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Palaeoenvironments of Neoproterozoic carbonates in part of the Schisto-Calcaire Subgroup, West Congo Belt, Democratic Republic of Congo (DRC): lithostratigraphy, sedimentology and diagenesis

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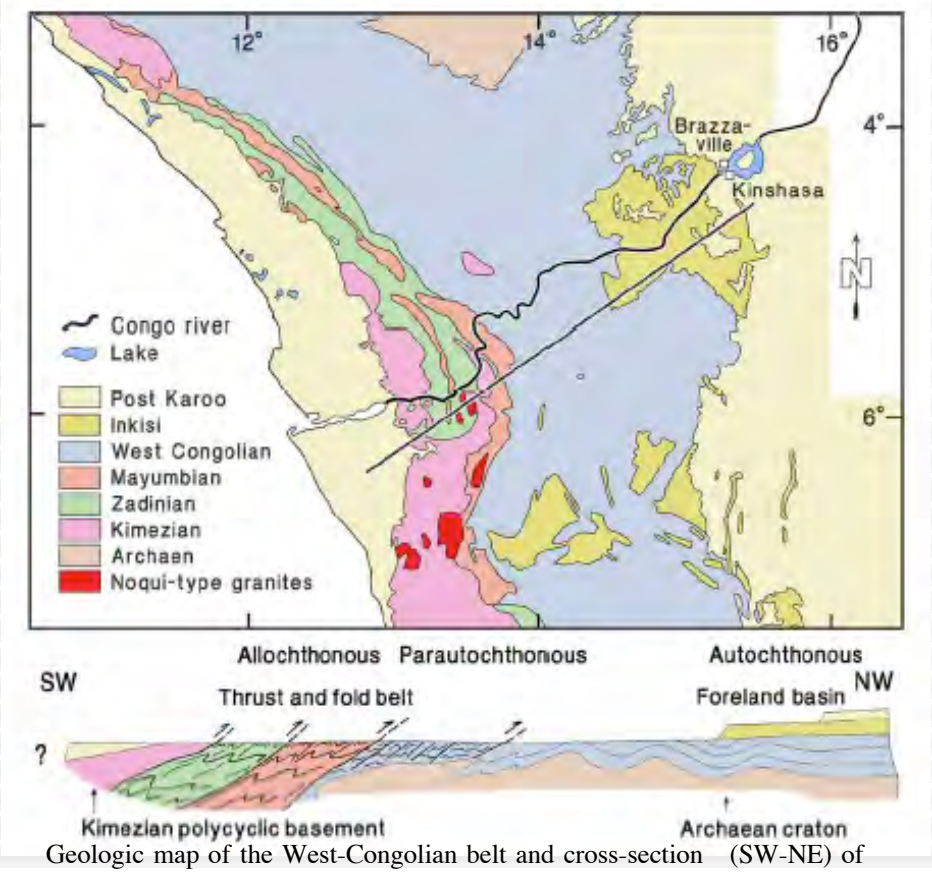
Objectives

Lithostratigraphic and palaeoenvironmental study from 4 boreholes crossing the lower part of the Schisto-Calcaire Subgroup in Bas-Congo (Democratic Republic of Congo)

- Characterize the sedimentary environments and their evolution in the Neoproterozoic (542 to 1000 My) in Bas-Congo

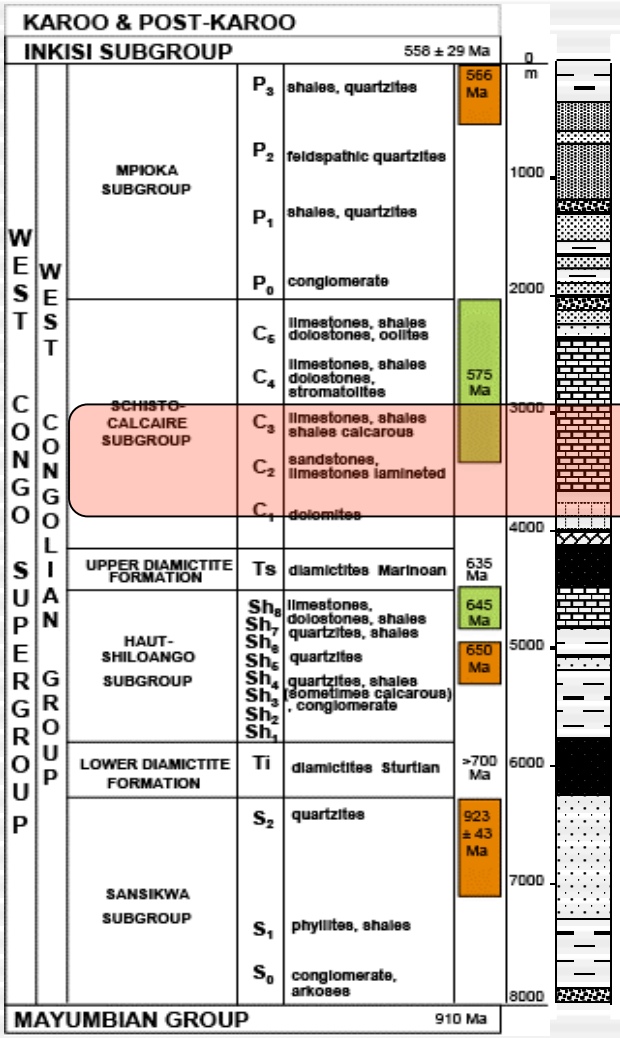
- Characterize the sedimentary environment in the geologic and geodynamic contexts of the panafrican West-Congolian belts (ca. 550 My) in the border of the Congo craton

- Determine the role of microbial organisms in the carbonate deposits (early mineralizations and hydrocarbons)



Geologic map of the West-Congolian belt and cross-section (SW-NE) of the belt (Frimmel *et al*. 2006)

Lithostratigraphy:



Synthetic lithostratigraphic subdivision of the West-Congolian belt (West-Congo Supergroup) (Modified after Tack *et al*. 2004 in progress)

Rb/Sr isotopes datation (Poidevin 2007)

SHRIMP datation on zircons (Frimmel *et al.* 2006)

After Alvarez *et al. 1995*

Limestones with oolites and cyanobacterial mats

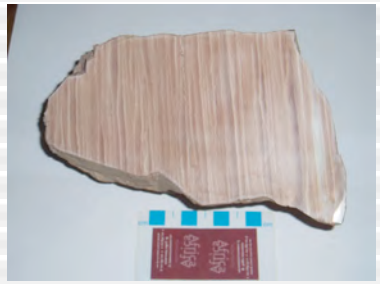
Limestones with stromatolites

Limestones with oolites and pisolites

Limestones with cyanobacterial mats

« CAP CARBONATE »

Marinoan diamictites



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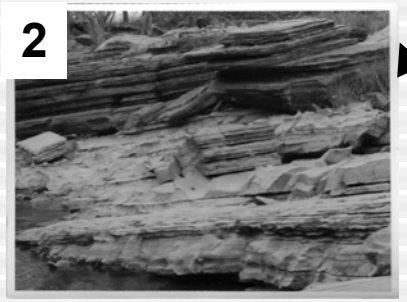
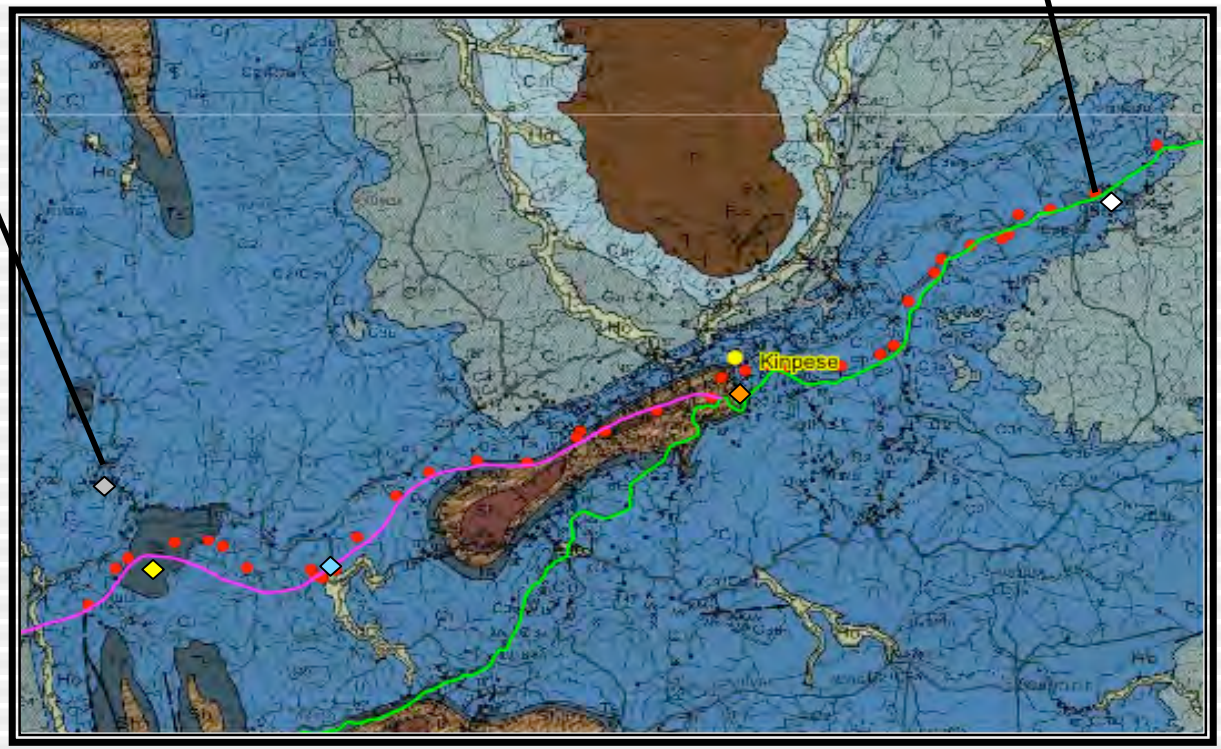
Localization of boreholes in Bas-Congo, Kimpense area

« CILU » quarry in Lukala. The red lign represent the limit between the C3b/C4a



Photography of the border of the Kwilu river 1) Laminar texture in limestones. Right bank of the Kwilu river ; 2) finely laminar green limestones. Right bank of the Kwilu river



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Schisto-Calcaire Subgroup (C2 and C3)

Petrographic description and interpretation

From analyze of thin sections, 9 microfacies have been identified (MF1 à MF9) and constitute the standard sequence

This sequence represents the evolution of the subtidal zone with detrital materials, cyanobacterial mats and intraformational conglomerates (MF1, MF2, MF3, MF4) to an evaporative supratidal zone - sebkha - (MF5, MF6, MF7) strongly altered by diagenesis (MF8, MF9).

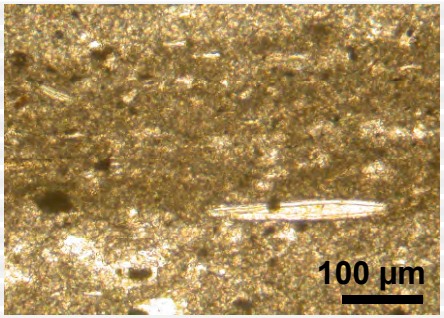
Microfaciès		Description		Interprétation
9		Mudstone chertifié	SUPRATIDAL	Sebkha
8		Microsparite		
7		Conglomérat intraforma-tionnel et à caliches à oolithes, pisolithes et lumps		Chenal supratidal
6		Mudstone microsparitisé à péloïdes, nodules et copeaux		
5		Mudstone de laminations ondulantes à cyanophycées		Platiers à Cyano-phycées
4		Conglomérat intraformationnel	INTER	
3		Mudstone de laminations stromatolithiques		
2		Mudstone de laminations planes parallèles à cyanophycées		
1		Mudstone argilo-détritique	SUB	Lagon

Standard sequence of microfacies for the Kwilu (S, 1 et 2) and Lukala boreholes. SUB = subtidal, INTER = intertidal, SUPRA = supratidal.

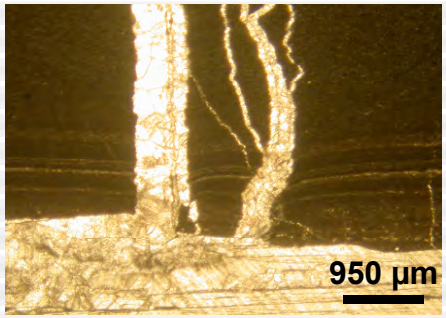
BC 302, core 119
Schisto-Calcaire Subgroup (C2):
Faisceau du Kwilu CI
Kwilu 1 borehole

Core 14
Schisto-Calcaire Subgroup (C3):
Faisceau du Kwilu CI
Lukala borehole

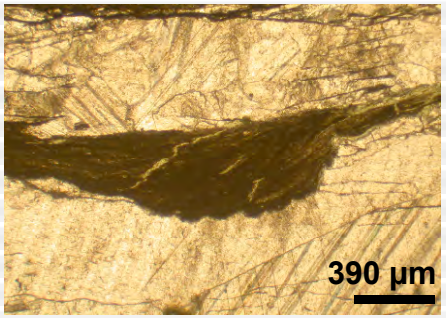
MICROFACIES STANDARD SEQUENCE



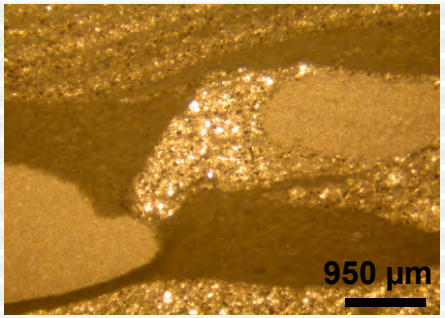
MF1



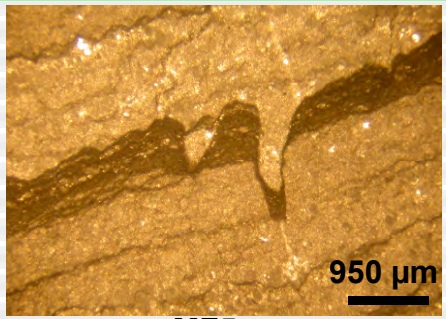
MF2



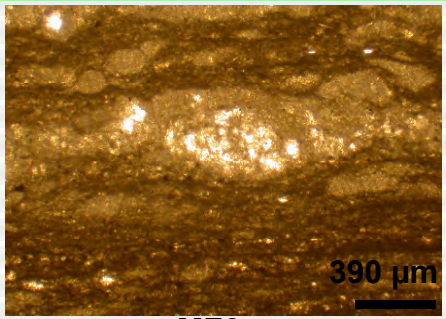
MF3



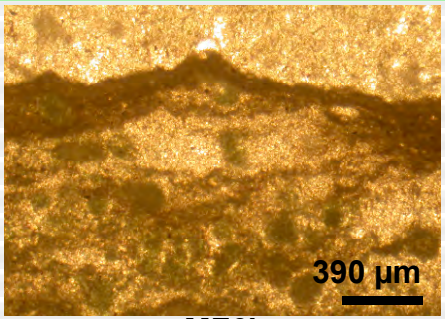
MF4



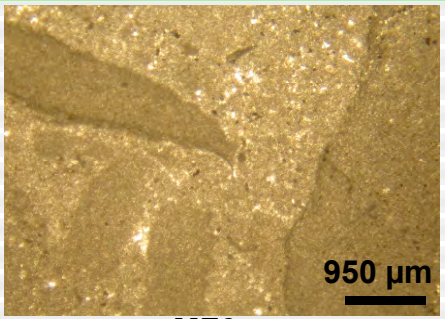
MF5



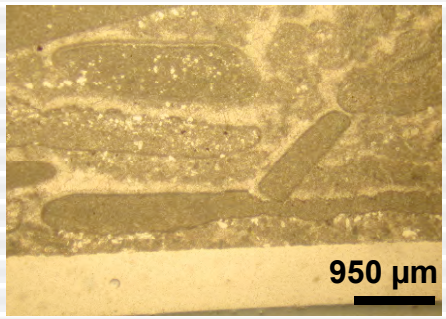
MF6a



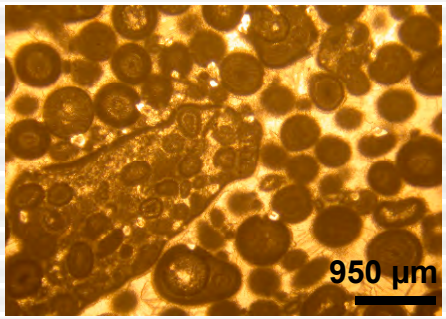
MF6b



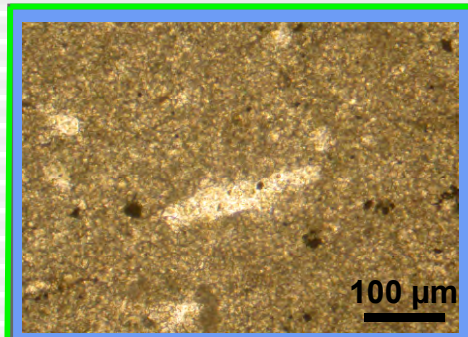
MF6c



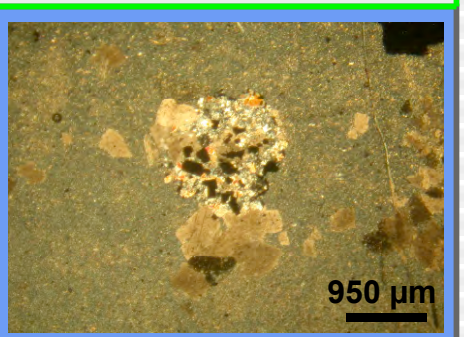
MF7a



MF7b



MF8



MF9

Subtidal to intertidal zones
Supratidal zone with supratidal channels
Sebhka

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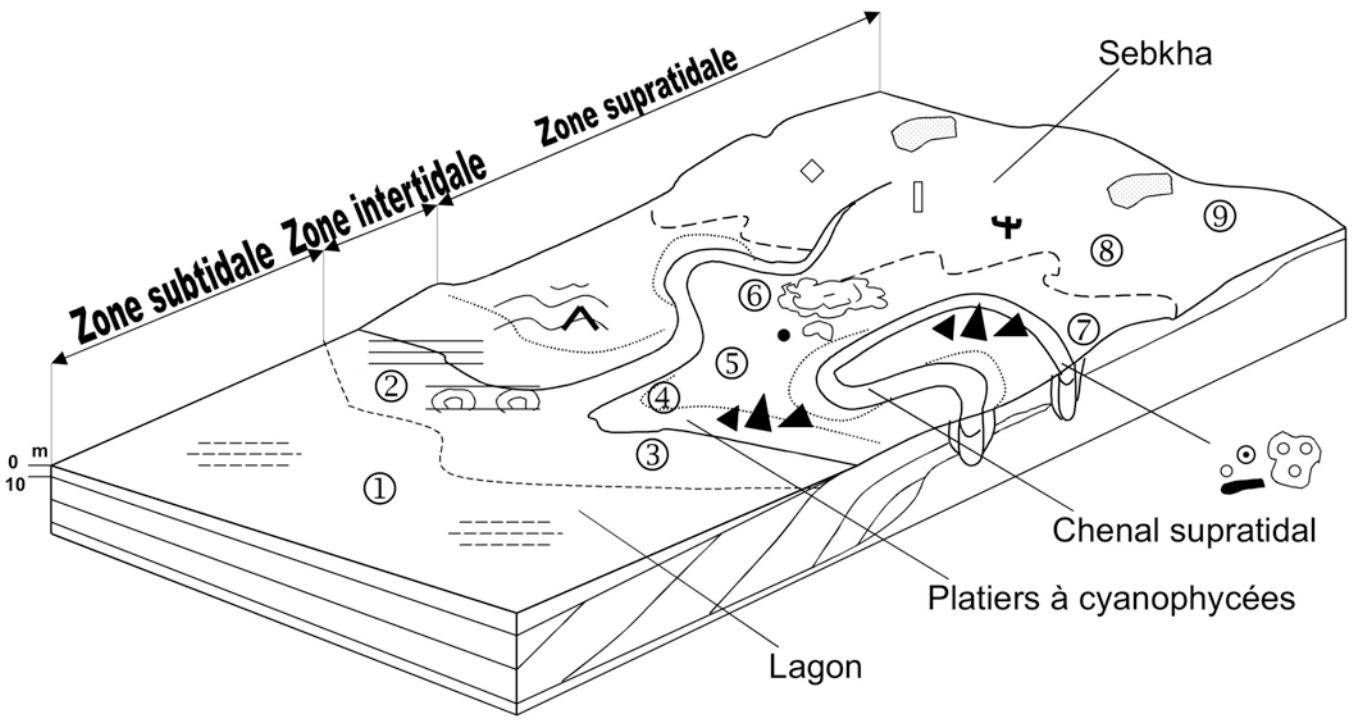
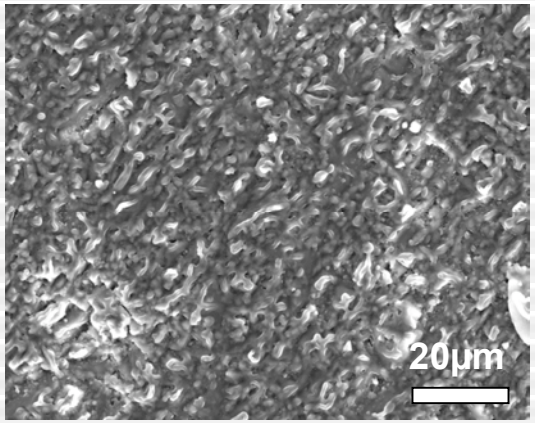
TIDAL FLAT PALAEOENVIRONMENT

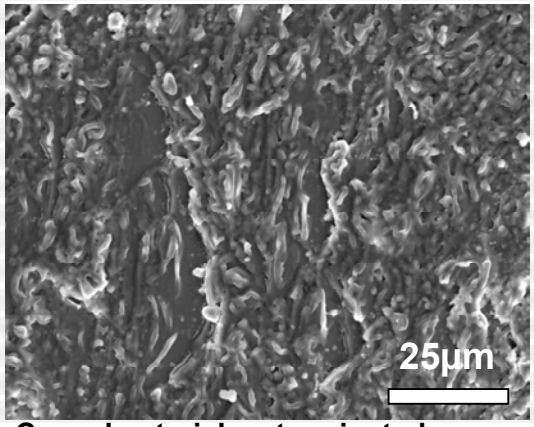


Sedimentary model of the tidal flat in Kwilu-Lukala area in Bas-Congo (Democratic republic of Congo). The numbers (1 à 9) correspond to microfacies of the standard sequence (modified after Ginsburg and Hardie 1979, Kinsman 1966). Indicative vertical scales and no horizontal scale.

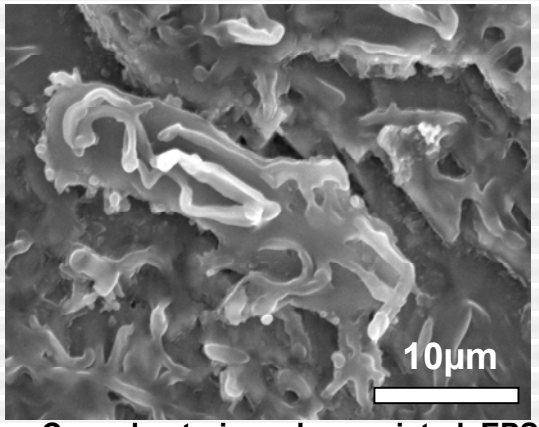
SEM analysis of Microfacies 2 : CYANOBACTERIAL BOUNDSTONES



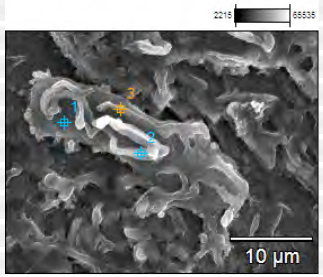
Cyanobacterial mats grouped in bushes

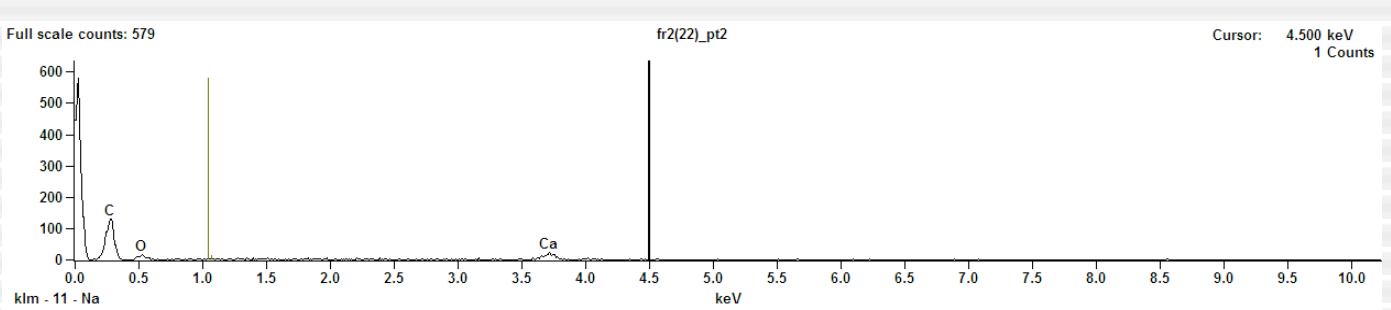


Cyanobacterial mats oriented perpendiculary to the stratification



Cyanobacteria and associated EPS



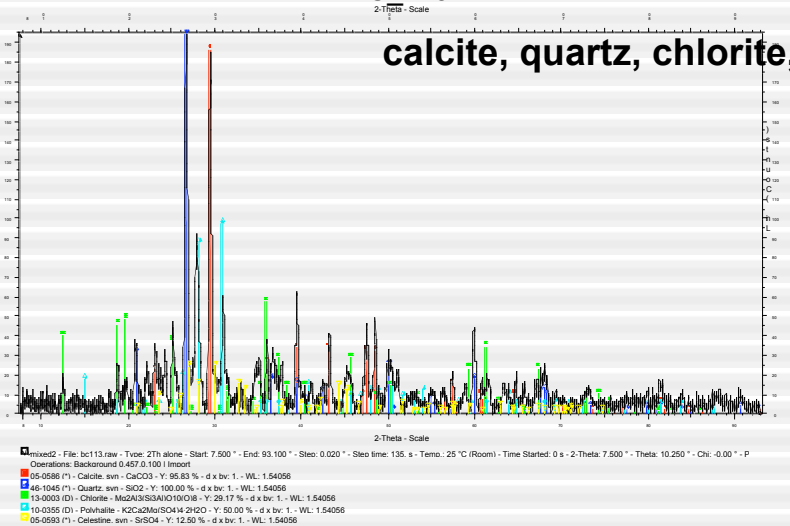


Normalized Wt-%	C-K	O-K	Ca-K
fr2(22)_pt2	57.13	30.24	12.63

XRD : MAIN MINERALOGICAL CONSTITUENTS OF THE CARBONATES (MF1-MF9)

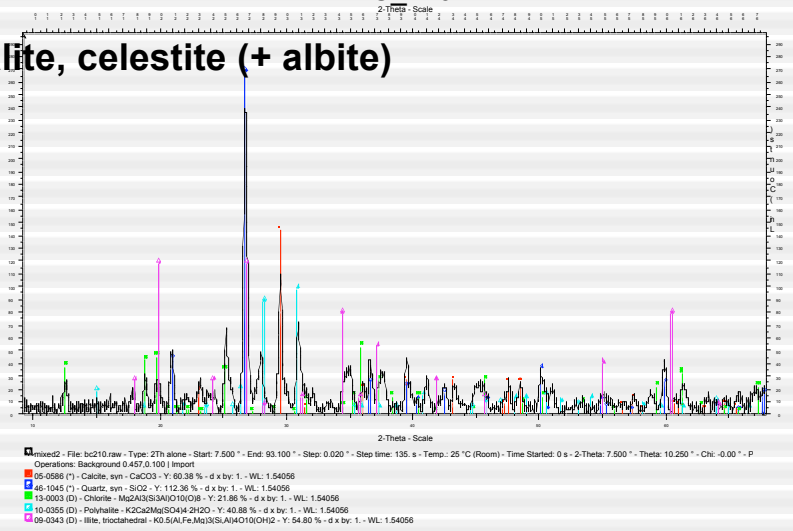
calcite, quartz, chlorite, polyhalite, celestite (+ albite)

BC_113



X-Ray diffraction on the sample BC113
(core BC-295, Lukala borehole)

BC_210



X-Ray diffraction on the sample BC210
(core S-54, Kwilu S borehole)

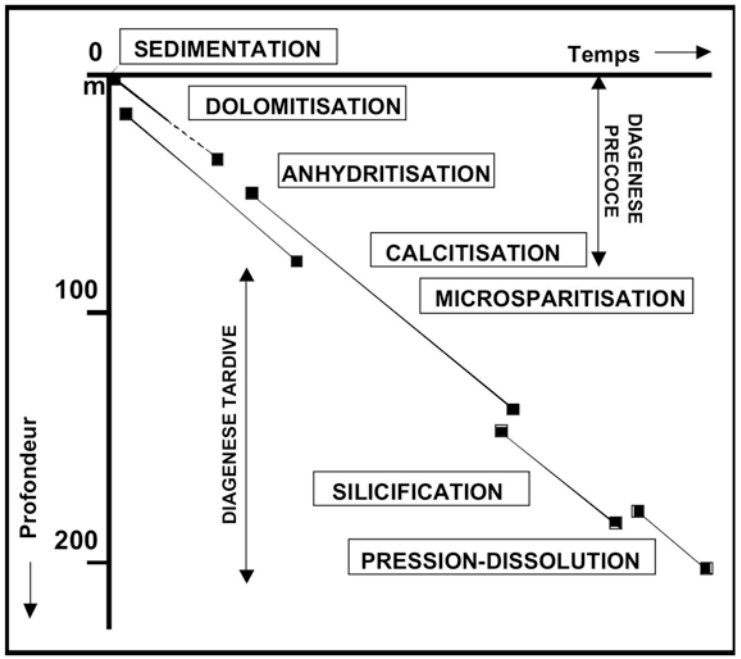
Diagenesis

Early diagenesis

- Sedimentation (original muds - micrite-, gypsum)
- Dolomitisation (replacement of micrite)
- Anhydritisation (replacement of gypsum by anhydrite)
- Calcitisation-microsparitisation (replacement of dolomite)

Intermediate to late diagenesis

- Calcitisation-microsparitisation (replacement of dolomite)
- Silcification (replacement of dolomite and calcite)
- Pression-dissolution (stylolites)



Diagenetic sequence of Kwilu n°S, 1, 2 and Lukala boreholes. The figured depths are indicative.

Schisto-Calcaire Subgroup

diagenetic sequence	mineral cement	occluded porosity	shape	size
→ time	1. micrite	original calcite or aragonite	anhedral	<5 μm
	2. gypsum	original gypsum	euhedral	30-50 μm
	3. dolomicrite	replacing calcite or aragonite	anhedral, rhomb, idiotop ic, mosaic	>5 μm
	4. anhydrite	replacing gypsum	subhedral	50-200 μm
	5. microspar	replacing dolomite	Mosaic, planar	>10->100 μm
	6. Silica	replacing dolomite and calcite	microcrystalline	>5 μm
	7. pression - dissolution	-	-	-

Isotopic data - carbon and oxygen

Oxygen ∂ ^{18}O

Negative values (-8‰ to -12‰) indicate a meteoric influence or a increase of temperature resulting from burial

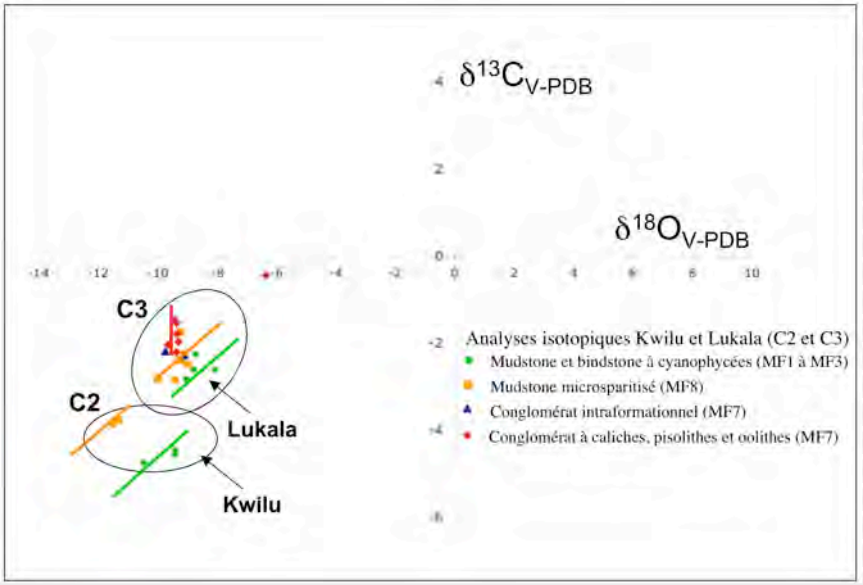
No evaporitic influence (except BC186).

Carbon ∂ ^{13}C

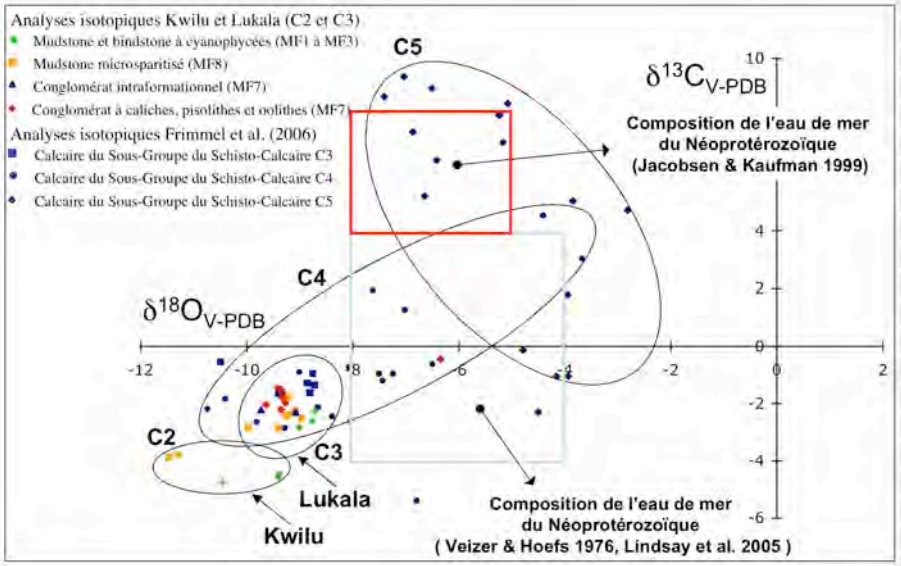
Negative values (-2‰ to -6‰) suggest an atmospheric influence of CO_2 in a vadose environment.

Possible influence of bacterial sulfato-reduction reaction.

No evaporitic influence in the C2 and C3 in Bas-Congo.



$\delta^{13}C_{V\text{-}PDB}/^{18}O_{V\text{-}PDB}$ diagram of the Kwilu (S, 1 et 2) (stratigraphic interval C2) and Lukala boreholes (stratigraphic interval C3)



$\delta^{13}C_{V\text{-}PDB}/^{18}O_{V\text{-}PDB}$ isotopic diagram containing the data of Frimmel et al. (2006) (stratigraphic interval C3, C4 et C5), the Kwilu (stratigraphic interval C2) and Lukala boreholes (stratigraphic interval C3). The composition of the Neoproterozoic seawater is from Veizer and Hoefs (1976), Lindsay *et al*. (2005), Jacobsen and Kaufman (1999).

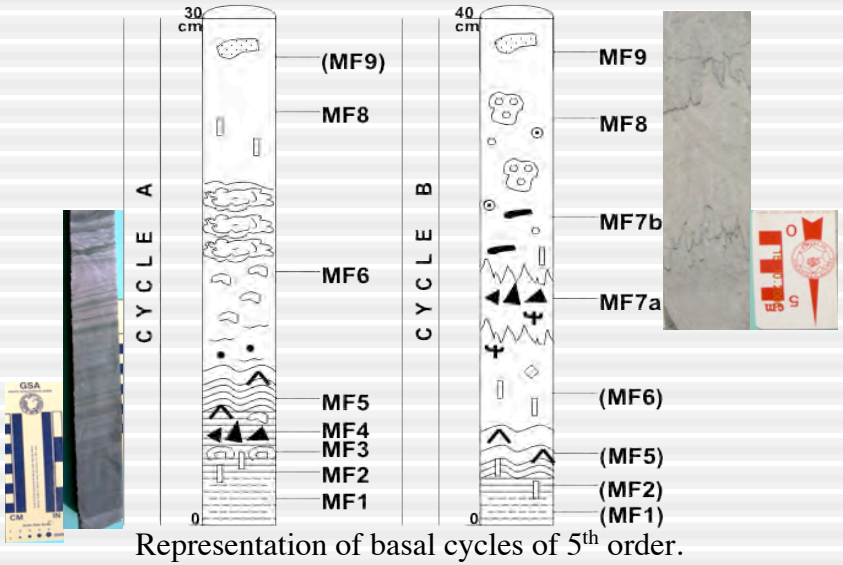
Sequence stratigraphy

The recognition of a 3rd order sequence is impossible and the stratigraphic resolution is too complex (truncated and masked sequences by the diagenesis)

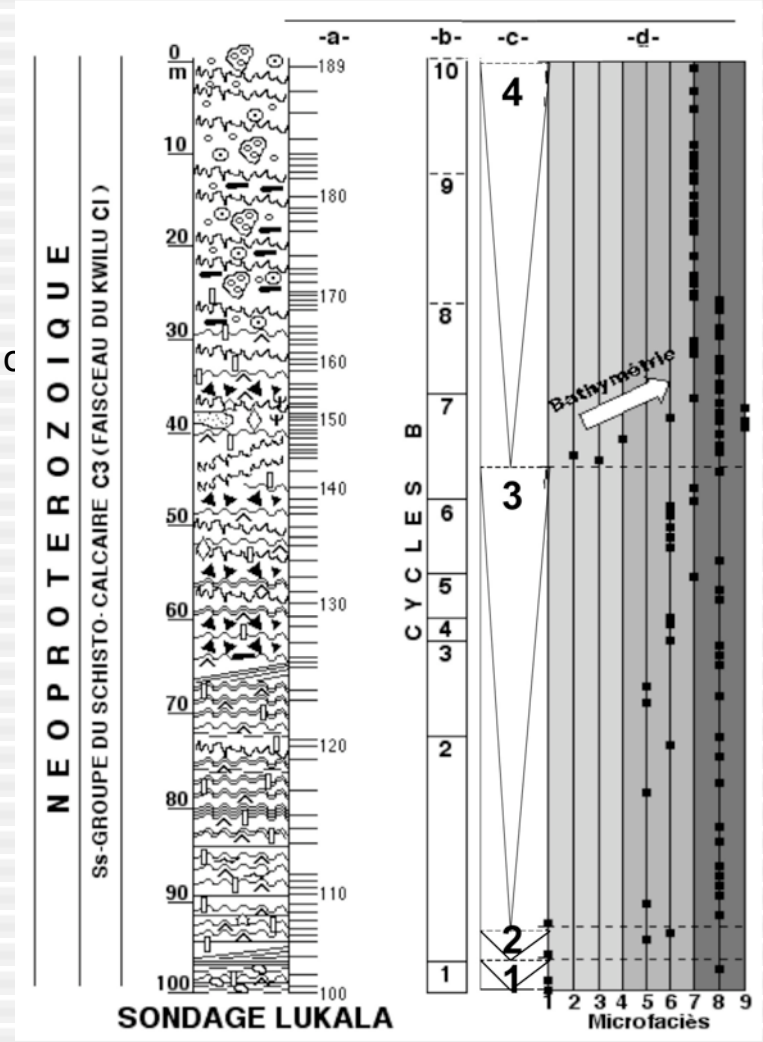
4th et 5th order 'parasequences'

The petrography allows to etablish 2 basic cycles (cycle A c cycle B) orelementary parasequences of 5th order).
The cycles record local bathymetric variations of seawater.

In conclusion, impossibility to define a stratonomic evolution for the parasequences of 4th order.
The correlations of 4th and 5th orders are impossible to establish between the different boreholes in the sedimentary basin



Representation of basal cycles of 5th order.



Stratigraphic log of Lukala borehole. Column a = position of analysed samples (petrography), Column b = amalgam of sequences of 4th and 5th orders, Column c = parasequences of 4th order, Column d = standard sequence of microfacies 1 to 9. The arrow corresponds to the bathymetric evolution

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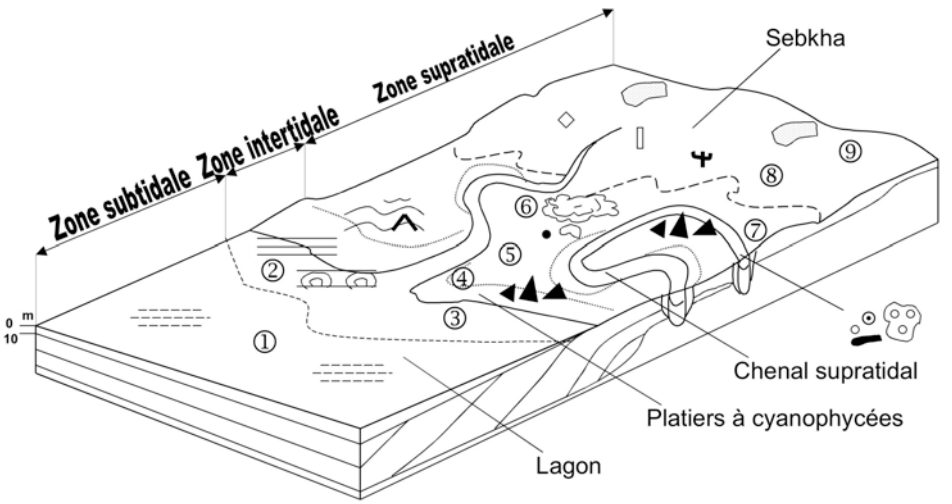
Conclusion

Sedimentary model consists to semi-restricted to restricted lagoonal subtidal environments evolving to evaporitic supratidal environment with sebkha.

The diagenesis is complex and subjected to polyphased and overlapped stages. The diagenesis contains an early diagenesis with sedimentation, dolomitisation, anhydritisation and microsparitisation; intermediate to late diagenesis with microsparitization, silicification and pressure-dissolution.

The isotopes of carbon and oxygen indicate the increase of temperature resulting from the regional burial ($\delta^{18}O$ de -8‰ à -12‰) and a meteoritic influence resulting from vadose conditions during sedimentation ($\delta^{13}C$ de -2‰ à -6‰).



Sedimentary model of the tidal flat of the Kwilu-Lukala deposits in Bas-Congo (Democratic Republic of Congo). The numbers (1 à 9) correspond to microfacies of the standard sequence (modified after Ginsburg and Hardie 1979, Kinsman 1966). Indicativee vertical scale and no horizontal scale.


Thanks