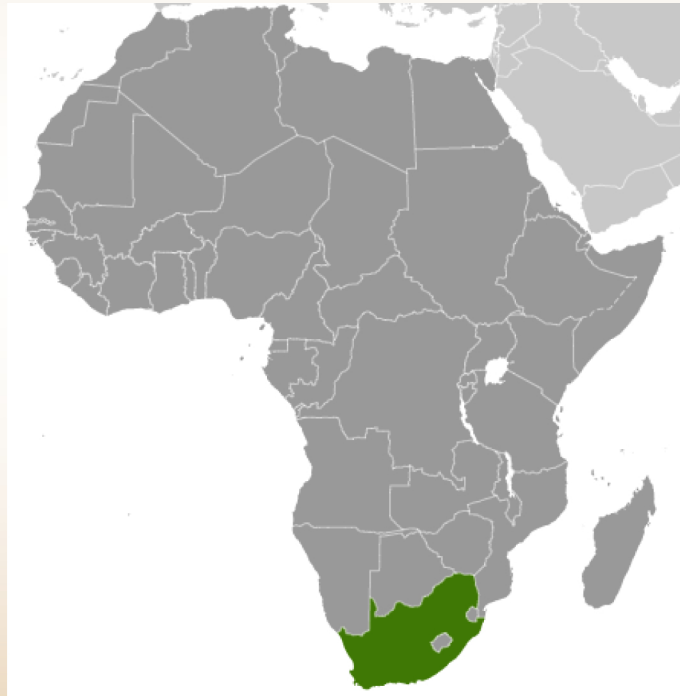


Fathi Habashi

My trips to

South Africa



2015

My Trips to South Africa

Volume derived from



Fathi Habashi

Department of Mining, Metallurgy, and Materials Engineering
Laval University, Quebec City, Canada

2015

The Book

The present volume is derived from *De Re Metallica. A Metallurgist on the Move*, which is a diary of the trips the author has undertaken during his professional career. He visited many industries, universities, research centres, and museums and participated in many conferences. The book therefore reflects the state of extractive metallurgy since he left his home country Egypt and went to study in Vienna. *De Re Metallica* is in seven volumes fully illustrated mainly by coloured photographs. It includes a short history of the place visited and its main sightseeing sites. Volume 1 Egypt, Volume 2 Canada, Volume 3 United States, Volume 4 Latin America, Volume 5 Asia [in two parts], Volume 6 Europe [in two parts], and Volume 7 Russia & other countries. Total number of pages was 5500.

Since these volumes could not be separated and therefore they will not be available to many readers, I decided to split the book into selected 29 small units, each representing one country or a group of countries closely related geographically. The present volume is one of these volumes.



The Author

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*To Nadia,
Hani, and Hatem
with love*

Other Books by the Author

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Technical

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- Volume 1: General Principles (422 pages), 1969 (reprinted 1980) (out of print), Gordon & Breach Science Publishers.
 - Volume 2: Hydrometallurgy (468 pages), 1970 (reprinted 1980) (out of print), Gordon & Breach Science Publishers.
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- F. Habashi, D. Hendricker, C. Gignac, *Mining and Metallurgy on Postage Stamps*, 1999, 335 pages.
- F. Habashi, *Extractive Metallurgy Today. Progress and Problems*, 2000, 325 pages.
- F. Habashi, *From Alchemy to Atomic Bombs*, 2002, 350 pages.
- F. Habashi, *Schools of Mines. The Beginnings of Mining and Metallurgical Education*, 2003, 604 pages.
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- F. Habashi, *The Copts of Egypt*, 2006, 92 pages.
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- F. Habashi, *Aqua Science Through the Ages. An Illustrated History of Water*, 2010, 166 pages.
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Preface

De Re Metallica. A Metallurgist on the Move is a diary of the trips the author has undertaken during his professional career. He visited many industries, universities, research centres, and museums and participated in many conferences. The book therefore reflects the state of extractive metallurgy since he left his home country Egypt and went to study in Vienna. The book is in seven volumes fully illustrated mainly by coloured photographs. It includes a short history of the place visited and its main sightseeing sites. Volume 1 Egypt, Volume 2 Canada, Volume 3 United States, Volume 4 Latin America, Volume 5 Asia [in two parts], Volume 6 Europe [in two parts], and Volume 7 Russia & other countries. Total number of pages was 5500.

Since these volumes could not be separated and therefore they will not be available to many readers, I decided to split the book into selected 28 small units each representing one country or a group of countries closely related geographically as shown below.

1	Arab Countries	Jordan, Kuwait, Morocco, Syria, Tunis
2	Austria	
3	Australia & Southeast Asia	Australia, Cambodia, Indonesia, Malaysia, Philippines, Thailand, Vietnam
4	Balkans	Albania, Bosnia, Bulgaria, Croatia, Greece, Romania, Serbia, Slovenia
5	Baltic Countries	Latvia, Lithuania, Poland
6	Brazil	
7	Canada	
8	Caribbean	Cuba, Puerto Rico, Venezuela
9	Caucasus	Armenia, Azerbaijan, Georgia
10	Central Asia	Afghanistan, Kazakhstan, Mongolia, Uzbekistan
11	Central Europe	Czech Republic, Slovakia, Hungary, Switzerland
12	Chile and Argentina	
13	China	
14	Egypt	
15	England and France	
16	Germany	
17	Iberian Peninsula	
18	India	
19	Italy and Vatican	
20	Japan and Korea	
21	Low Countries	

22	Mexico	
23	Middle East	Iran, Turkey
24	Peru and Bolivia	
25	Russia	
26	Scandinavia	
27	South Africa	
28	USA	

I hope in this way the book will available to a large number of readers.

Fathi Habashi

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Chapter 1

Introduction

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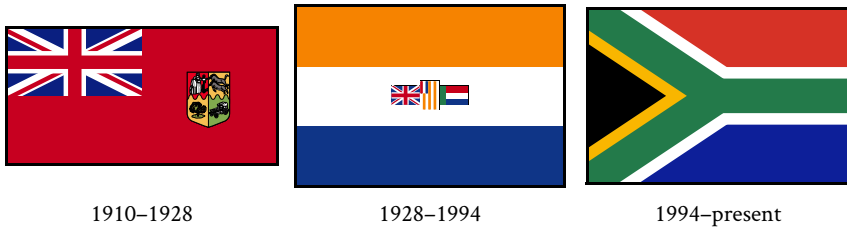


Figure 1.1: Flags of South Africa.

The Republic of South Africa is a heterogeneous mixture of Black Africans, Afrikaans, British, Indians, Malayans, French Huguenots, and many others from Europe and Asia. A decisive date in its recent history is the collapse of the Apartheid Regime in 1994. For a metallurgist, South Africa is the country of diamonds, gold, platinum, and many other metals. In 1887 Cecil Rhodes (1853–1902) was able to take control of the De Beers Mining Company after the discovery of diamonds at Kimberley in 1866. It was there in Kimberley where the so-called School of Mines was inaugurated in 1896.

The Gold Rush of 1886 in the Witwatersrand district was responsible for the foundation of Johannesburg. It was there that the cyanidation process was first introduced. The Gold Rush resulted in the Boer War 1899–1902. Platinum was discovered in the Bushveld Igneous Complex deposits in 1924 in what became known as the Republic of Bophuthatswana, a Bantustan, i.e., a “homeland.” This Republic like other African Homelands was dismantled after the collapse of the Apartheid Regime. Visits to the country before and after the Apartheid era were conducted.

Visitors to South Africa had the option to buy a “See South Africa” ticket at a reduced price if one extends his visit for two weeks which was an excellent opportunity to visit a number of cities. The first visit was when apartheid was at its peak and the airport in Johannesburg was nearly empty because of boycotting by most airlines. The second visit was during the negotiation to end apartheid and Johannesburg airport became very busy and crowded. Also Black Africans became visible in the city and the appearance of many minibuses transporting them. The third was after the collapse of the apartheid system.



Figure 1.2: Republic of South Africa and her neighbours.

In 1987 the South African Chemical Society celebrated its 75th anniversary in a conference held at Durban in which I was invited to deliver a keynote lecture (Figure 1.3). During the conference an invitation was received from participant Chemistry Professor H. Mehra from Umtata to give a seminar to his students at the University of Transkei. Professor Mehra is the author of a 1 000-page *Advanced Inorganic Chemistry* that went into 11 editions. Other invitations were received from Professor Jan du Preez at the University of Port Elizabeth, University of Witwatersrand in Johannesburg. Visits were also made to Mintek, SASOL, and Buffelsfontein Gold Mining Company — all in the neighbourhood of Johannesburg. A short stop was made at Cape Town. The South African Chemical Society had also sessions held at Rhodes University in Grahamstown.

In 1993 a lecture tour to South Africa included the Chemistry Department of the University of Port Elizabeth and the University of Cape Town. In 2000, a short course on hydrometallurgy was given at the Metallurgy Department of the University of Pretoria. A summary of the visits and the lectures delivered is given in Tables 1.1–1.2.

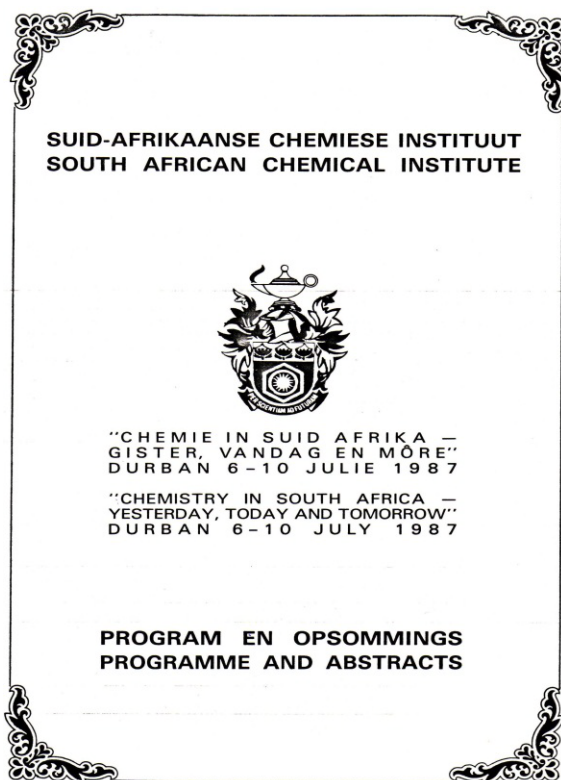


Figure 1.3: Front sheet of South African Chemical Society 75th Anniversary program in 1987.

Table 1.1: Visits to the Republic of South Africa.

Dates	Visits	Purpose
July 2–26, 1987	Durban	75th Anniversary of S. African Chemical Society
	Umtata	Lecture at the University
	Grahamstown	National Convention of Teachers
	Port Elizabeth	Lecture at the University
	Cape Town	Cultural visit
	Johannesburg	Witts University
	Randburg	Mintec
	Sasolburg	Oil from coal
May 29–June 15, 1993	Port Elizabeth	Lecture tour
	Johannesburg	Witts University
	Rustenburg	Nickel industry

Dates	Visits	Purpose
February 15–27, 2000	Randburg	Mintec
	Germiston	Mineral Processing Research Laboratory of Johannesburg Consolidated Investment Company
	Stellenbosch	University
	Cape Town	University
	Pretoria	Cultural visit
	Pretoria	Hydrometallurgy short course, Univ. of Pretoria

Table 1.2: Lectured delivered during the visits.

Date	Lecture Title	Organization
July 7, 1987	Extractive Metallurgy Today. Progress & Problems	South African Chemical Institute 75th Jubilee Convention. Durban, Natal
July 14, 1987	A Hundred Years Anniversary of Hydrometallurgy	National Convention of Teachers of Mathematics, Physical Science, and Biology. Grahamstown
July 22, 1987	Extractive Metallurgy. An Introduction	Department of Chemistry, University of Transkei, Umtata, Transkei
July 23, 1987	A Hundred Years Anniversary of Hydrometallurgy	Mintek, Randburg, Transvaal
June 3, 1993 [Morning]	Dissolution Processes in Hydrometallurgy	Department of Chemistry, University of Port Elizabeth
June 3, 1993 [Afternoon]	Precipitation Processes in Hydrometallurgy	
June 7, 1993	Extractive Metallurgy Today. Progress & Problems	Department of Metallurgy, University of Witwatersrand, Johannesburg
June 9, 1993	History in the Metallurgy Curriculum	Department of Metallurgy, University of Witwatersrand, Johannesburg
June 10, 1993	Extractive Metallurgy Today. Progress & Problems	Faculty of Engineering, University of Cape Town
June 11, 1993	Chemical Engineering versus Chemical Technology	Department of Metallurgy, University of Witwatersrand, Johannesburg
June 15, 1993	The Periodic Table and Metallurgy Students	Department of Metallurgy, University of Witwatersrand, Johannesburg
February 18, 2000	The Development of Hydrometallurgy	Department of Metallurgy, University of Pretoria
February 21–25, 2000	Short Course on Hydrometallurgy	Department of Metallurgy, University of Pretoria

HISTORICAL INTRODUCTION

The area now known as South Africa was first mentioned by Portuguese explorer Bartolomeu Dias in 1486. Vasco da Gama recorded sighting of the Cape of Good Hope in 1497, and the area did not have regular contact

with Europeans until 1652, when Jan van Riebeeck (1619–1677) and other employees of the Dutch East India Company were sent to the Cape to establish a station for ships travelling to the Dutch East Indies and build the Castle of Good Hope (Figures 1.4–1.5). The castle was built between 1666 and 1679 having the shape of a pentagon and an almost 10 metre high wall from massive boulders. The castle now forms the military headquarters for the Cape Province and houses a museum.



Figure 1.4: Jan van Riebeeck (1619–1677) arrives in Table Bay in April 1652. A painting by Charles Davidson Bell (1813–1882).

The city grew slowly during this period and had to import slaves from Indonesia and Madagascar. Many of these became ancestors of the first Cape Coloured communities. Jan van Riebeeck is considered the founder of South Africa.

The Dutch became a great colonial power with possessions in southeast Asia, in southern Africa, in the Caribbean, and in South America. The empire-building started in 1595 during the reign of Maurice of Nassau (1584–1625) son of William of Orange, who led the Dutch through revolt to independence from Spain. The seventeenth century was the glorious period, when Amsterdam developed into the most prosperous city in Europe in a short time. In only half a century, her population grew from 60 000 to 200 000, which made it Europe's third largest city, after London and Paris.

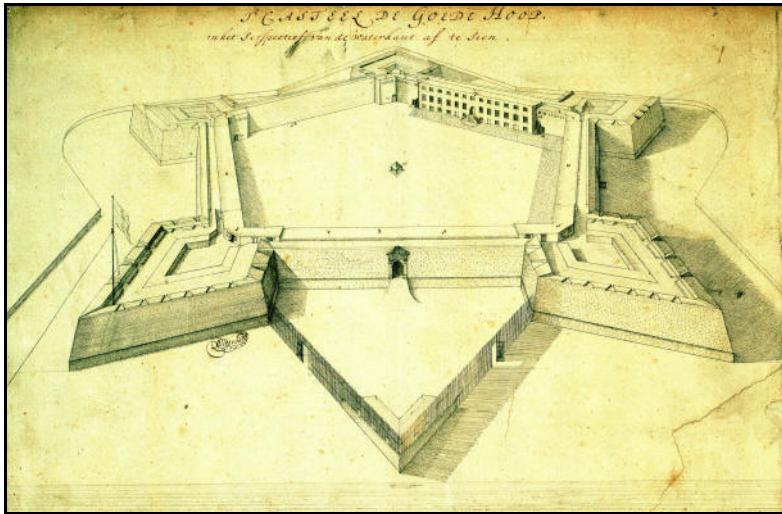


Figure 15: Castle of Good Hope built between 1666 and 1679.

The Netherlands became very attractive to artists, who produced many paintings, sculptures and other art works for her wealthy citizens. Of these may be mentioned Frans Hals (1580–1666), Rembrandt van Rijn (1606–1669), Jacob van Ruisdael (1628–1682), Jan Vermeer (1632–1675), and Vincent van Gogh (1853–1890). Two Dutch philosophers are also worth noting. The first is Desiderius Erasmus (1469–1536) who published, among other things, the Greek text of the New Testament in 1516 with a Latin translation. It was this edition that Luther used for his German Bible translation. The second is Baruch Spinoza (1632–1677), who was excommunicated in 1656 from the Jewish community because of independence of thought.

The Netherlands was also an important publishing centre. For example, Louis Elzevier (1540–1617), whose name also appears as Elsevier, founded his publishing house in 1583 at Leiden, which was continued by his descendants until 1712, and the name is still used today. The great reputation of the Dutch as ship builders and sailors, enticed Peter the Great, in 1697, to spend eight days in the shipyard in Amsterdam. The Maritime Museum in Amsterdam is one of the largest and best of its kind in the world, and has a large collection that illustrate Holland's past. There are other aspects of the development of Dutch shipping such as herring fishing. In all aspects of history, waterways have played an important part, not only because of the trading by sea but also because of the transport between Dutch cities by canal barges.

During the seventeenth century, Dutch merchant ships sailed every sea and brought wealth back home. A famous Dutch navigator, Abel Janszoon

Tasman (ca.1603–1659), was sent to discover the hypothetical “Southland,” i.e., Terra Australis. By sailing around it, Tasman discovered that the Southland really existed and formed the continent that he named New Holland, now known as Australia. He also discovered Tasmania, named after him, and New Zealand, which he named after the Dutch province of Zeeland. Being skilled ship builders and sailors, the Dutch managed to have important colonies in southeast Asia, South Africa, and South America. Amsterdam has an excellent museum devoted to these colonies and her neighbouring countries — the Tropenmuseum, i.e., the Museum of the Tropics.

SUGGESTED READINGS

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A. Cowey, *Mining and Metallurgy in South Africa. A Pictorial History*, Mintek 1994.

J. Gunther, *Inside Africa*, Harper & Brothers, New York 1955, pages 449–691.

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- The Land of Apartheid Heresy: July 2–26, 1987
- Lecture Tour in Four Continents: Europe (Finland, Russia), Indonesia, Australia, S. Africa], May 2–June 16, 1993
- Pretoria, February 15–27, 2000

O. Lehmann, *Look Beyond the Wind, The Life of Dr. Hans Merensky*, 232 pages, Howard Timmins, Cape Town, South Africa 1959.

Chapter 2

The Cape Colony

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The Huguenots	11		

In 1652, the Dutch East India Company established a settlement in the Cape of Good Hope as refreshment post for Dutch ships heading to the East Indies. During this period, they met the Bushmen and Hottentot tribes. Gradually, the settlement expanded north coming in contact with other black African tribes such as Xhosa, Sotho, Venda, and others. In 1778, the Fish River was recognized as a boundary for the white settlers, including the French Huguenots and Germans.

The Dutch noticed that the native Africans wore a variety of copper ornaments that they prized highly. Copper quickly became the established currency of barter (Figure 2.1) for sheep, cattle, and other supplies. Ships passing the Cape carried quantities of copper plate and wire for this purpose. In 1685, the commander of the Dutch East India Company at the Cape sent an expedition to search for copper deposits. A rich deposit was found at the “Copper Mountain,” but because of the remoteness and aridity of the region, exploitation did not start until 1852.

After the Napoleonic Wars, Britain occupied the Cape of Good Hope. From 1806 onwards, large numbers of English, Scottish, and Irish settlers arrived at the Cape. By that time, the Dutch settlers became known as Boer-Afrikaners, i.e., the African farmers, and their language was no longer Dutch but Afrikaans. Dissatisfied with British rule, in 1835 the Boer-Afrikaners began migrating to the north, across the Orange River, and as far as the Limpopo River (the border with present-day Rhodesia). The movement became known as the Great Trek (Figure 2.2). Friction with black tribes resulted in casualties. After a series of small battles, the first Boer-Afrikaan Republic was established in 1840, but only four years later was annexed by Britain.

A massive granite structure outside Pretoria was built in 1937 to honour the Voortrekkers (Pioneers) who left the Cape Colony in the thousands between 1835 and 1854, was constructed to describe the history and the meaning of the Great Trek (Figures 2.3–2.4). In the 1850s, the British, finding the imperial burden too heavy in South Africa, signed conventions recognizing the establishment of an independent Boer-Afrikaans Republic in the Transvaal (1852) and the Orange Free State (1854).

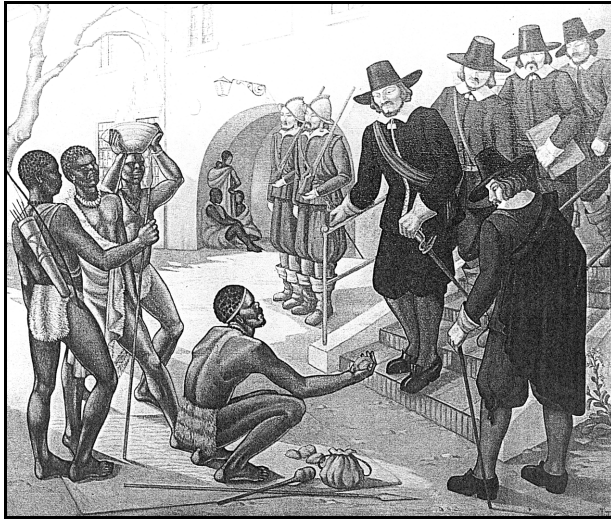


Figure 2.1: A mural at South Africa House in London depicting Hottentots showing pieces of copper to Simon van der Stel (1639–1712) first Governor of the Cape Colony at the Castle in 1681.

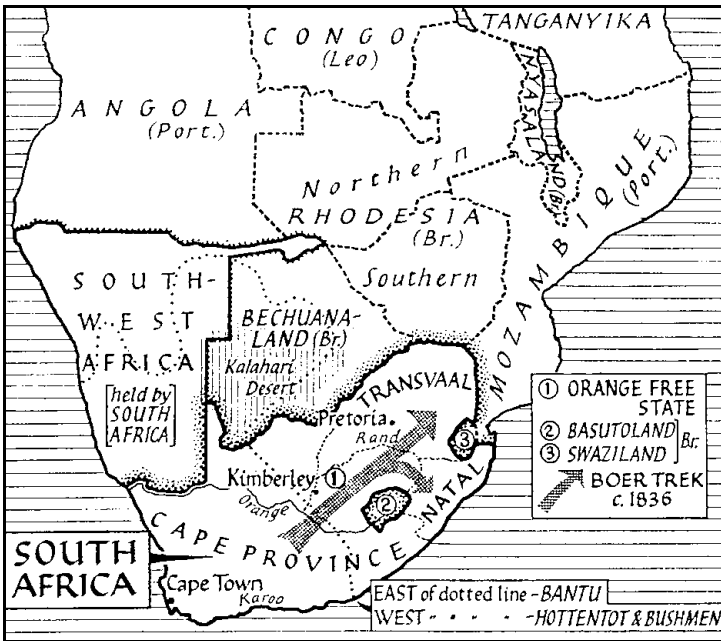


Figure 2.2: Colonization of Southern Africa.



Figure 2.3: Voortrekkers' monument outside Pretoria.



Figure 2.4: Voortrekkers' monument outside Pretoria.

The Malays and the Indians

The first Malay are mostly Javanese from Indonesia who were enslaved in 1654 and transported by the Dutch East India Company to the Cape Colony. They were followed by political dissidents and Muslim religious leaders who opposed the Dutch presence in what is now Indonesia and were sent

into exile. The first batch of Indians came to South Africa during the British Regime in 1860 to work on the sugarcane plantations of Natal. The rest are descended from Indian traders who migrated to South Africa shortly afterwards.

The Huguenots

Huguenot, a nickname associating the Protestant cause with some unpopular politics in France in the Middle Ages. They became known for their criticisms of worship as performed in the Roman Catholic Church in particular the ritual. The Church fanatically opposed the Huguenots, attacking pastors and congregants as they attempted to meet in secret for worship. The height of this persecution was St. Bartholomew's Day massacre in 1572 which resulted in many Huguenots to immigrate; many came later to the Cape Colony. A monument in Stellenbosch honouring the Huguenots for their contribution to the building of South Africa was constructed (Figure 2.5).



Figure 2.5: Monument in Stellenbosch honouring the Huguenots for their contribution to the building of South Africa.

Namibia

As a result of the defeat of Germany in World War I South Africa was granted a mandate over her colony of South West Africa. When South Africa imposed her apartheid policy, an uprising took place in 1966 and demands by African leaders led the United Nations to assume direct responsibility over the territory. The colony gained independence in 1990 following the War of Independence and is now known as Namibia.

Chapter 3

Mineral Discoveries and the Boer War

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DIAMOND

In 1868, a young boy picked up, on the bank of the Orange River, not far from Hopetown, a pretty little pebble which he took home, a pebble which was later found to be a 21-carat diamond. This created an excitement in the area, but it was not until 1869 that another pebble, this time weighing 83 carats, was discovered in the same region. Thus began the diamond industry in South Africa — before then, diamonds came only from India and Brazil. Thousands of farmers from South Africa and adventurers from Europe and North America soon arrived to take part in collecting the treasure (Figures 3.1–3.2).

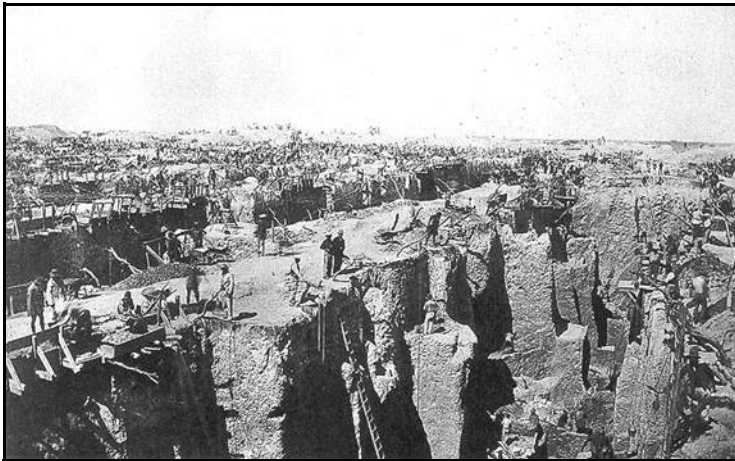


Figure 3.1: Early miners recovering diamond from the Kimberly pit.

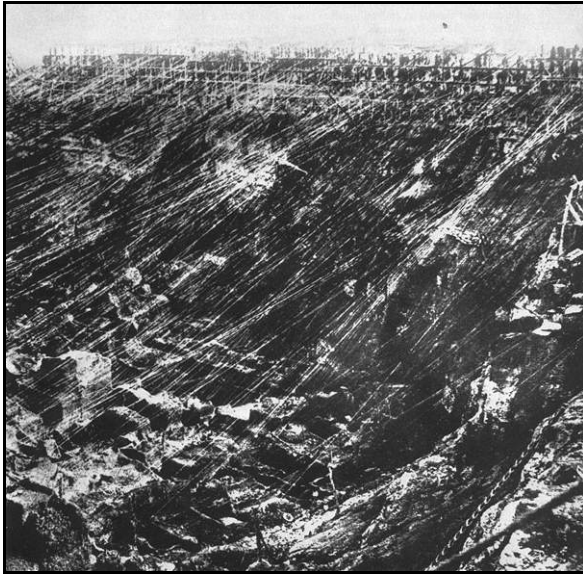


Figure 3.2: A photograph dated from 1876, ten years after the discovery of diamond, shows cables linking hundreds of claims in Kimberley's pipe to the brink of the mine to haul up buckets of rock to be processed on the surface for diamond recovery.

Among those arrived to South Africa at the time of discovery of diamond was a young 18-year-old from England called Cecil John Rhodes. Several years after his arrival, Rhodes founded a company to exploit diamonds from the mine that became known as Kimberley, named after John Wodehouse Kimberley, the British Colonial Secretary during the period 1870–1874. In 1887, Rhodes (Figure 3.3) was able to take control of the De Beers Mining Company, which was named after a farm owned by two Boer brothers called De Beer, where diamonds were found.

In 1908, diamonds were also found in the coastal desert of South West Africa, the German colony neighbouring South Africa on the Atlantic shore. The Anglo American Corporation of South Africa founded in 1917 bought the rights of the German owners of the diamond mines. Instrumental in this transaction was Ernest Oppenheimer (1880–1937) (Figure 3.4), an English businessman who settled in South Africa and was able to secure a large loan from the House of Morgan in the United States, with the help of mining engineer Herbert Hoover (who became later President of the United States) — hence the name Anglo American.

It is now well established that diamonds were formed in the upper mantle, beneath the Earth's crust, and then carried to the surface by volcanic action in an underground column, or pipe, of diamond-bearing rock called kimberlite or "blue rock" (Figure 3.5). Kimberlite is composed mainly of oli-

vine, serpentine, mica, with the pyroxene family of minerals enstatite and other minerals. Weathering processes disintegrated kimberlite and other rocks at the earth's surface and scattered the stones hundreds of kilometres.



Figure 3.3: Cecil Rhodes (1853–1902), founder of De Beers.

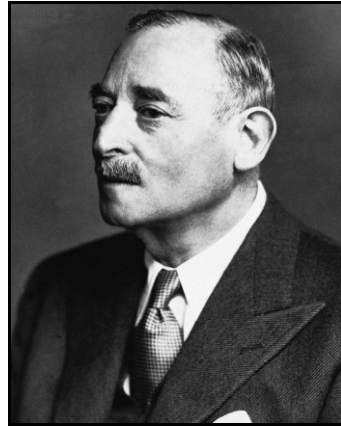


Figure 3.4: Ernest Oppenheimer (1880–1957), founder of Anglo American.

The pipes are generally vertical and range in shape from nearly circular to elliptical. They range in size from only a few metres in diameter to the well-known pipes in the Kimberley district of South Africa which have surface areas from 10 to 30 acres (Figure 3.6).

Weathering is particularly effective in warm humid climates where near-surface rock formations, including kimberlite, are broken down and the products carried away by river systems and deposited over widely scattered areas, often far from their sources. Some geologists believe that a thickness of at least one kilometre of rock has been eroded away in the Kimberley region of South Africa and distributed by streams. Diamonds and other hard, weather-resistant minerals, released from the disintegrating kimberlite, are concentrated by flowing water and are deposited in topographically favourable localities to form the alluvial deposits found today. Due to the high specific gravity of diamonds they tend to be concentrated at the bottom of alluvial deposits.

The Diggers' Memorial fountain was erected in honour of diggers past and present in the Ernest Oppenheimer Gardens (Figure 3.7). Oppenheimer was the first Mayor of Kimberley when Beaconsfield and Kimberley were combined into a city in 1912

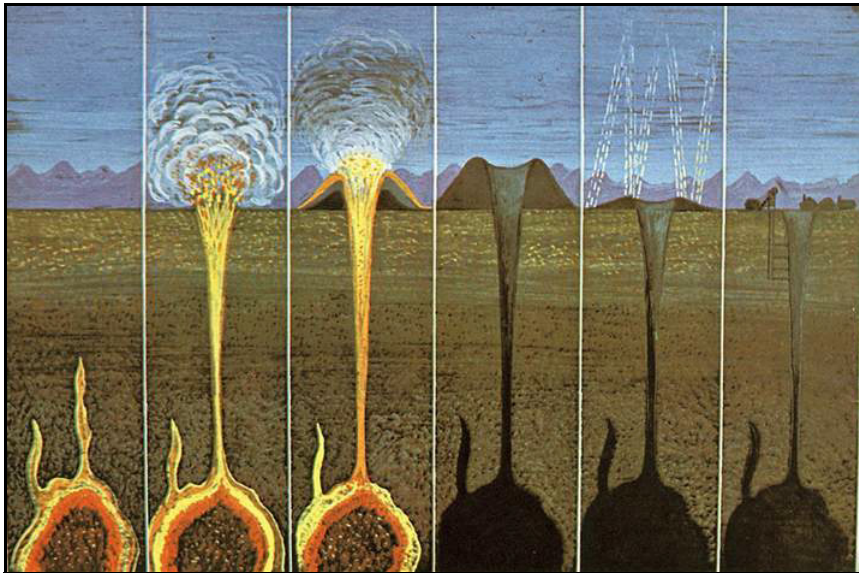


Figure 3.5: The making of a diamond mine. The pressure of the molten magma begins to crack the surrounding rock. The crack then reaches the surface and the volcanic cone is formed. When eruption is complete, the cone is then almost completely weathered through the centuries. When the pipe is discovered mining starts, first by open pit, then by underground mining methods (after Linari-Linholm).



Figure 3.6: Kimberley, the famous diamond mine. The first South African School of Mines was founded near there. The mine is now abandoned and is filled with water.



Figure 3.7: The Diggers' Memorial fountain erected in honour of diggers past and present in the Ernest Oppenheimer Gardens.

Diamond research

The Diamond Research Laboratory was founded by De Beers in Johannesburg in 1947 (Figure 3.8). It was first concerned with the technical aspects of industrial diamond but gradually started research into the fundamental properties of diamond as a crystal. It contracted research on diamond in many universities in England which resulted in a well documented book entitled *Physical Properties of Diamond* published in 1965. The De Beers Diamond Research Laboratory developed a method using a soap solution made of corn-acid oil and caustic soda. Treatment with this solution produces a water-repellent surface on the diamond but not on the other minerals. Material from alluvial deposits is also concentrated by X-ray separation. Diamonds tend to luminesce in an X-ray beam, whereas most of the associated minerals do not. Luminescence excites a photomultiplier that triggers a gate that diverts the diamonds from the path of the gravel passing through the machine.



Figure 3.8: The diamond monument at De Beers Research Laboratories in Johannesburg. The stainless steel spheres represent the tetrahedral structural unit of diamond with an atom at its centre, held together by covalent bonds.

GOLD

In March 1886, an Australian gold miner, George Harrison, discovered a rocky outcrop of the main gold-bearing reef known as Witwatersrand, literary the White Water Ridge (Figure 3.9). The highland, which forms the watershed between the Vaal and Limpopo rivers, is about 100 km long and 37 km wide; its average elevation is about 1 700 metres. Its rich gold deposits, occurring in conglomerate beds known as reefs. The tailing dumps of the gold mines stretch the entire length of the ridge, and chains of lakes created by water pumped from the mines occupy adjoining valleys. It did not take long for fortune-seekers from all over the world to flock to the area. Within 10 years, the settlement became known as Johannesburg and became the largest in South Africa. The Witwatersrand Gold Rush was a major contributing factor for the outbreak of the Boer War in 1899 (Figure 3.10).

It was the profits from diamonds that made possible the financing of the gold industry. Rhodes founded the Gold Fields of South Africa Company in London during the celebrations of the Golden Jubilee of Queen Victoria. Oppenheimer also got involved in gold mining. By coincidence, the cyanidation process for leaching gold was discovered by John Stewart MacArthur

in Glasgow, Scotland, in 1887 and was immediately applied with success to the South African ores. The adoption of this process marks the beginning of modern hydrometallurgy. Today, about 1 billion (10^9) tons of ore are treated worldwide by cyanide solution to recover gold — the largest tonnage of any mineral raw material treated chemically.

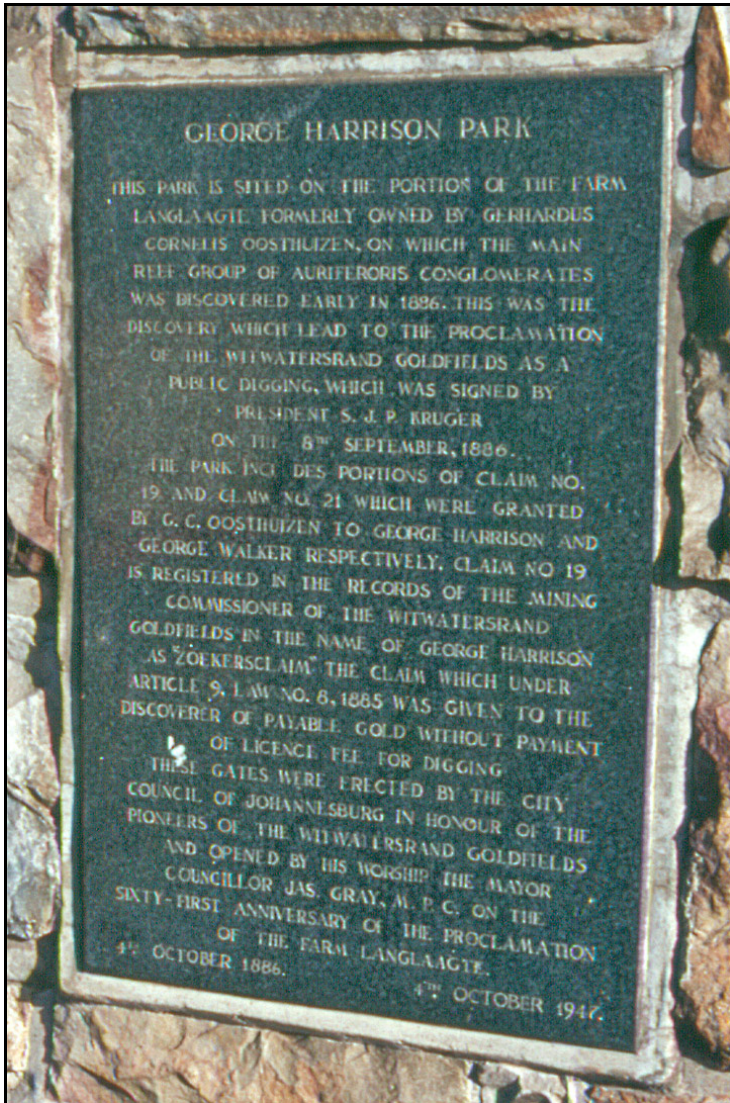


Figure 3.9: A plaque commemorating the discovery of gold in 1886.



Figure 3.10: Postage stamps issued to demonstrate the influence of gold on the transformation of Johannesburg.

THE BOER WAR (1899–1902)

In 1852 the area occupied by the Boer became known as the Zuid-Afrikaansche Republiek, later Transvaal, i.e., across the Vaal River. When in 1868 diamond was discovered major transformations of the colony took place. When few years later in 1886, the Witwatersrand was discovered in Transvaal some 40 km south of the Boer capital at Pretoria, thousands of British and other prospectors streamed over the border from the Cape Colony and from across the globe and settled near the mines. The city of Johannesburg sprang up as a shanty town nearly overnight.

The Uitlanders, i.e., foreigners, rapidly outnumbered the Boers on the Rand. The Afrikaners, resentful of the uitlanders' presence, denied them voting rights and taxed heavily the gold industry. Cecil Rhodes (1853–1902) then Prime Minister of the Cape Colony together with the British mine owners sought to overthrow the Boer government. In 1895, he sponsored an armed incursion on the Transvaal carried out by a British colonial statesman Leander Starr Jameson and his Rhodesian and Bechuanaland policemen over the New Year weekend of 1895–1896. It was intended to trigger an uprising by the Uitlanders in the Transvaal but the raid was a catastrophic failure which forced Cecil Rhodes to resign.

In September 1899, his successor sent an ultimatum demanding full equality for British citizens resident in Transvaal. War started October 1899 (Figure 3.11) when the British Empire was at its zenith in power and prestige and Queen Victoria (1819–1901) (Figure 3.12) had recently celebrated

her Diamond Jubilee.

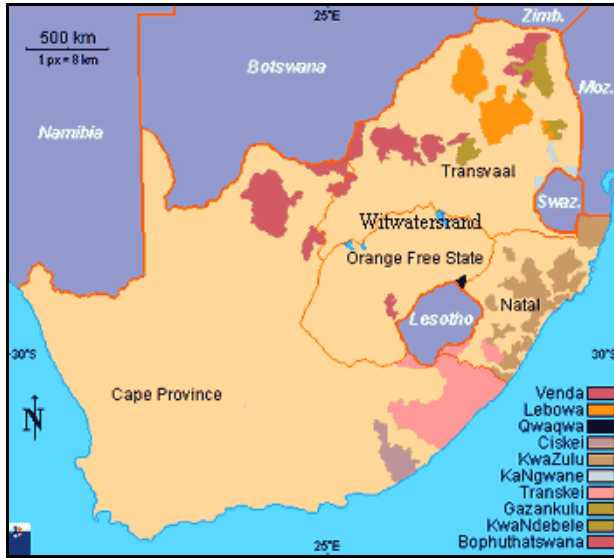


Figure 3.11: Map showing South African colonies at the time of the Boer War.



Figure 3.12: Queen Victoria.



Figure 3.13: Horatio Kitchener.

When Horatio Kitchener (1850–1916) (Figure 3.13) became Commander-in-Chief in South Africa in 1900 he initiated a policy of extermina-

tion directed against the Boer population. Boer farms were destroyed, crops were burnt, livestock were slaughtered, and the majority of captured men fighters were sent abroad to Saint Helena, Bermuda, Ceylon, India, and other countries while Boer women and children were imprisoned in concentration camps under deplorable conditions. The policy was ruthlessly applied and included Black Africans although they were not hostile to the British. Tens of thousands lost their lives. In the end in 1902, the Boers lost, the Transvaal and the Orange Free State became British colonies. This resulted in the formation of the Union of South Africa under the banner of the British Empire in 1910.

PLATINUM

The Bushveld Complex is a large igneous intrusion contains some of the richest ore deposits on Earth. The reserves of platinum group metals are the world's largest, and there are vast quantities of iron, tin, chromium, titanium and vanadium. The Complex has its geographic centre located north of Pretoria. It covers over 66 000 km² an area the size of Ireland. The complex varies in thickness, sometimes reaching 9 km thick. A map in Figure 3.14 shows the Bushveld platinum mines.

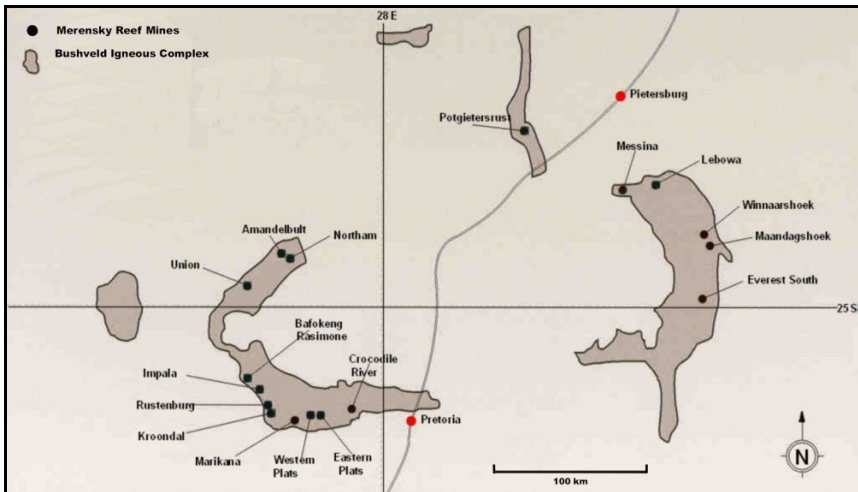


Figure 3.14: Map showing the Bushveld platinum mines in Bophuthatswana: Impala, Rustenburg, etc., and Pretoria. Johannesburg is a little below Pretoria

The ore bodies within the complex include the UG2 reef containing up to 43.5% chromite, and the platinum-bearing horizons Merensky Reef and Plat Reef. The Merensky Reef varies from 30 to 90 cm in thickness. It is a norite with extensive chromitite and sulfide layers or zones containing the

ore. The Reef contains an average of 10 ppm platinum group metals in pyrrhotite, pentlandite, and pyrite as well as in rare platinum group minerals and alloys. About 80% of the platinum and 20% of the palladium mined each year are produced from these horizons.

The discovery of the Bushveld Igneous Complex deposits was made in 1924 by a district farmer. This was an alluvial deposit but its importance was recognized by Hans Merensky (Figure 3.15), whose prospecting work discovered the primary source in the Bushveld Igneous Complex and traced it for several hundred kilometres by 1930. Extensive mining of the Reef take place when an upsurge in the demand for platinum group metals used in exhaust pollution control in the 1950s, made exploitation economically feasible.



Figure 3.15: Hans Merensky.

Impala Platinum Limited, has its primary operations concentrated on the Impala lease area on the western limb of the Bushveld Complex, near the town of Rustenburg. Some 28 000 people are employed by Impala Platinum. The majority of mining operations extend to a depth of around 1 000 metres below surface.

Dr. Hans Merensky (1871–1952), South Africa's most famous prospector and mining geologist, was born in Botshabelo, South Africa. Studied at State Academy of Mining & University of Berlin, and was a Consulting Geologist in Johannesburg. In 1924, he discovered a 48-km platinum reef that was named after him. In his later years on his farm, Westfalia, he donated much of his wealth to universities, schools, libraries, hospitals, charities cultural organisations and people in need. One of his greater contributions was enabling the University of Stellenbosch to create a forestry faculty.

Four postage stamps issued on August 15, 1979 by Bophuthatswana (Figures 3.16–3.19). A stamp shows pouring of platinum and an African worker while the other stamps summarize the importance of platinum in

the chemical industry, in telecommunications satellites, and in jewellery. Bophuthatswana meaning “gathering of the Tswana people.”



Figure 3.16: Processing a platinum ore.

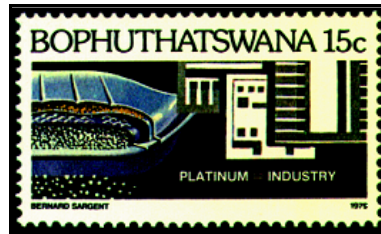


Figure 3.17: Use of platinum as a catalyst in the chemical industry.



Figure 3.18: Use of platinum in space industry.

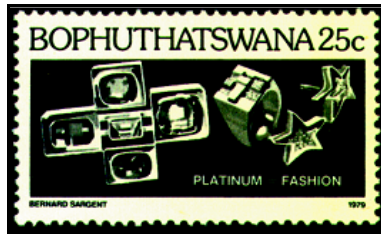


Figure 3.19: Use of platinum in jewellery.

Chapter 4

Apartheid and Bantustans

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APARTHEID

Apartheid, meaning *separateness* in Afrikaans, was a system of legal racial segregation enforced by the National Party government in South Africa between 1948 and 1994. Inhabitants in South Africa were classified into racial groups: Black, White, Coloured, and Indian (Figure 4.1), and residential areas were segregated by means of forced removals. Blacks were stripped of their citizenship, legally becoming citizens of one of ten tribally-based self-governing homelands or *bantustans*, four of which became nominally independent states. The government segregated education, medical care, and other public services, and provided black people with services inferior to those of whites.

Before the institution of the apartheid system, the British colonial rulers had introduced a system of pass laws in the Cape Colony and Natal during the 19th century. Laws were passed to restrict the movement of Blacks into these areas. Blacks were not allowed onto the streets of towns in the Cape Colony and Natal after dark and had to carry their passes at all times. In 1892, Indians were deprived of the right to vote. In 1905 the General Pass Regulations Bill denied Blacks the vote altogether, limited them to fixed areas. The Native Land Act of 1913 prevented all Blacks, except those in the Cape, from buying land outside “reserves.” In 1918, Blacks were forced into “locations” which provided cheap labour for white industry. Other laws were issued preventing Blacks from practising skilled trades and others which banned any land sales to Indians.

Apartheid sparked significant popular uprisings and protests that were met with the banning of opposition and imprisoning of anti-Apartheid leaders. As unrest spread and became more violent, state organizations responded with increasing repression. In 1974, resistance to Apartheid was encouraged by Portugal’s withdrawal from Mozambique and Angola since she could no longer afford to continue combating liberation movements in its colonies.

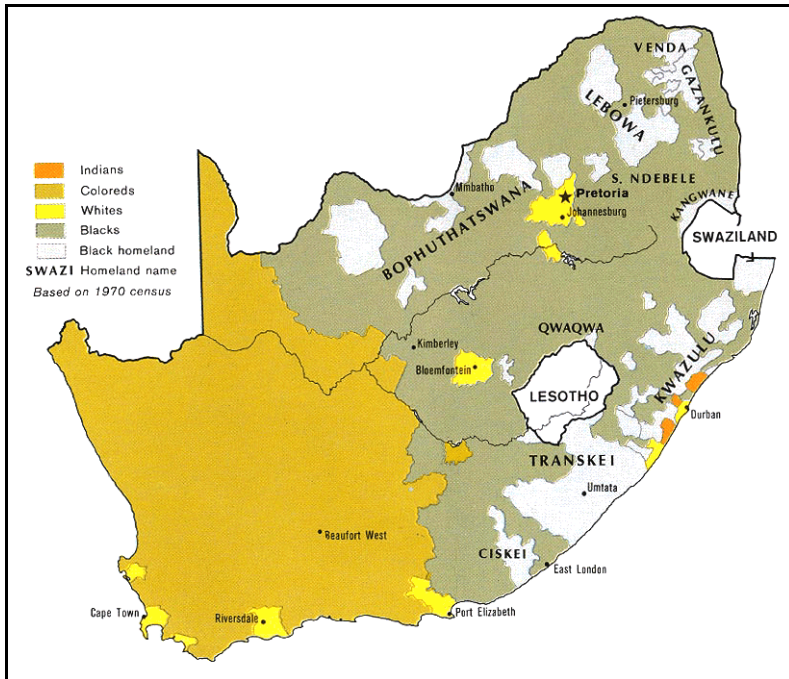


Figure 4.1: Racial map of South Africa.

By 1980, international opinion turned decisively against the Apartheid regime. During the 1980s, the government led by P. W. Botha police action and strict enforcement of security legislation resulted in hundreds of arrests and bans. Numerous political offenders were executed. Serious political violence was a prominent feature of South Africa from 1985 to 1989. The newspapers were full of killing and violence news. Some items illustrating these problems were collected in the newspapers during the 1987 visit (Figures 4.2–4.4).

In 1990, President Frederik Willem de Klerk began negotiations to end apartheid, culminating in multi-racial democratic elections in 1994, which were won by the African National Congress under Nelson Mandela (1918–2013) (Figure 4.5). Mandela was a Xhosa lawyer, anti-apartheid revolutionary, and a politician. He served 27 years in prison, from 1963 to 1990, won Nobel Peace Prize in 1993, and became President of South Africa from 1994 to 1999.

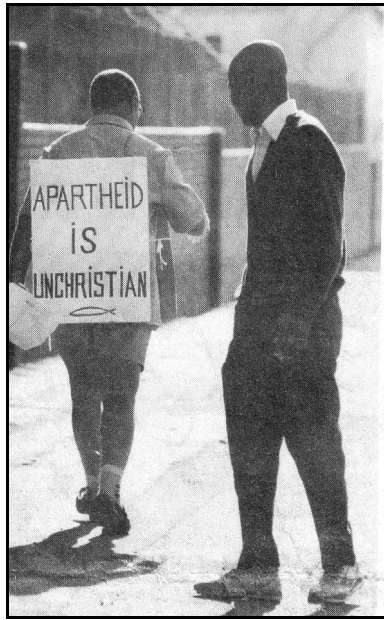


Figure 4.2: A photo published during my stay in 1987.

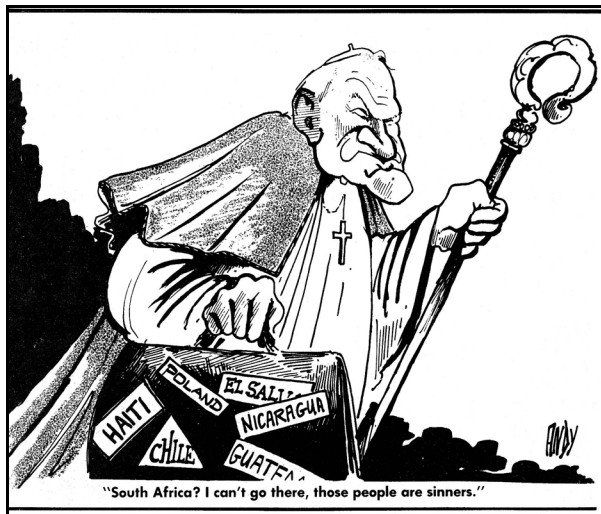


Figure 4.3: A newspaper cartoon showing Pope John Paul II as saying, "South Africa? I can't go there, these people are sinners."

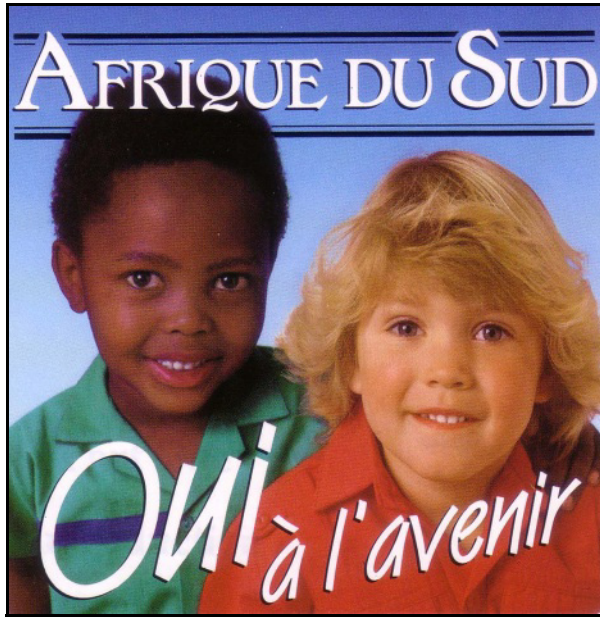


Figure 4.4: The cover to one of the South African brochures against Apartheid.



Figure 4.5: Nelson Mandela (1918–2013).

BANTUSTANS

A Bantustan, a Black African homeland, was territory set aside for Black inhabitants of South Africa and South-West Africa as part of the policy of Apartheid. Ten Bantustans were established in South Africa, and ten in neighbouring South-West Africa (then under South African administration), thus making each of those territories ethnically homogeneous. 'Bantu' (meaning 'people' in the Bantu languages) and '-Stan' (meaning 'land of' in the Persian, Urdu, and Armenian languages). Some of the Bantustans received independence. In South Africa, Transkei, Venda, Bophuthatswana, and Ciskei were declared independent, while others (like KwaZulu, Lebowa, and QwaQwa) received partial autonomy. The condition of sovereign independent states was not recognized outside of South Africa. Lesotho and Swaziland were not Bantustans, but independent countries, and are former British Protectorates. They were granted their independence by Britain in the 1960s.

Well before the National Party came to power in 1948, South African governments had established "reserves" in 1913 and 1936, with the intention of segregating Black South Africans from Whites. National Party Minister for Native Affairs (and later Prime Minister) Hendrik Frensch Verwoerd built on this, introducing a series of measures that re-shaped South African society. Local tribal leaders were coopted to run the homelands, and uncooperative chiefs were forcibly deposed. Over time, a ruling Black elite emerged with a personal and financial interest in the preservation of the homelands. While this aided the homelands' political stability to an extent, their position was still entirely dependent on South African support.

About 55% of South Africa's population lived in the Bantustans; the remainder lived in South Africa proper, many in townships and slums on the outskirts of South African cities. This was, among other reasons, because the economy of white South Africa depended on access to a black labour force.

The Bantustans began to be given independence in 1976, with Transkei the first to obtain this status. Their territories were broken up into numerous, non-contiguous enclaves, and the boundaries between these were very convoluted. For example, Bophuthatswana consisted of seven enclaves dispersed in the northwest of South Africa (Figures 4.6–4.7). The homeland was set up to house Setswana-speaking peoples with its capital Mmabatho situated in an area bordering Botswana. In 1983, it had more than 1 430 000 inhabitants. Two attempts to reverse the state were suppressed by South Africa.

The Bantustans were generally poor, with few local employment opportunities being available. Their single most important home-grown source of revenue was the provision of casinos and topless revue shows,

which the National Party government had prohibited in South Africa proper. This provided a lucrative source of income for the South African elite, who constructed large resorts such as Sun City in the homeland of Bophuthatswana — a short trip from Pretoria (Figures 4.8–4.9).

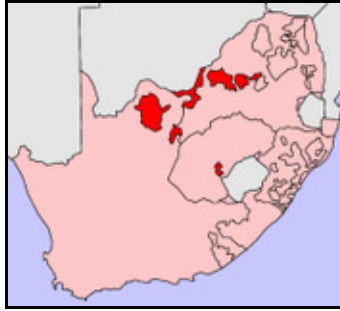


Figure 4.6: Location map of Bophuthatswana shown in red patches.



Figure 4.7: Location map of Sun City region, Pretoria, Johannesburg, and Rustenburg [top right].

The Bantustans' governments were invariably corrupt and little wealth trickled down to the local populations, who were forced to seek employment as "guest workers" in South Africa proper. Millions of people had to work in often appalling conditions, away from their homes for months at a time. Not surprisingly, the homelands were extremely unpopular among the urban Black population, many of whom lived in slum housing. The allocation of individuals to specific homelands was often arbitrary. Many individuals assigned to homelands did not live in or originate from the homelands to which they were assigned, and the division into designated ethnic groups often took place on an arbitrary basis, particularly in the case of people of mixed ethnic ancestry.

In 1994, after the fall of Apartheid, the Bantustans were dismantled and their territory reincorporated into the Republic of South Africa. Re-incorporation was mostly achieved peacefully, although there was some resistance from the local elites.



Figure 4.8: Sun City.



Figure 4.9: Swimming pool in Sun City Hotel.

Chapter 5

Cities Visited

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DURBAN

The discovery of the natural harbour of Durban dates back to Christmas Day 1497, when passing Portuguese seafarers named it “Rio de Natal” (the River of Christmas). In 1823, a European trader and his party settled in the area. Until that time, the only people in the area were the indigenous Zulus. The small white settlement grew into a town and twelve years later it was named after the acting Governor of the Cape colony, Sir Benjamin D’Urban. The Zulus did not favour the European settlement especially when the Voortrekkers arrived. Mistrust grew resulting in a series of bloody battles. In 1844 the British Government annexed the region to the Cape Colony becoming the new province of Natal. They then brought in thousands of Indians to work on the sugar plantations. Today they form the largest Indian population outside India.

The conference of South African Chemical Society was held at Hotel Elengeni in Durban the capital city of Natal Province (Figures 5.1–5.4).

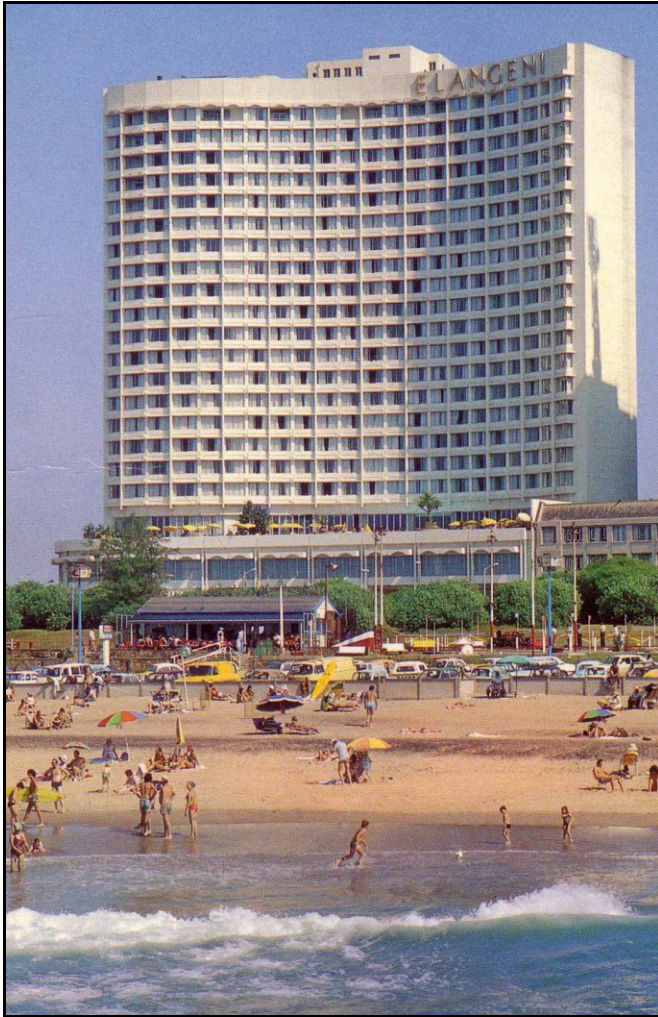


Figure 5.1: Hotel Elengeni in Durban, Natal.



Figure 5.2: Presenting a paper at the Chemical Society Meeting [Elangeni Hotel].



Figure 5.3: Durban 1987: from left to right. Fathi Habashi, Michael Laing (1938–2012), Mayor of Durban Stanley H. Lange, Nadia Habashi.



Figure 5.4: With Prof. George Kauffman and wife from California State University, Fresno, USA.

UMTATA, TRANSKEI

Transkei (Figure 5.5), which means “the area beyond the Kei River,” is a region situated in the Eastern Cape of South Africa. It is also the name of an Apartheid-era Bantustan (1963–1994) with its capital at Umtata (now Mthatha). The main language is Xhosa while various smaller languages are also spoken. To enter Transkei, a visa was needed (Figure 5.6).

The Chief Matanzima ruled the territory as a de facto puppet-state dictator, banning local opposition parties and buying for himself and his family at subsidized prices Transkei farmlands offered by the South African Government. From 1978 to 1980 territorial disputes prompted Transkei to sever diplomatic relations with South Africa. In 1987, there was a military coup d'État. From that point onwards the Transkei was in alliance with the African National Congress. It was re-incorporated into the new South Africa on 27 April 1994.

GRAHAMSTOWN

Grahamstown was founded in 1812 as a military outpost by Lieutenant-Colonel John Graham as part of the effort to secure the eastern frontier of British influence in the then Cape Colony against the Xhosa. In 1904, Rho-

des University College was established in the city through a grant from the Rhodes Trust and in 1951 it became Rhodes University (Figure 5.7). The city has an interesting museum about Black Africans and a Cathedral (Figures 5.8–5.9). A conference was held at the University after the Durban Conference.



Figure 5.5: Map of Transkei.



Figure 5.6: Entry visa to Transkei in 1987.



Figure 5.7: Rhodes University in Grahamstown.



Figure 5.8: Inside Grahamstown Museum [Photo by Fathi Habashi].

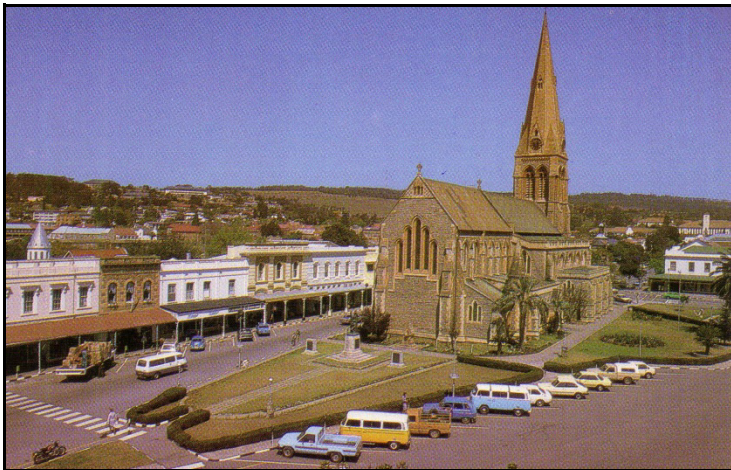


Figure 5.9: Grahamstown Cathedral.

PORT ELIZABETH

The Portuguese explorer Bartolomeu Dias, after having rounded the Cape of Storms (Cape Town) in March 1488, stepped ashore. Until the 18th century the region did not become more than just a refreshment station on the sea routes to Mozambique and the Far East. In 1820 British settlers started to arrive and the Acting Governor renamed the settlement after his late wife Elizabeth. There is an interesting monument dedicated to the memory of the large number of horses killed during the Boer War (Figures 5.10–5.11).

The University of Port Elizabeth was a White-only institution. In January 2005, Nelson Mandela Metropolitan University was formed through the merger of the University of Port Elizabeth, the Port Elizabeth Technikon, and the Port Elizabeth campus of Vista University (Figures 5.12–5.13).

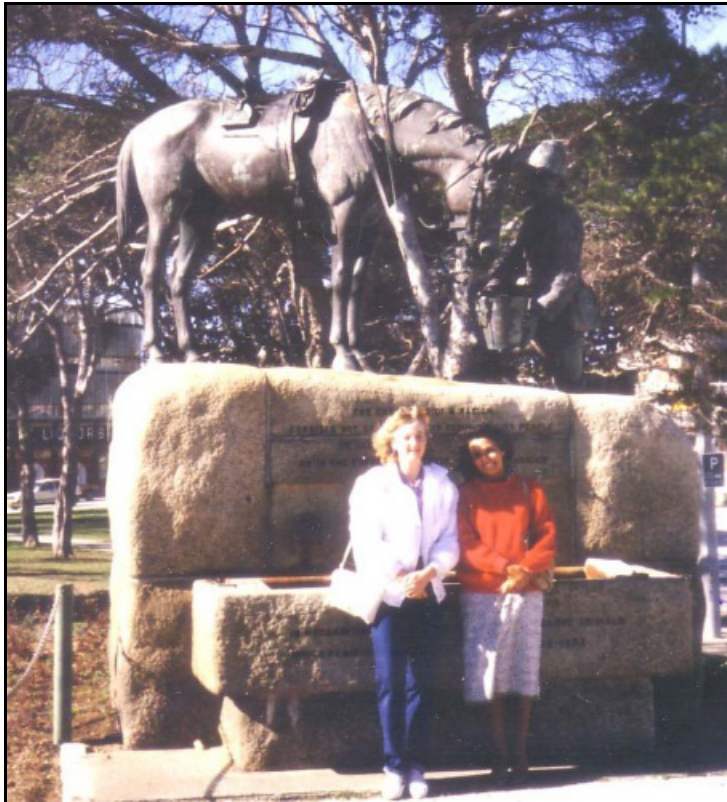


Figure 5.10: Monument to horses [Photo by Fathi Habashi].



Figure 5.11: Detail of the monument to horses.



Figure 5.12: University of Port Elizabeth.



Figure 5.13: Port Elizabeth, 1987. From left to right: Nadia Habashi, Professor Jan du Preez, graduate student Jeanny Broadhurst [Photo by Fathi Habashi].

Tsitsikamma National Park

A few days were spent at Tsitsikamma National Park with Prof. Jan du Preez and his wife (Figures 5.14–5.15).

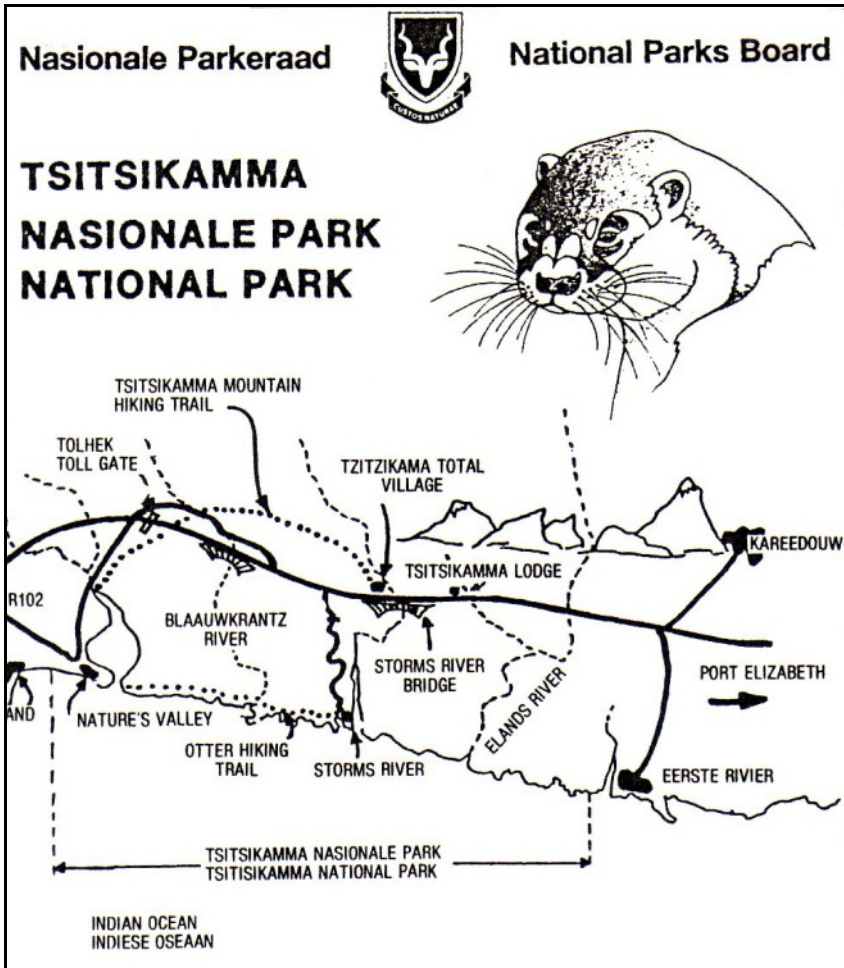


Figure 5.14: Location map of Tsitsikamma National Park.

Swartskops Seesout

A salt production facility in the outskirts of Port Elizabeth. Executive Chairman: G. T. V. W. Schoonbee, Guide: Brian Lawrence [Production Manager].



Figure 5.15: Port Elizabeth 1993: with Professor Jan du Preez at Tsitsikamma National Park near Port Elizabeth.

JOHANNESBURG

Johannesburg, also known as Jo'burg, is the largest city in South Africa and the capital of Gauteng, the wealthiest province in the country (Figure 5.16). It is the source of a large-scale gold and diamond trade, due to its location on the mineral-rich Witwatersrand range of hills.

University of Witwatersrand

The University of Witwatersrand (Figure 5.17) is closely related to Technikon Witwatersrand [see below]. Both had their origin in Kimberley when in 1896 the South African School of Mines was founded. In 1904 it was moved to Johannesburg and changed its name to the Transvaal Technical Institute, in 1906 it became the Transvaal University College, and in 1910 it became the South African School of Mines and Technology. In 1922 it was granted university status and re-named the University of the Witwatersrand. In 1959, the Extension of University Education Act forced restricted registrations of black students in the university. It became desegregated once again prior to the abolition of Apartheid in 1990.



Figure 5.16: Johannesburg and its surroundings.



Figure 5.17: University of Witwatersrand.



Figure 5.18: Johannesburg 1987: with Professor Peter King (1938–2006) in his office at the University of Witwatersrand [Photo by Nadia Habashi]. Prof. King moved later to University of Utah in Salt Lake City.



Figure 5.19: 1993: With some faculty members of Wits University. Prof. H. Eric [second from left] and Prof. Frank Letowski [extreme right].



Figure 5.20: 1993: With students of Wits University.

Technikon Witwatersrand

In 1894, the Government of the Cape Colony instituted a scheme providing for two year's preliminary instruction to be given at the South African College in Cape Town followed by a third year of technical instruction at Kimberly, and a fourth year at Johannesburg. The mining course commenced in 1895 in Cape Town. In 1896 when the School of Mines was inaugurated in Kimberly, graduates proceeded to the Rand where they were committed to the care of various mine managers to study gold mining.

In 1899, the work at Kimberley was disrupted by the Boer War and the School was closed in 1900. In 1901, the military authorities permitted the senior students to proceed to the Rand making it possible again for them to spend time on a gold mine. In 1903 it fused with the Transvaal Technical Institute when it was established in Johannesburg. In addition to the technical subjects, instruction was also provided in arts, science, and law. This resulted in a name change in 1906 to Transvaal University College and occupying a new building completed in 1909 (Figure 5.21).

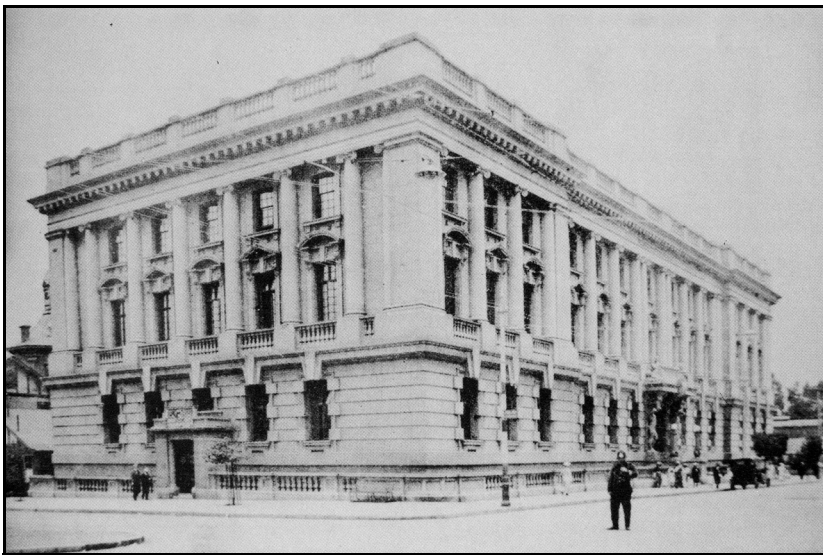


Figure 5.21: Transvaal University College in 1909 in Johannesburg, the successor of Kimberley School of Mines..

In 1910, however, the arts were transferred to Pretoria and retained the name Transvaal University College, and what remained in Johannesburg became known as the South African School of Mines and Technology. When the University of South Africa was established in 1916, the School of Mines and Technology became a constituent part and in 1920 changed its name to University College, Johannesburg. In 1924, reorganization in the

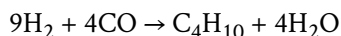
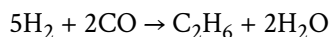
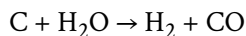
education system took place and the Witwaterstrand Technical Institute — the Technikon Witwatersrand of today — was declared a place of higher education. A meeting was held with the Dean of the Faculty of Mining and Metallurgy (Figure 5.22).



Figure 5.22: Visit to Technikon in Johannesburg in 1993. From left to right: Prof. Frank Letowski from Wits University, Fathi Habashi, Dr. R. V. R. Handfield-Jones, Dean, Faculty of Mining and Metallurgy [Photo by Nadia Habashi].

SASOL

SASOL, which stands for South African Synthetic Oils Limited, is a mature technology of synthetic fuel manufacture based on the 1920s German Fischer–Tropsch reaction and Bergius hydrogenation chemistry. During the Second World War Germany had limited access to natural crude oil for producing fuel for its war effort. With rich coal deposits in the country and in occupied Poland and Bohemia, a number of large synthetic fuel plants were rapidly constructed. The long running embargo by Western countries compelled the Apartheid regime to build SASOL plants. The plants are located at Sasolburg and Secunda (Figure 5.23). Sasol's original plant at Sasolburg was commissioned in 1955. Two large production facilities were commissioned in the early 1980s in Secunda. There are four basic phases in a plant:



- Gasification of coal into synthesis gas or reforming natural gas into synthesis gas, which is primarily a mixture of carbon monoxide and hydrogen
- Purification of the synthesis gas to remove impurities such as sulfur
- Liquefaction of the gas
- Processing the liquid into fuel.

A number of chemicals are also extracted from the Fischer–Tropsch processes. These include solvents, polymers, ethylene, propylene, and waxes. Sasol also produces ammonia, fertilizers, and explosives.



Figure 5.23: Sasol plant in South Africa.

RUSTENBURG

The Rustenburg Base Metals Refiners is owned by Anglo American and consists of two metallurgical plants: the magnetic concentration plant and the base metals refinery (Figure 5.24). The Refinery treats Waterfall converter matte to produce base metal products and a precious metal concentrate for further treatment at Precious Metals Refinery (PMR).

GERMISTON

A visit was paid to the Mineral Processing Research Laboratory of Johannesburg Consolidated Investment Company in Germiston, a suburb of Johannesburg. The Investment Company is the largest producer of platinum in the world and is known as JCI. The visit was organized by Norbert Hanf.



Figure 5.24: Visit to Rustenburg in 1993. From left to right: Norbert Hanf, Peter Nofal (Guide), Fathi Habashi, Zdenek Hofirek (graduate of Prague Institute of chemical Technology, Guide). [Photo by Nadia Habashi].



Figure 5.25: Mintek, South Africa's national mineral research organization.

RANDBURG

The mineral wealth in South Africa incited the Government in 1934 to create a large research centre that became known as Mintek — acronym for Mineral Technology located in Randburg, a Johannesburg suburb (Figures 5.25–5.26). It became a world leader in mineral and metallurgical innovation and is specialising in mineral processing, extractive metallurgy, and related areas. Working closely with industry and other R&D institutions, the organisation provides service test work, process development and optimization, consulting, and innovative products to clients worldwide.



Figure 5.26: Beer with Roger Paul [right] and Mike Dry, of Mintek, and family, 1987 [Photo by Fathi Habashi].

Anglo-American Research Laboratory is also located in Randburg (Figure 5.27).

General Mines Research Laboratory, known as Genmin, is situated on the outskirts of Johannesburg next door to Mintek (Figure 5.28). Host: Trevor Tunley and Jenny Broadhurst, former student of Prof. Jan du Preez.



Figure 5.27: Chemists at Anglo-American Research Laboratory. From left to right: Dr. Suha Rohani, Fathi Habashi, Dr. J. Tumilty [Photo by Nadia Habashi].



Figure 5.28: 1993 visit to General Mines bacterial leaching pilot plant for the pre-treatment of pyrite-containing gold.

STELLENBOSCH

Stellenbosch is about 50 km east of Cape Town, founded in 1679 by the Governor of the Cape Colony, Simon van der Stel. Soon after the first settlers arrived, especially the French Huguenots, grapes were planted in the fertile valleys around Stellenbosch and soon it became the centre of the South African wine industry (Figure 5.29). The town is home to the Uni-

versity of Stellenbosch founded in 1863 (Figure 5.30). Visit to the University in June 1993. Hosts: Professor Leon Lorezen and Professor Jannie Van Deventer.



Figure 5.29: Typical house in Stellenbosch.



Figure 5.30: University of Stellenbosch.

CAPE TOWN

Cape Town (Afrikaans: *Kaapstad*; Xhosa: *iKapa*), at the tip of Africa (Figures 5.31–5.33), is the second most populous city in South Africa. It is the provincial capital of the Western Cape, as well as the legislative capital of South Africa, where the National Parliament and many government

offices are located. Cape Town was originally developed by the Dutch East India Company as a supply station for Dutch ships sailing to Eastern Africa, India, and the Far East. Jan van Riebeeck's arrival on 6 April 1652 established the first permanent European settlement in South Africa. Cape Town quickly outgrew its original purpose as the first European outpost at the Castle of Good Hope, becoming the economic and cultural centre of the Cape Colony. Until the Witwatersrand Gold Rush and the development of Johannesburg, Cape Town was the largest city in South Africa. As of 2007, the city had a population of 3.5 million.

University of Cape Town (Figure 5.34) was founded in 1829 as the South African College, and is the oldest university in South Africa. Visit to the Department of Chemistry in July 1987. Hosts: Professor Klaus Koch [a German from Windhoek] and graduate student Cheryl Sacht. Visit in 1993 to Chemical Engineering Department, host: Professor Jean-Paul Franzides. Lecture delivered: "Recent Advances in Extractive Metallurgy."



Figure 5.31: Map of Cape Town showing Cape of Good Hope.

Mineral World is a plant processing gemstones at Simontown, 25 km south of Cape Town. The Gold of Africa Museum is located in the historic Martin Melck House (Figures 5.35–5.38). The Museum is dedicated to the history and artistry of African gold. It contains the world-renowned collection of West African gold artefacts originally from the Barbier–Mueller

Museum in Geneva, as well as artefacts from the ancient gold civilisations of southern Africa. It displays the world's most comprehensive collection of African gold and also includes photographs about the Apartheid system that once existed in South Africa.



Figure 5.32: Aerial view of Cape Town.



Figure 5.33: Cape of Good Hope.



Figure 5.34: University of Cape Town.



Figure 5.35: Gold Museum in Cape Town.



Figure 5.36: View inside Gold Museum in Cape Town.



Figure 5.37: View inside Gold Museum in Cape Town.



Figure 5.38: Example African gold object at the Museum.

PRETORIA

Pretoria was founded by the Voortrekkers in 1855 on the banks of the Apies River. They named it after one of their leaders, Andries Pretorius (1798–1853) (Figure 5.39). In 1860, it became capital and seat of government of the Transvaal Republic. Pretoria is 50 km of Johannesburg International Airport. It is a gateway to the Kruger National Park and Sun City. A short course on hydrometallurgy was held at the University of Pretoria (Figure 5.40).



Figure 5.39: Monument to Andries Pretorius (1798–1853) in Pretoria.



Figure 5.40: With course participants at the University of Pretoria. Middle row from left to right: course organizer Professor Roelf F. Sandenbergh, Fathi Habashi [February 2000].

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