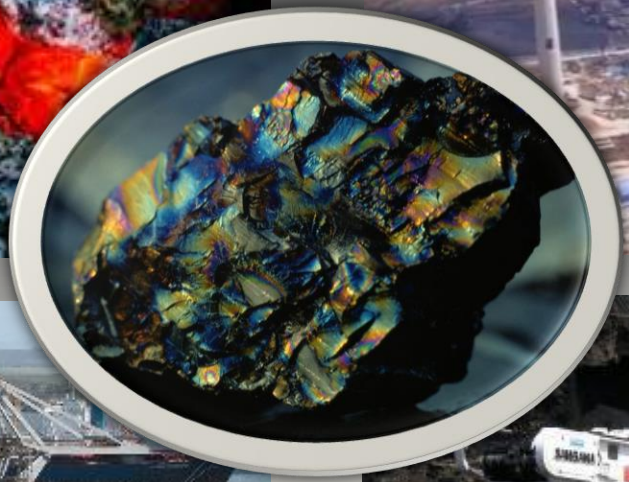
Some African Coal Deposits



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Principal Geologist

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Disclaimer and Data Sources

The data used in this presentation have been derived from numerous disparate sources, mostly publicly available. Data sets were often not comprehensive enough and had to be married with other data sets to achieve a fuller picture. Data sets could often not be compared on a strictly like-for-like basis. Data have had to be presented as arithmetic not weighted averages and are thus illustrative only. Nevertheless, I believe the data are sufficient to show the general trends. Caveat emptor!

- Mining Review
- Mining Weekly
- Inside Mining
- Creamer Media: Real Economy Insight
- Coal Strategy 2018 (Minerals Council of SA)
- ESI Africa (2006)
- carbonbrief.org
- coalminingmatters.co.za
- indexmundi.com
- exxaro.com
- globalcoal.com
- Global Energy Monitor
- miningmx.com
- riozim.co.zw
- Department of Energy
- Department of Mineral Resources
- Minerals Bureau
- Minerals Council of South Africa
- Statistics SA
- South African Coal Statistics & Marketing Manual (2000)
- SANS 10320 (2020)
- The Mineral Resources of South Africa (1998)
- Chatupa (1991)
- Hancox (2016)
- Hawadi (2012)
- Kelello & Sifiso (2018)
- Maponga (2017)
- Matyanga (2012)
- Moyo (2012)
- Mutsinya (2012)
- Various coal industry colleagues
- Various company Resource & Reserves Reports (*publicly available)*
- Xavier Prevost, XMP Consulting (pers. Comm.)

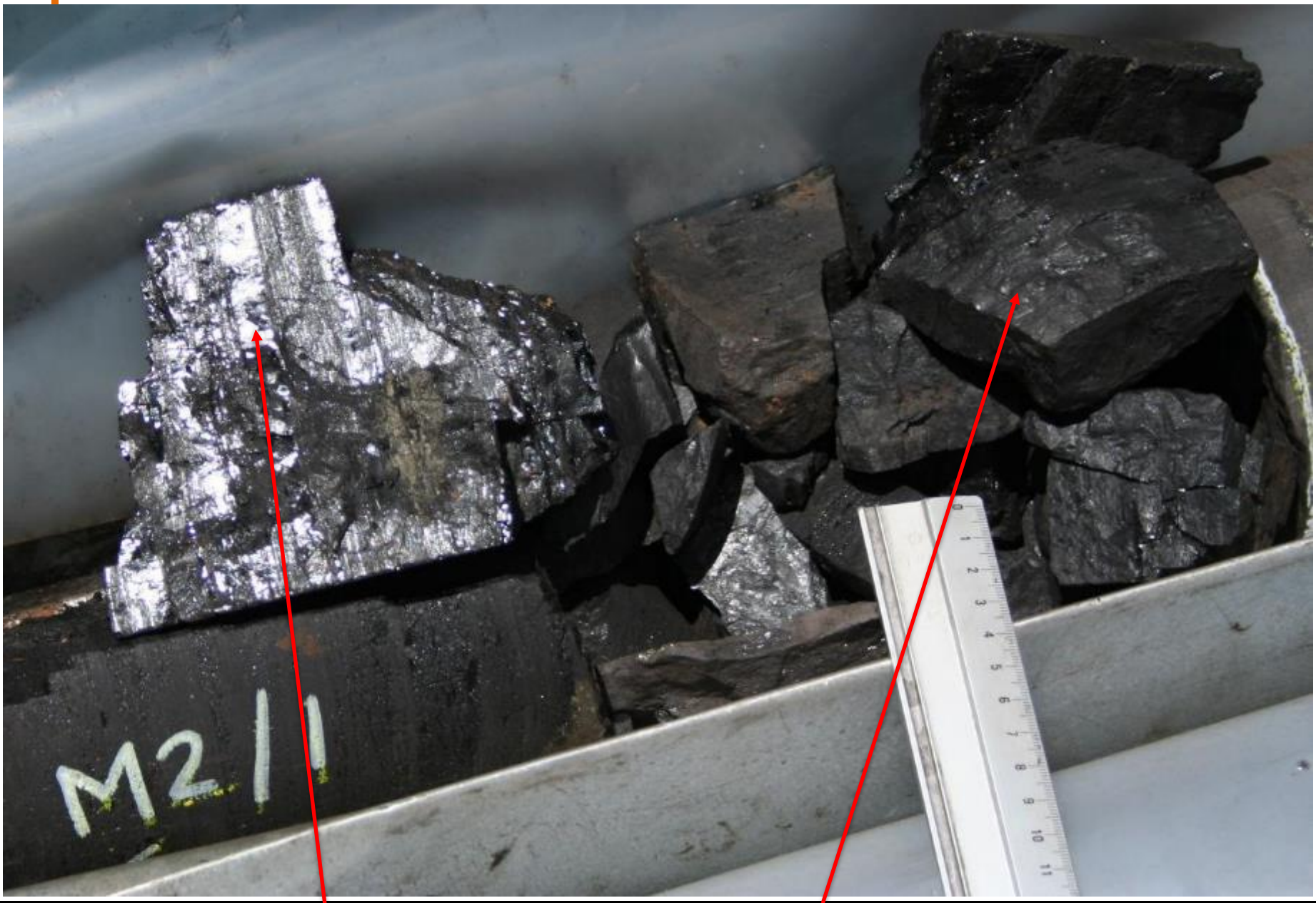
Images: Creamer Media, Crown Publications, Climate Home News, inceconnect.co.za, minergycoal.com, mining.com, zitamar.com, on-the-rand.co.uk, agefotostock.com, sepmstrata.org, hiveminer.com, grida.no, 123rf.com, Wikipedia, ng.boell.org, scotese.com, company websites

Agenda

- Coal Basics
- Depositional Environments
- Periods of Coal Formation
- African Coal Deposits
- Spotlight on …..
    - Botswana
    - Malawi
    - Mozambique
    - South Africa
    - Tanzania
    - Zambia
    - Zimbabwe

Coal Basics 1

- Organoclastic combustible sediment (made up of organic particles)
- Formed by anaerobic decay of vegetation in depositional aqueous environments (no free oxygen)
- Coalification: plants → peat → coal by removal of water and oxygen
- Consists of a mixture of macerals (organic equivalents of minerals) and minerals (inorganic matter, contaminants)
- Maceral groups
  - Vitrinite – woody material; bright glassy appearance
  - Exinite/liptinite – spores, resins, cuticles; dull
  - Inertinite – oxidized plant material; very dull
- Common minerals
  - Pyrite – blebs, nodules, disseminated; organic & inorganic
  - Siderite - nodules
  - Calcite – veins, cleats



Banded bright coal, major vitrinite bands

Banded dull coal, minor vitrinite laminations

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Pyrite blebs

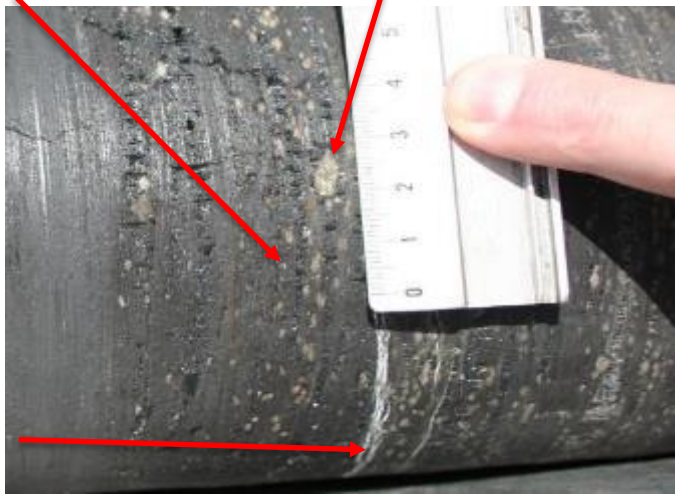
Siderite nodules

Calcite cleats, veins

Siderite blebs

Pyrite nodules

Calcite veins



Coal Basics 2

- Grade – determined by tectonic setting: controls sediment supply and accumulation space
- Type – determined by climate: determines plant species, which determines maceral composition; ratio of macerals to minerals determine coal type
- Rank – the degree of coalification - the transformation of

vegetable matter → peat → *Brown coal* lignite →

sub-bituminous coal → bituminous coal → semi-anthracite → anthracite → meta-anthracite

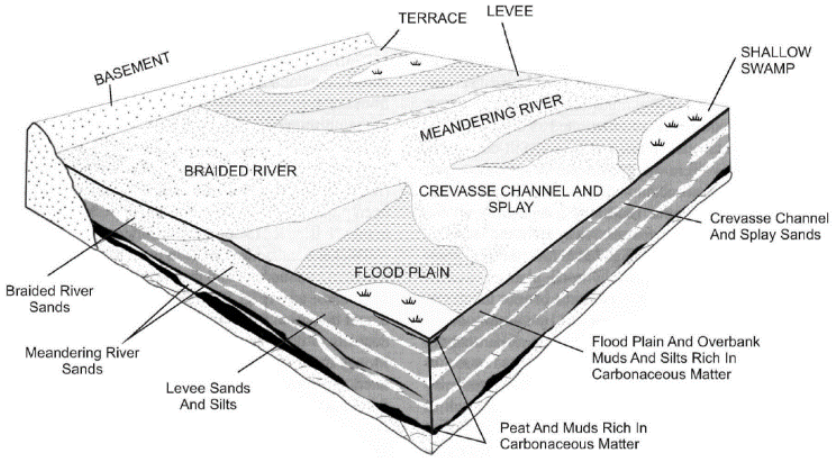
Black coals

- Determined by burial (depth, pressure), heat and time

Depositional Environments

- Fluvial
- Fluvio-deltaic
- Deltaic
- Fluvio-lacustrine
- Fluvio-lacustrine
- Lacustrine
- Alluvial fan
- Marsh

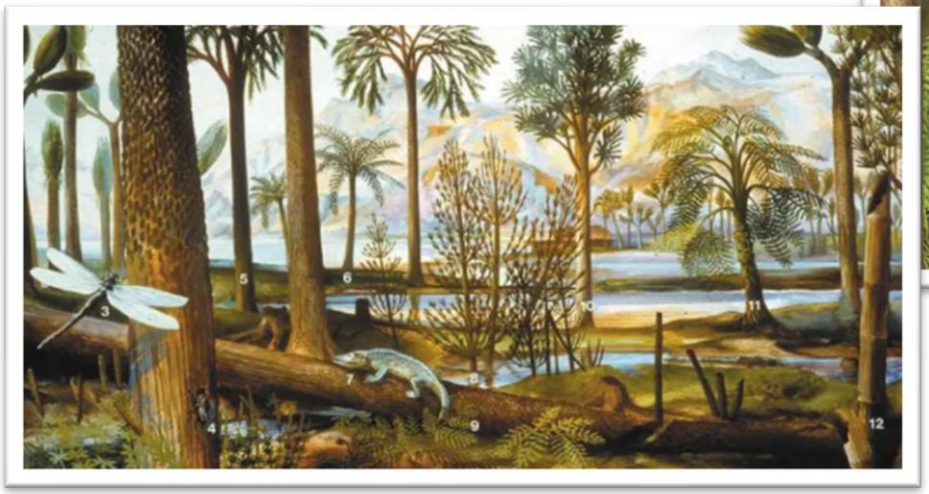
Accumulation: in situ *vs* detrital
Southern Africa – mainly detrital = higher ash



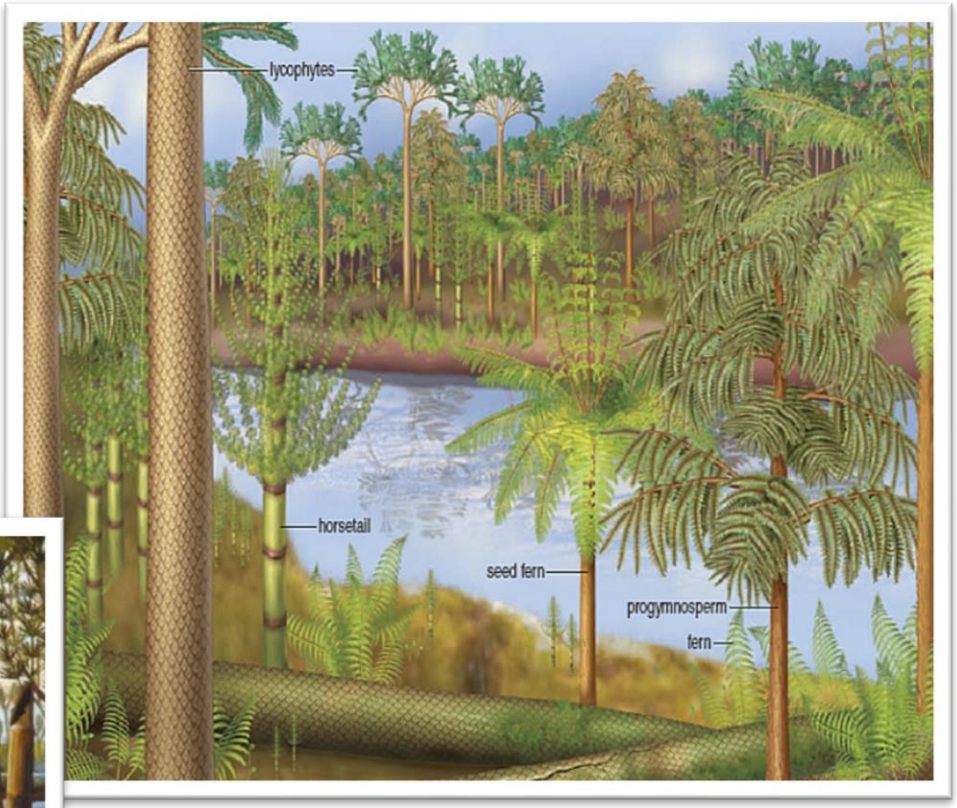
Periods of Coal Formation 1

- **Carboniferous* (359 – 299 Ma)**
  - Laurasia (northern Pangea)
  - Tropical climate
  - Flora: cycads, seed ferns, horsetails, club mosses, scale trees
  - Anthracite, bituminous
  - Vitrinite-rich; bright, low ash coals; high sulphur

**Carboniferous (Latin) = carbo (coal) + fero (I bear)*



Source: treasurecoastnatives.wordpress.com



Source: chegg.com

Carboniferous coal plants

Periods of Coal Formation 2

- **Two coal-forming periods ("Karoo age"):**
  - Late Carboniferous – Early Permian (307 – 275)
  - Late Permian (267 – 260 Ma)
- Gondwana (southern Pangea)
- Cold temperate climate (after Dwyka glaciation)
- Flora: early conifers, seed ferns with tongue-shaped leaves
- Anthracite, bituminous, subbituminous
- Inertinite-rich; banded bright-dull moderate-high ash coals; low sulphur

Source: scitechdaily.com

Source: samnoblemuseum.ou.edu

Permian coal plants

Periods of Coal Formation 3

- **Cretaceous – Paleogene - Neogene (145 – 2.6 Ma)**

Period	Climate	Flora
Cretaceous	Tropical	Flowering plants, leafy trees, conifers, ferns
Paleogene	Tropical but cooling & drying	Conifers, grasslands
Neogene	Drastic cooling to last Ice Age (Pleistocene)	Deciduous plants, grasslands

- Anthracite, bituminous, subbituminous, lignite
- Frequently huminite:vitrinite-rich; ash & sulphur variable, moisture frequently high

**Huminite = low reflectance vitrinite*

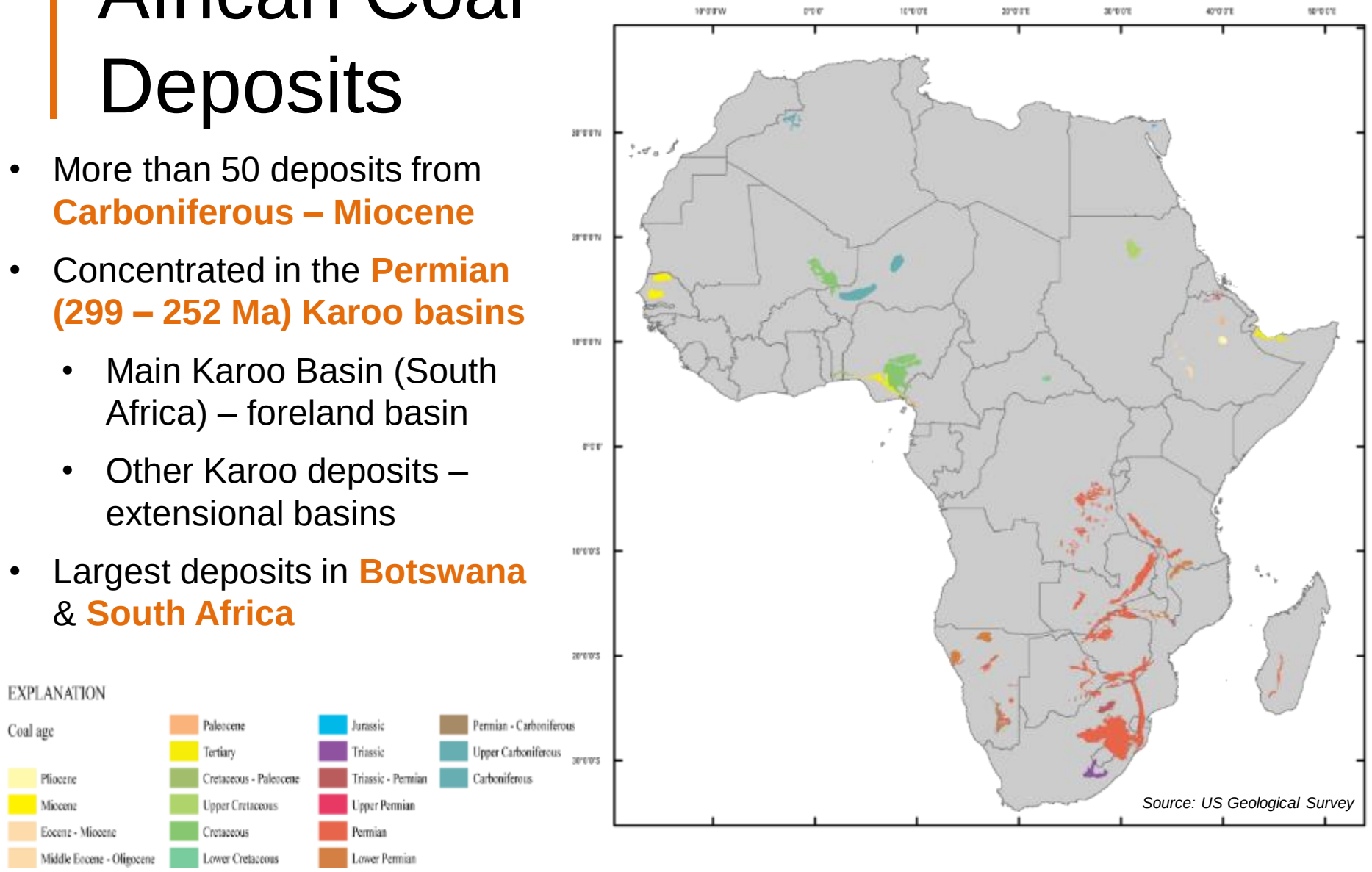
Source: sciencephoto.com

Source: fieldmuseum.org

Cretaceous to Neogene coal plants

African Coal Deposits

- More than 50 deposits from **Carboniferous – Miocene**
- Concentrated in the **Permian (299 – 252 Ma) Karoo basins**
  - Main Karoo Basin (South Africa) – foreland basin
  - Other Karoo deposits – extensional basins
- Largest deposits in **Botswana** & **South Africa**



Late Carboniferous-Permian 1

Central & southern Africa

- Botswana (mined) 15 coalfields
  - Morupule (9.5m), Mmamabula (5.4 m): bituminous
- DRC (undeveloped)
  - Small, separate basins in east: bituminous
- Eswatini (Swaziland) (mined)
  - Mpaka Colliery: bituminous (closed)
  - Maloma Colliery: anthracite
- Kenya (undeveloped)
  - Mui Basin (SE part of the country)
- Madagascar (artisanal)
  - Imaloto (2 m), Vohibory (2.3 m), Ianapera (0.6 m), Sakoa & Sakamena (3-7 m), bituminous
- Malawi (domestic market)
  - Livingstonia (1-2 m), Ngana (1-15 m), very variable laterally and vertically; North Rukuru, Lengwe, Mwabvi (very thin); bituminous

Late Carboniferous-Permian 2

- Mozambique (mined)
  - Sub-basins east of Tete: Moatize/Benga: bituminous, coking, 6m (mined); Minjova, Ncondezi, Muaradzi, Mutarara: bituminous (unmined)
  - Sub-basins west of Tete: Mucanha-Vuzi/Sige (unmined), Sanângoè-Mefídézi (mined): bituminous, coking
  - Niassa, Nampula, Manica, Maputo, Gaza – unmined coalfields
- Namibia (undeveloped)
  - Aranos, Toscanini: sub-bituminous-bituminous
- South Africa (mined)
  - 17 coalfields: bituminous, anthracite, coking
- Tanzania (mined)
  - 8 coalfields: bituminous
- Zambia (mined)
  - Mid-Zambezi Valley (Maamba & Siankondobo Collieries): bituminous
  - Barotse, Luangwa (unmined)
- Zimbabwe (mined)
  - Mid-Zambezi Valley - Entuba, Sengwa, Hwange: thermal, coking, 5 -17m
  - Save-Limpopo & Tuli: semi-anthracite

Cretaceous 1

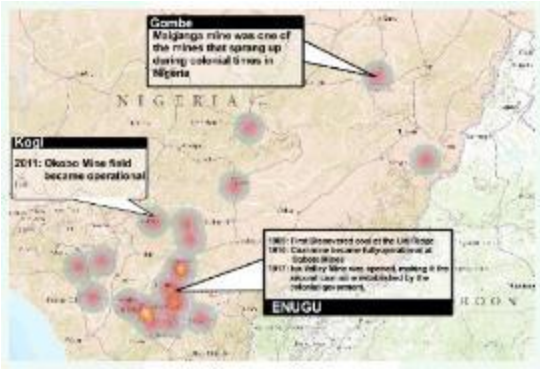
North & West Africa

- Related to Gondwana break-up & global sea-level fluctuations
  - Algeria (previously mined)
    - Bechar & Abadla: coking
  - Egypt (mined)
    - Sinai - Al Maghara: sub-bituminous, bituminous
  - Morocco (mined)
    - Jerada (0.7m), Ezzhiliga, Tindouf-Draa
    - Meknes-Fez: lignites
  - Ethiopia (undeveloped)
    - Chilga, Wuchale, Dobre-Brehan,Delbi-Moye, Yayu, Nejo, Lalo-Sapo, Mush Valley: lignite – sub-bituminous

Cretaceous 2

- Mali (undeveloped)
  - Mali-Niger basin around Bourem:

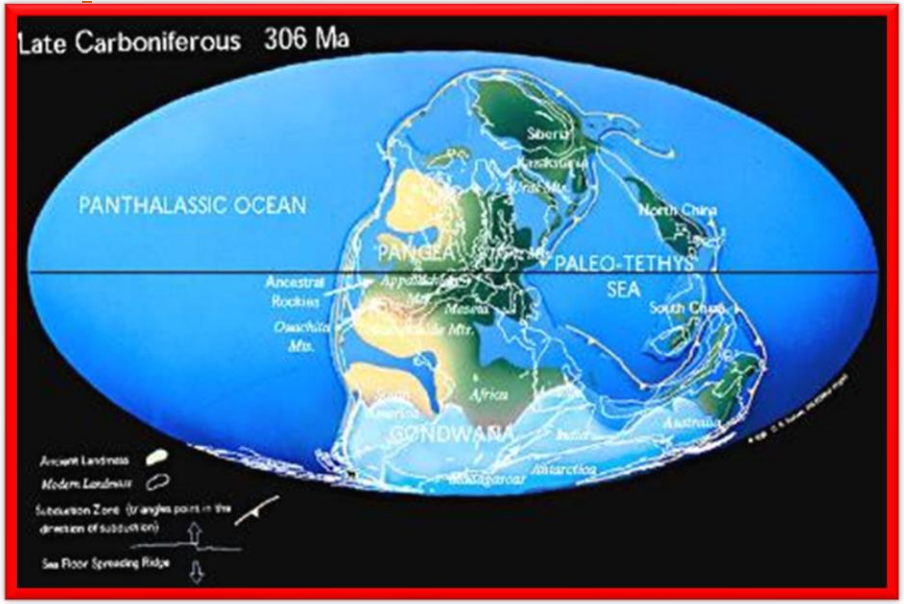
    brown coal, 2 m
- Niger (domestic use)
  - Mali-Niger basin: thermal coal, low quality
- Nigeria (previously mined; minor current production)
  - Enugu, Ezimo, Orukpa, Okaba, Ogboyoga Coalfields: high volatile sub-bituminous; high ash, low sulphur, 1 – 3m thick
  - Asaba: lignite, high volatile, high ash, low sulphur
- Also: Libya, Mauritania, Senegal, Benin, Sudan

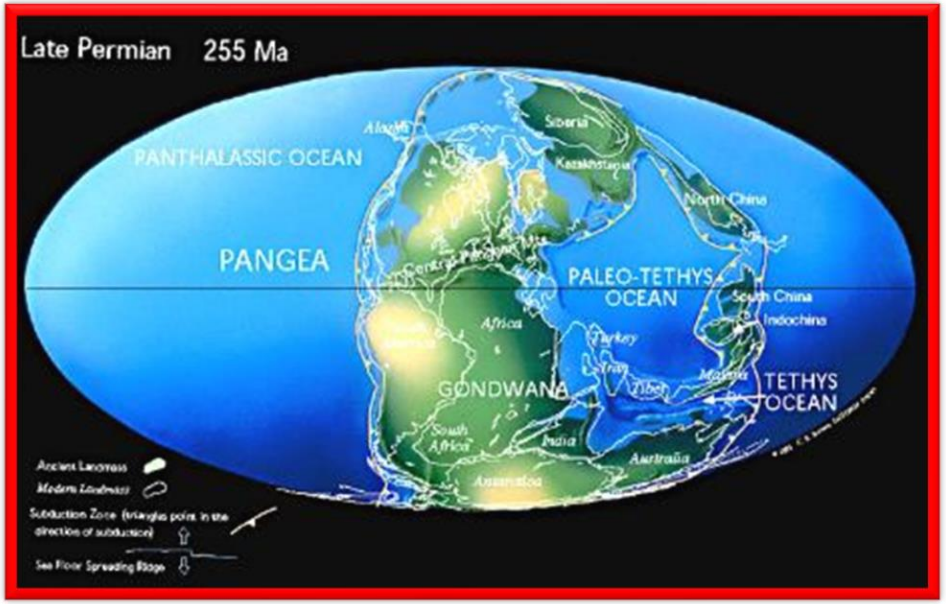


Paleogene-Neogene

Scattered localities

- Angola (undeveloped)
  - Lungue-Bungo River (east) and Luanda (west): lignite
- Cameroon (undeveloped)
  - Bamenda district: lignites interbedded with lava flows
- Madagascar (undeveloped)
  - Antanifotsy: lignite


Late Carboniferous 306 Ma
PANTHALASSIC OCEAN
PANGEA
PALEO-TETHYS SEA
North China
Ancestral Rockies
Ouachita Mts.
Mesena
Africa
GONDWANA
India
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Late Permian 255 Ma
PANTHALASSIC OCEAN
Siberia
Kazakhstania
North China
PANGEA
PALEO-TETHYS OCEAN
South China
Indochina
Africa
Turkey
Tibet
Malaya
GONDWANA
TETHYS OCEAN
South Africa
India
Australia
Antarctica
Ancient Landmass
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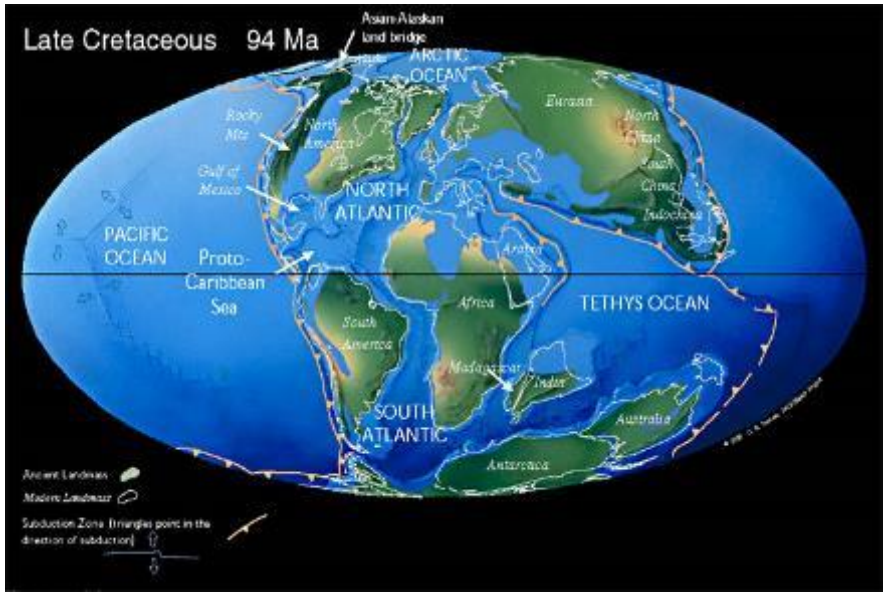
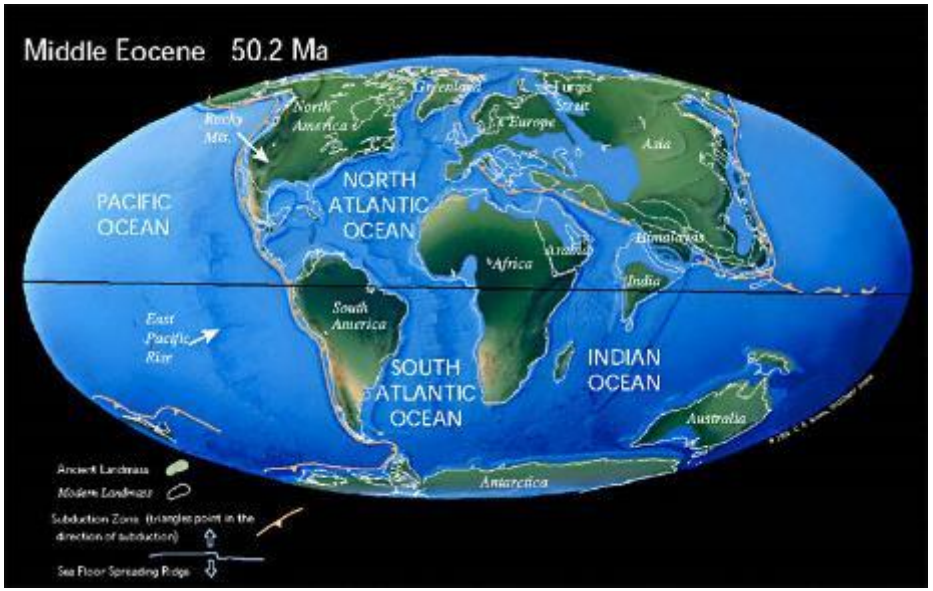
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Late Cretaceous 94 Ma
Asian-Alaskan land bridge
ARCTIC OCEAN
Eurasia
North China
Rocky Mts
North America
Gulf of Mexico
NORTH ATLANTIC
PACIFIC OCEAN
Proto-Caribbean Sea
Arabia
Africa
TETHYS OCEAN
South America
Madagascar
India
SOUTH ATLANTIC
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)


Middle Eocene 50.2 Ma
Greenland
Drake Passage
Rocky Mts.
North America
Europe
Asia
NORTH ATLANTIC OCEAN
PACIFIC OCEAN
Himalayas
Arabia
Africa
India
East Pacific Rise
South America
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge

Spotlight on …

- **Botswana:** 2 operating collieries:
  - 1973 - Morupule (AAC)
  - 2019 - Masama (Minergy)
- **Malawi:** ~3 operating collieries:
  - 1987 - Mchenga Coal Mine (Livingstonia Coalfield; mainly U/G, 26.5 Mt reserves, 0.9 Mtpa)
  - ? - Nkhachila Coal Mine (North Rukuru Coalfield; open pit)
  - ? - Kaziziziwi Coal Mine (Livingstonia Coalfield)
- **Mozambique:** 3 operating collieries:
  - 1893 - 1st mining at Moatize, shipped downriver to England, stopped as too expensive
  - 1925 - Mining resumed in Moatize area
  - 1950s - Chipanga mines (Carbomoc concessions)
  - 1980s - Chipanga 11, now Minas Moatize (Beacon Hill, closed)
  - 2011 - Moatize (Vale)
  - 2012 - Benga (RTCM, now ICVL)
  - 2012 - Chirodzi (JSPL)
- **South Africa:** numerous operating collieries:
  - 1864 - Penshaw (Molteno, closed in 1913)
  - 1865 - Talana Colliery, 1st UG colliery, used to provision steam ships
  - 1880 - Bedford & Maccauvlei
  - 1888 - Boksburg, Brakpan, Dundee, Klip River
  - 1886-9 - Brugspruit, Maggies, Steenkoolspruit
  - 1892 - Cassel (Springs)
  - 1897 - Douglas, T&DB, Landau
  - Many others since

Note: Some dates vary in different source materials; these are "best estimates"

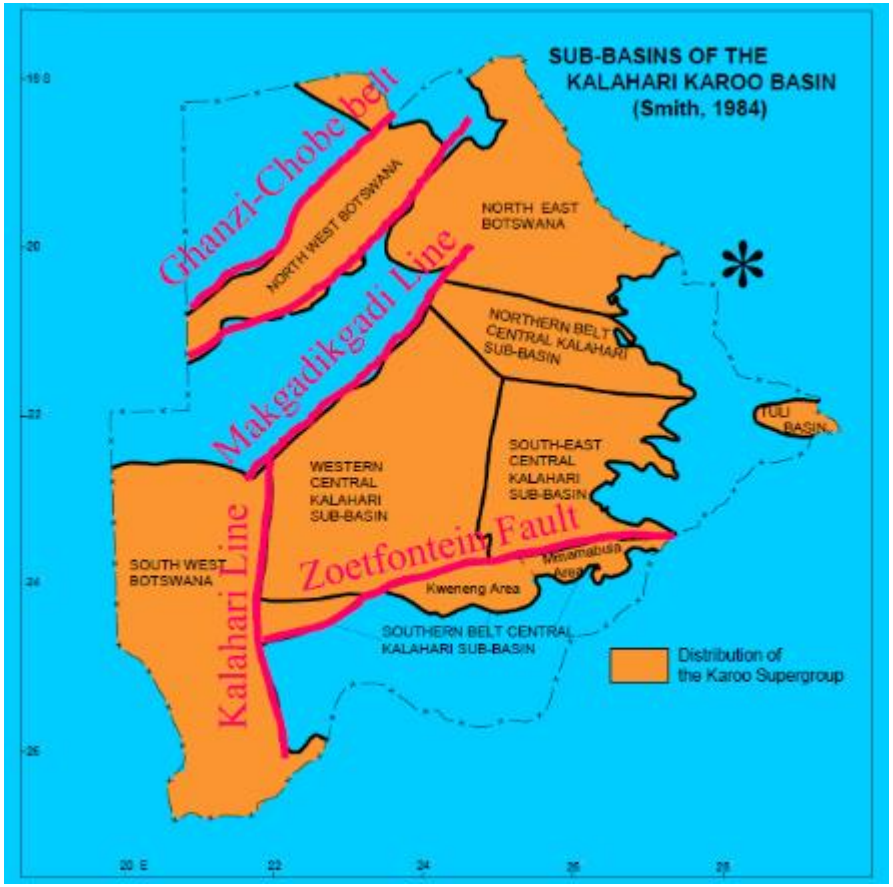
Spotlight on …

- **Tanzania:** 3 operating collieries:
  - 1988 - Kiwira Coal Mine
  - 2011 - Ngaka Coal Mine (u/g)
  - 2017 - Rukwa Coal Project (o/c)
- **Zambia:** 2 operating collieries:
  - 1967 - Maamba (o/c)
  - ~2000 - Collum Coal Mine (u/g)
- **Zimbabwe:** ~?? operating collieries:
  - 1903 - Hwange (u/g, o/c)
  - 1994 - Sengwa (o/c)
  - ~2002 - Zambezi Gas (Entuba coalfield, coal mine & CBM exploration; 200 Mt reserves; supplies Hwange PS)
  - ? - Makomo Resources (o/c, supplies Hwange PS)
  - ? - Western Coal (Rautenbach; supposedly mined near the Bumbusi Heritage site inside the Hwange National Park)
  - ? - Tuli Coal Mine (o/c; coking & thermal; closed)

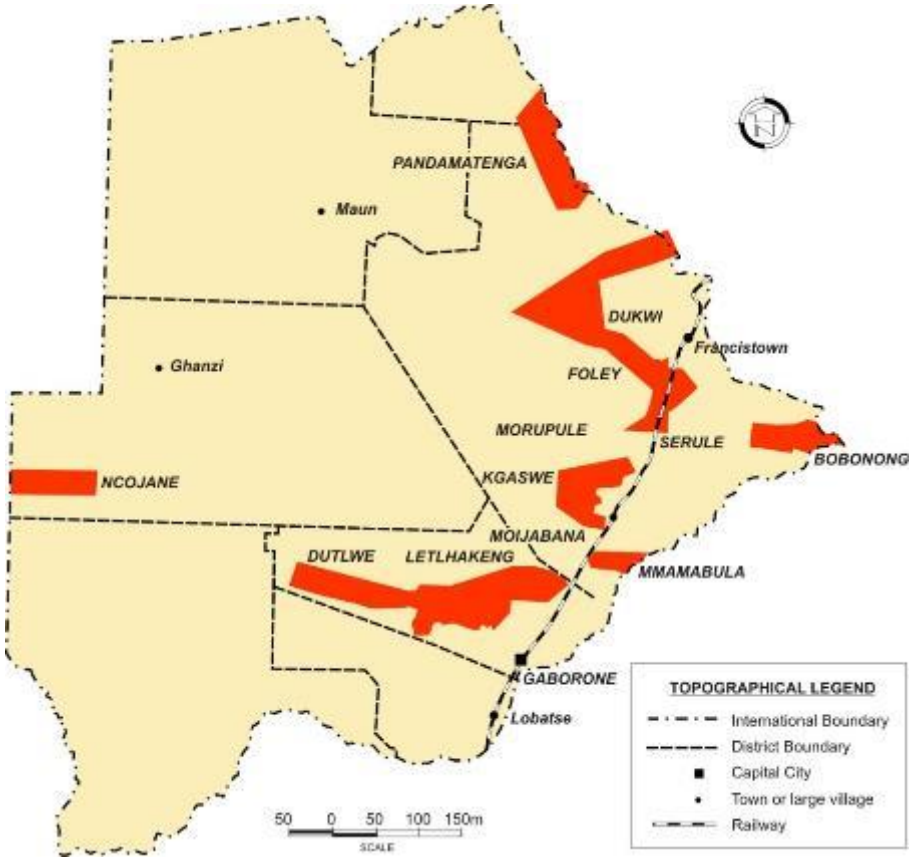
Note: Some dates vary in different source materials; these are "best estimates"

Botswana

Basins associated with major interpreted geophysical lineaments (after Modie, 2007)



Major Coalfields



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Kalahari Karoo Basin Geology

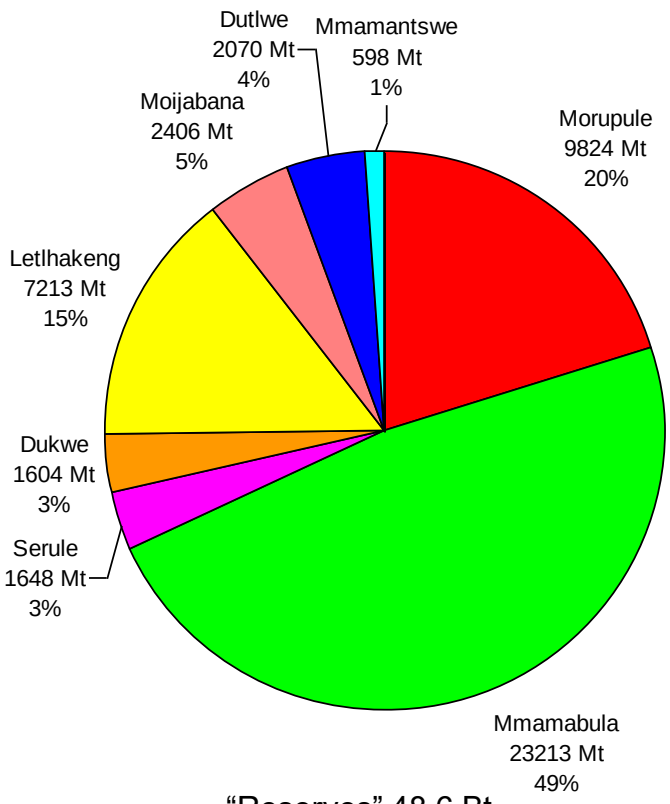
- One of several Permo-Carboniferous SW Gondwana basins
- Initial deposition - Late Carboniferous glaciation
  - Polymictite, mudstone, siltstone, sandstone
- Followed by coal accumulation in a variety of depositional settings:
  - Fluvio-deltaic, lacustrinal, marginal marine
  - Mudstone, siltstone, sandstone, limestone, coal
- Continuing climate amelioration led to more terrestrial deposits
  - Lacustrinal, fluvial, aeolian
  - Mudstone, sandstone
- Final deposition – capped by early Jurassic basaltic volcanism (c.185 –177 Ma)
  - Extensional tectonics of Gondwana break-up
  - Intrusion of doleritic dykes and sills

Coal Characteristics

- Dull/Dull lustrous – Mixed coal; rarely Bright (Serowe & Taukome seams)
- Frequently grades subtly from mudstone/carbonaceous mudstone - muddy coal - dull heavy coal - dull coal/mixed coal
- Often finely laminated
- Pyritic, sideritic, calcitic
- Inherent moisture slightly higher than Witbank-type coals (±5% ad)

Resources and Reserves - 212 Bt!

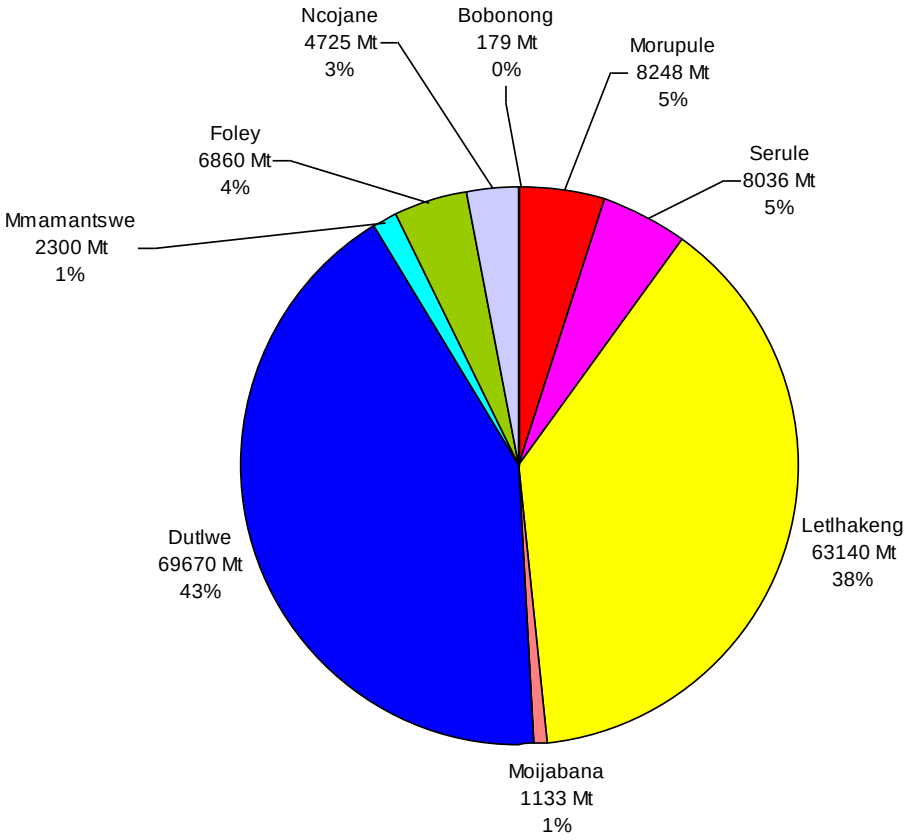
From Company Data



"Reserves" 48.6 Bt
(derived from Measured, Indicated & Inferred resources)

(after Chatupa, 1991)

"Undiscovered"

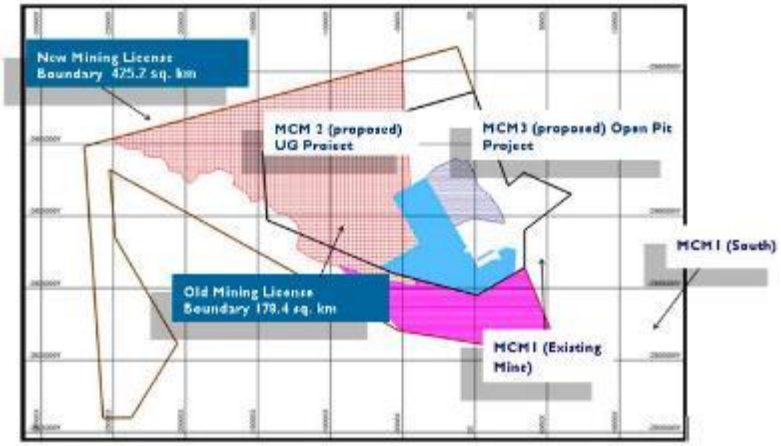


"Resources" 164.3 Bt
(incl. hypothetical & speculative resources)

Morupule Coal Mine

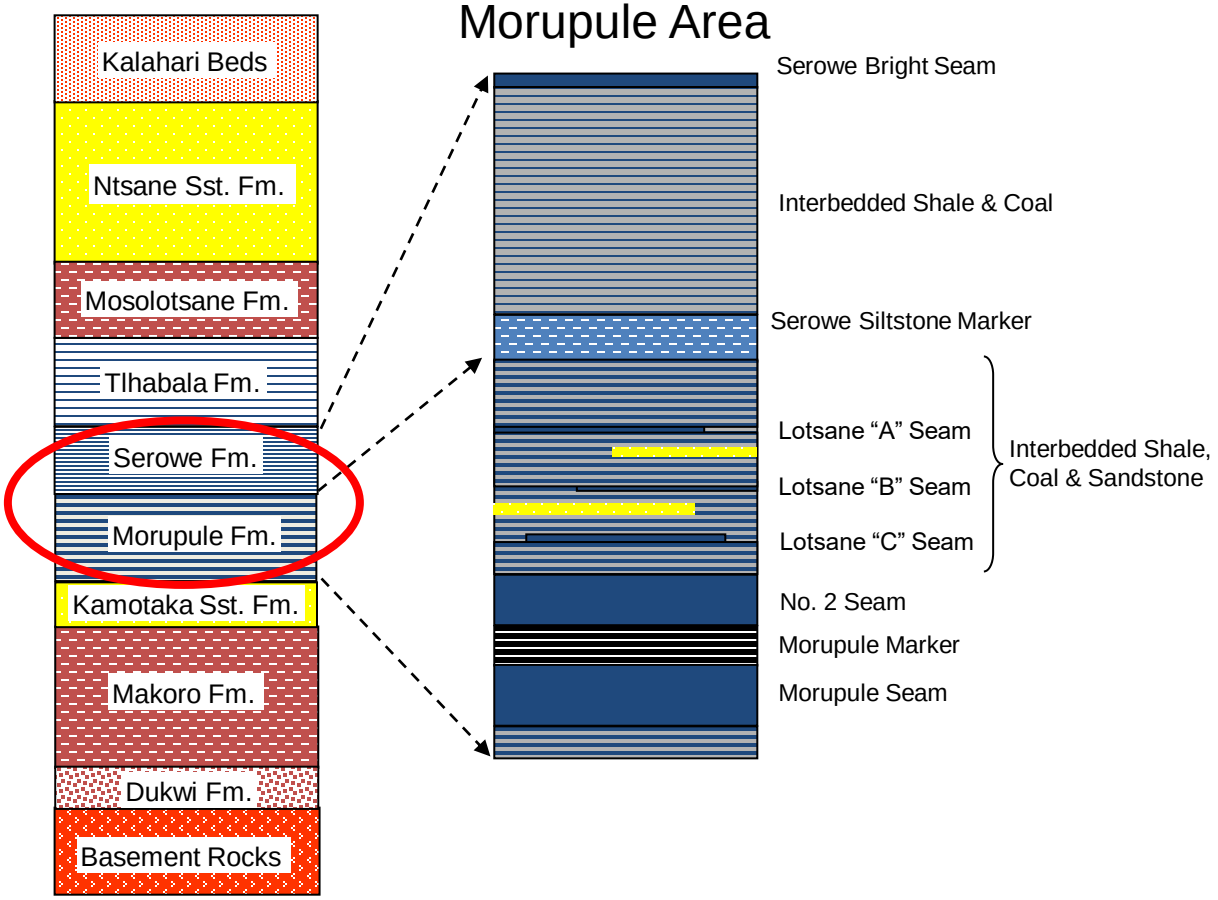
- Started in 1973 by AAC
- Now 100% GoB owned
- Morupule Coalfield near Palapye
- Main/No. 1 Seam; 9m thick
- MCM1 - underground with ~3 CM sections, 1 D&B section
- Motheo OC Mine 1 Mtpa
- ~4 Bt reserves; LoM > 1000 years
- ~2.8 Mtpa RoM; 3.8 Mtpa once OC fully operational

- Products (raw & washed):
  - Thermal coal (Morupule B PS)
  - Ferro-alloy industries (low sulphur)
  - Export to Namibia, Zimbabwe, Zambia, RSA
  - Local Botswana & southern Africa domestic use
  - Cement manufacture



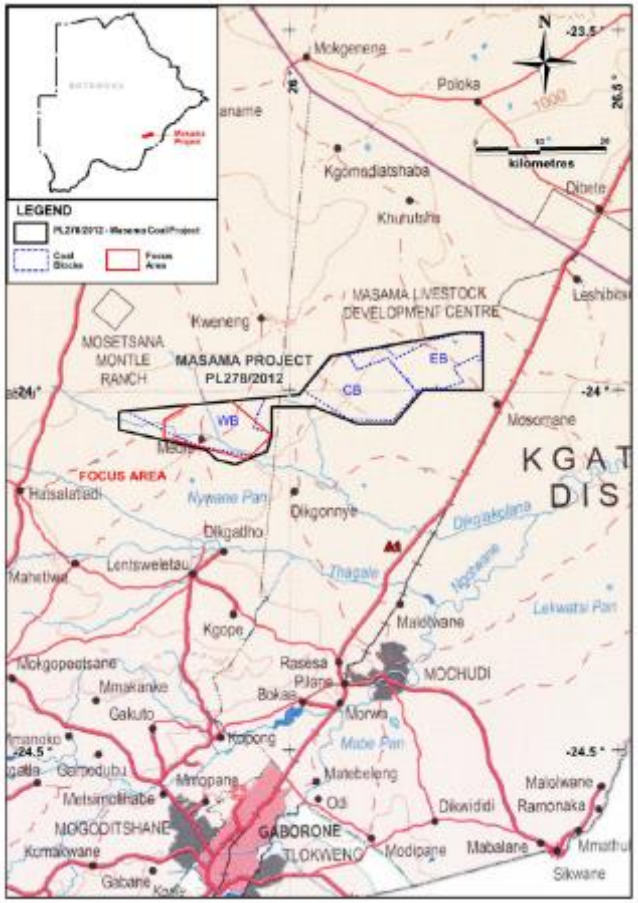
Morupule Stratigraphy

Southeast Central
Kalahari Sub-basin



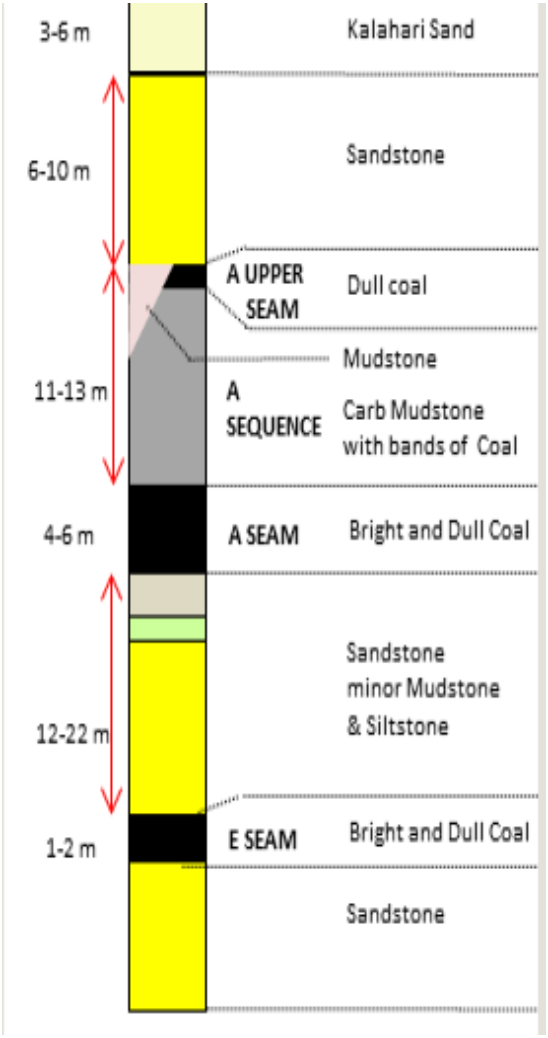
Masama Coal Mine

- Started in 2019 by Minergy Coal
- SW Mmamabula Coalfield near Kweneng
- West Block - A and E seams; 1.5 – 5 m thick
- ~79 Mt MI OC resources
- ~7 Mt I UG resources
- 1.2 Mtpa RoM; LoM ~100 years
- Products
  - Raw: ~22 MJ/kg; 19 – 24% ash; ~2% TS
  - Washed: ~26 MJ/kg; 10% ash; ~20.4% TS @ 60-70% yield
  - Export quality thermal coal



Source: Masama CPR 29/09/2017; https://www.minergycoal.com/about-masama/competent-persons-report/

Masama Stratigraphy



Source: Minergy Investor Presentations; https://www.minergycoal.com/documents/presentations

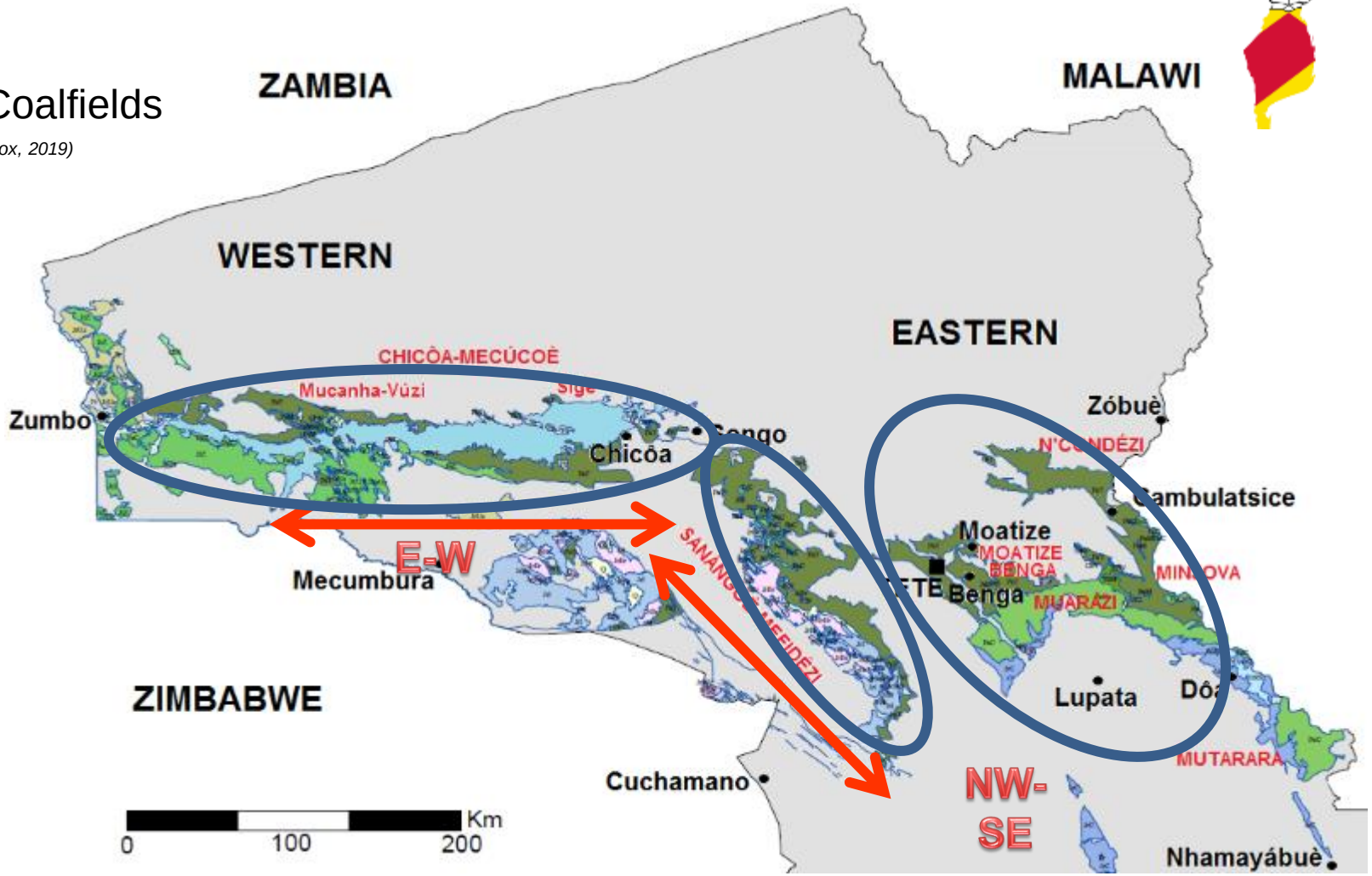
Malawi

- Northern deposits more important than southern as less structurally deformed
- Most economically important – Livingstonia and Ngana Basins (northern)
  - Disconnected, down-faulted, half-graben sub-basins on eastern flank of major basement high
  - Lithostratigraphy very similar to Tanzania
- 1985 - Kaziziziwi Coal Mine (Livingstonia Coalfield)
- 1987 - Mchenga Coal Mine (Livingstonia Coalfield; mainly U/G, 26.5 Mt reserves, 0.3 Mtpa, thermal/industrial)
- - Nkhachila Coal Mine (North Rukuru Coalfield; open pit)
- - Eland Coal Mine (Lufira Coalfield)

Mozambique

Tete Coalfields

(after Hancox, 2019)



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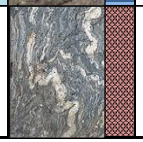
Depositional Environments

Era	Period	Super-group	Group	Formation	Stratigraphy	Depositional Environment	Depositional Process	Coals Contained	Coal Characteristics	
									P%	S%
Palaeozoic	Permian	Karoo	Lower Karoo	Matinde Fm.		Fluvial	River channel system?	Discordant lenses		
						Marsh	Marsh system with thick (approx. 20-30m) coal packages consisting of interbanded coal and mudstone. Sandstone partings commonly display coarsening up sequences.	Thicker upper seams	0.03	0.9
						River Channel and Marsh	Transition zone between the underlying river channel system with a series of abandoned channels and the overlying marsh system with thick mudstone dominated packages.	Discordant lenses N+	0.02	1.1
						Fluvial	River channel system with a series of abandoned channels. Seams are less correlatable.	J,K,L,M	0.01	1.0
				Mo tize Fm.		Fluvial	River channel system with correlatable seams.	H,I	0.08	0.9
								F,G	0.06	0.8
						Braided Delta	Braided delta system with interchannel coal formation.	E	0.08	0.8
								D	0.08	0.9
						Post Glacial	Post Glacial outwash fans and channels. Lake and marsh system at top of sequence containing C-seam.	C	0.11	0.7
								B	0.01	0.9
								A	0.00	1.3
	Carboniferous			Vuzi Fm.		Glacial	Glacial till deposited by melting glaciers.			
Meso Proterozoic	Stenian					Intrusive	The Tete Complex is the basement rock consisting of serpentinised gabbro; the basement includes intrusive stocks and plutons.			

(after Lloyd, 2019)

Resources and Reserves

- Lack of reliable numbers that illustrate the real situation
- The Mining Directorate of Mozambique (DNM, 2012) compiled a table of coal reserves (JORC) with the information provided by the coal companies and with more recent updates:
  - TOTAL ~ 29 Bt,
  - Measured/Indicated ~ 12 Bt
  - Inferred ~ 17 Bt
- Current marketable reserves:
  - > 450 Mt of coking coal
  - > 400 Mt of thermal coal
- Current estimated additional resources:
  - 600 Mt of metallurgical coal
  - 2,4 Bt of thermal mineable resources (locked by logistics)

(after Pinheiro, 2019)

Moatize Mine

- Started in 2011 by Vale
- Old Carbomoc concessions
- Moatize basin of Moatize Coalfield
- Sousa Pinto, Chipanga, Bananeiras, Intermedia
- OC T&S
- ~11 Mtpa sales
- ~1.9 Bt reserves

- Products:
  - HCC
  - Thermal middlings
  - Exports to India, Europe, Eastern Asia, N & S America
  - Export via Nacala

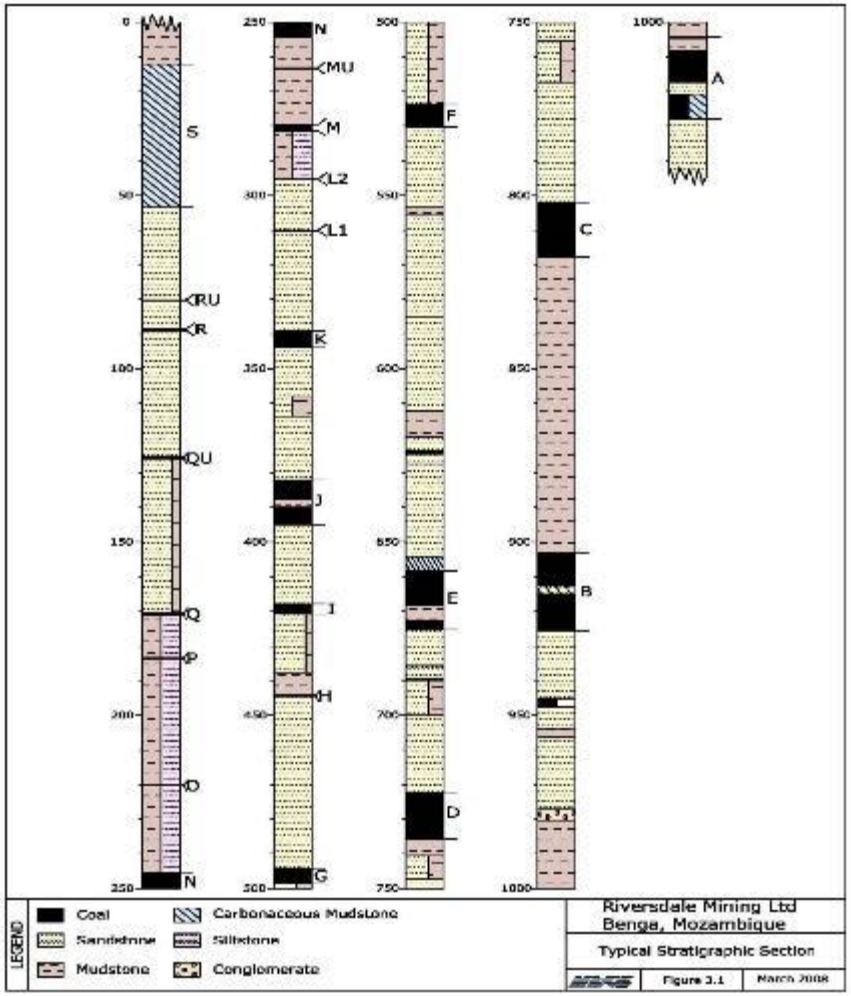
Benga Mine

- Started in 2012 by RTCM; 2014 bought by ICVL*
- 2015 – 2018 operations suspended (low coal price)
- Benga basin of Moatize Coalfield
- C, D & E Seams (Chipanga, Bananeiras, Intermedia)
- OC T&S
- 200 Mt proven reserves

- Products:
  - HCC 10-13.5% ash (1.6 Mtpa exported to India via Beira)
  - Thermal 27.5 – 28% ash
  - Power Grade 50 – 60% ash
  - 35:10:50 (balance 5% tailings)

** International Coal Ventures Ltd*

Moatize & Benga Stratigraphy



Moatize F^{m} Seam Names

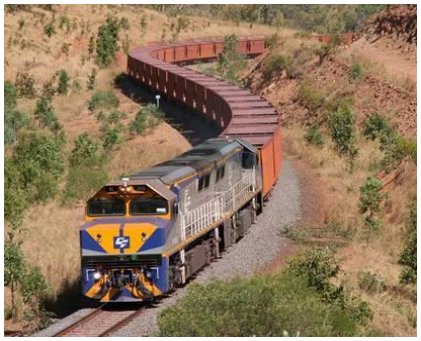
Benga	Moatize
E	Intermedia
D	Bananeiras
C	Chipanga
B	Sousa Pinto Upper
A	Sousa Pinto Lower

Source: Riversdale Mining Ltd

Chirodzi Mine

- Started in 2012 by JSPL*
- Sanângoè-Mefídézi Coalfield
- Chipanga Seam equivalent
- 10 Mtpa RoM
- OC T&S
- 2.7 Bt; LoM 25 years

- Products:
  - CC (semi-hard)
  - Thermal middlings
  - Exports via Beira

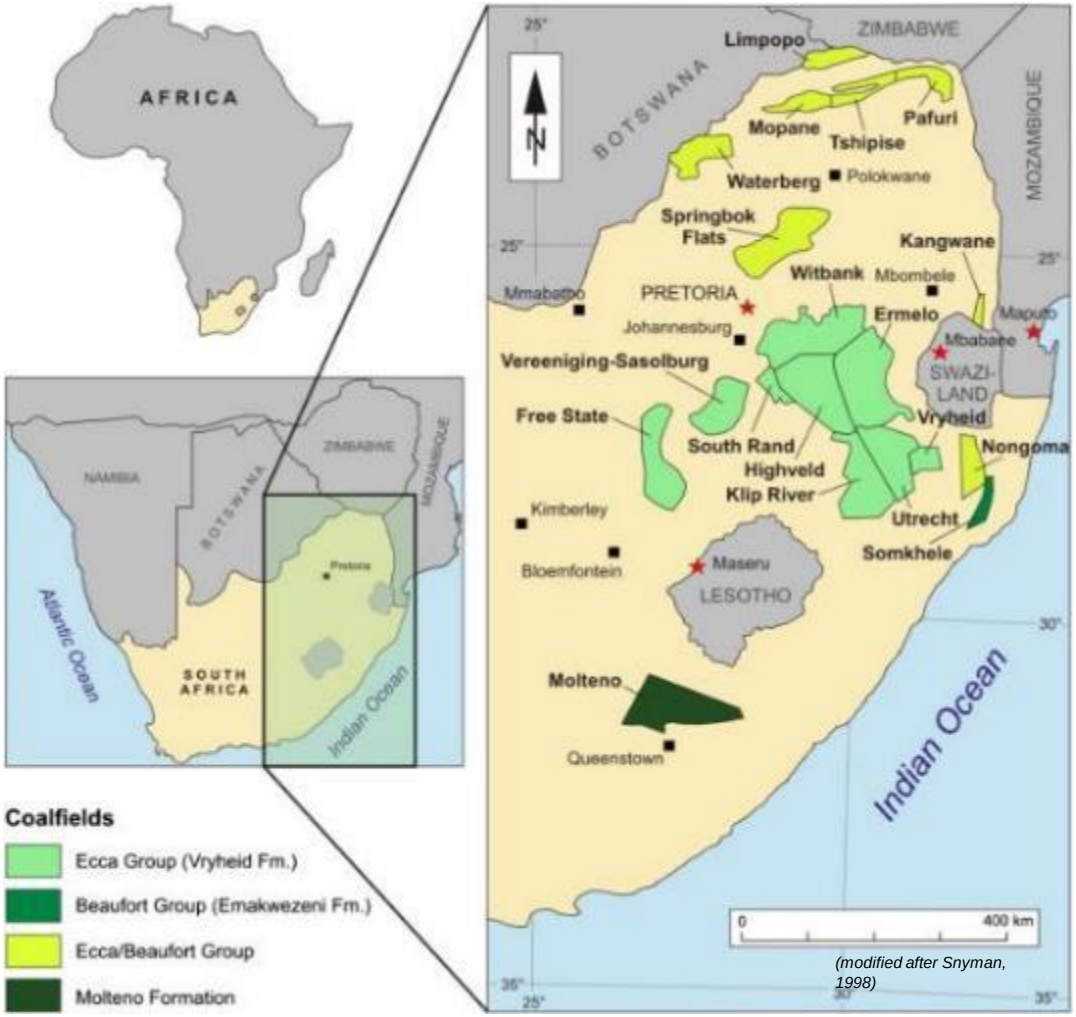


** Jindal Steel & Power Ltd*

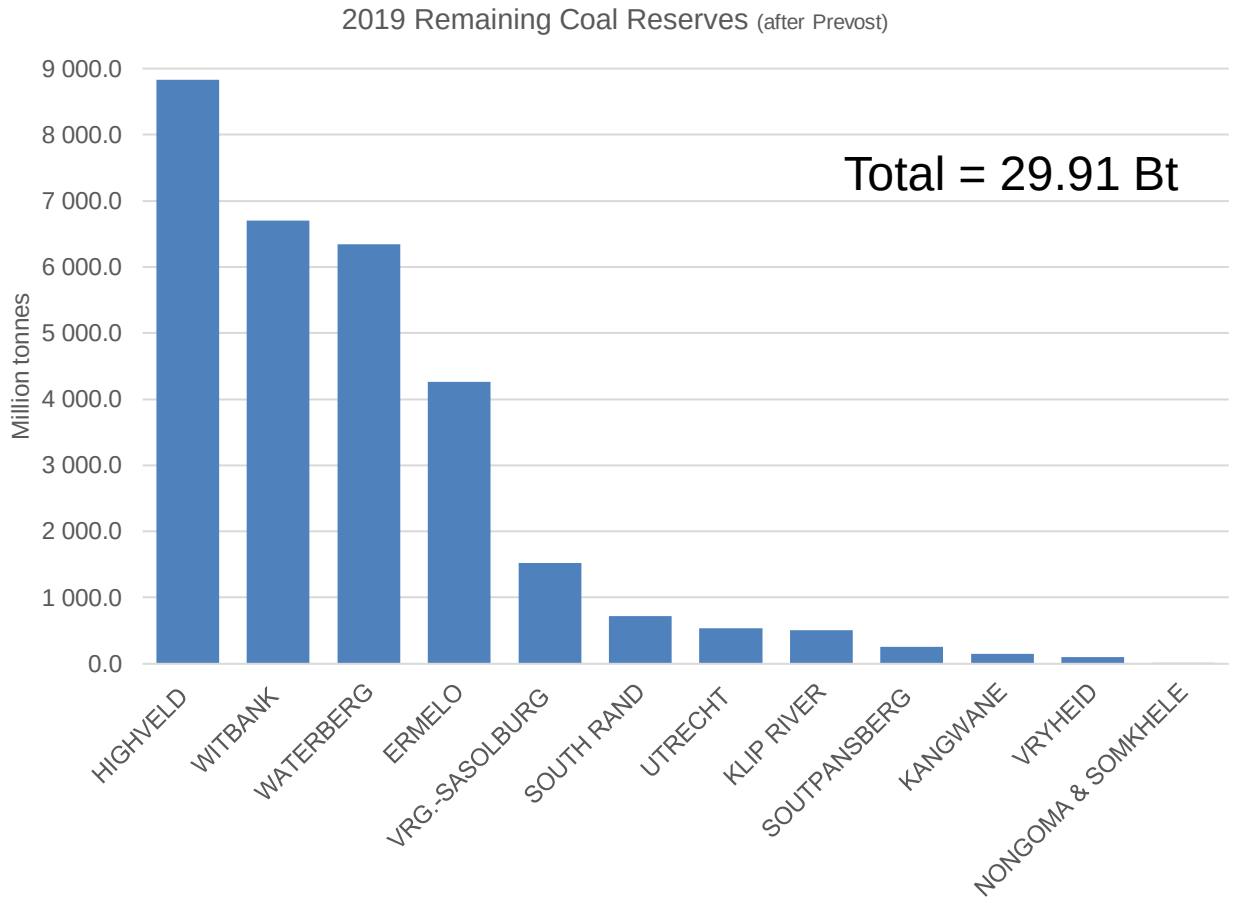
South Africa

19 Coalfields

- Ecca (oldest) - Main Karoo Basin coalfields Ecca-Beaufort – northern coalfields, Kangwane, Nongoma
- Beaufort – Somkhele
- Molteno (youngest) – Molteno-Indwe



Remaining Coal Reserves 2019



These estimates include coal in pillars and remnants that may not ever be recoverable

Not reported according to SAMREC

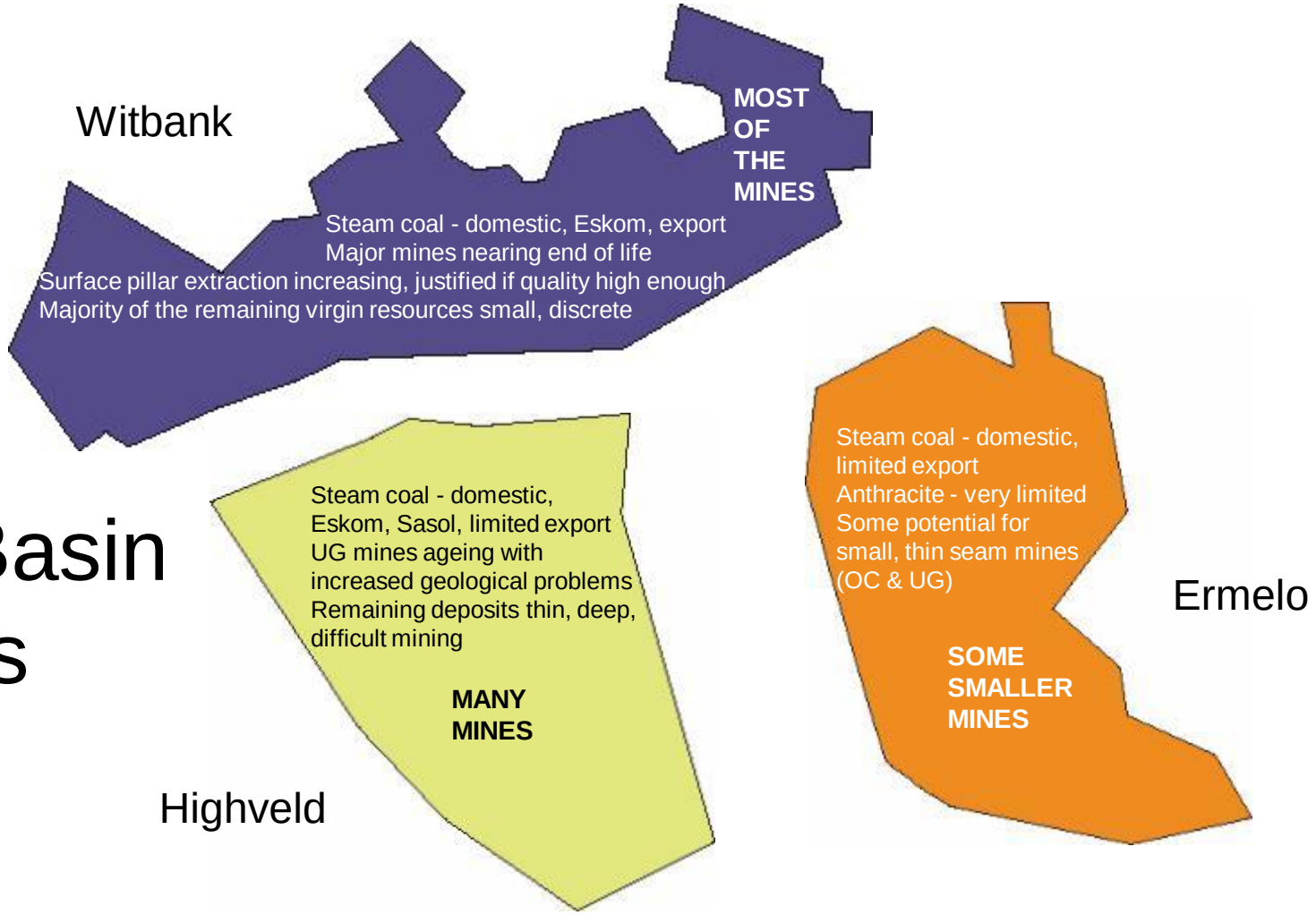
(after Prevost, 2021)

Production

- “The coal industry is the biggest in the mining sector in South Africa” – Minerals Council South Africa
  - 24% of mining production volume in 2020
  - Average annual production since 1982: ~270 Mtpa
  - 70% consumed locally
  - 70% of electricity generated from coal
  - RBCT primary export port

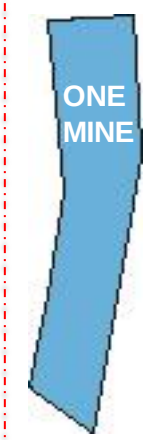
- **2020**
  - 252.2 Mt (-2.4%)
  - 91 459 employees (-3.9%)
  - Total sales R132.9 billion (-6.0%)
  - 36% of total exports by value
- **2019**
  - 258.9 Mt (+2.2%)
  - 92 230 employees (+3%; 19% of mining employment)
  - Total sales R139.3 billion (-4.5%)
  - 39% of total exports by value
- **2018**
  - 252.6 Mt (+0.16%)
  - 86 919 employees (+5.3%)
  - Total sales R139.4 billion (+7%)
  - 49% % of total exports by value

Coalfields and Coal Utilisation



Central Basin Coalfields

KZN and Kangwane



Kangwane

Anthracite

KZN Coalfields

Anthracite, lean coal, steam coal
Virtually no coking coal left
Mostly depleted
Maybe potential for a few small, thin seam UG mines
Limited OC potential

Utrecht

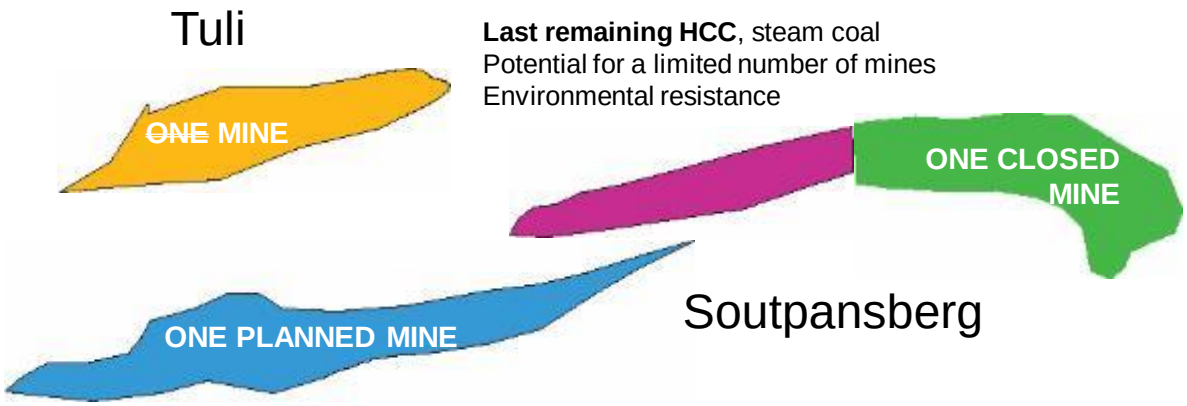
Vryheid

Klip River

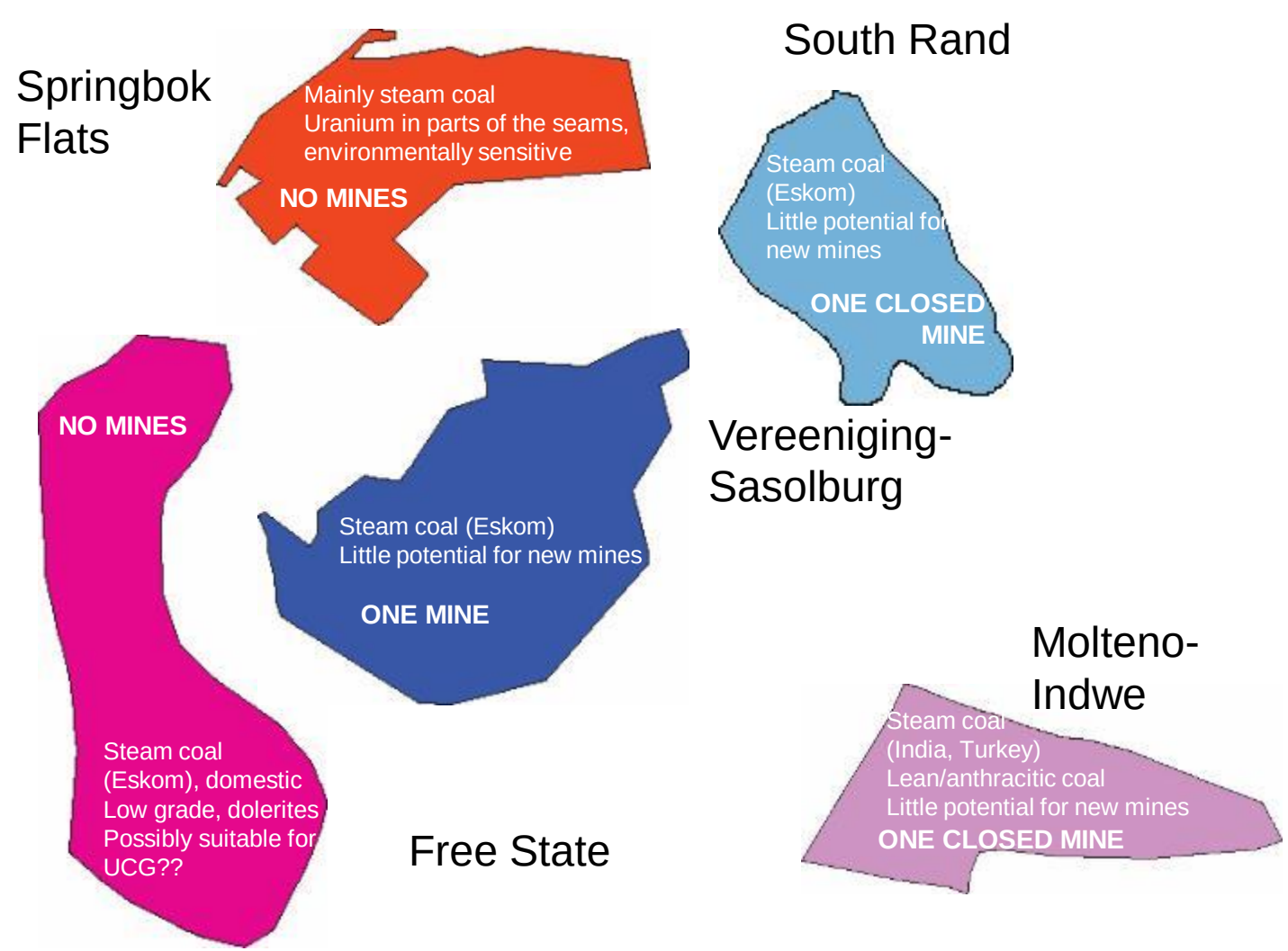
Nongoma

Somkhele

Limpopo Coalfields



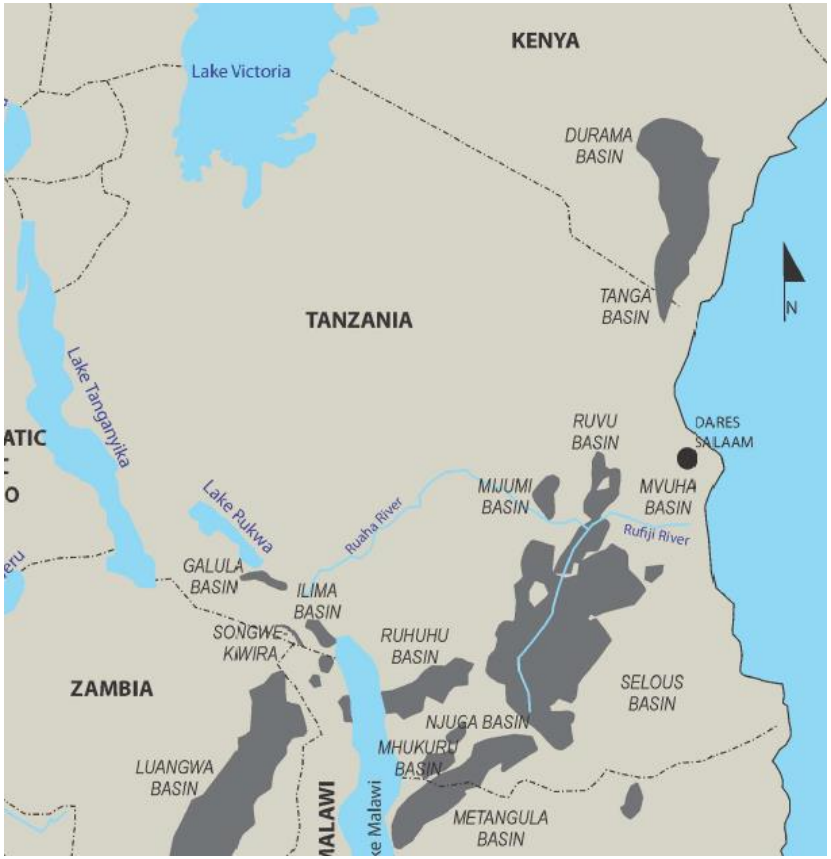
Low Grade Coalfields



Tanzania

- Eight main coal basins from northeast to southwest
- Coal-bearing formations: Mhukuru & Mchuchuma
- Most economically important are the Ruhuhu and Songwe-Kiwira Basins (southwest)

Major Coalfields



Source: Hancox, 2016

Basin Geology

- Karoo-equivalent deposits occur from the Kenyan border in the northeast (Tanga Basin) to Lake Malawi in the southwest (Ruhuhu and Mhukuru Basins)
- Coal seams in numerous separate NNE-NE-striking sub-basins:
  - Extensional rift systems
  - Fault-controlled grabens/half-grabens
  - Some syndepositional faulting at base and top of Beaufort Group
- Most complete Karoo succession is in the Ruhuhu Basin – Songea Group (type section for East African Karoo stratigraphy)
- Economic seams in the Mchuchuma Formation:
  - Lower facies: sandstone-dominated with metres-thick coal seams with relatively low ash and total sulphur
  - Upper facies: siltstone, mudstone, coaly siltstone dominated with thin, impersistent poor quality coal seams with high ash and total sulphur

Coal Characteristics

- Medium to high rank bituminous coal (thermal)
  - Ash: 20 – 45% (mainly kaolinite, quartz, carbonates, sulphur minerals)
  - Inherent Moisture: <15%
  - Volatile Matter: 20 – 30%
  - Total Sulphur: 1 – 3%
  - Calorific Value: ~25 MJ/kg
  - High inertinite, low - medium vitrinite, low liptinite

Resources and Reserves

- Barlow Jonker estimate:
  - Total resources: 1 800 Mt
  - Total reserves: 322 Mt
- IEA estimate (2005):
  - Recoverable reserves: 200 Mt

Rukwa Coal Project

- Edenville Energy plc
- NW of Lake Rukwa
- “Bar-coded” deposit
- Grade C bituminous thermal (CV: 8 – 17 MJ/kg *in situ*)
- 171 Mt Measured & Indicated resources (JORC)
- Open pit truck & shovel
- October 2021 RoM – 2 240 Mt, washed product 1 024 Mt (150% increase since September)
- Domestic sales
- 120 MW mine-mouth power station planned

Mbeya Coal Project

- Owned by Kibo Mining plc but currently subject to disposal procedure
- South of Lake Rukwa
- Coalfield discovered in 1934, mapping commenced in 1950/51
- Galula (or Songwe-Rukwa) Basin in the southwest near Lake Rukwa
- Steeply dipping: 19 - 24°
- 37.78 Mt probable reserve
- Average LoM CV 15 MJ/kg
- Modified terrace mining – trucks & surface miners
- To supply adjacent 300 MW mine mouth power station

Zambia

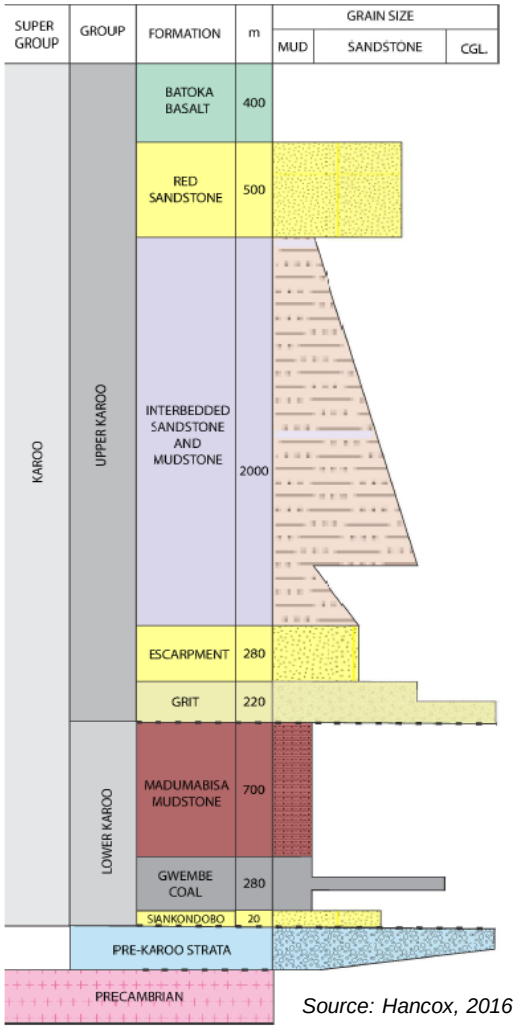
- Coal found in rift basins:
  - Luangwa Basin (unexploited)
  - Mid-Zambezi Basin
    - 3 sub-basins: Nkandabwe (Collum Mine - suspended), Siankondobo (Maamba Colliery), Mulungwa
  - Lukusashi Basin (unexploited) Kafue Basin (unexploited)
  - Barotse Basin (unexploited)
- Bituminous thermal coals
  - High ash content (~25%)
  - Moisture content ~2%
  - Total sulphur content 1 - 4%

Coal Basins

Source: Hancox, 2016

Mid-Zambezi Stratigraphy

- Subdivided into the Lower and Upper Karoo successions (separated by an unconformity):
- Upper Karoo:
  - Batoka Formation – basalt
  - Red Sandstone
  - Interbedded arenaceous continental sedimentary rocks and overlying mudstones
- Lower Karoo:
  - Madumabisa Mudstone Formation - fine grained lacustrine sediments
  - **Gwembe Coal Formation** - conglomerate, coal, sandstone & carbonaceous siltstones & mudstones (only unit with coal deposits)
  - Siankondobo Sandstone Formation, tillite & basal conglomerate



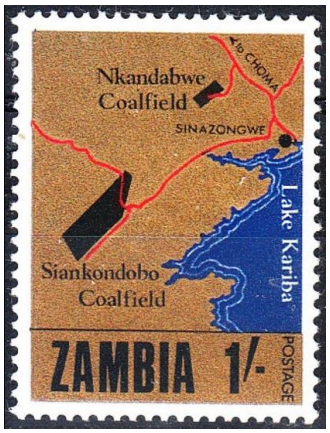
Source: Hancox, 2016

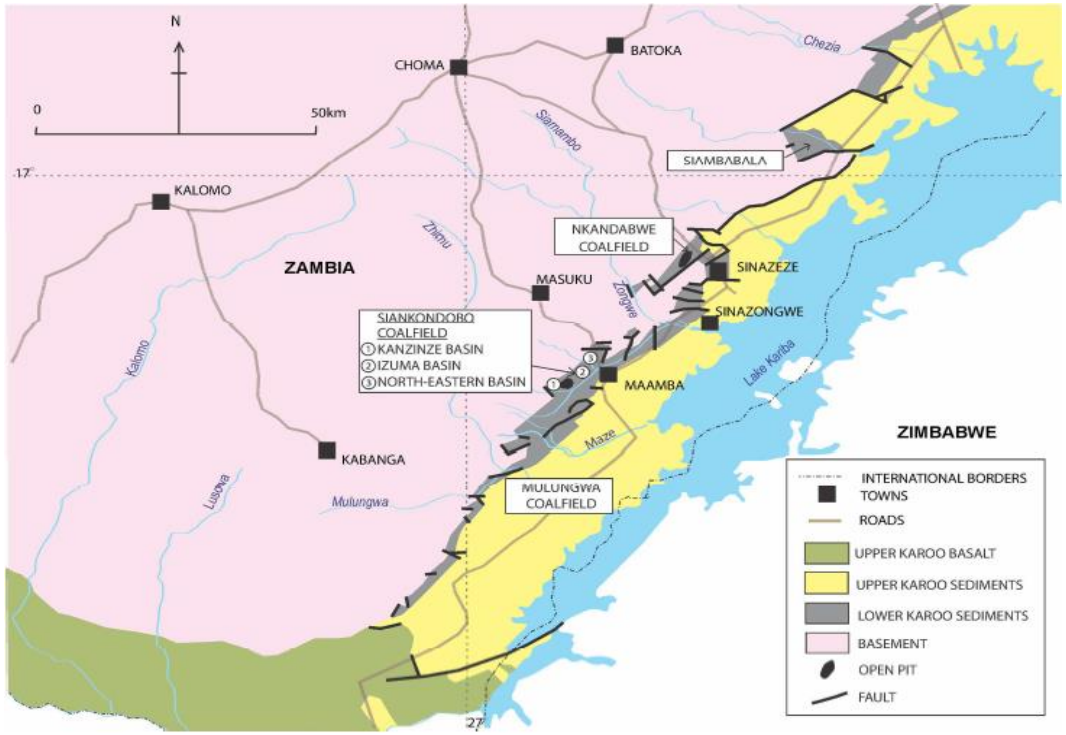
Mid-Zambezi Basin Structure

- Major structural feature is NE-SW orientated Zambezi escarpment, formed by the major bounding fault of the Deka Fault zone
  - Separates the Zimbabwe Craton to the SE from the Choma-Kalomo block to the NW
- Tectonism was followed by downwarping; subsequent sedimentation resulted in deposition of the Karoo succession
- Basin is asymmetrical due to greater subsidence on the Zambian side:
  - Maximum sediment thickness of 5 km (Zambia) and 1.3 km (Zimbabwe)
- Dips SE from nearly horizontal to 45 degrees
- Extensive faulting parallel to the rift margins downthrows Karoo sequence against Precambrian rocks
- Numerous high angle normal faults cut the coalfield - displacements up to 160 m

Mid-Zambezi Basin

- Half-grabens dipping to SE
- Strike NE-SW





Source: Hancox, 2016

Maamba Colliery

- 1967 - original mine started in Nkandabwe Coalfield, then SW moved to Siankondobo Coalfield
- Open pit truck & shovel
- Owned by Nava Bharat (Singapore) Pte (65%) and Zambia Consolidated Copper Mines Limited (35%)
- Previously government owned
- ~140 Mt reserves
- Mine mouth 300MW power plant

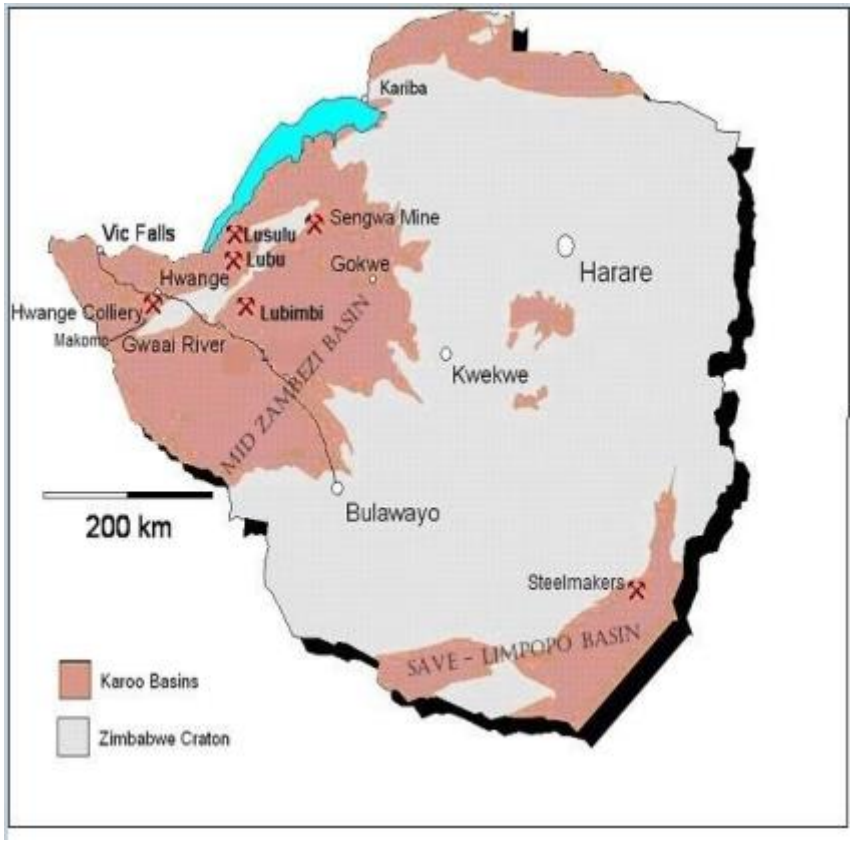
Products (raw & washed):

- Raw qualities
  - Ash 21.4%; VM 19.0; CV 25.98 MJ/kg; TS 2.21%
- Washed – nuts, peas, fines
  - Ash 18 – 20%; VM 18 – 21%; CV 6294 – 6482 kcal/kg; TS 0.7 – 1.5%
- Unwashed – fines
  - Ash 22 – 30%; VM 16-18%; CV 5353 – 6106 kcal/kg; TS 1.6 – 2.5%
- Duff/slurry –
  - Ash 22 – 30%; VM 16 – 18%; CV 5353 – 6106 kcal/kg; TS 2 – 3%

Zimbabwe

- Mid-Zambezi Basin
  - Sinamatella-Western Areas-Hwange-Entuba-Sengwa (N & S)
  - Dahlia/Gwayi-Hankano-Lubimbi
  - Sebungu, Lubu, Lusulu, Sessami, Kaonga, Bari, Nebiri, Marowa, Mlibizi
- Mana Pools-Cabora Bassa Basin
  - Msambansovu, Strange's Coal
- Save-Limpopo Basin
  - Sabi Valley, Mkwasine, Malilongwe, Bendezi, Chivumburu, Bubye (E & W)
- Tuli Basin
  - Singwedzi, Umzingwane, Massabi

Major Coalfields



Source: Maponga, 2017

Basin Geology

- Coal-bearing areas around edges of Zimbabwe craton (mainly W & E, smaller areas N & S)
- Mainly thermal coals
  - Hwange – coking & thermal coal
  - Save-Limpopo – semi-anthracite
  - Tuli - coking & thermal coal
- Mid-Zambezi – less faulted & intruded; thicker & better quality
- Save-Limpopo – deep (>300 m), severely faulted & intruded (dolerite dykes swarms), high gas content, interbedded clastic bands, high ash coals, poor washability,

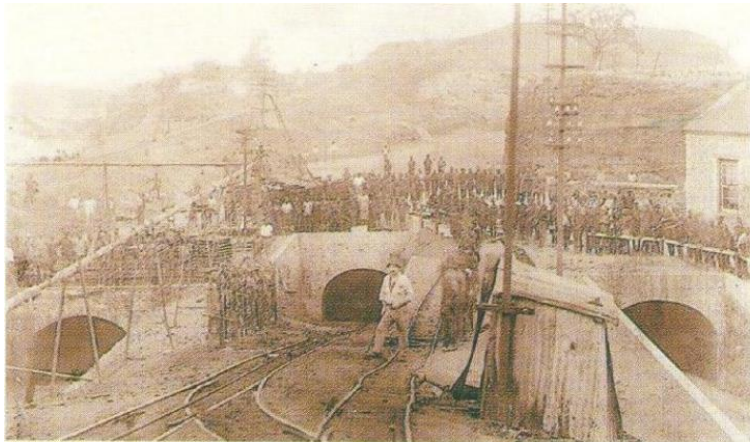
Resources and Reserves

- 2012 FFF Zimbabwe Coal Indaba
  - Hollaway 10.2 Bt
    - Mid-Zambezi 9.6 Bt (Lubimbi 3 Bt)
    - Save-Limpopo & Tuli 0.6 Bt
  - Hawadi 12 – 26.6 Bt
  - Mutsinya 26.6 Bt GTIS resources (2003 estimate)
    - Mid-Zambezi 24.8 Bt (Lubimbi 22 Bt)
    - Save-Limpopo & Tuli 1.7 Bt
  - Matyanga > 30 Bt resources
- Zimbabwe Geological Survey (undated)
  - 12 Mt resources
- BGR (2019)
  - 25 Bt resources
  - 0.5 Bt reserves

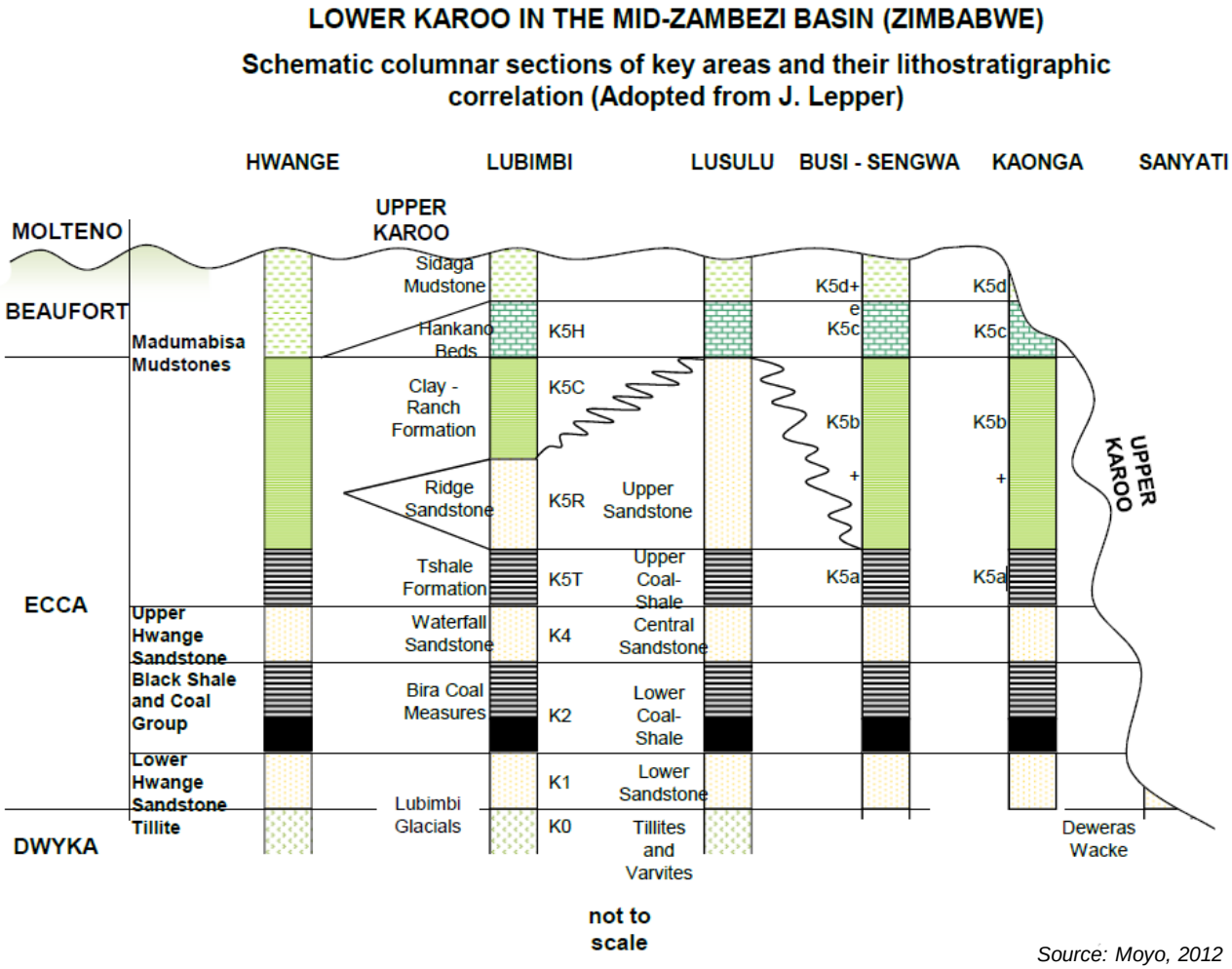
Hwange Coal Mine

- Exploration started around 1892; first claims pegged 1895
- Mining started in 1903 at No 1 Colliery by Wankie Coal, Railway & Exploration Company
- Went on to develop other shafts
- Production peaks:
  - 1955 – 1970: >3.5 Mtpa
  - 1990 – 1997: > 5 Mtpa
  - Peak production in 1991: 5.9 Mtpa
- Hwange Main Seam (lowermost seam)
  - ~9.5 m thick
  - Bright coking coal @ base (4.72 m)
  - Dull power coal @ top (4.77 m)
- Phosphorus & ash increase to roof; TS & VM decrease to roof
- Mechanized underground B&P (CMs, shuttlecars, roofbolters)
- Opencast (dragline)

- Products:
  - Thermal coal (24% ash max) – Hwange Power Station
  - Coking coal (CV 30 MJ/kg, ash 10%, 1.5% TS, 2.0 CSN)
  - Industry
  - Agriculture



Hwange Stratigraphy



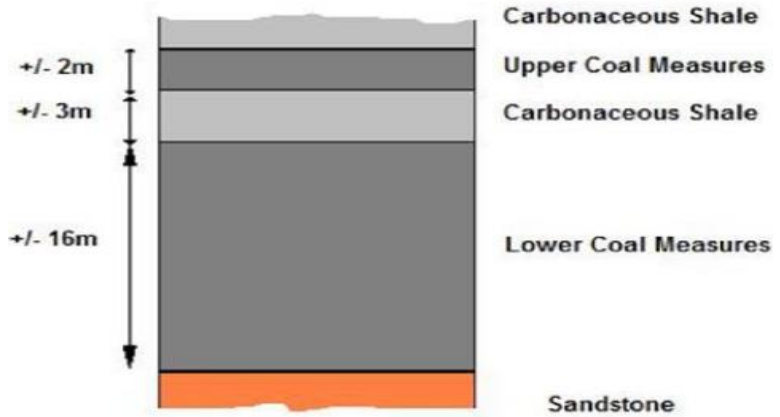
Source: Moyo, 2012

Hwange Coal Hub

- Special mining grants issued:
  - Afrochine Energy (Tsingshan Steel; Dinson – exploring inside & alongside Hwange National Park)
  - Zimbabwe Zhongxin Coking Company (JV - Zimbabwe Defence Forces & Yuxia ZhongXin Coking Company; coal mine)
  - Zimbabwe ZhongXin Electrical Energy (Coal-fired power plant - Phase 1: 50 MW complete, Phases 2: 270 MW; part of Hwange PS expansion, another 600 MW planned by 2025)
  - Beifer Investments (plans coal mine near Dinde; EIA legitimacy questioned; potential environmental issues – drinking water contamination, forced relocations, air & water pollution, destruction of cultural heritage sites)
- Current drilling:
  - Reportedly, around 10 Chinese companies operating/drilling
  - Some drilling close to Hwange National Park boundary (potential environmental issues)
  - Some grants cover safari areas adjacent to HNP (local & environmental objections)
  - Numerous Chinese companies/projects:
    - Chilota South Mining, Chaba Mine, Hwange Coal Gasification, Zimzhongzhin, Tsingshan Holding Group, Liberation Mining, JinAn/Tutu Coking

Sengwa Colliery

- Owned by RioZim Ltd & Rio Tinto plc (50:50)
- Open pit – T&S
- 1.336 Bt resources @ average SR ~4 bcm(~1 Bt M&I)
- > 0.525 Bt proved reserves
- Average raw qualities:
  - CV 17 MJ/kg, ash 22-29%, VM 21%, TS 0.3%
- Senga Power Station (financial close not yet achieved)
  - 2 800 MW (4 x 700 MW; only 700MW permitted to date)
  - To be constructed by China Gezhouba Group Corp (Power China subsidiary)
- Potential CBM/CTL?



Source: Hollaway, 2012

Assessed Status New Coal Projects – Global Energy Monitor (2021)

Project	Country	Capacity (MW)	Status	Assessment
ZhongXin	Zimbabwe	300	Likely	Under construction, but delayed due to COVID
Mabesekwa Export Independent Power	Botswana	600	Unclear	Incomplete financing, pre-construction, partially licensed
Morupule IPP	Botswana	600	Unclear	Unfunded, pre-construction
Sese Integrated Power	Botswana	450	Unclear	Partially licensed, unfunded
Lubhuku	Eswatini	300	Unclear	Only announced
Imaloto Coal	Madagascar	60	Unclear	Pre-construction planning
Rukuru	Malawi	100	Unclear	Pre-construction, no recent info
Benga (Kibo Energy)	Mozambique	300	Unclear	Pre-construction, submitted draft PPA
Ncondezi	Mozambique	300	Unclear	Delayed, but submitted revised plans
Tete	Mozambique	200	Unclear	No recent info, pre-permit stage
Musina-Makhado	South Africa	3000	Unclear	Pre-permit, no recent news
Mbeya Coal to Power	Tanzania	300	Unclear	Pre-construction
Binga Unit 1A + 1B	Zimbabwe	700	Unclear	Pre-construction, planning
Sengwa	Zimbabwe	2800	Unclear	Pre-construction, faces opposition, new Phase 2
Yayu	Ethiopia	90	No/Unlikely	Cancelled but could revive
San Pedro Port	Ivory Coast	700	No/Unlikely	No progress, likely dead
Lamu Power	Kenya	1050	No/Unlikely	Licenses revoked, likely dead
Kamwamba	Malawi	300	No/Unlikely	Delayed pre-construction
Pamodzi Unit 1	Malawi	120	No/Unlikely	Shelved
Khanyisa	South Africa	300	No/Unlikely	Funders withdrew, licenses revoked
Transalloy	South Africa	150	No/Unlikely	Complex under force majeure
Western Coal and Energy	Zimbabwe	600	No/Unlikely	Extremely Preliminary

Thank you for listening!

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