REVIEW OF THE KAROO SUPERGROUP IN THE ZAMBEZI VALLEY

Brent Barber - Dec 2015

- Karoo sequence sedimentary and predominantly basic igneous rocks, accumulated fragment-ation of Gondwana : Late Carboniferous – Early Jurassic .
- Preserved in basins in E + S Africa & SE South America.
- Max extent deposition, Early Permian, ±4.5 million km^2. Present outcrop Africa ±300,000 km^2.

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KAROO SUPERGROUP-ZIMBABWE

Outcrops 1/3 country – three main locations:

1. Zambezi Valley in N
2. Save-Limpopo Valley in S
3. Small, centrally located, Featherstone Outlier

CONTROL KAROO DEPOSITION

- Dominant factors tectonic activity and palaeo-climatic variation response NW drift relative North Pole - off NW Africa in Ordovician to SE continent in Triassic

Climatic Setting – Central & Southern Africa

Cretaceous:		Semi-Arid
Jurassic:		Semi- Arid
Triassic:	Late Early	Arid Semi-Arid
Permian:	Late Early	Warm Temp Cold Temp
Carboniferous:	Late	Arctic → Cold Temp

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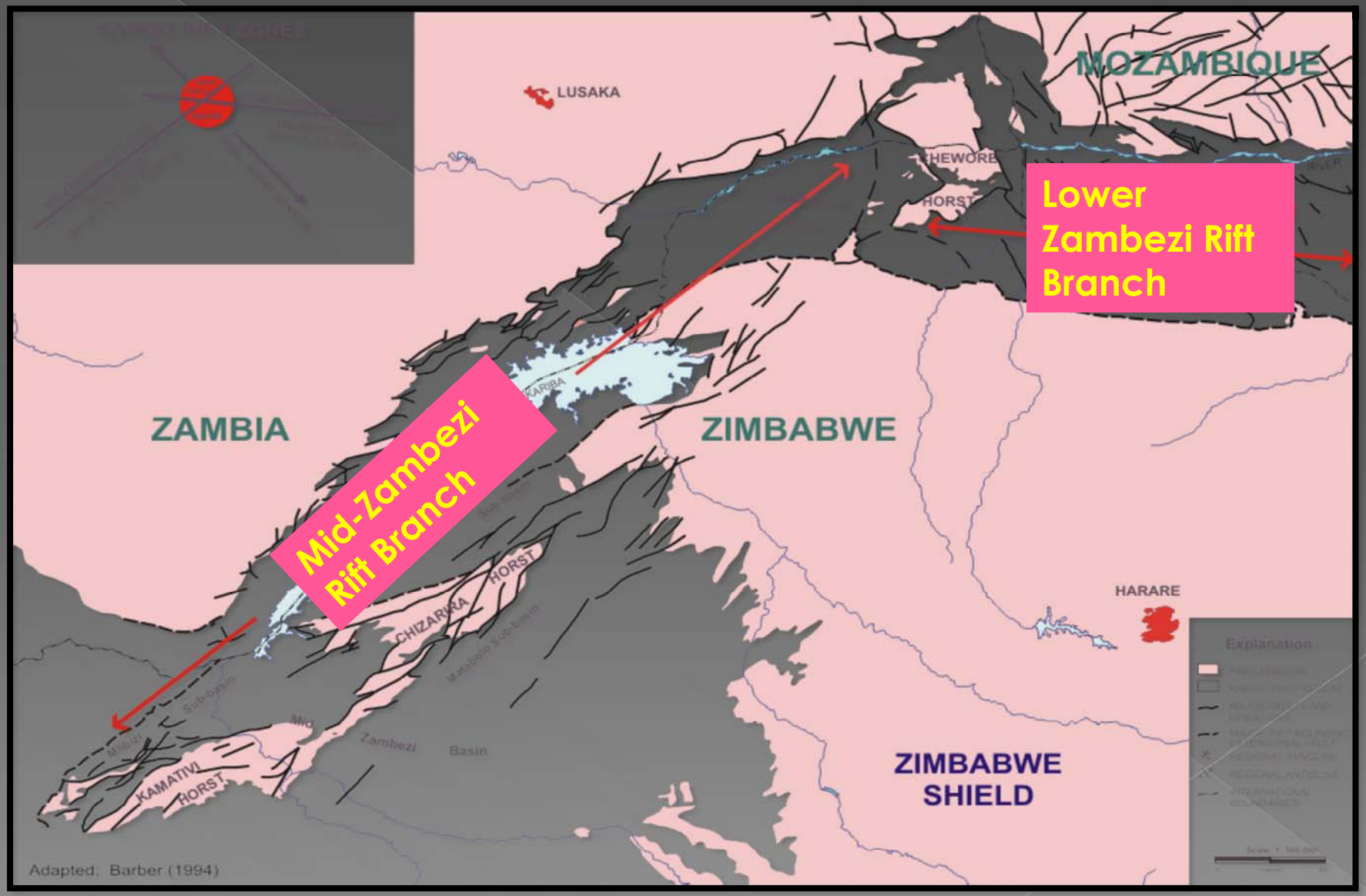
ZAMBEZI RIFT SYSTEM

- Mid- Zambezi, Lower Zambezi & Luangwa Rift Branches – failed triple junction
- Trends branches controlled reactivation re-existing structures
- Karoo top 1133m Chirambakadoma Hill indicates main uplift horst followed onset rifting during Triassic – Cretaceous times.
- Mobil (1993) reported stratigraphic ranges ±4,600m Mid-Zambezi to >12,000m in the Cabora Bassa basins.

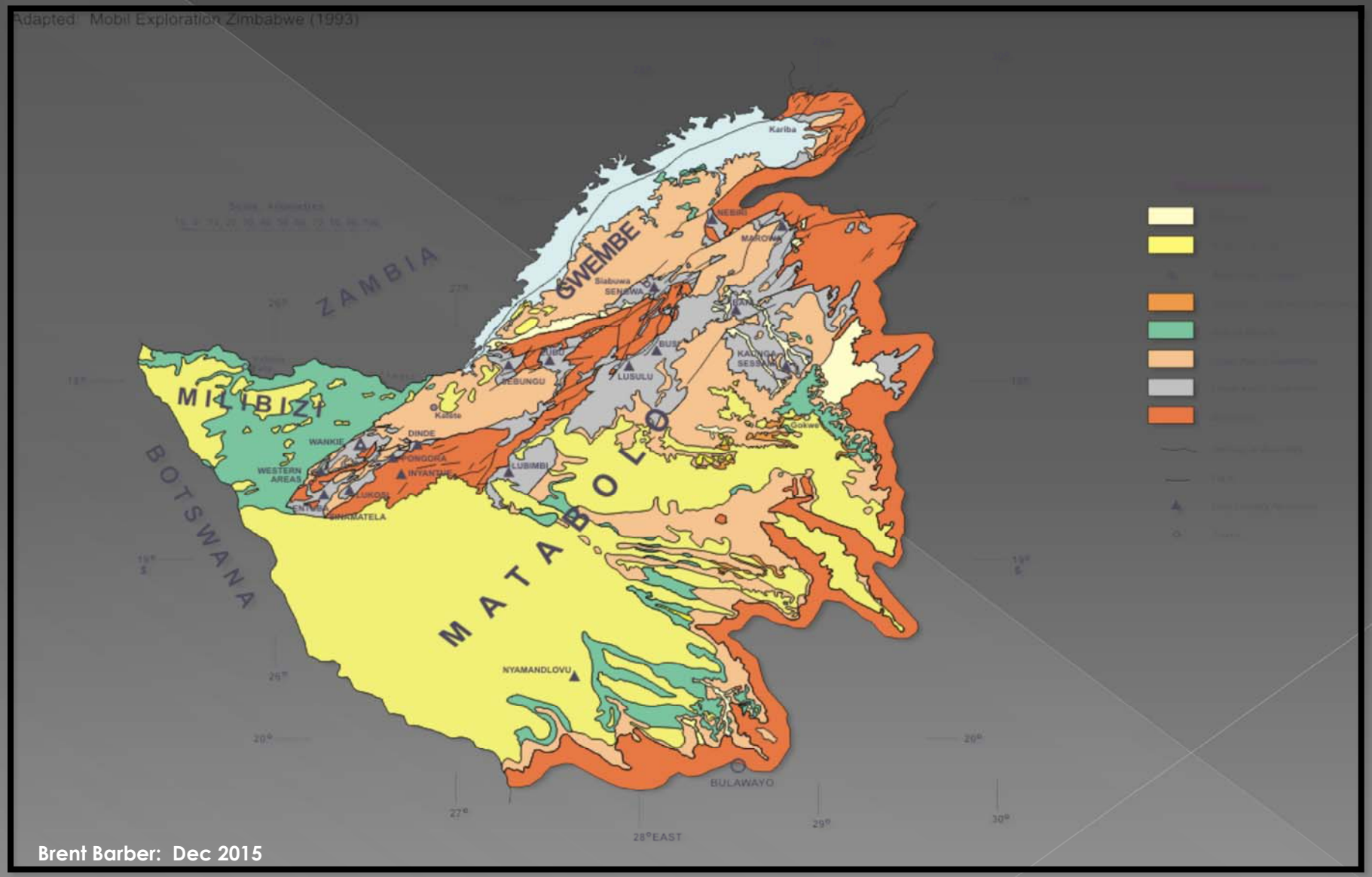
KAROO: ZAMBEZI RIFT SYSTEM



Sinakumbe & Likupekupe

- Relationship arenaceous red-beds Devonio-Ordovician aged Sijarira Group with the similarly dated Sinakumbe Group in the Gwembe sub-basin in Zambia requires further investigation.
- Similarly linkage Ordo-Silurian aged Likupekupe Formation in W Zambia raises spectre Palaeozoic depositories with marine influence being present at depth.

Mid-Zambezi Basin



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Mid-Zambezi Basin Axes

- Matabola / Gwembe / Mlibizi Sub-Basins - NE-trending axes - developed Late Permian > Upper Madumabisa and later times.
- Necessitates lows either side Chizarira and Kamaivi Horsts = Gwembe and Matabola Troughs and approaching N rift boundary = Sinazonwe Trough

ZRS: TECTONIC DEVELOPMENT

Divides Karoo Supergroup in two:

- **Lower Karoo:** Late Carboniferous – Late Permian / Early Triassic = Sag Basin ~ Low strain thinning lithosphere prior rifting

- **Upper Karoo:** Early Triassic – Early Jurassic = Rifting

ZAMBEZI RIFT SYSTEM: TECTONIC DEVELOPMENT

Late Cretaceous – Tertiary: 4th Major Episode Rifting predating / associated EARS

Early Jurassic: 3rd Major Episode Rifting – Batoka Basalt Fm / Dande Fm

Middle Triassic: 2nd Major Episode Rifting – Pebbly Arkose → Forest Sandstone

Late Permian – Early Triassic: 1st Major Episode Rifting – Chete Fm / Angwa Fm

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LOWER KAROO GROUP

- Permo-Carboniferous sediments laid-down cratonic sag basins, exhibiting subdued deformation, during arctic to warm temperate climatic interval.
- Substantial accumulations coal intercalated fluvial, deltaic, paludal and predom. shallow water lacustrine sediments

UPPER KAROO GROUP

- Following onset of rifting Early Triassic, as the climate warmed and became drier, sequence initially predominantly fluvial red beds then succeeded playa and aeolian sediments deposited semi-arid to arid settings

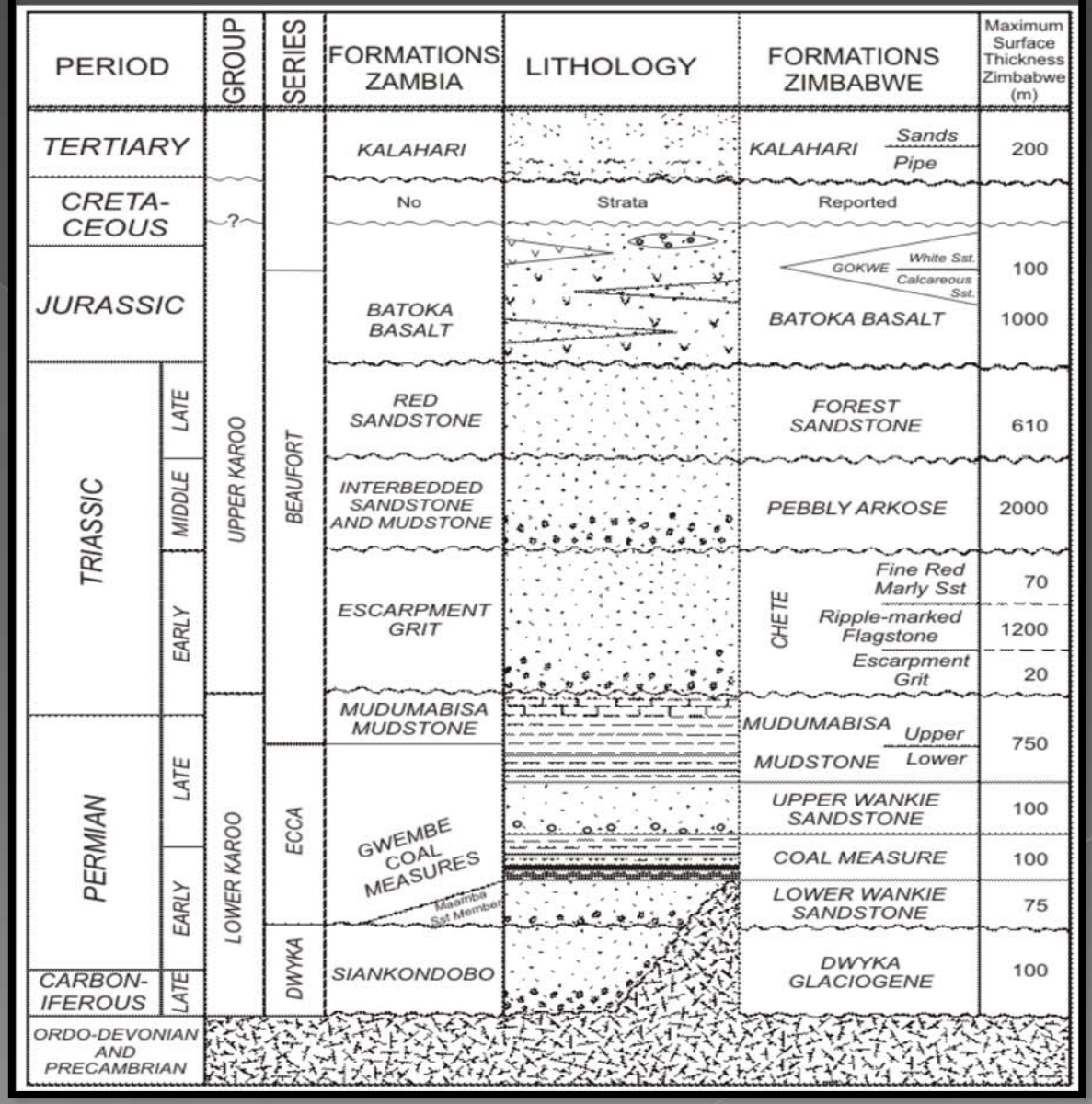
STRATIGRAPGHY

- Lithostratigraphic correlation due lack macro- and micro-fossil identification.
- Consequence tendency persists, despite the fact that lacustrine and rift basin facies are some of the most dynamic and complex sedimentary settings, to view the Karoo and younger rocks as non-diachronous ‘layer-cake’ deposits

MID-ZAMBEZI BASIN

TABLE 2: LITHOSTRATIGRAPHIC COLUMN MID-ZAMBEZI BASIN, ZAMBIA AND ZIMBABWE.

(Barber: In Press.)



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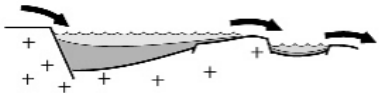
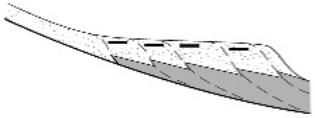
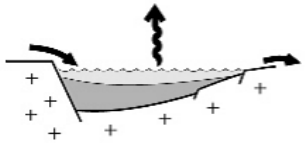
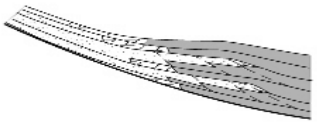
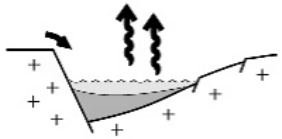
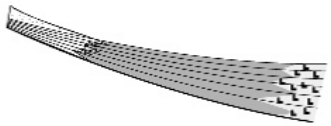
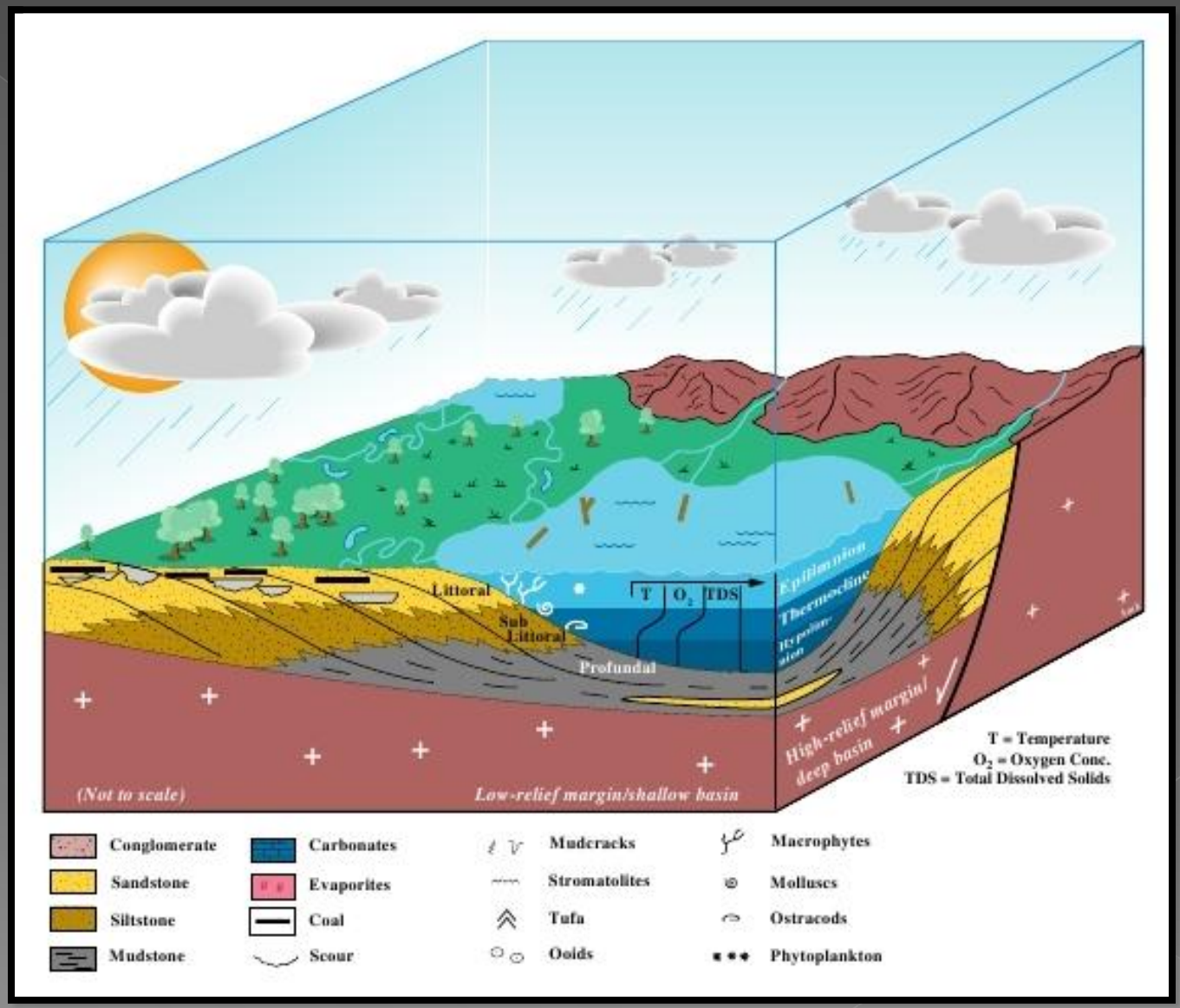
LACUSTRINE TYPE & FACIES

Lake Type & Lacustrine Facies Association	Stratigraphy
OVERFILLED  ***Fluvial-Lacustrine Facies Association***	Maximum progradation:  • Parasequences related to lateral progradation (relatively subtle) • Maximum fluvial input
BALANCED-FILL  ***Fluctuating-Profundal Facies Association***	Mixed progradation and desiccation:  • Distinct shoaling cycles common • Fluvial input variable
UNDERFILLED  ***Evaporative Facies Association***	Maximum desiccation:  • High-frequency wet-dry cycles • Minimum fluvial input

OVERFILLED BASIN



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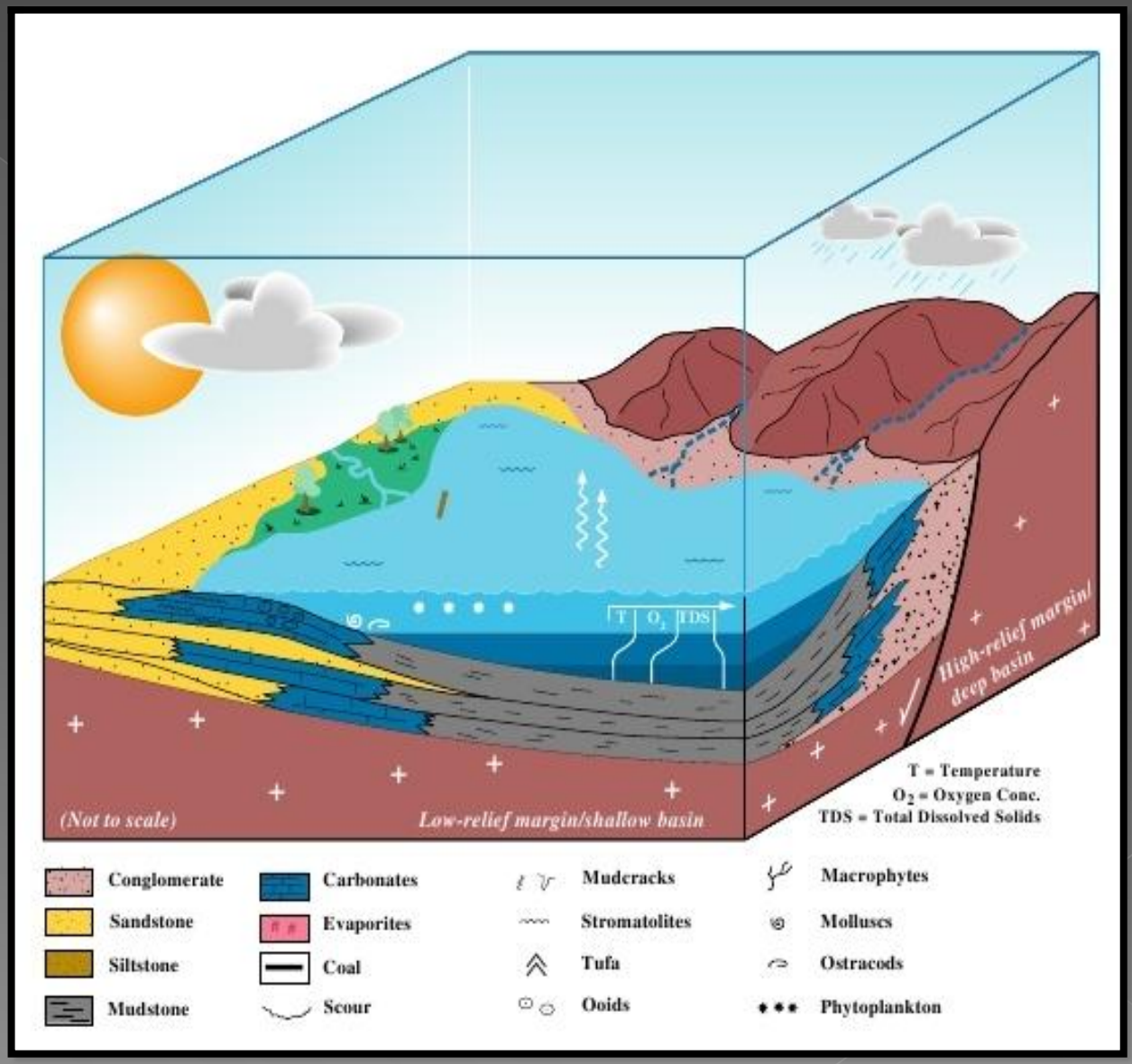
BALANCED BASIN



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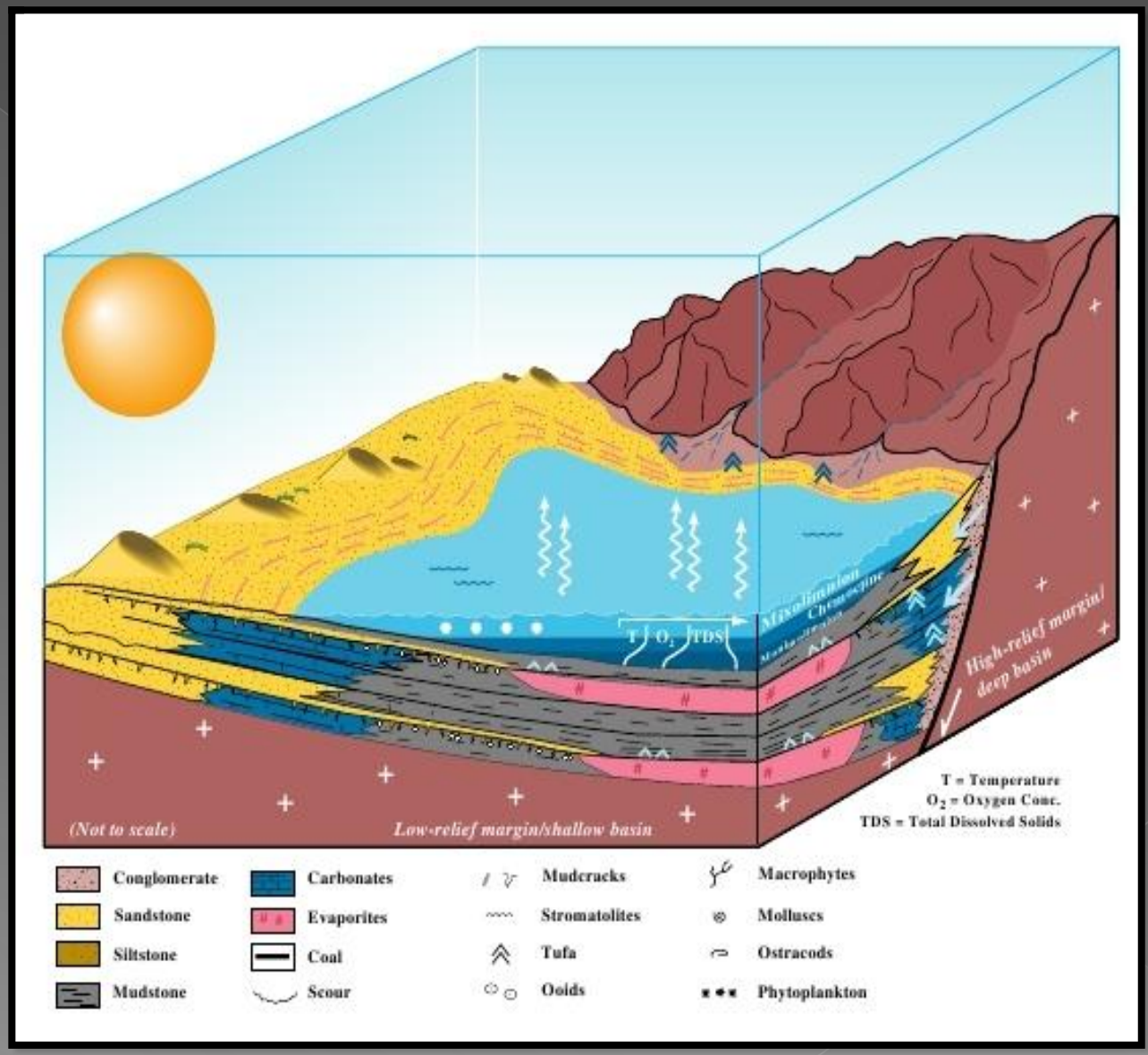
UNDERFILLED BASIN



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MEMBERS		DESCRIPTION			CLAY MINERAL COMPOSITION	FIELD EVIDENCE	DEPOSITIONAL ENVIRONMENT	GEOCHEMICAL FACIES
UPPER MADUMABISA MUDSTONE (±210M)	**k5f** (±120m)	Alternating units thin, greenish, fine-grained sandstone and black-grey mudstone.			No samples investigated	Type locality flooded by Lake Kariba	Lacustrine. Hot semi-arid.	Neutral pH. Mild oxidising.
	k5e (±90m)	Poorly laminated, pale-green, marly mud- & siltstone with horizons ≤0.5m thick containing abundant limestone nodules defining bedding. Frequency calcareous units, which often possess a distinct bituminous, oily odour, decreases upwards. The uppermost limestone beds are frequently rich in mollusc debris.			Interstratified mica - smectite, forming 50% clay fraction, with some analcime	Abundant limestone nodules	Waning lacustrine. Hot semi-arid	Alkaline. Oxidising. Calc. Carbonate.
MIDDLE MADUMABISA MUDSTONE (±290M)	**k5d** (±180)	Soft mudstone offering limited exposure, which weathers khaki-green, containing barite & ironstone concretions and rare limestone beds. Sedimentary structures not observed. Only identified E of Sub-basin.	Tendency to form large, open, often undulating grassy areas devoid of trees, commonly known as Sidaga Plains, which contrast sharply with the mopane covered areas underlain by the Lower and Upper Madumabisa Mudstone Members.		Very high smectite content, associated with mica, plagioclase & some analcime.	Barite spherolites & ironstone concretions. Nodules limestone rare. Palaeontological: Endothion Zone – Dadoxylon	Dry lacustrine. Warm temperate. Possibly associated with volcanic activity	Alkaline. Oxidising. Calc. carbonate.
	k5c (±110m)	Massive marlstone and mudstone characterised by both bedded and concretionary yellow, often cellular, limestone exhibiting cone-in-cone structures. Sandstone horizons developed locally			Dominated by kaolinite, associated with berthierite or smectite, mica and sporadic analcime.	Nodules limestone. Palaeontological: Tapinocephalus Zone.	Lacustrine. Temperate.	Alkaline. Mild oxidising. Calc. carbonate.
LOWER MADUMABISA MUDSTONE (±150M)	**k5b**	Medium to dark-grey, fissile, sideritic, carbonaceous mudstone containing impure coals, beds of pale, blocky mudstone. In the west of the Sub-basin significant horizons of sandstone, such as the Ridge Sandstone, are developed.		Carbonaceous matter ⇑ content decreases upwards	Uppermost beds, towards Ecca – Beaufort, kaolinite decreases in favour of mica & chlorite. Minor anatase and smectite.	Coal. Siderite.	Lacustrine. Cool temperate.	Mildly acidic. Reducing. Iron carbonate.
	k5a	Pale grey-white mudstone containing sideritic pisolites / Carbonaceous mudstone with coal laminations / Impure, hypautochthonous commonly impure coal seams interbedded with carbonaceous mudstone.			Kaolinite associated with minor anatase & rare smectite	Coal. Siderite.	Lacustrine -Paludal. Cold temperate.	Acidic. Reducing. Iron carbonate.

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MID-ZAMBEZI BASIN

Upper Karoo Group

- **Chete Formation**

  - Fine Red Marly Sandstone Member (k8)
  - Ripple Marked Flagstone Member (k7)
  - Escarpment Grit Member (k6)

Lower Karoo Group

- **Matabola Formation**

  - Upper Madumabisa Mudstone Member ($k5^{c-f}$)
  - Lower Madumabisa Mudstone Member ($k5^{a+b}$)
  - Upper Wankie Sandstone Member (k4)

- **Hwange Formation**
  - Black Shale And Coal Member (k2-3)
  - Lower Wankie Sandstone Member (k1)

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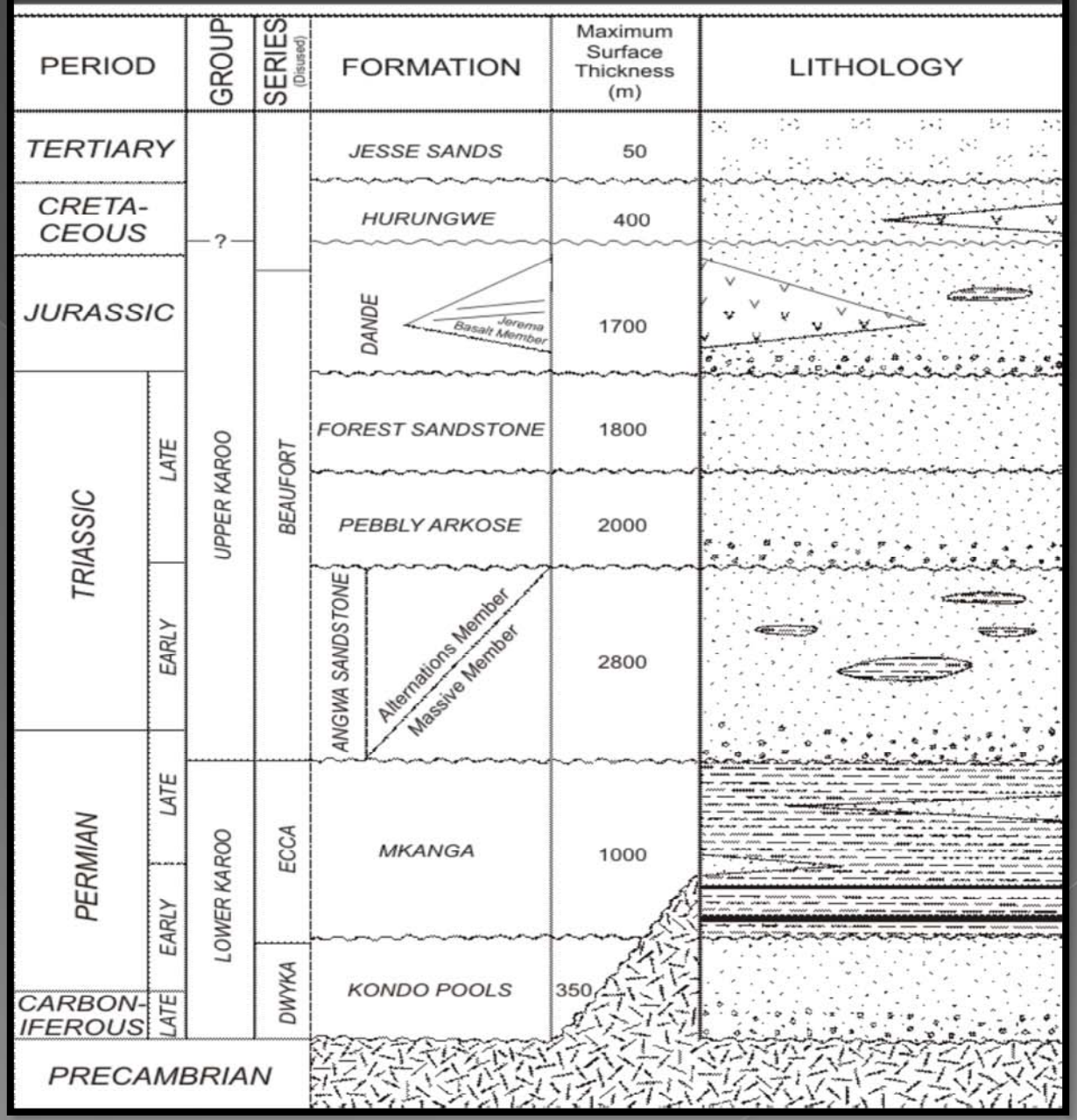
CABOA BASSA BASIN

TABLE 9: LITHOSTRATIGRAPHIC COLUMN CABORA BASSA BASIN, ZIMBABWE.



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Lower Karoo – Cabora Bassa

Two Formations:

- Kondo Pools
- Mkanga

- Thickness exposed adjacent Chewore Horst: 1,000 – 1,500m

KONDO POOLS FORMATION

Unlikely freshwater turbidites – interpretation amalgamation dispersed observations limited exposures – but shallow water debris flow and fluvio-limno-glacial deposits:

- Rip-up clasts.
- Fossil plant-bearing laminations
- Wetland palynological indicators
- Overlain carbonaceous, coal-bearing Mkanga Formation conformably (Oesterlan, 1998) or across sub-parallel unconformity (Barber, 1993 & 2001; Mobil, 1993).

MKANGA FORMATION

Mudrocks range composition from:

- Basal dark black-grey, carbonaceous to coaly mudstones, containing thin coals, deposited over-filled basins with paludal margins.

to

- Medium green-grey mudrocks, low organic matter contents, containing calcareous intercalations and quartz pseudomorphs after calcite, gypsum and possibly halite, deposited under-filled basins during warm temperate to semi-arid climatic interval during the Late Permian or after.

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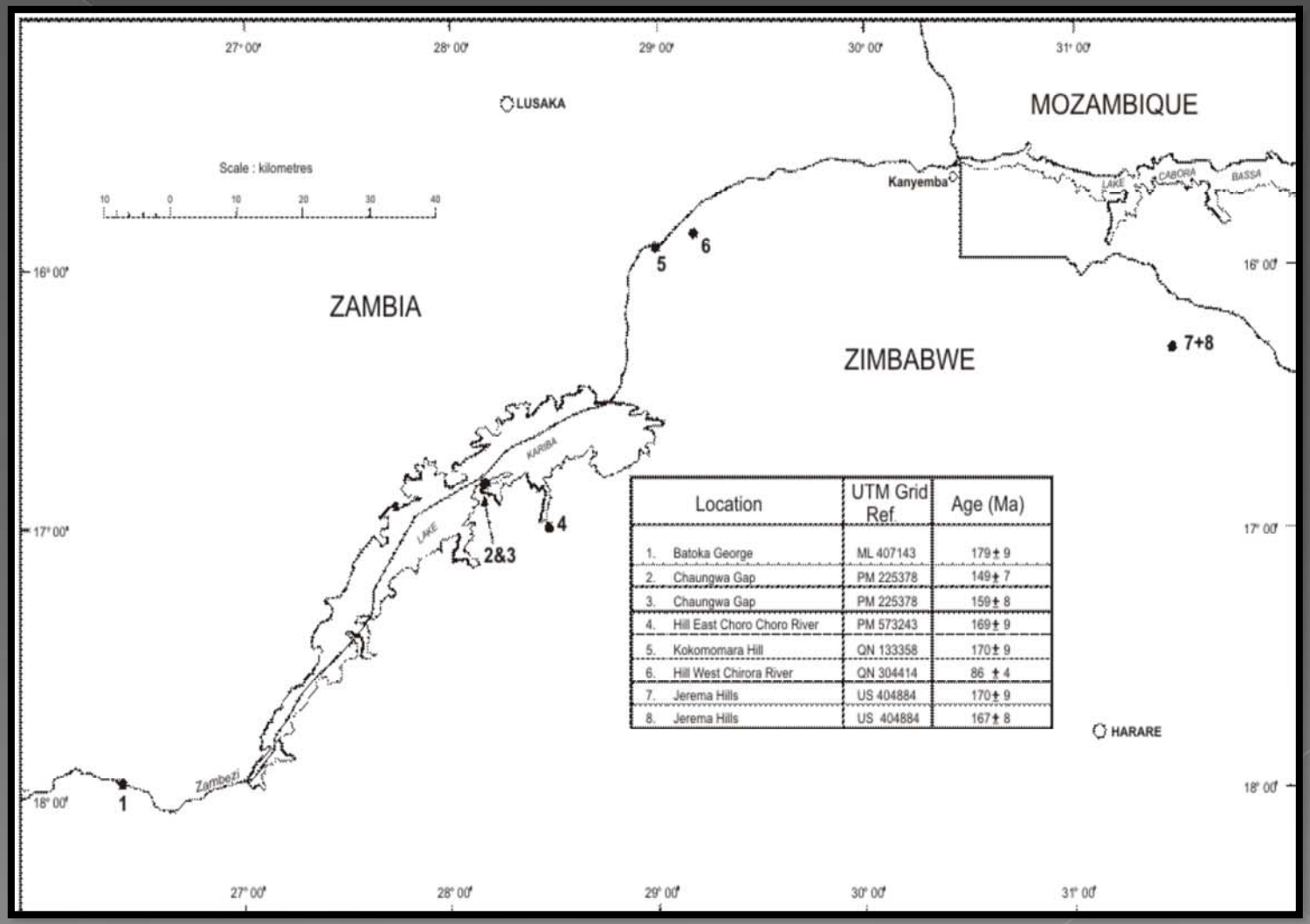
END KAROO DEPOSITION

- Widespread volcanic activity - mantle plumes generated decompression during lithospheric thinning.
- Isotopic dating indicates deposited ±5 million years, ±179 – 183 Ma, Early Jurassic.
- Ar^{40}/Ar^{39} ages 179-180 Ma reported Jones et al. (2001) basalts Batoka Gorge.
- K/Ar datings NW Zim but ages, $179^{\pm 9}$ - $86^{\pm 4}$ Ma indicate continued Jurassic and possibly into Cretaceous.

BASALT AGE DATES



Location	UTM Grid Ref	Age (Ma)
1. Batoka George	ML 407143	179 ± 9
2. Chaungwa Gap	PM 225378	149 ± 7
3. Chaungwa Gap	PM 225378	159 ± 8
4. Hill East Choro Choro River	PM 573243	169 ± 9
5. Kokomomara Hill	QN 133358	170 ± 9
6. Hill West Chirora River	QN 304414	86 ± 4
7. Jerema Hills	US 404884	170 ± 9
8. Jerema Hills	US 404884	167 ± 8

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END KAROO - ZIMBABWE

Difficult distinguish red-beds but sediments intercalated Cretaceous lavas Mana Pools visually different Dande Formation. If age corroborated could provide support either:

- Two deposition events - accumulation Dande Fm, postulated cease Jurassic, followed Late Cretaceous sediments (*Hurungwe Fm*), or
- Deposition Dande Formation continued into Late Cretaceous.

Intercalated Dande Fm question Karoo or post-Karoo significant contains Late Jurassic dinosaur fossils correlated Gokwe Fm in Mid-Zambezi Basin.

As no regional marker horizons recognised sub-dividing Dande Fm - unless invisible timeline imposed – necessitates extending age Karoo into Late Cretaceous. Failure render Batoka Basalt Formation post-Karoo necessitating sub-division.