Biostratigraphy and Palynofacies of Four Exploration Wells from the Albertine Graben, Uganda*

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Abstract

The Albertine graben forms the northernmost part of the western arm of the great East African Rift System (EARS). It runs from Rwanda in the south to the Uganda/Sudan border in the North. Within this graben, the ages of the sediments especially in the subsurface, and their palaeoecological and palaeoclimatological implications have been unknown despite the extensive exploration for oil.

Biostratigraphic studies recently carried out on four wells from the Semliki and Kaiso-Tonya basins located within the graben resulted in recognition of over 80 types of palynomorphs with their respective frequency distributions. This in turn resulted in a palynostratigraphic zonation of the basins. Four distinctive zones ranging from Lower Miocene to Pleistocene were established in the Semliki Basin. Two of these zones are also evident in the Kaiso-Tonya Basin. Comparisons made with the stratigraphic occurrence of similar microfloras recorded by numerous authors within tropical areas permitted calibration of the palynozones. The formations in which they were identified have thus been dated.

The source of palynomorphs was probably in the hinterland and other adjacent low-laying land such as swamps, transported to the depositional site by streams as observed from the palynoflora spectrum. Sediment accumulation involved deposition in deep freshwater environment, followed by deposition in a shallow fresh-brackish water deltaic environment, and finally, by fluvial or fan delta deposition in lake margin facies. Burial of sediments was not deep enough for their organic contents to be rendered thermally mature. Variations in depositional conditions and source areas are in the character of the assemblages and in the density of palynomorph population, interpreted to be predominantly due to climatic fluctuations. The climate that prevailed was probably warm and humid.

Biostratigraphy and Palynofacies of Four Exploration Wells from the Abertine Graben –Uganda.

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At

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PRESENTATION OUTLINE

1. **Introduction**
   - The Albertine Graben
   - Tectonic setting and geologic history
   - Study objectives
2. **Materials & methods**
   - Sample processing
   - Analysis and interpretation of data
3. **Preliminary Results**
   - Biostratigraphy
   - Correlation
   - Paleoenvironments
4. **Conclusion**

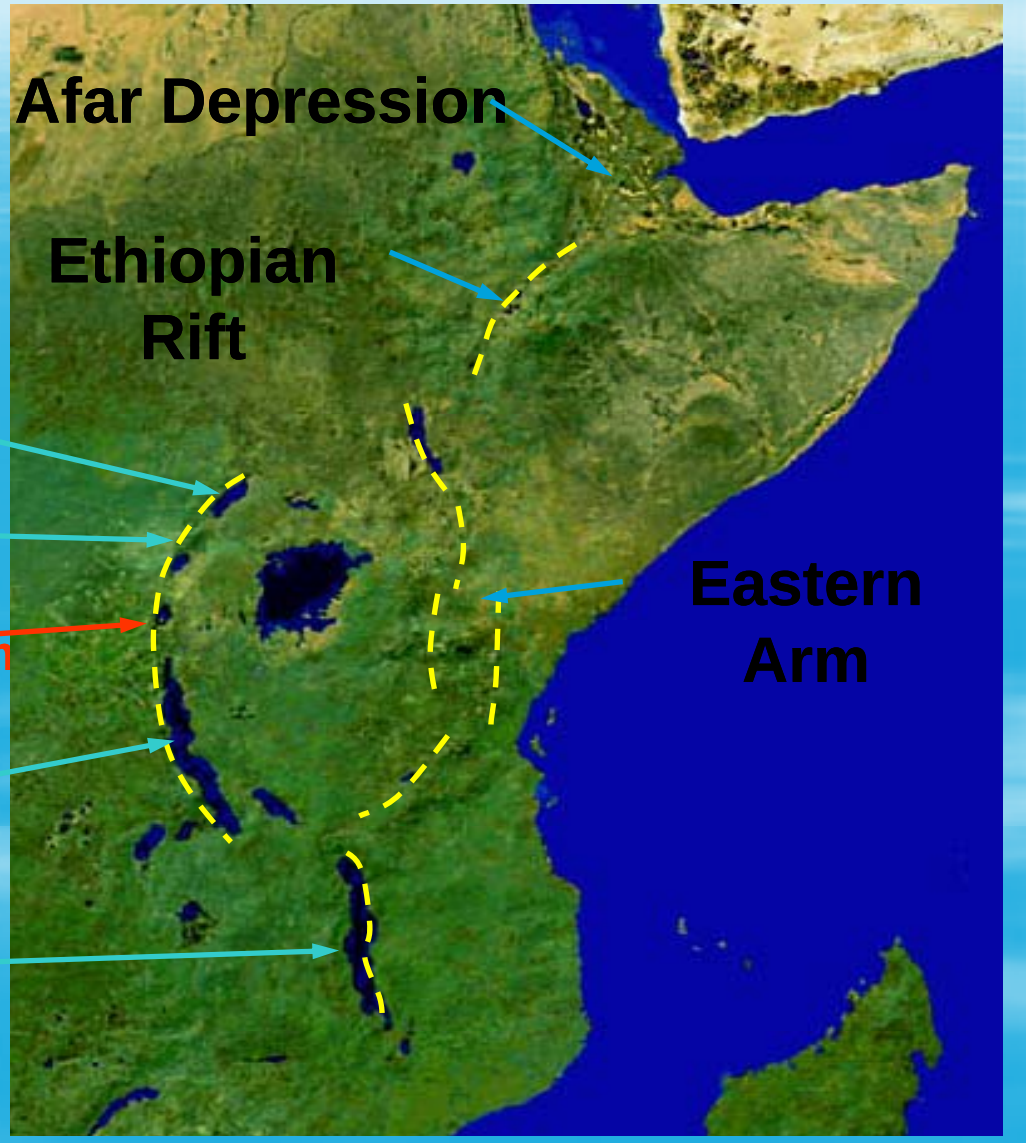
THE ALBERTINE GRABEN

THE EAST AFRICAN RIFT SYSTEM

- Northern most part of the Western arm of the East African Rift System.

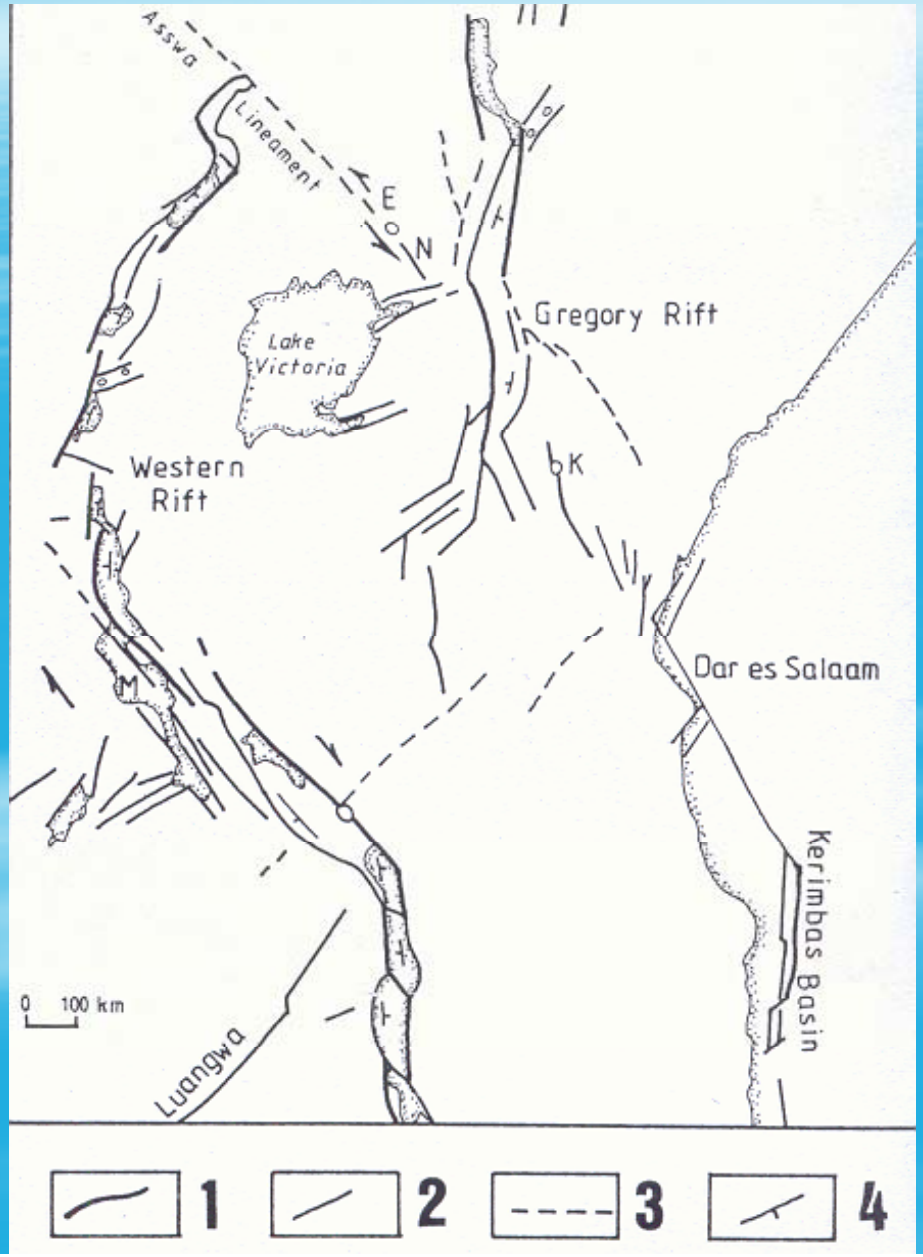
- Stretches from Rwanda in the south to Sudan/Uganda border in the north.

- Shared with the Democratic Republic of Congo



THE ALBERTINE GRABEN;

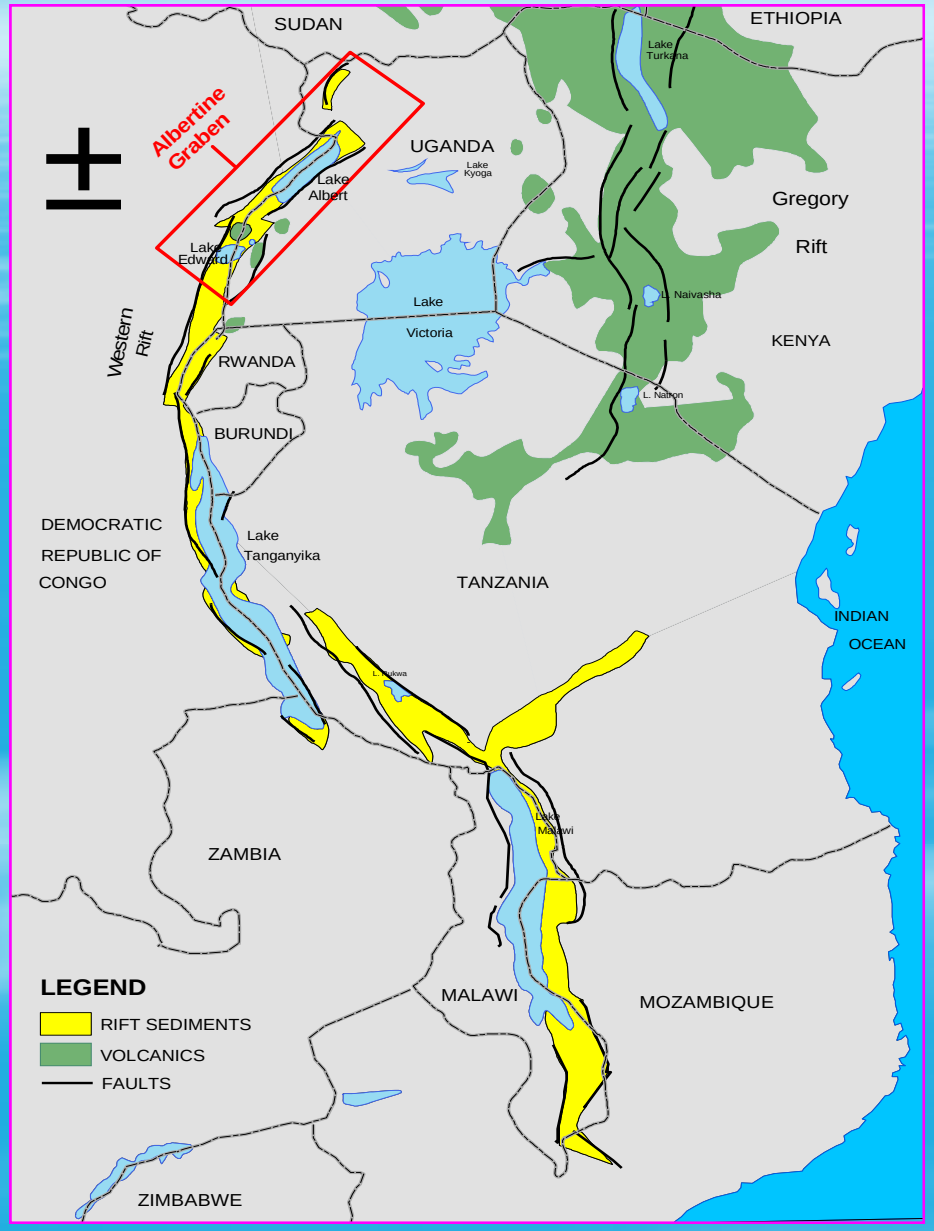
Tectonic Setting and Geologic History



- Characterized by a big boundary faults on one side, sets of smaller step faults
- Major faults are normal, trending NE-SW.
- Trends N-S, north of L. Albert,
  - Along the Nile northwards until they are terminated by the NW-SE trending Aswa shear zone.

THE ALBERTINE GRABEN;

Tectonic Setting and Geologic History



- Less volcanism compared to eastern branch

- Altitude: 500m ASL prior to faulting.

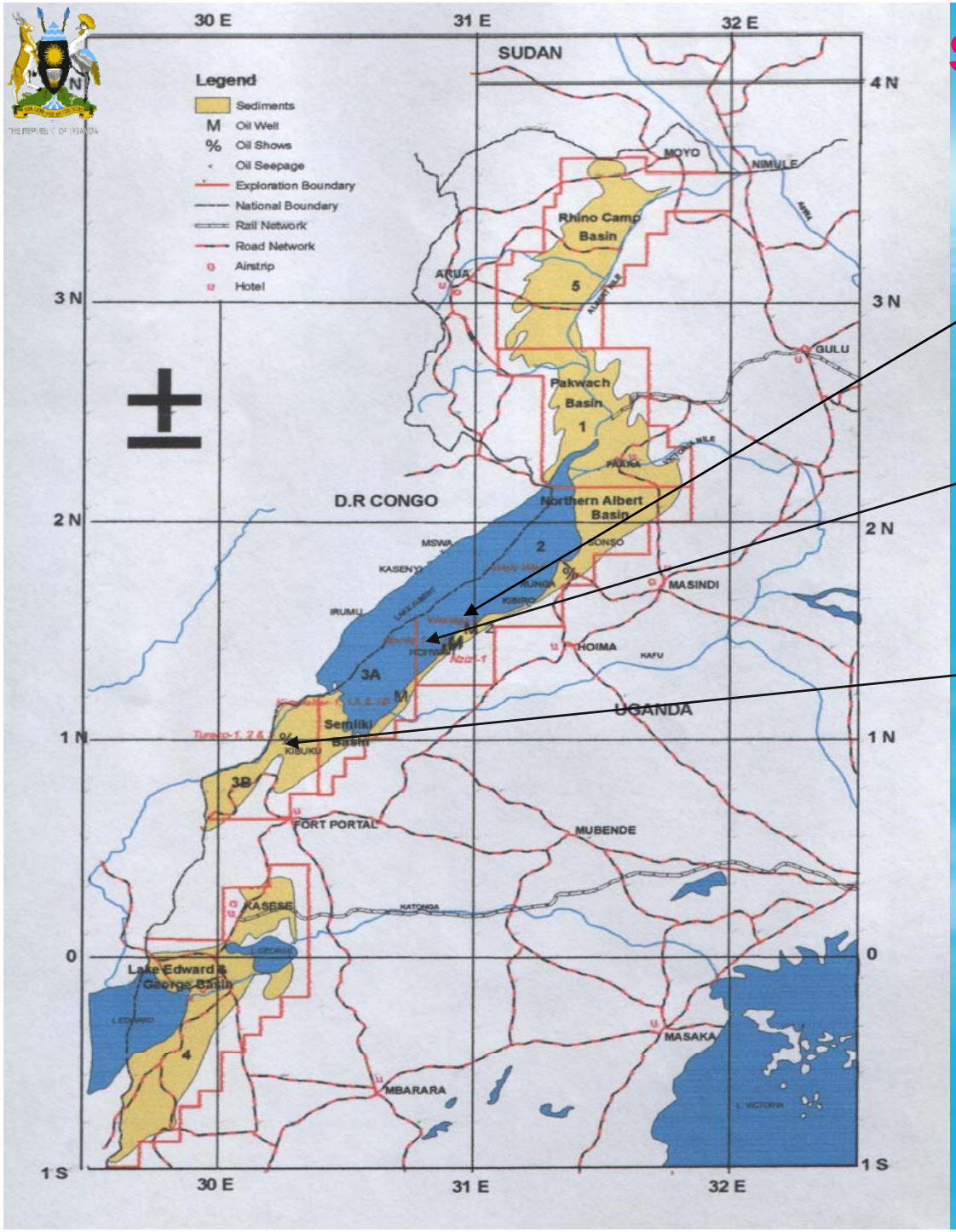
  - Faulting later formed a shallow downwarp filled with fluviatile sediments and evaporites.

- Both pre-rift & syn-rift sections exposed

  - The pre-rift: high-grade metamorphosed and igneous.

  -Syn rift section: clastic sediments in fluvio-deltaic & lacustrine environments

SAMPLE LOCATIONS



Waraga- well (North Albert Basin)

Mputa-1 & Mputa-2 well: Approx 2 km apart (North Albert Basin)

Turaco well (Semliki Basin)

STUDY OBJECTIVES

Previous biostratigraphy studies;

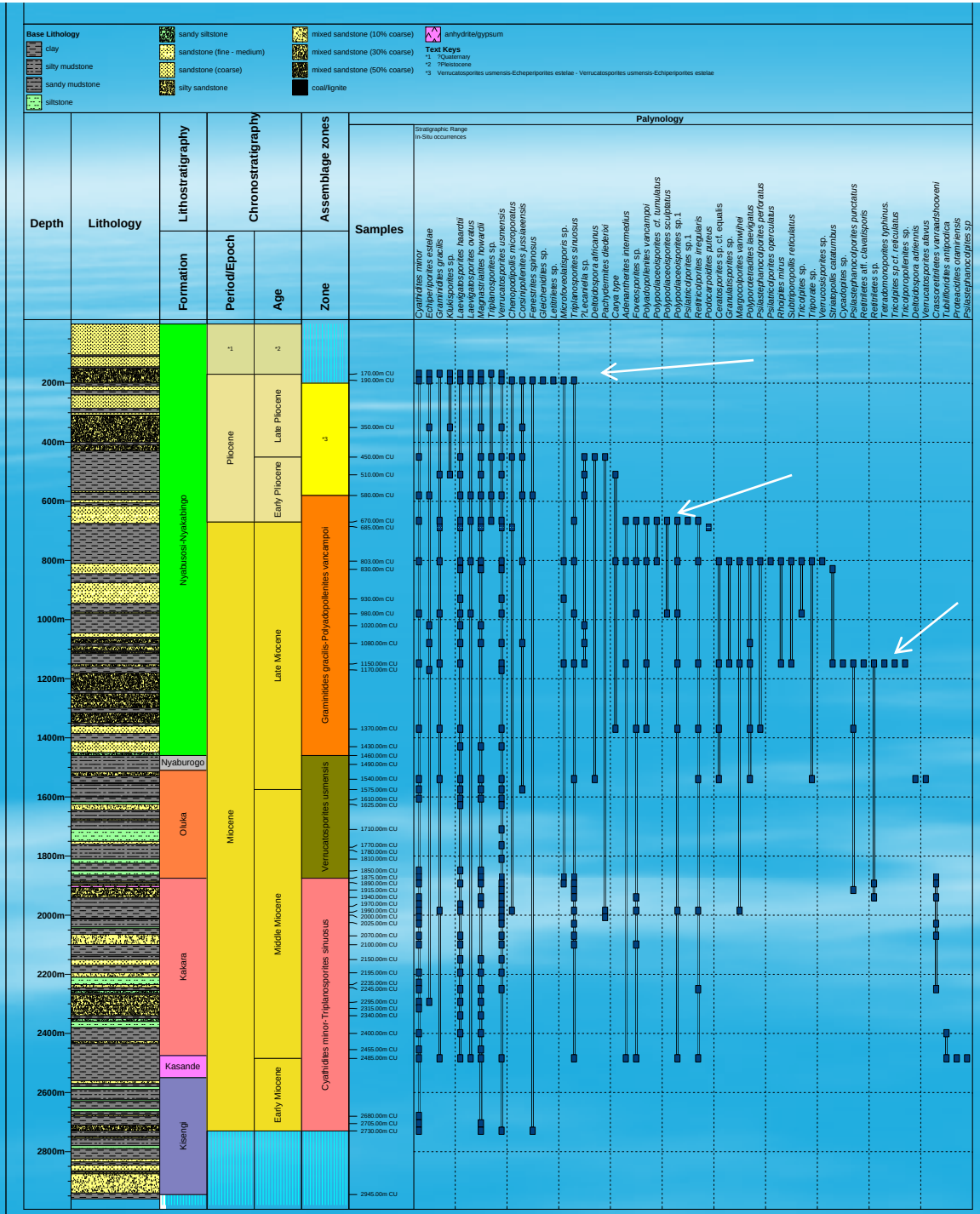
- Based on macropalaeontology of surface samples
- Spore and pollen studies mainly in quaternary palynology.

- But the age and paleoenvironments of subsurface sediments remain unknown.

- **This study therefore aims to:**
- Determine the possible age of the sediments in subsurface
- Construct a palynostratigraphic zonation and correlation
- Interpret sedimentary environments, composition of the vegetation and climate during the period of deposition.

MATERIALS AND METHODS

- **Materials used:** Rock cuttings.
- **Methods:**
  - **Sample processing:**
    - Standard palynological techniques; spores, pollen, algal remains, and POM are the key extracts
  - **Slide examination:**
    - By Leica DM transmitted light microscope at x1000 under oil.
    - 200 specimens counted per slide
    - Turaco well- reference section for the area



PRELIMINARY RESULTS

Palynological zonation

•Four informal zones described;

1:*V.usmensis-E.estelae zone*

Characteristics:

-FDO of *V. usmensis*, *V. favus* and *E.estelae* (Top).

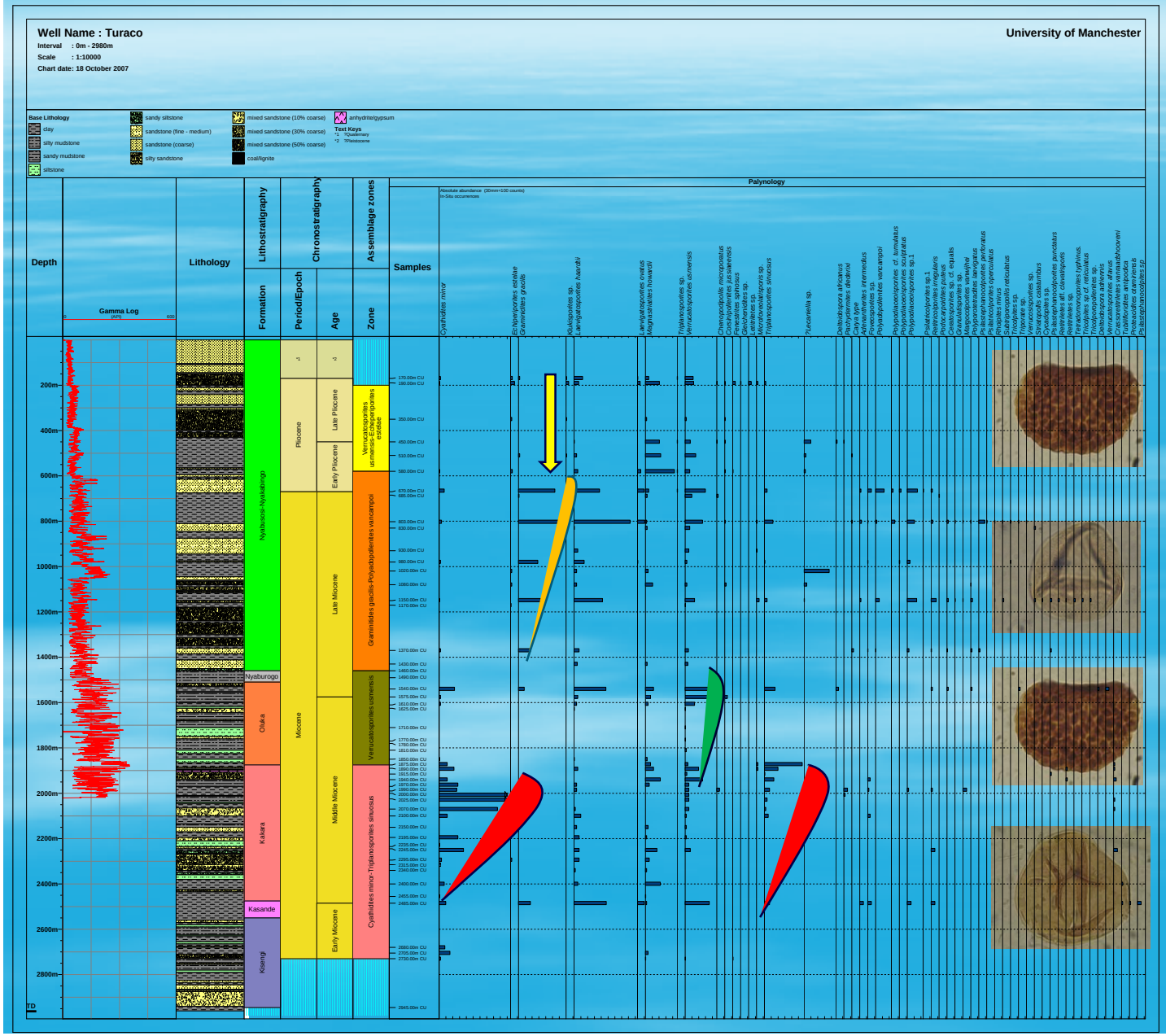
-influx of *Graminitides gracilis* influx (Base)

Occurrence:

- 580 m - 200 m,
- •Absent in other wells

PRELIMINARY RESULTS Contd

Palynological zonation



2. *G. Gracilis-P.vancampoi* zone:

•influx of *G.gracilis* & FDO of *P. vancampoi*

•1465-580m, absent in the other wells

3. *V. usmensis* zone:

•increase in abundance of *V. usmensis*

•1800 -1465m, absent in other wells

4. *C.minor-T. sinuosus* zone

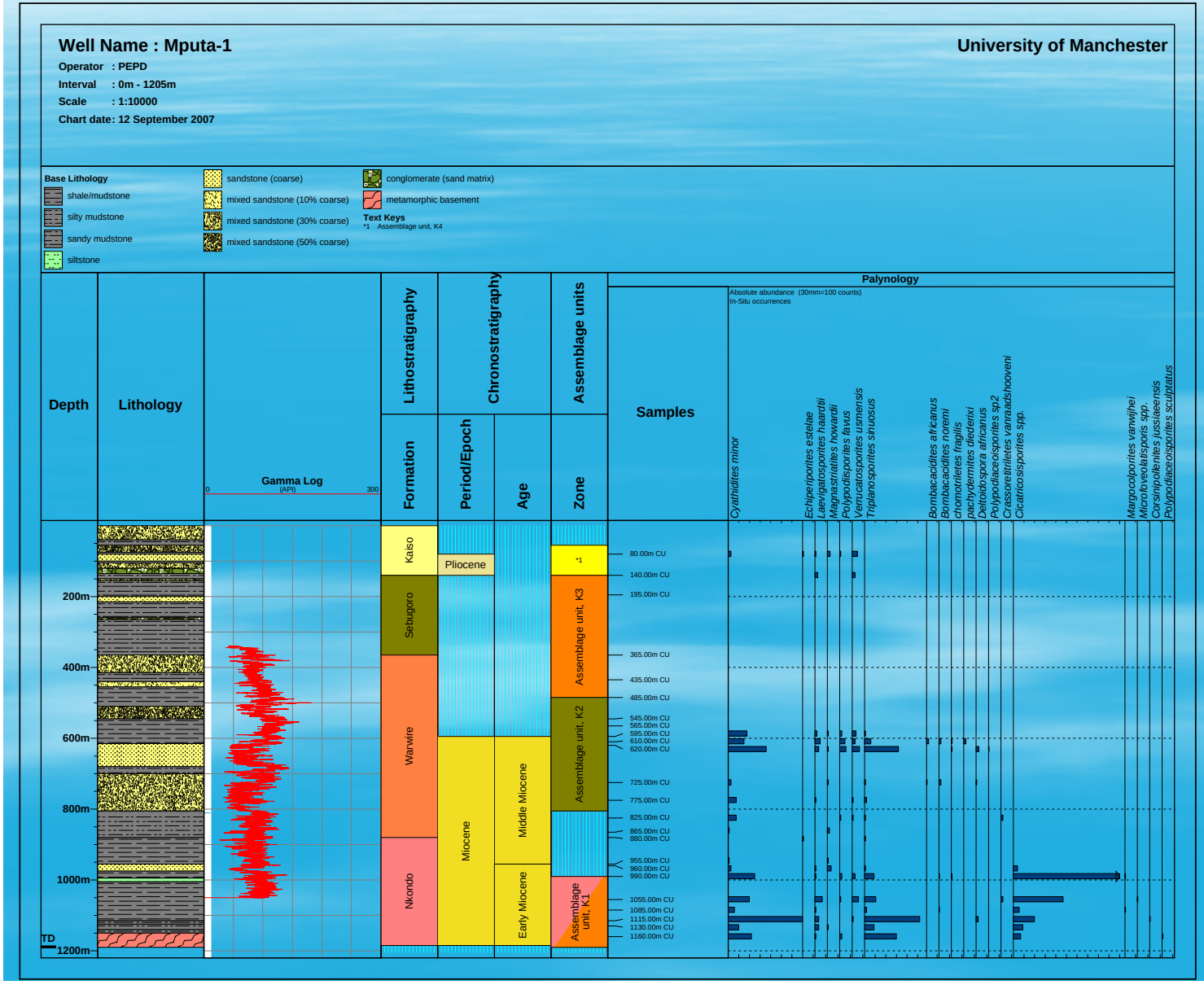
-influx of *C. Minor* & *T. Sinuosus*. Present in all wells

•1900m-Base:Turaco

•595-1160m Mputa-1

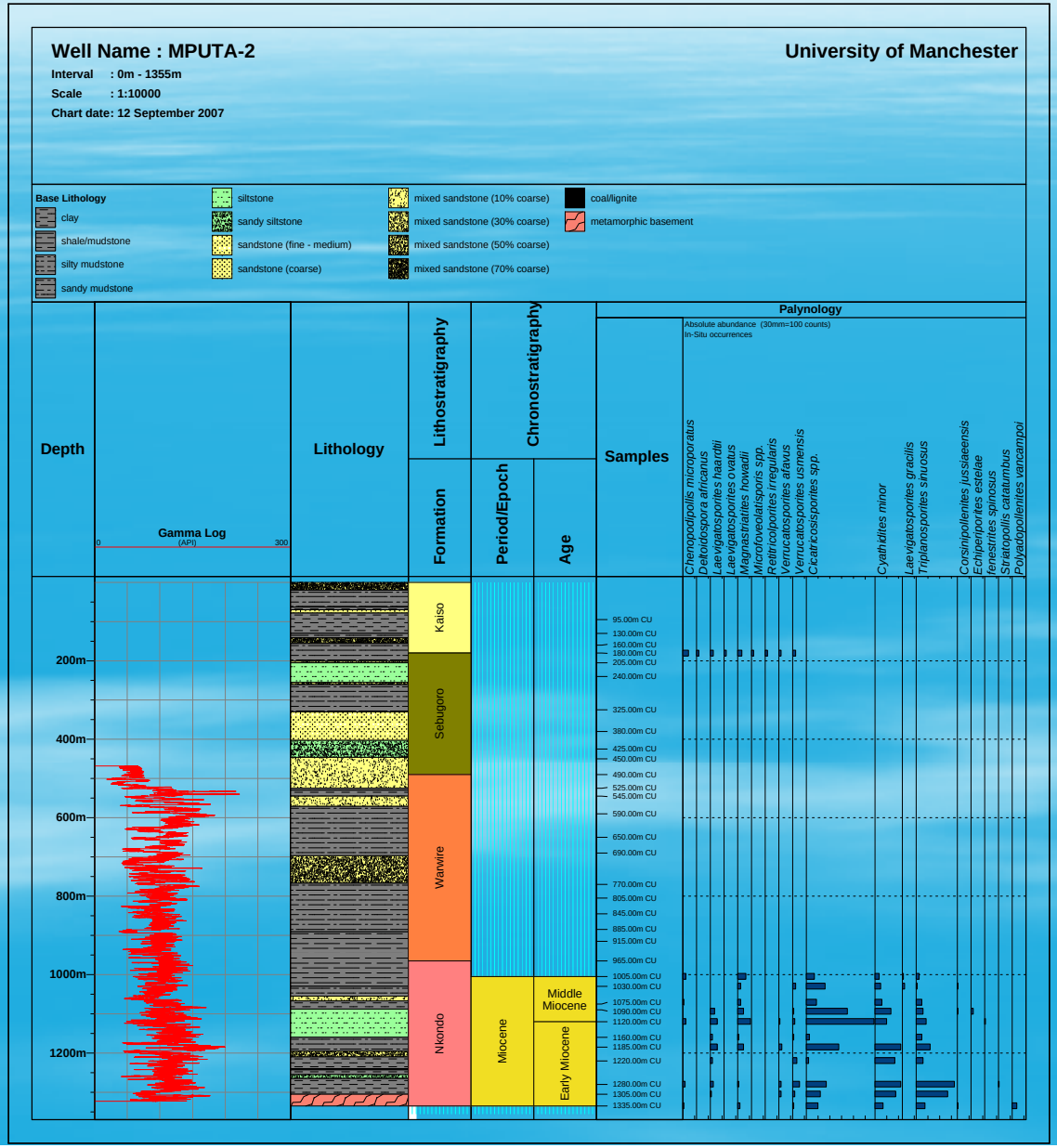
•1005-1335m Mputa-2

PRELIMINARY RESULTS Contd.

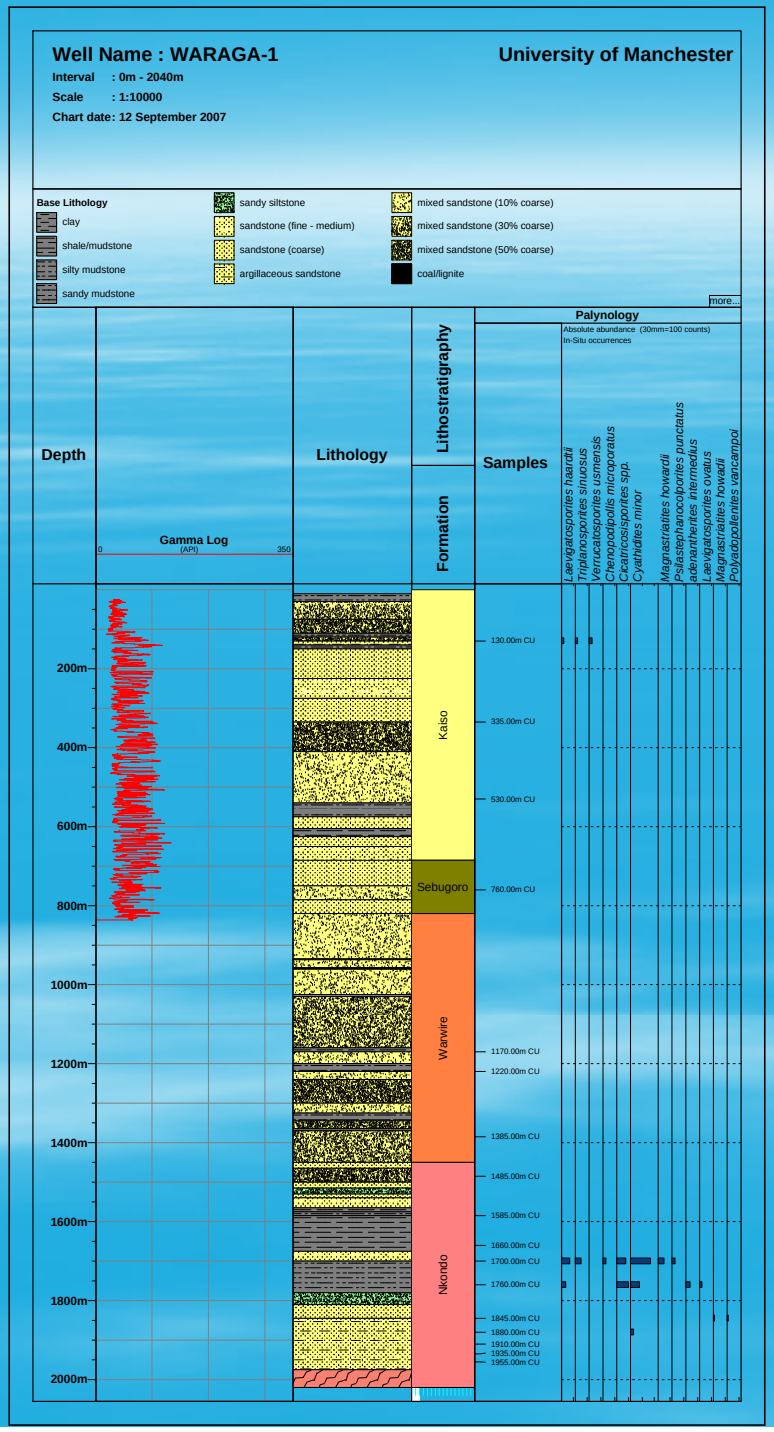


- Shallow sections of the Mputa-1 wells lear of palynomorphs
- Deeper sections characterised by an influx of spores

PRELIMINARY RESULTS Contd.



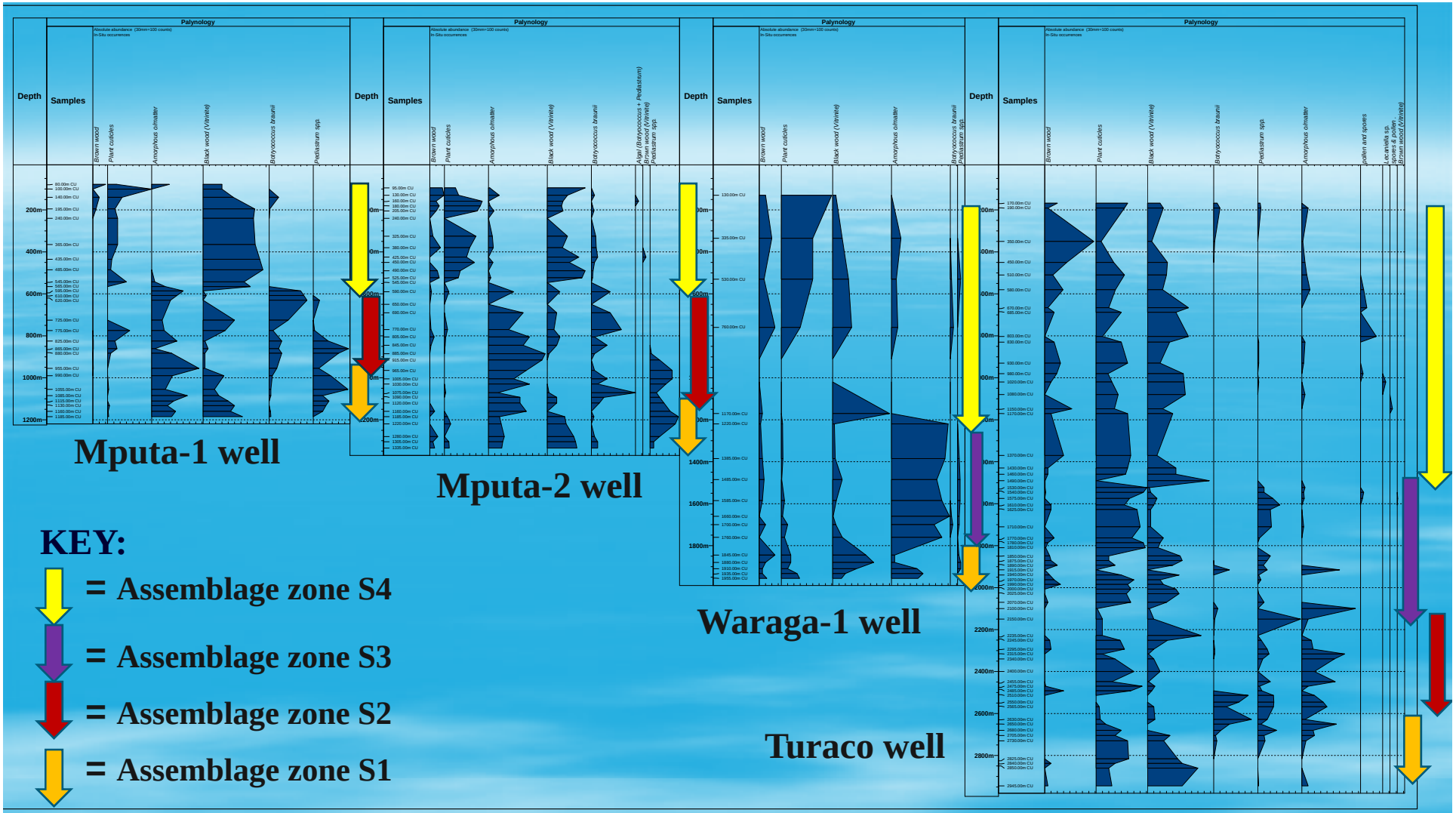
- Shallow sections of the Mputa-2 well lean of palynomorphs
- Deeper sections characterised by an influx of spores



PRELIMINARY RESULTS Contd.

- The entire Waraga-1 well was almost lean of palynomorphs apart from a few sporadic occurrence towards the base of the well

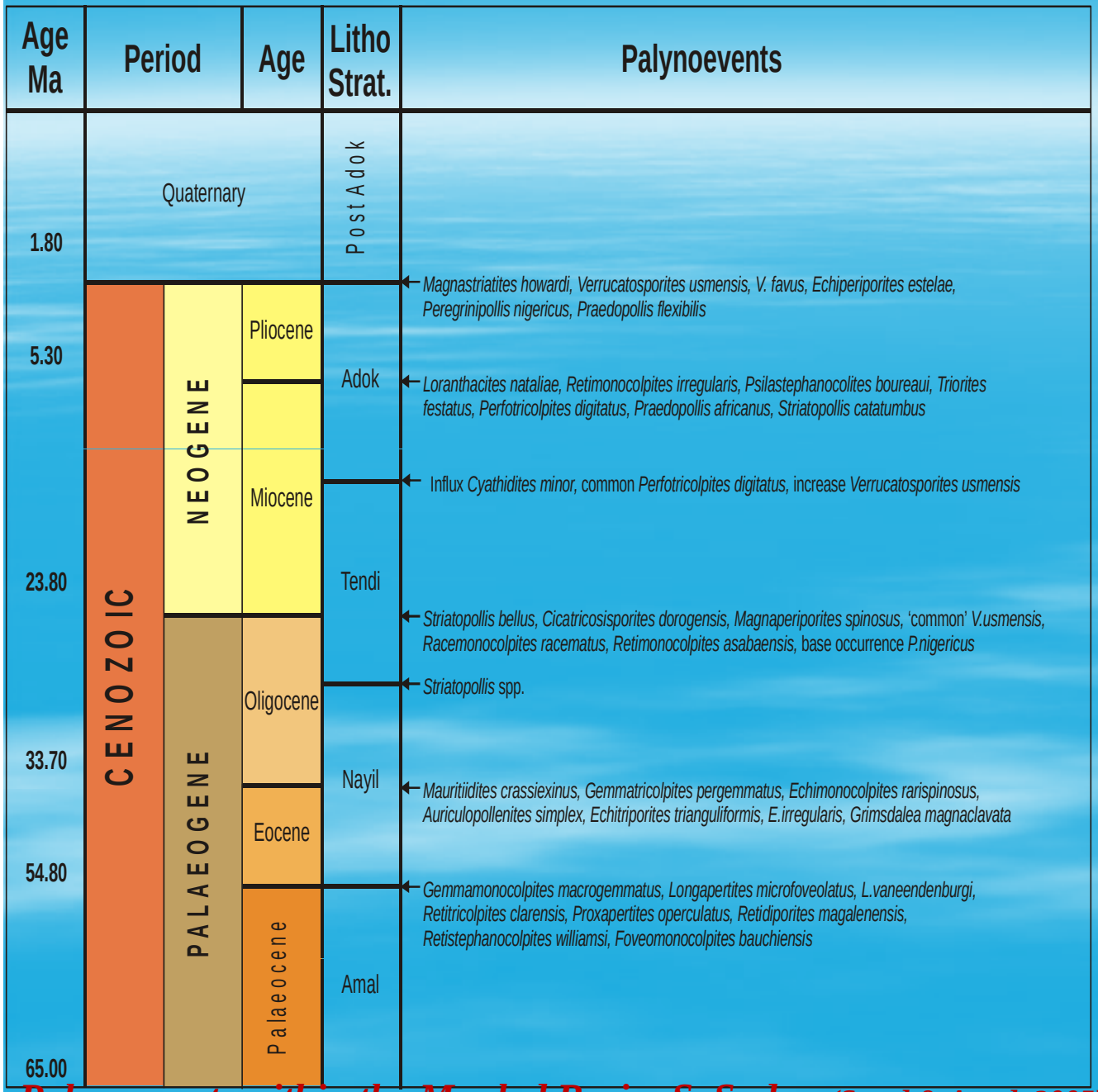
- Palynofacies and wireline log data for the four wells however show similarities



Comparison of palynofacies data associations within the four wells shows :

1. ***V.usmensis-E.Estalae***	**2.*G. gracilis-P. vancampoi*:**	***V. usmensis zone***
Not clear: Mputa-1	485m (base): Mputa-1	800-485m: Mputa-1
Not clear: Mputa-2	525m (base): Mputa-2	771-525m: Mputa-2
Not clear:Waraga-1	1600m (base):Waraga-1	Not clear:Waraga-1

AGE OF ZONES: Comparisons with the Muglad Basin, S. Sudan.



Palynoevents within the Muglad Basin, S. Sudan ***(Stead & Awad, 2005)***

V.usmensis-E.estelae zone:

•FDO *V. usmensis*-Pliocene

***G. gracilis – P. vancampoi* zone:**

•High *G. Gracilis*-Pleistocene

***V. usmensis* zone:**

•Increase in *V.usmensis*-Mid –Miocene

***C. minor & T. Sinuosus* zone:**

•Influx of *C. minor* & *T. sinuosus*-Mid-Miocene

•Increase of *M.howardii* & FDO of *C. Dorogensis:* Oligocene

AGE OF ZONES: Comparisons with the Muglad Basin, S. Sudan.

Age Ma	Period	Age	Litho-Strat.	Zones		Index Taxa	
	CENOZOIC	Quaternary	Post Adok	1		*Gramineae* *Chenopodipollis microporatus*	
1.80							
		NEOGENE Pliocene	Adok	2	2a	*Verrucatosporites* spp.	*Peregrinipollis nigericus* Top *V. usmensis*
5.80					2b		*Loranthacites nataliae* Top *Perfotricolpites digitatus*
		NEOGENE Miocene	Tendi	3	3a	Abundant *Cyathidites minor* *Perfotricolpites digitatus*	Common *V.usmensis*
23.80					3b		*Cicatricosisporites dorogensis* *Magnastriatites howardi*
		PALAEOGENE Oligocene	Nayil	4	4a	*Striatopollis* spp.	*Racemonocolpites* spp. *Praedapollis flexibilis*
33.70					4b		*Retimonocolpites asabaensis* *Corsinipollenites jussiaeensis*
		PALAEOGENE Eocene					
54.80							
		PALAEOGENE Paleocene	Amal	5	5a	*Mauritiidites crassiexinus* *Echimonocolpites rarispinosus*	*Proxapertites operculatus* *Mauritiidites crassiexinus*
					5b		*Retimonocolpites retifossulatus*
65.00							

Palynozones within the Muglad Basin, S. Sudan

AGE OF ZONES: Comparisons with the other areas in Africa

1. ***V.USEMENSIS-E.ESTALAE* ZONE**

- *V. usmensis*: Pliocene-Miocene: Burundi (Sah, 1967)
- FDO *M. howardii*- Pleistocene: intertropical areas of Africa,S. America and Asia (Germeraad *et al.*,1968)
- FDO of *V. usmensis*, *E.estelae* and *P. Diederixi:*Pliocene in Congo, Gabon, Cameroon, Angola, Nigeria Togo, Niger and Mali (Salard-Cheboldaeff , 1990)

- **Suggested age:** Mid Pliocene-Pleistocene

***2. G. GRACILIS - P. VANCAMPOI* ZONE**

•Worldwide increase in Miocene-Pliocene (Germeraad et al., 1968)

• FDO *P.vancampoi:* Miocene, Congo, Gabon, Cameroon, Angola, Nigeria, Togo and Niger-Mali. (Salard-Cheboldaeff, 1990)

• FDO *R. irregularis*: Pliocene of above basins (Salard-Cheboldaeff, 1990) and Pliocene of Burundi (Sah, 1967).

•**Suggested age**: Early/mid Pliocene age

AGE OF ZONES: Comparisons with the other areas in Africa.

3. *VERRUCATOSPORITES USMENSIS* ZONE

•High *V. usmensis* & *C.Vanraadshooveni:* Mid-Miocene zone in Niger delta (Oboh et al., 1992, Oboh & Salami, 1989)

•LDO of *P. Diederixi*: Mid-Miocene, Niger delta (Oboh et al., 1992 and Oboh & Salami,1989)

Suggested age: Late Miocene-Early Pliocene

4: *C. MINOR-T. SINUOSUS* ZONE

High numbers of *M. howardii*:

•Late and Mid Miocene: Niger delta (Oboh *et al.*, 1992 and Oboh & Salami, 1989)

•Early Miocene: Cameroon (Rull, 2001)

•Early Miocene-Oligocene interrtopical areas of Africa, S. America and Asia (Germeraad *et al.*1968)

LDO C. Vanraadshooveni:

•Useful marker of Mid-Upper Miocene in the Niger delta (Oboh & Salami,1989 and Oboh *et al*., 1992)

•Lower Miocene–Pliocene the basins of Nigeria, Togo and Niger-Mali. (Salard-Cheboldaeff, 1990).

Suggested age: Early-Mid Miocene

Boundaries of suggested assemblage zones

Boundaries between the individual zones suggested only tentatively defined because;

- Precise stratigraphic ranges of many of the species encountered not accurately known in the area studied.
- There are long barren intervals in many of the thick sandy sequences.
- Diagnostic fossils were encountered only occasionally in some intervals.
- Shale bed sequences yielded the largest and most diverse palynofloras, but they represent only a small part of the total section.
- Some of the spore and pollen ranges do not seem to conform to those reported for the taxa elsewhere .

PALYNOFACIES ANALYSIS

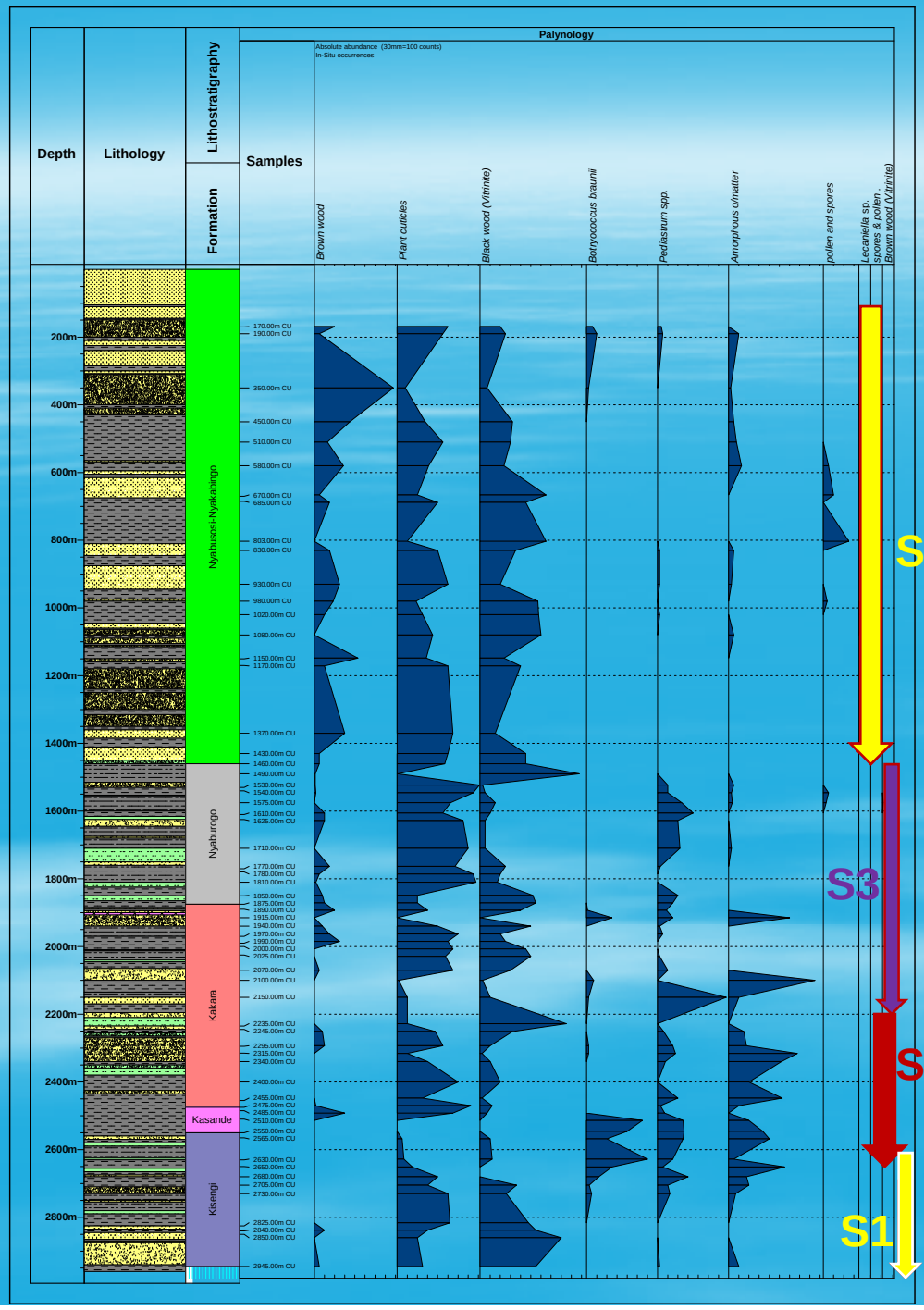
- Analysis of palynodebris, palynomorphs and algal remains.

- Used to:
  - asses major changes in depositional energy levels, hence, the likely depositional settings (from distributional changes).

  - Asses salinity variations basing on variations in abundance of marine, brackish water and terrestrially derived taxa.

  - To suggest the general palaeocology an palaeoclimate of area basing on specific palynomorph abundances.

PALYNOFACIES ANALYSIS



Four Assemblage units established: S1, S2, S3, & S4

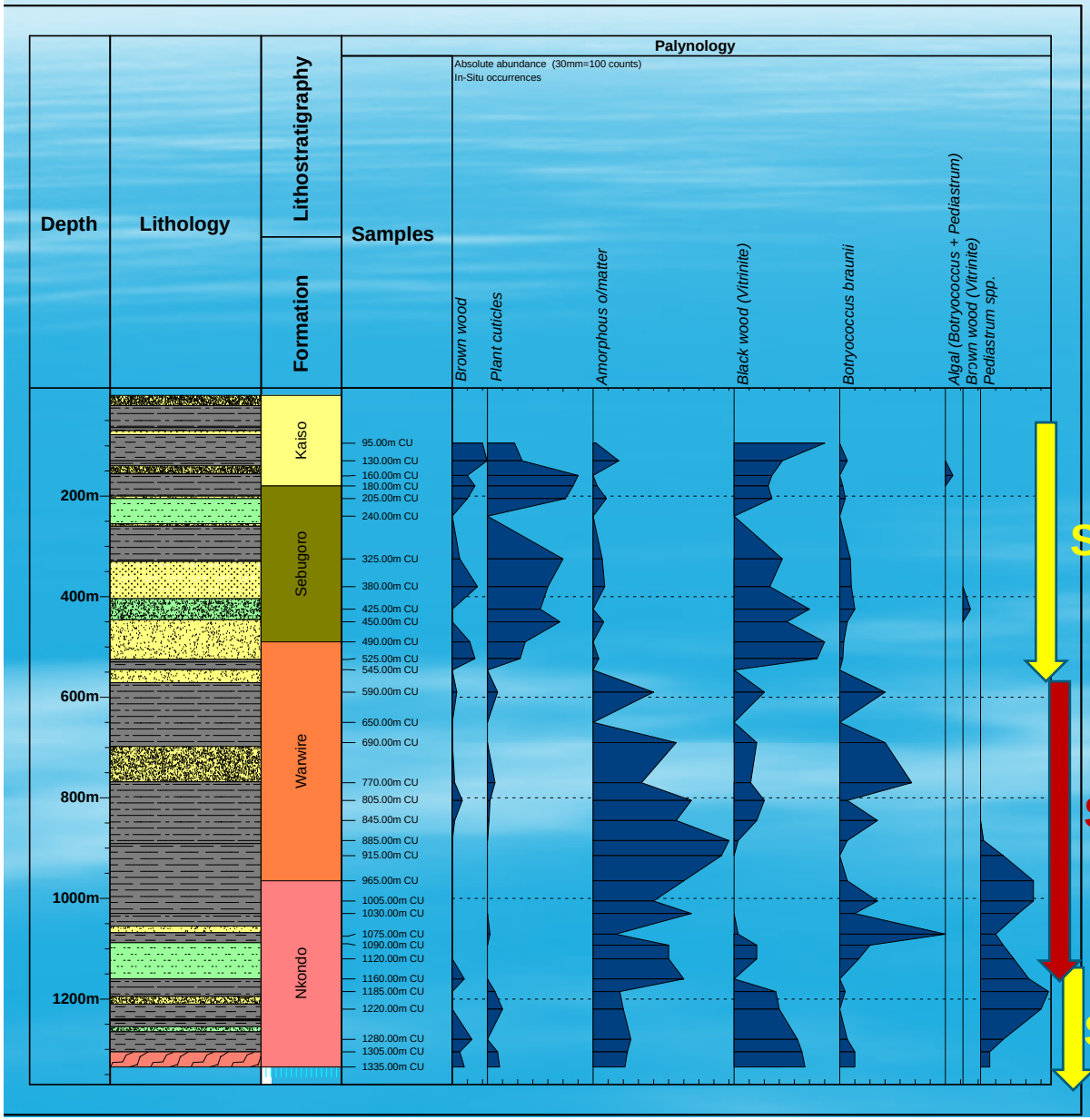
Unit S1: high black wood, plant cuticles and low *Pediastrum & Botryococcus* sp.

•Suggestive of delta front, prodelta or fluvial-deltaic facies (Nagy *et al*., 1984; Tyson, 1987, 1995).

Suggested: Deltaic inner lacustrine conditions

Climate within S1: warm & hot, generally dry climate at the time: due to scarce fern spores

PALYNOFACIES ANALYSIS



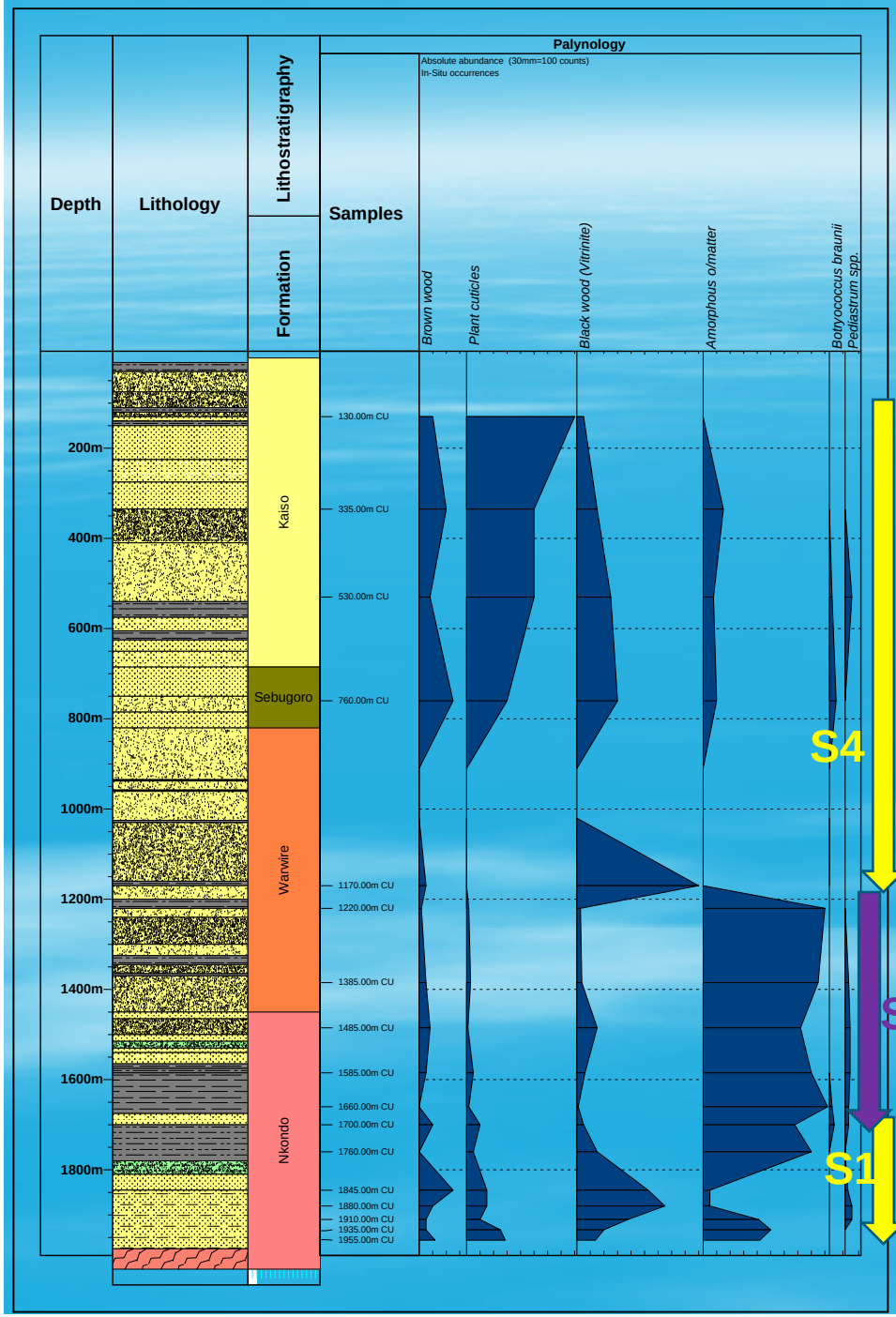
Unit S2; abundant *Botryococcus* sp., *Pediastrum* sp., AOM and common-abundant fern spores.

•Suggestive of deposition by low energy currents in reducing , fresh-brackish waters free from sediments and subaerial plants

(i.e. fresh-brackish water open lacustrine conditions)

•**Climate:** warm and wet due to abundance of fern spores.

PALYNOFACIES ANALYSIS

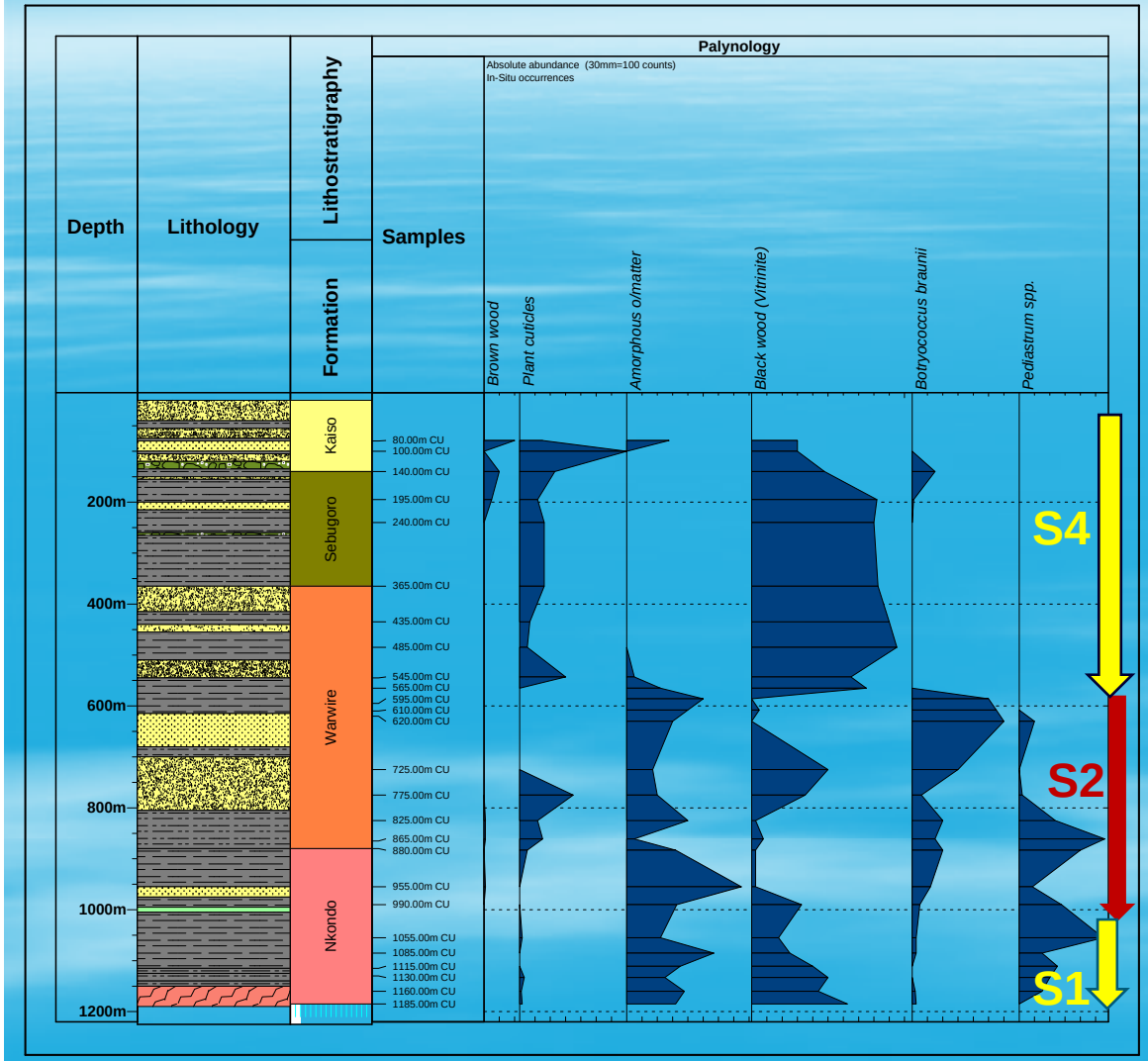


S3: High *Pediastrum*, AOM, plant cuticles, and black wood , and fern spores.

A marginal-lacustrine facies with fresh-brackish water marsh-swamp/lagoonal and/or deltaic depositional setting suggested.

Climate: moist, warm and fairly humid. Wetter and more humid than S2.

PALYNOFACIES ANALYSIS

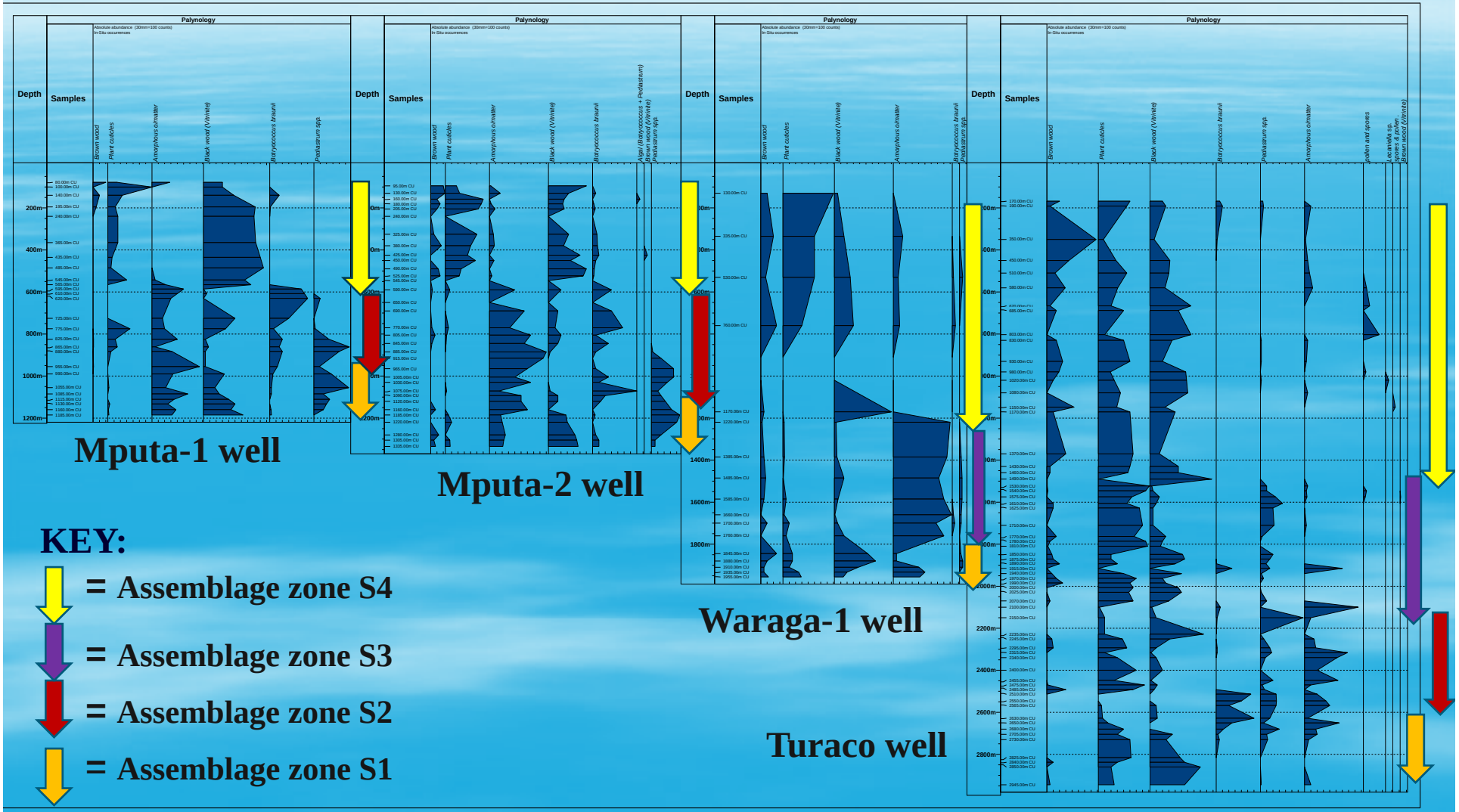


Unit S4: abundant grass pollen, fern spores; plant cuticles, black wood, brown wood in fine-v.coarse lithofacies

- Suggestive of deposition by high-energy tractional currents in a shallow, oxidising, fluvio-deltaic environment probably along active river channels close to sediment source.

- **Climate:** warm and dry as shown by abundant *Graminae* pollen and low fern spores.

PALYNOFACIES ANALYSIS



KEY:

= Assemblage zone S4

= Assemblage zone S3

= Assemblage zone S2

= Assemblage zone S1

Comparison of palynofacies data associations within the four wells shows

CONCLUSION

- The oldest subsurface sediments suggested to be Early-Mid Miocene.
- Depositional environments varies from fresh-brackish water open lacustrine through marginal lacustrine facies to fluvio-detaic environments.
- Areas represented by deeper successions were wet and warm while shallower successions were drier.
- The sediments within the two basins are comparable/correlatable
- Future plan: integrate palynological studies with chemostratigraphy, wireline log analysis, among others to fine tune further most of the aspects discussed.

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THANK YOU