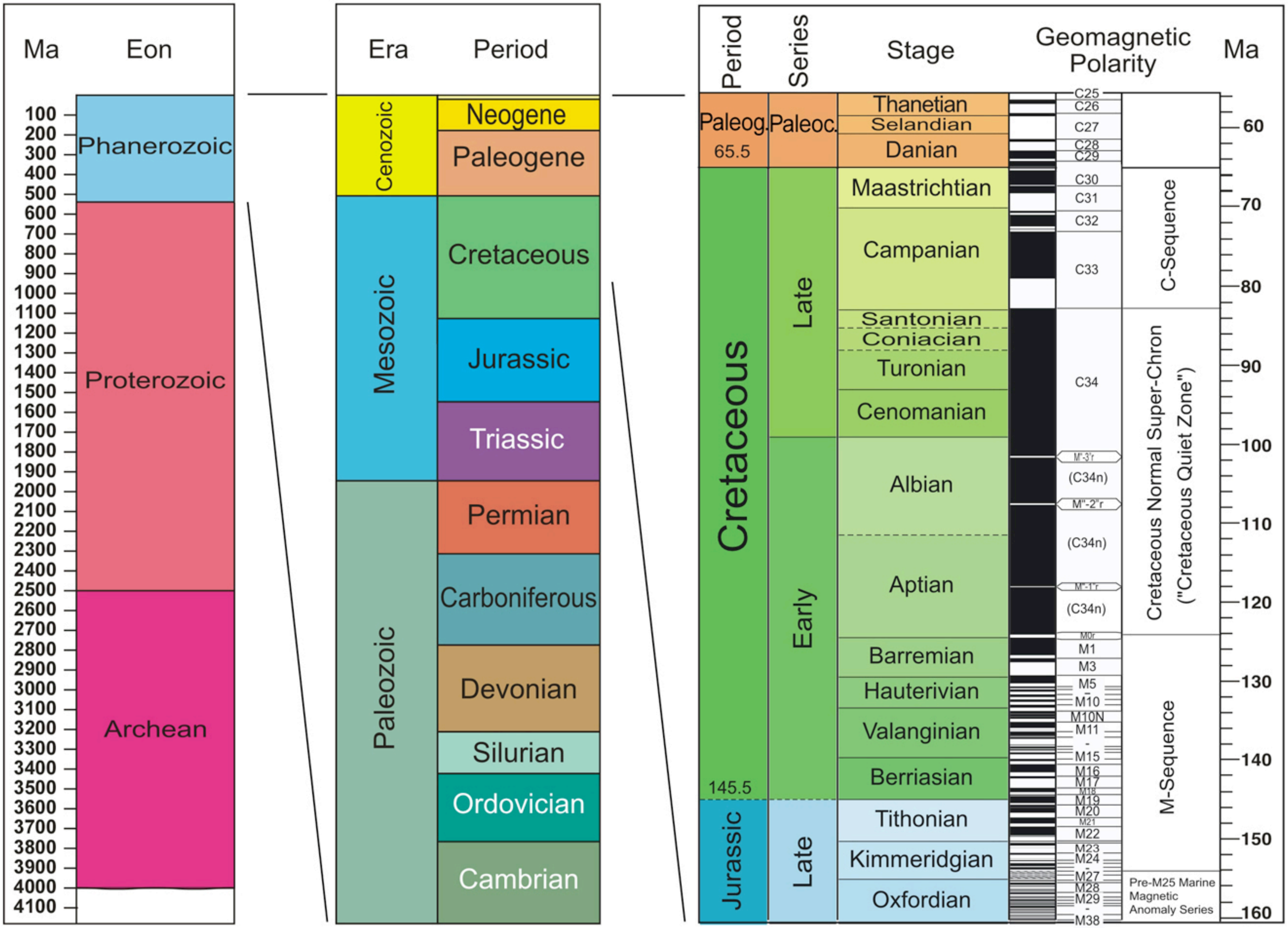
Cretaceous Geomagnetic Polarity Time Scale 2010

modified from Concise Geologic Time Scale (Ogg et al., 2008)



Cretaceous Geomagnetic Polarity Time Scale 2010

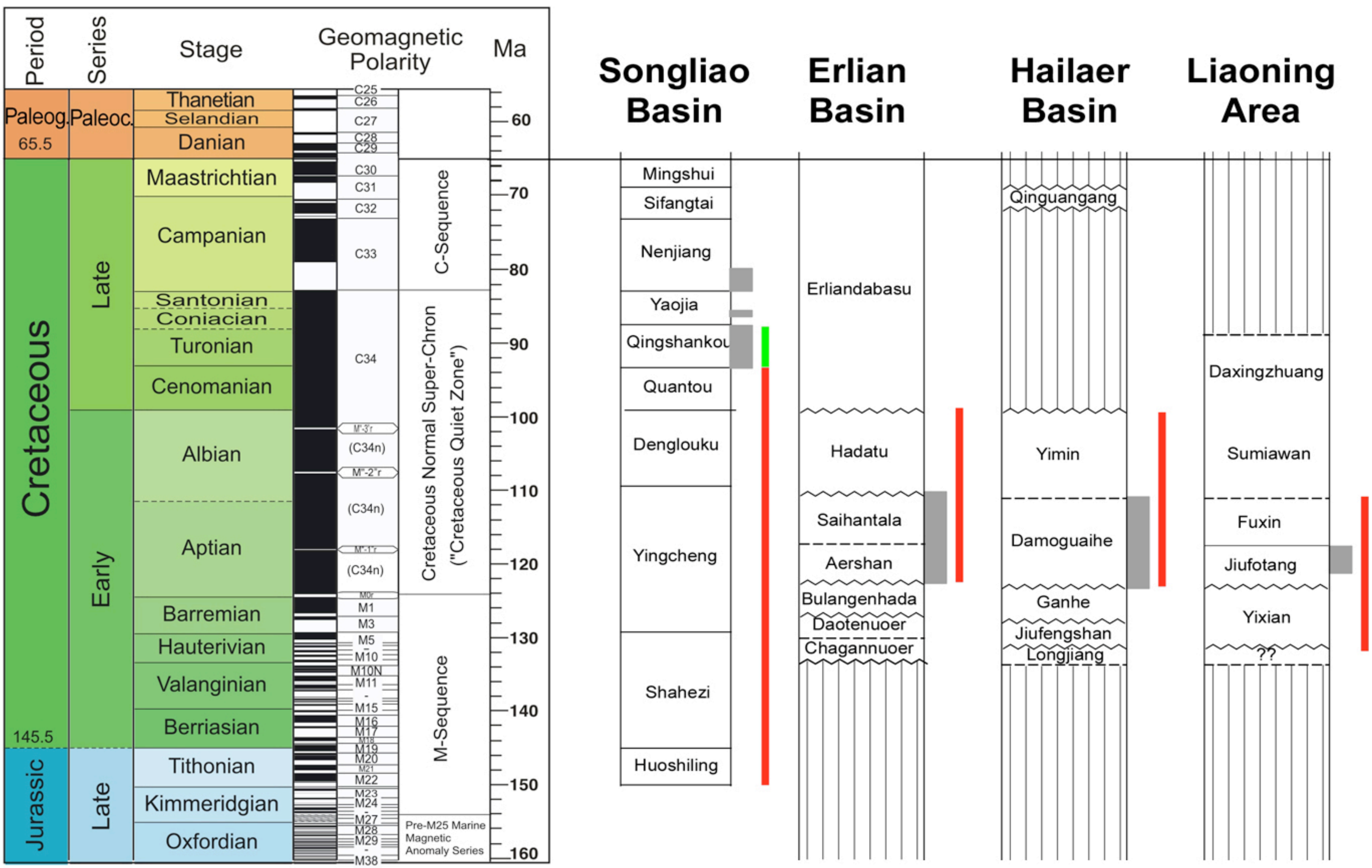
ICS

modified from Concise Geologic Time Scale (Ogg et al., 2008)

Project Intervals

Wu et al. 2009

Petroleum Source rocks



Why the Cretaceous Timescale in continental sequences in northeast China and eastern Inner Mongolia?

1. Early Cretaceous timescale is poorly constrained because more than ½ (Aptian-Albian) is in the Cretaceous normal superchron.

2. Early Cretaceous is well beyond reliability of numerical solutions of the planets and geological records provide constraints on fundamental frequencies it if we have high latitude records paired with low latitude ones with the long eccentricity cycles.

3. Northeast China and eastern Inner Mongolia sequences preserve Early Cretaceous lacustrine strata often with datable ashes which we can expect to yield an record of relatively local climate forcing with an orbital chronology including strong obliquity as well as precession from the high latitudes. Perfect counterpoint to low latitude petroliferous Aptian-Albian cyclical lacustrine strata or Brazil that would be expected to have excellent orbital chronology (but lack datable ashes).

4. Early Cretaceous of northeast China and eastern Inner Mongolia have unsurpassed record of life but lack good timescale or mechanisms for high-resolution correlation that can be provided by an orbital chronology.

5. Early Cretaceous of northeast China and eastern Inner Mongolia have significant petroleum source rocks and a well developed orbital timescale can help understand mechanisms of source rock development.

Establishing the Cretaceous orbital Timescale in Continental Sequences

1: Obtain long records of lacustrine environmental change.

2. Produce Fourier , evolutive Fourier, and Wavelet spectra of records in the depth domain (thickness, without age model). Examine for linkages between multiple frequencies spanning 3 orders of magnitude that are the fingerprint of orbital forcing.

3. Develop age-model for sequence by tuning or direct dating by ashes or lava flows.

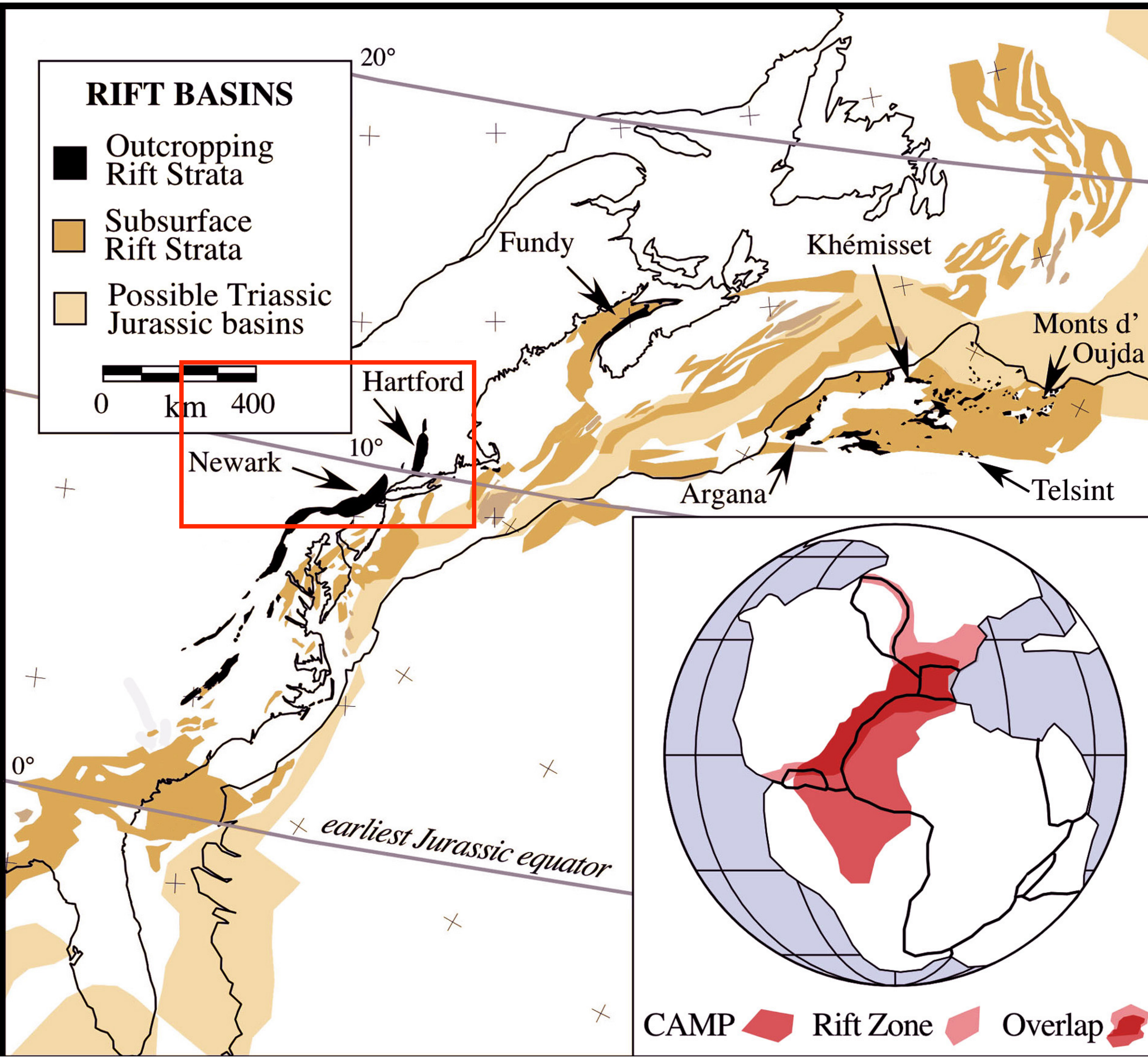
4. Examine spectral properties of tuned record. Tuning to one frequency must tune the others in an orbital record and must agree with radioisotopic constraints.

5. Identify long period eccentricity cycles at the 100,000 to 2,000,000 year level and their phase relationships for correlations laterally.

6. Build very long composite record and timescale by correlating sections in different basins.

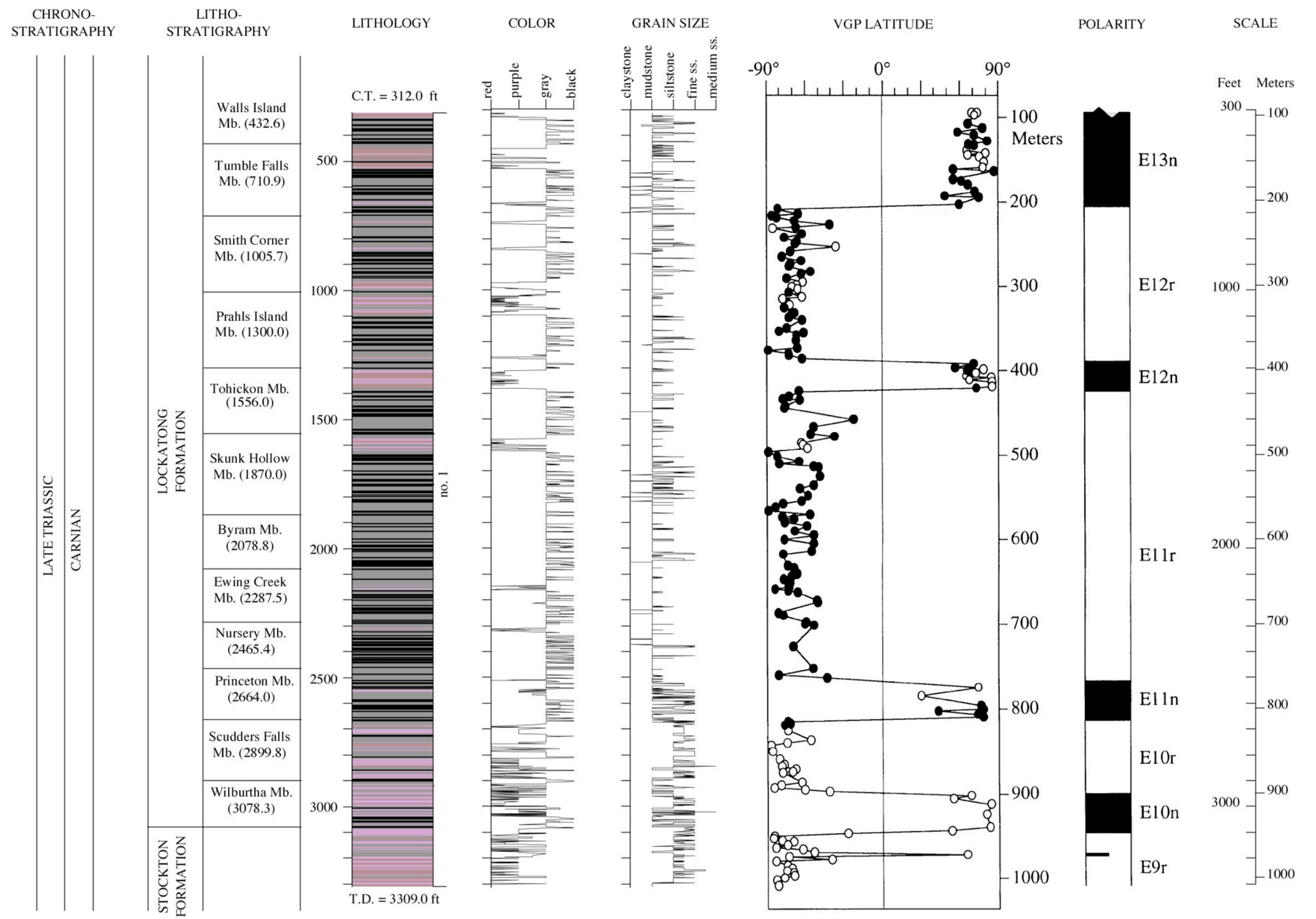
Example 1:
Triassic-Jurassic Newark Supergroup in Eastern North America

(Paul Olsen & Dennis Kent: 1995-2010)


RIFT BASINS
Outcropping Rift Strata
Subsurface Rift Strata
Possible Triassic Jurassic basins
0 km 400
20°
10°
0°
Fundy
Hartford
Newark
Khémisset
Monts d' Oujda
Argana
Telsint
earliest Jurassic equator
CAMP
Rift Zone
Overlap

Late Triassic, Lockatong Formation, Eureka, PA

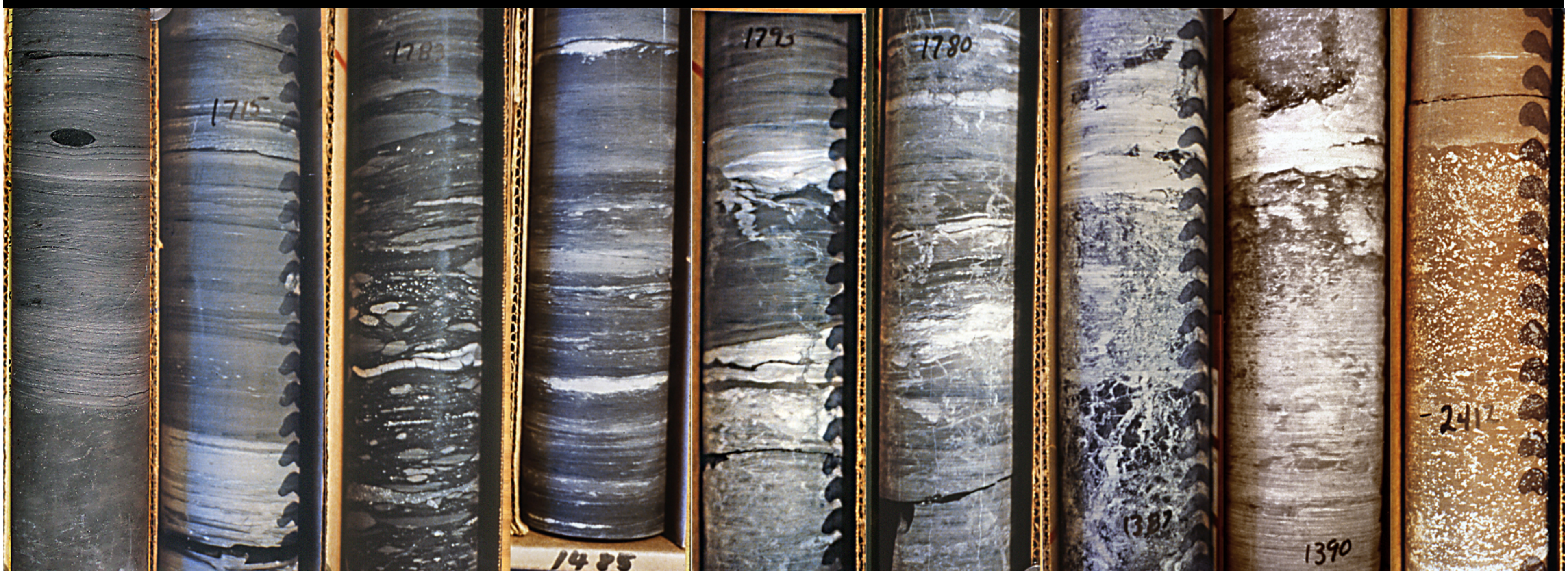
NURSERY # 1



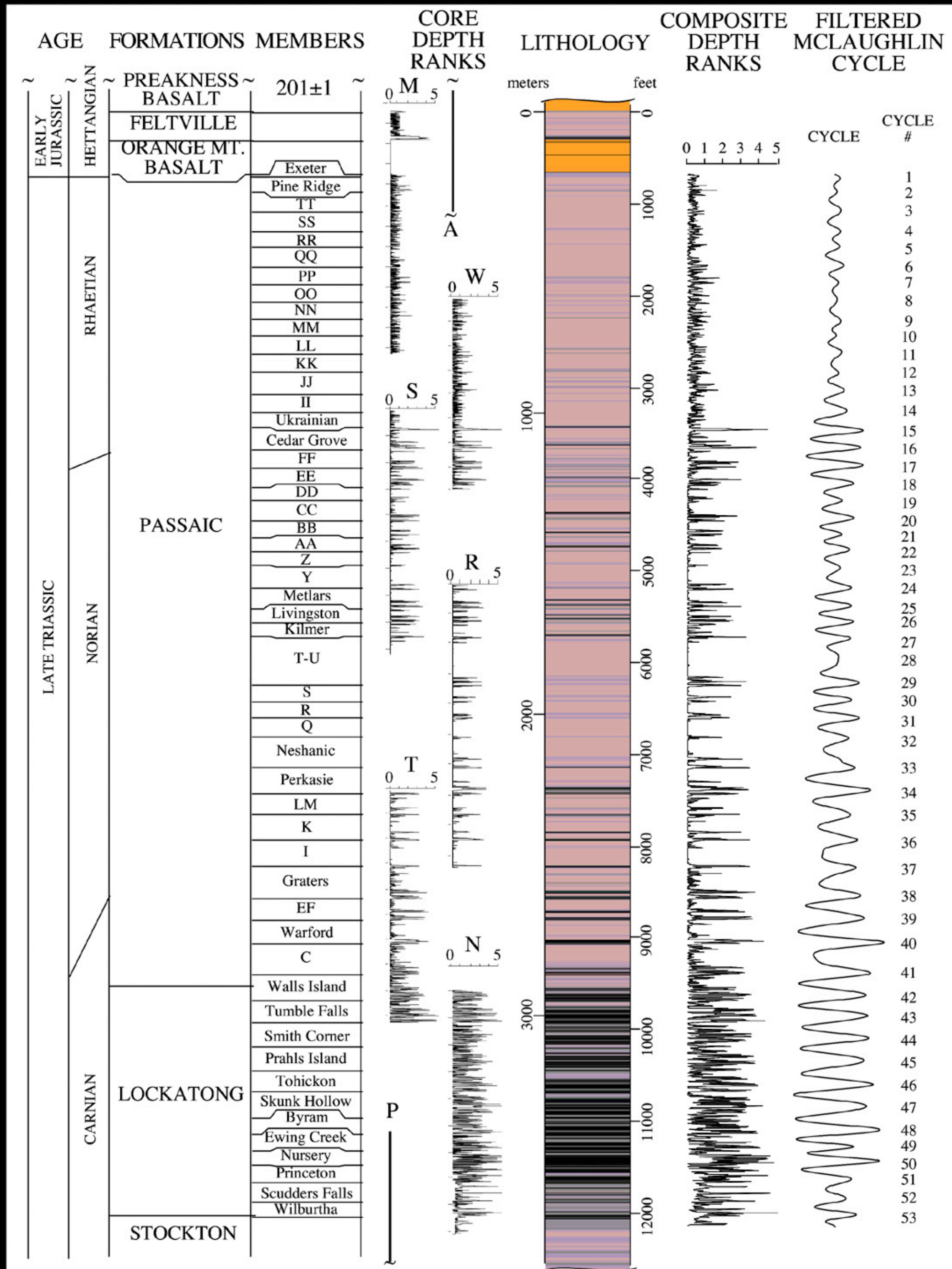
CHRONO-
STRATIGRAPHY
LITHO-
STRATIGRAPHY
LITHOLOGY
COLOR
GRAIN SIZE
VGP LATITUDE
POLARITY
SCALE
LATE TRIASSIC
CARNIAN
LOCKATONG
FORMATION
STOCKTON
FORMATION
Walls Island Mb. (432.6)
Tumble Falls Mb. (710.9)
Smith Corner Mb. (1005.7)
Prahls Island Mb. (1300.0)
Tohickon Mb. (1556.0)
Skunk Hollow Mb. (1870.0)
Byram Mb. (2078.8)
Ewing Creek Mb. (2287.5)
Nursery Mb. (2465.4)
Princeton Mb. (2664.0)
Scudders Falls Mb. (2899.8)
Wilburtha Mb. (3078.3)
C.T. = 312.0 ft
500
1000
1500
2000
2500
3000
T.D. = 3309.0 ft
no. 1
red
purple
gray
black
claystone
mudstone
siltstone
fine ss.
medium ss.
-90°
0°
90°
100
Meters
200
300
400
500
600
700
800
900
1000
E13n
E12r
E12n
E11r
E11n
E10r
E10n
E9r
Feet
Meters
300
100
200
1000
300
400
500
2000
600
700
800
3000
900
1000

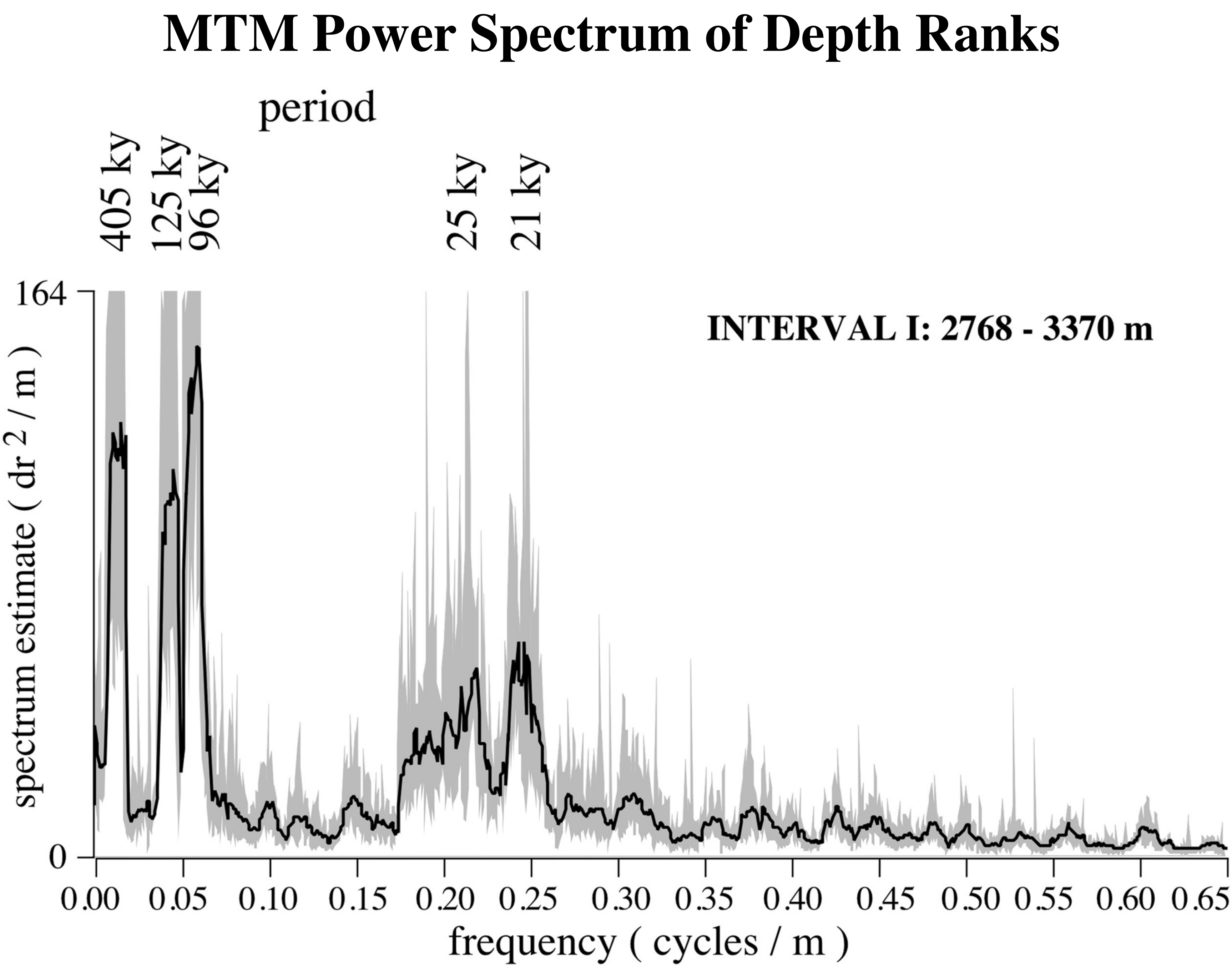
Depth Ranks

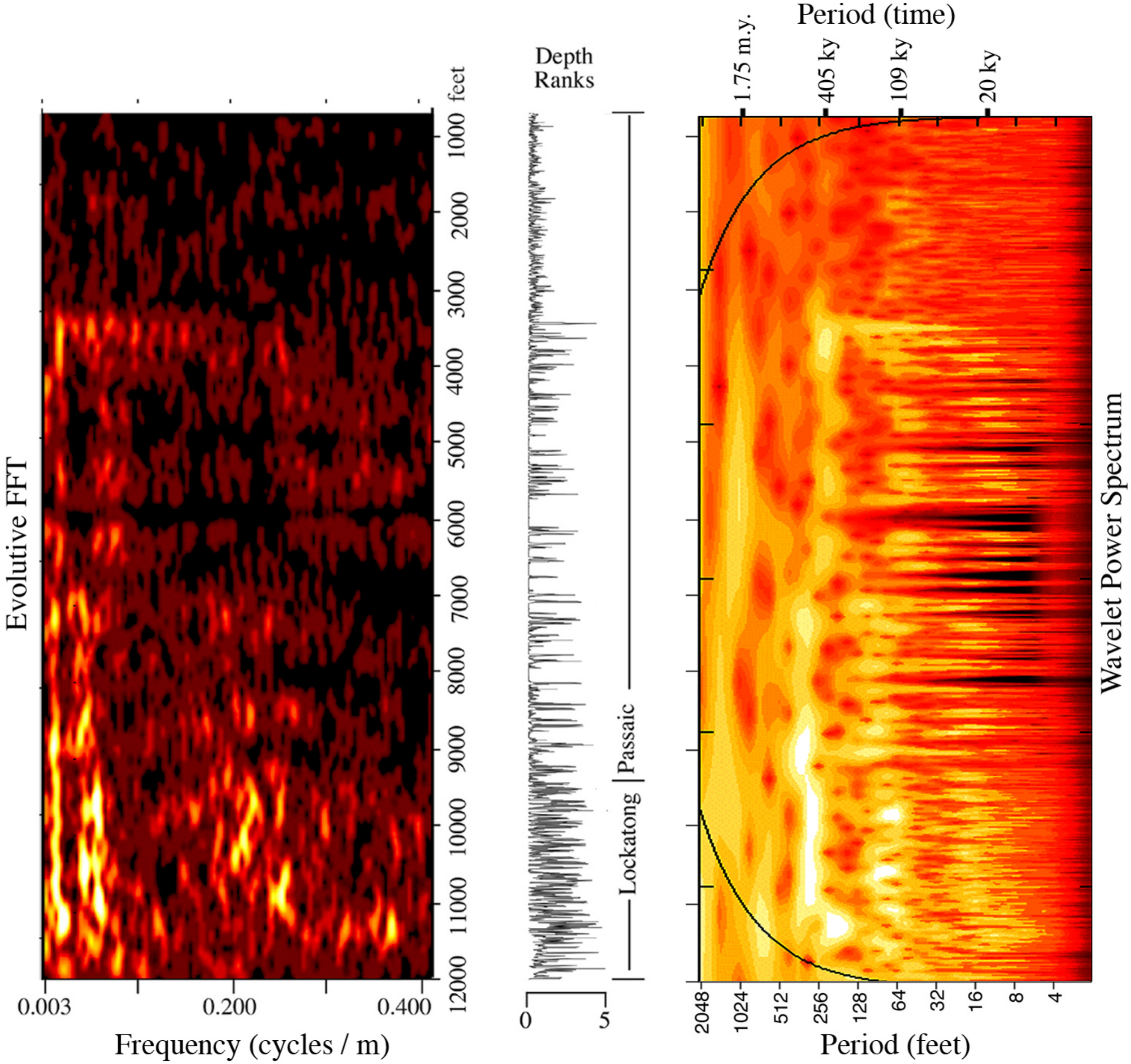
5 4 3.5 3 2 1.5 1 0.5 0



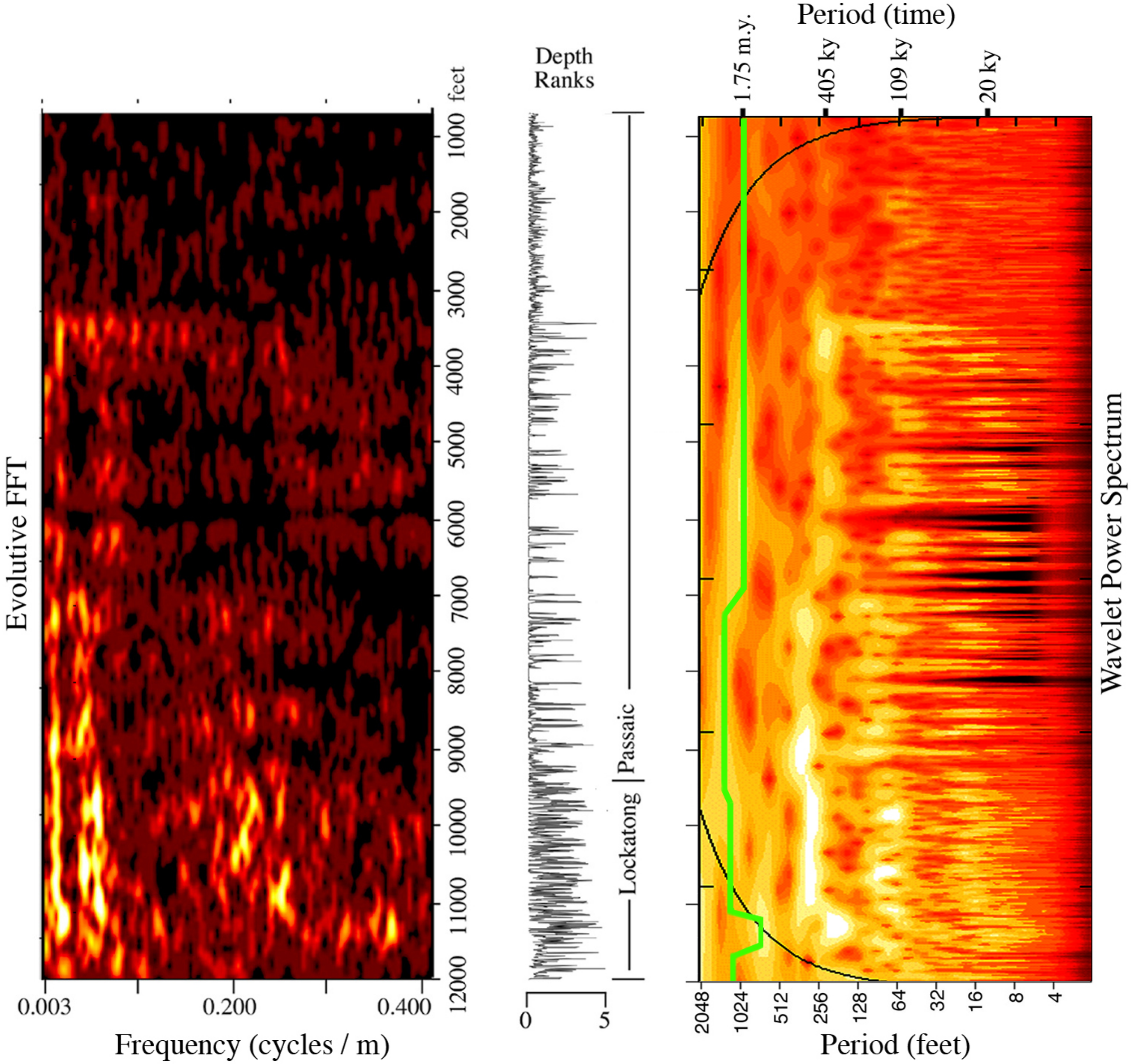
Examples of Cores


AGE
FORMATIONS
MEMBERS
CORE DEPTH RANKS
LITHOLOGY
COMPOSITE DEPTH RANKS
FILTERED MCLAUGHLIN CYCLE
EARLY JURASSIC
HETTANGIAN
RHAETIAN
NORIAN
CARNIAN
LATE TRIASSIC
PREAKNESS BASALT
201±1
FELTVILLE
ORANGE MT. BASALT
PASSAIC
LOCKATONG
STOCKTON
Exeter
Pine Ridge
TT
SS
RR
QQ
PP
OO
NN
MM
LL
KK
JJ
II
Ukrainian
Cedar Grove
FF
EE
DD
CC
BB
AA
Z
Y
Metlars
Livingston
Kilmer
T-U
S
R
Q
Neshanic
Perkasie
LM
K
I
Graters
EF
Warford
C
Walls Island
Tumble Falls
Smith Corner
Prahls Island
Tohickon
Skunk Hollow
Byram
Ewing Creek
Nursery
Princeton
Scudders Falls
Wilburtha
M
A
W
S
R
T
N
P
meters
feet
CYCLE
CYCLE #

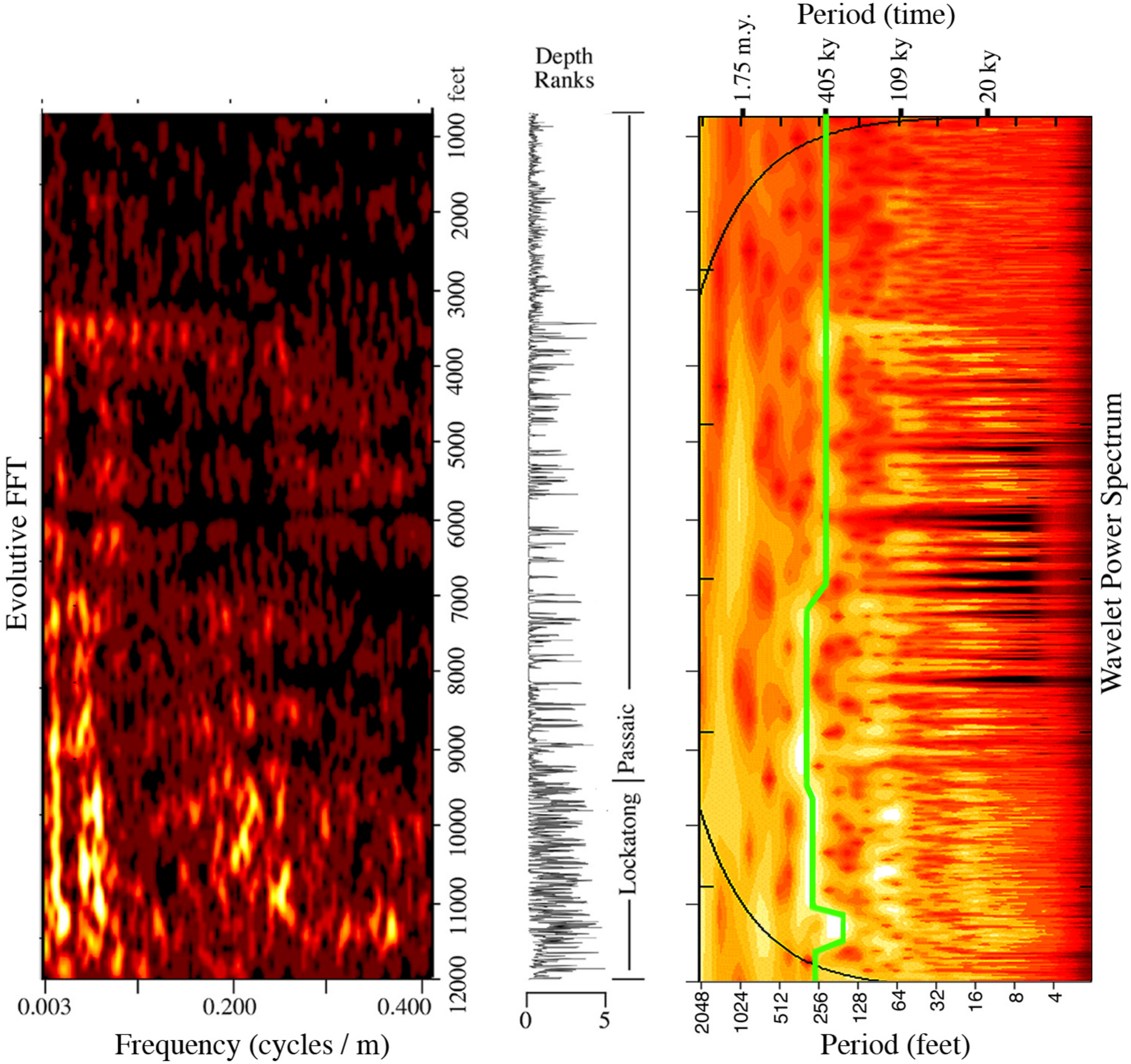

MTM Power Spectrum of Depth Ranks
period
405 ky
125 ky
96 ky
25 ky
21 ky
164
0
INTERVAL I: 2768 - 3370 m
spectrum estimate (dr 2 / m)
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65
frequency (cycles / m)



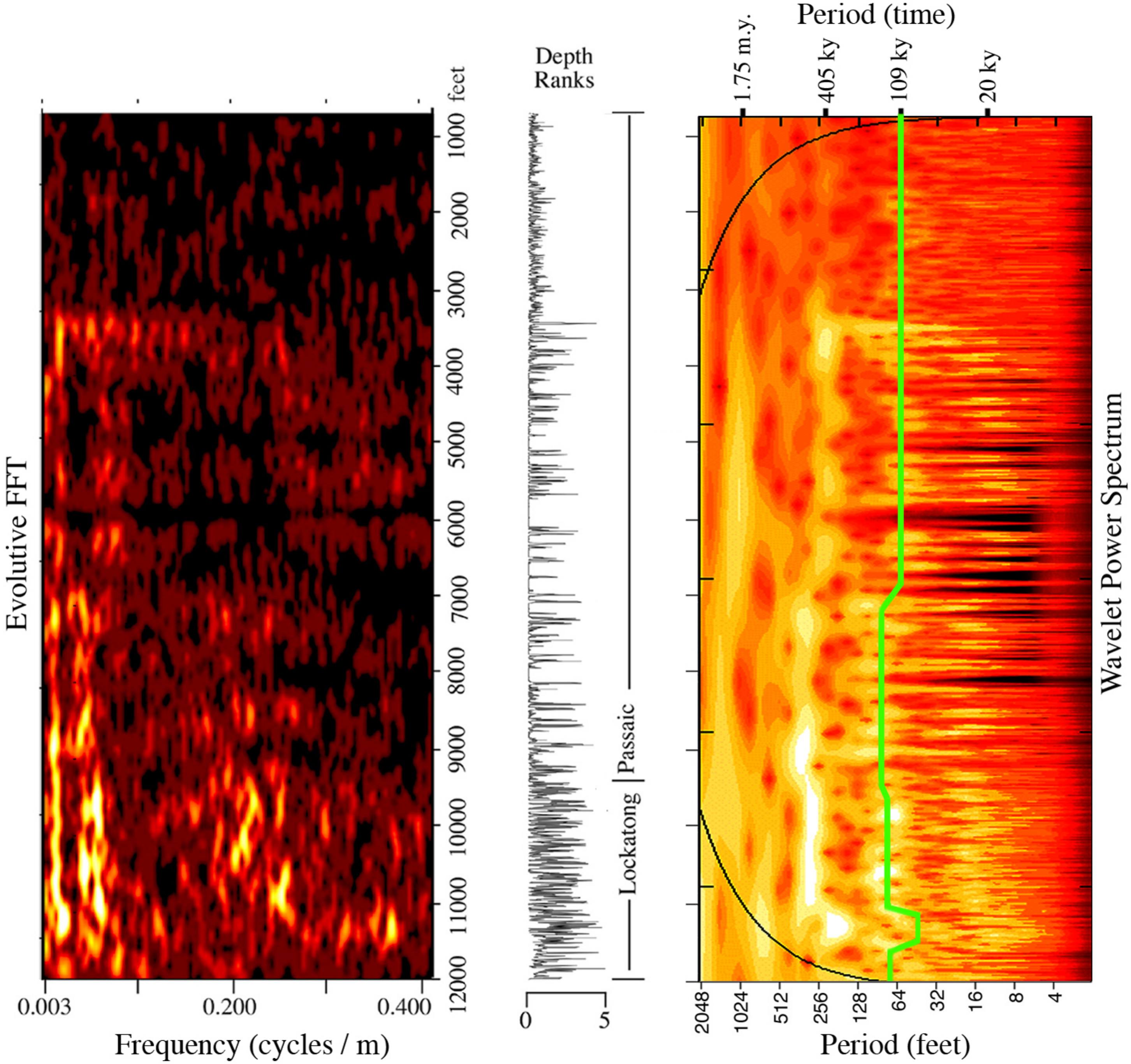
Evolutive FFT
feet
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0.003
0.200
0.400
Frequency (cycles / m)
Depth
Ranks
0
5
Lockatong
Passaic
Period (time)
1.75 m.y.
405 ky
109 ky
20 ky
2048
1024
512
256
128
64
32
16
8
4
Period (feet)
Wavelet Power Spectrum



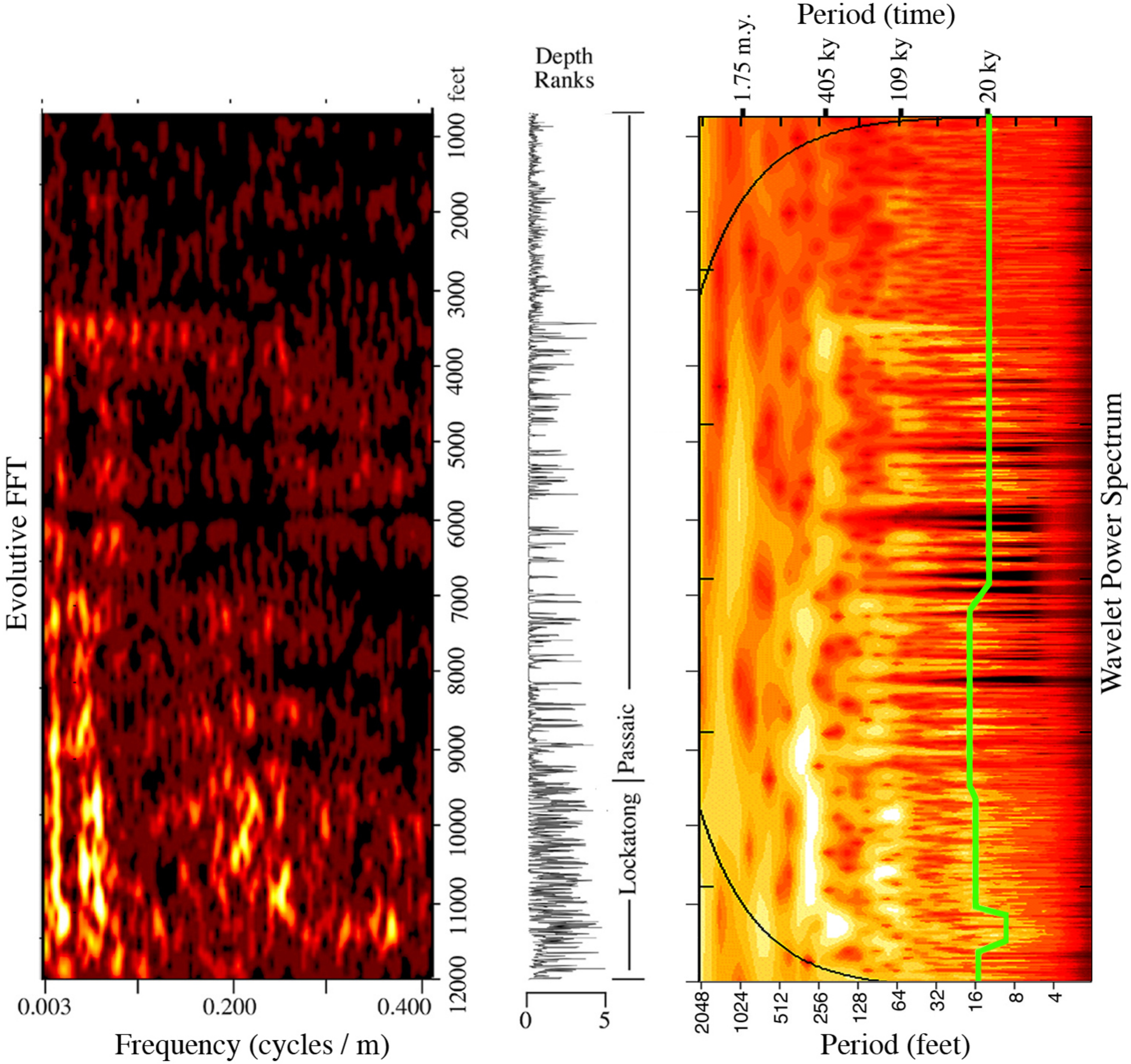
Evolutive FFT
feet
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0.003
0.200
0.400
Frequency (cycles / m)
Depth
Ranks
0
5
Lockatong
Passaic
Period (time)
1.75 m.y.
405 ky
109 ky
20 ky
2048
1024
512
256
128
64
32
16
8
4
Period (feet)
Wavelet Power Spectrum



Evolutive FFT
feet
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0.003
0.200
0.400
Frequency (cycles / m)
Depth Ranks
0
5
Lockatong
Passaic
Period (time)
1.75 m.y.
405 ky
109 ky
20 ky
2048
1024
512
256
128
64
32
16
8
4
Period (feet)
Wavelet Power Spectrum

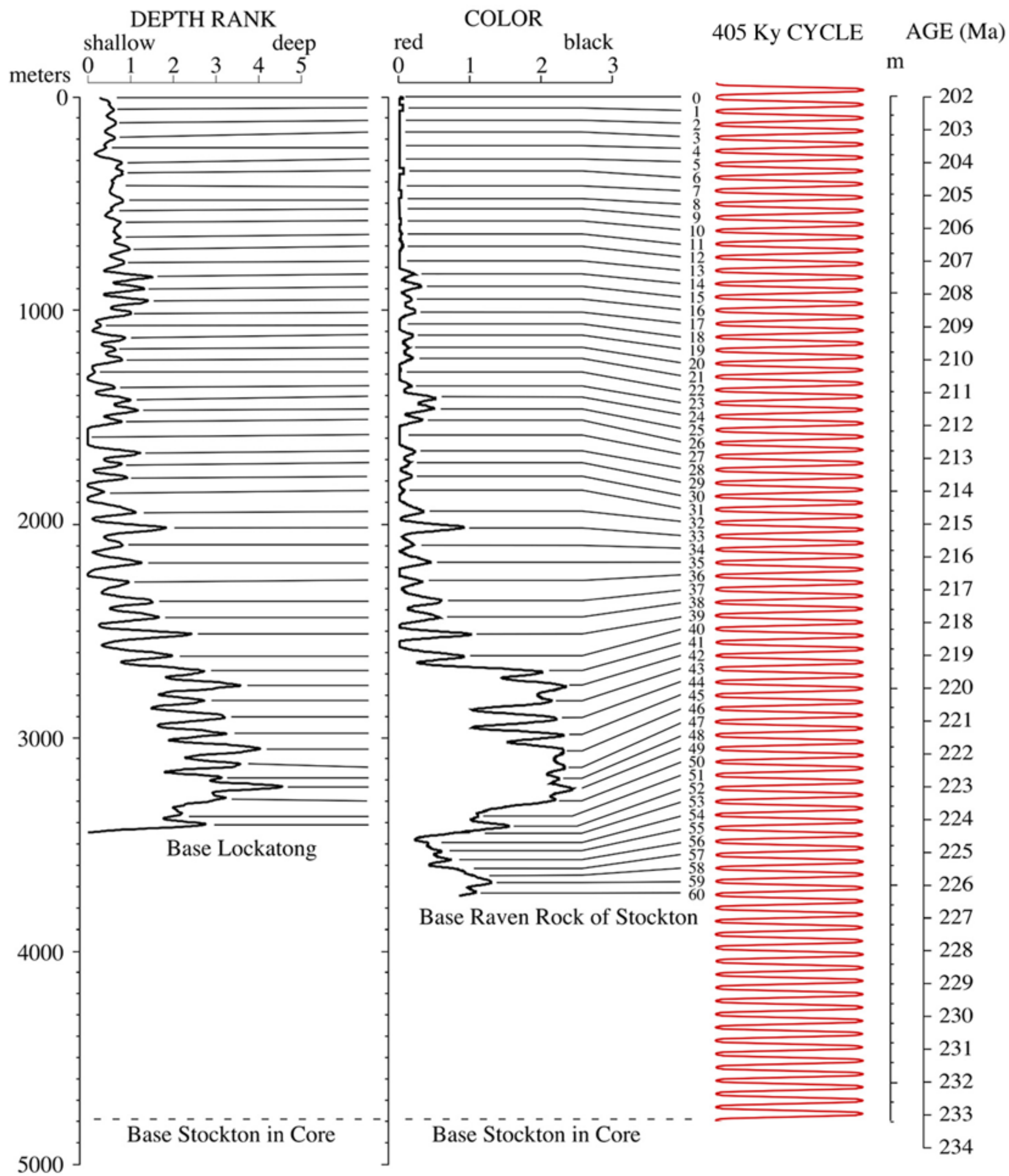


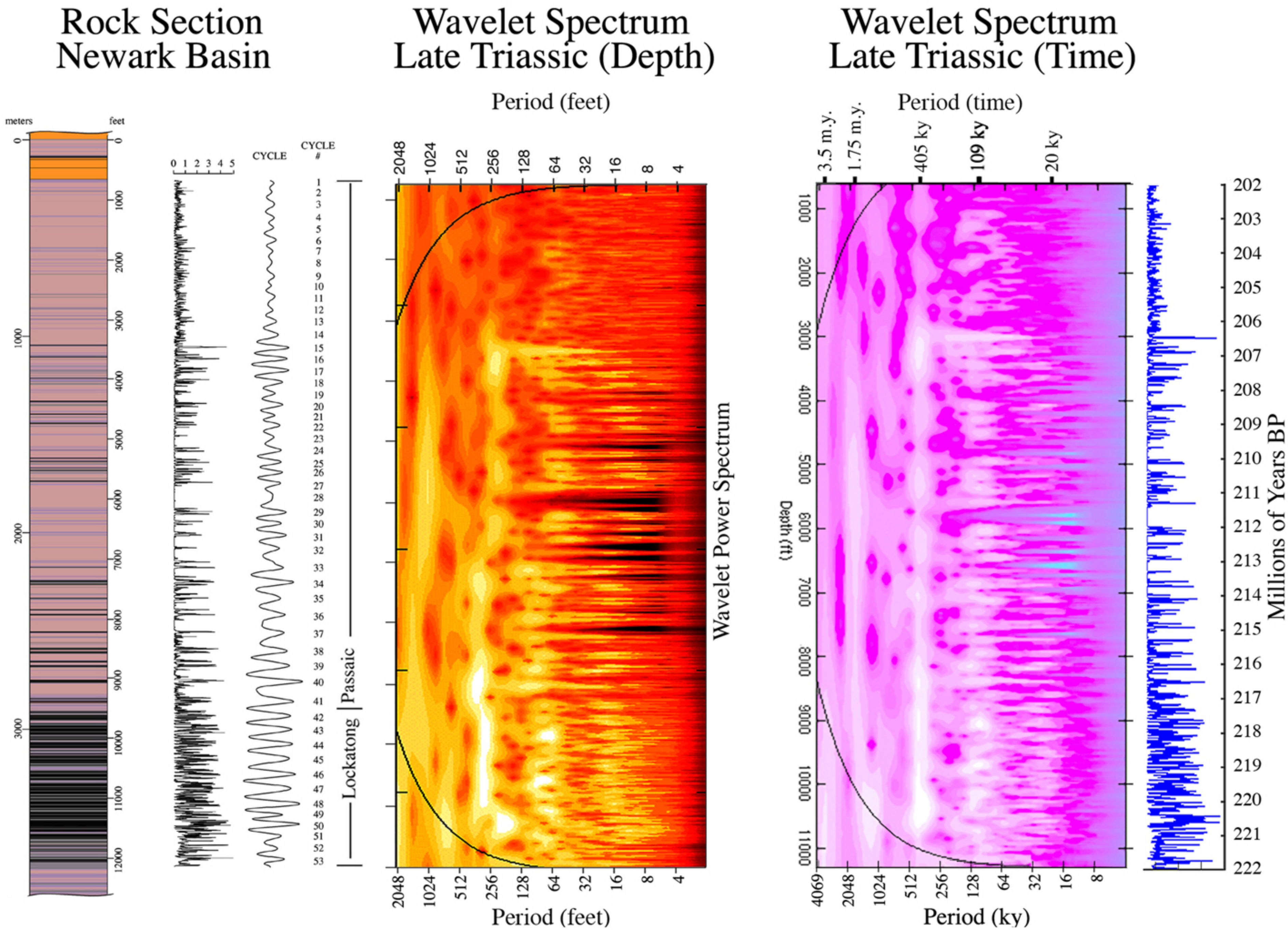
Evolutive FFT
feet
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0.003
0.200
0.400
Frequency (cycles / m)
Depth
Ranks
0
5
Lockatong
Passaic
Period (time)
1.75 m.y.
405 ky
109 ky
20 ky
2048
1024
512
256
128
64
32
16
8
4
Period (feet)
Wavelet Power Spectrum



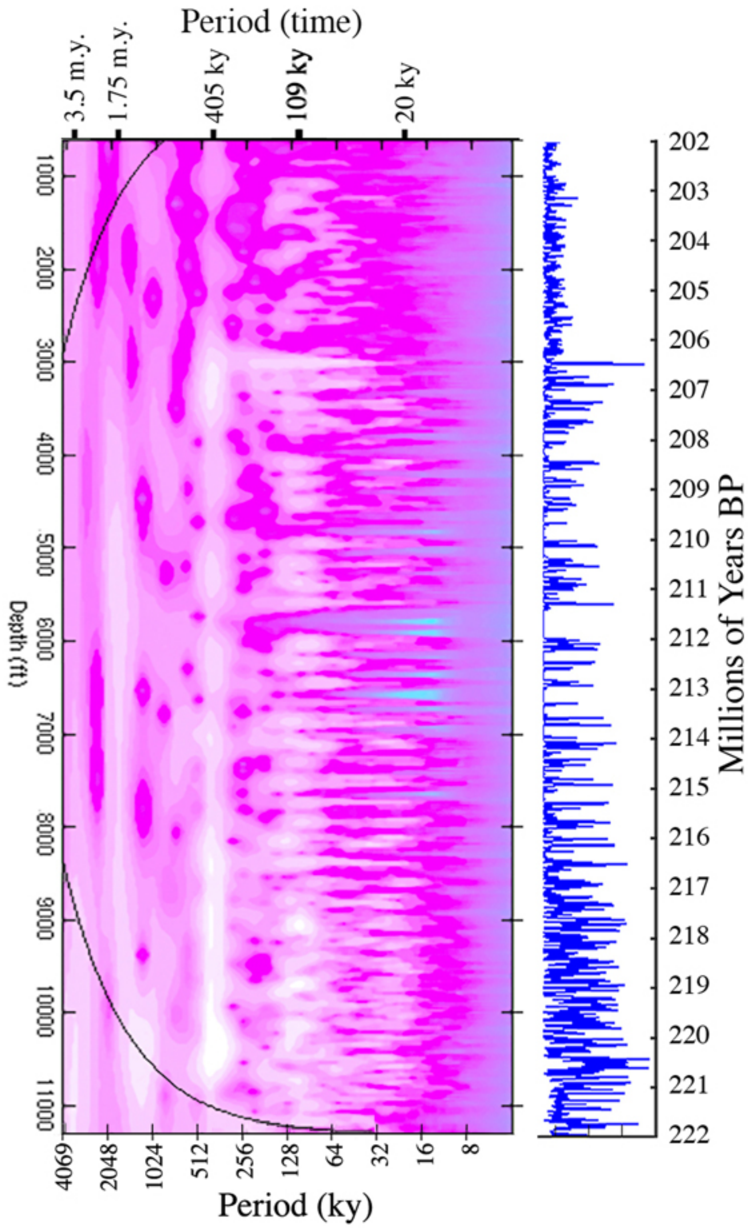
Evolutive FFT
feet
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0.003
0.200
0.400
Frequency (cycles / m)
Depth
Ranks
0
5
Lockatong
Passaic
Period (time)
1.75 m.y.
405 ky
109 ky
20 ky
2048
1024
512
256
128
64
32
16
8
4
Period (feet)
Wavelet Power Spectrum

Tuning to the 405 ky cycle

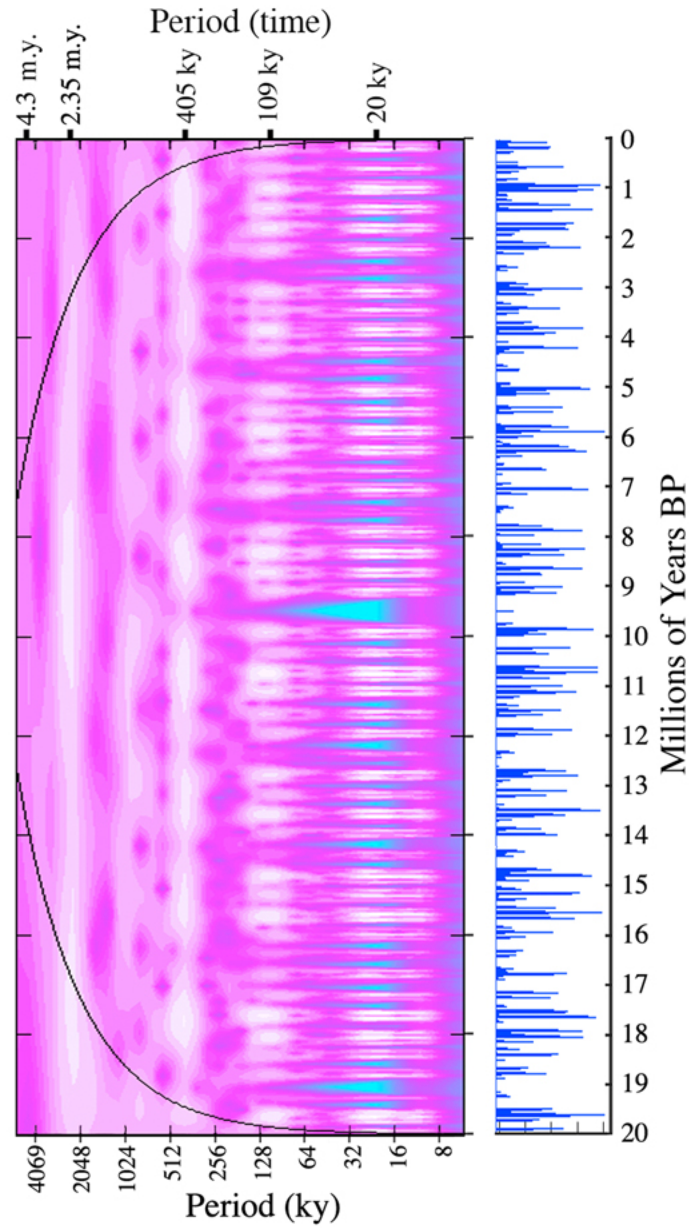


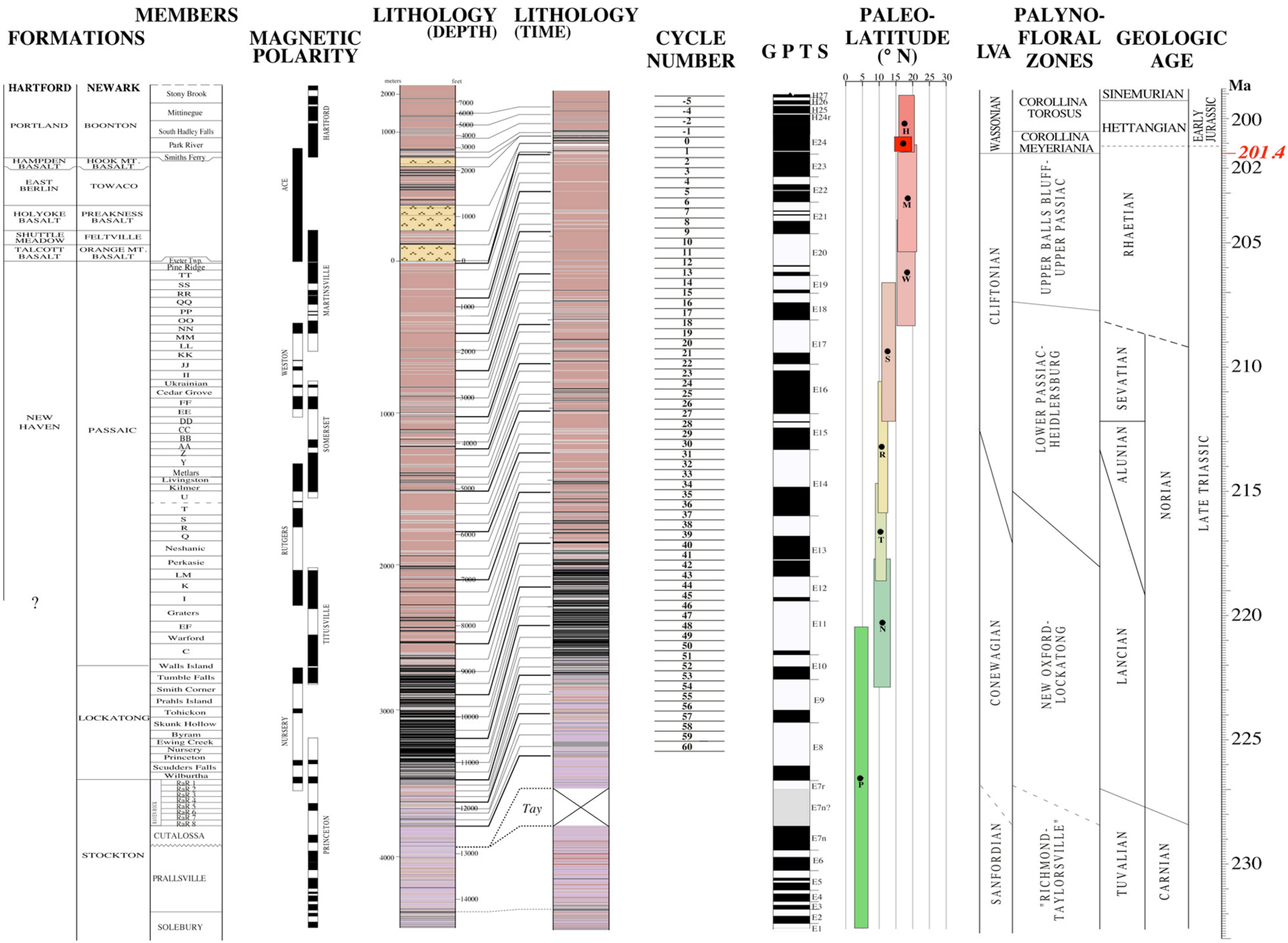

Rock Section
Newark Basin
Wavelet Spectrum
Late Triassic (Depth)
Wavelet Spectrum
Late Triassic (Time)
meters
feet
CYCLE
CYCLE #
Lockatong
Passaic
Period (feet)
2048
1024
512
256
128
64
32
16
8
4
Wavelet Power Spectrum
Period (time)
3.5 m.y.
1.75 m.y.
405 ky
109 ky
20 ky
Depth (ft)
Period (ky)
4069
Millions of Years BP

Wavelet Spectrum Late Triassic (Time)



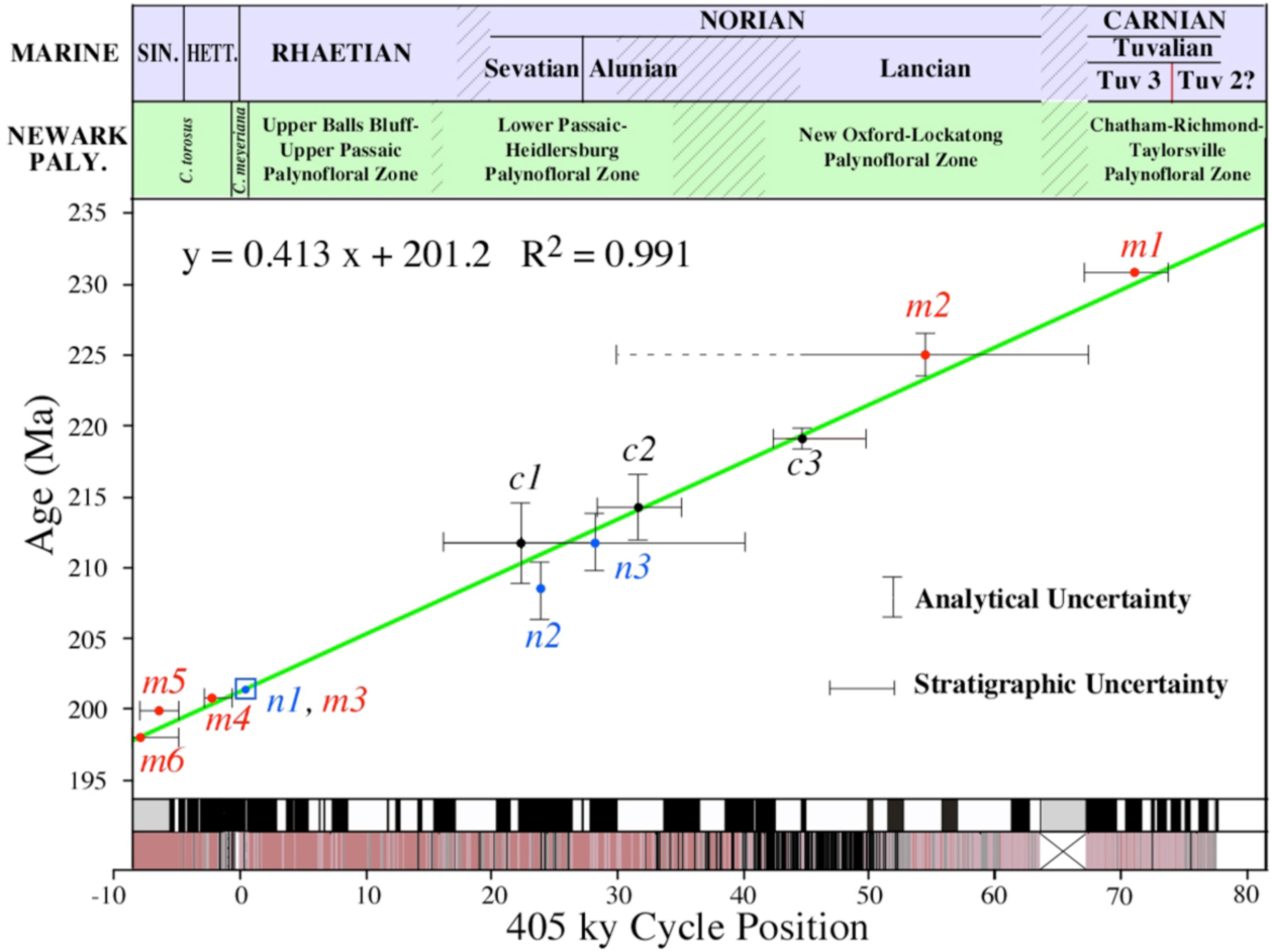
Wavelet Spectrum Neogene (Time)





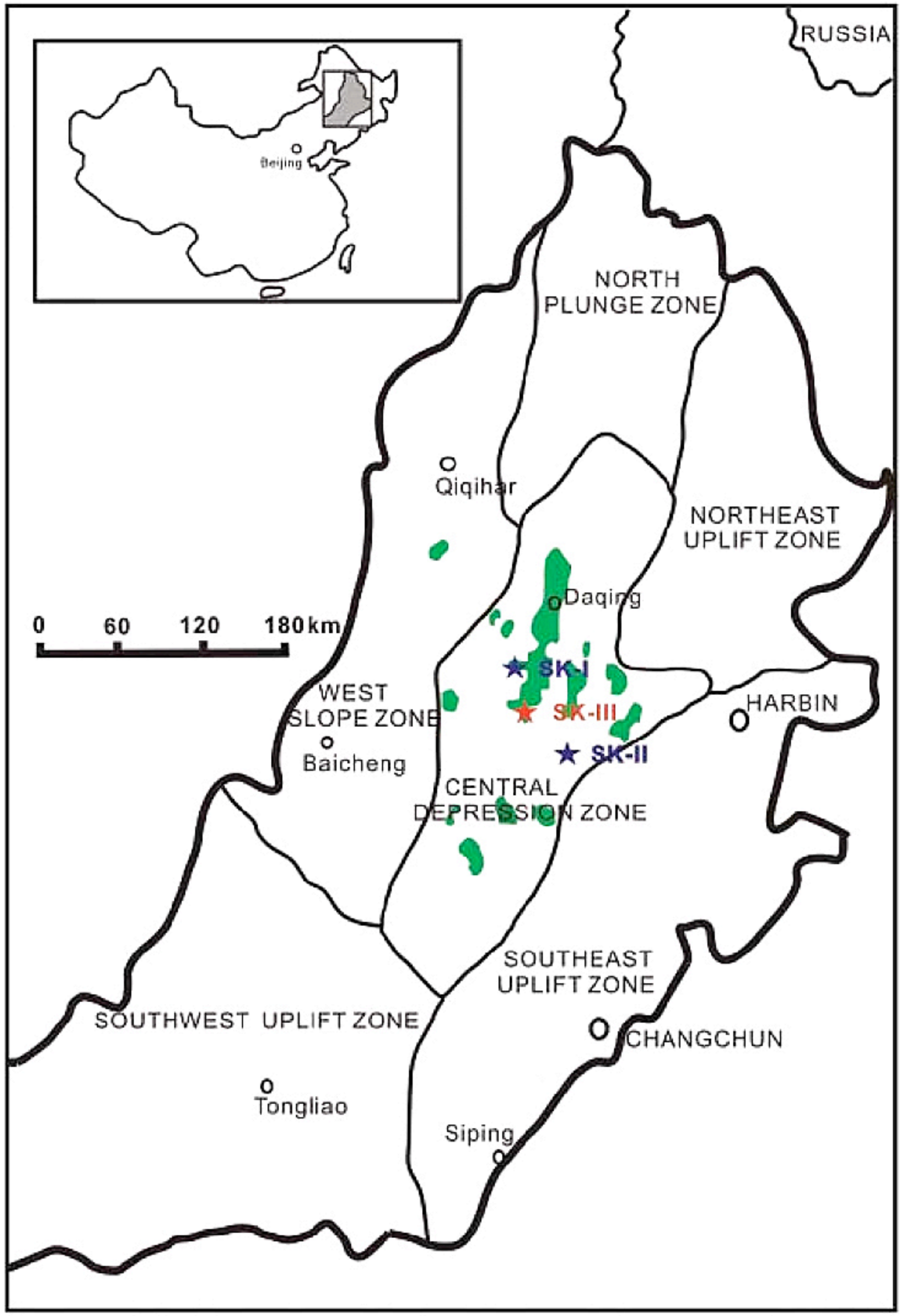
FORMATIONS
MEMBERS
MAGNETIC POLARITY
LITHOLOGY (DEPTH)
LITHOLOGY (TIME)
CYCLE NUMBER
G P T S
PALEO-LATITUDE (° N)
LVA
PALYNO-FLORAL ZONES
GEOLOGIC AGE
HARTFORD
NEWARK
PORTLAND
BOONTON
HAMPDEN BASALT
HOOK MT. BASALT
EAST BERLIN
TOWACO
HOLYOKE BASALT
PREAKNESS BASALT
SHUTTLE MEADOW
FELTVILLE
TALCOTT BASALT
ORANGE MT. BASALT
NEW HAVEN
PASSAIC
LOCKATONG
STOCKTON
Stony Brook
Mittinegue
South Hadley Falls
Park River
Smiths Ferry
Exeter Twp.
Pine Ridge
Ukrainian
Cedar Grove
Metlars
Livingston
Kilmer
Neshanic
Perkasie
Graters
Warford
Walls Island
Tumble Falls
Smith Corner
Prahls Island
Tohickon
Skunk Hollow
Byram
Ewing Creek
Nursery
Princeton
Scudders Falls
Wilburtha
CUTALOSSA
PRALLSVILLE
SOLEBURY
HARTFORD
ACE
MARTINSVILLE
WESTON
SOMERSET
RUTGERS
TITUSVILLE
NURSERY
PRINCETON
meters
feet
Tay
WASSONIAN
CLIFTONIAN
CONEWAGIAN
SANFORDIAN
COROLLINA TOROSUS
COROLLINA MEYERIANIA
UPPER BALLS BLUFF-UPPER PASSAIC
LOWER PASSAIC-HEIDLERSBURG
NEW OXFORD-LOCKATONG
"RICHMOND-TAYLORSVILLE"
SINEMURIAN
HETTANGIAN
RHAETIAN
SEVATIAN
ALUNIAN
LANCIAN
TUVALIAN
NORIAN
CARNIAN
EARLY JURASSIC
LATE TRIASSIC
Ma
201.4

Cycles vs. Ages

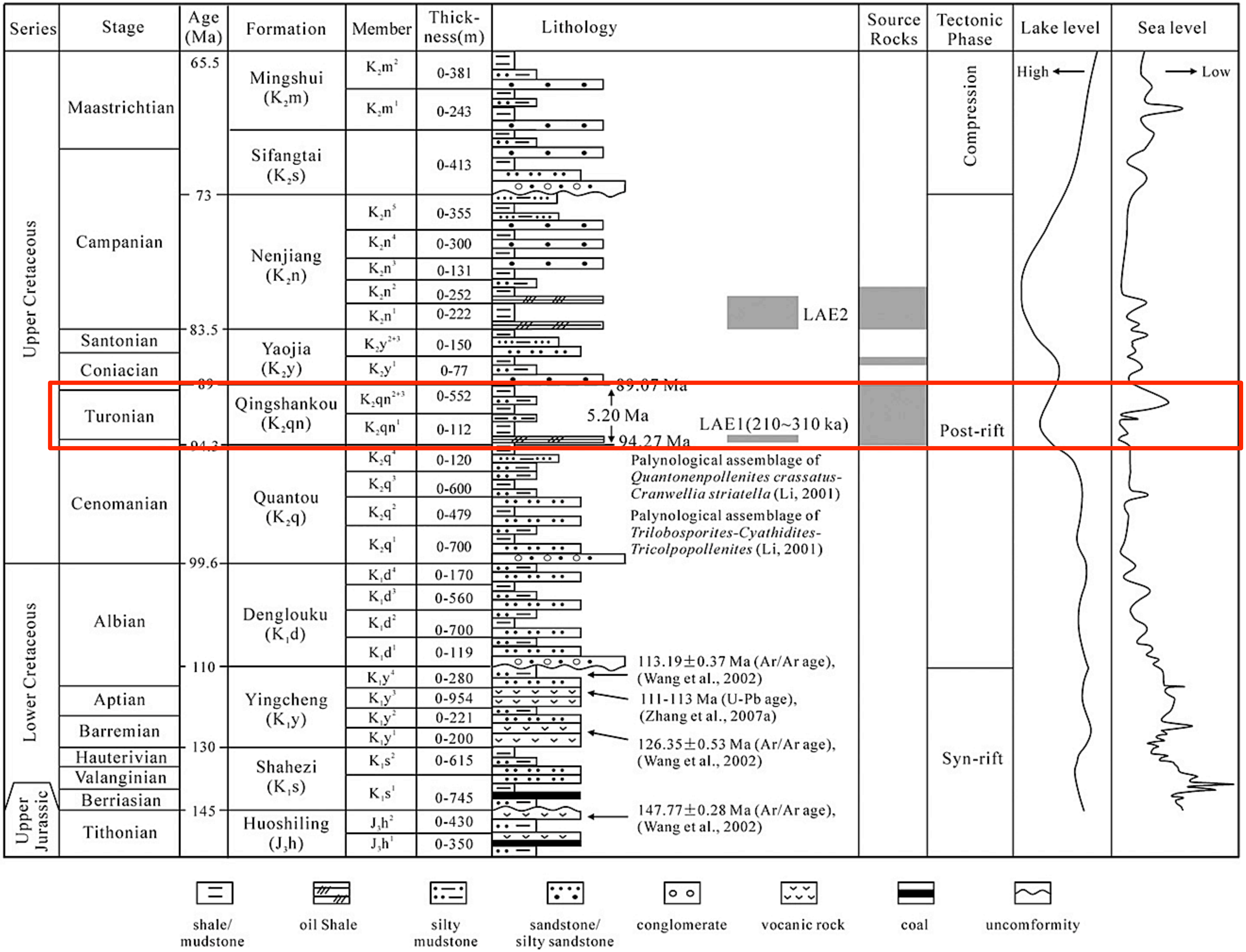


Example 2:
Qingshankou Formation
Late Cretaceous of the Songliao Basin, Northeast China

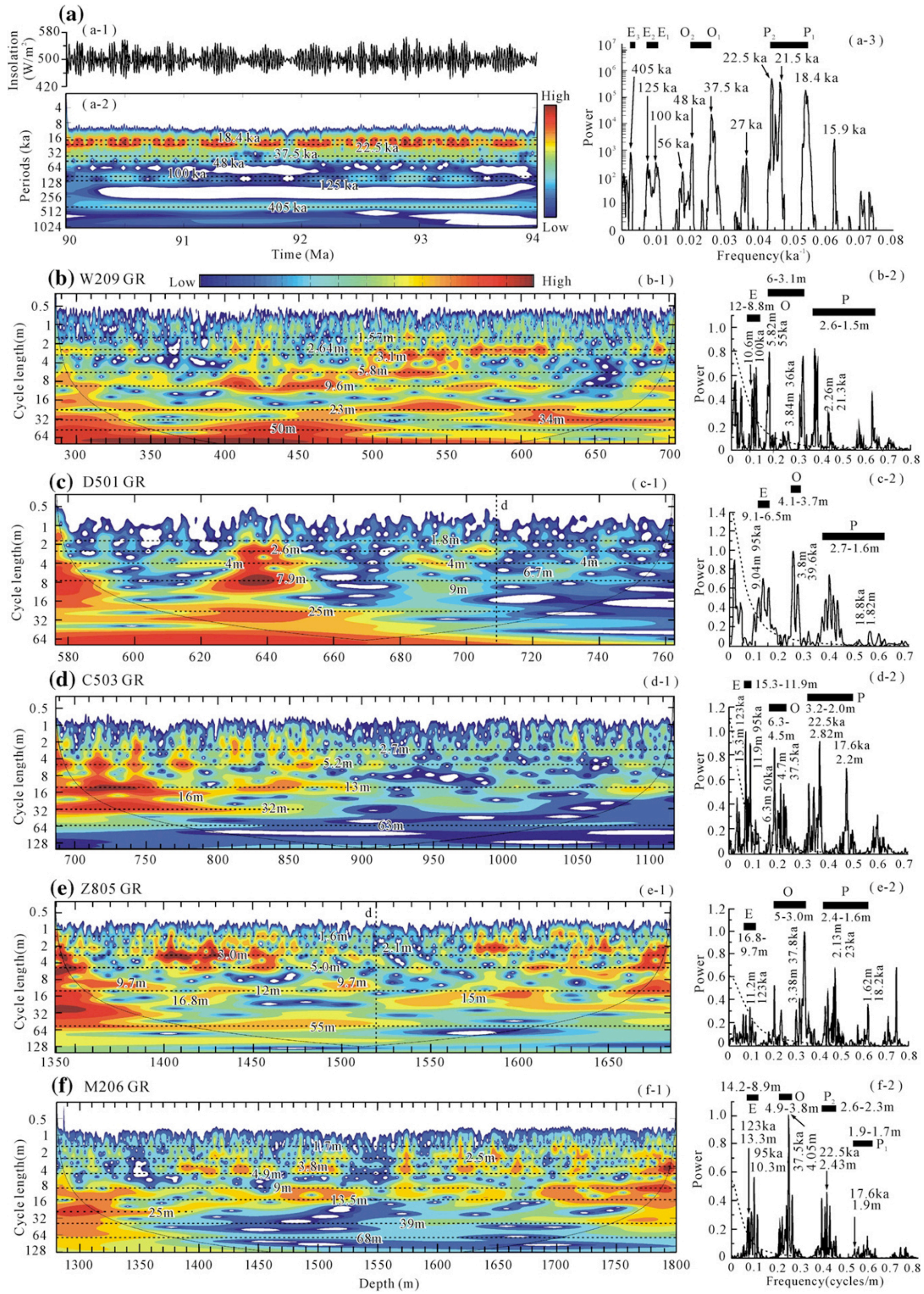
(Huaichun Wu et al.: 2009)

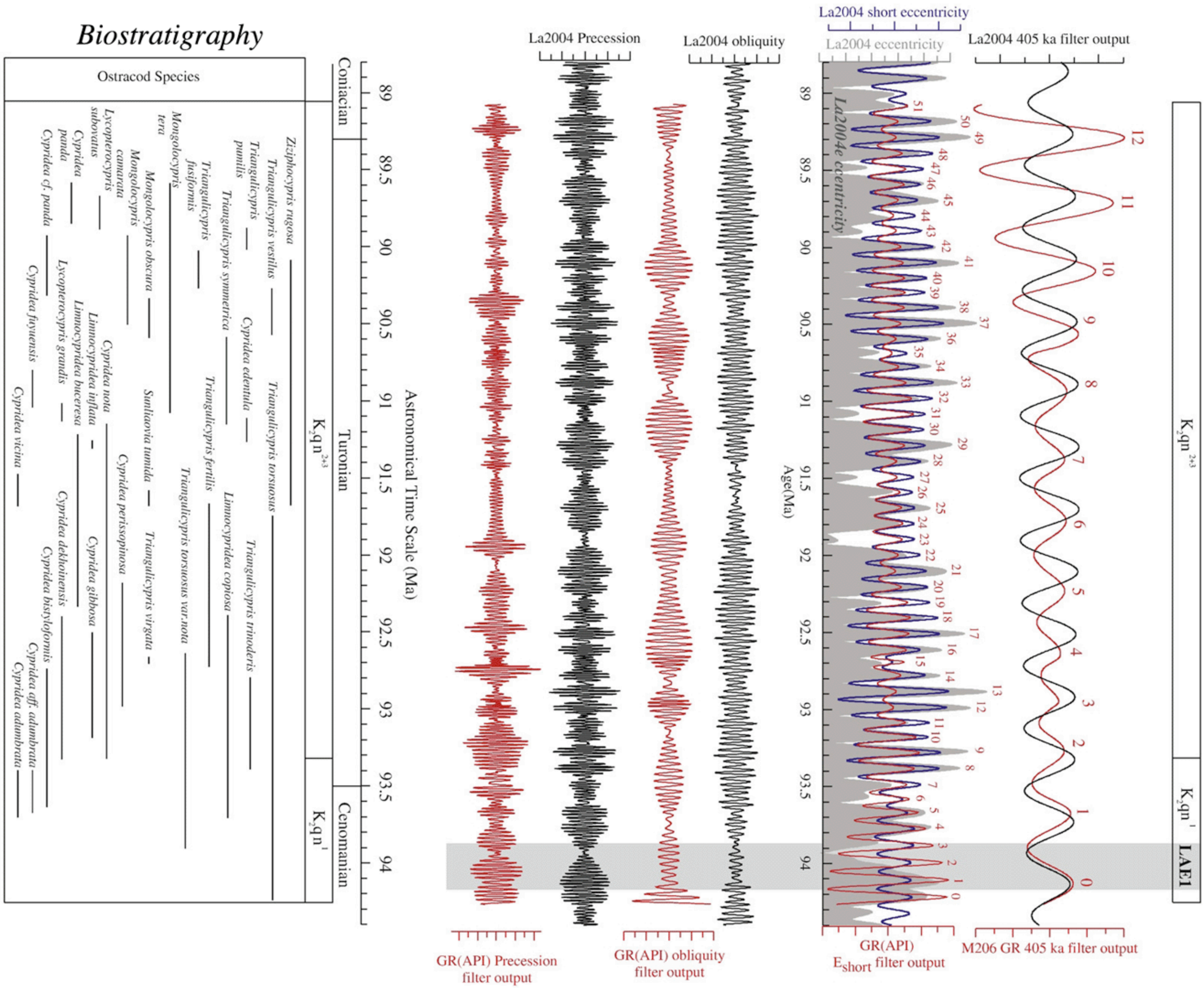


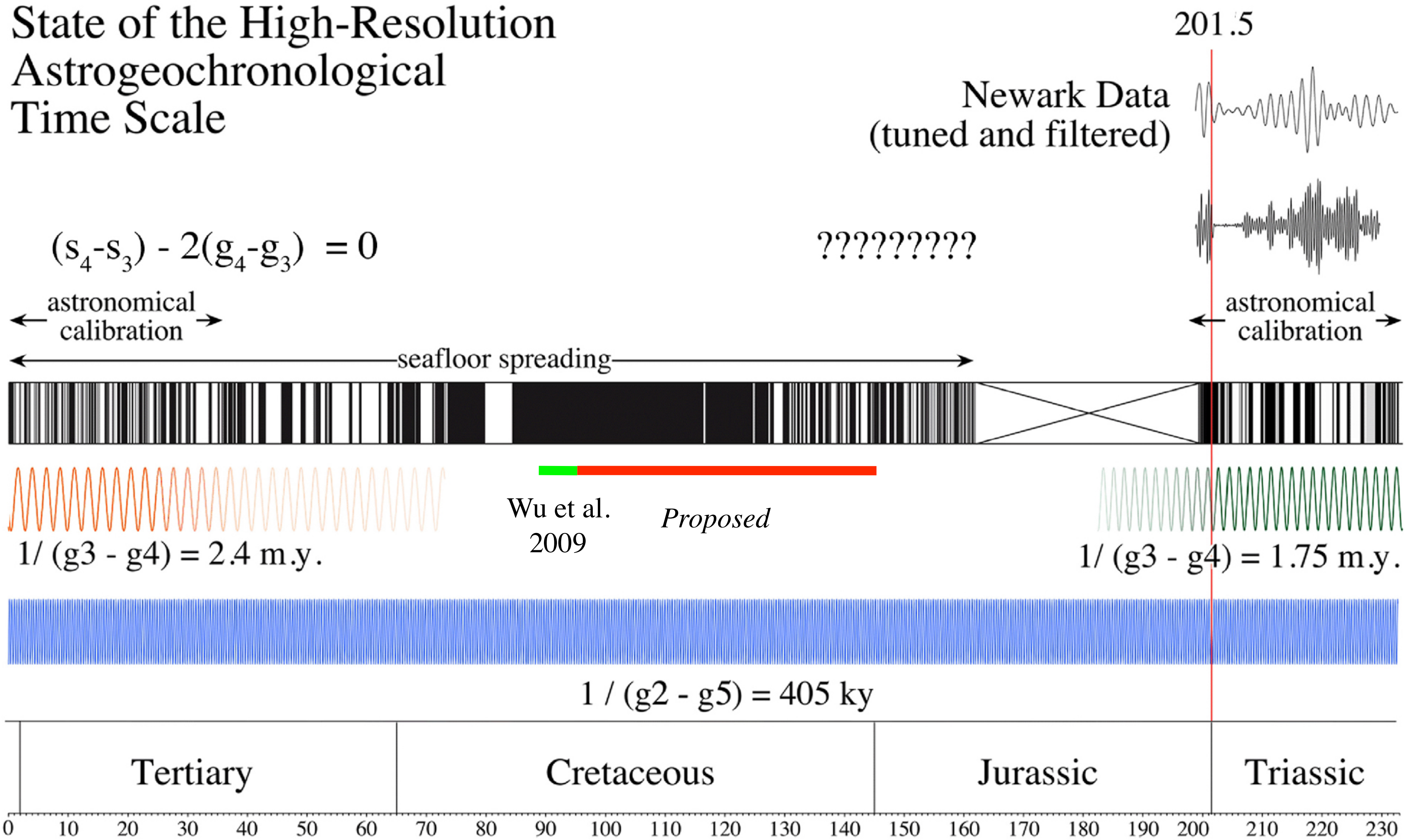
CHENGSHANG WANG & YONGJIAN HUANG, 2009



Series
Stage
Age (Ma)
Formation
Member
Thick-ness(m)
Lithology
Source Rocks
Tectonic Phase
Lake level
Sea level
Upper Cretaceous
Lower Cretaceous
Upper Jurassic
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Barremian
Hauterivian
Valanginian
Berriasian
Tithonian
65.5
73
83.5
89
94.3
99.6
110
130
145
Mingshui (K2m)
Sifangtai (K2s)
Nenjiang (K2n)
Yaojia (K2y)
Qingshankou (K2qn)
Quantou (K2q)
Denglouku (K1d)
Yingcheng (K1y)
Shahezi (K1s)
Huoshiling (J3h)
0-381
0-243
0-413
0-355
0-300
0-131
0-252
0-222
0-150
0-77
0-552
0-112
0-120
0-600
0-479
0-700
0-170
0-560
0-700
0-119
0-280
0-954
0-221
0-200
0-615
0-745
0-430
0-350
LAE2
89.07 Ma
5.20 Ma
94.27 Ma
LAE1(210~310 ka)
Palynological assemblage of Quantonenpollenites crassatus-Cranwellia striatella (Li, 2001)
Palynological assemblage of Trilobosporites-Cyathidites-Tricolpopollenites (Li, 2001)
113.19±0.37 Ma (Ar/Ar age), (Wang et al., 2002)
111-113 Ma (U-Pb age), (Zhang et al., 2007a)
126.35±0.53 Ma (Ar/Ar age), (Wang et al., 2002)
147.77±0.28 Ma (Ar/Ar age), (Wang et al., 2002)
Compression
Post-rift
Syn-rift
High
Low
shale/ mudstone
oil Shale
silty mudstone
sandstone/ silty sandstone
conglomerate
vocanic rock
coal
uncomformity




Biostratigraphy
Ostracod Species
Coniacian
Turonian
Cenomanian
Astronomical Time Scale (Ma)
La2004 Precession
La2004 obliquity
La2004 short eccentricity
La2004 eccentricity
La2004 405 ka filter output
Age(Ma)
GR(API) Precession filter output
GR(API) obliquity filter output
GR(API) E_{short} filter output
M206 GR 405 ka filter output
LAE1
K_2qn^{2+3}
K_2qn^1


State of the High-Resolution Astrogeochronological Time Scale
201.5
Newark Data (tuned and filtered)
(s4-s3) - 2(g4-g3) = 0
?????????
astronomical calibration
astronomical calibration
seafloor spreading
Wu et al. 2009
Proposed
1/ (g3 - g4) = 2.4 m.y.
1/ (g3 - g4) = 1.75 m.y.
1 / (g2 - g5) = 405 ky
Tertiary
Cretaceous
Jurassic
Triassic
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230

What would we get?

1. Major progress towards timescale for Early Cretaceous.
2. Timescale for oil shales in China
3. Timescale for Early Cretaceous biota
4. Eventually correlation with Brazilian petroliferous lacustrine deposits and understanding of source rock evolution.
5. Progress towards constraints on possible numerical solutions for Solar System behavior and its chaotic behavior beyond Cenozoic.
6. Progress towards insolation target curves for any arbitrary time that can be the basis for a Phanerozoic time scale with a < 20 ky stratigraphic *precision* and *accuracy*.
7. Possible improvements in precision of 10^4 to 10^{10}) in celestial mechanical measurements (Laskar, 2008).

Publication Venues?

1. Nature / Science.
2. PNAS (Olsen is member of US National Academy of Science).
3. Science in China.
4. Earth and Plantary Science Letters.
5. Icarus.
6. Journal of Geophysical research.
7. Philosophical Transactions of the Royal Society of London.
8. Palaeogeography, Palaeoclimatology, and Palaeoecology.