CHEMICAL & PETROGRAPHIC COMPOSITION AND DEPOSITIONAL ENVIRONMENT OF THE HWANGE COAL SEAM

OUTLINE

- Coal and the Zimbabwean economy in general
- Coal basics: General
- Coal Composition: Chemical and Petrographic)
- Hwange Coal: chemical and petrolographic composition and distribution
- Suggested depositional environment of the Hwange Main Seam

OUTLINE (Cont)

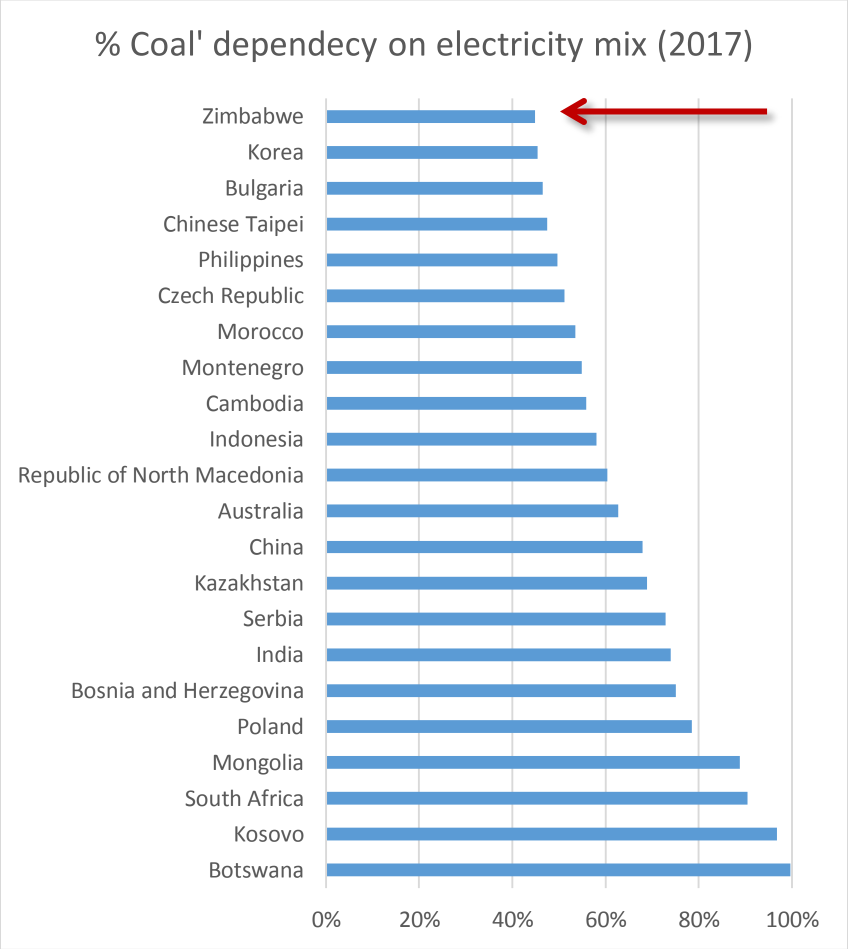
- Conclusion.

COAL AND ZIMBABWE'S ECONOMY

- Coal has been one of the mainstays of economic development in Zimbabwe for some 118 years with the first load of coal leaving the No.1 Shaft at Hwange Colliery.
- Prior to that Zimbabwe coal requirements came from Wales, in the UK.
- The fossil fuel now plays a vital role in almost all major sectors of the economy and social life in Zimbabwe.
- Coal has become to Zimbabwe what oil is the Middle East countries.
- Talking of coal is synonymous with talking of the Hwange Coal Seam

COAL AND ZIMBABWE'S ECONOMY (Cont)

- Endowed with abundant coal resources, some of which are of high quality, Zimbabwe, a developing country, was in 2017 reported to be one of the world's top 22 countries with heavy dependence on coal (graph opposite) for their energy needs (IEA Statistics, 2017).



COAL BASICS: GENERAL

- This “black stone that burns” is probably the most complex and heterogeneous naturally occurring substance that Mother Nature ever brought forth, then decided to bury in its belly.
- It is not as monotonously black as the “unconverted” view it.
- It is an amazing source of the most valuable necessities of our lives.

COAL BASICS:COMPOSITION

- Petrographic composition
- Chemical composition

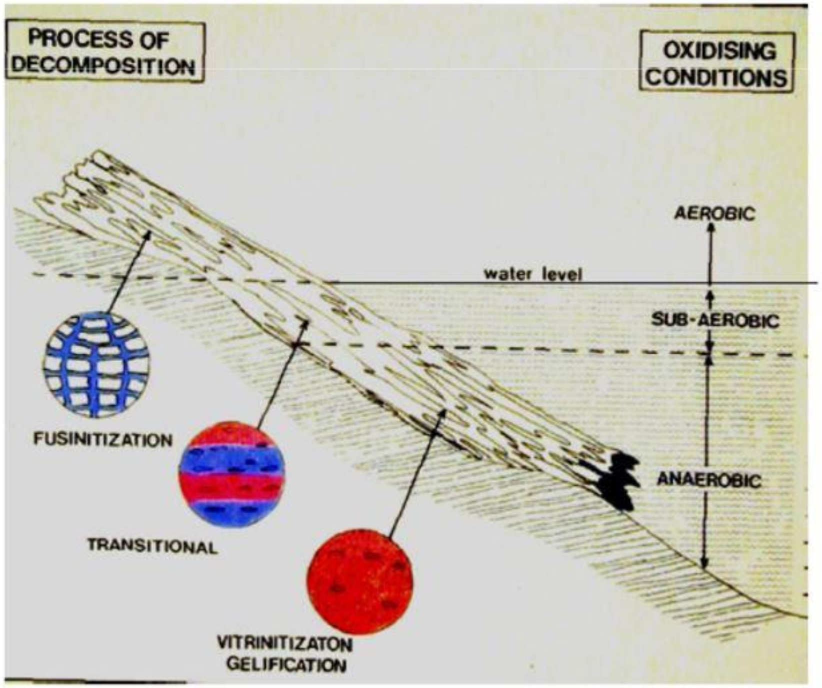
B) **PETROGRAPHIC COMPOSITION**

- Organic Component(coal building blocks);
  - Reactives – vitrinites and lipnites
  - Non reactive – inertinites
- Inorganic (minerals such as sulphides, silicates, carbonates, etc.)
- The composition of organics determines the **type** of coal:
  - Vitrinic
  - Fusic
- While the inorganics determine the **grade** of coal.

CHEMICAL STRUCTURE OF MACERALS

- Vitrinite: **High oxygen** content with oxygen levels steadily decreasing with increase in rank (prone spontaneous combustion).
- Inertinite: **high carbon** and **low oxygen**, **hydrogen and volatile matter** content (not readily oxidized/ignited)
- Liptinite: **More hydrogen-rich** than any of the other groups (oxidizes more rapidly than vitrinite and inertinite).

FORMATION OF MACERAL GROUPS



INERTINITE FORMATION
Fusinite

Semifusinite formation

VITRINITE FORMATION

B) CHEMICAL COMPOSITION

- Proximate analysis (meaning “first”)
- Inherent moisture:
  - Water that remains within pores and fissures of coal after surface moisture has been removed
- Ash:
  - ✓ Residue that remains after complete combustion of a coal;
  - ✓ Made up of oxides of iron, aluminium, titanium magnesium, calcium and silicates; and
  - ✓ Is an important indicator of coal quality.

B) **CHEMICAL COMPOSITION (Cont)**

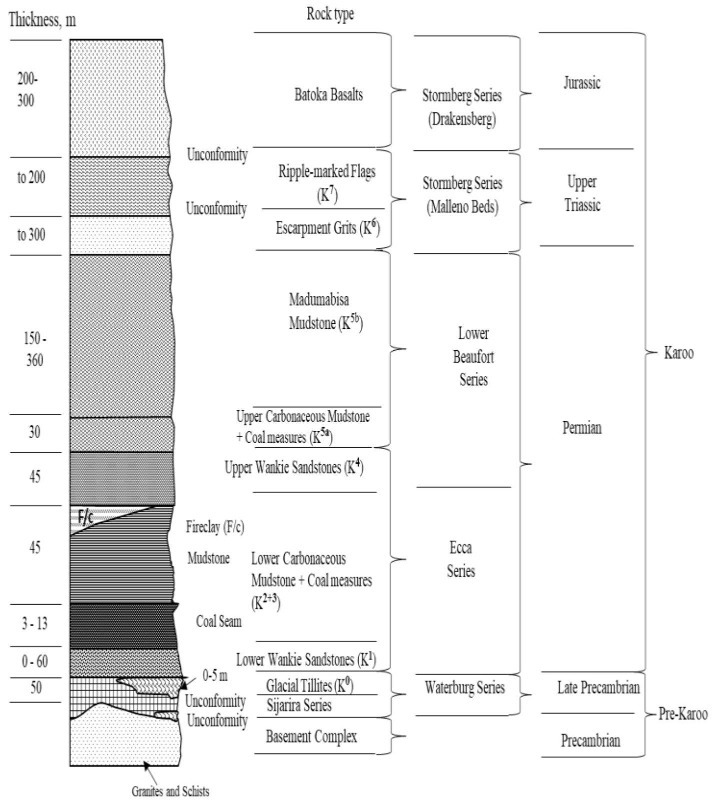
- Volatile Matter :
  - Comes from organic and inorganic sources
  - Include gases such as methane, carbon dioxide, carbon monoxide and hydrogen sulphides

B) **CHEMICAL COMPOSITION (Cont)**

- Ultimate Analysis:
  - This divides the coal into its ultimate chemical components
  - These include elementary carbon, hydrogen, oxygen, nitrogen and sulphur
- Calorific Value
  - Indicates the heat value per quantity of coal (BTU, MJ/kg, Kilocalories per kg)
  - Indicator of the content of combustible elements – carbon and hydrogen.

THE HWANGE STRATIGRAPHY

- Coal is Permian in age;
- It was deposited on sandstone called the Lower Hwange Sandstone Formation; and
- Overlain in turn by the Upper Hwange Sandstone Formation.



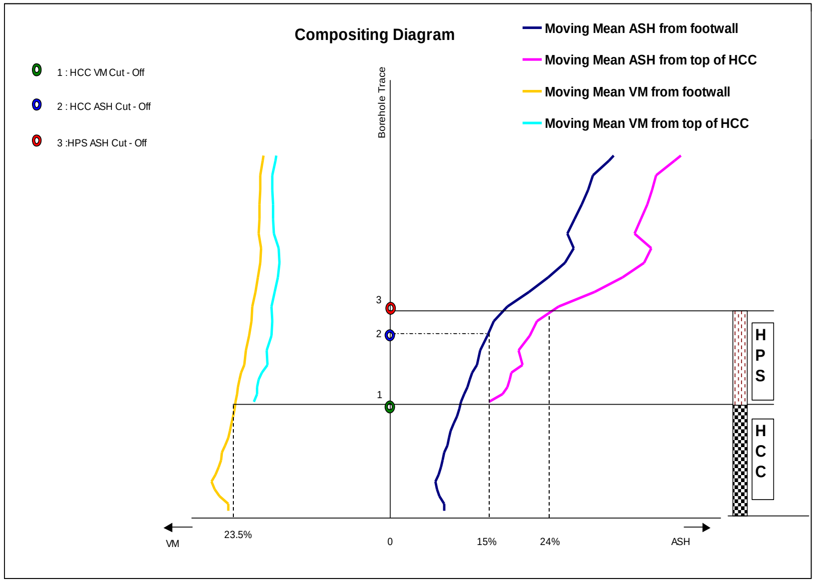
PROXIMATE ANALYSIS OC &UG

Sample Code (m)	Moisture (%)	Ash content (%) a.d	Volatile matter (%)	Fixed Carbon (%)
Chaba 7-8m	1.86	11.93	20.99	65.22
Chaba 6-7m	1.81	12.88	20.14	65.17
Chaba 5-6m	1.82	12.35	19.46	66.37
Chaba 4-5m	1.74	13.4	18.15	66.71
Chaba 3-4m	1.57	8.55	19.78	70.10
Chaba 2-4m	1.42	6.04	24.16	68.38
Chaba 1-2m	1.43	8.64	23.81	66.13
Chaba 0-1m	1.20	5.54	28.84	64.42

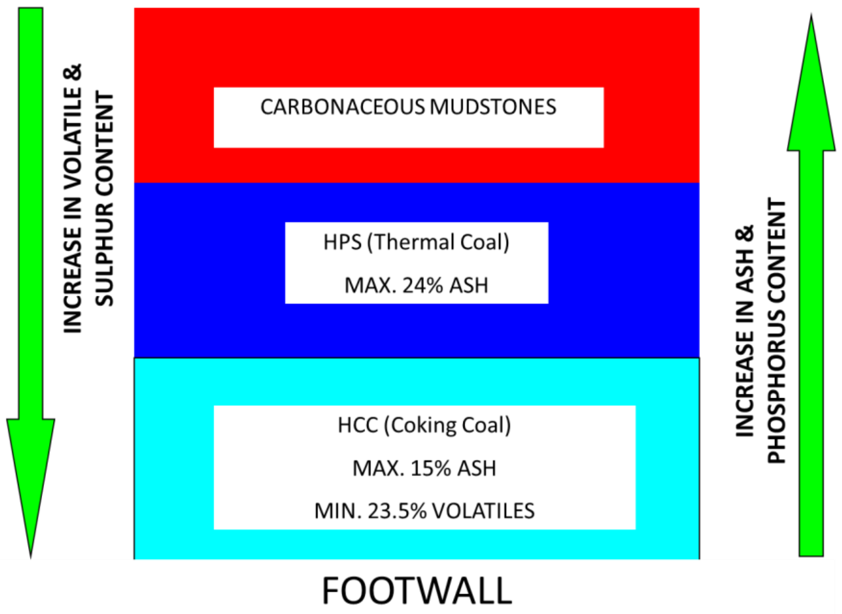
Sample Code	Sample Interval	Moisture (%)	Ash (%)	Volatile (%)	Fixed Carbon(%)
1553	330 – 360cm	0.4	15	20.2	64.4
1552	300 – 330cm	1	11.1	20.7	67.2
1551	270 – 300cm	0.5	10.9	23	65.6
1550	240 -270cm	0.4	10.7	21.8	67.1
1549	210 – 240cm	0.5	12.2	27.3	60
1548	180 -210cm	0.8	8.7	25.5	65
1547	150 – 180cm	0.6	7.4	27.2	64.8
1546	120 - 150cm	1.1	7.9	23.5	67.5
1545	90 – 120cm	0.8	12.1	24.2	62.9
1544	60 – 90cm	0.6	9.3	27.4	62.7
1543	30 - 60cm	0.9	7.4	27.6	64.1
1542	0 -30cm	0.2	8.9	29.3	61.6

HWANGE MAIN SEAM MODELLING

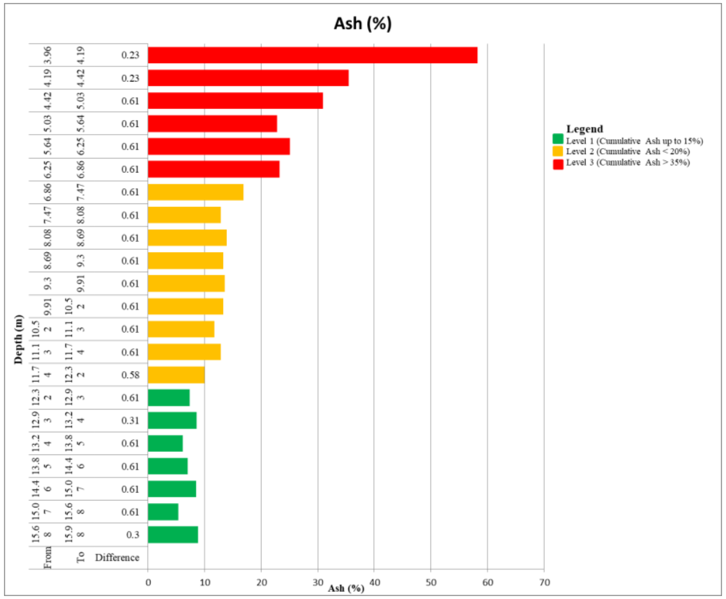
- This is referred to as the coal compositing procedure.
- Uses ash and volatile matter moving means.
- Cut-off values for coking coal are maximum ash of15% and minimum volatile matter of 23.5%



THE GEOLOGICAL SEAM MODEL

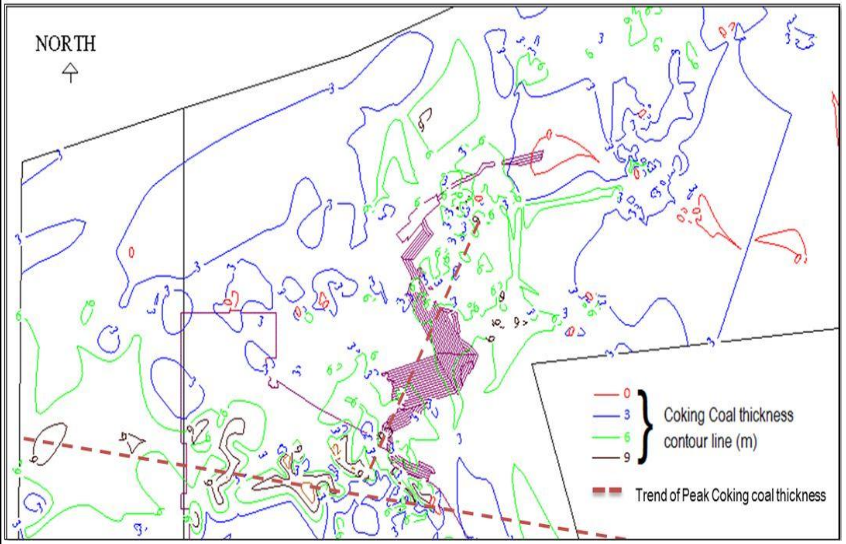


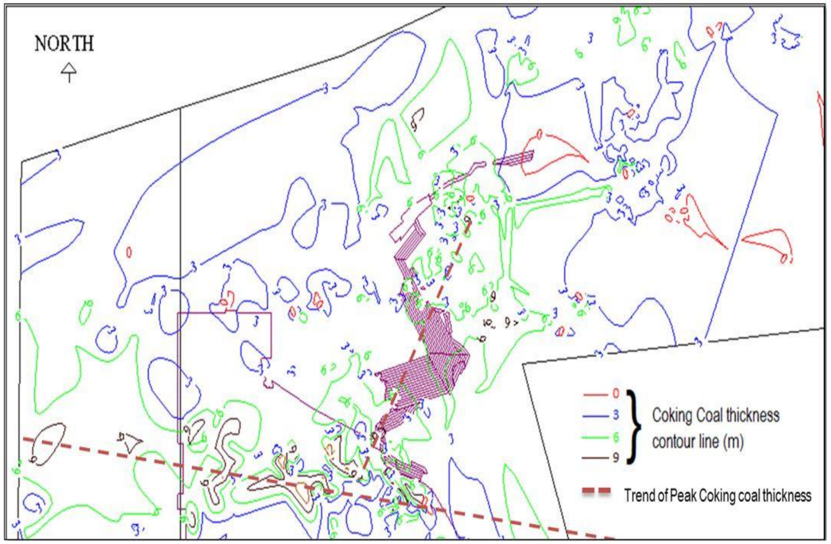
GRAPHIC PRESENTATION OF HWANGE SUBSEAM DEVELOPMNT



- Opposite is a graphic presentation of Hwange Coalfield sub-seam development based on ash values (BH1067); and
- Three sub-seams evident marked by cumulative ash values of 15, 20m and 30%.
- “Jumps” in ash values related to prevailing environmental changes.

THICKNESS CONTOURS FOR THERMAL AND COKING COALS

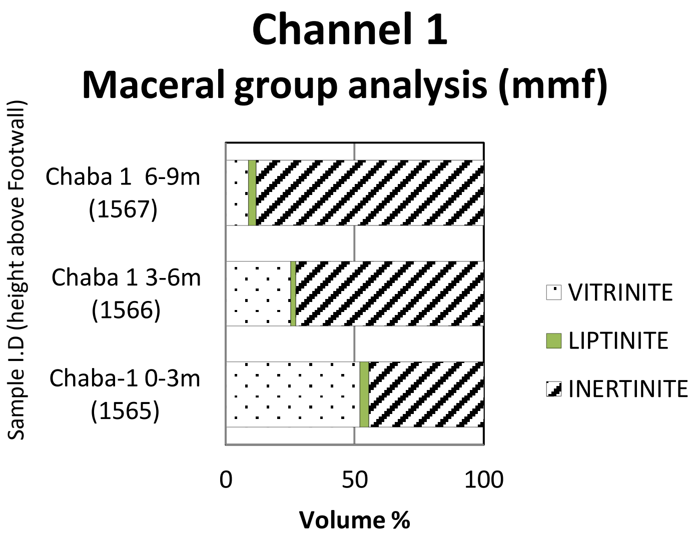




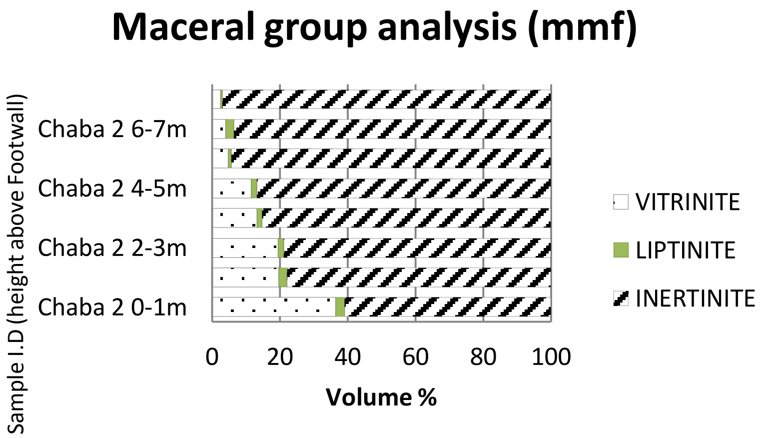
SUMMARY OF PROXIMATE ANALYSIS

- The basal layer of +- 5m is low ash and high volatile matter coal (good quality coal);
- This is overlain by or grades into a relatively high ash +- 6m thick coal with low volatile matter contents used as thermal coal; and
- The remainder of the geological seam is too high in ash content for current markets (ZPC) and is current discarded as waste
- There are no recognisable parting within the seam, save some jumps in ash content presumably due

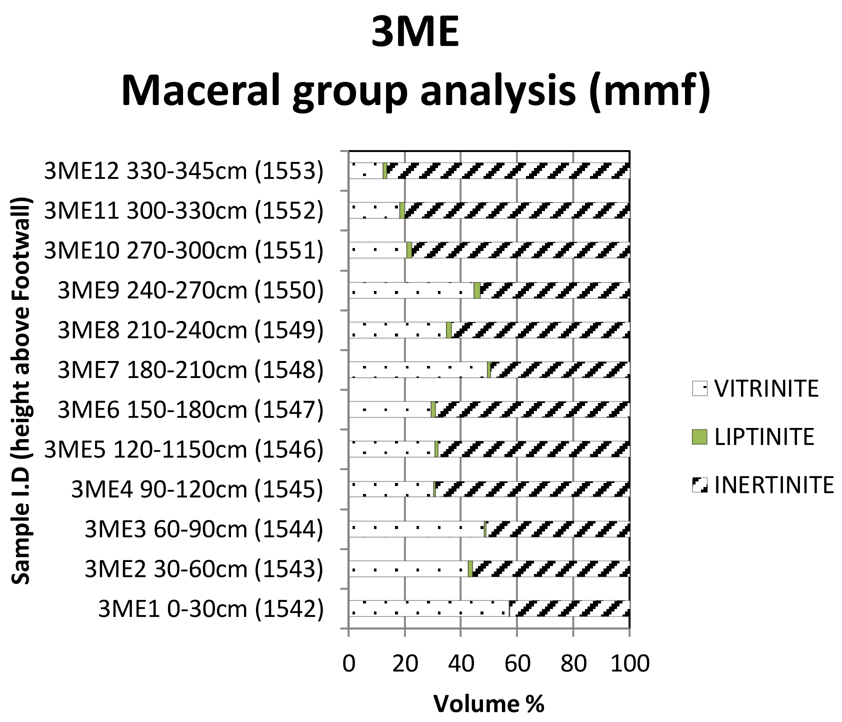
VERTICAL VARIATION OF MACERALS (O.C C1 & C2)

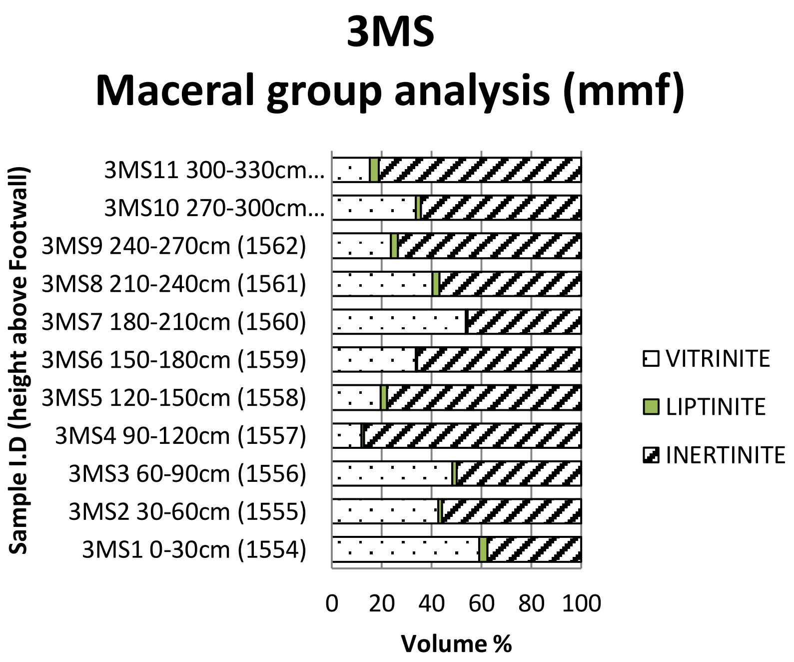


Channel 2



MACERAL GROUP ANALYSIS FOR U/G COAL





SUMMARY OF MACERAL ANALYSIS RESULTS

- For Chaba:
  - Channel 1 - Basal 3m vitrinite dominant (i.e., coal should coke) and the rest inertinite dominate (i.e., noncoking); and
  - Channel 2 – Basal 1m vitrinite dominant, and rest is non coking.
- Underground Mine:
  - Cyclic but basal 2.5m vitrinite constitutes approximately 50% of the maceral component.
  - Basal 0.30m vitrinite constitutes some 60%

SUGGESTED DEPOSITIONAL ENVIRONMENT OF THE SEAM

- The development of a huge depression or basin is a pre-requisite for the accumulation and preservation of the plant remains. This was satisfied by the development of Mid-Zambezi Basin;
- The basin was subsequently occupied by a giant freshwater lake and along the shoreline of the lake developed wet peat swamps;
- It was in one of such peat swamp that the Hwange Coal Seam was developed from luxurious vegetation which included the giant Glossopteris-Gangamopteris vegetation flourished.

SUGGESTED DEPOSITIONAL ENVIRONMENT OF THE SEAM (Cont.)

- From the maceral development and proximate analyses obtained:
  - The low ash, vitrinite-rich basal horizon of the Hwange Main Seam represents an initial wet forest swamp characterised by a high-water table;
  - A gradual fall in the water table exposed the later accumulating vegetative matter to increasing oxidation and decomposition, indicating an increasingly dry forest swamp environment with the greater influx of mineral matter by water and/or wind; and

SUGGESTED DEPOSITIONAL ENVIRONMENT OF THE SEAM (Cont.)

- This was followed by drowning of the shoreline either by higher subsidence of the ground or a rise of the lake water due lake water due to transgression.

CONCLUSION

- In conclusion, the depositional environment at the time the Hwange Coal was formed commenced as a wet forest swamp with a high water table; and
- This gave way to a dry forest as the water table dropped; and
- Subsidence/ transgression drowned the shoreline.

CONCLUSION (Cont)

- These are the geological circumstances that led to the creation of a coal seam whose attributes are consistent with virtually all energy related applications