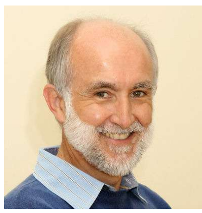
A Brief History of South African Smelting

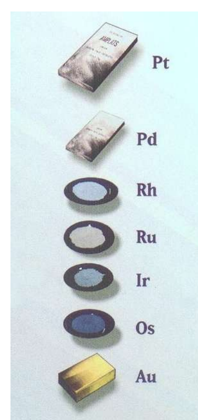


Rodney Jones

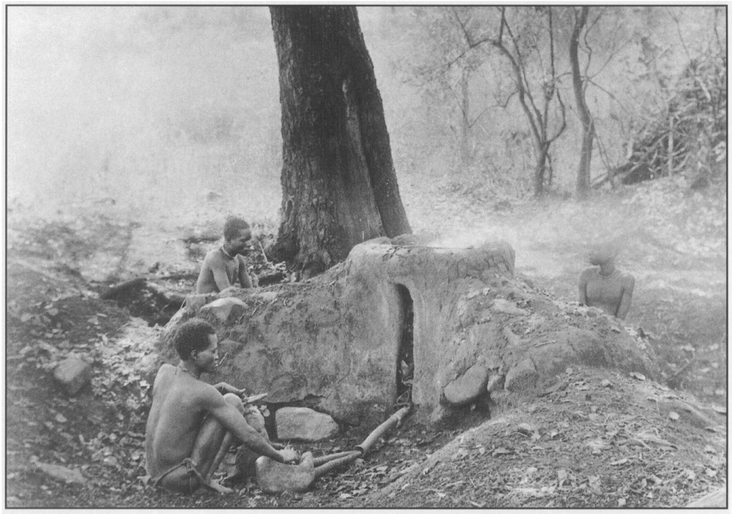
27 May 2026

Mineral wealth of South Africa

- South Africa is the country endowed with the highest value of mineral (non-oil) reserves in the ground
- It has the Bushveld Complex, the Witwatersrand Gold Basin, and the Kalahari Manganese Field
- South Africa has over 90% of the world's reserves of platinum group metals, the world's largest chromite reserves, as well as significant quantities of manganese, vanadium, and titanium, amongst other metals
- Southern Africa has a relatively long history of small-scale mining and smelting, and a more recent but highly prominent history of smelting on an industrial scale
- It should be remembered that electric smelting is less than 150 years old



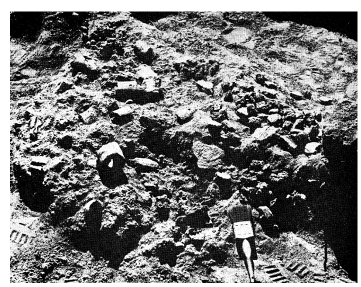
Early smelting in South Africa



'Makaties iron foundry ... east of the Spelonken'. This remarkable photograph, taken in 1888 by H. Gros, shows a typical Venda iron-smelting furnace in operation. The operators are each using two bellows made of hide. Straightened antelope horns channel the air blast through three clay tuyères to the charge in the furnace (Africana Library, Johannesburg)

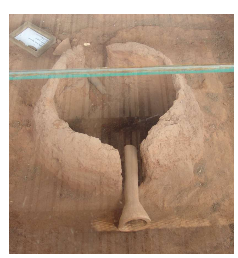
Early smelting of iron in South Africa

- Mason (1974) produced evidence from Broederstroom (near what is now Johannesburg) for the production of iron and copper, the farming of cattle and sheep, and the construction of large villages, from at least AD 460 onwards



Earliest traces of iron smelting in the Transvaal. Tuyeres, iron slag, and iron ore, dated AD 460.

- Low-shaft bloomery furnaces of the Iron Age were found at Melville Koppies (dated to ~1400 AD) and other sites in the vicinity of Johannesburg.



Timeline for industrial commodities in South Africa

Copper	1850s/1860s	O’okiep
Diamonds	1867	Kimberley
Gold	1886	Johannesburg
Silver	1891	Delmas
Lead	1891	Delmas
Iron	1901	Pietermaritzburg
CaC_2 and FeSi	1918	Germiston
PGMs	1937	Rustenburg
Manganese	1939	Newcastle
FeCr	1942	Vereeniging
Stainless Steel	1943	Vereeniging
Vanadium slag	1968	Witbank (eMalahleni)
Silicon	1974	Polokwane
Ilmenite	1977	Richards Bay
Tin	1979	Rooiberg
FeV	2002	Brits

Ancient history of copper smelting

- Smelting history goes back at least 6000 years to the copper smelters of the Timna valley near Eilat in Israel
- Copper is the world's oldest metal and was used in Africa more than 5000 years ago for water plumbing in the Pyramid of Cheops in Egypt. The Egyptians obtained their copper from Israel and from Cyprus.
- Copper artefacts found in sub-Saharan Africa date back to 4000 BC
- Ancient sites in present day Zambia and DRC date back to 400 AD

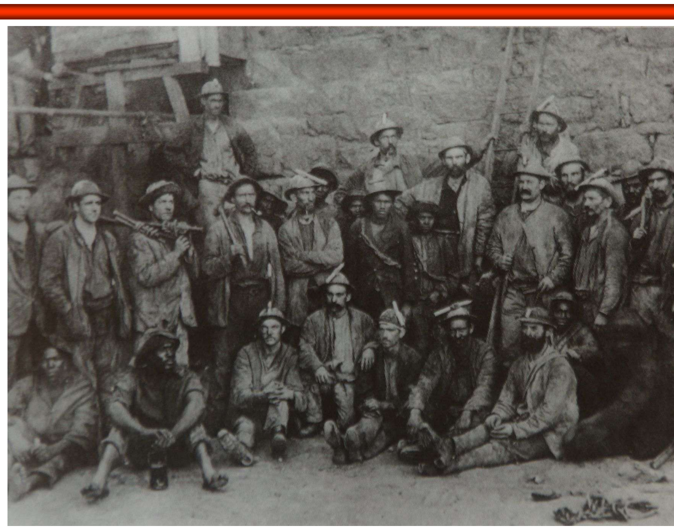
Ancient mining tools

O’okiep Copper Company

- Simon van der Stel ‘discovered’ the 'Copper Mountain' at Springbok in 1685
- The first South African mining company was formed there in 1852 to mine the copper deposits. Other notable firsts for this mining district include the first South African geological report and geological map.
- In the 1860s, Okiep became the most important mine of the Cape Copper Company. In 1866, a narrow-gauge railway line was built to Port Nolloth on the coast. This line was primarily used to convey the partially smelted copper matte to the coast from where it was exported for further refining in South Wales. Because there was an insufficient supply of water to operate steam locomotives on this line, the service was pulled by mules until as late as 1890.

The mule train between O'okiep Mine & Port Nolloth, ~1880

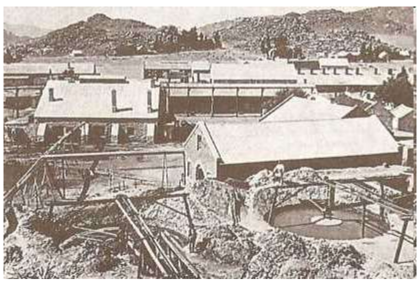
O’okiep Copper Company



Copper miners preparing to go underground at O’okiep, ~1890.
Note the candles attached with clay to their helmets.
(Cape Archives, Digging Deep)

O’okiep Copper Company

- Cupola furnaces were in place at the smelter
- Production by the Cape Copper Company ceased in 1919 as a result of the post-war economic slump, and Okiep soon became a ghost town
- The O'okiep Copper Company was floated on the New York stock exchange during the 1940s
- In the 1960s, O'okiep Copper Company paid the highest dividend ever on the NYSE for that period



O'okiep Mine ore dressing floors, ~1890

A Cornish Beam Engine House on the site of Okiep Mine

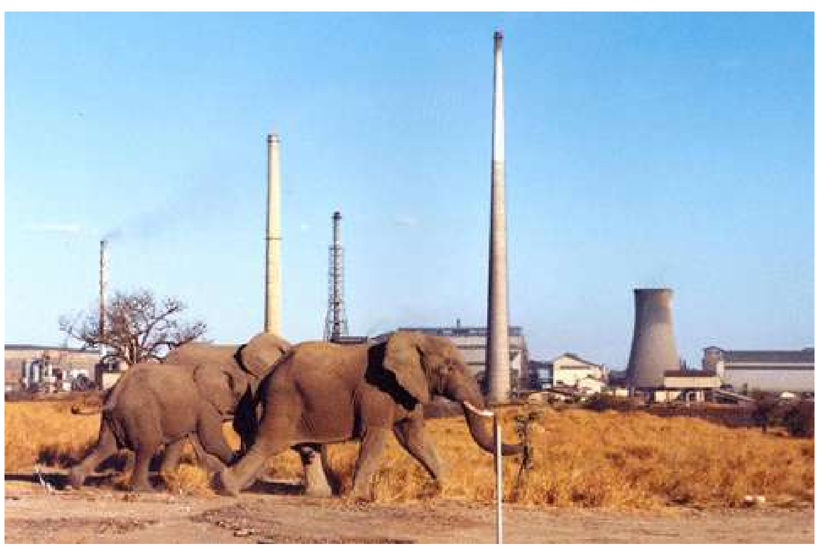
Copper smelting – O’okiep, Messina, Palabora

- Industrial-scale smelting began in South Africa in the 1850s or 1860s when copper was produced by the O'okiep Copper Company in cupola furnaces
- Messina Copper Mine was producing a high-grade matte by 1914
- (Copper smelting started in the Zambian copper belt in 1931, with two reverberatory furnaces and two Peirce-Smith converters at Nkana)
- In 1966, Palabora Mining Company started smelting copper in a coal-fired reverberatory furnace and three Peirce-Smith converters

Palabora Mining – Phalaborwa, South Africa

- The Palabora smelter commenced in 1966, and consists of a single coal-fired reverberatory furnace, three Peirce–Smith converters, two anode refining furnaces, a holding / scrap melting furnace and an anode casting wheel, and a sulfuric acid plant
- The smelter nameplate capacity was originally 80 kt/a, but was improved and upgraded to 120 kt/a by 1972
- Underground mining commenced 2001; open pit was closed end 2003
- In 2004, the smelter feed was supplemented with imported concentrates
- Originally a joint venture between Rio Tinto and Anglo-American, the facility is now operated by a new consortium comprising South African and Chinese interests
- Nominal copper capacity at Palabora is 160 kt/a

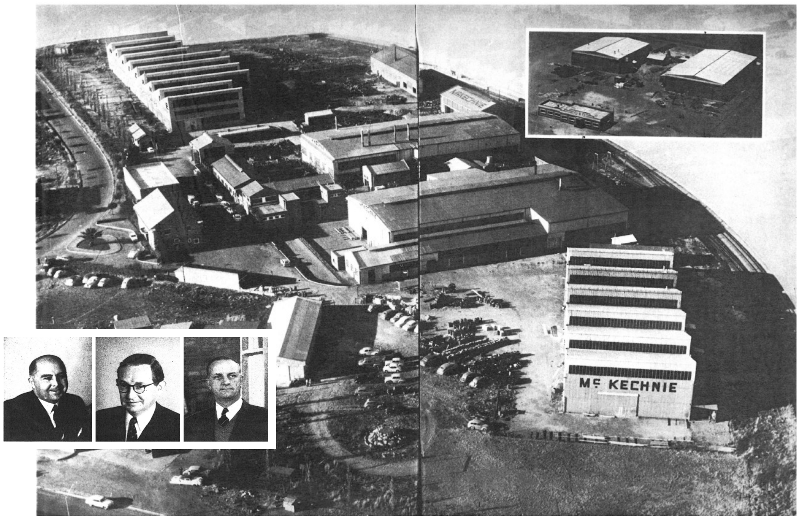
Palabora Mining Company



A mine, smelter, and wildlife sanctuary (adjacent to Kruger Park)

Copalcor – Germiston, South Africa

- Founded in 1949 as McKechnie Brothers SA (Pty) Ltd
- Photograph shows growth over first 10 years (1949-1959)



Copalcor – Germiston, South Africa

- South Africa’s largest secondary copper smelter
- Scrap-melting induction furnaces supply molten metal for slab casting, hot rolling, and extrusion of copper and brass
- Three furnaces provide capacity to smelt over 400 tons per month, roughly 5 kt/a
- Copalcor also manufactures various furnace components, including busbars, contact shoes, furnace side-wall coolers, tap-blocks and launders

copalcor


Furnace


Slab Casting


Hot Rolling

World mine production of copper in 2025, kt/a

Chile	5300	23%
DRC + Zambia	**4140**	**18%**
Peru	2700	12%
China	1800	8%
Russia	1300	6%
USA	1000	4%
Australia	730	3%
Indonesia	710	3%
Canada	500	2%
Other	4820	21%
TOTAL	**23 000**	**100%**

U.S. Geological Survey, Mineral Commodity Summaries, April 2026

- South Africa produces ~64 kt/a (0.3%) of the world's copper
- 40% of South Africa's copper production is a by-product of the PGM industry

- China refines 14 000 kt/a (~50%) of the world's copper

Diamonds and Gold

- Discovery of diamonds in Kimberley in 1867, and the discovery of gold, especially around Johannesburg in 1886, changed South Africa's economy from being based on agriculture to being based on mining
- The legacy of colonialism dates back to this period
- Mines required expensive machinery, and the consolidation of small claims, thereby ushering in the era of large capital and the mining magnates
- The money accrued from diamond mining in Kimberley provided capital for opening up the new goldfield

Perspective on South African gold

- The Witwatersrand gold basin is unique, being the most immense gold resource with the poorest grade
- It has yielded almost one third of all the gold ever mined in the world. More than 1.5 billion ounces of gold has been extracted.
- South Africa still has more gold underground than has been mined
- Peak SA production was 1000 t in 1970
- South Africa was the largest producer until 2006 (300 t)
- Production in 2025 was ~90 t
- Employment dropped by 400 000 gold miners (from 500 000 to 100 000)

Argent Silver Mine

- The story of silver is an almost forgotten chapter in South Africa's smelting history
- In 1891, silver was first produced at the Argent Mine near Delmas, in two reverberatory roasting furnaces and two blast furnaces
- Currently being studied by an industrial archaeologist

Argent Silver Mine

Foundations

Circular foundations of a roaster

Rectangular foundations of a reverberatory furnace

Argent Silver Mine

Blast furnace remnants

Argent Silver Mine

•Slag dump is extensive, and highly ordered

Early lead smelting

- In South Africa, lead was first discovered at the Maitland River in 1782, and was worked for a short period early in the 19th century (Snodgrass, 1986). Before the introduction of breech-loading arms, lead was smelted in the Transvaal for use in the Boer Republics. The lead deposits that were exploited were mainly in the Transvaal near Argent station, where a smelter was erected between 1889 and 1893. Between 1922 and 1925, the Argent Mines and Smelter were operated by Transvaal Silver & Base Metals Limited, which produced about 360 t of crude lead per month from a blast furnace for refining overseas.

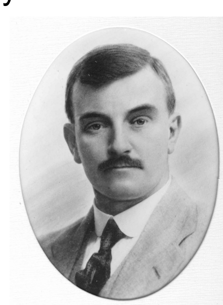
- These Argent deposits were mined intermittently until 1957, when they finally closed down, the most productive periods being between 1882 and 1893, 1922 and 1925, and 1951 and 1957. A total of 16 250 t of metallic lead was produced.

Secondary lead smelting at Fry's Metals

- Fry's Metals and Castle Lead Works are members of the Zimco Group of Companies
- Castle Lead began manufacturing lead products near Cape Town Castle in 1933, and now has branches in Krugersdorp, South Africa, and in Kitwe, Zambia
- Fry's Metals began in Wadeville, Germiston ~1947
- Uses rotary furnaces to smelt recycled lead-acid batteries as well as lead concentrates. Refines lead, antimony, and tin alloys.
- Produces ~55 kt/a of lead and lead alloys for the battery and electrical cable industries

Iron and steel

- Iron was first smelted on a large scale in South Africa in 1901, near Pietermaritzburg, in a primitive blast furnace, by Samuel Light Green
- The Union Steel Corporation electrically melted steel scrap in 1911
- The first industrial-scale smelting of iron ore began in Pretoria in 1918, in a blast furnace constructed by Professor George Stanley (SAIMM President 1914-1915)



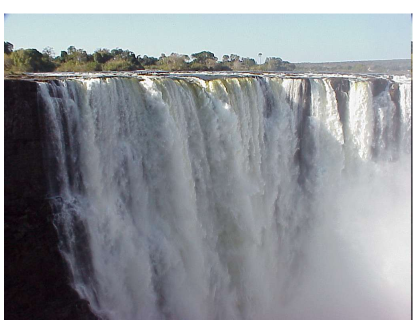
- The Iron and Steel Corporation of South Africa (Iscor) was formed in 1928.

Hendrik van der Bijl

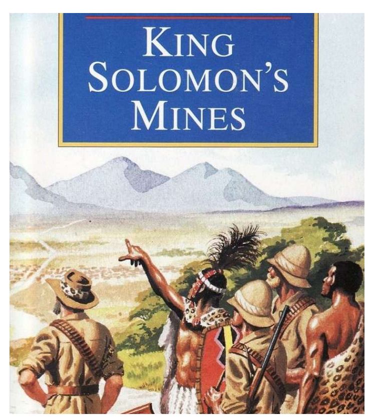
- Dr Hendrik van der Bijl (1887 – 1948), FRS, was one of South Africa's greatest industrialists
- He came from an influential family, and studied physics in Stellenbosch and Germany, then worked in the USA
- He returned to South Africa in 1920, and was asked by Prime Minister Jan Smuts to advise the government in the planning of South Africa's industrial development
- In 1922, he founded the Electricity Supply Commission (Escom) and chaired it until 1948
- He established the South African **Iron and Steel Corporation (Iscor)** in 1928, with the first steel produced in Pretoria in 1934, followed by Vanderbijlpark steel works and town in 1947. (Iscor was taken over by what is now Arcelor Mittal in the early 2000s.)
- He also founded the **African Metals Corporation (Amcor)** in 1937, the Industrial Development Corporation (IDC) in 1940, Vecor in 1945, and Safmarine in 1946

Ferro-alloy smelting (and gold mines) needed electrical power

- Sir Henry Rider Haggard suggested to Cecil Rhodes that the Victoria Falls could be used to power gold mining on the Rand. The British South Africa Company (BSA) formed the Victoria Falls Power Company in 1906. Unfortunately, the Victoria Falls has a meagre and unpredictable flow in the dry season, but speculators made a lot of money anyway.



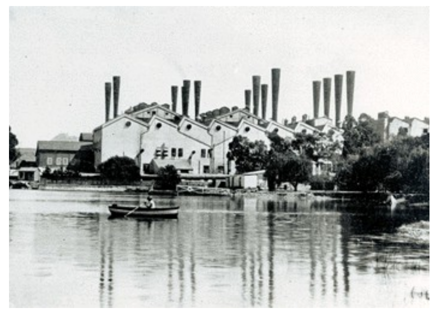
Victoria Falls is not the highest, nor the widest, but has the largest sheet of falling water, 1.7km wide and 108m high



1885 book by Sir Henry Rider Haggard

Simmerpan Power Station

- Power stations were built closer to the gold mines in the 1890s
- The Victoria Falls Power Company changed its name to the Victoria Falls and Transvaal Power Company Limited in 1909, and built **turbine-based power** stations. It became dominant because of **cheaper power** prices.
- Amongst the first, and perhaps the most important was the Simmerpan Power Station (1909–1957) on the banks of Simmer Pan or Victoria Lake (now known as Germiston Lake). This site remains in use as the central control centre of Eskom's power network for all of South Africa.



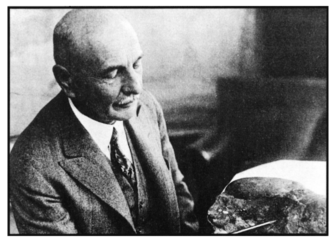
Start of South Africa's Ferro-alloys Industry – Rand Carbide

- Rand Carbide Limited came into being in **1918 in Germiston** for the production of calcium carbide and ferrosilicon
- Rand Carbide **moved to Witbank** (now known as eMalahleni in Mpumalanga) in 1926 **to avail itself of cheaper power** and because it envisaged the use of the coal there as a raw material
- *Since those early days, the production of carbide has been greatly expanded, and the company has diversified into the production of ferrosilicon and intermediate products, char, electrode paste, electrode casings, and steel drums, both for its own use and for supply to other manufacturers employing electric furnaces*
- *(During 1978, Highveld Steel and Vanadium Corporation acquired the total issued share capital of Rand Carbide Limited)*

Platinum and PGM smelting

- Platinum in the Bushveld Complex was first documented by William Bettel (the first President of what has become SAIMM) in 1906 (Cawthorn, 2007)
- The great geologist, PA Wagner, concluded in 1923 “that it would never pay to work the chromite rock for that metal (platinum) alone”
- Dr Hans Merensky (1871–1952) is regarded as the father of the platinum industry in South Africa, having identified economic deposits


William Bettel


Hans Merensky

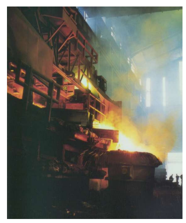
Platinum and PGM smelting

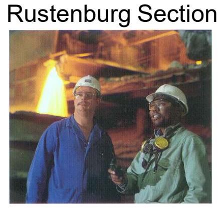
- Platinum Group Metals (PGMs) have been mined in South Africa since 1923
- The platinum smelting industry began in 1937 with a small blast furnace and a Great Falls converter at Rustenburg Platinum Mines.
- Blast furnace technology was replaced by a six-in-line electrical furnace in 1969. Subsequent smelting furnaces have all been electrical.

Valterra Platinum (formerly Anglo American Platinum)

Mortimer Smelter
Union Section

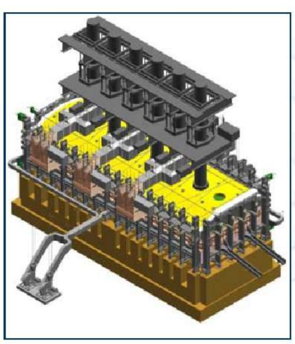
Waterval Smelter
Rustenburg Section





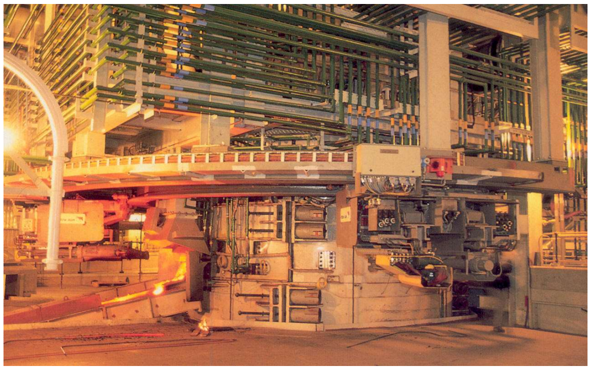
Valterra Platinum – Polokwane smelter

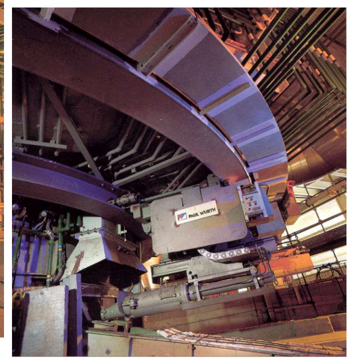
- High-power 68 MW six-in-line rectangular furnace switched on in 2003
- Furnace matte is sent to the Waterval smelter for centralised converting



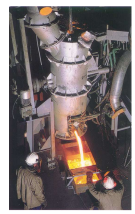
- **Capacity :**
  - **650,000 t/a (87 tph)**
- **Power :**
  - **68 MW (168MVA)**
- **Power density :**
  - **250 kW/m^2**
- **Matte temperature :**
  - **1,550^{O}C**
- **Slag temperature :**
  - **1,600^{O}C**

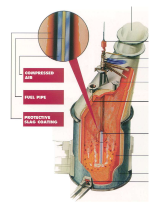
Valterra Platinum – ACP plant, Rustenburg



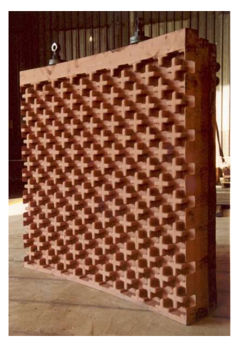


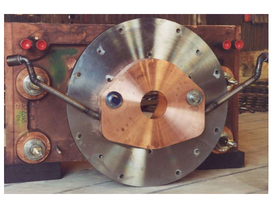
•Developed by Anglo Platinum, based on Ausmelt technology



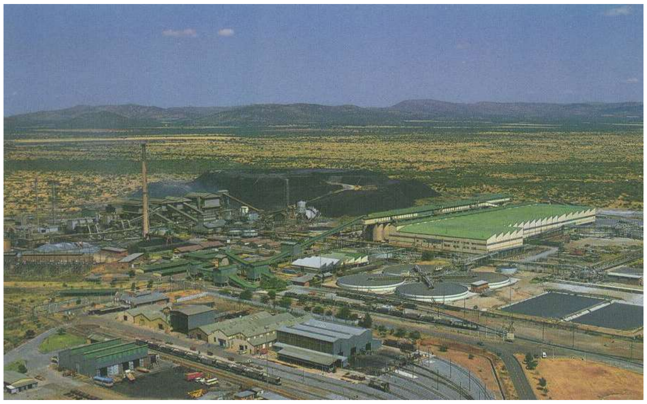


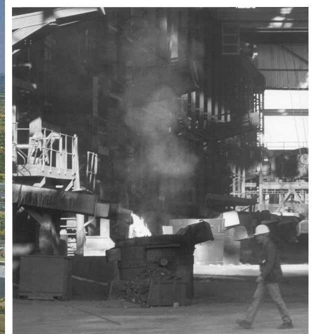
Valterra Platinum – Slag cleaning furnace, Rustenburg





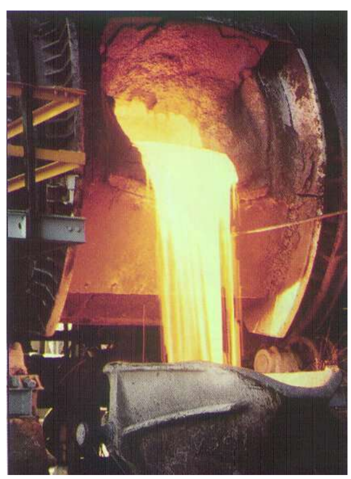
Impala Platinum (1969)



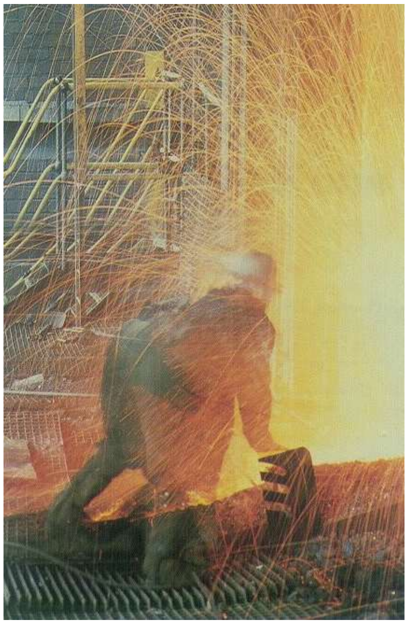


- Large integrated smelter using older established technology (six-in-line furnaces and Peirce-Smith converters)
- Toll treatment of a range of concentrates
- Previous deal with A1 to co-smelt autocatalysts

Impala Platinum – Converting



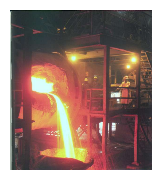
Sibanye Stillwater (formerly Lonmin Platinum) (1971)

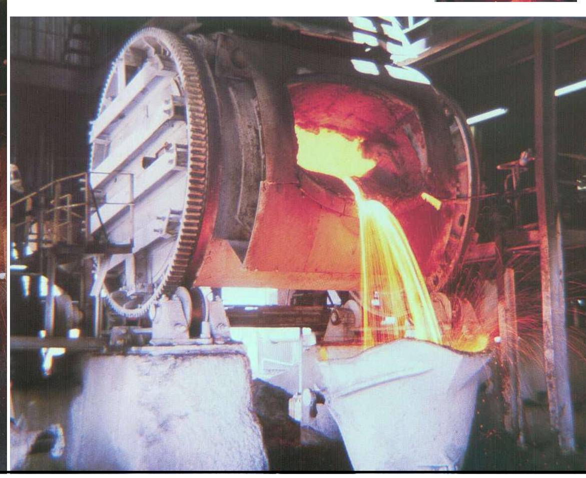


- Uses rectangular and circular furnaces
- First to smelt high quantities of UG2 ore (high Cr) concentrates

Sibanye Stillwater– Converting

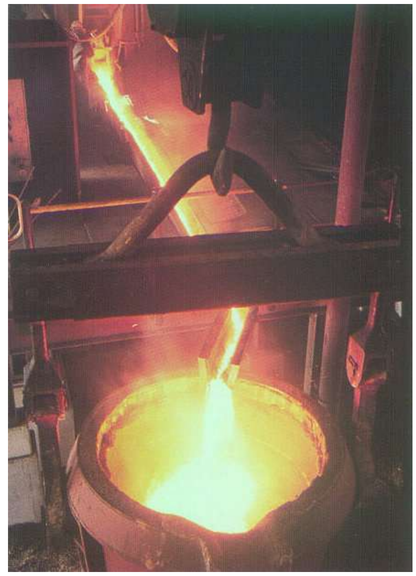
•Peirce-Smith converters





Northam Platinum (1992)

- One six-in-line rectangular furnace, built in 1992
- Peirce-Smith converters



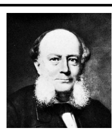
New PGM smelting furnace at Northam (2017)

- Northam Platinum constructed a new circular furnace to be able to accommodate reducing conditions (using carbon) to control the chromite content introduced by UG2 concentrates from their Booysendal mine

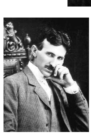
Manganese and Amcor

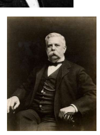
- Amcor (African Metals Corporation) was started by Hendrik van der Bijl in 1937 to supply ferro-alloys to the state-owned steelmaker Iscor
- Used a 10 ft hearth blast furnace in Newcastle, Natal to produce pig iron and HCFeMn
- Two rectangular 3 MVA electric furnaces were started in Vereeniging in 1942 to produce HCFeMn and FeSi, followed by two 1.2 MVA tilting refining furnaces for producing medium- and low-carbon alloys
- The plant was relocated to Meyerton where it was known as Samancor Manganese's Metalloys plant
- By the time the Vereeniging plant closed in 1954, it had produced HCFeMn, HCFeCr, FeSi, M/LCFeMn, M/LCFeCr, FeW (ferrotungsten), FeTi, Pb, martensitic 13% Cr stainless steel, low carbon 18/8 austenitic stainless steel, and mild steel

Chromite smelting – Timeline (electrical and chemical)

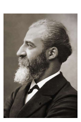


- 1878: William Siemens
  – DC arc furnace



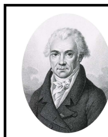


- 1887 & 1888: Nikola Tesla and George Westinghouse
  – AC power was widely used



- 1893: Henri Moissan
  – produced ferrochromium

- 1900: Paul Héroult
  – AC electric furnace



- 1797: Louis Nicolas Vauquelin
  – discovered chromium

- 1820: Michael Faraday
  – produced Fe-Cr alloys

- 1913: Harry Brearley
  – invented Stainless Steel

- 1924: William Hatfield
  – produced 18/8 stainless
- 1967: AOD process

Summary of chromite smelting to produce ferrochromium

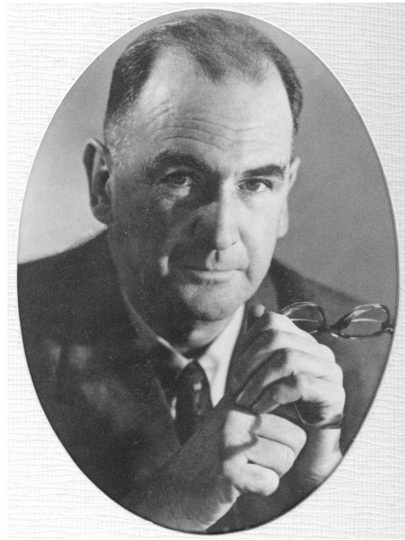
- Chromite mining in South Africa began in 1921
- The Vereeniging smelter of **African Metals Corporation (Amcor)** commenced production in **1942** and made FeMn, FeSi, and high-carbon FeCr (having previously produced small quantities of FeMn in 1939)
- The first South African stainless steel was produced in 1943 by Amcor in Vereeniging
- *Zimbabwe Alloys (originally called Rhodesian Alloys, and sometimes claimed to be the first ferrochromium plant in Africa) was founded in 1949 in Gwelo (now Gweru)*
- Rand Mines (RMB Alloys) started smelting chromite to produce the first low-carbon ferrochromium in South Africa at Middelburg in 1964

Amcor

- The secretive ferro-alloys industry did not share much information (especially around the World War II years), so Amcor relied heavily on Rand Carbide for furnace expertise
- Amcor's Meyerton smelter (Kookfontein) was commissioned in 1951
- The Vereeniging smelter was decommissioned in 1954, and the furnaces were transferred to Meyerton
- In 1959, Ferrometals (Witbank) was acquired for the production of charge chrome

William Bleloch

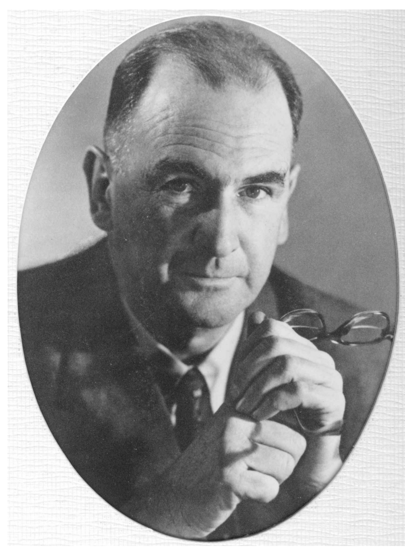
- William Bleloch (1906–1991) was a chemical engineer and metallurgist
- Best known for recovery of vanadium and pig iron from vanadiferous magnetite. In 1948 he conducted large-scale tests overseas on the magnetite of the Bushveld Complex. He demonstrated that vanadium could be recovered, and that pig iron suitable for steelmaking could be produced.
- He acted as Technical Adviser to Rand Mines Limited during the development of a process to produce chromium steel from Bushveld ore, and during the construction and initial operation of the commercial plant



Dr William Bleloch
SAIMM President, 1956–1957

William Bleloch

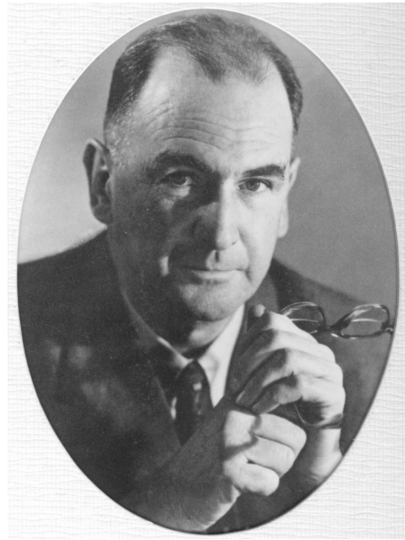
- He often stressed the importance of producing metal from the country's ores, rather than exporting them at much lower profit
- When the University of the Witwatersrand conferred upon him the degree of Doctor of Science and Engineering *honoris causa*, the citation said 'William Bleloch can truly be called the father of our electrochemical and electrometallurgical industries, the importance of which to our economy and the welfare of our people can scarcely be overstated'



Dr William Bleloch
SAIMM President, 1956–1957

William Bleloch and RMB Alloys

- The years 1959/1960 signalled the start of unprecedented metallurgical developments, resulting in the commissioning of the RMB (Rand Mines Bleloch) Alloys low-carbon ferrochromium plant (April 1964), the Transvaal Alloys low-carbon ferrochromium plant (1964), the Southern Cross Steel plant (December 1966), and the Highveld Steel and Vanadium plant (February / December 1968)



Dr William Bleloch
SAIMM President, 1956–1957

Initial LCFeCr testwork at Crown Mines and in Germiston

- Initial work was done using a test furnace at Crown Mines, then the process was demonstrated in Germiston at a site owned by Scaw Metals (in Refinery Road, Driehoek). FeCr was successfully made in September 1960.
- Did you know that the name Scaw Metals stands for "*Steel Ceilings and Aluminium Windowframes*"?
- A month later, Scaw Metals used some of the FeCr to make a test heat of stainless steel (18% Cr and 8% Ni)

Testwork in Driehoek, Germiston

- In 1961, an alumino-silicon reductant was made in a circular (3-electrode) 1.5 MW furnace, and a 3.5 MW quadrangular 3-in-line furnace.
- The solidified reductant was carried to the Scaw open-arc 3-electrode furnaces.
- Chromite, lime, and reductant were smelted and then the FeCr was poured from ladle to ladle, over and over again, to produce low-carbon ferrochrome (a variant of the Perrin process which uses ferro-silico-chrome in place of Bleloch's alumino-silicon).

Charging a modest-sized open-arc furnace at Driehoek, Germiston

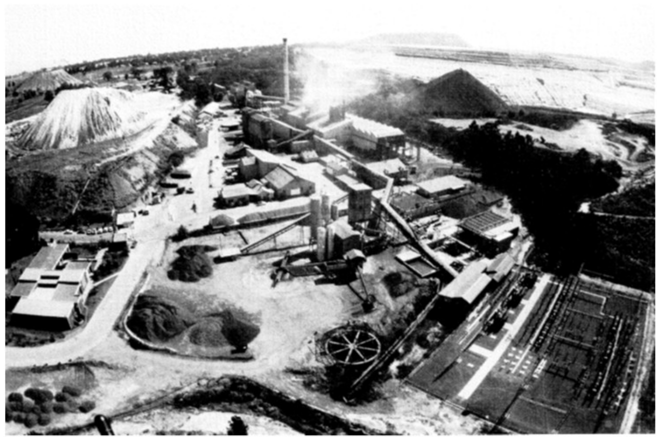
Three-in-line 3.5 MVA furnace, pioneered at Driehoek and transferred to Middelburg. In 1969, it was shown that round sub-arcs with electrodes in a triangle would be 50% more efficient, so they were changed.

Low-carbon FeCr for stainless steel

- The first production-scale low-carbon ferrochromium in South Africa was made in Middelburg by RMB Alloys in 1964
- This low-carbon ferrochrome was used to make stainless steel at Scaw Metals, Union Steel, and in Sheffield
- The MS&A group began making FeCr in earnest in 1964, when RMB Alloys moved from the trial operation in leased premises in Germiston to a new plant outside Middelburg
- Building of the RMB Alloys plant was financed by Rand Mines (40%), Industrial Development Corporation (20%), Scaw Metals (15%), and others
- Initially there were two 7.5 MW three-in-line rectangular sub-arc furnaces for producing reductant, and three 7.5 MW open-arc furnaces
- The planned output was 18 000 t/a of low-carbon FeCr
- Transalloys started up about two weeks after the plant in Middelburg. They were designed to produce 15 000 t/a LCFeCr, plus 5 000 t/a of charge chrome.

Palmiet Chrome, Krugersdorp

- Palmiet Chrome Corporation of Krugersdorp began making FeCr in 1963
- Palmiet was taken over by RMB Alloys in October 1969
- A new (second) sub-arc furnace started up commercially in April 1970

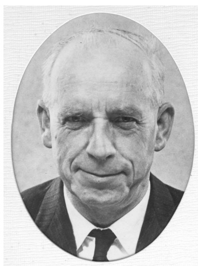


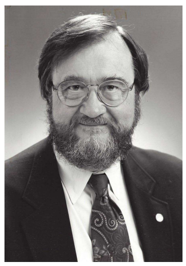
Stainless steel

- In 1963, RMB approved funds for pilot stainless steel trials at Driehoek. Bleloch wanted to use Transvaal titaniferous magnetite, which contained vanadium. By retaining the V in the SS, up to 3% Cu could be added to make an easier-rolled and corrosion-resistant alloy. This project proceeded slowly not because of technical reasons, but because of marketing constraints (competing with their FeCr customers).
- Southern Cross Steel began stainless steel production in Middelburg in 1966/7, and had a target output of 25 000 t/a
- In 1969, Southern Cross Steel and RMB Alloys merged to become Middelburg Steel and Alloys (MS&A), which provided flexibility in the production balance of steel and alloys
- Middelburg Steel and Alloys was registered in 1968, and took over these companies, plus the local foundry Thos Begbie and Sons

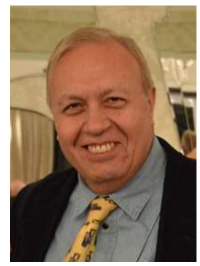
Pyrometallurgical research in South Africa

- Early South African research into chromite smelting took place largely under the auspices of the Pyrometallurgy Research Group, located at the University of the Witwatersrand, and jointly funded by Mintek's predecessor the National Institute of Metallurgy
- This was established in the late 1960s to serve the industrial boom in the ferro-alloys industry
- Significant work was done under the direction of Professors D.D. (David) Howat, [and R.P. (Peter) King], C.W.P. (Charlie) Finn, and R.H. (Hurman) Eric, and many leading pyrometallurgists came out of this group


David Howat

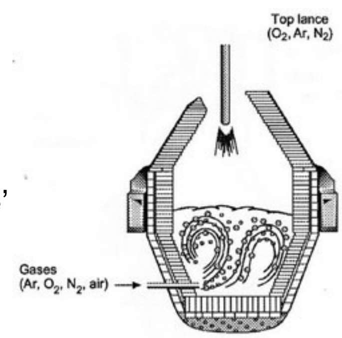

Charlie Finn


Charlie Finn & Peter King


Hurman Eric

Argon-Oxygen Decarburization (AOD) in 1967

- The argon-oxygen-decarburization (AOD) process for the manufacture of stainless steel was invented by Bill Krivsky of Union Carbide in the USA in 1967
- It removed carbon without oxidising chromium
- This created a significant market for 'charge chrome' and high-carbon ferrochromium containing 50–55% Cr (which is what South African chromites typically produce) instead of the conventional 65–70% Cr
- This facilitated the expansion of the South African FeCr industry, as the Transvaal chromite ores (which have a lower Cr:Fe ratio than many other ores) became acceptable as raw materials
- The AOD process substantially decreased demand for low-carbon FeCr
- Southern Cross Steel installed an AOD facility in 1973



Charge chrome

- Charge chrome was cheaper to make than LC FeCr, and could use coke or char as reductants
- Charge chrome experiments began in earnest in December 1969, using the same sub-arc furnace that was originally used at Crown Mines and Driehoek, Germiston

South Africa & Electric smelting

- South Africa has a plentiful coal supply
- Many large coal-fired power stations were built from the 1960s to 1980s. Reserve margin was 55%. Power was cheap.
- Need to beneficiate minerals
- Massive advantage of cheap power for ferro-alloy smelting

Abundant power drove growth – 1960s and 1970s

- **Abundant and cheap electricity in the 1960s and 1970s provided the impetus for a rapid expansion of industrial smelting capacity**
- During the oil crisis of the 1970s, **South Africa's plentiful and cheap coal-based thermal power** helped to grow the ferro-alloys industry
- South Africa's coal and anthracite provide the primary energy source for the generation of electricity, as well as reductants, as well as feed for the manufacture of electrodes
- In the 1960s, various substantial plants were established in the basic metals sector (such as Highveld Steel, RMB Alloys, Southern Cross Stainless Steel, and the Alusaf aluminium smelter)
- Installed power of SA's ferro-alloy furnaces grew by a factor of four during the 1970s

Ferro-alloys developments – 1960s and 1970s

- Transalloys was started in 1960 in Witbank as an integrated HCFeCr / LCFeCr plant, based on the Perrin process. (During 1967, the plant was converted from FeCr to FeMn production.)
- Palmiet Chrome Corporation started producing charge chrome on 22 February 1963 at the plant near Krugersdorp. (On 28 December 1983, the first DC plasma arc furnace for ferrochromium production was commissioned at Palmiet.)
- In 1971 Feralloys Limited erected a ferrochromium smelter at Machadodorp for the production of charge chrome and LCFeCr
- Amcor and SA Manganese merged in 1975 to become Samancor Limited

Further developments – 1970s to current

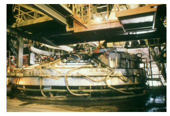
- The CMI plant of JCI at Lydenburg (now part of Glencore) came into being during 1975 for the production of charge chrome, based on the Showa Denko SRC process
- A number of smelters were built over the coming years. These included: Tubatse Ferrochrome (1975), Chromecorp (1987), SA Chrome (1987), Purity Ferrochrome (1991), Hernic Ferrochrome (1995), ASA Metals (1997), Tata Steel (2006), and International Ferro Metals (IFM)
- Many of the independent producers have been taken over by either Samancor Chrome (later owned by Kermas) or Glencore (previously Xstrata Alloys). These two groups dominate the production of FeCr.
- Glencore have operations at Rustenburg, Wonderkop, Lydenburg, Boshoek, and the large-scale Lion plant
- Throughout the industry, business restructuring and consolidation is currently underway

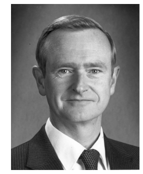
Samancor Chrome

- **Samancor Chrome's history goes back as far as 1975**, *when it was established as a listed entity on the Johannesburg Stock Exchange, as a result of a merger between SA Manganese Ltd and* **Amcor Ltd**. *SA Manganese was formed in 1926 to mine manganese ore deposits in the Northern Cape, whilst Amcor was established in 1937 to exploit mineral deposits for the steel industry and to process those minerals into ferro-alloys.*
- *The Kermas Group, acquired Samancor Limited from Billiton and Anglo American after the unbundling of the manganese business during 2005 and 2006, and renamed the company, now holding only the chrome business, Samancor Chrome Limited.*
- *During the early part of 2016 and latter part of 2017, Samancor Chrome successfully acquired the ferrochrome smelting assets and chrome mining assets from the business rescue practitioner of International Ferrometals, and likewise the smelting assets from the business rescue practitioners of ASA Metals through a series of transactions, the latter together with* **Sinosteel**.

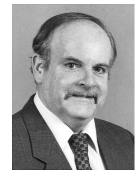
Chromite smelting – DC arc furnaces

- A major breakthrough in the treatment of chromite fines occurred with the first industrial application, at Palmiet Ferrochrome, of a 12 MW (16 MVA) DC arc furnace for the production of ferrochromium in 1984

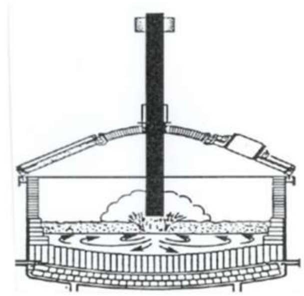


Peter Jochens

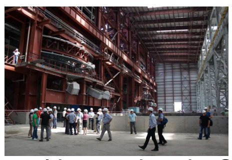


Nic Barcza

- Over the next 25 years, the largest individual DC furnace capacity increased to 60 MW in South Africa (two in place)



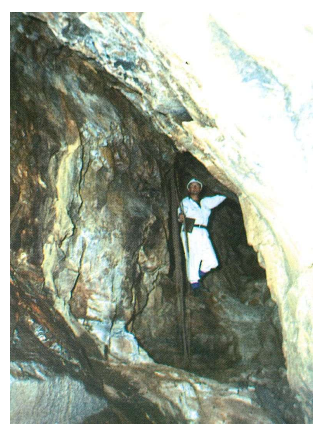
- In 2013, four 72 MW DC arc furnaces for chromite smelting were built in Kazakhstan



- Ring of Fire chromite smelting project in Canada has chosen a DC furnace

Early smelting of tin in South Africa

- Remnants of 'ancient' Iron Age tin workings, including small slag heaps, tuyeres, and pottery sherds, have been found at Rooiberg in the Waterberg area
- Some tin was found with a purity of approximately 95%
- **Tin mining** (of high-grade cassiterite) in this area goes back to at least the **mid 1400s**, based on radiocarbon dating of a piece of mining timber found in an ancient shaft. Dating of tin smelting furnaces is less certain, as only the bottoms of furnaces remain (containing slag and prills of tin). (Friede & Steel, 1976)
- It has been suggested that the original tin miners were contemporaries of the ancient gold miners of Zimbabwe who had moved south prospecting for gold and copper (from Phalaborwa and Messina)
- Friede (1980) suggests that ancient mining in the Transvaal ended around the middle of the 1800s, probably as a result of Nguni raids, and the emergence of three powerful kingdoms (Zulu, Matabele, and Sotho) from the succession of wars when many smaller tribes were displaced or destroyed



Tin smelting

- Modern mining of tin in South Africa began in about 1904
- The two major producers of tin, Rooiberg Tin and Zaaiplaats Tin, both commenced operations in 1908, and a few smaller operations were started around 1907
- A tin smelter was installed at Rooiberg Tin in 1979
- Rooiberg used two 550 kVA submerged-arc electric furnaces with a production capacity of ~2 kt of metallic tin per year. Three 10 t electric refining kettles are used to produce a tin product with a purity of more than 99.9%.
- A smaller smelter at Iscor, Vanderbijlpark, with a capacity of less than 1 kt of metallic tin per year, was based on one 350 kVA submerged-arc electric furnace (Uys, 1977)
- The Zaaiplaats smelter used gas-fired reverberatory furnaces

Tin smelting

- Smelting of cassiterite is done by using carbon to reduce SnO_2 to metallic tin. The conditions required for the process also reduce sulfides and oxides of most other base metals, so a high-grade tin concentrate is required as a feed material, in order to minimize impurities.
- South African concentrates typically contain 60–70% Sn and 3–15% Fe. A two-stage smelting process can be used to treat this material. The first stage (gentle reduction) leaves a slag containing ~20% Sn. A second stage (stronger reduction) forms a tin-iron alloy (known as hardhead) that is recycled to the primary smelting furnace, and a low-grade slag is rejected. Ferrosilicon (75% Si) can be used as a reducing agent in the secondary smelt, and the iron is rejected as a low-grade FeSi product, and metallic tin is produced instead of the hardhead tin-iron alloy.

Vanadium slag from titaniferous magnetite

- William Bleloch published research in 1949 showing that complex magnetite from the Bushveld Complex could be smelted in an electric furnace to produce pig iron containing vanadium, and a separate titania slag. The alloy could be converted (using an oxygen top-blown shaking ladle), resulting in a V-rich slag.
- Highveld Steel and Vanadium Corporation was established in 1960 in Witbank (now eMalahleni)
- A rotary kiln – electric furnace (RKEF) flowsheet was used
- Commissioned in 1968, the initial plant had four Lurgi rotary kilns and four 27 MVA closed-top submerged-arc Elkem furnaces. Later upgraded to 10 pre-reduction kilns and 6 submerged-arc furnaces (Rohrmann, 1985).
- Plant was shut in 2015

Silicon

- Africa has only one silicon smelter, located in Polokwane
- Silicon Smelters (now part of Ferroglobe) started in 1974
- Three 48 MVA furnaces use local quartz and wood-derived charcoal to produce chemical- and metallurgical-grade silicon
- Under care and maintenance since 2024, and remains at risk of permanent closure
- Ferroglobe also uses one furnace at their eMalahleni plant to produce Si

Silicon Smelters plant in Polokwane
www.ferroglobe.com

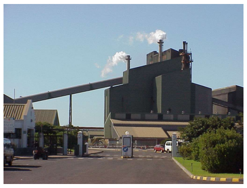
Ilmenite smelting to produce titania slag

- Ilmenite smelting to produce titania slag and pig iron started in 1977/1978 with two AC open-arc six-in-line furnaces at Richards Bay Minerals. Two more six-in-line furnaces were added later.

- Anglo American and the forerunner of Exxaro built four DC arc furnaces between 1994 and 2003. These now belong to Tronox.

Ilmenite smelting (DC arc furnaces)

- 25MW DC furnace at Namakwa Sands in 1994
- 35MW DC furnace followed in 1998



- Two further 36MW DC furnaces at Ticor near Empangeni were commissioned in 2003

- A 30MW furnace was commissioned for CYMG in China in 2009

Ferrovanadium

- Located near Brits, Rhovan (or Rhombus Vanadium) is an open-cast mine and smelter complex, which mainly produces ferrovanadium and vanadium pentoxide
- A mine and concentrate plant was built in 1989 (to supply concentrate to Union Steel Corporation
- The FeV plant was built in 2002
- Constructed a 25 MW solar photovoltaic plant to supply operational needs in 2024
- FeV is produced by aluminothermic reduction of V_2O_3 in a DC arc furnace

In summary, on the brighter side

- Pyrometallurgy remains essential as long as metals are required
- South Africa has great mineral deposits
- Experienced pyro engineering companies
- Good processes
- Electric smelting will continue to have a large part to play in the South African economy
- In the past, we had the benefit of abundant coal to generate plentiful, reliable, and cheap power
- Now we have abundant sunshine and wind, and the opportunity to once again generate plentiful power, this time in an environmentally beneficial way, and to develop processes to take advantage of the new cleaner way of doing things – an exciting challenge for the future!


Thank you