



An overview of copper smelting in southern Africa

Rodney Jones, Mintek

Phillip Mackey, PJ Mackey Technology Inc.



World mine production of copper in 2014, kt/a

Chile	5800	31%
China	1620	9%
Peru	1400	7%
USA	1370	7%
DRC	1100	6%
Australia	1000	5%
Russia	850	5%
Zambia	730	4%
Canada	680	4%
Mexico	520	3%
Kazakhstan	430	2%
Poland	425	2%
Indonesia	400	2%
Other	2400	13%
TOTAL	18 700	100%

U.S. Geological Survey, Mineral Commodity Summaries, January 2015



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Ancient history of copper

- Africa has a long history of copper, well into ancient times
 - ❑ 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
- Today, copper is as important as ever, and the region holds much promise
 - ❑ Africa today produces 10% of the world's copper and this figure can increase



Ancient mining tools



Modern technology

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.
- Throughout the second millennium BC, copper was produced in Cyprus by extracting it from copper sulfide ores. The ancient Cypriots pioneered pyrometallurgical processing of copper, using the surrounding forest to supply energy for the process, and adding fluxing materials from areas close to the mines.
- The smelting of copper sulfide ores in Cyprus lasted for more than 3500 years and produced more than 200 000 tons of copper metal. Many slag heaps remain to this day.

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

- 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

O'okiep Copper Company

- In 1984, Newmont sold the Okiep Copper Company to Goldfields of South Africa
- Assets from the O'okiep Copper Company were acquired by Metorex in 1998. Reprocessing of the slag dump over a seven-year period by flotation methods started in 2002. Metorex managed the mine and smelter, sourced concentrate feed for the smelter, and marketed the resulting blister copper. O'okiep smelted its own concentrate, as well as concentrate from Maranda and Chibuluma. Concentrate was converted to blister copper at the smelter, and the product was exported, with the metal being refined in Europe.
- Today, Okiep (its modern spelling) is a small ex-mining town that is going through tough times, despite having been, at the turn of the previous century, arguably the richest copper mining area in the world.



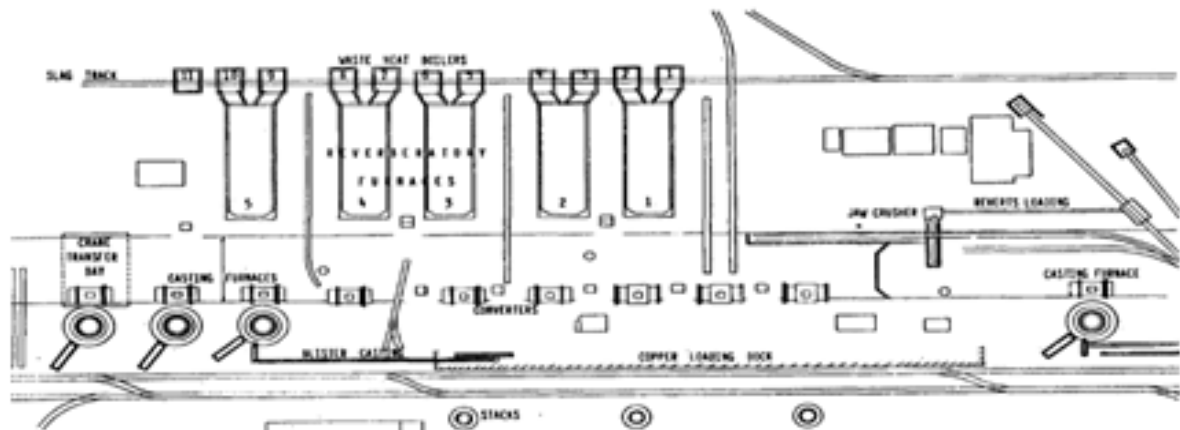
Nkana Smelter, Kitwe, Zambia



- Commissioned in 1931
- Peak production in 1971 was 330 kt/a and it was one of the largest and most efficient in the world at the time
- 5 large reverberatory furnaces and 6 Peirce-Smith converters, and El Teniente converter in 1994
- Technology is now outdated – plant was closed in 2009



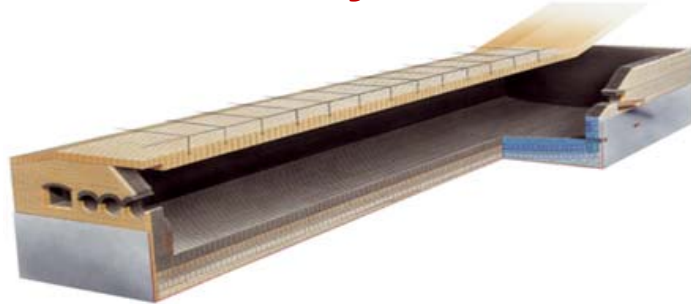
Converter aisle



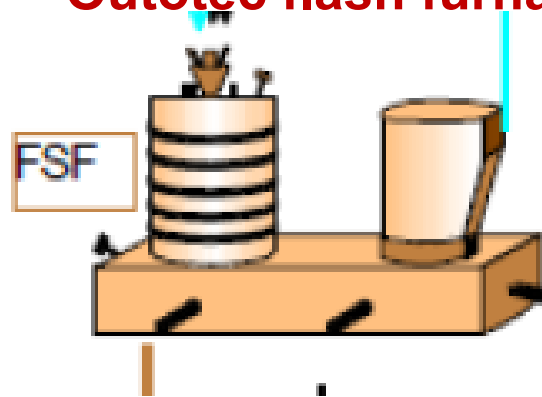
Main Smelting Technologies in use in Africa

No.	Technology
1	Fuel fired reverberatory furnace
2	Outotec flash furnace (making matte)
3	Outotec flash furnace (Direct copper)
4	ISASMELT™ TSL
5	Ausmelt TSL

Reverberatory furnace



Outotec flash furnace



TSL



Southern African Copper Smelters in operation

Smelter	Location	Copper capacity	
Kansanshi	Solwezi, Zambia	300 kt/a	IsaSmelt
KCM (Konkola Copper Mines)	Nchanga, Chingola, Zambia	300 kt/a	Flash
Chambishi (China Nonferrous Metal Mining Group)	Chambishi, Zambia	250 kt/a	IsaSmelt
Mopani	Mufulira, Zambia	185 kt/a	IsaSmelt
Palabora	Phalaborwa, South Africa	160 kt/a	Reverb
Dundee Precious Metals	Tsumeb, Namibia	45 kt/a	Ausmelt
BCL Ni-Cu smelter	Selebi Phikwe, Botswana	30 kt/a	Flash
Rubamin	Likasi, DRC	20 kt/a	
Copalcor	Germiston, South Africa	5 kt/a	
TOTAL		1295 kt/a	

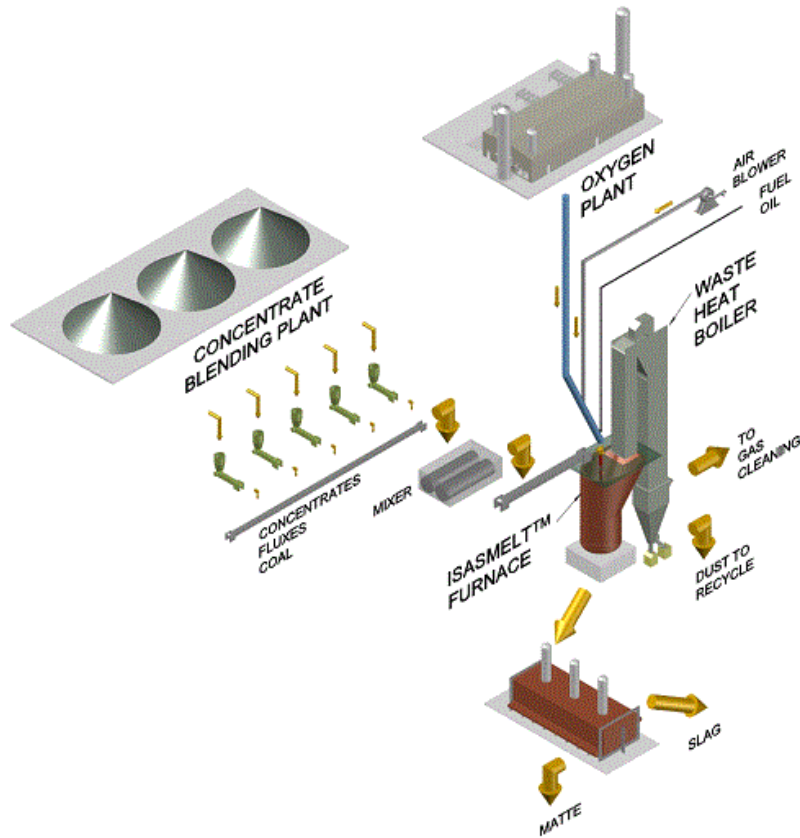


Kansanshi – Solwezi, Zambia

- Kansanshi – Solwezi, North-Western Province, Zambia
- First Quantum Minerals (80%); ZCCM-IH (20%)
- A major producer of SX-EW copper
- Benefit of pyro-hydro integration is 1.0 million t/a of low-cost sulfuric acid



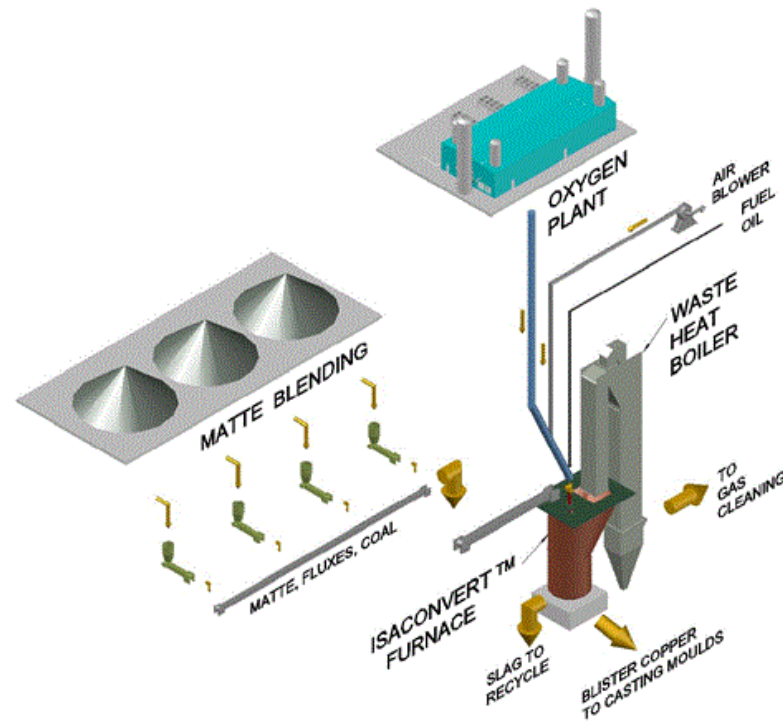
Kansanshi – Solwezi, Zambia



- Newest copper smelter in Zambia
- IsaSmelt furnace, matte-settling electric furnace, 4 Peirce-Smith converters, 2 anode furnaces
- Will process 1.2 Mt/a of copper concentrate
- Will produce 300 kt/a of anode copper
- First copper produced in December 2014

Kansanshi – Solwezi, Zambia

- Previously announced plans for IsaConvert furnace to produce blister copper from crushed matte
- Proposed plans to double the size of the smelter seem to be on hold

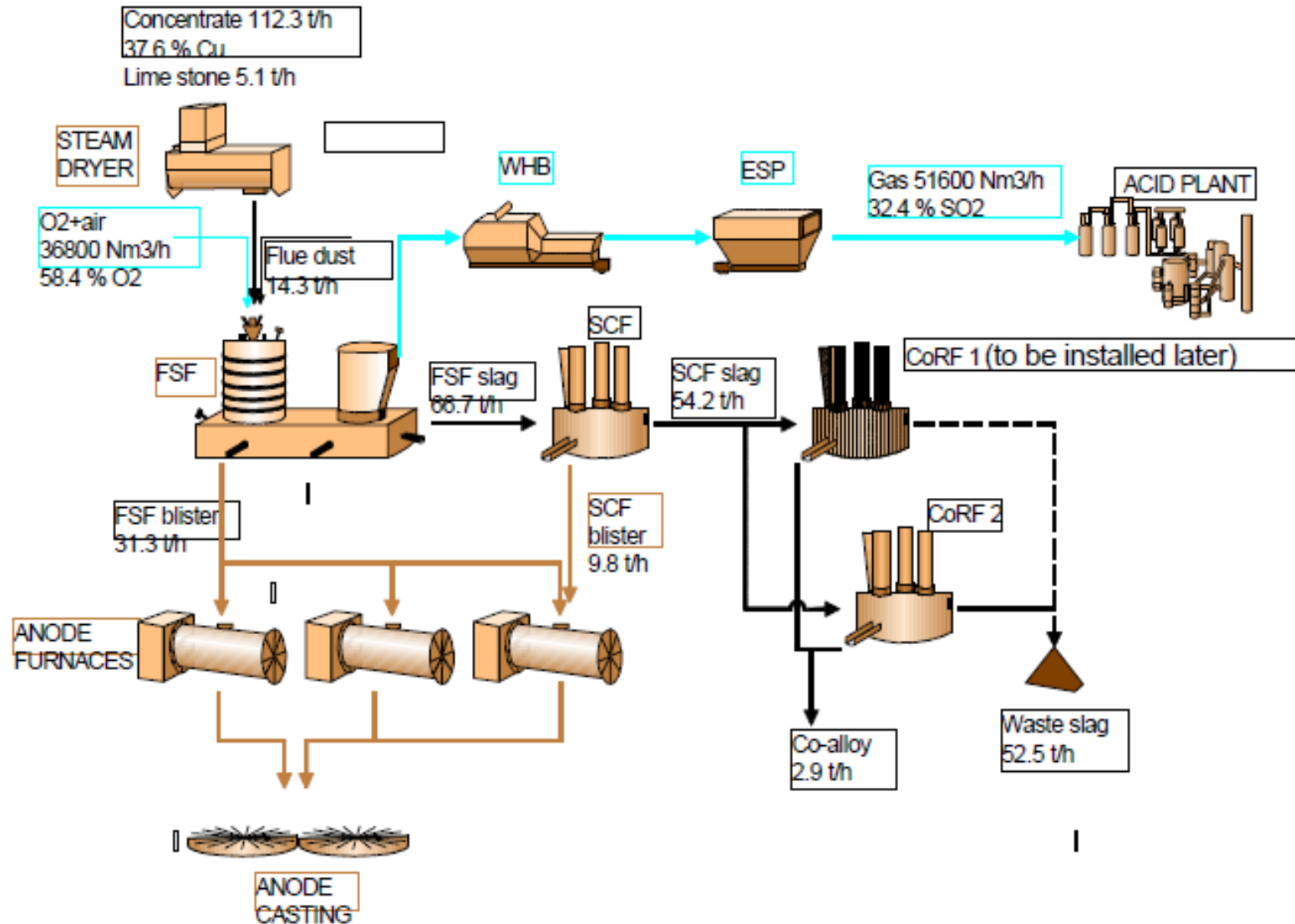


Konkola Copper Mines Nchanga Smelter – Chingola

- Konkola Copper Mines' (KCM) Nchanga smelter in Zambia uses Outotec Flash Smelting technology and it is designed to produce blister copper in one stage
- There are two other Direct Blister Flash Smelters operating in the world: KGHM in Poland and Olympic Dam in Australia. The KCM smelter is tailored to the treatment of copper concentrates that contain cobalt.
- The smelter commenced commercial operation in 2008, and now the smelter is producing more than 17 000 tons of primary copper in a month
- The smelter has concentrate smelting capacity of 849k t/a, with a copper content of 312 kt/a
- The Zambian Copperbelt copper concentrate feed is notable for its high copper content, low Fe/SiO₂ ratio, and cobalt content, so is blended with some chalcopyrite concentrate
- Slag from the smelting furnace is subjected to two stages of electric slag cleaning. In the first stage, Cu in the slag is reduced by coke from 18% Cu to 5% Cu, and in the second stage it is further reduced to recover the metal values in the form of Cu-Fe-Co alloy.

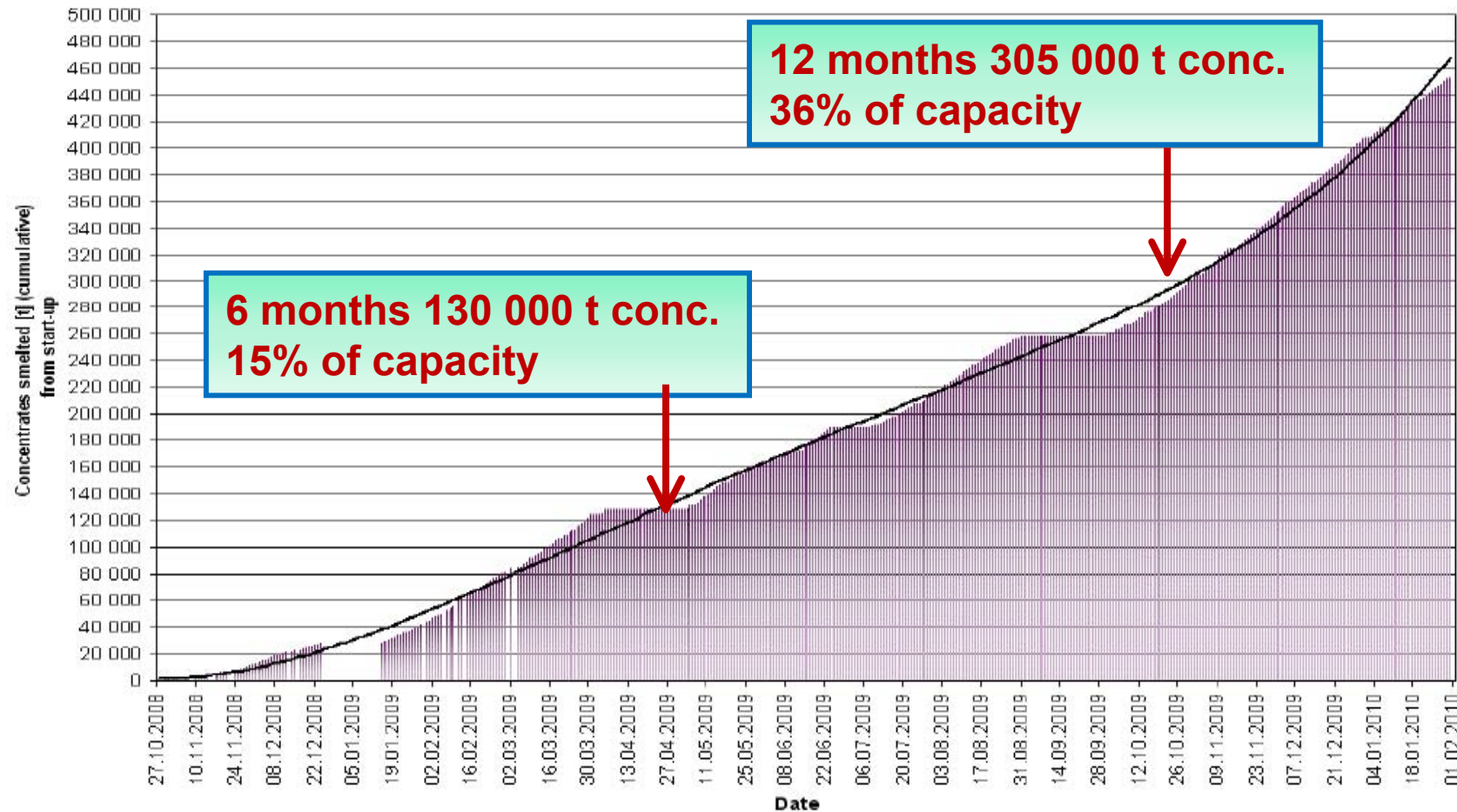
Konkola Copper Mines Nchanga Smelter – Chingola

Capacity 300 kt/a copper; commenced 2008



Konkola Copper Mines Nchanga Smelter – Chingola

- 17 month ramp-up Nchanga smelter (Oct 2008 to Feb 2010)
- Concentrates smelted (cumulative) from startup
- Profile corresponds to McNulty Type 4 - about as expected for a new technology plant



Mopani Copper – Mufulira, Zambia



Mufulira smelter



Acid plant

- 1937: Plant started with reverb furnaces
- 1971: Replaced by an electric smelting furnace
- 2006: IsaSmelt plant commissioned
- IsaSmelt furnace was designed to initially smelt 650 kt/a of concentrate, with the potential to expand to 850 kt/a in the future
- The plant comprises a new feed preparation system, electric settling furnace, waste heat boiler, electrostatic precipitator, gas cleaning plant, oxygen plant, and acid plant. Improvements were also made to the converter aisle and anode plants.
- This project, on a brownfield site in a remote area, took 28 months from signing of the engineering and licence agreement to achieve the first feed on in the furnace in September 2006. The smelter underwent a shutdown and rebuild in June 2014.
- The smelter is owned by a joint venture company, Carlisa Investments Corporation, comprising First Quantum Minerals, ZCCM-IH, and Glencore
- Copper production is estimated to be about 185 kt/a

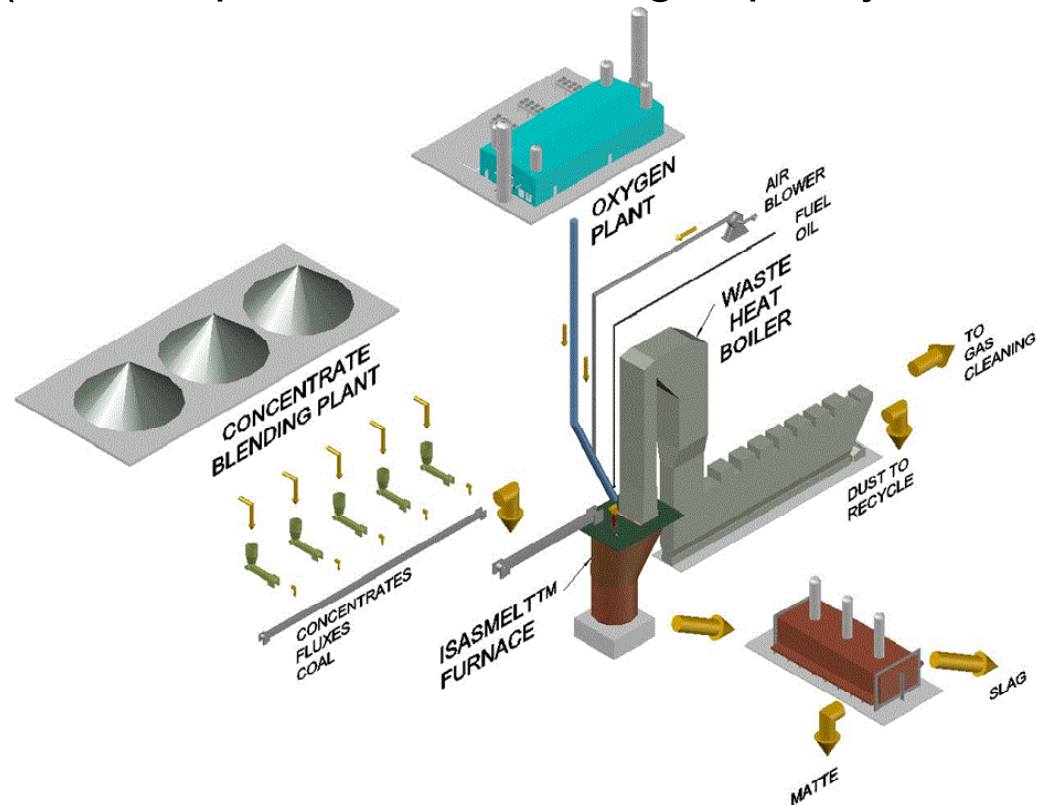
Palabora Mining – Phalaborwa, South Africa

- 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
- 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



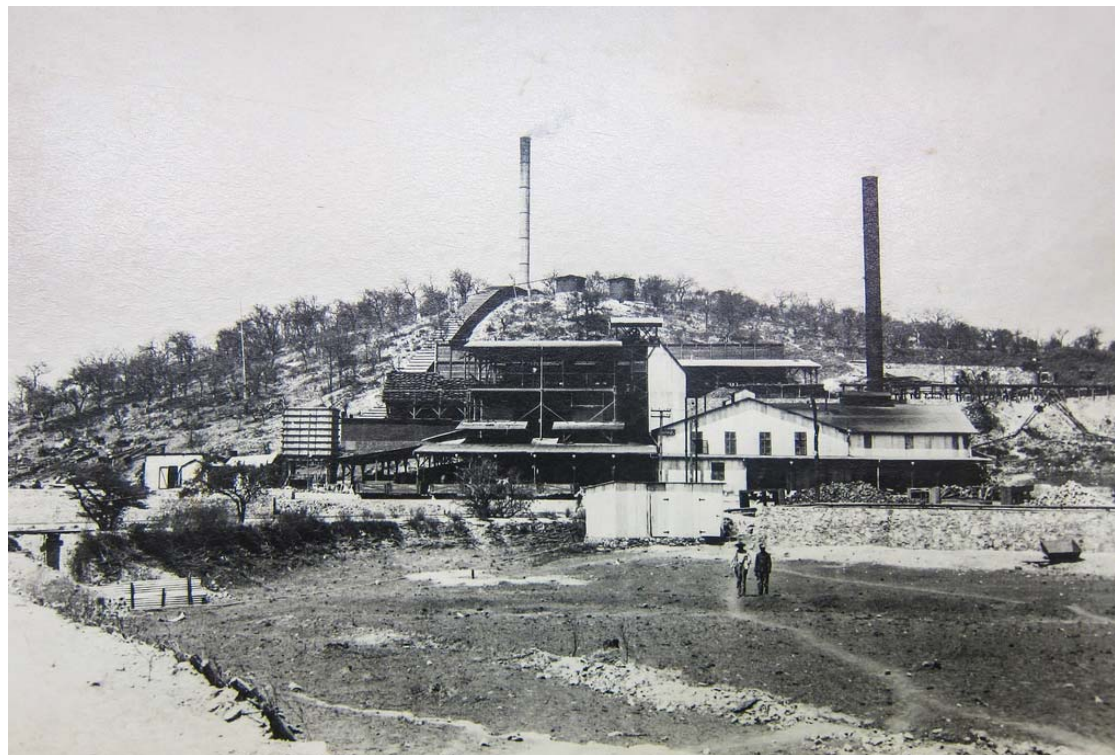
Chambishi (China Nonferrous Metal Mining Group)

- Construction began on the Chambishi Copper Smelter of Yunnan Copper Corporation (YCC), in November 2006, and the smelter began producing copper at the end of 2008
- The IsaSmelt smelter was initially designed to produce 150 kt/a of blister copper, but has since been expanded to reach 250 kt/a of blister copper (which represents a smelting capacity of 750 kt/a of feed)



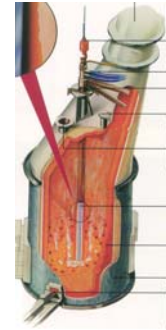
Dundee Precious Metals – Tsumeb, Namibia

- Photograph shows the old Tsumeb smelter in 1910, with the stack built on the hill to give extra lift to the off-gases
- The 'new' smelter, commissioned in 1963, is located 5 km away from the old smelter



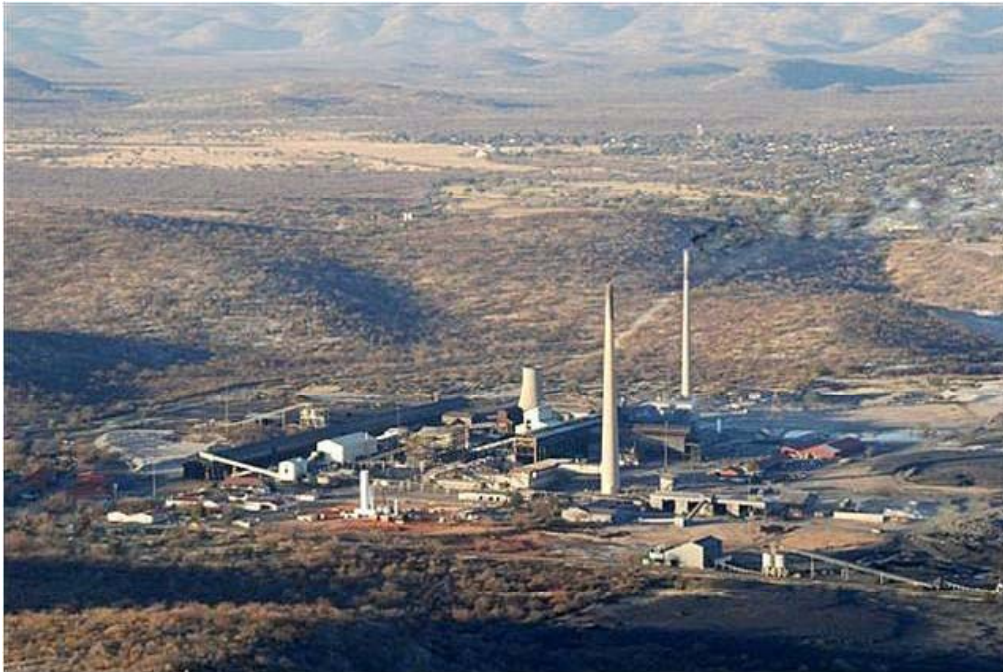
Dundee Precious Metals – Tsumeb, Namibia

- Tsumeb polymetallic smelter closed 1994
- Ongopolo Mining and Processing
- Namibia Custom Smelters (Weatherly International)
- Bought by its current owners, Dundee Precious Metals, in 2010
- The facility consists of two primary smelting furnaces, the old reverberatory furnace, as well as a refurbished Ausmelt Top-Submerged Lance (TSL) furnace, with Peirce–Smith converters used to treat the matte
- One of only a few smelters in the world which is able to treat arsenic- and lead-bearing copper concentrates
- Blister copper (40-50 kt/a) is delivered to refineries for final processing, and As_2O_3 is sold to third-party customers



Dundee Precious Metals – Tsumeb, Namibia

- Present concentrate capacity: 190 to 220 kt/a
- The smelter is being transformed into a world-class toll-smelting plant to handle complex concentrates
- The acid plant is presently under construction and will be commissioned later in 2015



BCL Ni-Cu Smelter – Selebi Phikwe, Botswana

- BCL began operations in late 1950s
- Outotec flash furnace commenced treating Ni-Cu in 1973
- One of the largest in physical size
- Treats 120 t/h of Ni-Cu concentrate
- 3 Peirce-Smith converters; 2 electric slag-cleaning furnaces
- Produces ~ 30 kt/a of copper in Cu-Ni matte



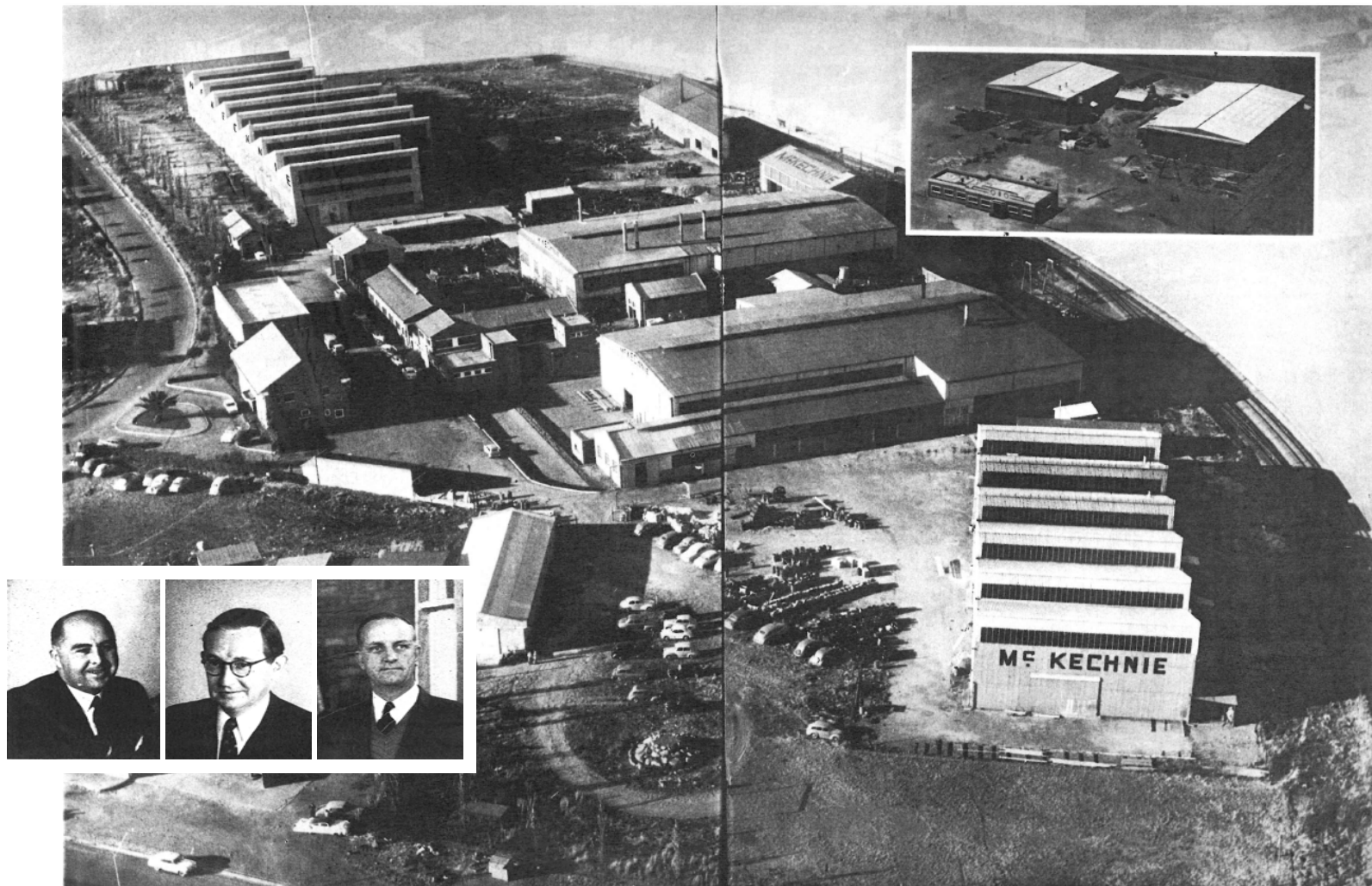
Rubamin – Likasi, DRC

- A small smelter treating primarily malachite ore
- Commercial production of copper blister started in 2008
- Installed power of 20 MVA
- Produces 20 kt/a of blister copper



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



Furnace



Slab Casting



Hot Rolling



Conclusions

- Africa has significant reserves of copper, and African copper has once again begun to play a key role in contributing to meeting the rising global demand for copper
- A number of plants with modern technology hold great promise
- Currently, copper production capacity in southern Africa is around 1.2 million metric tons per annum
- Projections indicate that by 2025, global refined copper demand will increase to 29.5 million metric tons, up from the 22.4 million ton level anticipated for 2015
- This will require dozens of new mines, and the equivalent of 10 to 12 new 0.5 million tons of copper/year-sized copper smelters
- Fortunately, Africa has significant reserves of copper, and African copper can once again play a key role in supplying this rising global demand for copper

Mintek's DC furnaces

<http://www.mintek.co.za/Pyromet/>

