LIEGE, BELGIUM: Geology/UR PPM

Paleobotany-Paleopalynology-Micropaleontology

UNIVERSITÉ de Liège

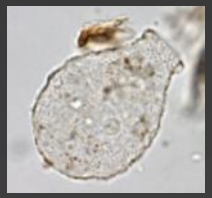
EVOLUTION OF THE EARLY BIOSPHERE

marine biosphere

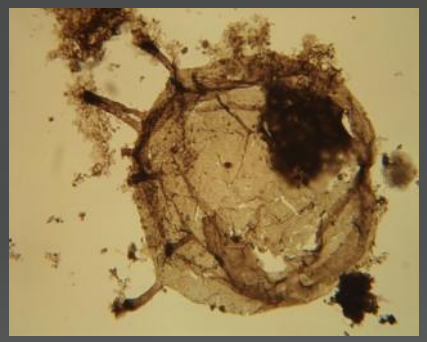
continental biosphere

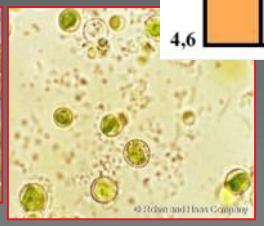
Origin and early evolution of life
Paleobiology
Extreme life-Early Earth analogs
Biosignatures-Astrobiology

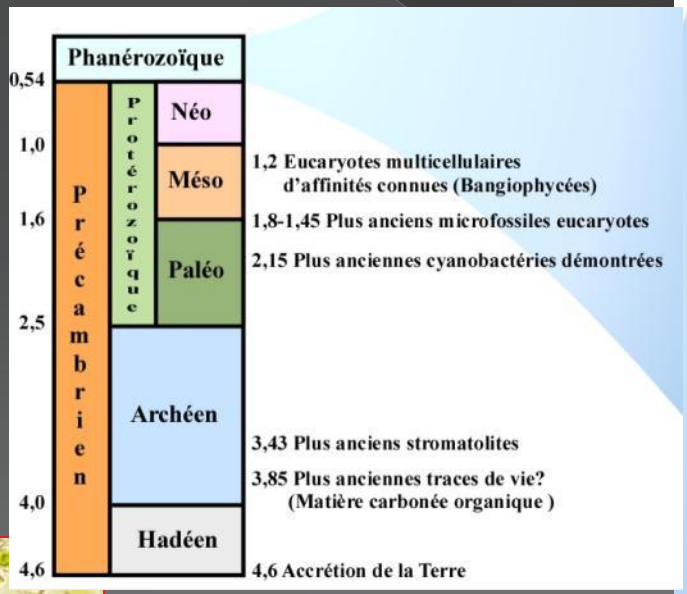
Paleoecology
in Holocene peatlands

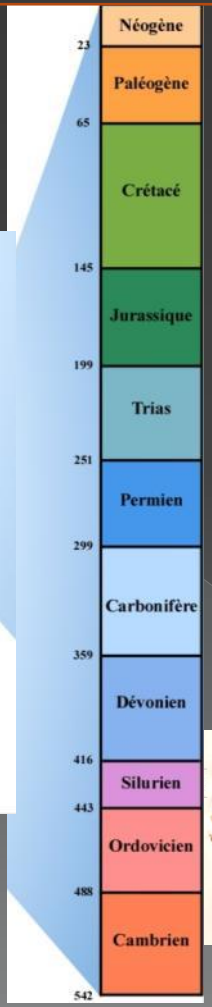


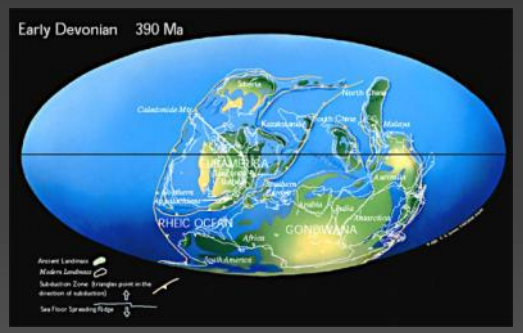
Early land plants
Terrestrialisation
Biostratigraphy
Paleogeography

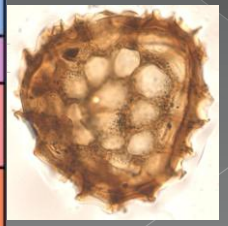


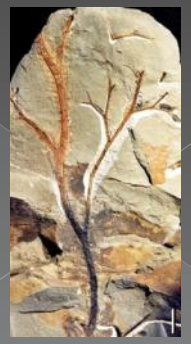


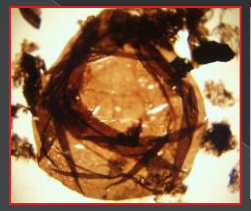
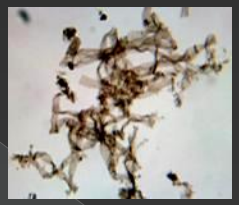
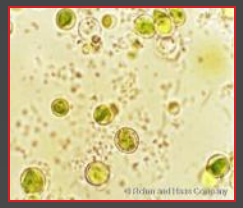










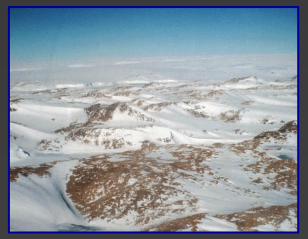

Microscopy

nm-µm scale

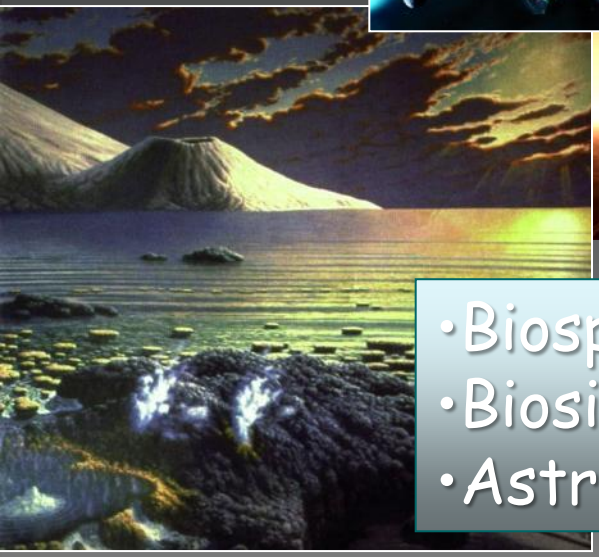
Microchemistry

Comparison
Fossil/extant microbial life
in diverse natural environments
in extreme conditions (analogs)
by artificial fossilization



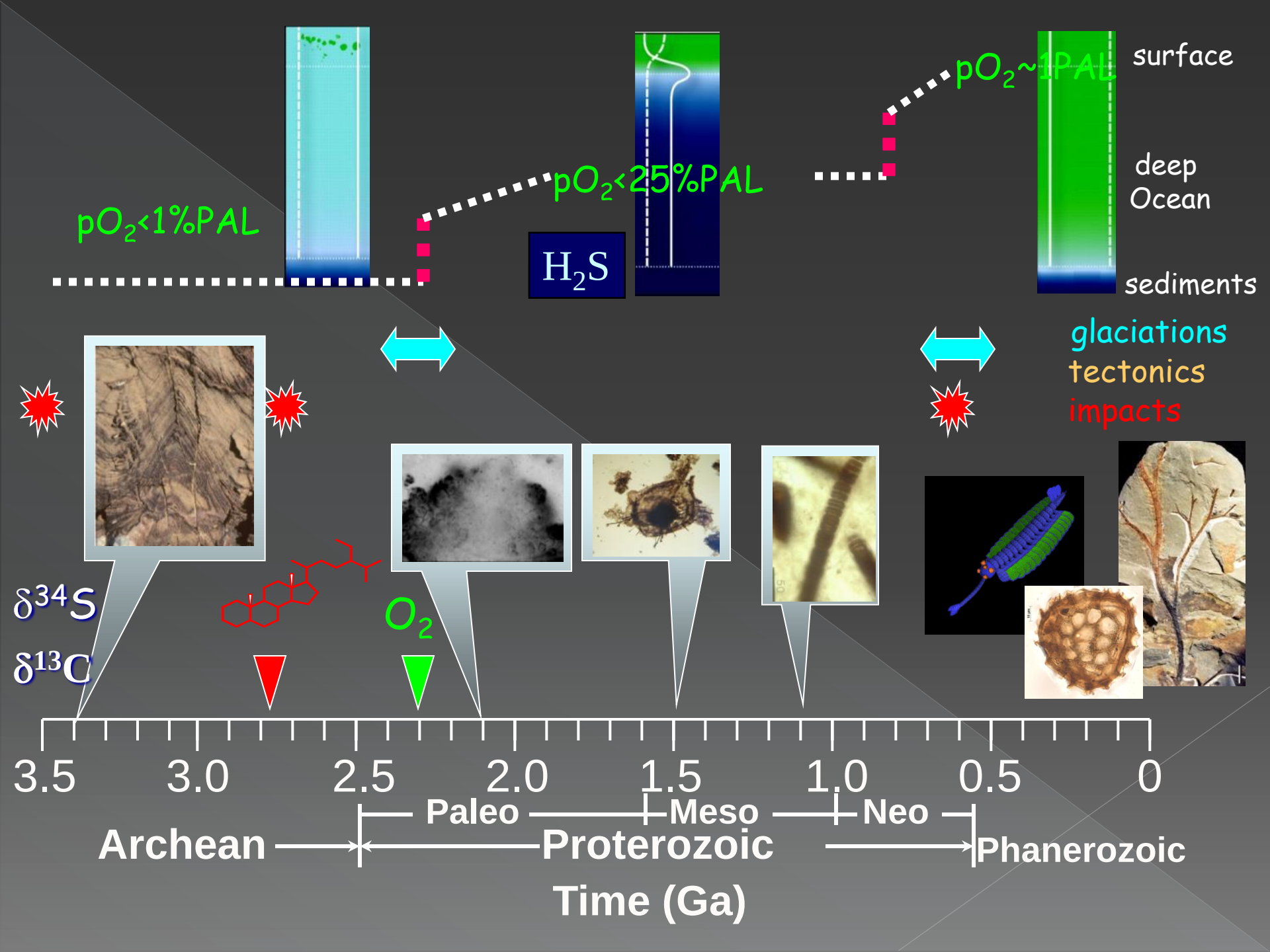






- Paleobiology: metabolism, biological affinities, ecology
- Geology: paleoenvironments, biomineralization-datings
- Molecular phylogeny

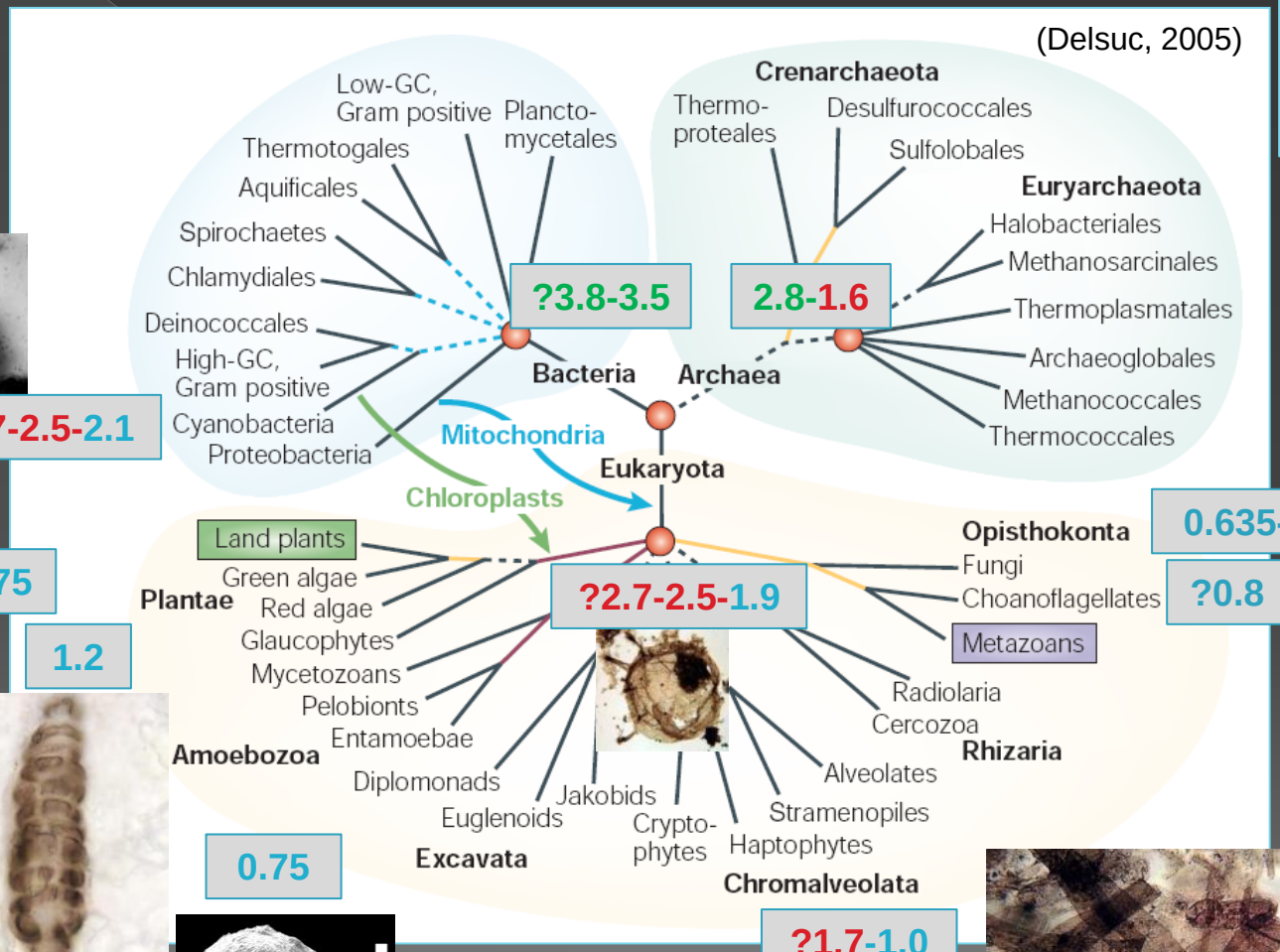
- Biosphere evolution
- Biosignatures
- Astrobiology

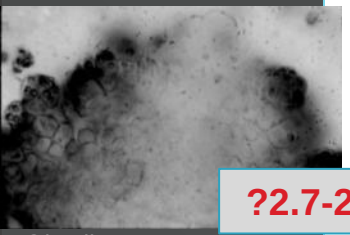

pO2<1%PAL
pO2<25%PAL
H2S
pO2~1PAL
surface
deep Ocean
sediments
glaciations
tectonics
impacts
δ34S
δ13C
O2
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Archean
Paleo
Meso
Neo
Proterozoic
Phanerozoic
Time (Ga)

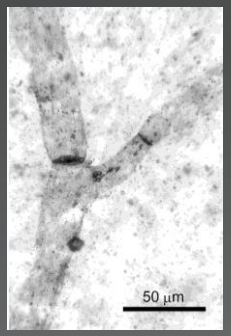
Calibration of the tree of life

Fossils
biomarkers
Isotopes

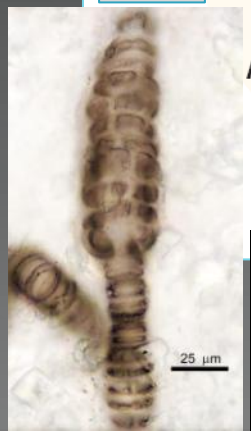
(Delsuc, 2005)




@knoll



@Butterfield



@Butterfield


@Porter


@Xiao


@Butterfield

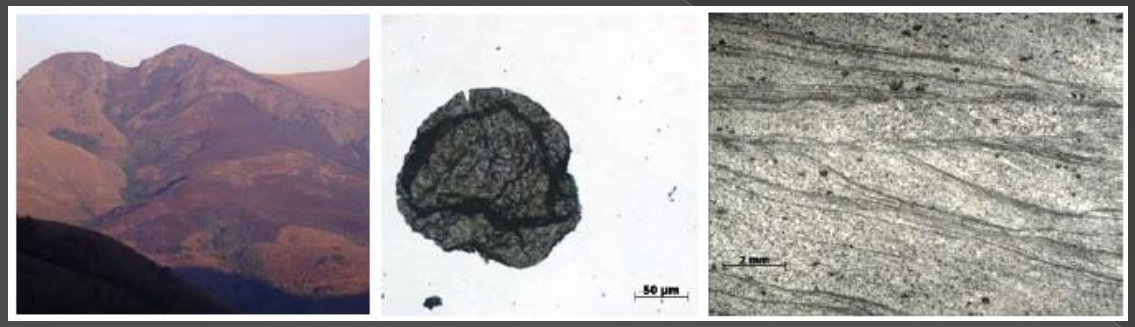
Early microbial ecosystem in the mesoarchean ocean

nature

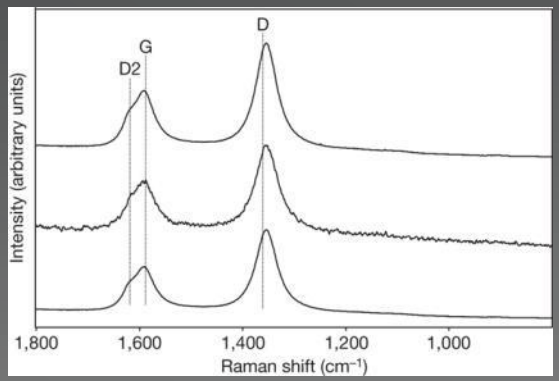
LETTERS

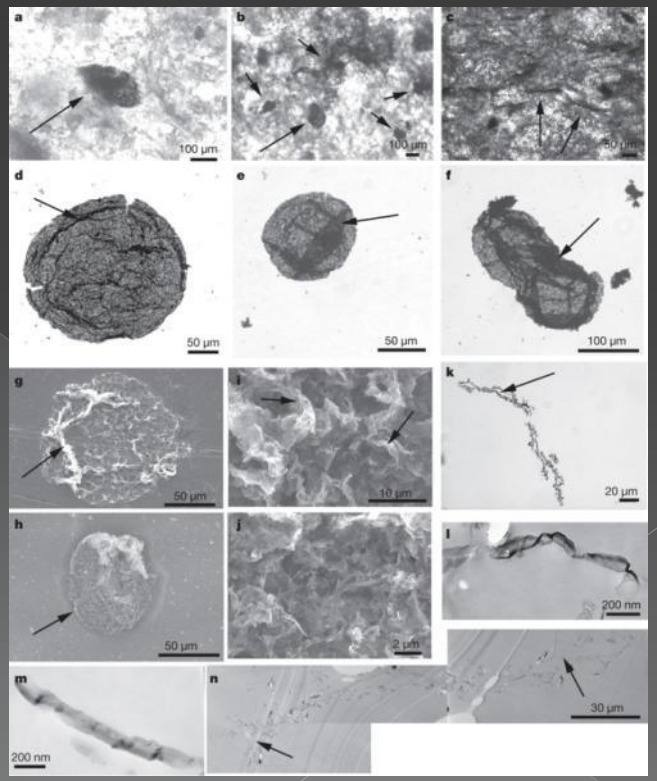
Organic-walled microfossils in 3.2-billion-year-old shallow-marine siliciclastic deposits

Emmanuelle J. Javaux[1], Craig P. Marshall[2] & Andrey Bekker[3]



Barberton, South Africa





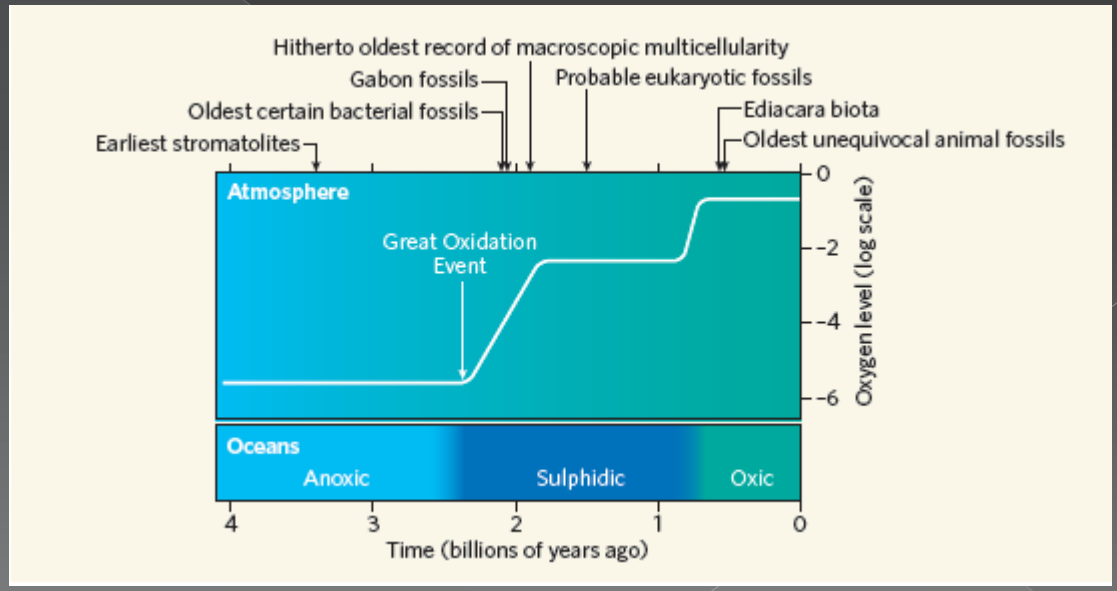
Nature, 463, 934-938, 2010.

Origin and evolution of multicellularity: Macroscopic multicellular life in the Paleoproterozoic

Large colonial organisms with coordinated growth in oxygenated environments 2.1 Gyr ago

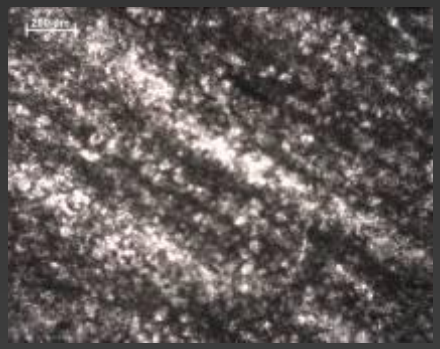
Abderrazak El Albani[1], Stefan Bengtson[2], Donald E. Canfield[3], Andrey Bekker[4], Roberto Macchiarelli[5,6], Arnaud Mazurier[7], Emma U. Hammarlund[2,3,8], Philippe Boulvais[9], Jean-Jacques Dupuy[9], Claude Fontaine[1], Franz T. Fürsich[11], François Gauthier-Lafaye[12], Philippe Janvier[13], Emmanuelle Javaux[14], Frantz Ossa Ossa[1], Anne-Catherine Pierson-Wickmann[9], Armelle Riboulleau[15], Paul Sardini[1], Daniel Vachard[15], Martin Whitehouse[16] & Alain Meunier[1]

Francevillian, Gabon



NATURE|Vol 466|1 July 2010

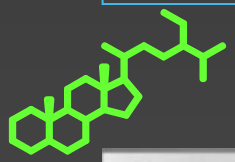
Oxygenation and microbial ecosystem evolution in the early paleoproterozoic



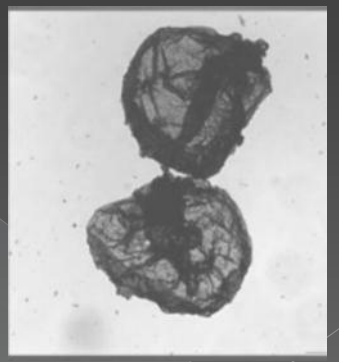
ICDP FAR DEEP

$\delta^{34}S$

$\delta^{13}C$



Karelia, Russia



2.2-1.9 Ga

Microscopy, microchemistry

ESF ArchEnviron

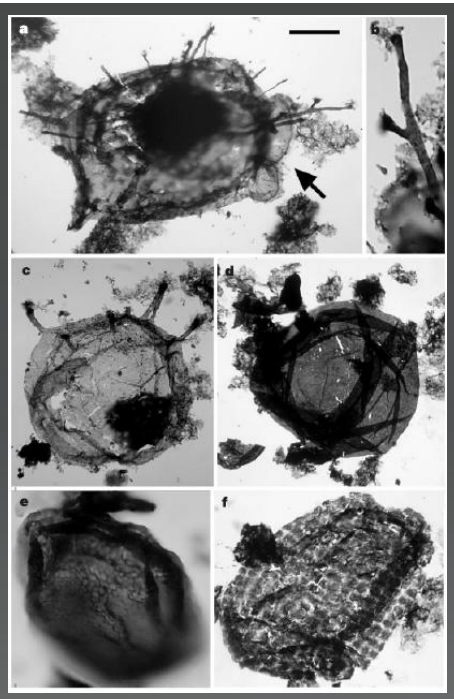
Paleobiology and Evolution of cyanobacteria and early eukaryotes

CC ULG

Morphological and ecological complexity in early eukaryotic ecosystems

NATURE | VOL 412 | 5 JULY 2001 |

Emmanuelle J. Javaux*, Andrew H. Knoll* & Malcolm R. Walter†



ELSEVIER Precambrian Research 138 (2005) 208–224

Combined micro-Fourier transform infrared (FTIR) spectroscopy and micro-Raman spectroscopy of Proterozoic acritarchs: A new approach to Palaeobiology

Craig P. Marshall [a,*], Emmanuelle J. Javaux [b], Andrew H. Knoll [c], Malcolm R. Walter [a]

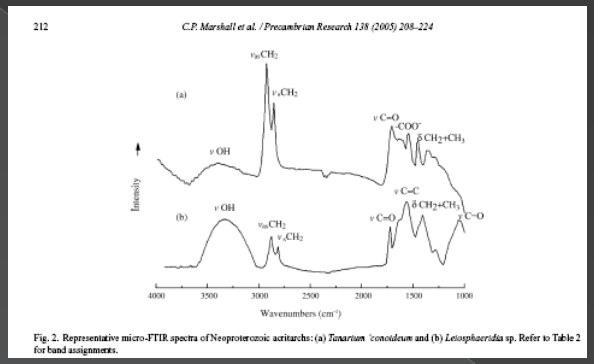
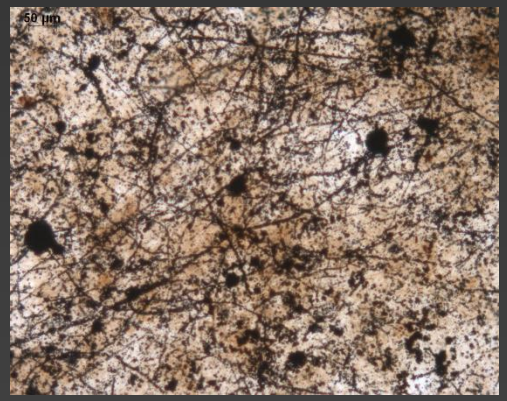
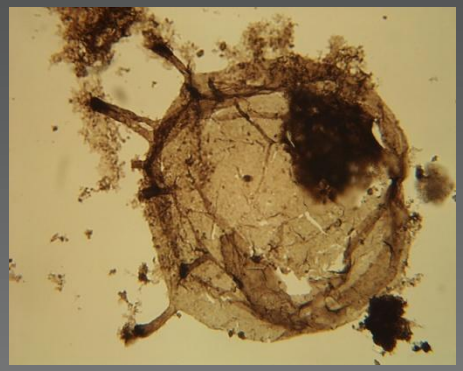


Fig. 2. Representative micro-FTIR spectra of Neoproterozoic acritarchs: (a) *Tanarium conoideum* and (b) *Leiosphaeridia* sp. Refer to Table 2 for band assignments.

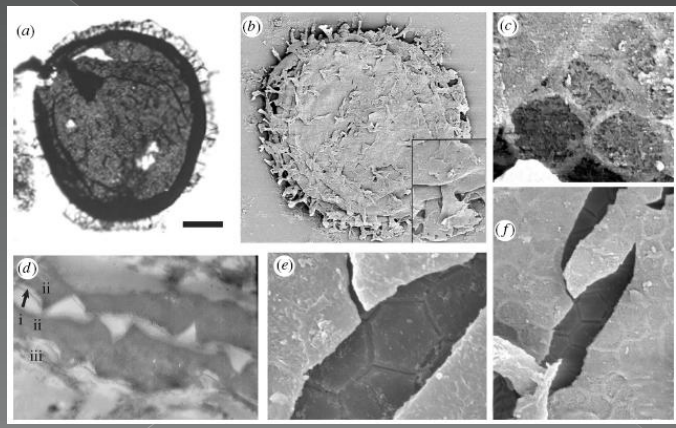




Geobiology (2004), 2, 121–132

TEM evidence for eukaryotic diversity in mid-Proterozoic oceans

EMMANUELLE J. JAVAUX[1], ANDREW H. KNOLL[2] AND MALCOLM R. WALTER[3]



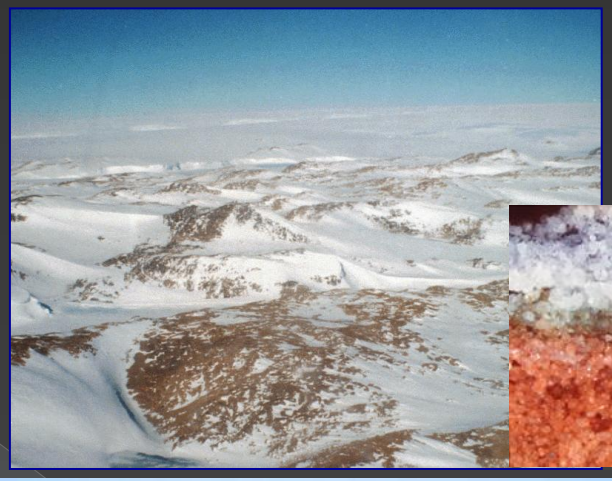
DESCRIPTION AND MICROSCALE ANALYSIS OF SOME ENIGMATIC PALYNOMORPHS FROM THE MIDDLE DEVONIAN (GIVETIAN) OF LIBYA

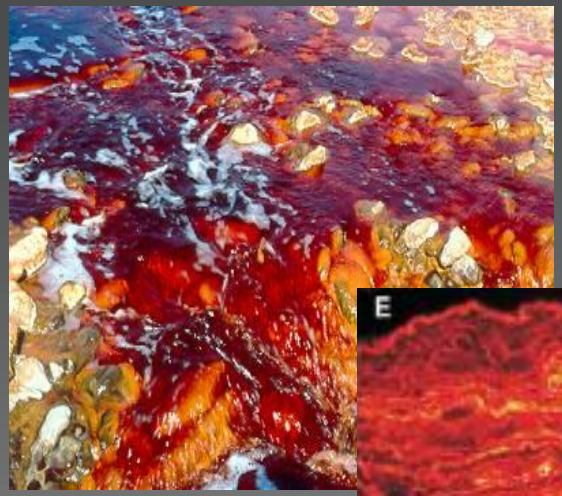
PALYNOLOGY, VOLUME 33 — 2009

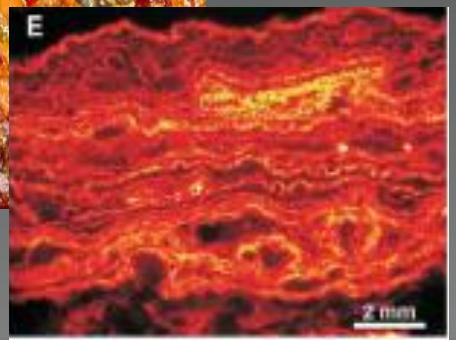
P. Steemans, E. Javaux, P. Breuer, A. Le Hérissé, C.P. Marshall, F. de Ville de Goyet

ESF CAREX

Preservation of traces of life in extreme environments

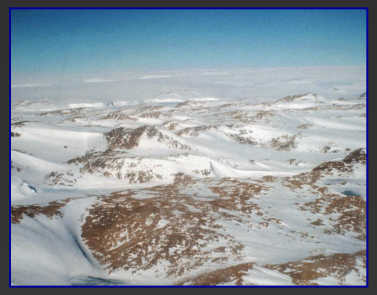






ESF CAREX

FRFC 2009-13

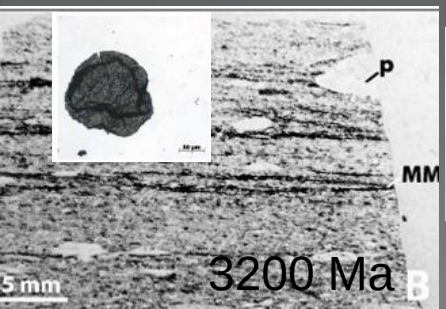


- *Fossilisation of cyanobacteria: phylogenetic, micropaleontological and sedimentological approaches and implications for the early biosphere evolution*

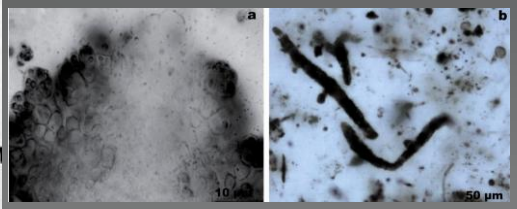
  (PI: Javaux, co-I: Wilmotte, Fagel, FNRS postdoc: K Lepot; coll BAS, U Gent)

lac Nella,
Larsemann Hills, 70°S

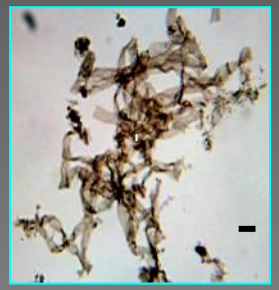
- Characterization of diagnostic cyanobacteria biomarkers
  - microscopy (morphology, ultrastructure, pigments fluorescence),
  - microchemistry (micro-FTIR, HPLC),
  - sedimentology-mineralogy (IR, MEB, XRD)
  - Genetics (see AW)
  - Artificial Fossilisation
- Comparison with fossil mats and microfossils



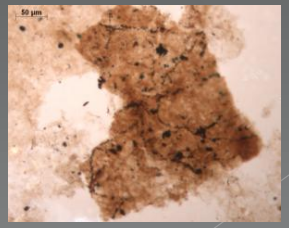
3200 Ma



1900 Ma



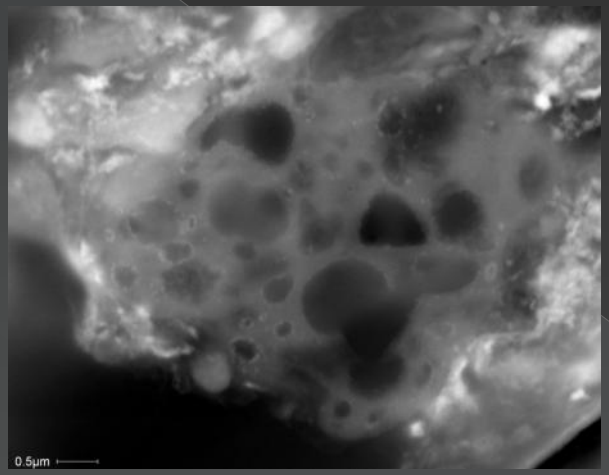
1500 Ma



800 Ma

today

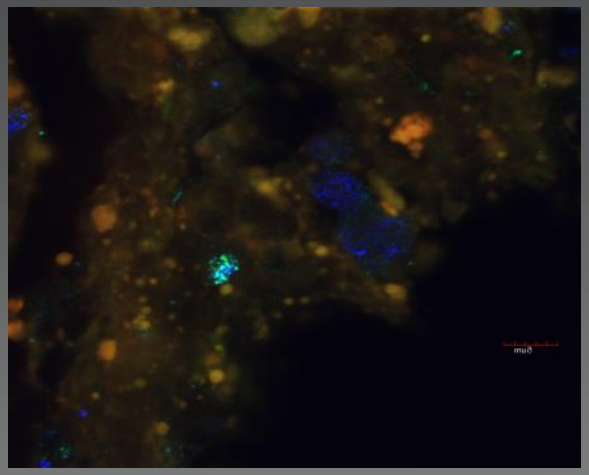
MEB
Coccoidal microfossils and EPS
in situ in sediments



Organo-mineral imprints in fossil cyanobacterial mats of an Antarctic lake

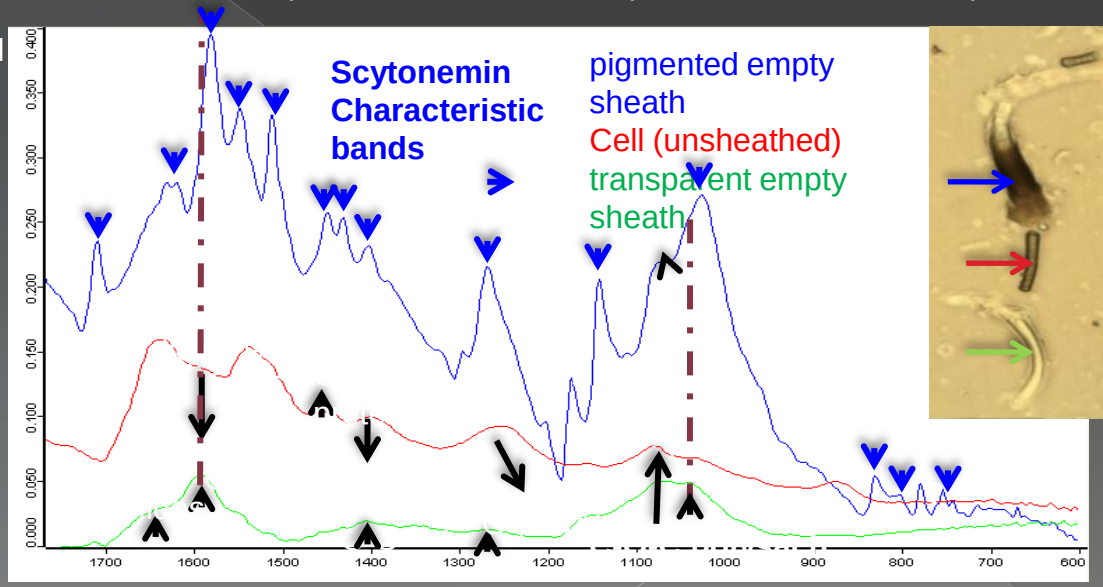
Kevin Lepot[1], Léo Deremiens[2], Zorigto Namsaraev[2,7], Philippe Compère[3], Emmanuelle Gérard[4], Elie Verleyen[5], Ines Tavernier[5], Dominic A. Hodgson[6], Wim Vyverman[5], Annick Wilmotte[2], Emmanuelle Javaux[1]

In-situ Fluorescence by Cyanobacterial pigments (orange) and carbonate grains (blue) with laser confocal scanning microscope



Micro-IR spectroscopy on fresh and artificially fossilized cyanobacteria cells/sheaths (culture)

EDTA separation cells / sheaths (calothrix s39 CULTURE)



Astrobiology

Astron Astrophys Rev
DOI 10.1007/s00159-010-0030-4

REVIEW ARTICLE

Habitability: from stars to cells

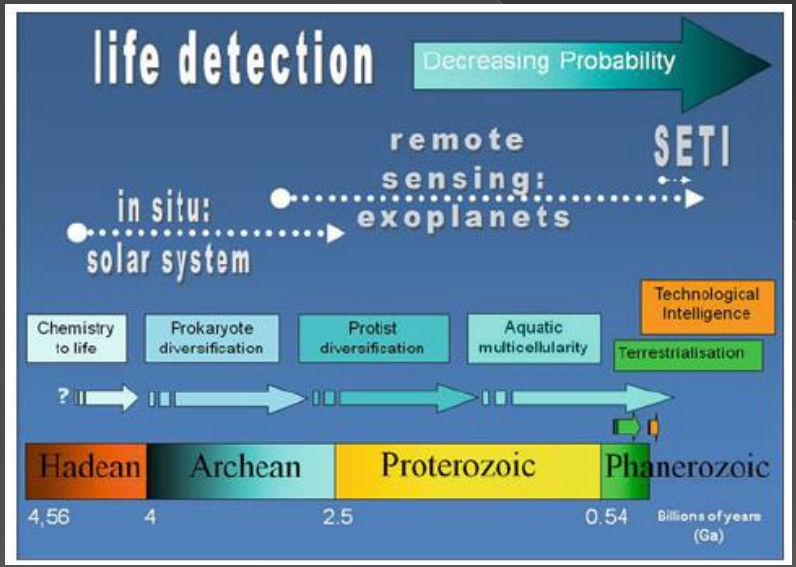
Emmanuelle J. Javaux · Véronique Dehant

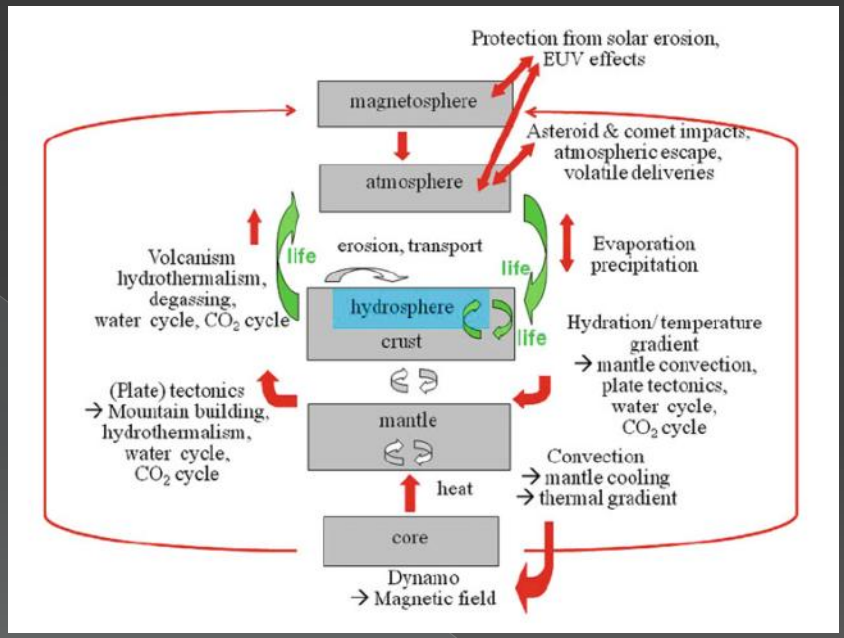
Space Sci Rev
DOI 10.1007/s11214-008-9357-9

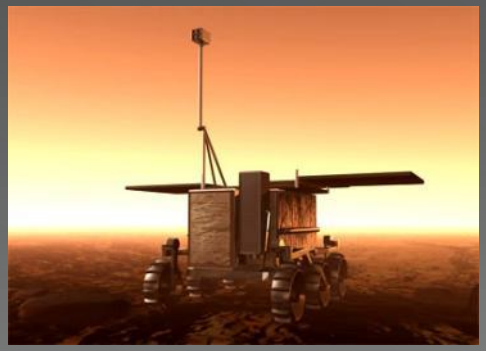
"Strategies of Life Detection": Summary and Outlook

Oliver Botta · Jeffrey L. Bada · Javier Gomez-Elvira · Emmanuelle Javaux · Franck Selsis · Roger Summons

Received: 22 February 2008 / Accepted: 22 February 2008







- projet AYA2009-11681 Research and Innovation Ministery of Spain *Identification of potential habitats for life on Early Mars using recent planetary data, terrestrial analogs and experimental modeling (4y)*

CLUPI- EXOMARS ESA

FNRS Contact group www.astrobio/oma.be