manganese is normally added to the steelmaking process in the form of ferromanganese and silicomanganese alloys.

**Manganese supply**

Manganese is one of the more abundant elements in the world's crust, but very few manganese concentrations are economically exploitable. According to the USBM, 41% of total world reserves are found in South Africa and 37% in the USSR. These two together with seven other countries possess 99% of the world reserves of 5,400 Mt, sufficient for 210 years of consumption at current levels. In addition to these reserves there are extensive deep sea resources.

<table>
<thead>
<tr>
<th>Country production</th>
<th>Per cent of total world production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>6.5 8.8 1.1 1.8</td>
</tr>
<tr>
<td>Brazil</td>
<td>8.4 7.4 2.0 6.4</td>
</tr>
<tr>
<td>China</td>
<td>4.2 7.1 na 12.2</td>
</tr>
<tr>
<td>Gabon</td>
<td>9.2 9.7 na na</td>
</tr>
<tr>
<td>India</td>
<td>6.4 5.8 2.6 3.2</td>
</tr>
<tr>
<td>Japan</td>
<td>- - 19.0 7.9</td>
</tr>
<tr>
<td>Norway</td>
<td>- - 9.3 8.4</td>
</tr>
<tr>
<td>South Africa</td>
<td>24.5 15.2 6.4 11.6</td>
</tr>
<tr>
<td>USA</td>
<td>- - 11.9 1.9</td>
</tr>
<tr>
<td>USSR</td>
<td>6.8 40.5 17.3 16.8</td>
</tr>
<tr>
<td>Others *</td>
<td>4.0 5.5 30.4 29.8</td>
</tr>
<tr>
<td>Total, world</td>
<td>100.0 100.0 100.0 100.0</td>
</tr>
<tr>
<td>Total (Mt)</td>
<td>24.0 22.7 5.6 5.4</td>
</tr>
</tbody>
</table>

*most importantly FRG, France, Italy, Spain and the UK
Sources: BGS, RMG Data.

Table 3 above shows that South Africa's role as a leading ore producer has deteriorated, while its position as a ferromanganese producer has improved. The table also reflects the dramatic shift in the ferroalloy market from i. a. US and Japanese ferroalloy producers to the production of ferroalloys in many ore producing countries. The South African manganese industry is almost entirely controlled by two South African companies, Gencor and Anglovaal, and the giant US steel producer USX Corporation.
Table 4. *Major cobalt producing countries 1975 and 1988*

<table>
<thead>
<tr>
<th>Country</th>
<th>Per cent of total world production</th>
<th>Mine cobalt</th>
<th>Refinery cobalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
<td>7.4</td>
<td>9.0</td>
</tr>
<tr>
<td>Botswana</td>
<td></td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td>4.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Cuba</td>
<td></td>
<td>5.2</td>
<td>5.1</td>
</tr>
<tr>
<td>N Caledonia</td>
<td></td>
<td>5.8</td>
<td>5.1</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td>1.2</td>
<td>1.9</td>
</tr>
<tr>
<td>USSR</td>
<td></td>
<td>5.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Zaïre</td>
<td></td>
<td>52.9</td>
<td>41.0</td>
</tr>
<tr>
<td>Zambia</td>
<td></td>
<td>9.0</td>
<td>15.4</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td></td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>8.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Total, world 100.0 100.0 100.0 100.0
Total (kt) 32.9 39.0 22.0 26.9

Note: Belgium’s only refiner of cobalt does not report production, which is substantial. Much of the metal recorded under Zaïre is believed to be further processed in Belgium.

Sources: BGS, RMG Data.

*Substitutes and recycling*

Various other ferrous metals and, in a wider perspective, advanced materials can replace cobalt – fully or partially – in many applications, although in some cases accompanied by some loss in effectiveness. The potential for increased recycling is significant.

*Dependence of the industrialized market economies*

The US depends on imports for about 85% of its cobalt demand. The main suppliers from 1981–85 were Zaïre 34% and Zambia 19%.

Most of the production from Zaïre is transported via South African ports. This is the reason why the US considers cobalt to be a strategic mineral. It could be questioned whether this is correct since there are alternative routes. The fastest is the railroad to the Angolan port of Lobito, but due to UNITA attacks this route has been closed since 1975. A second is to Dar-es-Salaam in Tanzania.
National stockpiles are kept by the US, UK, Germany, France and Japan. The US National Defence Stockpile (GSA) is currently 23 t, covering 3 years of imports.

There is no mining of cobalt in Sweden. In 1988, 580 t was imported, of which 25% came from Zaïre and Zambia. There were no imports from South Africa.

Effects of sanctions

In spite of the small volume involved, the USBM considers the alternate route via Dar-es-Salaam too congested to be considered realistic. The cost of flying the deliveries from Zaïre to the US is estimated at 4 million USD/year, which would add about 10% to the price.

If an embargo would affect the export of cobalt from Zaïre and Zambia, it is assumed that Sweden would turn to alternative suppliers.

Positive sanctions

Improving the regional transport system would increase the reliability of cobalt transport to the western countries. There are several improvements that should be done. These would include upgrading of the railroads to Lobito and Dar-es-Salaam and help in ending the disturbances from UNITA attacks.

Vanadium

Vanadium is primarily used as an alloying agent in steel production. The addition of small amounts of vanadium to steel can significantly improve its strength, toughness and ductility. Its major uses are in highrise buildings, bridges, pipelines and automobiles.

Vanadium supply

Vanadium is mainly obtained as a by-product of iron and uranium mining, but also out of slag from steel processing. In the 1980s, Venezuelan crude oil has become an increasingly important source. South Africa possesses about 50% and the USSR 45% of the world vanadium reserves, vanadium in crude oil excluded.

South Africa normally accounts for 35-45% of world production. The vanadium produced in the USSR is normally consumed within the centrally planned economies. China exports an average of 4 kt of concentrates and residuals and 2.2 kt of vanadium pentoxide per year in 1983-85. The
world vanadium mining industry is dominated by the South African giant Anglo-American Corporation (AAC).

Table 5. Major vanadium producing countries 1975 and 1988

<table>
<thead>
<tr>
<th>Country production</th>
<th>1975</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>-</td>
<td>11.4</td>
</tr>
<tr>
<td>Namibia</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td>Finland</td>
<td>4.7</td>
<td>-</td>
</tr>
<tr>
<td>South Africa</td>
<td>39.6</td>
<td>47.0</td>
</tr>
<tr>
<td>USA</td>
<td>16.0</td>
<td>14.3e</td>
</tr>
<tr>
<td>USSR</td>
<td>33.6</td>
<td>27.4</td>
</tr>
<tr>
<td>Total, world</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total (kt)</td>
<td>26.8</td>
<td>35.1</td>
</tr>
</tbody>
</table>

e = estimate

Sources: BGS, RMG Data.

Substitutes

Steels containing various combinations of other alloying ingredients, as well as heat-treated carbon steels, can be substituted for steels containing vanadium. Molybdenum, tungsten and niobium are among the substitutes.

Dependence of the industrialized market economies

The United States consumed an average of 5.0 kt/year of contained vanadium during the 1984–86 period. Domestic recovery of vanadium as a by-product from uranium mining covered a significant part of the US consumption until the mid-1980s when uranium production became uneconomic. The US produced on average 2.0 kt/year of vanadium from oil residuals in the 1984–86 period or 40% of domestic consumption.


For the EEC, an embargo on South African vanadium would cause difficulties in the short term until the market is adjusted according to an EEC report in 1985.

Sweden imports all its needs of vanadium. There has been no direct import from South Africa after 1985, but secondary imports of refined products are coming mainly from central Europe.
Sweden possesses subeconomic resources of vanadium in iron ore, in slag from steel industry and in shales. If needed, production of vanadium could start fairly soon based on the slag products. It is estimated that the slag products alone would be sufficient for a production of 4 kt/year of contained vanadium.

**Effects of Vanadium sanctions**

The vanadium world market is considered fairly insensitive to an embargo. China is a potential supplier in case of an embargo. It is estimated that the market adjustment would add 20% to the price, at a cost of about 7 million USD/year to the US economy. *(USBM, 1988, p. 1-43)*

A Swedish study *(Kommerskollegium, 1981)* finds that the comparatively important role of South Africa as a supplier of vanadium is due to marginal price advantages, and that no serious concern for the supply of vanadium could be found.

*Hanlon and Omond* point out that vanadium and molybdenum often are interchangeable and that the steep increase of the price of molybdenum in 1979 increased the demand for vanadium. When the price of molybdenum dropped again, re-substitution took place.

**Titanium**

**Uses**

Rutile (titanium dioxide) and ilmenite (iron-titanium oxide) are the raw materials for the manufacture of titanium metal and of white pigments used for colourant in paints, paper, plastics, etc. Titanium metal is used in aerospace applications because of its high strength-to-weight ratio, and resistance to heat and corrosion. About 85% of the combined rutile-ilmenite production is used for TiO2 pigments, and only 13% for titanium metal.
Supply

Table 6. Major titanium producing countries 1975 and 1988

<table>
<thead>
<tr>
<th>Country</th>
<th>Per cent of total world production</th>
<th>Titanium ores</th>
<th>Titanium sponge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>36</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>21</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>Norway</td>
<td>9</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Japan</td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>South Africa</td>
<td>0</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>USA</td>
<td>15</td>
<td>4e</td>
<td>21</td>
</tr>
<tr>
<td>USSR</td>
<td>6</td>
<td>6</td>
<td>59</td>
</tr>
<tr>
<td>Others</td>
<td>13</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Total, world</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total (kt)</td>
<td>1 495</td>
<td>2 600</td>
<td>59</td>
</tr>
</tbody>
</table>

e = estimate

Sources: BGS, RMG Data.

The largest reserves of rutile and ilmenite are either sand deposits found in Australia and South Africa or rock deposits found in Canada and Norway. Australia is the largest producer, followed by Canada and South Africa. There is only one titanium ore producer in South Africa, Richards Bay Minerals, which is controlled by RTZ Corp of the UK and Gencor of South Africa. Operations started in 1977. Recent capacity expansions will further increase South Africa’s production share.

For the manufacture of titanium metal, rutile is processed into titanium sponge.

Substitutes

There is no satisfactory substitute for titanium in aerospace applications. There are a number of subeconomic resources around the world. Significant beach sand resources exist in Malawi, Mozambique and Tanzania, and are being investigated, among others, in a SADCC regional study. *(UNRFRE, 1988)*

Dependence of the industrialized market economies

During the 1984–86 period, the United States imported an average of 260 kt of titanium-bearing slag per year, of which 36% came from South
Africa. The US also imported 135 kt of natural rutile, of which 22% from South Africa.

In the event of an embargo a trade pattern adjustment would occur. The annual cost for the US economy was estimated at 32 million USD/year. (*USBM, 1988, p. 1–38*)

**Antimony**

Antimony is a silvery white, brittle crystalline solid with poor electrical and heat conductivity properties. It is mainly alloyed with lead for use in batteries, as a flame retardant, cable coating and solder.

Nearly half of the world reserves are situated in China. Bolivia, USSR and South Africa possess about 5% each. There is only one antimony producer in South Africa, Consolidated Murchinson Ltd, which is controlled by AAC. Its position has drastically deteriorated in recent years.

**Table 7. Major antimony producing countries 1975 and 1988**

<table>
<thead>
<tr>
<th>Country</th>
<th>Share (%) of total world mine production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1975</td>
</tr>
<tr>
<td>Bolivia</td>
<td>22.4</td>
</tr>
<tr>
<td>China</td>
<td>15.3</td>
</tr>
<tr>
<td>South Africa</td>
<td>21.9</td>
</tr>
<tr>
<td>USSR</td>
<td>10.4</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>0.4</td>
</tr>
<tr>
<td>Others</td>
<td>29.6</td>
</tr>
<tr>
<td>Total, world</td>
<td>100.0</td>
</tr>
<tr>
<td>Total (kt)</td>
<td>71.9</td>
</tr>
</tbody>
</table>

Sources: BGS, RMG Data.

As a battery alloy antimony can be substituted by calcium, strontium, tin, copper and others. As a flame retardant it can be substituted by boron, bromine and others.

The United States imported an average of 59% of its consumption in 1983–85. China was the largest supplier of antimony metal (48%), and Bolivia the largest supplier of ores and concentrates (45%). South Africa was the main source of antimony oxide (36%). Alternative suppliers to South Africa are China, USSR, Bolivia and Mexico. The US Bureau of Mines believe that the economic effects of a US embargo on antimony would be small.
The Swedish consumption of antimony amounted to 112 t in 1988, all imported from China. Antimony is not considered as a critical mineral for Sweden.

Andalusite

Andalusite is an alumino-silicate together with kyanite and sillimanite. They are mainly used in the manufacture of refractory (heat resistant) bricks for metallurgical furnaces. The total world consumption is about 300 kt/year.

The United States accounts for 25–30% of world production, South Africa 30%, USSR and India about 10–15% each. All of these countries possess large reserves.

In most applications andalusite can be substituted by synthetic mullite. The US production of synthetic mullite adds another 50% to the volume of the US production of natural kyanite.

Andalusite and sillimanite were imported by the United States from South Africa on an average of 5.2 kt in 1984 and 1985.

The USBM believes that the economic effects of a US embargo on andalusite would be small (USBM, Open File Report 19–88.) The US refractory industry admits that it could return to the use of bauxite and clay, although some increased costs would be incurred.

In 1977 Sweden imported 33% of its needs of andalusite from South Africa. Imports from South Africa have been banned since 1987. Andalusite is not considered as a critical mineral. Kyanite, which can replace andalusite, has been produced in Sweden for several years.

Chrysotile asbestos

Asbestos is a name applied to a number of naturally fibrous minerals, of which the most important is chrysotile. Chrysotile, in turn, is grouped into a large number of grades. Its principal uses are in asbestos cement pipe, flooring and roofing products and friction products (such as brake linings).

"Zimbabwe is currently the only source of this grade asbestos in the world. The other major suppliers, Canada and South Africa, could mine this grade in the future but this has not been documented. Zimbabwe is heavily dependent on South Africa for transport of this asbestos through South African transportation routes, as only a very small portion is shipped via Mozambique ..." This is the US State Department’s motive of why chrysotile asbestos is placed on the certification list.

In 1986 the US imported 102 kt of chrysotile asbestos of which 99% from Canada and 9 t (!) from Zimbabwe. The US General Accounting
Office proposes that chrysotile asbestos could be transported by air freight in the event of an embargo. *(US GAO, Sept 1988, p. 45)*

**Industrial diamonds**

Industrial diamonds constitute the hardest known material and are used for grinding, sawing, drilling and turning of hard metals and stones. There is insufficient information on the known world reserves of diamonds and their distribution into industrial quality and gem stones. The largest reserves are found in Australia, Zaïre, Botswana, South Africa, Namibia, Angola, the USSR and Brazil.

The world production of natural diamonds amounted to about 90 million carats (Mct) in 1988. The huge Australian diamond pipes came into operation in 1985 increasing world production by 50%.

About 9% of total world diamond production is carried out in South Africa. Botswana’s share is about 16%. A high proportion of the diamonds from Botswana and South Africa is of gem quality while most of the diamonds from Australia, Zaïre and the USSR are of industrial grade. Synthetic diamonds, not included in the above figures, are manufactured in the US, Ireland and Sweden.

BGS estimated that the United States imported a total of 25 Mct in 1986 of natural diamonds including 16 Mct for industrial use. Of the industrial diamonds 29% (4.7 Mct) came from South Africa.

One reason why the US State Department has included industrial diamonds on the list of certified minerals might be that a South African company, De Beers Consolidated Diamond Mines, has a virtual international marketing monopoly via its subsidiary, the Central Selling Organisation (CSO) in London. It can be argued whether or not CSO could refuse to sell production from other countries than South Africa to the US. It seems possible that other countries would bypass CSO and sell direct to the customer.

Apparently there are a number of alternative suppliers in case of an embargo, except for a particular form of an industrial diamond type II-B which has an unique defence application. The USBM believes that the economic effects of a US embargo on industrial diamonds would be small.

**Sweden and the South African minerals**

More than 100 minerals were covered in a study made for the Swedish government in 1981 on the country’s dependence on South African minerals for its supply of raw materials. Ten of these minerals were studied more in detail. The study was updated in 1985. One major conclusion drawn from these studies was that Sweden was dependent on South
Africa for only a very few minerals, all of which could also be supplied from alternative sources.

In May 1987 the Swedish Parliament passed a law on a trade boycott of South Africa which came into effect in October the same year. Since then there has been no direct import of minerals to Sweden from South Africa.

However, imports of minerals via a third country were not covered by the boycott law. Ferromanganese has been imported from Norway with manganese ore of South African origin. Chromite ore, of South African origin too, has probably been imported to Sweden, since the exporting country, the United States, does not have chromite mining of its own. Automobile catalysts with platinum metals are imported from Germany, England, and the USA. The platinum metal components in these almost certainly origin from South Africa.

Summary

Table 8 summarizes the South African share of total world production of the minerals reviewed in this chapter. A subjective indication of the potential for supply diversification, based on an OTA study (see bibliography), is also shown in the table. The time lag for such diversifications to be implemented differs considerably between the minerals.

Table 8. South African share of total world production in 1987 and 1988

<table>
<thead>
<tr>
<th>Mineral</th>
<th>1988 share (%)</th>
<th>Potential for supply diversification.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ore</td>
<td>Metal</td>
</tr>
<tr>
<td>Chrome</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>Palladium</td>
<td>27</td>
<td>..</td>
</tr>
<tr>
<td>Platinum</td>
<td>67</td>
<td>..</td>
</tr>
<tr>
<td>Manganese</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Vanadium</td>
<td>47</td>
<td>..</td>
</tr>
<tr>
<td>Cobalt</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>(Cobalt, Zambia)</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>(Cobalt, Zaïre)</td>
<td>41</td>
<td>38</td>
</tr>
<tr>
<td>Titanium</td>
<td>14</td>
<td>-</td>
</tr>
</tbody>
</table>


As can be seen from Table 9 below, the dependency on "South Africa" as regards six minerals more or less boils down to dependency on two mineral conglomerates, the Anglo American Corporation, AAC, and Gencor, owned by South African National Life.
Other companies with substantial production of one of the minerals are Barlow Rand (chromite), nowadays owned by South Africa Mutual Life, Vametco (vanadium) and Anglovaal (manganese).

Table 9 shows the companies' shares of total world production of six important strategic minerals. AAC's and Gencor's dominance is highlighted. It can also be seen that the South African companies' share increased during the 1975-88 period for most of the minerals.

Table 9. South African companies' control of market economies mine production in 1975 and 1988 (in per cent)

<table>
<thead>
<tr>
<th></th>
<th>Chrome</th>
<th>Cobalt</th>
<th>Manganese</th>
<th>Platinum</th>
<th>Titanium</th>
<th>Vanadium</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAC</td>
<td>1988</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>48</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>52</td>
<td>1</td>
</tr>
<tr>
<td>Anglovaal</td>
<td>1988</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barlow Rand</td>
<td>1988</td>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gencor</td>
<td>1988</td>
<td>20</td>
<td>1</td>
<td>12</td>
<td>38</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>1988</td>
<td>42</td>
<td>8</td>
<td>25</td>
<td>86</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>26</td>
<td>4</td>
<td>12</td>
<td>78</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: RMG Data.
Historical perspective on supply cut-offs

In the years since the Second World War, supplies of several critical materials have actually been cut off quite abruptly on a few occasions. It is instructive to look at the reasons why the cut-offs occurred, how the economy and defense industries coped with the shortages, and how the imbalance of supply and demand was eventually corrected.

A report from the OTA in the US (OTA, 1985) analyzes four instances when US imports of critically needed materials were interrupted during the last four decades.

The first occurred in 1949 when, in a Cold War exchange of trade restrictions with the US, the USSR stopped the export of chrome and manganese ores to the US. The USA at that time depended upon USSR for 47% of its total chrome consumption, 31% of its manganese consumption and 57% of its platinum consumption.

The second interruption was the US boycott of chrome from Rhodesia (now Zimbabwe).

The third was a many months hiatus in the import of nickel from Canada as a result of a prolonged strike.

The fourth was a result of political disturbances in Zaïre, the so-called Shaba rebellion, which triggered major disruptions in supplies, inventories and prices for cobalt, although cobalt production was not actually reduced.

Both the first case, the USSR embargo on chrome and manganese in 1949 and the second case, the US embargo on imports of Rhodesian chrome in 1966–71 were politically motivated supply cut-offs. In neither of these cases were there serious effects on the US economy or any interruption of US defense production. The US response to both instances was, essentially, to find other foreign sources of supply.

After 1949, the US government was active in finding alternative suppliers and in upgrading the infrastructure of these suppliers by providing steel to improve i. a. the rail transport systems in India, South Africa and Ghana.

During the US embargo on Rhodesian chrome, the US government sold excess chrome from the national stockpile, but otherwise took little active part, leaving industry to find alternative suppliers. Industry was able to do so quite readily, due to several factors: The USSR promptly volun-
teered to serve as an alternate supplier, despite its opposition to the US war in Vietnam. Increasing prices drew other suppliers, such as Turkey and the Philippines into production. And the embargo leaked: France, Japan and Switzerland bought what was probably Rhodesian chrome from South Africa and Mozambique. Another important factor was a change in stainless steelmaking technology, which widely adopted the argon-oxygen decarburization process. This process made it possible to use high-carbon ferrochrome made from South African chromite in place of the more costly low-carbon ferrochrome from Rhodesian ores.

The third case, the 1969 nickel strike in Canada differed from the politically inspired embargoes described above in at least one important way: it caused actual shortages and acute price hikes. The strike occurred at a time of strong demand and tight supplies, and Canada was almost the sole supplier of nickel to the US. Even so, military and essential civilian production continued without interruption throughout the shortage. By 1970, world nickel prices were back to normal and supplies were ample.

The shortages and high prices elicited changes in the behaviour of US nickel users. They substituted other materials where they could, for example replacing nickel stainless steel with chromemanganese stainless steel, and many users turned to nickel recycled from scrap. And once more, the USSR supplies to the West increased. An important factor in recovering from the acute nickel shortage was the US government’s release of a large quantity of nickel at the end of the strike.

During the fourth case, the cobalt “shortage” of 1978–79, there was never any real interruption of supply. On the contrary, production in Zaïre and Zambia rose significantly in both years. But the combination of rapidly increasing world demand and fears of a supply cut-off, triggered by a rebel invasion of Zaïre’s mining region, set off a wave of panic buying. During the cobalt “shortage”, cobalt users turned quickly to substitutes and recycling. Under the spur of high prices, nonessential uses made way for essential.

Summing up, none of these four cases resulted in severe or long-lasting damage to the US. Technology provided an important means of responding to interruptions of supply in each of the examples. This is an important argument against all who emphasize negative consequences for the Western economies from an embargo on South African minerals.

However, there are some differences when comparing with the sanctions against South Africa, which makes the issue a bit more complicated. In 1949, small producers such as India and Turkey were capable of expanding their production to replace USSR supplies of chrome and manganese; today they are not. Nor are there any major new technologies in stainless steelmaking opening up new types of ore for exploitation, as the argon-oxygen decarburization process did for South African chrome ore.
A comparative analysis of some recent reports

We are now prepared to compare assumptions – explicit and implicit – and conclusions in some recent studies on the dependency of the MECs on South African minerals. Most of the studies have been referred to in Chapter 3. However, they could not be systematically compared in that chapter, as it was structured by mineral. This chapter will be structured according to issues, allowing a systematic comparison.

Our selection of documents is influenced by the fact that most of the studies deal with the US dependence and are carried out by US institutions/researchers. The reason for this US dominance, we believe, is simply that the argument of the vulnerability to cuts of imports from South Africa has played a more important role in the US than in other countries, and at the same time the important role of the US as a buyer of South African minerals increases this country’s interest in South Africa.

Europe and Japan often take a larger share than the US of their imports of chrome, ferrochrome, manganese and platinum group metals from South Africa. The strategic stockpiling of those minerals are considered to be smaller in Europe and Japan, which would put them in a weaker position than the USA. The number of (open) studies available for Europe are smaller, and for Japan they are so scarce that we have not found any. In the case of Japan this might be related to a reluctance on both sides in the South African–Japanese trade relations to make statistics public.

Thus, our choice of material is not at all comprehensive. Still we believe it is far-reaching enough to cover all of the main arguments raised in the debate on sanctions against South African minerals. It should be noted, however, that the point of departure for some of the studies are not international sanctions, but curtailment of supply from South Africa for other reasons, including decisions by the South African regime.

The reports we use

A few introductory remarks on some of the main studies we have used might be useful. A number of them are included in the matrix on the opposite page, which in a schematic way summarizes the way the studies deal with the South African minerals’ role in the market economy countries.

Most of the studies are from the USA, and are mainly concerned with the dependence of the US economy on mineral imports from South Africa. The so-called Comprehensive Anti-Apartheid Act (CAAAA) which was adopted in 1986 by the US Congress despite president Reagan’s resistance, is in itself one of of our points of departure. It exempted no less than ten minerals with the argument that they were critical to the US economy.
### Summary of some mineral dependency studies

<table>
<thead>
<tr>
<th>Issue study</th>
<th>CAAA</th>
<th>GAO</th>
<th>Time running out</th>
<th>Anderson-Blake</th>
<th>Jourdan</th>
<th>Shafer</th>
<th>Horton Bureau of Mines</th>
<th>Hanlon-Omond</th>
<th>EC</th>
<th>KK Sweden</th>
<th>Wright</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Minerals</td>
<td>Andalusite</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td></td>
<td>Antimony</td>
<td>Special asbestos</td>
<td>Special asbestos</td>
<td>Special industry diamonds</td>
<td>Andalusite</td>
<td>PGM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Special asbestos</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td></td>
<td>Chromium</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td></td>
<td>Industry diamonds</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td></td>
<td>Manganese</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
<td>Cobalt</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
<td>Vanadium</td>
</tr>
<tr>
<td>Use of strategic stocks</td>
<td>Not discussed</td>
<td>Not discussed</td>
<td>Yes</td>
<td>Not discussed</td>
<td>Not discussed</td>
<td>Yes</td>
<td>Substantial protection</td>
<td>Not discussed</td>
<td>Not discussed</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Possible recycling</td>
<td>Important for PGM, albeit insufficient</td>
<td>PGM</td>
<td>PGM</td>
<td>chromium</td>
<td>Vanadium</td>
<td>PGM</td>
<td>chromium</td>
<td>Vanadium</td>
<td>PGM</td>
<td>Chromium</td>
<td>Manganese</td>
</tr>
<tr>
<td>Price elasticity effects</td>
<td>Implicitly weak</td>
<td>Implicitly weak</td>
<td>Partly</td>
<td>Not discussed</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Not discussed</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>RSA control of transports from Zambia, Zaïre, Zimbabwe</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Support to transport systems</td>
<td>Support to transport systems</td>
<td>Support to transport systems</td>
<td>Support to transport systems</td>
<td>Support to transport systems</td>
<td>Potential problems if crisis</td>
<td>Weak</td>
<td></td>
</tr>
<tr>
<td>Technological changes</td>
<td>Not discussed</td>
<td>Catalysts PGM</td>
<td>Not discussed</td>
<td>Catalysts PGM Ceramics</td>
<td>Reduce manganese in steel</td>
<td>Not discussed</td>
<td>Negative for manganese</td>
<td>Not discussed</td>
<td>Possible increase</td>
<td>Continuous increase</td>
<td></td>
</tr>
<tr>
<td>USSR supply</td>
<td>Implicitly no change</td>
<td>Implicitly no change</td>
<td>Not discussed</td>
<td>Unpredictable</td>
<td>Zimbabwepmg + PGM Zimbabwe chromium</td>
<td>Manganese + Australia Botswana PGM</td>
<td>USA for several minerals</td>
<td>Not for PGM but in long term for the others</td>
<td>Zimbabwe PGM + PGM Chromium Botswana PGM</td>
<td>In case of Sweden for most minerals</td>
<td>PGM</td>
</tr>
</tbody>
</table>
The US General Accounting Office made a follow-up analysis of the CAAA in 1988 at the request of some leading members of the US Congress. An important report from the beginning of the 1980s was published by a Study Commission on US Policy Toward Southern Africa. Its impact was small, as it had been commissioned by the Carter administration, but published only during the first year of the Reagan administration. The discussion it attempted to contribute to has, however, become more relevant in later years. We have also frequently used material from the US Bureau of Mines, as can be seen from the bibliography.

Some of our material is taken from papers and articles by US and other scholars, who are arguing that the US official view is exaggerated or too alarmist when it comes to the real need for South African minerals. Such scholars are, for example, Michael Shafer, Stephen Wright, Paul Jourdan at the University of Zimbabwe, and Joe Hanlon/Roger Omond in their book _Sanctions Dilemmas_. An example of a South African perspective is given in the paper by E.W. Anderson and G.H. Blake.

Material on the degree of dependence of Europe and Japan is not as easy to find, but it is usually briefly dealt with in the US studies. We have also used an EEC report as well as UK material on the dependency of the EEC, and also some reports by British scholars, such as Barber/Blumfield/Hill and Brian Bolton. This material is from the first half of the 1980s, but we think that they are still relevant.

Finally we use a major analysis on Swedish dependence on South African minerals, carried out by the Swedish Board of Trade, and some additional Swedish material.

Although our material is in no way comprehensive, we are convinced that it covers all the main arguments used in the debate.

The studies are compared as to the following issues:
1. The number of minerals they consider critical;
2. Effects on the MECs of a curtailment in South African supply of the identified minerals, taking into consideration time perspective, options as regards recycling, technological developments, substitution, and alternative supply resources;
3. Recommendations as to sanctions.

### Number of minerals considered critical

The range of minerals identified as critical varies from study to study. The widest choice is that of the US State Department in the Comprehensive Anti-apartheid Act of 1986, where ten minerals are certified and thereby excluded from any sanctions. Paul Jourdan in his study (Jourdan, 1988) heavily criticizes the wide scope of the Act, and concludes that there are only two minerals for which alternative suppliers cannot meet US demand. Those are chromite and ferrochrome and the platinum group
metals. Most studies also include manganese and vanadium among the critical ones when it comes to the effects of sanctions.

The ten minerals certified in the US Comprehensive Anti-apartheid Act are:
- platinum group metals (platinum group metals) (Platinum, palladium, rhodium)
- Chrome and ferrochrome
- Manganese
- Vanadium
- Titanium (rutile and rutile substitutes)
- Cobalt
- Andalusite (an aluminium-bearing mineral)
- Antimony
- Chrysotile asbestos
- Natural industrial diamonds

In his critique Jourdan, after extensive assessment of research on the different minerals on the list, concludes: “For two minerals it was concluded that currently alternative suppliers could not meet US demand but there existed potential alternative sources within the southern African region. The minerals were:
1. chromite and ferrochrome (Zimbabwe) and
2. the platinum group metals (Zimbabwe and Botswana).”

(P. Jourdan, 1988, p 15.)

The US General Accounting Office, GAO, concludes, departing from the same list:

“Except for two of the platinum group metals (platinum and rhodium), a specific type of industrial diamond and grade of chrysotile asbestos, and andalusite, alternative supply sources exist for the certified strategic minerals imported from South Africa according to the Bureau of Mines data and to officials of the Bureau and Commerce and Defence Departments.” (US GAO, 1988, p. 42) The US GAO thus also excludes chrome from the list of critical minerals.

A slightly wider definition is used for other sources. “Chromium, manganese, and vanadium are indispensable in the production of steel. Platinum group metals serve as catalytic agents in refining petroleum and in reducing automobile emissions. These four minerals – imported from South Africa – are essential to Western industry and defence.” (South Africa: Time Running Out, 1981, p. 310) The same minerals are pointed out by Horton (Horton, 1985), which is not astonishing as both base their conclusions on the Bureau of Mines. The European Economic Community takes the same stand in a memo from 1985 (CEE).
Vanadium is left out in another study. On the other hand, cobalt is included, not because it is produced by South Africa, but by Zaïre and Zambia, and according to the report dependent on South Africa for transport. "In investigating the strategic minerals most at risk for the MECs, four metals are commonly identified: platinum, cobalt, chrome and manganese." (Anderson/Blake, 1982, p. 1)

As regards vanadium, a Swedish study concludes that the world market is relatively insensitive to cuts in the South African supply, as well as in the short run. (Kommerskollegium, 1981).

A study from the Office of Technology Assessment (OTA, 1985) in the US selects chrome, platinum, cobalt and manganese as first-tier strategic minerals. The motive for the selection is that they are considered critical and that their supply is vulnerable:
1. They are essential for national defense and other important industries.
2. For some of their essential uses no satisfactory substitutes are available.
3. There is little or no production of any of them in the US.
4. They are supplied by a very few countries (in central or southern Africa), which, together with the USSR, hold most of the world's known reserves.

Another ten minerals are selected as second-tier strategic minerals: bauxite/alumina, beryllium, columbium, industrial diamond, natural graphite, rutile, tantalum, tin, titanium sponge and vanadium. Of these minerals, only industrial diamonds, rutile/titanium and vanadium are of any interest in the context of this study.

The matrix on page 35 shows the minerals considered critical by different authors. Most of them focus on the four minerals chromite/ferrochrome, manganese/ferromanganese, the platinum group metals and vanadium. Although there are arguments for including those four in the category "critical", we find that there are a number of factors supporting those who argue that manganese and vanadium should not be included. Our conclusion thus is that two of the platinum group metals (platinum and rhodium), together with chromite/ferrochrome can be regarded as minerals, for which supply from South Africa is critical to the industrialized market economies. What degree of vulnerability this creates depends on a number of assumptions. It is even possible to use assumptions that would also make the dependency of those two minerals quite manageable.

Effects on the Market Economy Countries

Of the studies we have looked into, two are very critical of the conclusion that the degree of dependence on South African minerals is high, at least in a medium-term perspective.
Shafer argues that the fundamental and fallacious assumption underlying what he calls the alarmist position is that strategic mineral demand is inelastic.

He uses the USSR embargo on chrome and manganese to the US in 1949 as an example (see Chapter 4). Shafer points out – in accordance with the OTA study described earlier – that the supply cut-off only caused serious short-term disruption. However, it did not hamper a rapid mobilization for the Korean war two years later, and Shafer argues that things are no different today.

Shafer and others argue that in the case of a cut-off of minerals from South Africa, prices will increase, which will reduce demand and create substitution when this is possible, and expand supply through increased recycling, use of full existing capacity, in the medium-term perspective reopening of presently non-economic resources, and in the longer term perspective also of new mineral resources. Different views as to the scope of these factors explain most of the differences in the conclusions of different studies.

One way of analyzing the effects of a cut-off of South African minerals is to put a price tag on them. Consider, for example, the US Bureau of Mines calculations of the costs of a platinum group metals embargo for the US economy in Chapter 3.

Other studies assume that plausible scenarios will create problems for the MECs in the case of an end to the South African supplies. We will briefly go through the main relevant factors: Use or non-use of strategic stocks; assumptions as to recycling of metals; as to technological changes: as to market effects, as to transport dependency on South Africa for production in Zambia, Zaire and Zimbabwe; and as to changes in supply from the Soviet Union.

South Africa: Time Running Out counts on stockpiles, combined with increased recycling and a certain amount of substitution as a short-term buffer against disruption of the South African supply of chrome and platinum group metals. The main concern of this study when it comes to supply relates to manganese, while it argues that the US is potentially self-sufficient in vanadium.

In their chapter on minerals in The Sanctions Handbook Hanlon and Omond emphasize the role of the market mechanisms, through which price increases reduce demand through substitutions for other materials and expand supply through recycling, reduced hoarding and in a longer time perspective the opening up of new mines. The authors exemplify this by the long strike in Canada in 1969 that cut off much of the world’s nickel, and the effect of the Shaba rebellion on the supply of cobalt (see Chapter 4).

It is obvious that a key factor when assessing the degree of vulnerability is the elasticity of the demand and supply of the minerals that is assumed. With a high elasticity, demand is reduced with higher prices
and supply is increased by higher capacity utilization and increased recycling, and in the case of platinum possibly by selling off bars and jewelry.

One uncertain factor here is the timing. While prices react immediately on actual or assumed reduction of supply from South Africa, the supply from alternative sources as well as recycling have a lead time of something between a few months to a few years. In the meantime use of industrial and strategic stocks is the only method to cover a sudden slack of supply, together with any increased degree of capacity use that is possible. The flexibility of the industries thus is higher during an economic slump than during an economic boom.

When assessing the degree of vulnerability, assumptions as to availability of stocks are important in the short-term perspective and the flexibility of recycling and increased capacity utilization of existing alternative mines in the medium-term perspective. Those factors are normally difficult to quantify and are seldom explicitly discussed in our sources.

Technological changes

The effects of technical break-throughs are important in the long-term perspective, the lead time normally said to be between five and ten years. We have already seen how a change in stainless steelmaking technology was an important factor in easing the effects of the cut-off of Rhodesian chrome supplies (Chapter 4).

Another possible technological change is the substitution of palladium for platinum in car exhaust catalysts, which was recently reported by Ford (Chapter 3). Such a change will have important implications on the platinum group metals demand and reduce the dominance of South African production. Parallel to this, stricter environmental laws in Europe will increase the total demand for exhaust catalysts, independent of whether they are using platinum or palladium.

According to present information similar break-throughs in the steel industry as regards the use of ferrochrome and ferromanganese are not on the short-term agenda. Some change of demand might occur in the case of substitution of hard plastics or ceramics for steel in special applications.

Development of alternative mineral resources

Some of the studies, notably Jourdan and CEE emphasize the medium/long-term option to develop mineral resources in the neighbouring states in Southern Africa. (Jourdan calls this "positive sanctions".) Both studies argue that the chrome extraction in Zimbabwe could be expanded and that there are important resources of platinum group minerals in both
Zimbabwe and Botswana. As we have shown, according to most scholars/observers these two minerals are the most critical.

Expansion and especially the development of new mines are extremely expensive ventures, which can be undertaken only by the largest mining houses or through joint efforts. But preparatory studies and the development of infrastructure could be part of international support, which is what these two studies recommend as a line of action in order to reduce vulnerability. This also presupposes that actions are taken to secure transports independent of transit through South Africa. Upgrading of the railways to Mozambican and Angolan ports and protection against military attacks and sabotage are important measures for improving alternative supplies.

Different stages of processing

South African companies have gradually increased their refining capacity and the proportion of chromite and manganese ore exported as metals has increased. The result of this strategy is that a major part of the South African chromite and manganese ore is now processed into metals and alloys, which is then exported. At the same time companies in many of the major MECs have closed down their processing capacity. Instead of being dependent on imports of ore, those countries are today dependent on imports of alloys.

South Africa's dependency on export earnings from minerals

A perennial issue in the discussion is whether the industrialized market economies need South Africa's minerals more than South Africa needs the markets of those countries in order to get foreign exchange. There is no scientific answer to this question, but a glance at the South African trade statistics shows that the export earnings from minerals are important. Thus non-fuel minerals together covered the following shares of total export earnings respectively, with gold excluded, in 1986 and 1987:

<table>
<thead>
<tr>
<th></th>
<th>1986</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of total exports</td>
<td>23.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Per cent of total exports, excl. gold</td>
<td>38.2</td>
<td>34.3</td>
</tr>
</tbody>
</table>

*(EIU South Africa country profile 1988/89 and Quarterly no. 2, 1989)*
Official statistics do not identify individual minerals, but the following estimates of export earnings for the more strategic minerals would probably be accepted by most observers:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>million USD</th>
<th>% of total exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum group metals</td>
<td>1 500</td>
<td>7.5</td>
</tr>
<tr>
<td>Chromium, manganese, and their ferro-alloys</td>
<td>1 000</td>
<td>5.0</td>
</tr>
<tr>
<td>Vanadium</td>
<td>100</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2 600</td>
<td>13.0</td>
</tr>
</tbody>
</table>

Since 1985 there has been a net capital outflow from South Africa due to the reluctance of foreign banks and companies to provide new loans and investments together with repayment of old loans. To compensate for the capital outflow, the South African economy must run a substantial current account surplus. This situation will continue far into the 1990s.

In this situation the effects of stopping exports of mineral products will have serious consequences on the South African economy, while a reduction of export-earnings with 5% in a situation of strong net capital inflow would be easier to bear. This is also clear to decision-makers as can be seen from the following quotation:

“Foreign Affairs Minister Pik Botha reacted unequivocally to several voices raised for counter-sanctions by saying that strategic minerals will not be withheld from the west in retaliation for proposed sanctions. And Pat Retief, chairman of Rustenburg Platinum – which produces 45% of the world’s platinum – has condemned suggestions of retaliatory sanctions as an ‘irresponsible notion’.” (Southern Africa Report, Johannesburg, May 27, 1988)

Because of the extreme South African dominance, the platinum group metals are the ones most frequently mentioned as suitable for retaliation by the regime. The trade statistics of those minerals are kept secret by the regime, as are trade figures on an increasing number of minerals and other “strategic” goods in South African foreign trade. The export loss for South Africa, if platinum group metals would be excluded, is calculated to be around 1,500 million USD per annum. This corresponds to around 7.5% of total export earnings and between one-half and two-thirds of the current account surplus that is needed to cover the net capital outflow.

A disruption of the exports of chrome and manganese, including their ferro-alloys, would cost the South African current account less than a disruption of the platinum group metals exports, but still the annual loss can be estimated at around 1,000 million USD.

In conclusion, there are two main reasons – one economic and one political – why the South African regime will avoid imposing sanctions on its own economy – which would be the effect of retaliation in the field of minerals. 1) It would reduce the possibilities of achieving the necessary
current account surplus. And it would reduce production in other domestic industries as well as employment. 2) It would undermine the South African credibility as a mineral supplier and thereby increase efforts by the buyers to develop alternative sources. South Africa’s strategic value to the Western powers would also be lost, and as a consequence there would be no major reason to support the apartheid regime. The counter-sanctions card, thus, can only be used for bluffing.

Conclusions

All the studies and other documents we refer to are mainly based on the same data as regards the volume of South African and world production and exports, albeit covering different years. Nevertheless, their conclusions as to vulnerability of MEC industries/industrial branches differ widely, the main reason being different assumptions as to a number of issues outside the present volume of production and import dependency by the MECs, which affects the degree of possible substitution. The major studies differ on the following assumptions:

- Whether strategic stocks are released or not as a temporary measure – especially important in the case of the USA.
- The flexibility of the market forces, higher prices reducing demand, strengthening substitutions for other minerals, increasing production by opening up earlier non-profitable mines, increasing recycling of scrap, etc., containing the metals, releasing hoarded metals in the case of platinum.
- The timing of technological changes.
- Future supply from the Soviet Union.
- The degree of transport dependency on South Africa for the production in Zambia, Zaïre and Zimbabwe.

Some of the assumptions have effects in the short run, i.a. releasing of strategic and industrial stock piles, and price elasticity effects on the demand and supply side, such as substitution for other minerals, releasing of jewelry, coins and bars (platinum) on the market, increased recycling of scrap. Others have long term effects, i.a. technological changes, re-opening of mines or developing new mineral resources.

Bearing in mind the speculative character of the whole issue, we still would like to summarize by drawing some conclusions from the material we have studied:

- The effects of a disruption of one or several minerals from South Africa depends of course on how the disruption takes place: If it is sudden or gradual, how effective the cut-off is, if the cut-off is total or the result of sanctions from individual countries, and for what period the cut-off will continue.
- History shows that out of four cases during the last four decades, when imports to the US of critically needed materials were interrupted, none resulted in severe or long-lasting damage to the US.
- The most critical minerals to the industries in the MECs seem to be the platinum group metals, especially platinum and rhodium, and chromite/ferrochrome.
- Although disruption of South African minerals will create short-term, and, in the case of platinum group metals and chrome, medium-term, difficulties for industries in the MECs, many of the documents seem to exaggerate the effects.
- One factor not taken sufficiently into account by the "alarmist" authors, is the elasticity of demand and supply should a cut-off of supply from South Africa take place.
- For the USA, strategic and industrial stock-piles seem to be sufficient as buffers against short-term effects of any cut-off, provided they are released. Europe and even to a large degree Japan are in a more vulnerable situation as their stock-piles are much smaller or non-existent. In the case of a total cut-off from South Africa, some type of international coordination, similar to that for petroleum products after the oil price increases in 1973-4, would probably be created.
- It is extremely unlikely that South Africa will introduce sanctions on its own economy by halting the exports of any mineral. The economic and political costs would be too heavy.

When it comes to technical prospects for reducing dependence on South Africa the following table indicates conclusions for the main minerals, based on the OTA study.
Table 10. *Technical prospects for reducing the US dependence on four important South African minerals*

<table>
<thead>
<tr>
<th></th>
<th>Chrome</th>
<th>Cobalt</th>
<th>Manganese</th>
<th>Platinum group metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospects for increased substitution</td>
<td>Very good</td>
<td>Good</td>
<td>Poor</td>
<td>Fair–poor</td>
</tr>
<tr>
<td>Potential for increased recycling</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Potential for increased US production</td>
<td>Very poor</td>
<td>Poor (if subsidized: good)</td>
<td>Very poor</td>
<td>Fair–good</td>
</tr>
<tr>
<td>Potential for supply diversification</td>
<td>Poor–fair</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
</tr>
</tbody>
</table>


*Possible effects of the development in the Soviet Union and Eastern Europe*

It is too early to analyze in detail the effects of the significant political changes in the Soviet Union and Eastern Europe during 1989–90. One effect of this development, however, might be that the strong US reluctance towards being dependent on supplies from the Soviet Union might be reduced. As is clear from the review of ten strategic minerals above, the Soviet Union is the main alternative source for most of the minerals. With less reluctance on the part of US, Soviet supplies could replace those from South Africa, which would change the picture fundamentally, weakening the position of South Africa accordingly.

A factor that might support such a development is that minerals are the only Soviet products with which a possible increased future US export of i.a. capital goods can be financed. US export credits could delay when this would actually happen, but not indefinitely. On the other hand, a factor that might work in the opposite direction is scepticism from US companies as to the reliability of Soviet supplies. The new situation in the Soviet Union will most probably increase the number of strikes and other activities that can threaten regular supply.
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