Changes in Biosphere and Marine Environment across the End-Permian Mass Extinction at Shangsi, South China

Master Thesis

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Contents

Acknowledgements

Prof. Dr. Kunio Kaiho

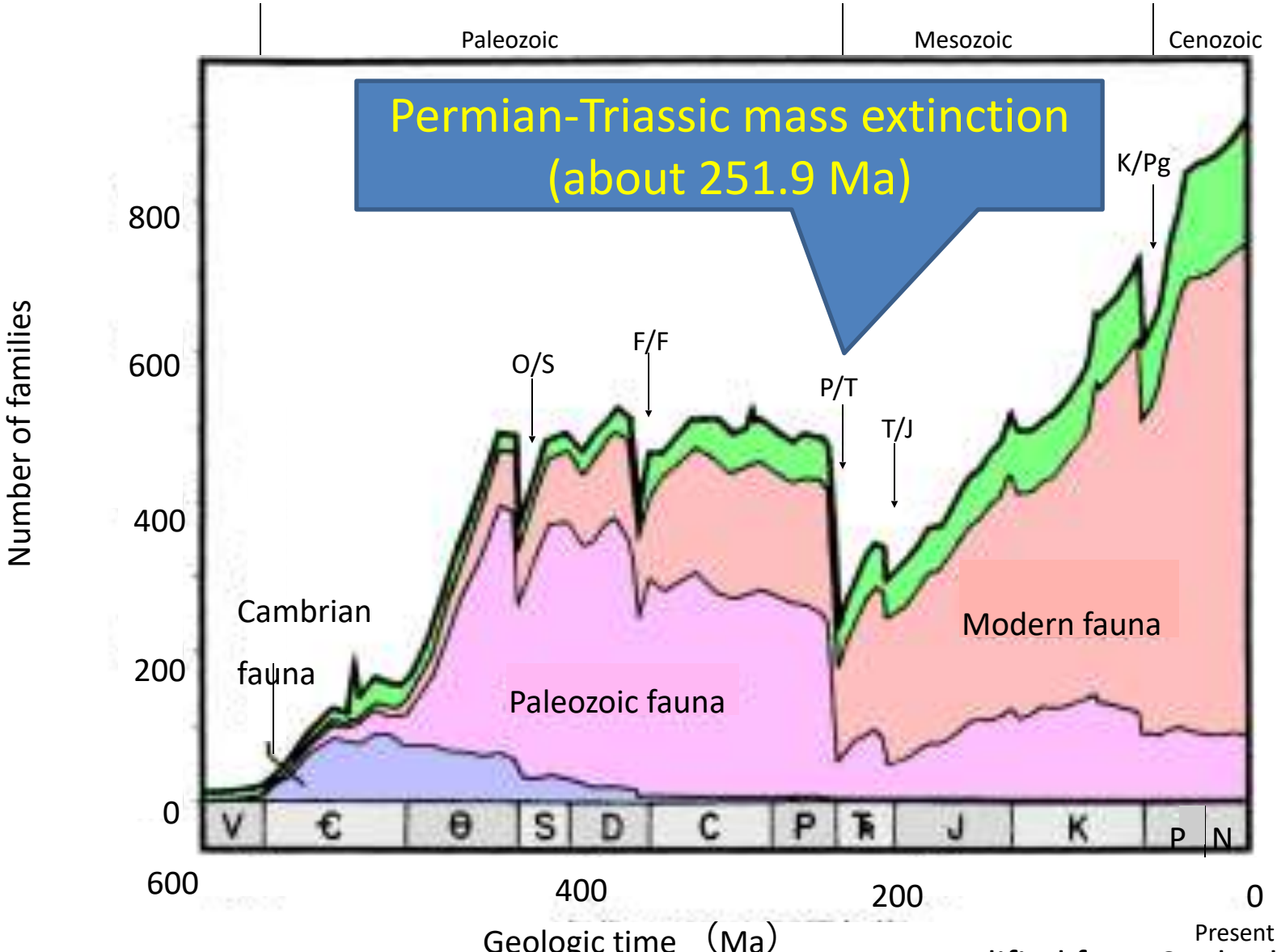
Dr. Ryosuke Saito

Kaiho Lab Members

Mass Extinction

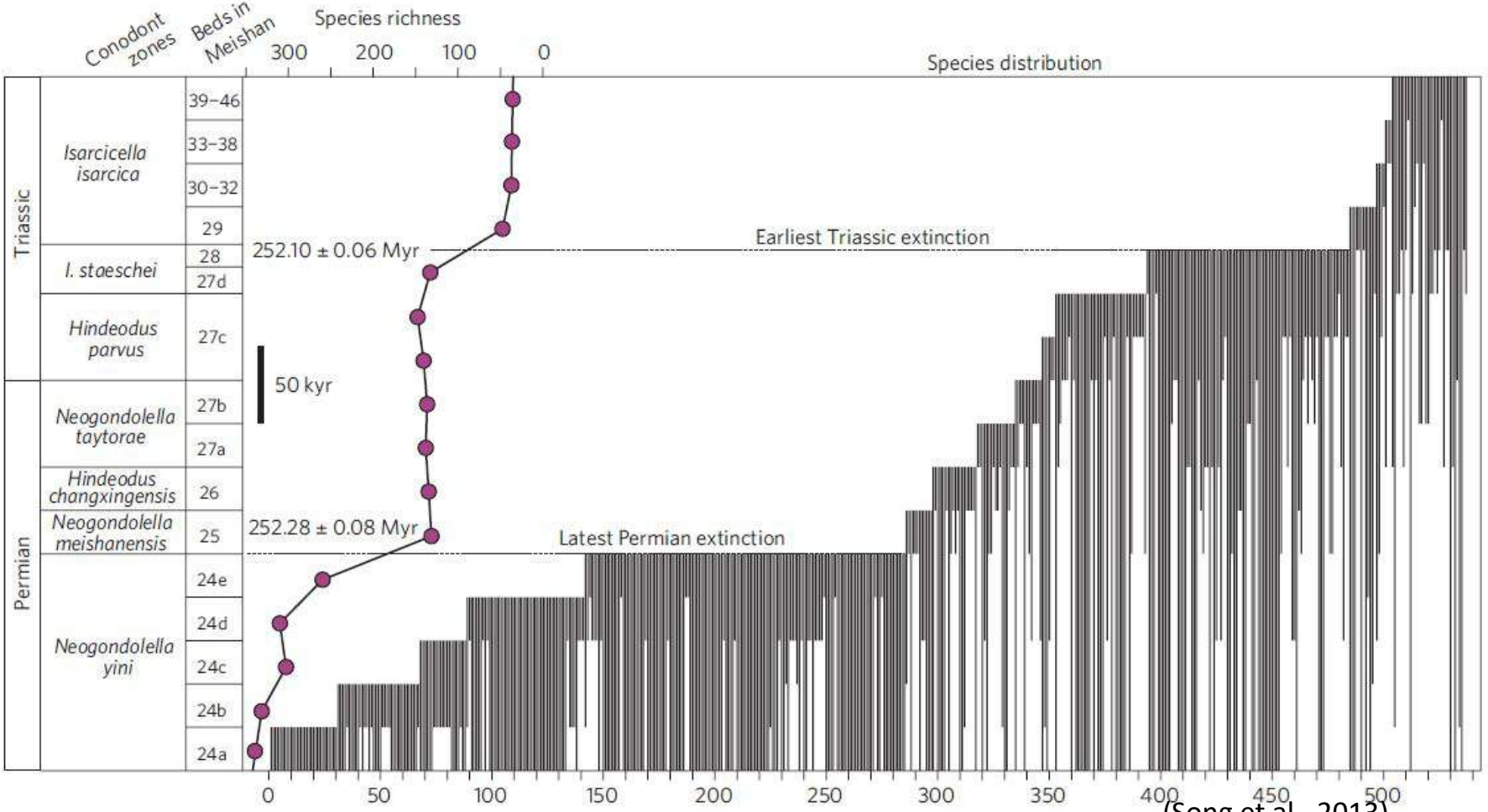
Introduction

Diversity of marine invertebrate during the Phanerozoic

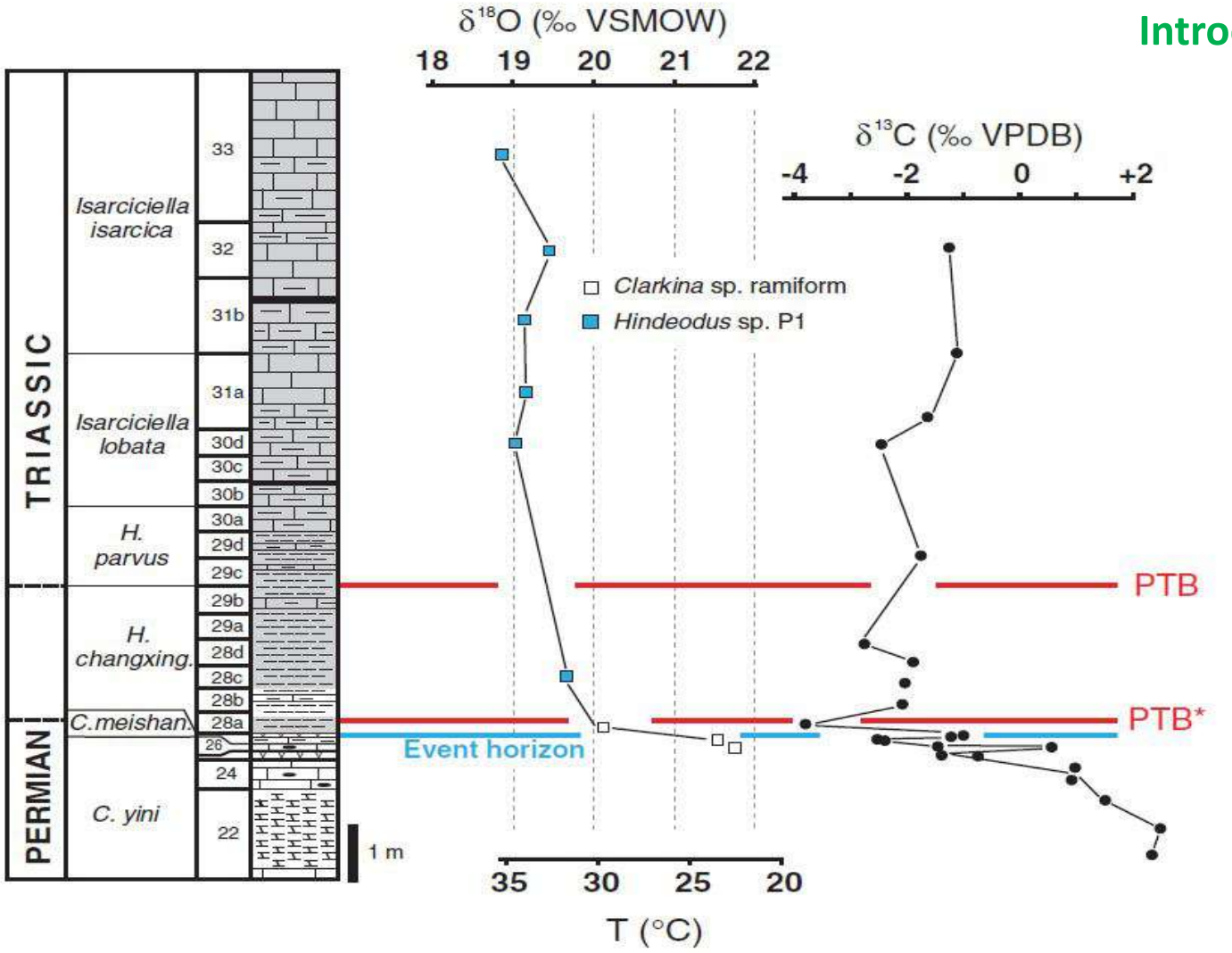


Modified from Sepkoski (1981)

First phase extinction in the latest Permian and a second phase extinction in the earliest Triassic (Yin et al., 2007)

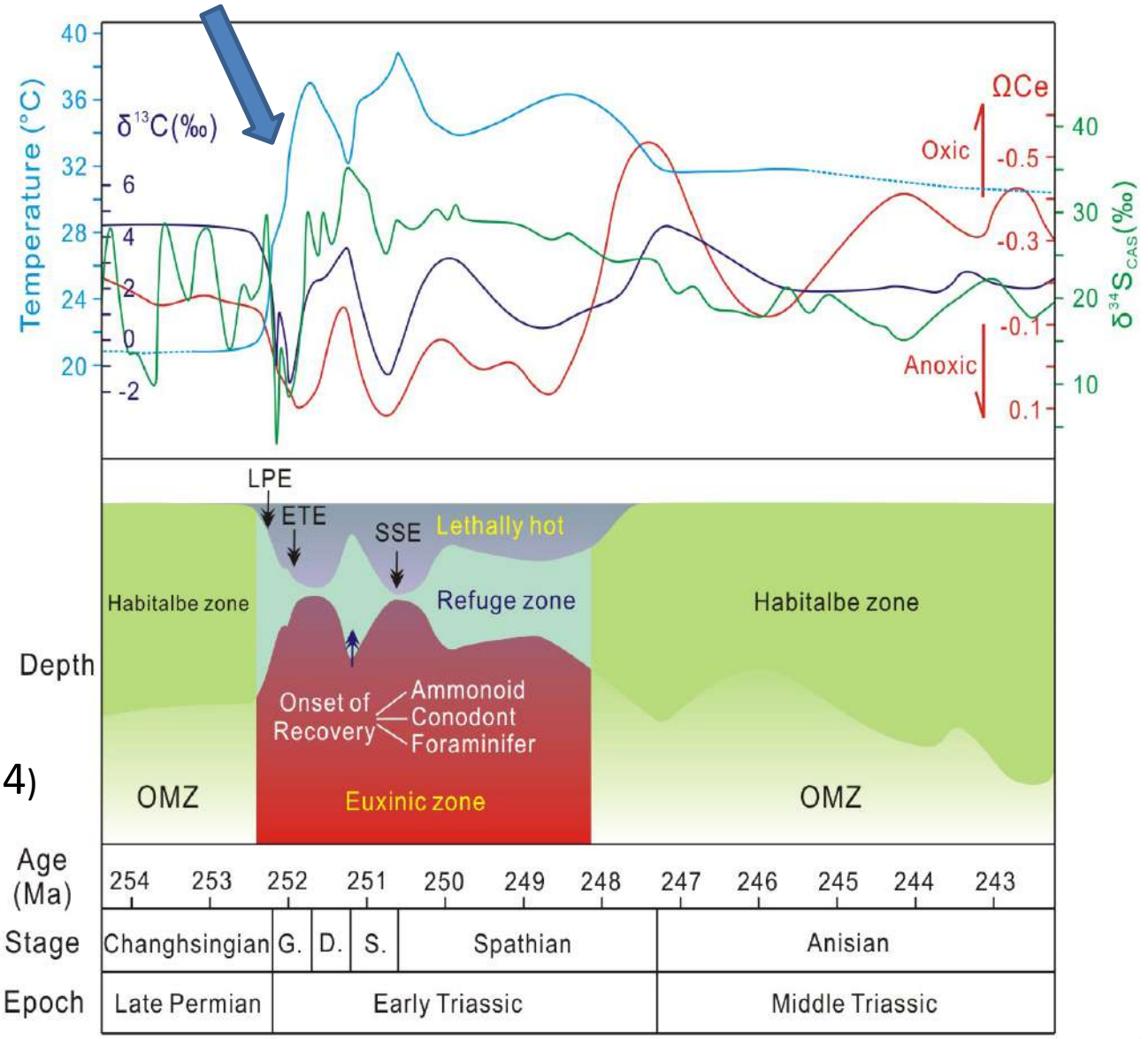


(Song et al., 2013)



Oxygen isotopes of conodont apatite, carbon isotopes and position of PTB at Shangsi (Joachimski et al., 2012).

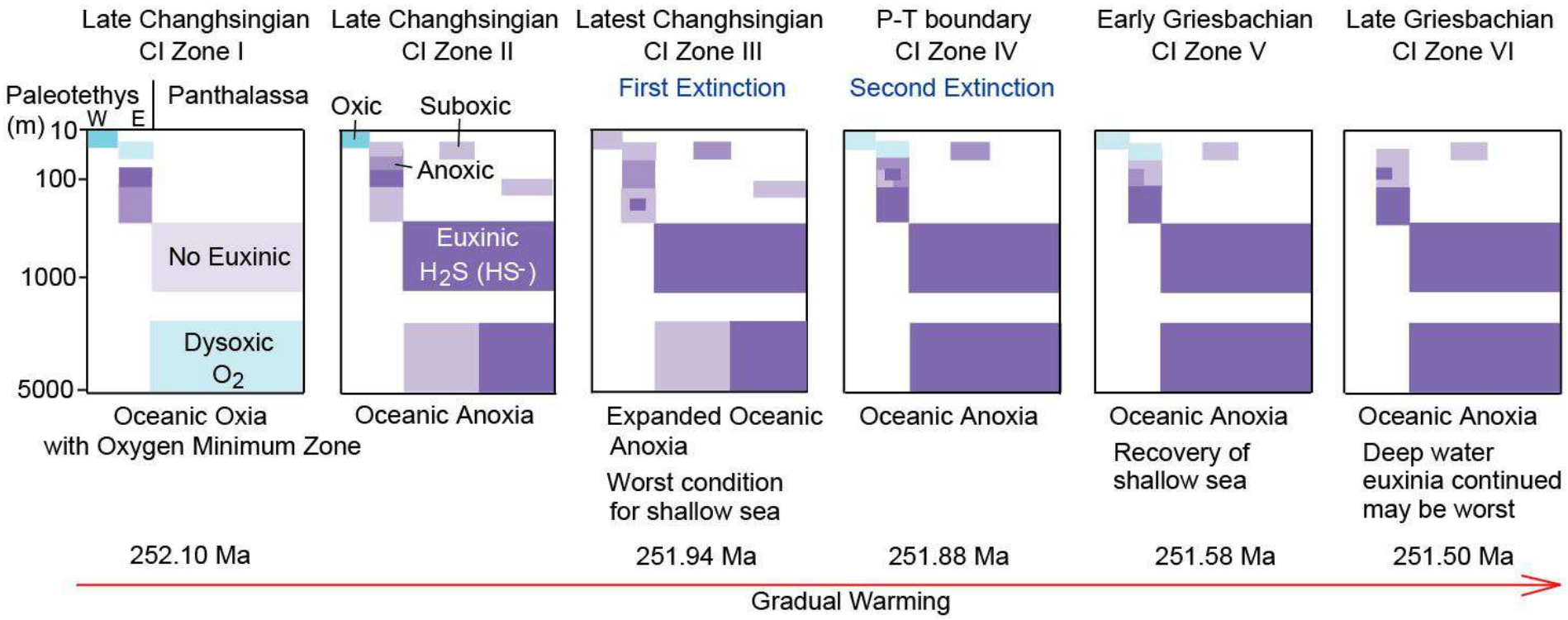
Paleotemperatures from the $\delta^{18}O$ of *Clarkina* increasing to 32°C above the event horizon in South China (Joachimski et al., 2012)



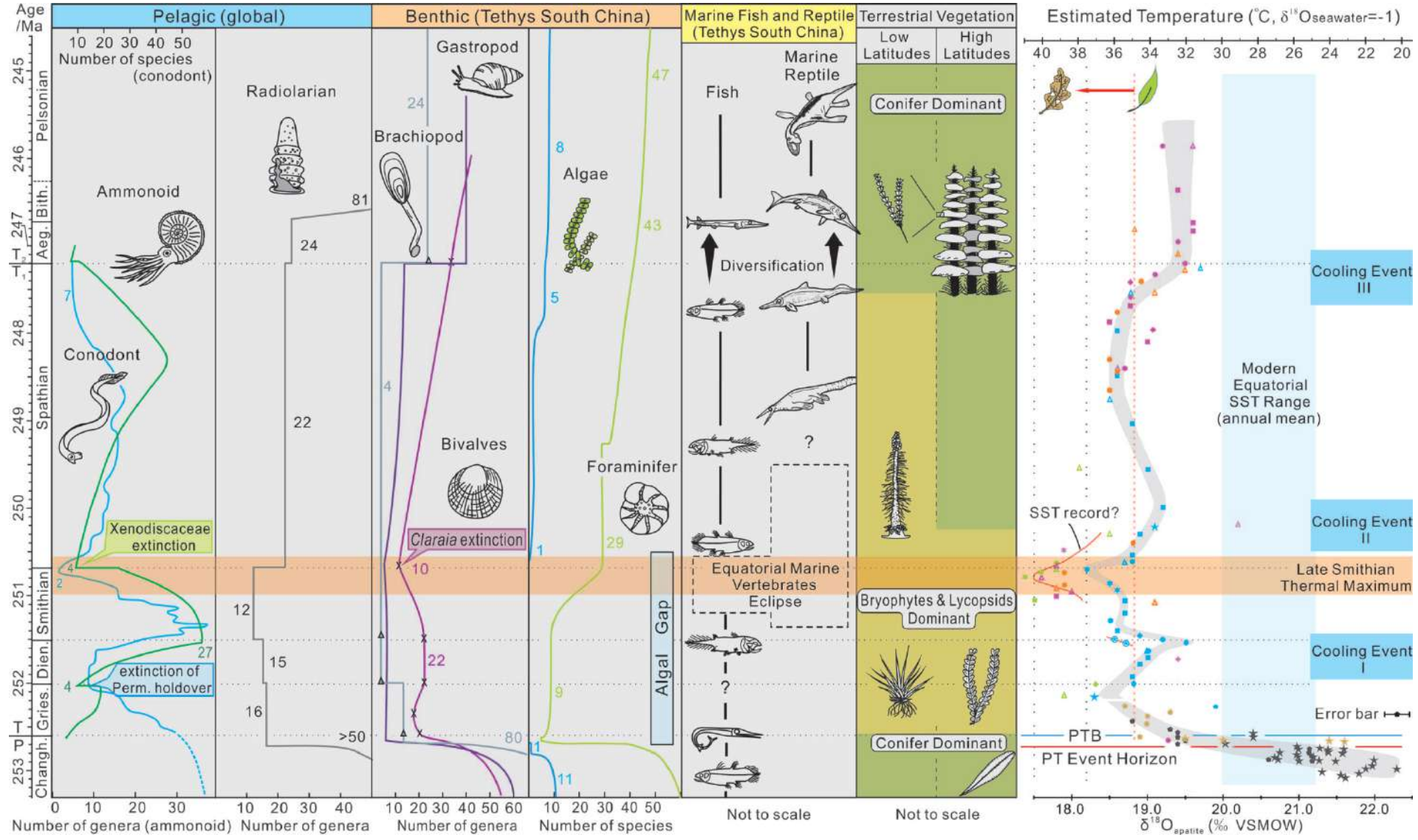
(Sun et al.,2014)

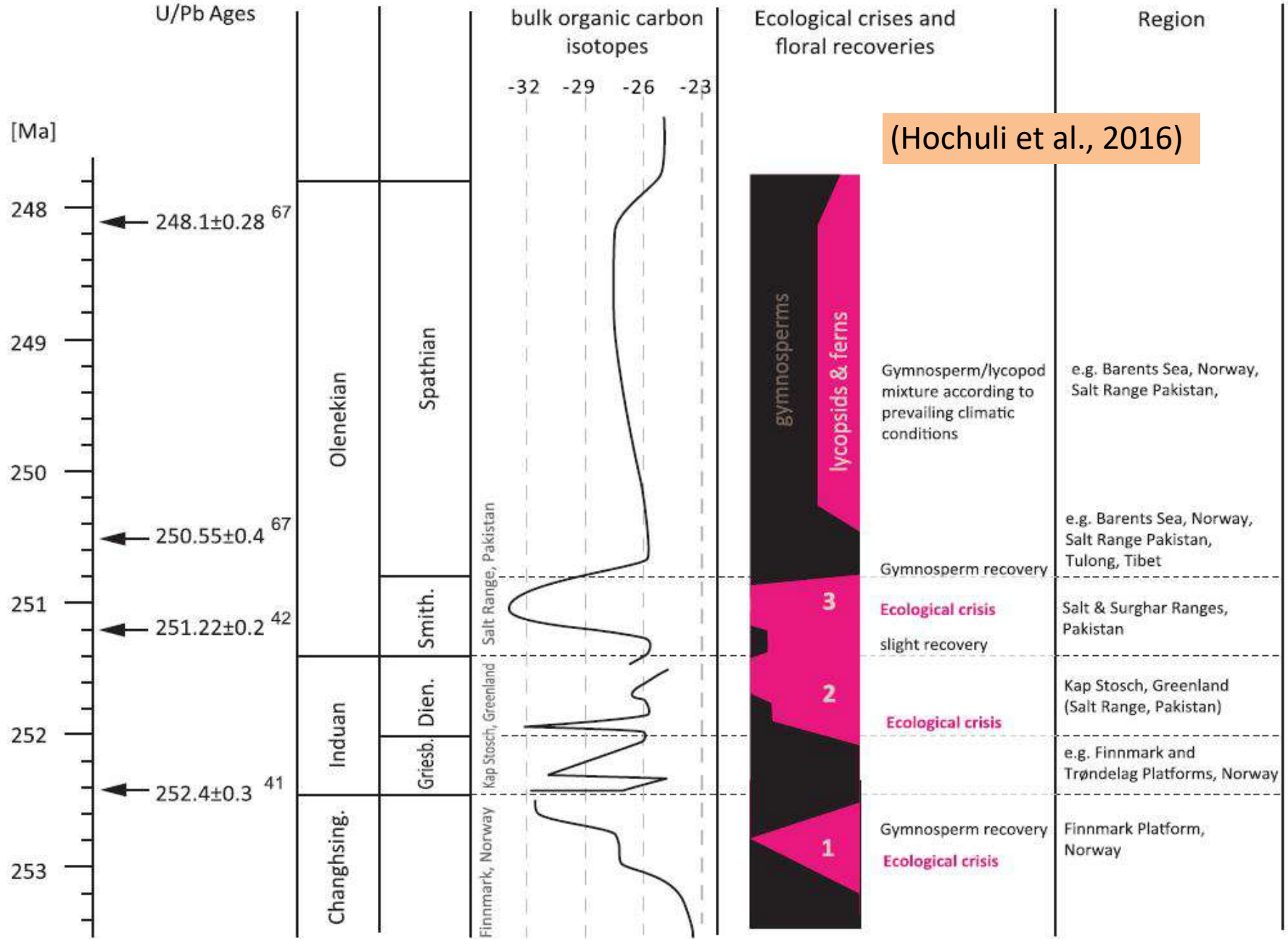
Summary of low latitude redox condition

(Kaiho et al., 2016)

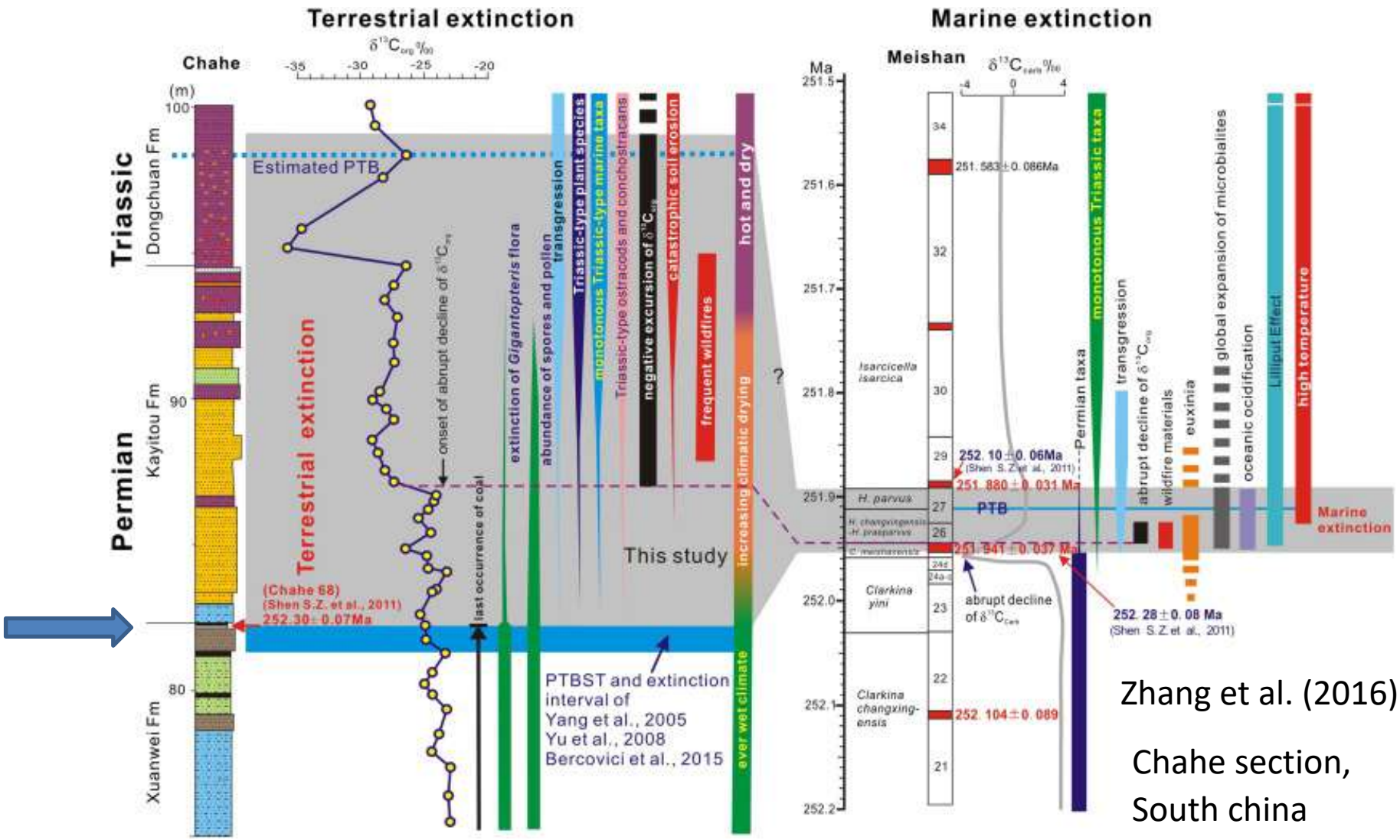


Early Triassic diversity of biota and temperature trends (Sun et al., 2012)





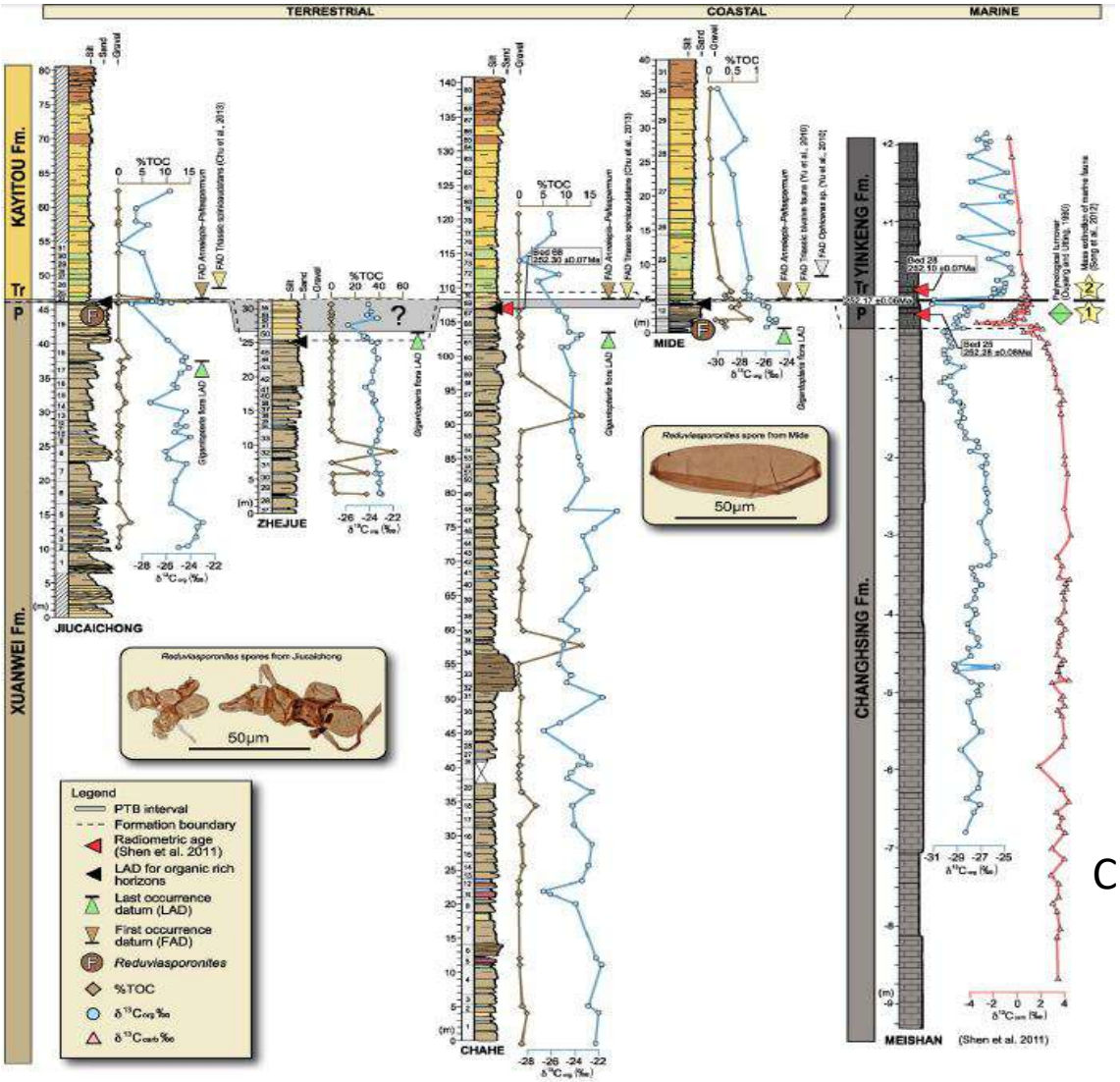
(Hochuli et al., 2016)



Zhang et al. (2016)

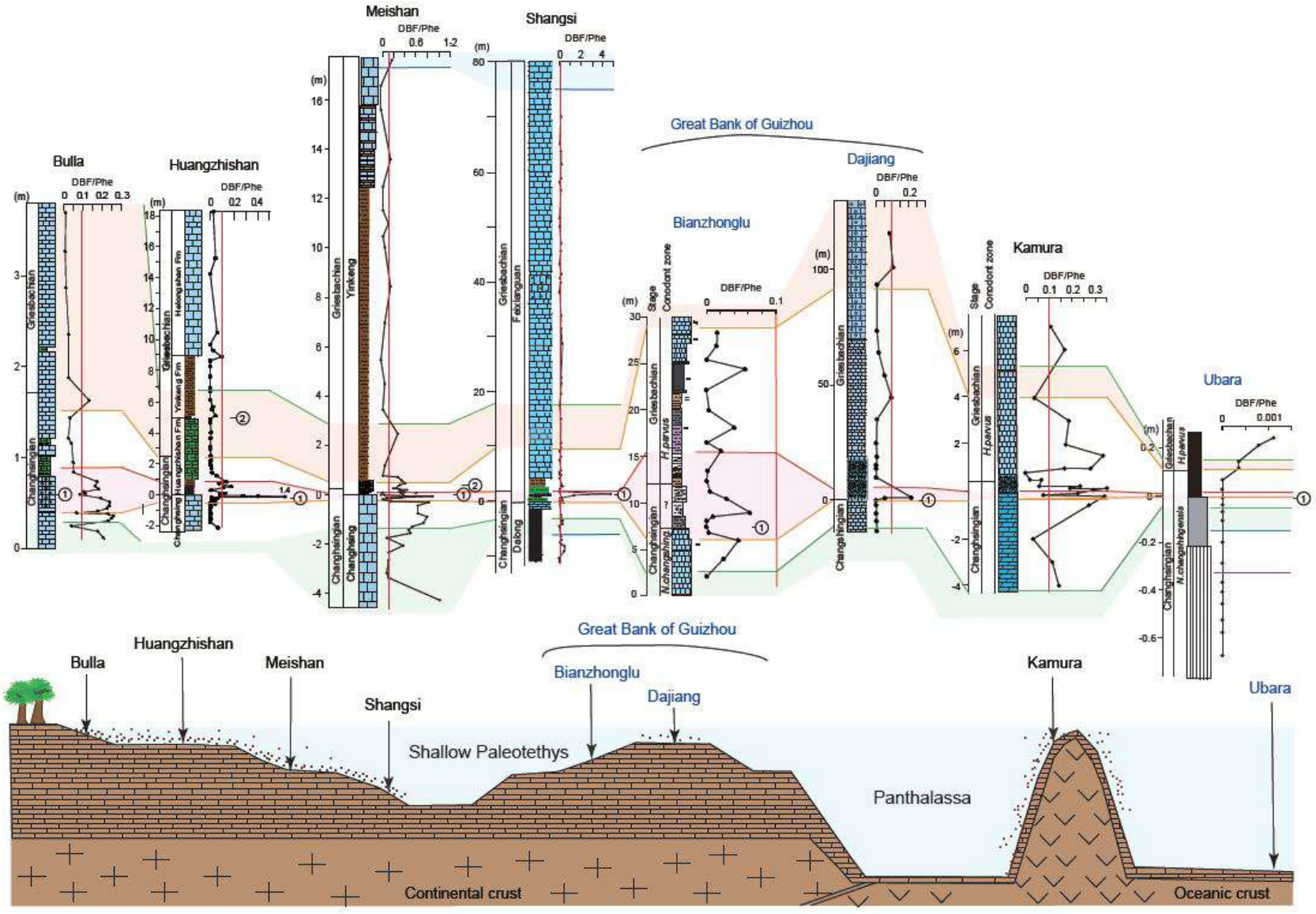
Chahe section, South china

Chahe, Juikai, Mide section in western Guizhou and eastern Yunnan in southwestern China

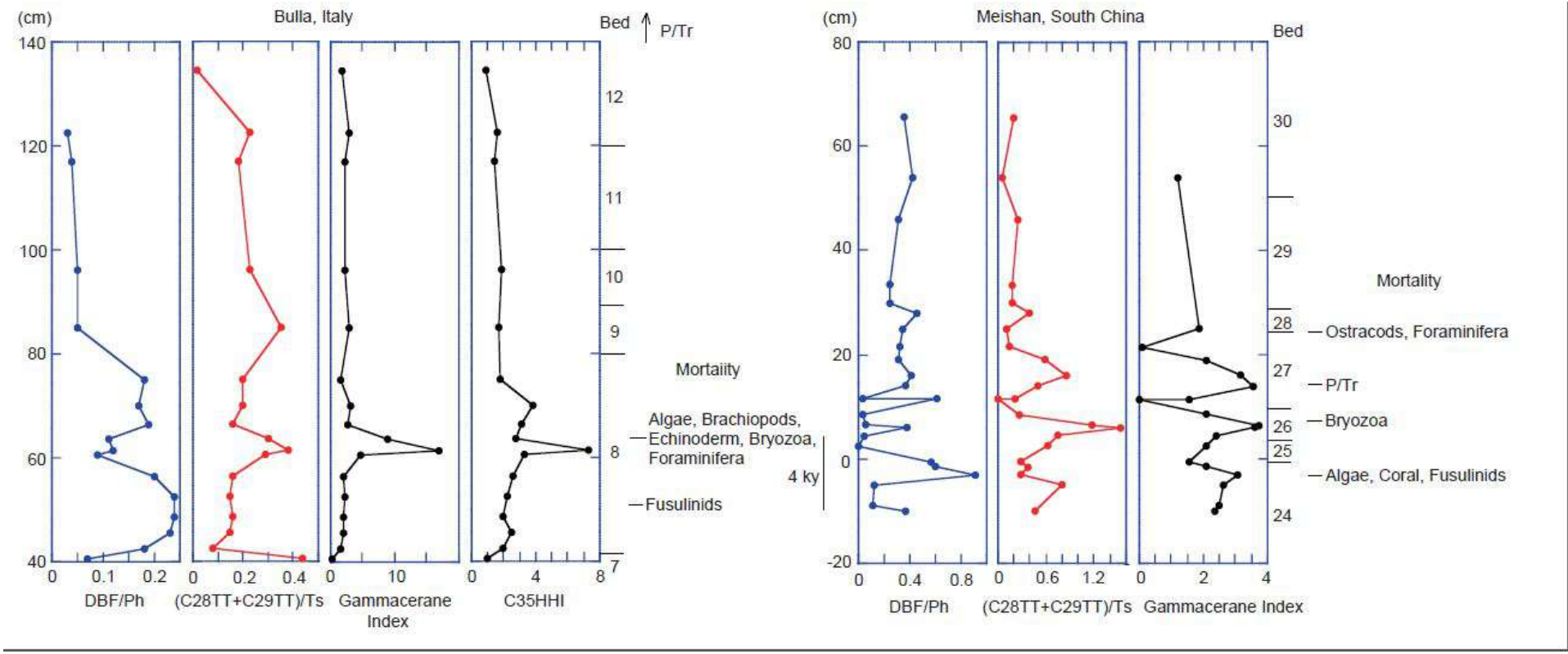


Cui et al. (2015)

Terrestrial collaspe evidenced by soil erosion index (Kaiho et al., 2016)

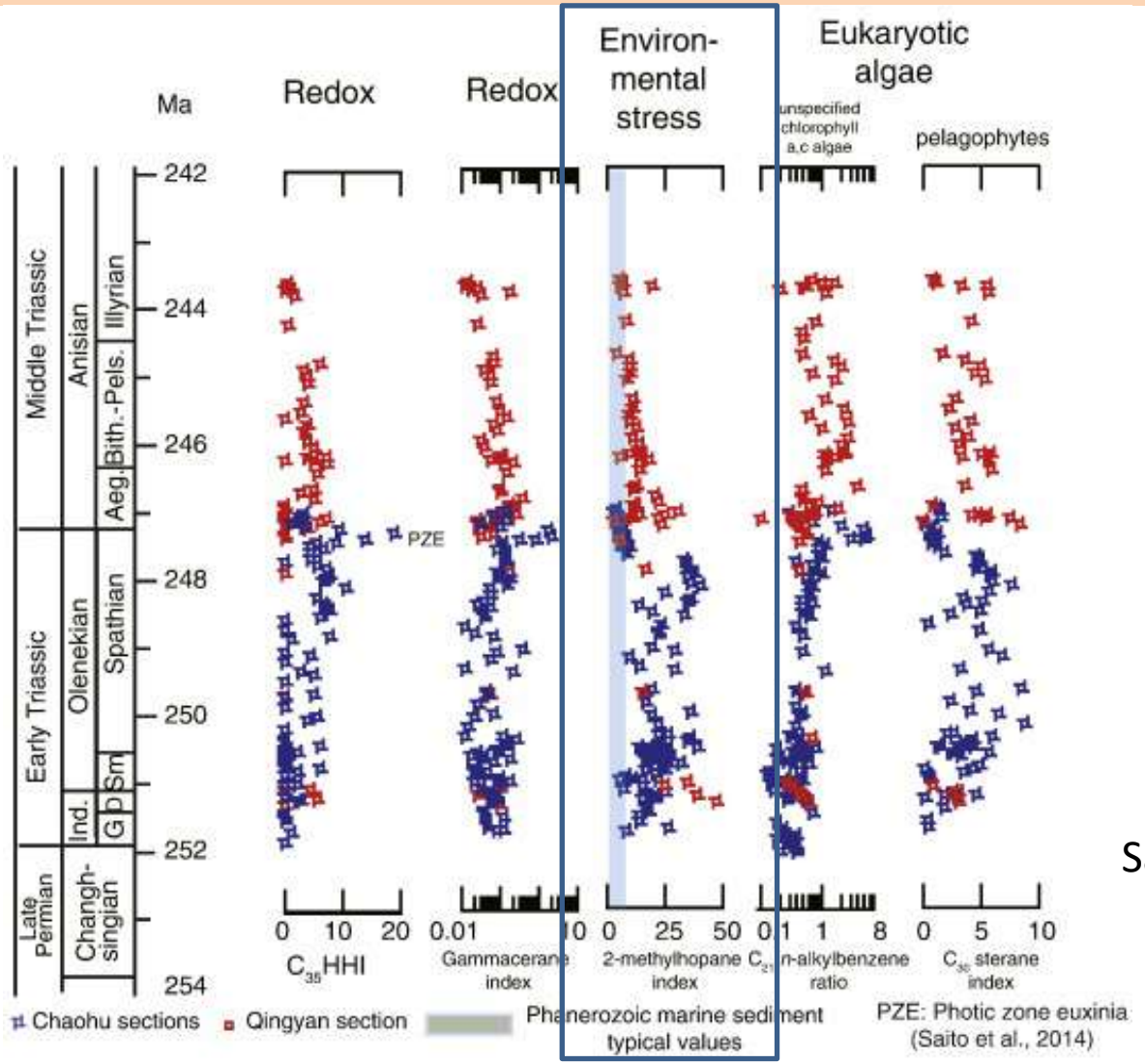


Soil erosion caused anoxia in near shore water coinciding with the latest Permian marine extinction



Kaiho et al. (2016)

In the LPE, environmental stresses were widespread in South China and persisted until the Early Triassic to early Middle Triassic (Saito et al., 2016).



Saito et al. (2016)

Purpose

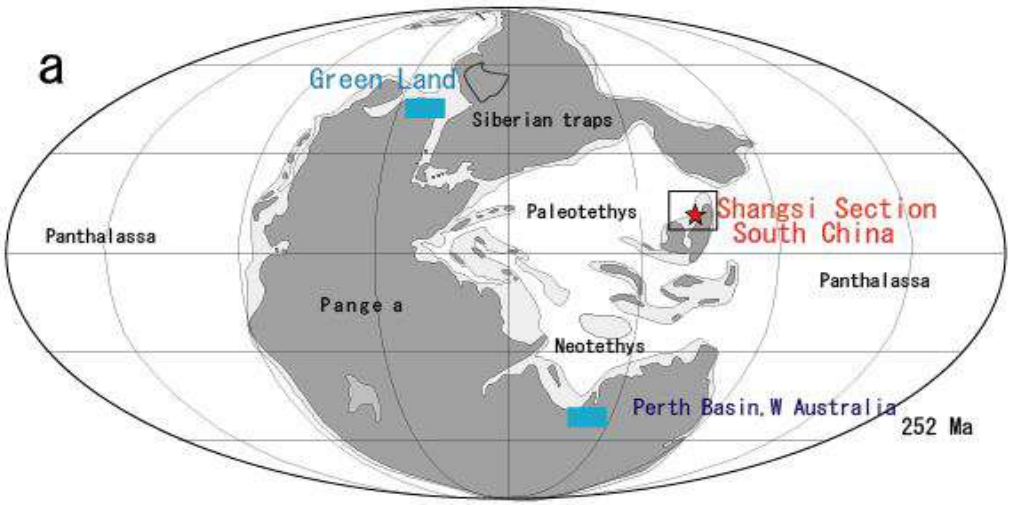
1. To reconstruct the biosphere and environmental stresses in low-latitude Paleotethys.
2. To identify the timing of terrestrial vegetation loss, marine mass mortality and environmental stresses in low-latitude Paleotethys.

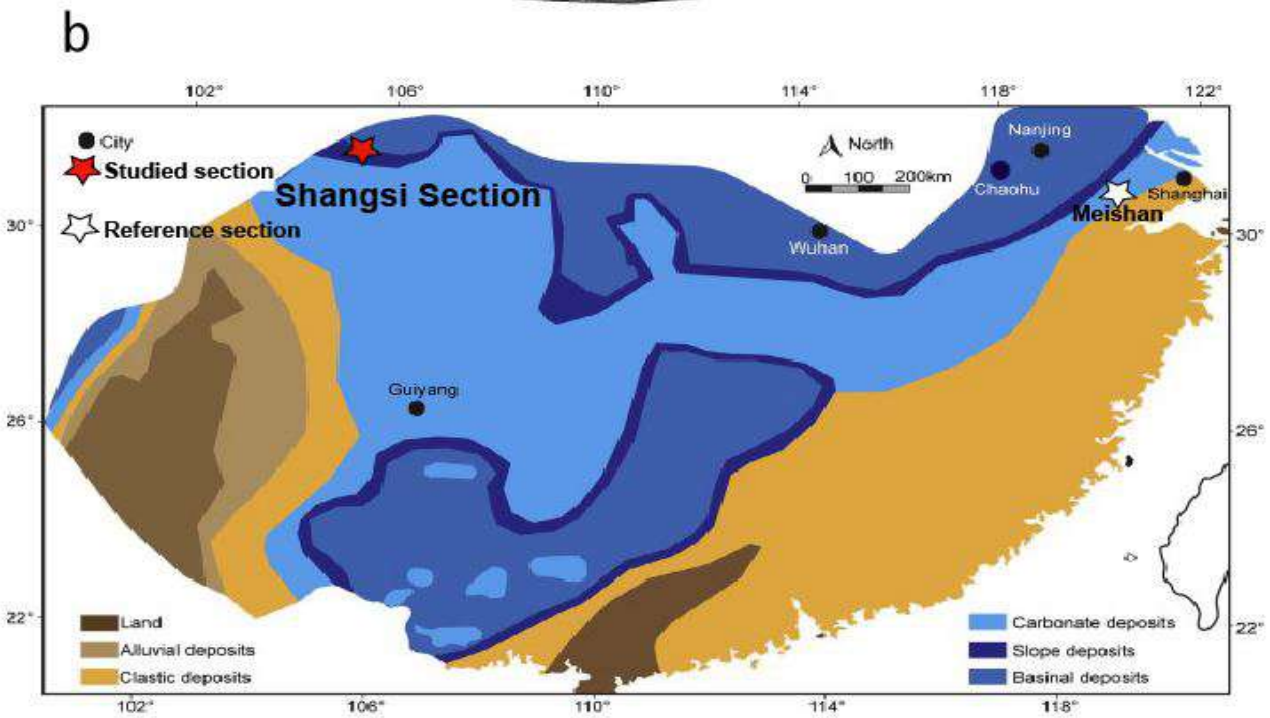
Why chose Shangsi section??

1. Richness and diversification of biomarkers to reconstruct the biosphere and environment.
2. Good conodont stratigraphy and stable carbon isotope data to identify the timing of those events.

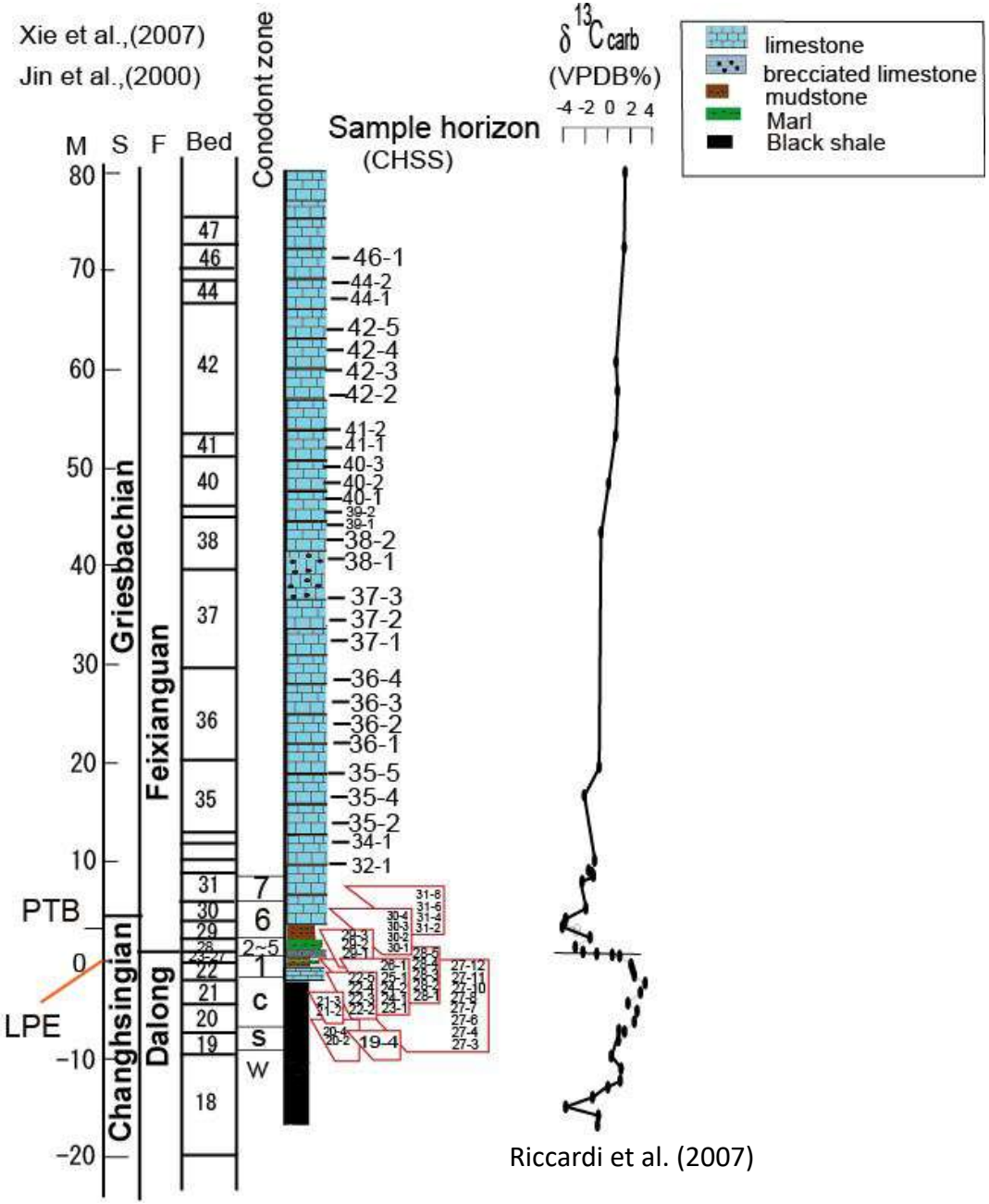
Geological setting

Study area





Lithology & sample horizon of the Shangsi section

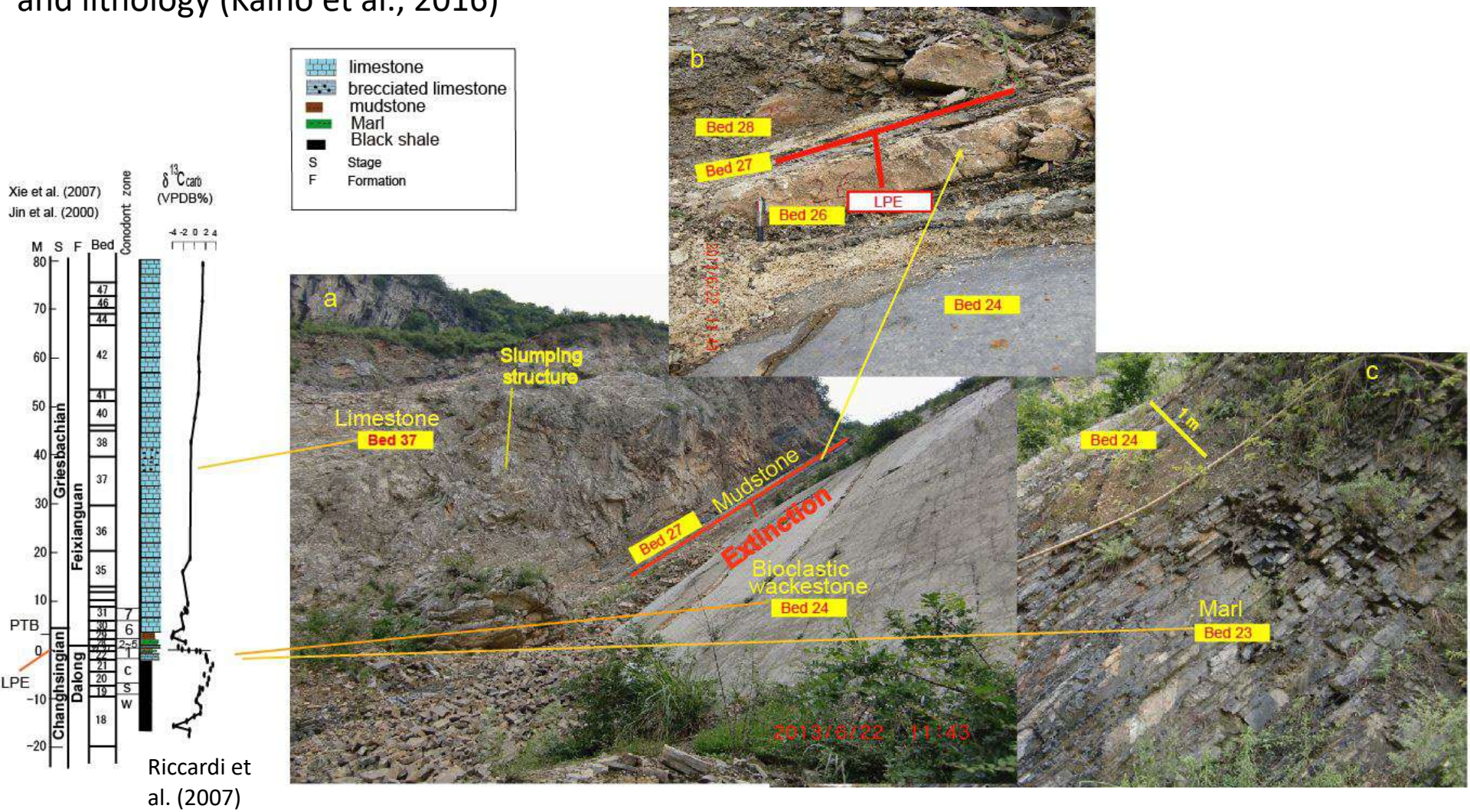


Riccardi et al. (2007)

Total 71 samples

Lithology of the Shangsi section

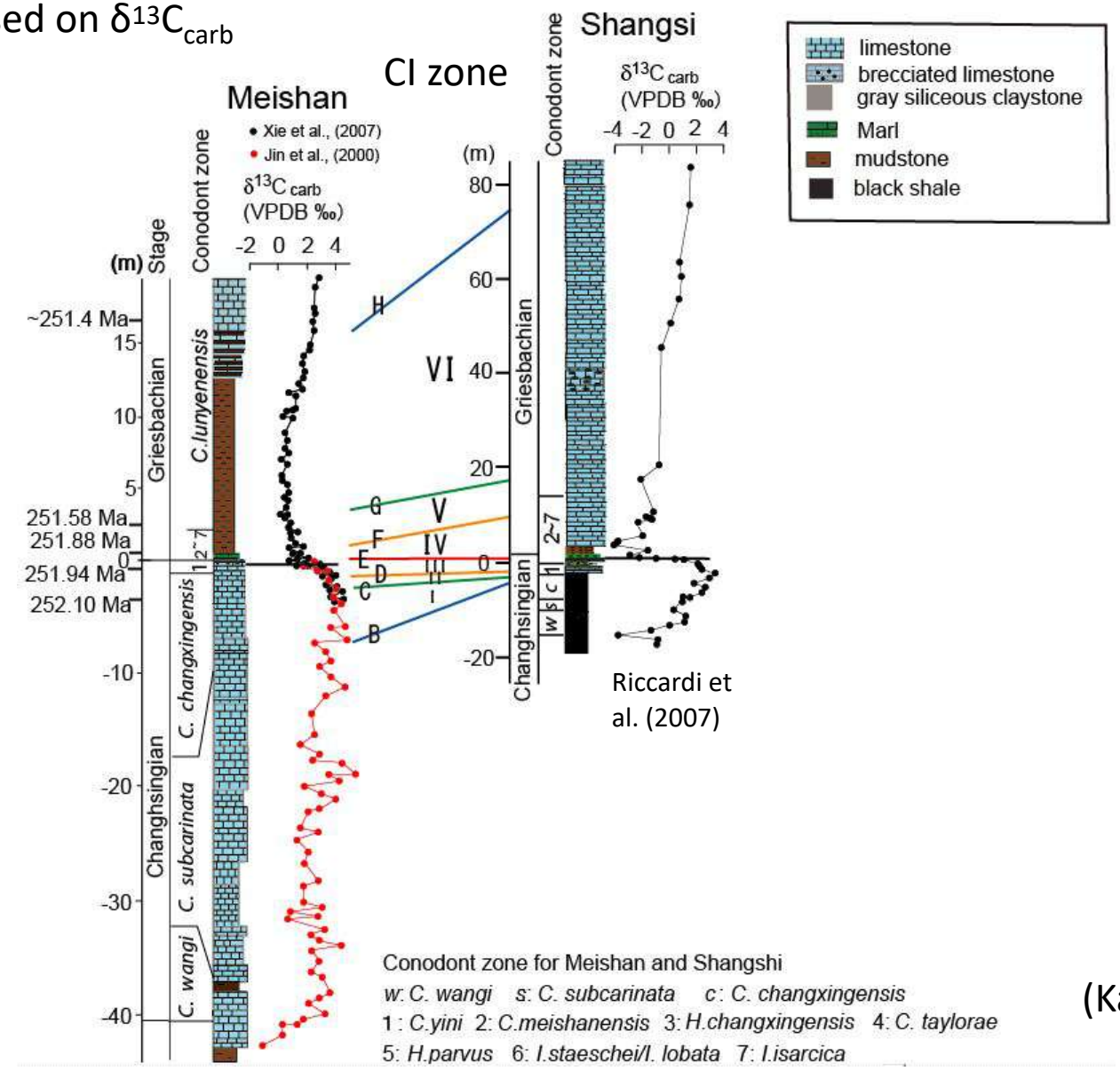
The water depth for Shangsi was estimated to be 200–300 m based on its slump structure and lithology (Kaiho et al., 2016)



Riccardi et al. (2007)

Stratigraphic framework

Correlation between the Meishan and Shangsi sections based on $\delta^{13}C_{carb}$



(Kaiho et al., 2016)

Methods

Seventy-one carbonate, shale, and marl samples were collected from the Shangsi section and analyzed using biomarkers.

1. Short chain n-alkane (n-C17, 19) proxy for bacteria and/or algae
2. Long chain n-alkane (n-C27, 29) proxy for higher plants

3. C31 2-methylhopane as proxy for the environmental stress

4. Isorenieratane as a proxy for the photic zone euxinia

5. C33 n-alkyle cycholohexane indicates the on set of marine ecosystem collaspe at P/T boundary.

Methods.....

Cutting surface of rocks (a)

⇩

Washing and crashing samples

⇩

Making powder

⇩

Soxlet extraction (b)

⇩

Concentration (c)

⇩

Separation in three fraction (d)

⇩

GC/MSMS measurement (e)

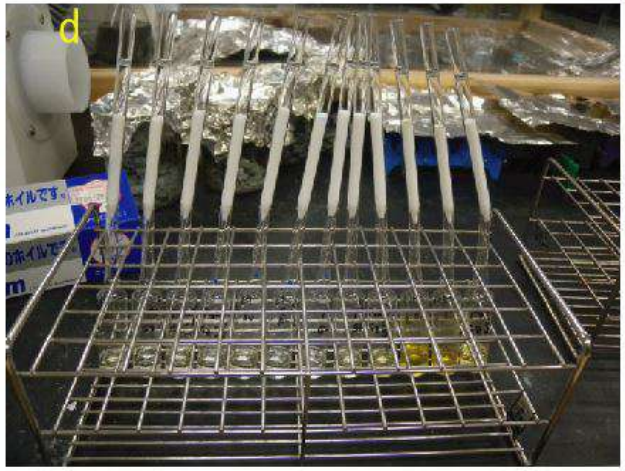
⇩

Full scan (n-alkane, C-33 n-alkyle Cychlohexene)

MRM (C30 Sterane,Isorenieretane C31,2-methyle hopane)

⇩

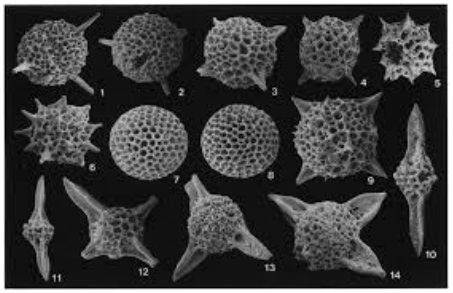
Data analysis and interpretation

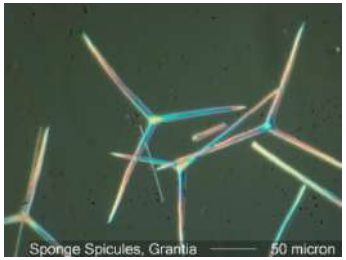


Laboratory experiment using soxlet and GCMSMS

Results

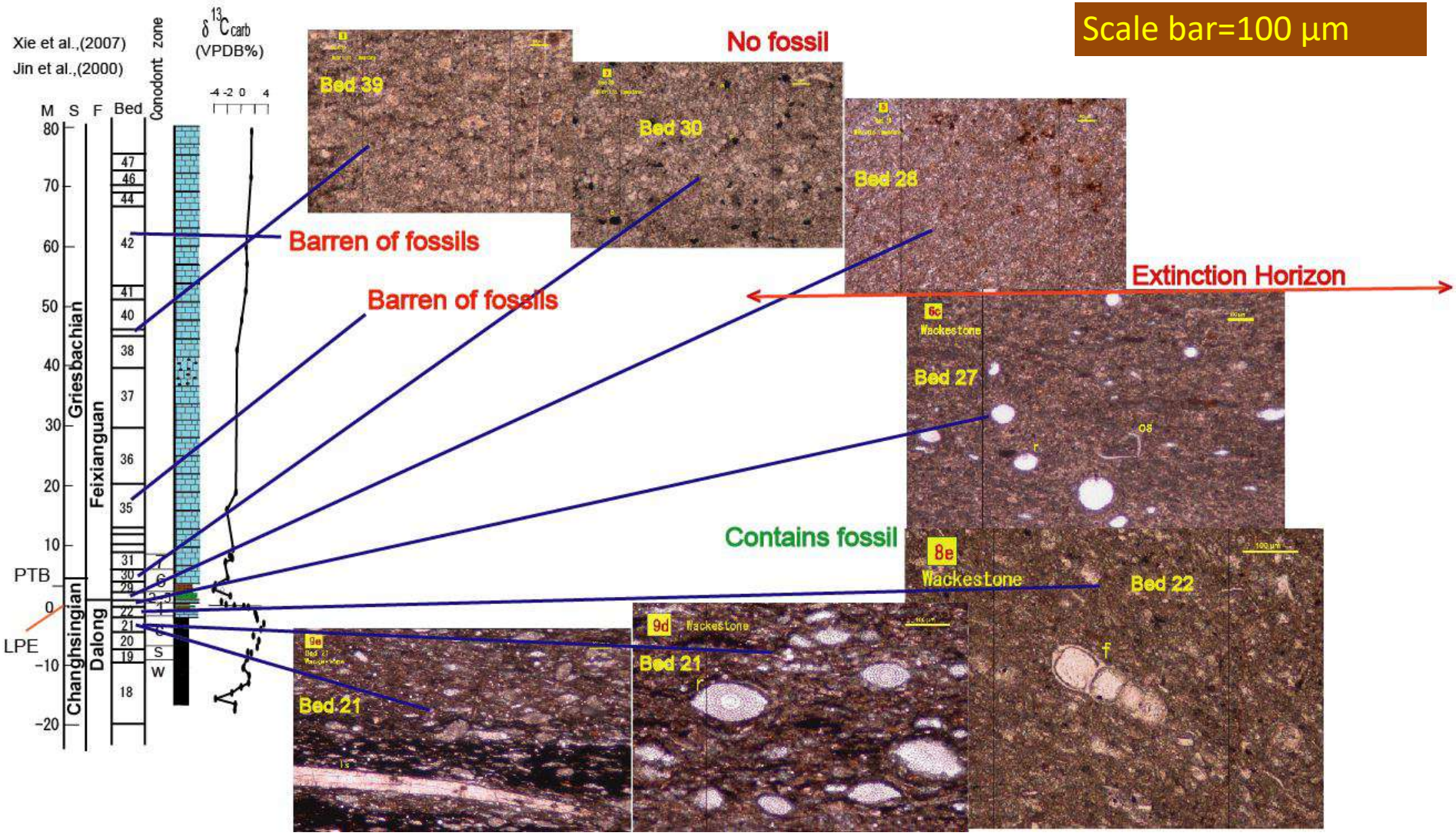
1. Fossil Record





Sample (CHSS)	Thickness (m)	Lithology	Classification	Fossil	Age (Ma)
39-1	40	Limestone	Micrite	-	251.50
31-8	5.8	Limestone	Fossiliferous micrite	Thin shelled bivalve	251.88
31-5	5.5	Limestone	Micrite	-	251.89
30-1	3.2	Limestone	Micrite	-	251.91
28-5	1.3	Marl	Micrite	-	251.93
27-6	0.1	Limestone	Radioralian wackestone	Radiolarian, sponge spicule, thin shelled bivalves, ostarcod	251.94
24-1	-2.6	Limestone	Radioralian wackestone	Radiolarian	251.99
22-5	-3.4	Marl	Radioralian wackestone	Radiolarian, thin shelled bivalves, foraminifera, ostracod	252.10
21-2	-7.7	Black shale	Radioralian black shale	Radiolarian, large sized bivalve shell	252.22

Very low diversity in the marine biosphere lasted in the Griesbachian after the marine crisis.



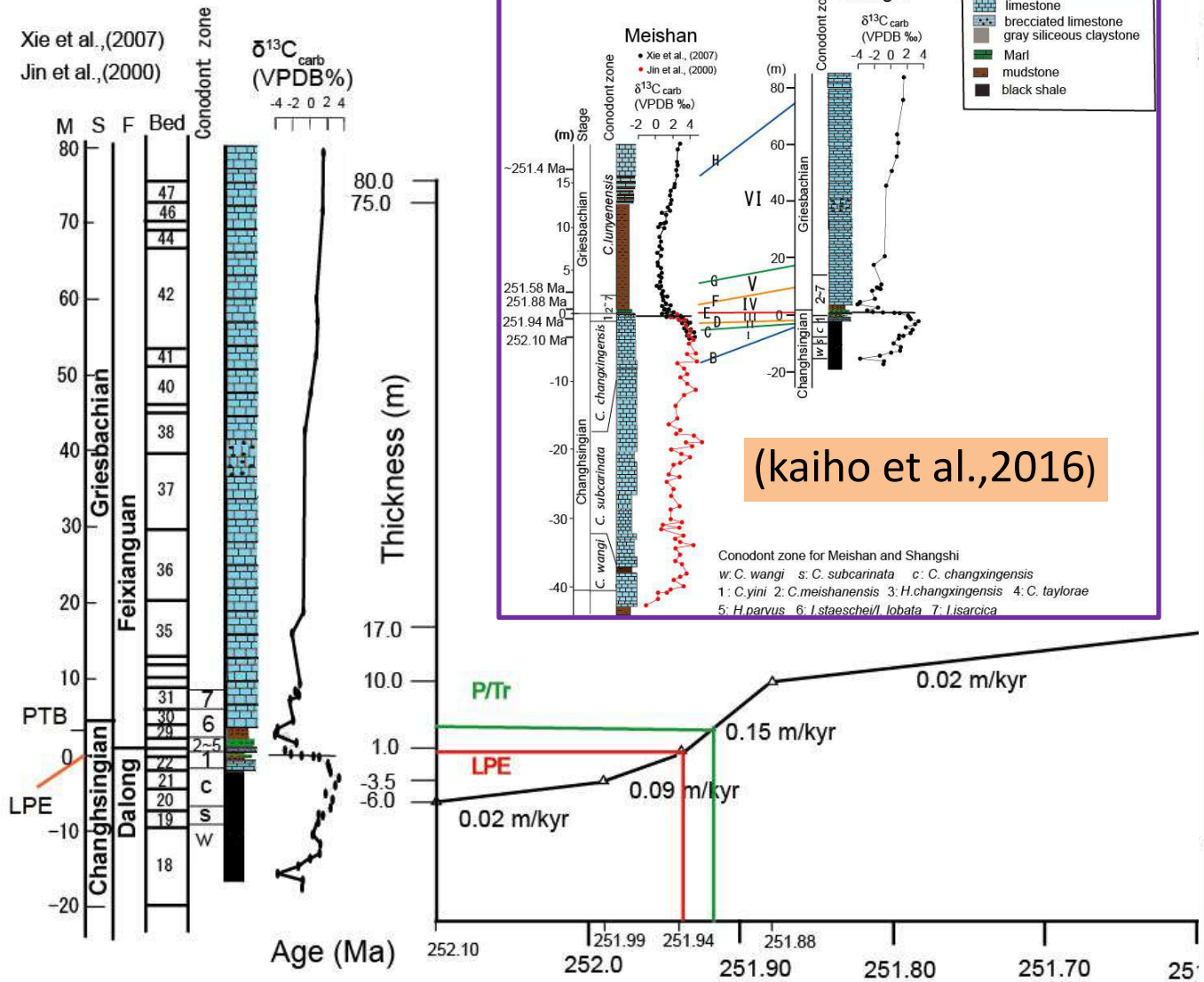
Results

Maturity

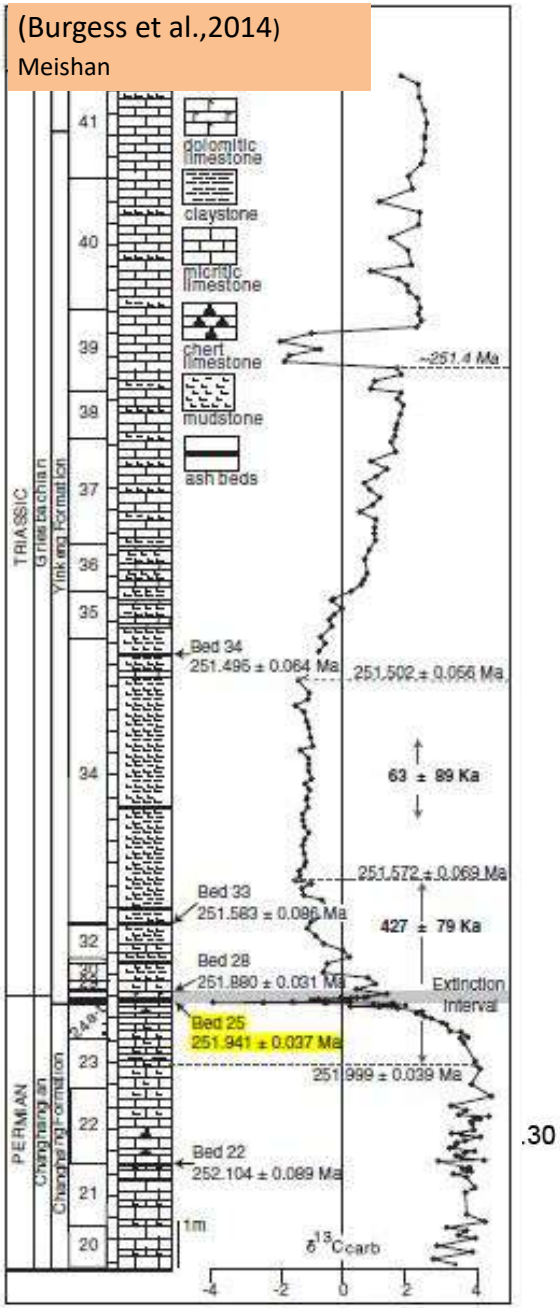
- The value of 22S/(22S + 22R) C31 homohopanes ranges 0.48–0.69.
- ββ/(αα + ββ) C29 sterane, ranged 0.16- 0.58.

- These values indicate the maturity of early to peak stage of oil generation (Peters et al., 2005).

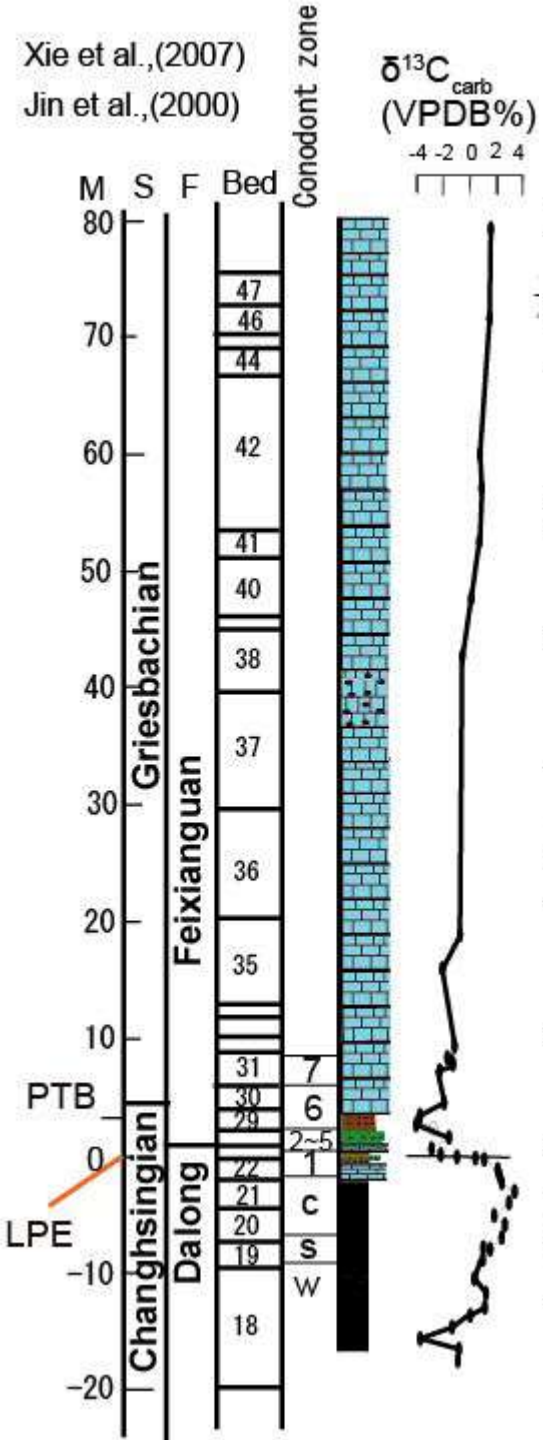
Age model of the Shangsi section

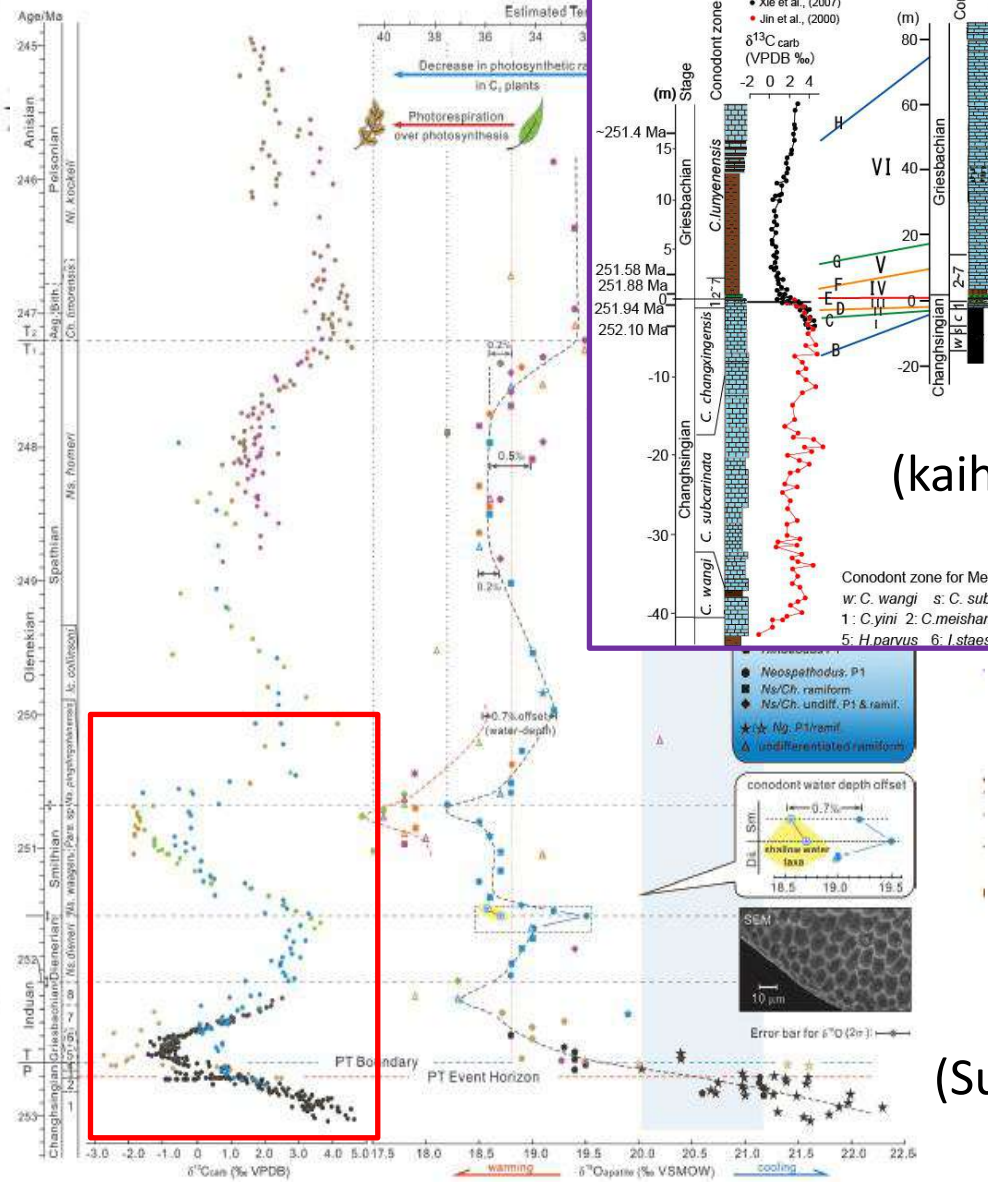


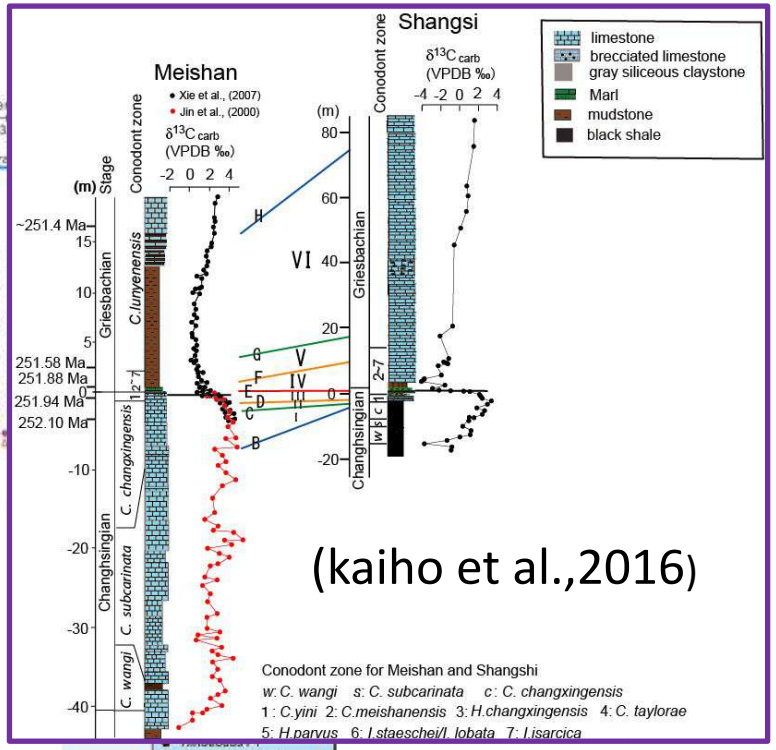
(kaiho et al.,2016)



Age model of the Shangsi section







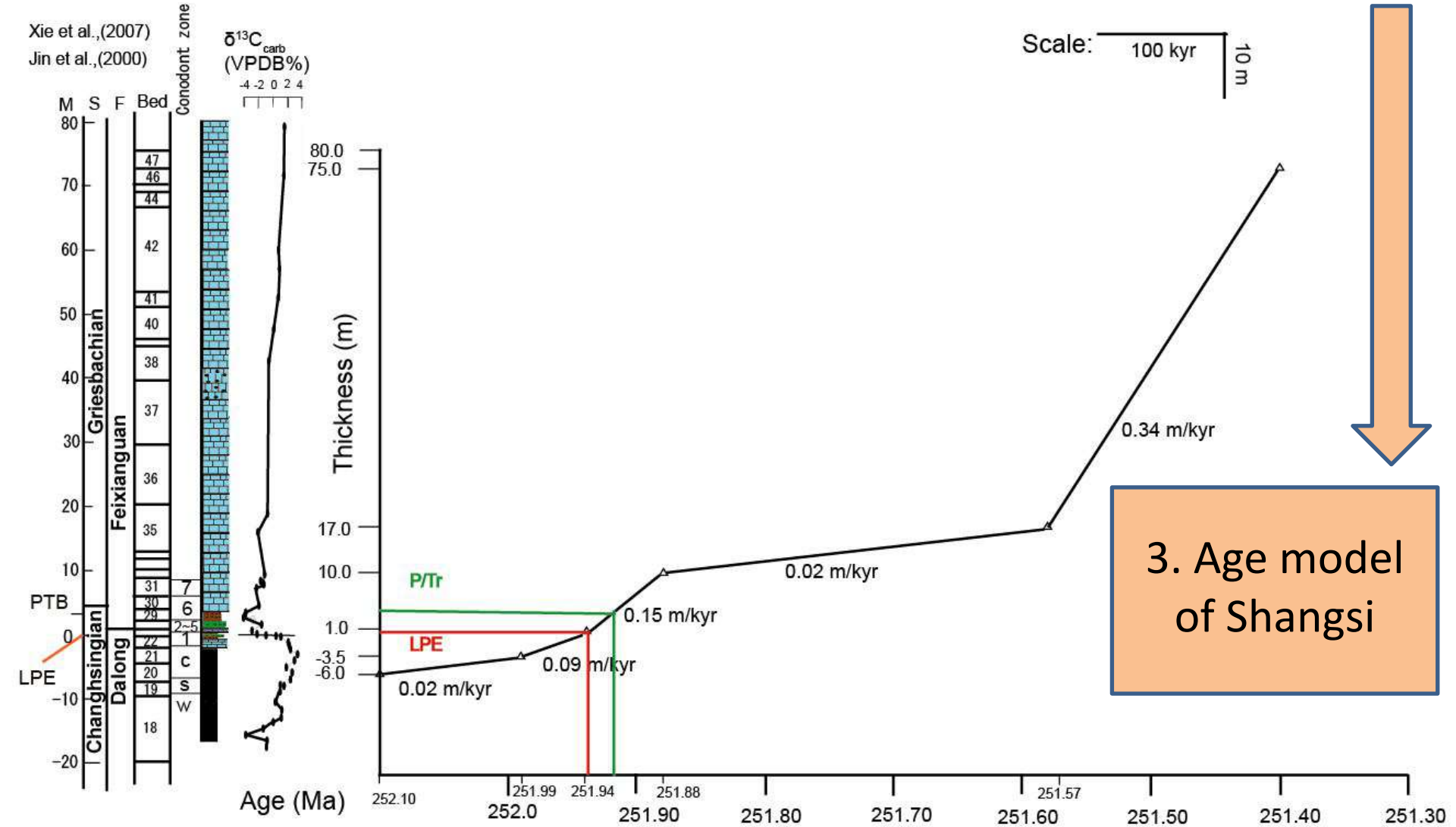
(kaiho et al.,2016)

(Sun et al.,2012)

Age model of the Shangsi section

1. Radiometric absolute age From Burgess et al. (2014)

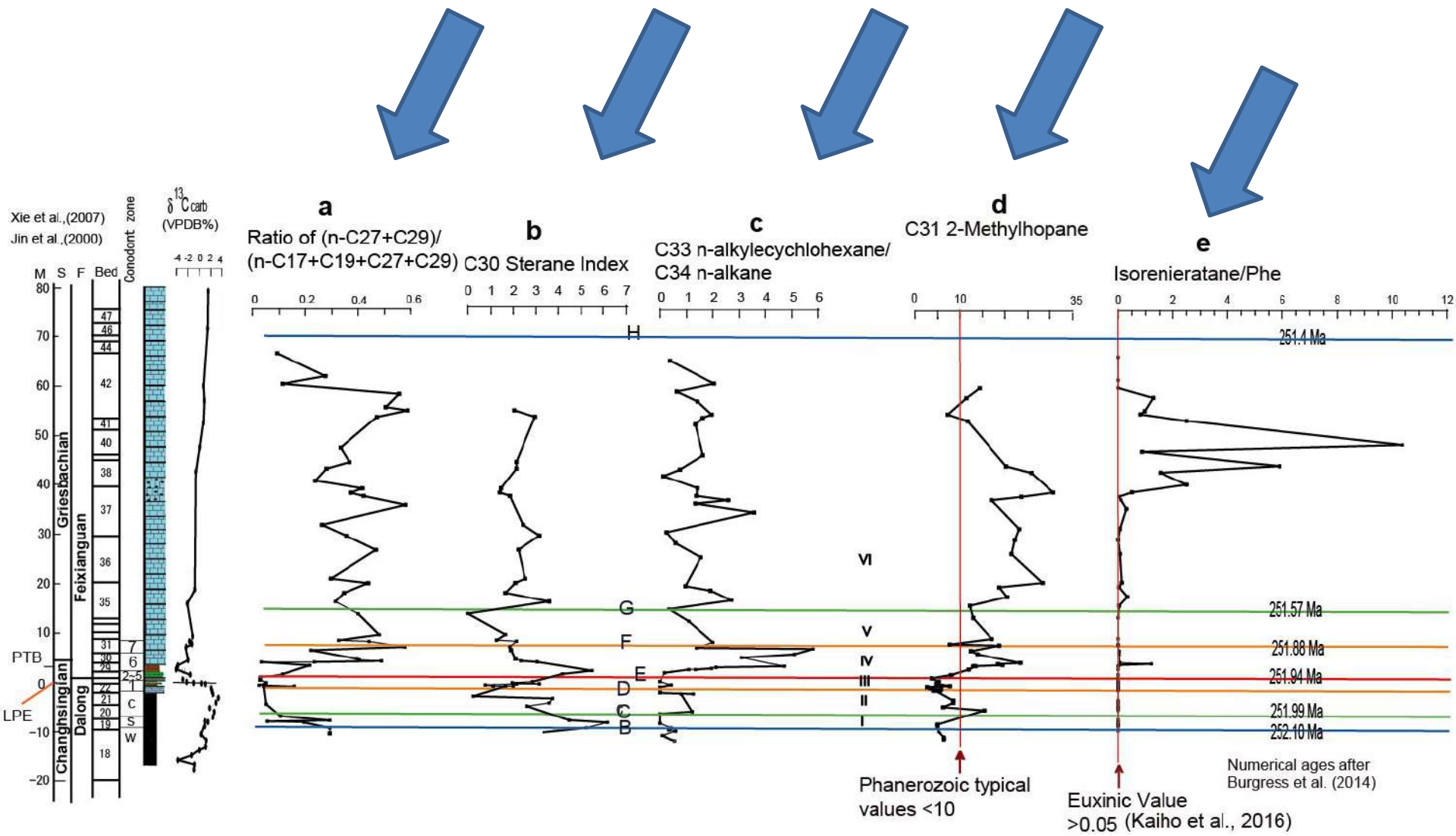
2. Correlation of $\delta^{13}C_{carb}$ isotope data and conodont with Meishan & Shangsi



3. Age model of Shangsi

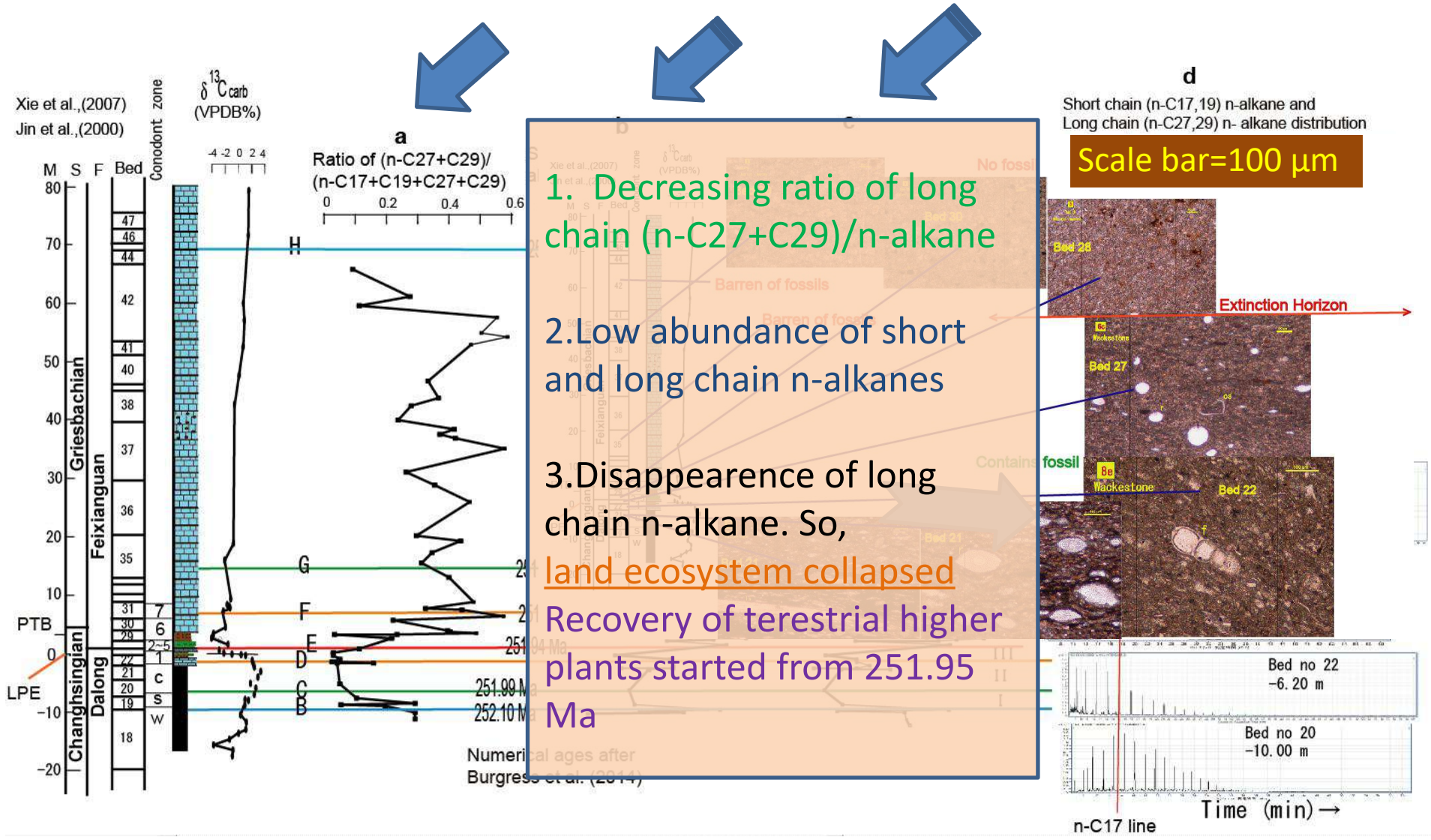
Results.....

Biomarker record



Discussion

Land ecosystem collapse



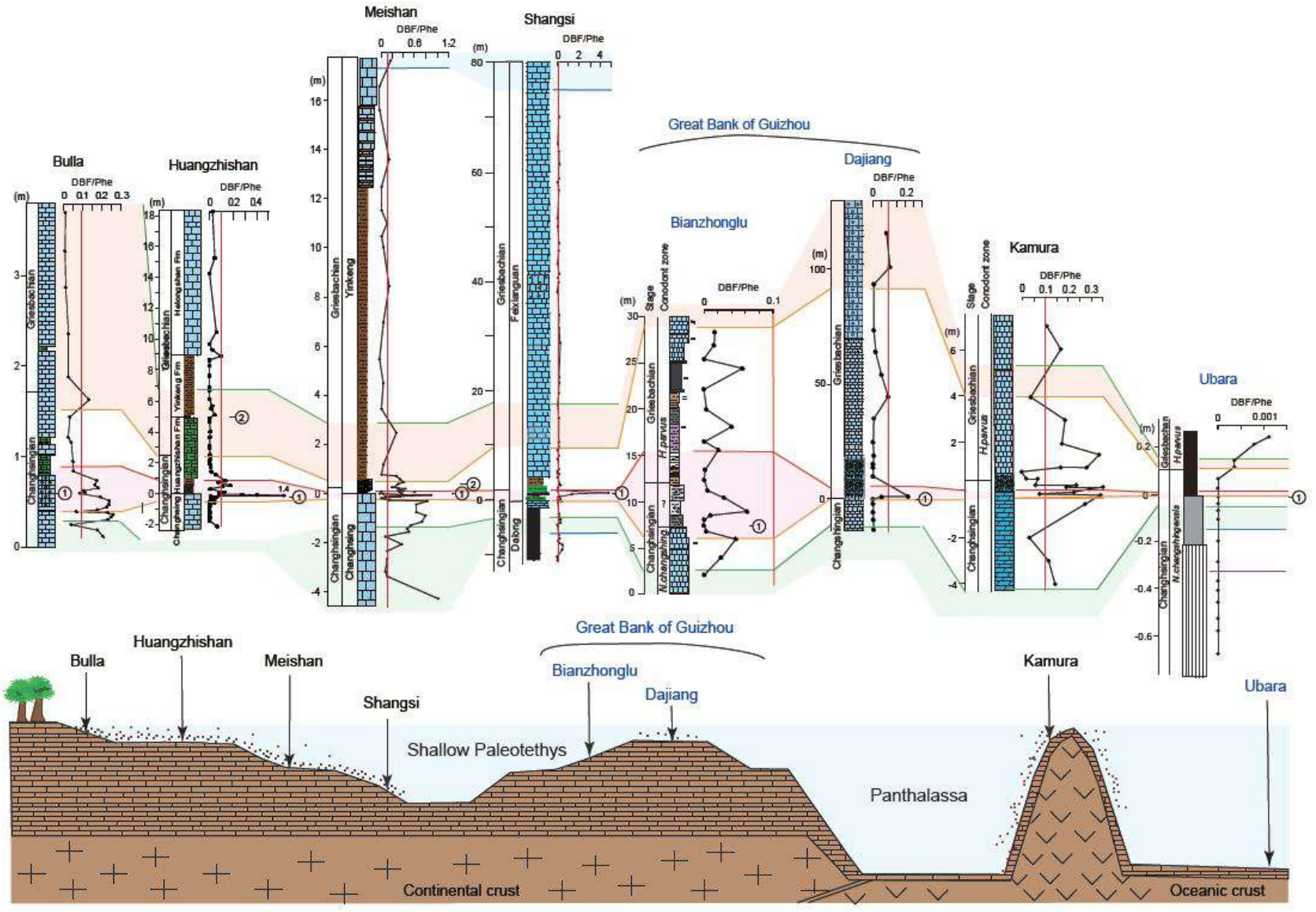
1. Decreasing ratio of long chain (n-C27+C29)/n-alkane

2.Low abundance of short and long chain n-alkanes

3.Disappearence of long chain n-alkane. So, land ecosystem collapsed

Recovery of terestrial higher plants started from 251.95 Ma

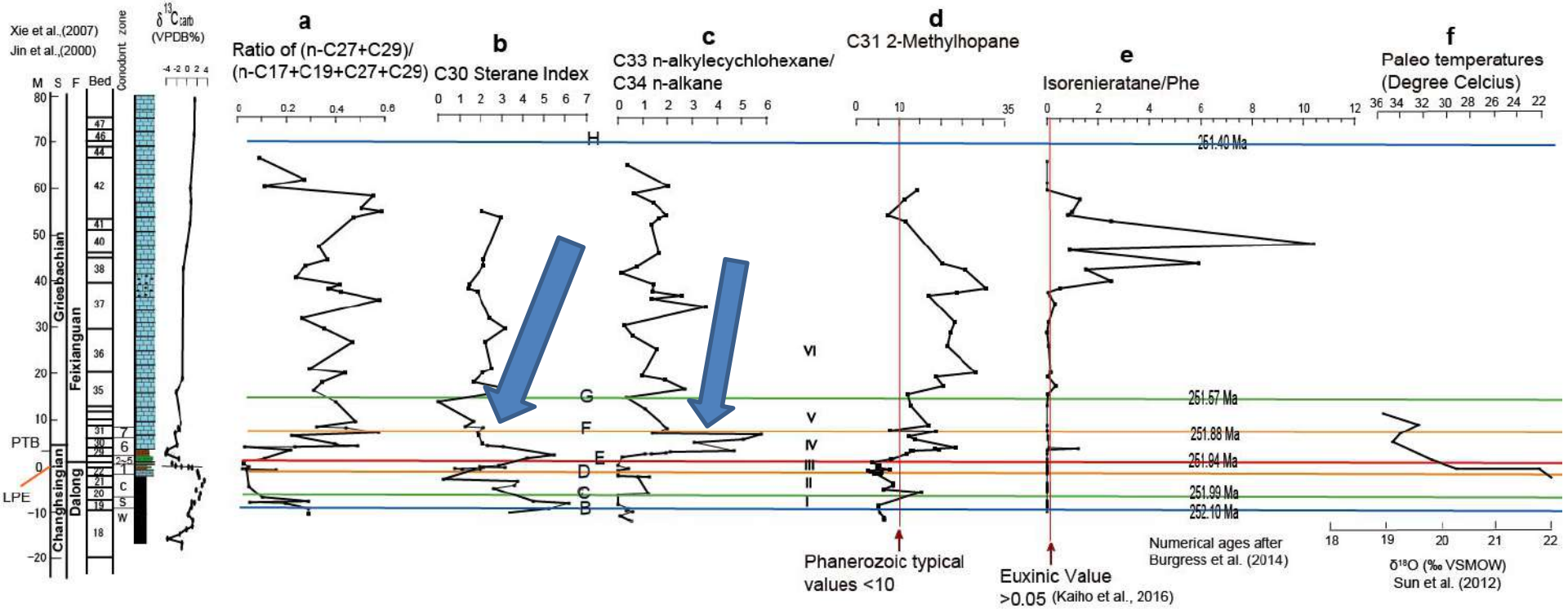
2nd terrestrial collaspe coincided with 1st phase of marine extinction (Kaiho et al., 2016)



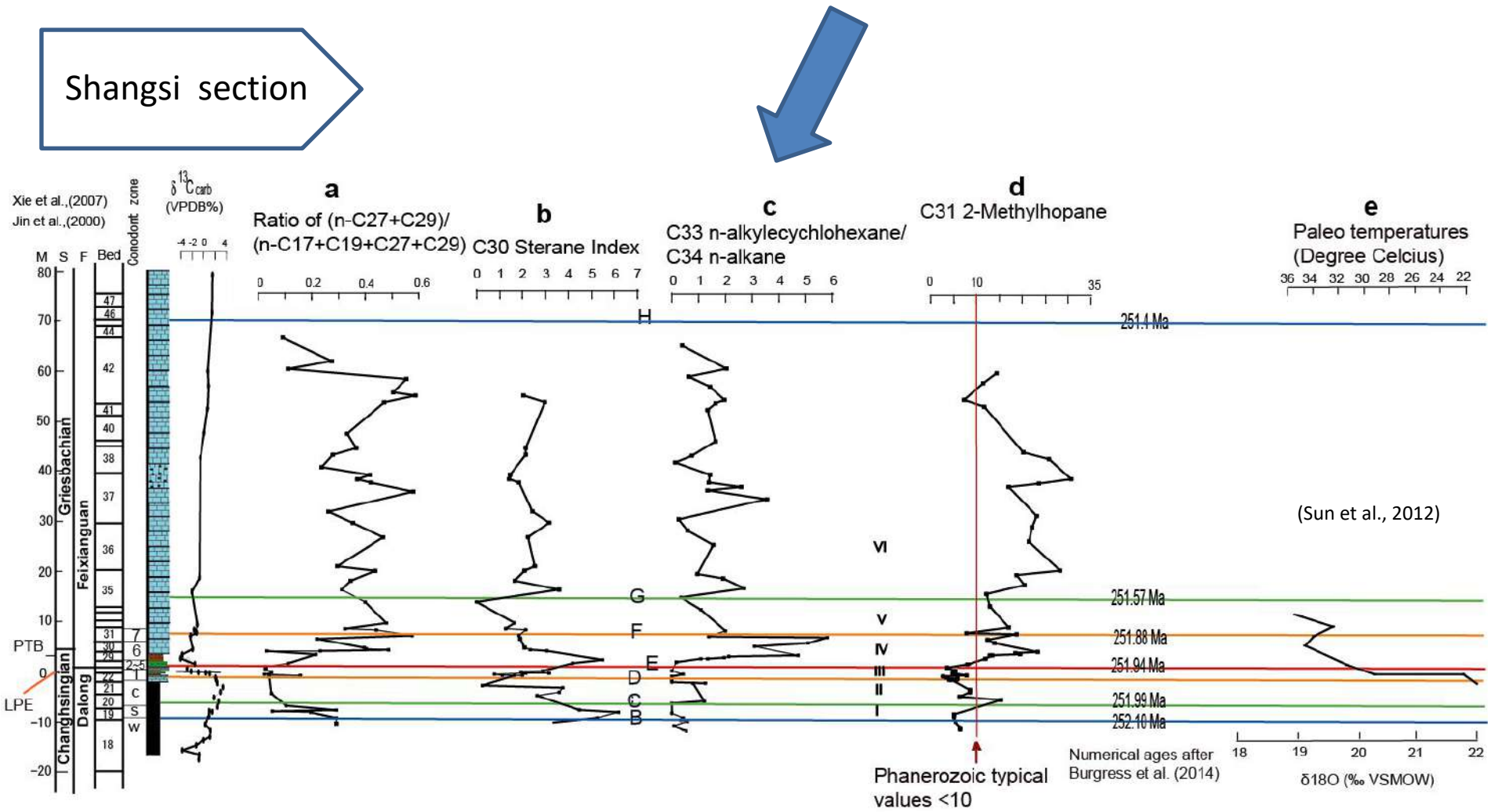
Discussion

Blooming of acritarchs

C33 n-alkylcychlohexane; for unusual ecology and environments at the P/Tr crisis (Grice et al., 2005).



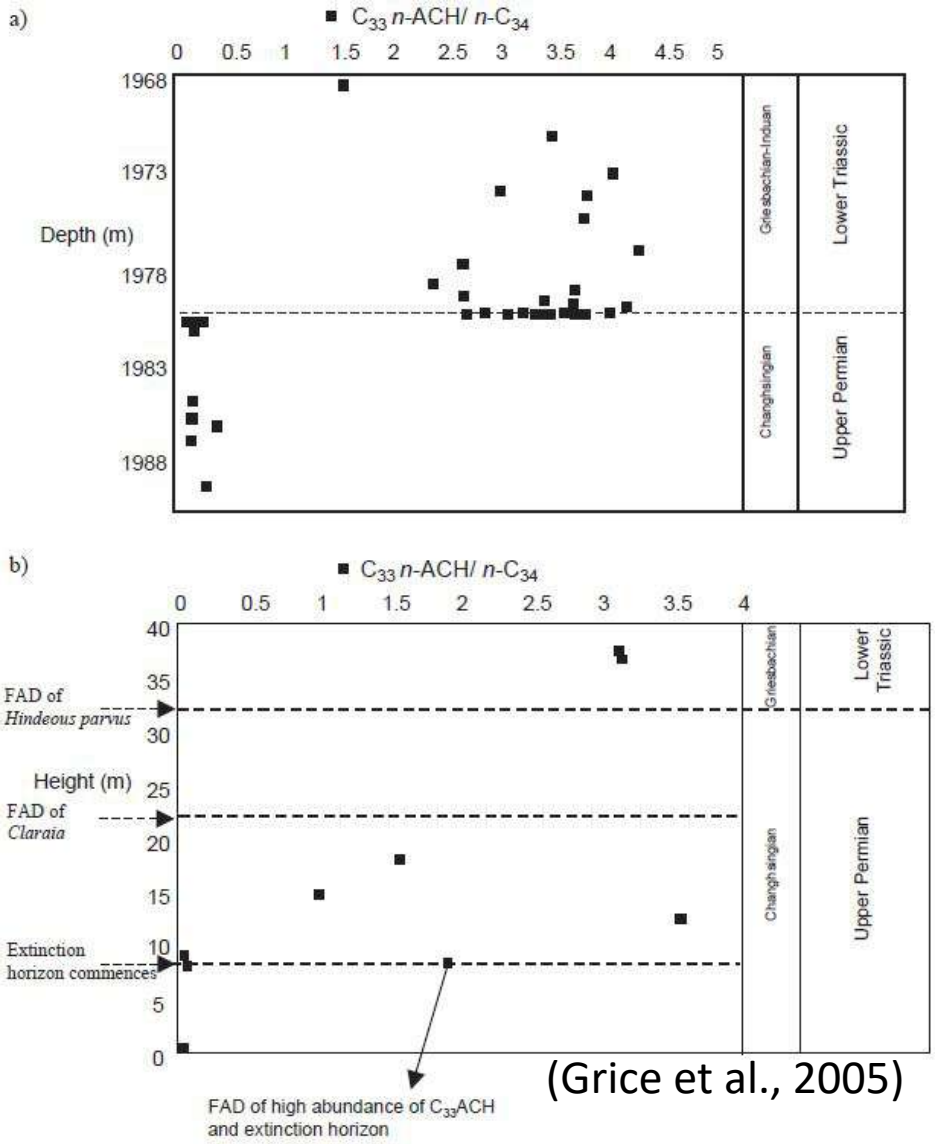
C33 n-alkane cychlohexane found first time in the Shangsi Section.
Previously, this feature reported from high latitudes (McIldowie and Alexander, 2005).



C33 n-alkylcyclohexane from high latitude at the latest Permian and the P/Tr boundary

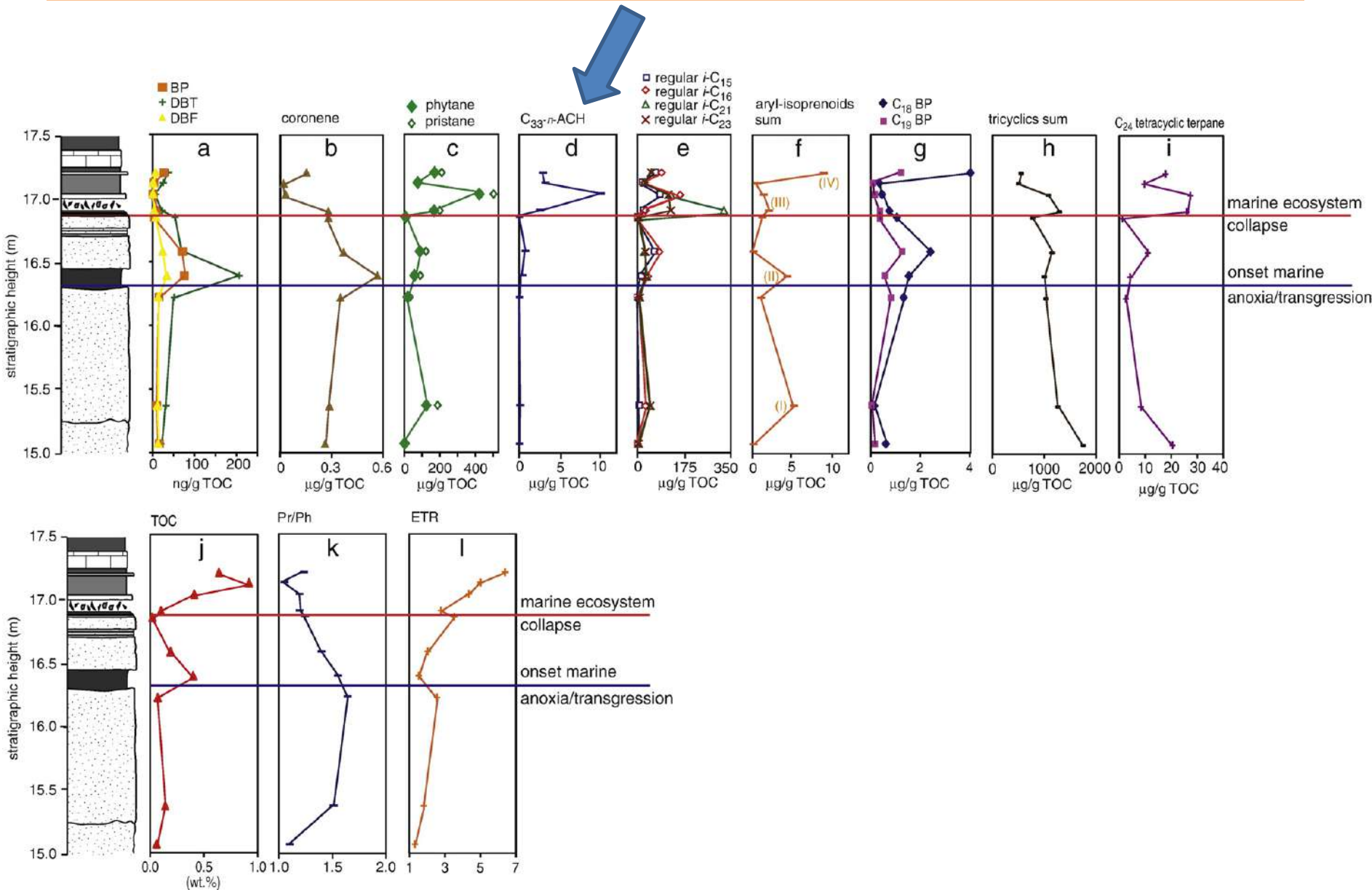
(a) Hovea#3 P–Tr core, Western Australia

(b) Schuchert Dal P–Tr section, East Greenland



(Grice et al., 2005)

C33 n-alkylcyclohexane (ACH) from high-latitude.
Lusitaniadalen, Spitsbergen, Norway at P/Tr (Nabbefeld et al.,2010)

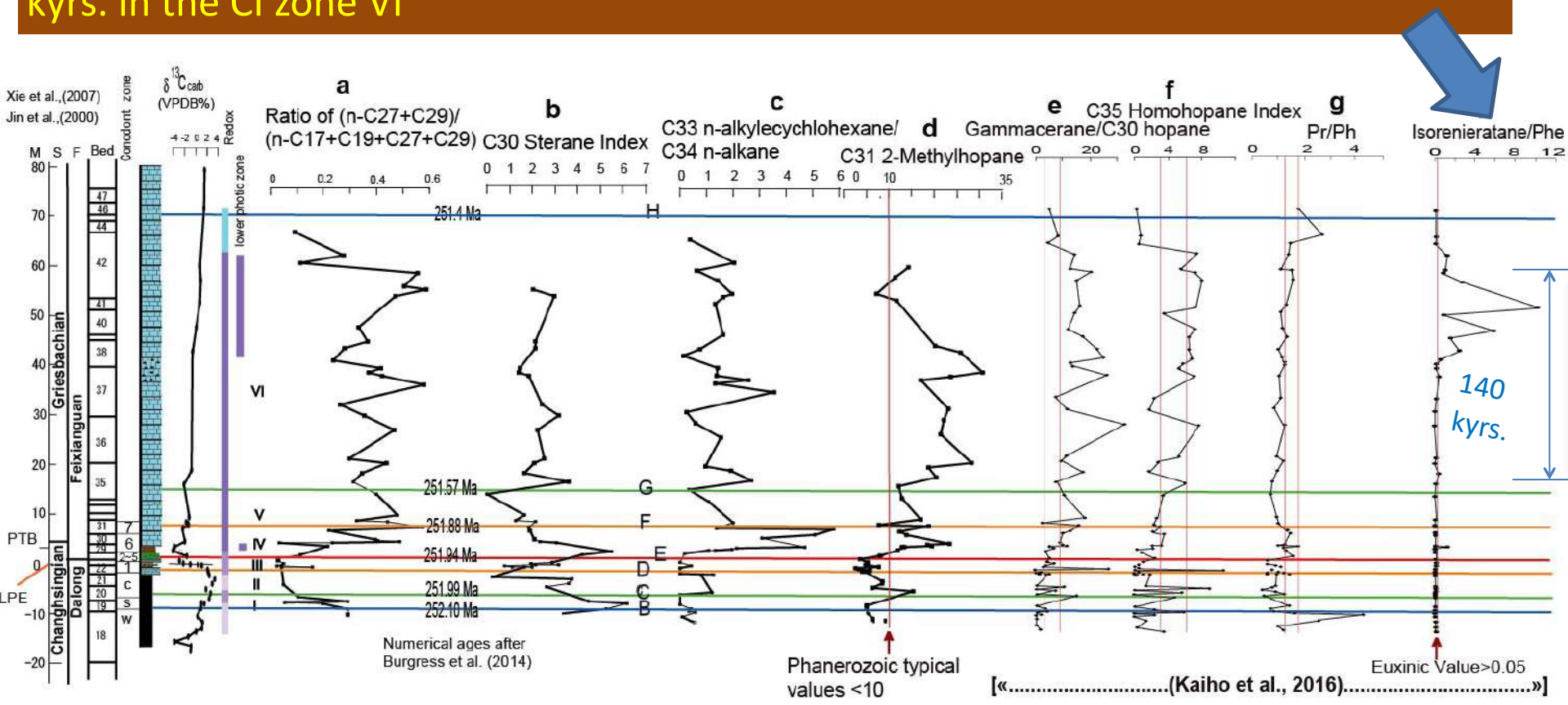


Discussion

Photic zone euxinia

Shangsi section

Photic zone euxinia occured in two phases and longest phase persisted during 140 kyrs. in the CI zone VI



Discussion

Environmental stress

- 2-methyhopane index (2-MHI) were a cyanobacterial proxy (Summons et al., 1999).

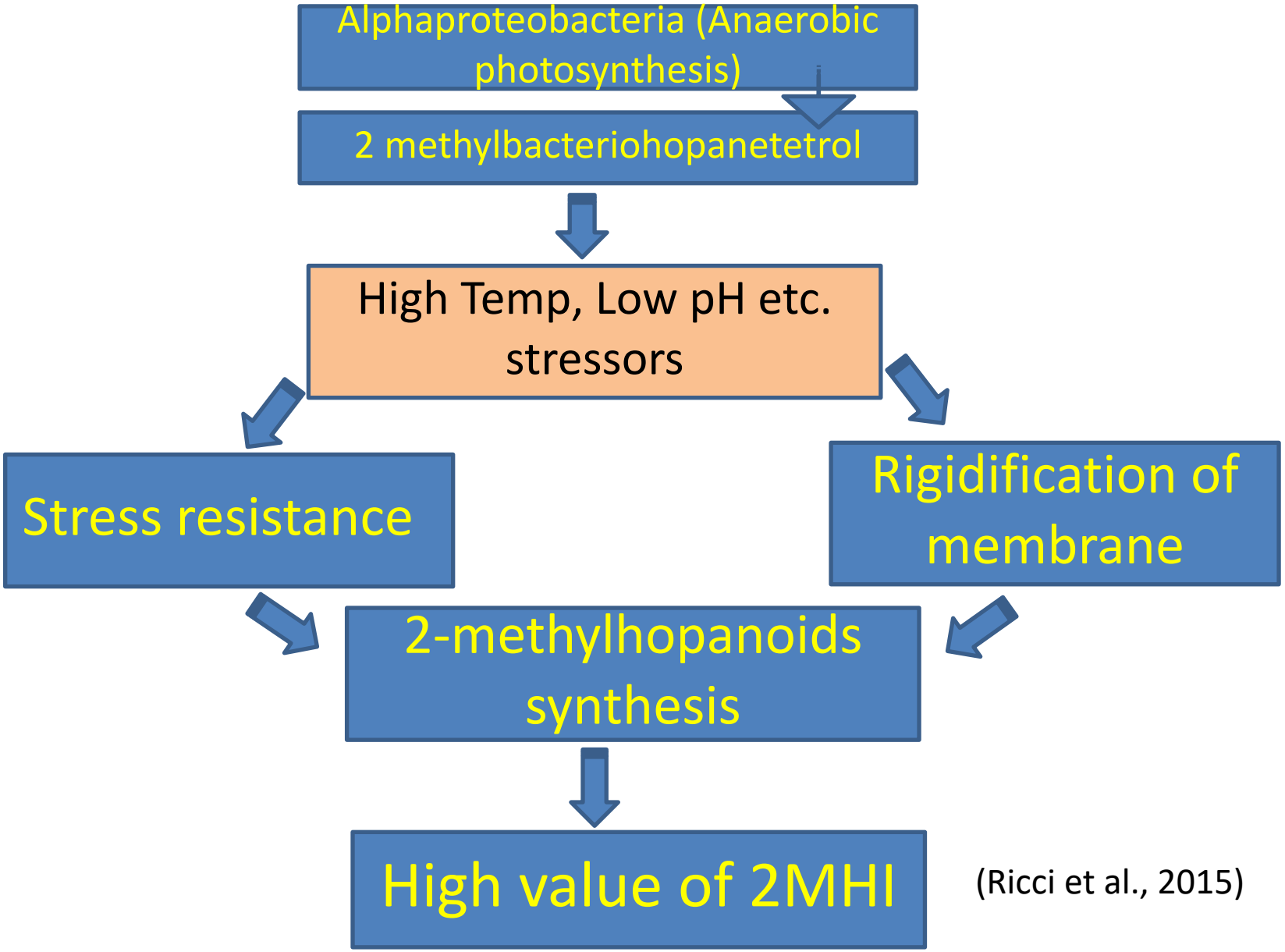
- Study reports, 2-MHI is no longer effective marker as a proxy for cyanobacteria, but, a proxy for environmental stress (Kulkarni et al., 2013; Ricci et al., 2014, 2015; Wu et al., 2015).

Discussion

Environmental stress

- Paleoenvironmental stresses (e.g.; high temperature, low pH and osmotic stress) (Saito et al., 2016).
- 2- methylhopanoids play a role in stress resistance by the rigidification of membranes (Kulkarni et al., 2013; Wu et al., 2015)
- Any of these stressors could enhance 2-methylhopanoid production, resulting in high values of 2-MHI (Ricci et al., 2015; Saito et al., 2016).

2-methylhopane index (2-MHI) pathway



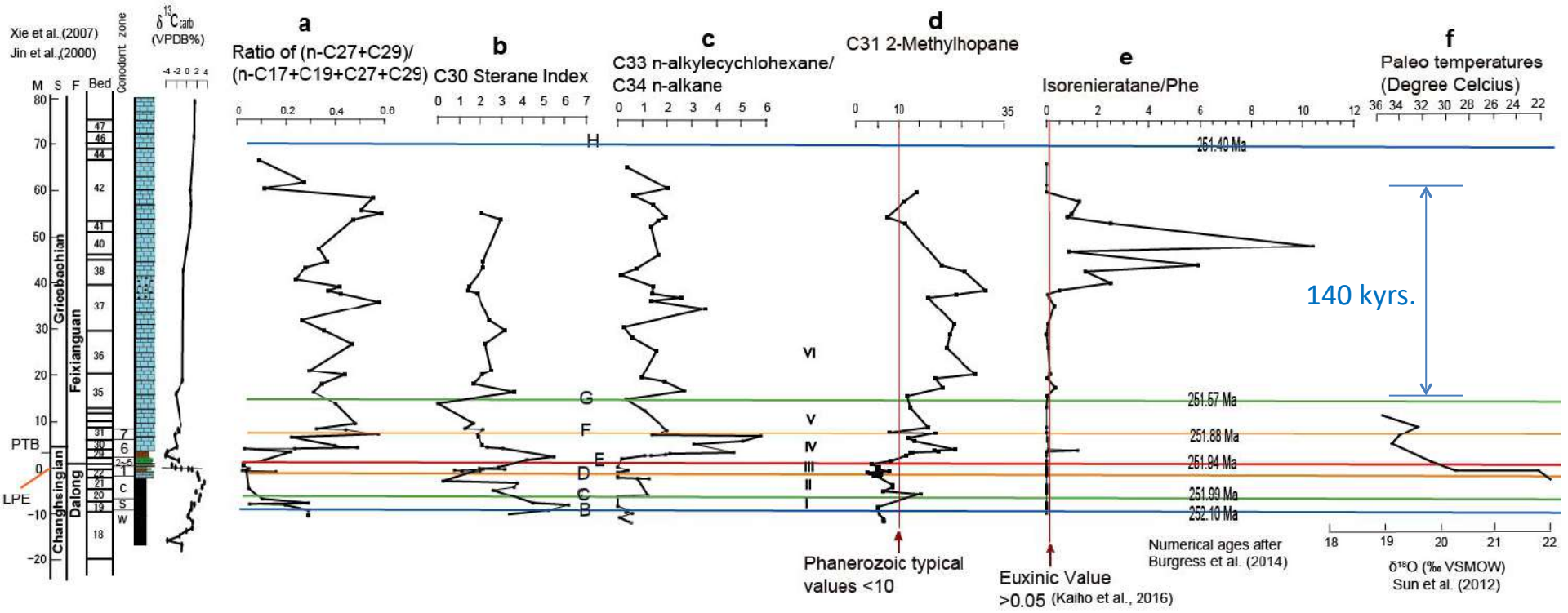
(Ricci et al., 2015)

Isorenieratane vs C31 2-methyl hopane

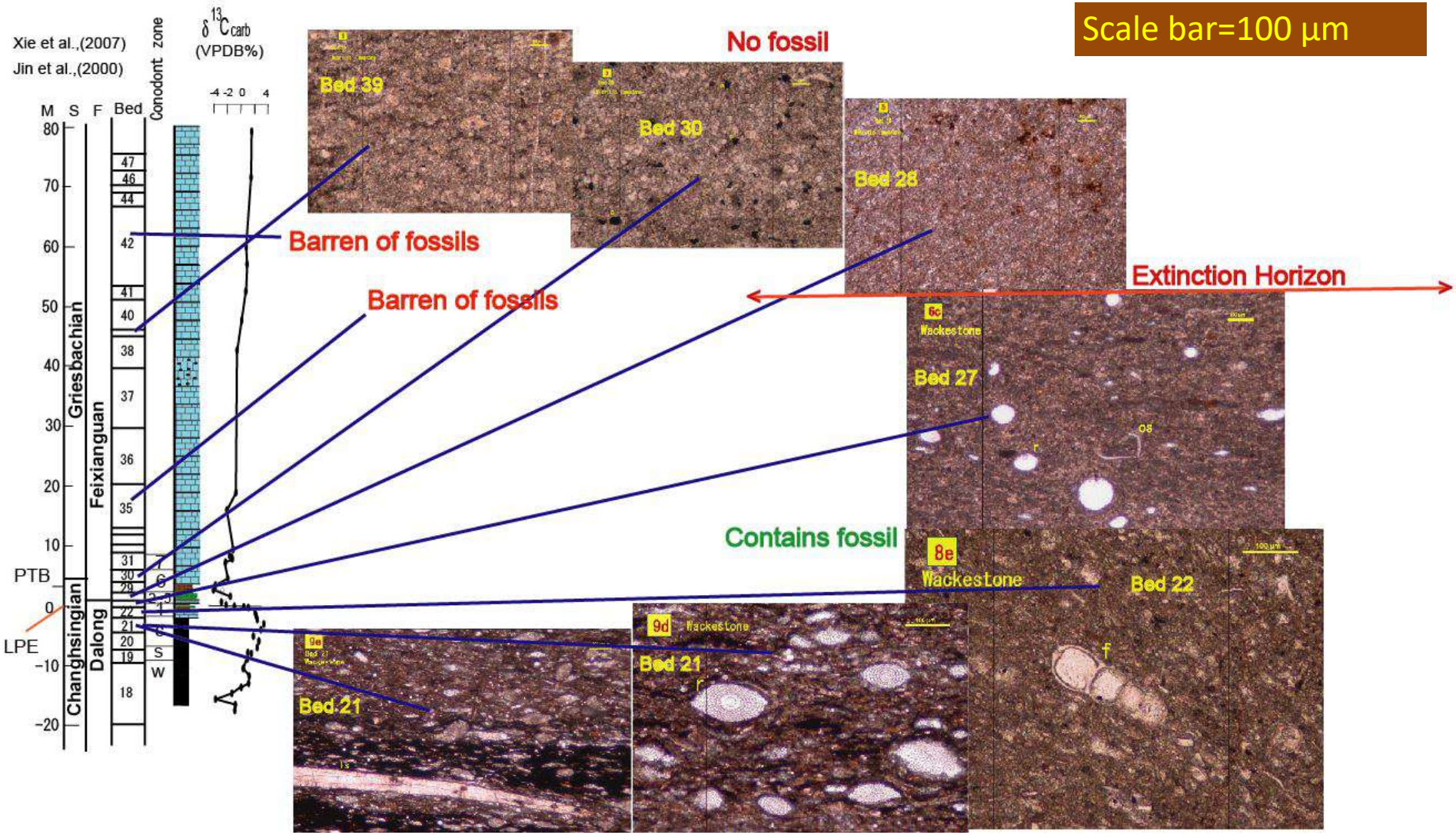
Isorenieratane and C31 2-methyl hopane coincided after the mass extinction.

Photic zone euxinia and environmental stress significantly prevalent after the end-Permian mass extinction.

Photic zone euxinia & environmental stress persisted around 140 kyr after the extinction event.



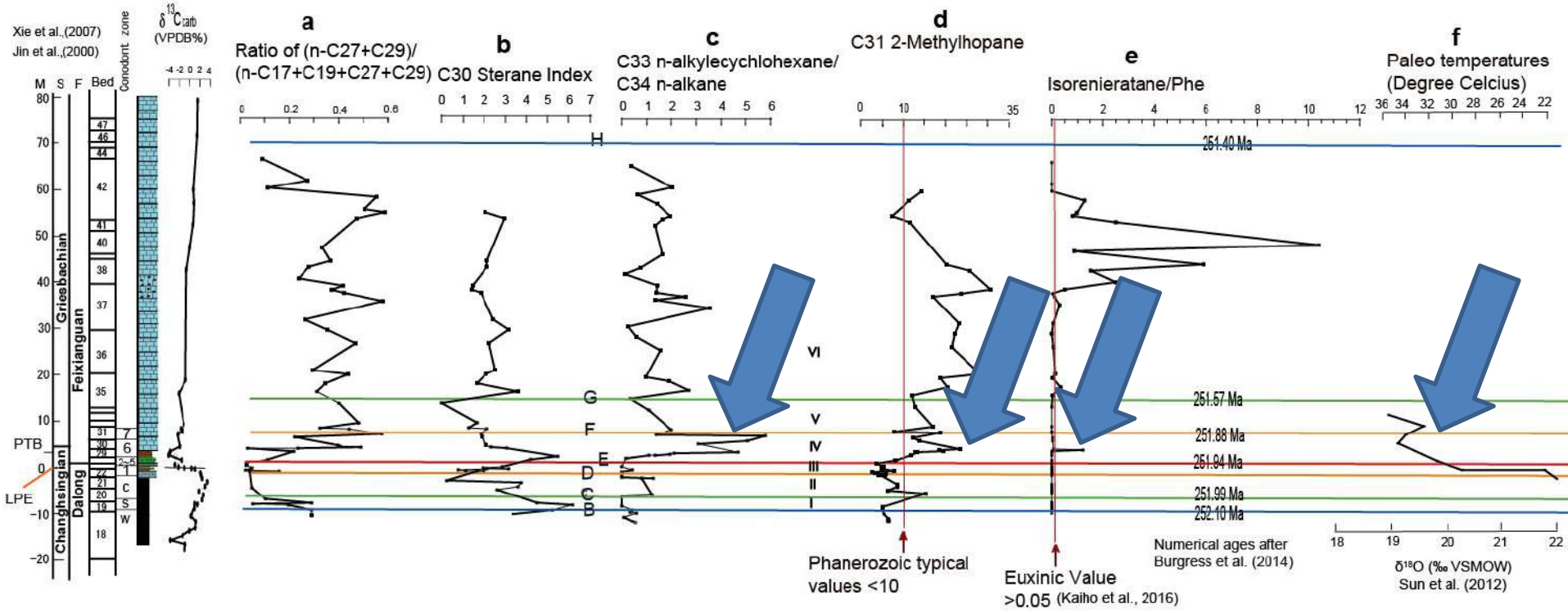
Photic zone euxinia and environmental stress suggest very low diversity in marine biosphare during the Griesbachian at shangsi.



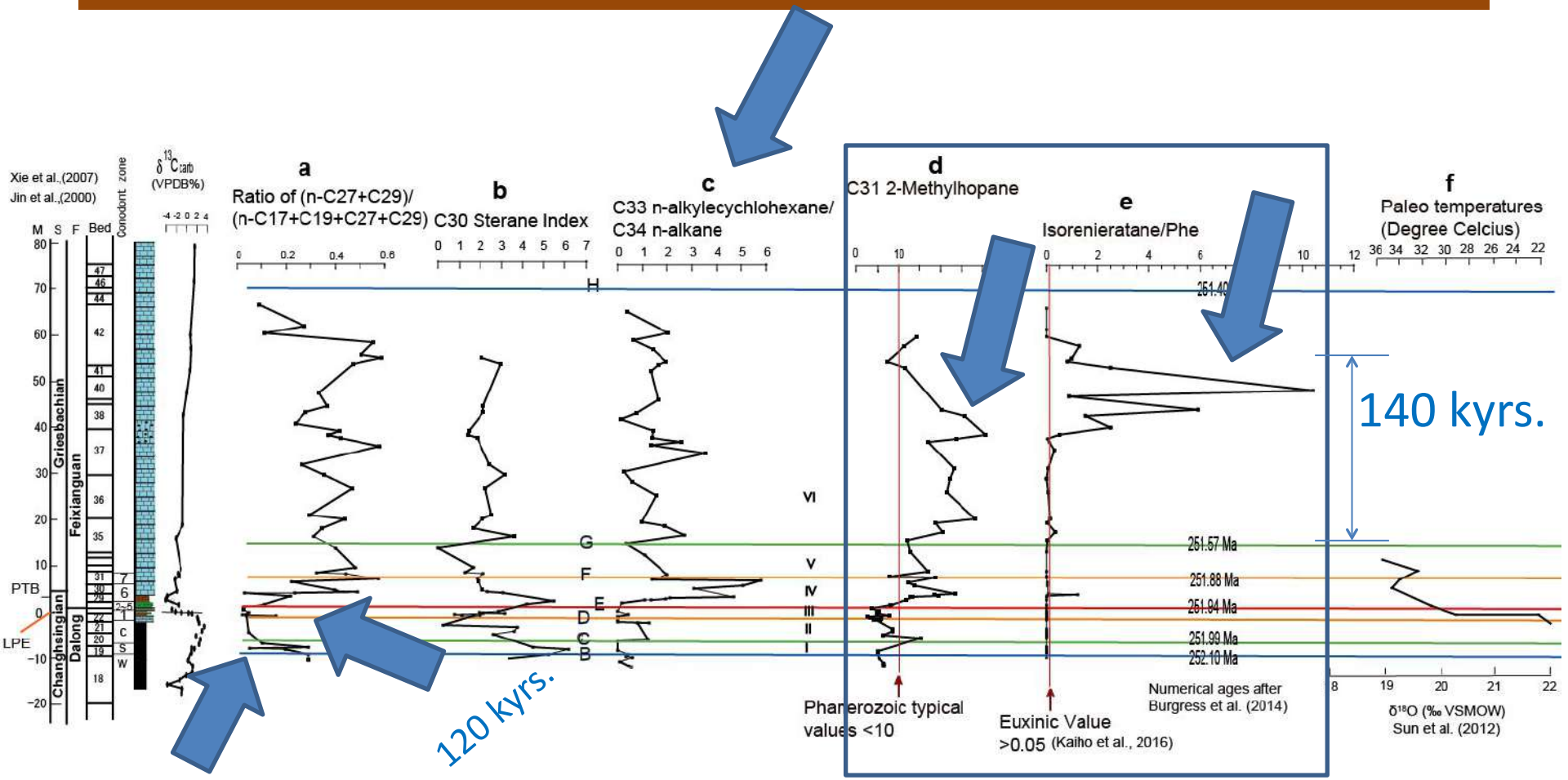
Discussion

Comparison of C33 ACH/n-C34 alkane & other biomarkers

Blooming of acritarchs (C33 ACH/n-C34 alkane increase) prevailed during the stress environment (C31 2-methyle hopane, $\delta^{18}O$ data for temp.) after the LPE.



Findings


Xie et al.,(2007)
Jin et al.,(2000)
δ13Ccarb (VPDB‰)
Conodont zone
M S F Bed
Griesbachian
Feixianguan
Changhsingian
Dalong
PTB
LPE
a
Ratio of (n-C27+C29)/ (n-C17+C19+C27+C29)
b
C30 Sterane Index
c
C33 n-alkylecychlohexane/ C34 n-alkane
d
C31 2-Methylhopane
e
Isorenieratane/Phe
f
Paleo temperatures (Degree Celcius)
H
G
F
E
D
C
B
VI
V
IV
III
II
I
120 kyrs.
140 kyrs.
251.57 Ma
251.88 Ma
251.94 Ma
251.99 Ma
252.10 Ma
Phanerozoic typical values <10
Euxinic Value >0.05 (Kaiho et al., 2016)
Numerical ages after Burgess et al. (2014)
δ18O (‰ VSMOW) Sun et al. (2012)

Conclusion

- **A significant decrease in terrestrial higher plants occurred 120 kyrs before the marine extinction (LPE) at the Shangsi section.**

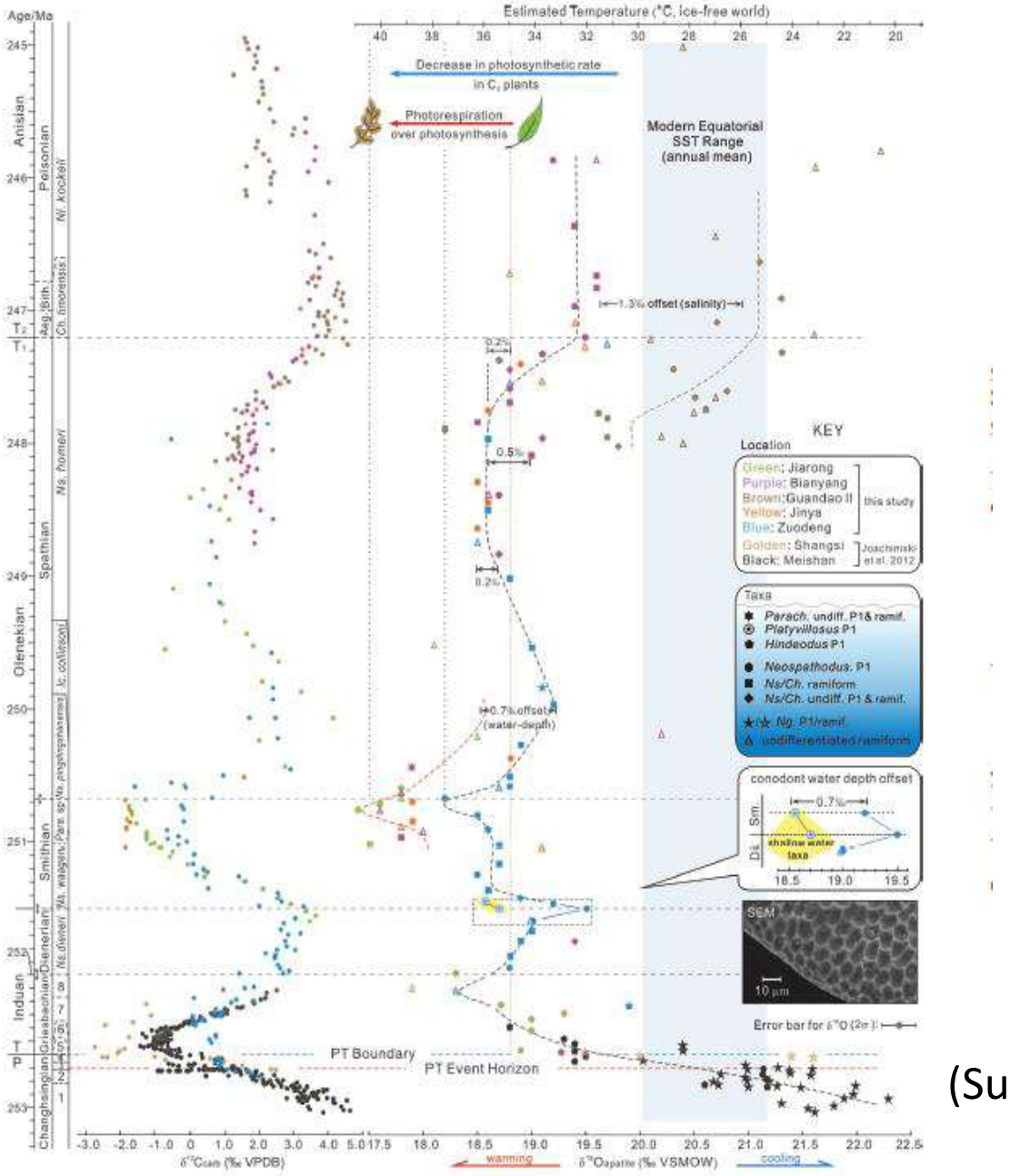
- After 10 kyrs of the marine extinction (LPE), the onset of recovery of terrestrial higher plants started at the Shangsi section.

- First time, I identified C33 n-alkylcyclohexane in low latitudes, indicates the marine acritarch blooming spanning the P/Tr boundary in low and high latitudes.

- **The double coincidence of environmental stress and photic zone euxinia occurred near the P/T boundary and in the upper Greisbachian which demonstrates very low diversity in marine biosphere at the Shangsi section.**

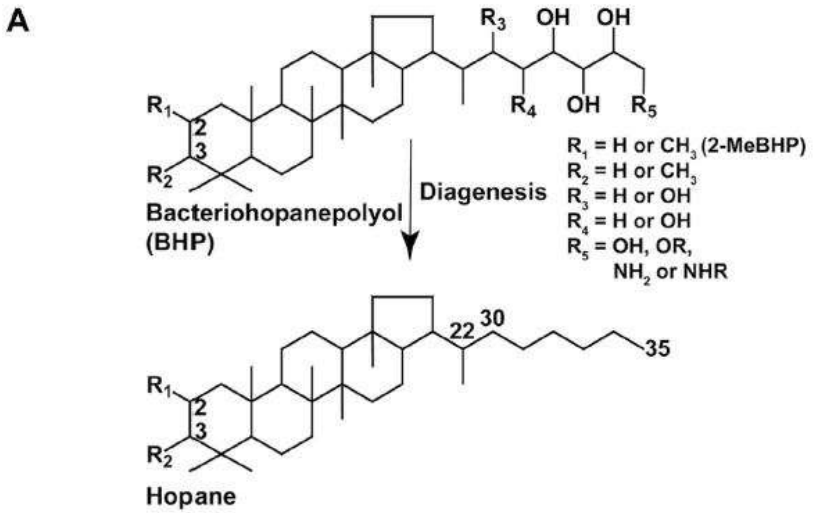
Thank you very much

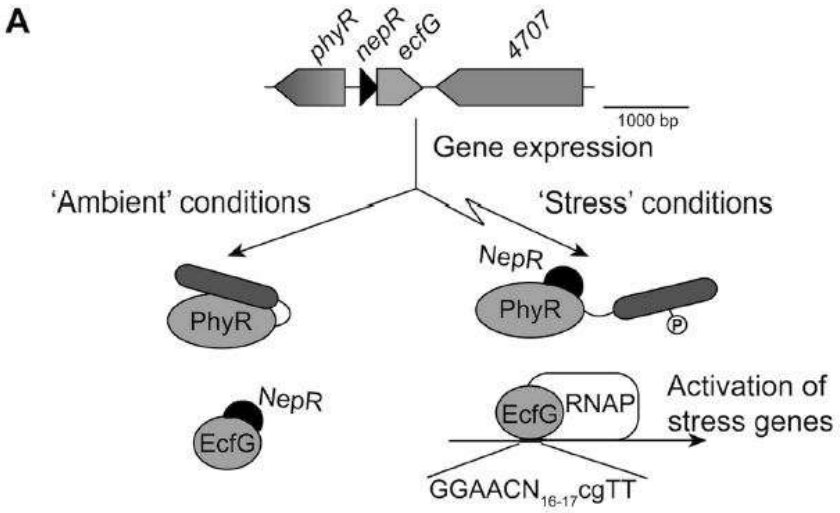
Question and Answer!!!

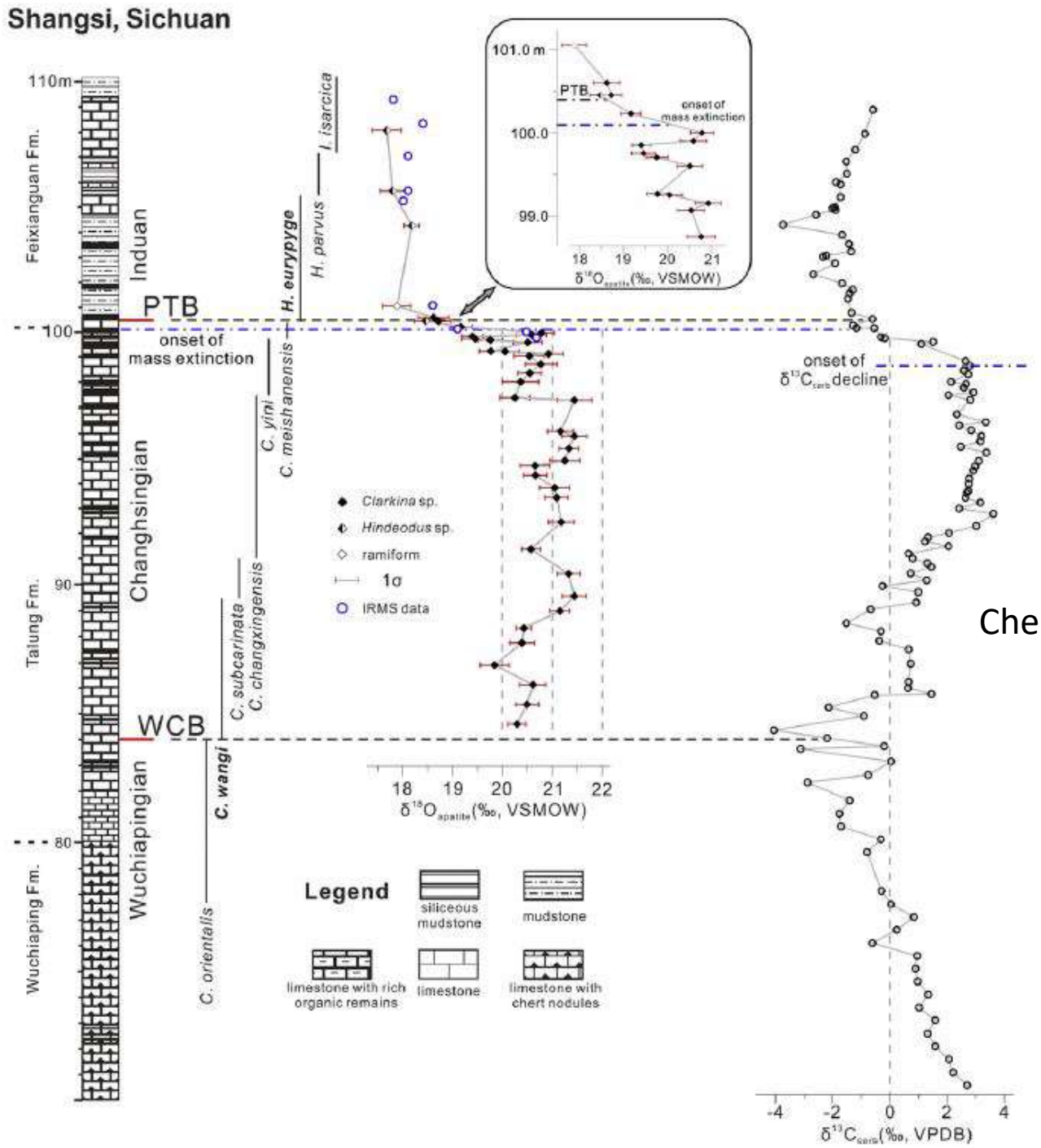


(Sun et al., 2012)

Kulkarni et al., 2013







Chen et al., 2016