Present and Paleosurface Temperatures: The Start of the Subsurface Temperature Story

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Why do we care?

Surface temperatures affect our calculated subsurface temperatures

Today
In the past

Proper attention to surface temperatures marks you as a careful worker

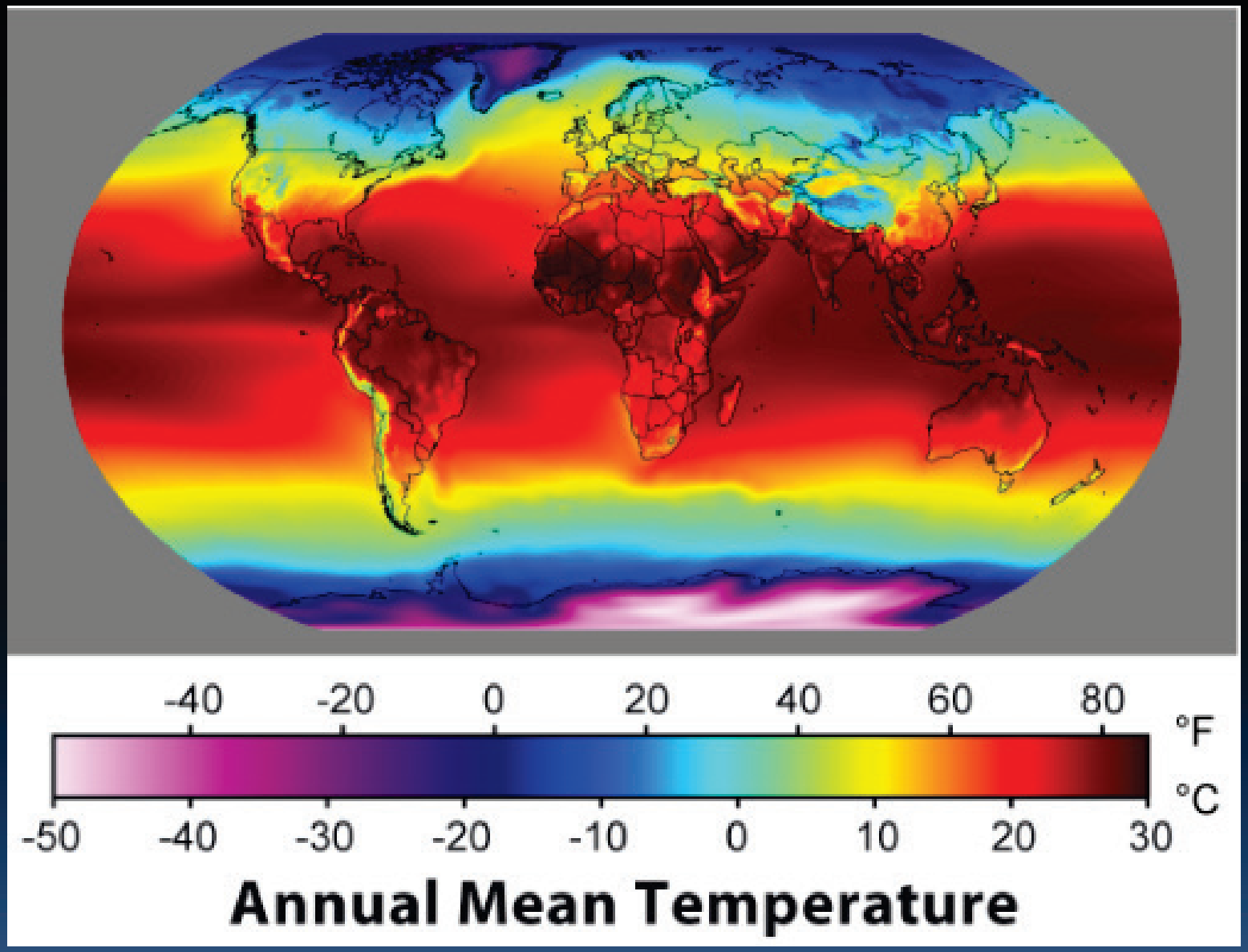
Present-day surface temperatures

Onshore
Offshore

Paleosurface temperatures

Onshore
Offshore

Present-day surface temperatures



Present-day onshore surface air temperatures

Barker's (2000) equation for sea level

T_{surf} (^{o}C) = 27.6 – 0.0414*L – 0.00599*L^2

where L is the absolute value of latitude in degrees

Correct for elevation by subtracting

6.4^{o}C/km of elevation

(standard adiabatic lapse rate)

Correct for difference between air and rock temperatures

Examples of air temperatures

Port Moresby, PNG (9.67^{o}S, elev. 47 m)

Tsurf = 27.6 – 0.4 – 0.6 – 0.3 = 26.3^{o}C [26.9^{o}C]

PNG Thrust and Fold Belt (5.5^{o}S, elev. 2700 m)

Tsurf = 27.6 – 0.2 – 0.2 – 17.3 = 9.9^{o}C

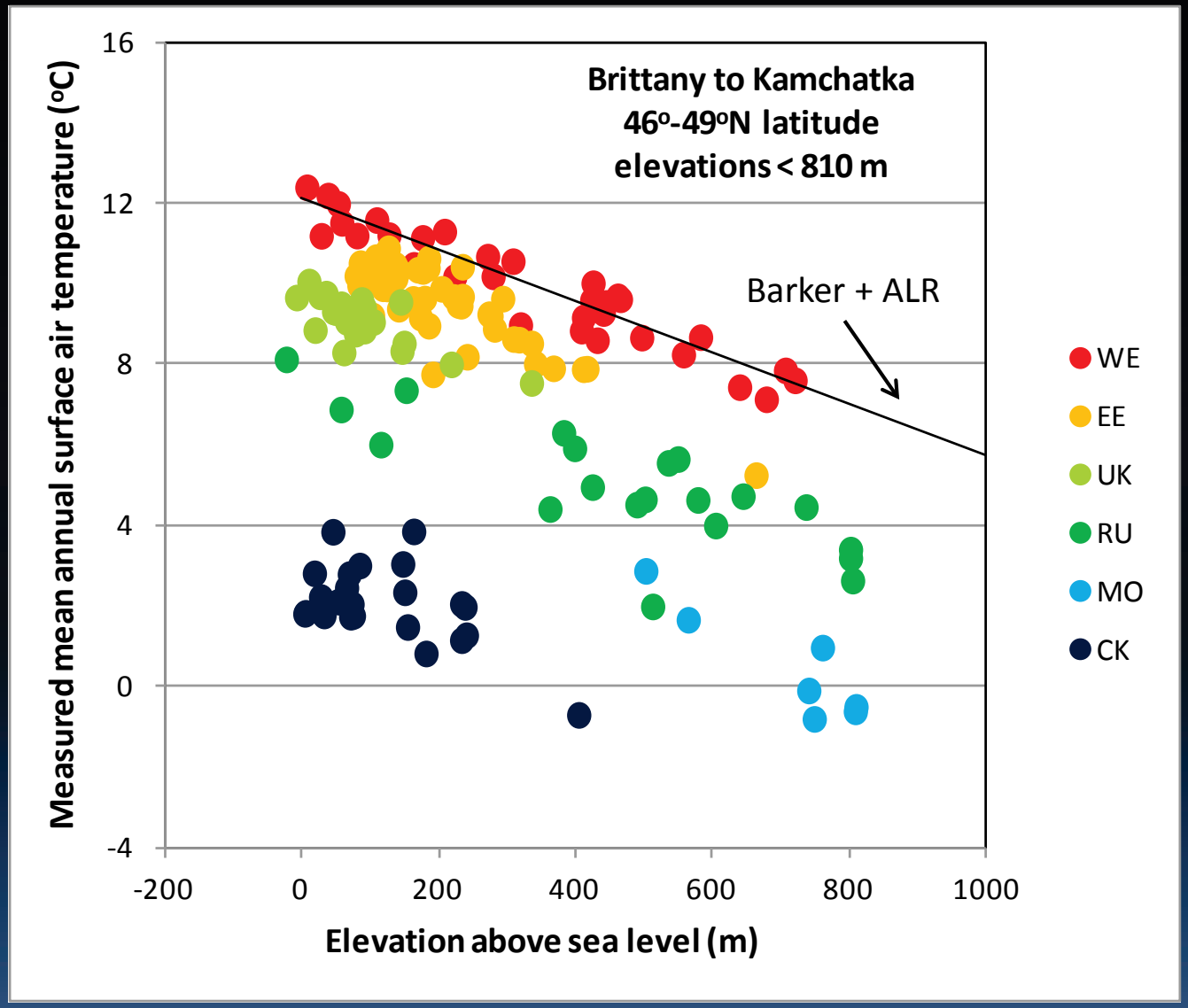
Confidence levels

Non-continental climates: ± 1.5^{o}C

Continental climates: ± 3.5^{o}C ??

Accuracy can be improved using weather data to calibrate a local model

Deviations related to degree of continentality (from www.worldclimate.com)

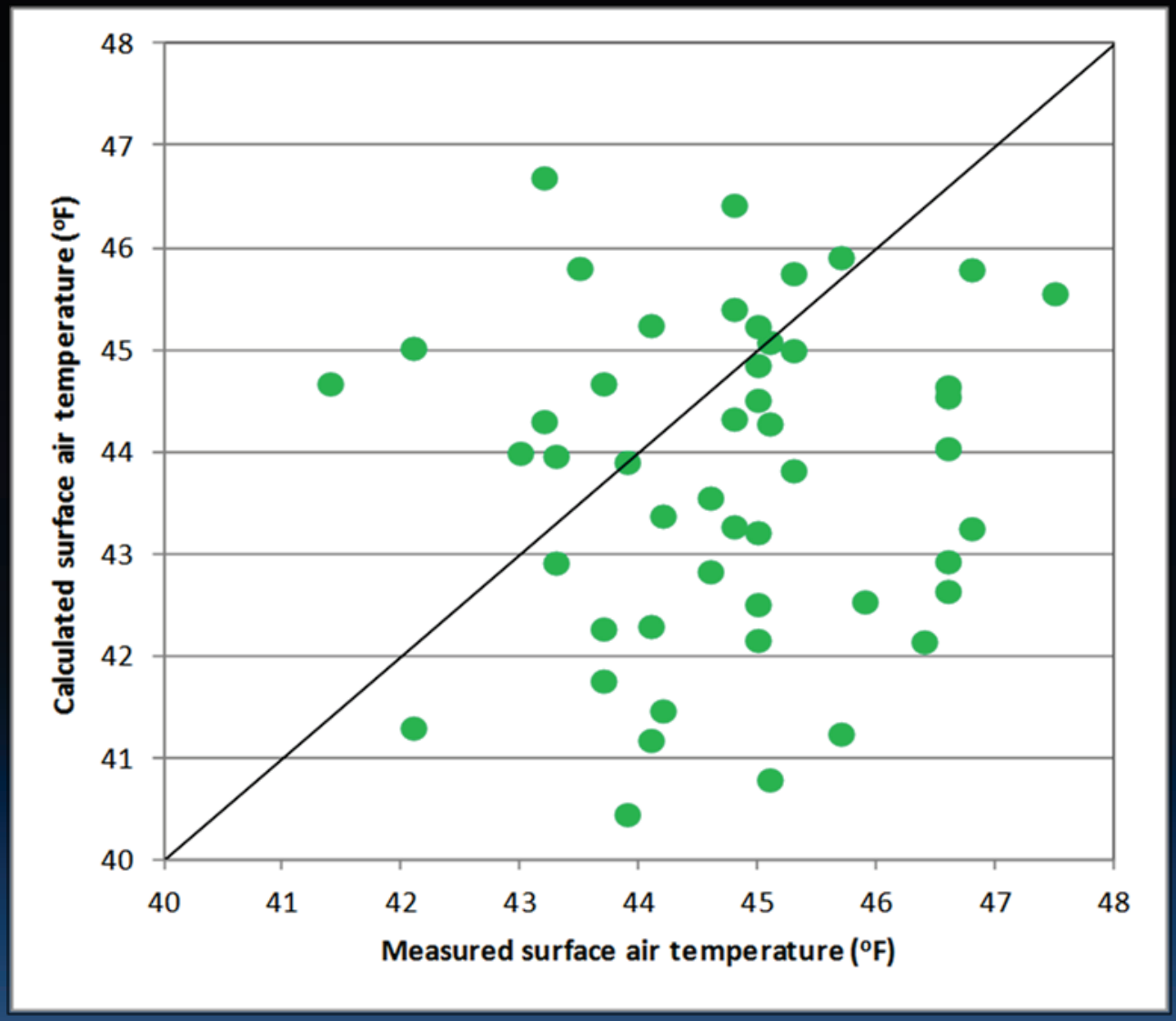


Sources of weather data

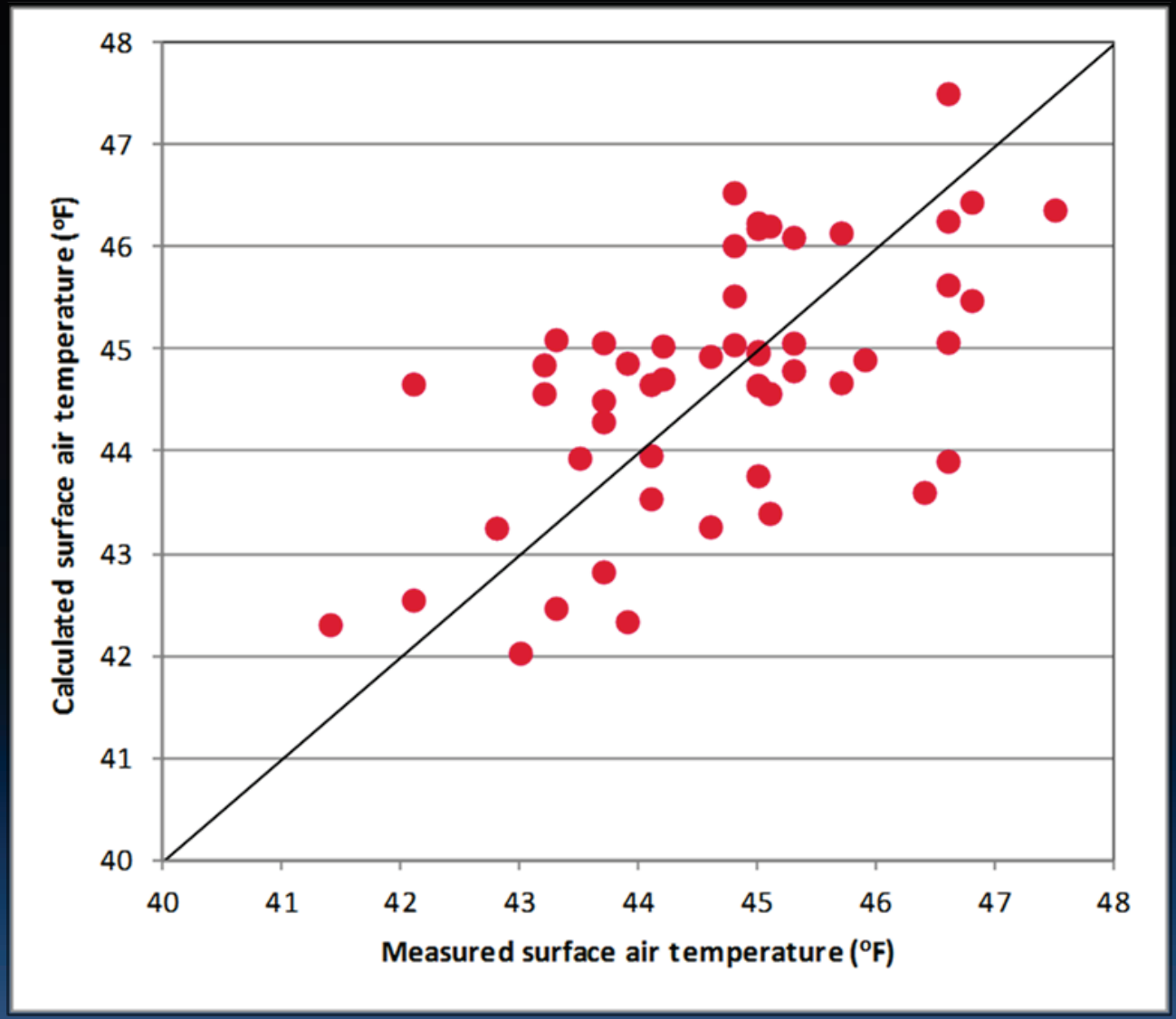
www.worldclimate.com

Gives mean annual air temperatures, elevations, latitude, and longitude

Powder River Basin: raw data



Powder River Basin: after calibration



Local calibration in PRB

Adjust constants in latitude equation

Adjust adiabatic lapse rate

Add dependence on longitude, since degree of continentality decreases westward into the mountains

In PRB 95% of calculated values are within 2.3^{o}F of measured values

Near-surface rock temperatures

Old studies suggest that near-surface rock temperatures are 1^{o} to 2^{o}C cooler than mean annual surface air temperatures

Newer research?

Present-day offshore “surface” temperatures

Actually they are sea-floor temperatures,

not water or air temperatures

Depend on

Water depth

Latitude

Degree of isolation of water body

Nomograph of Beardsmore and Cull (2001)

Crustal Heat Flow

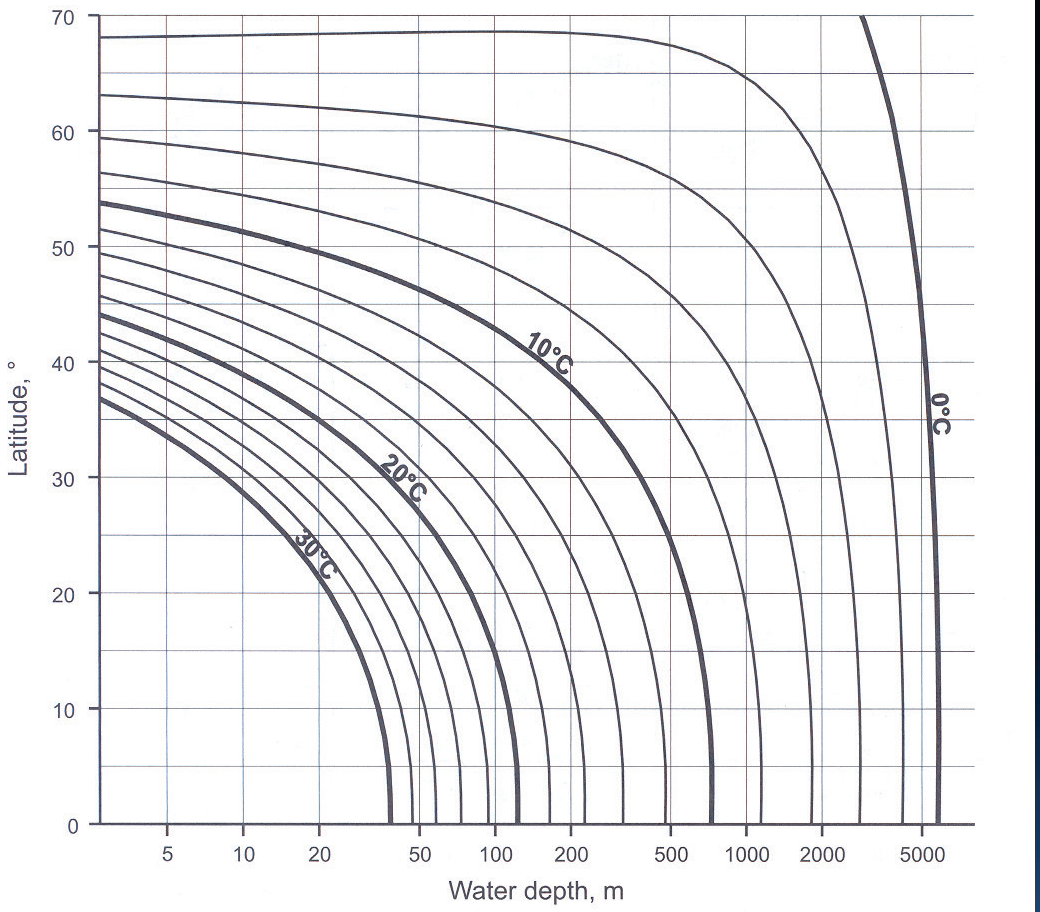
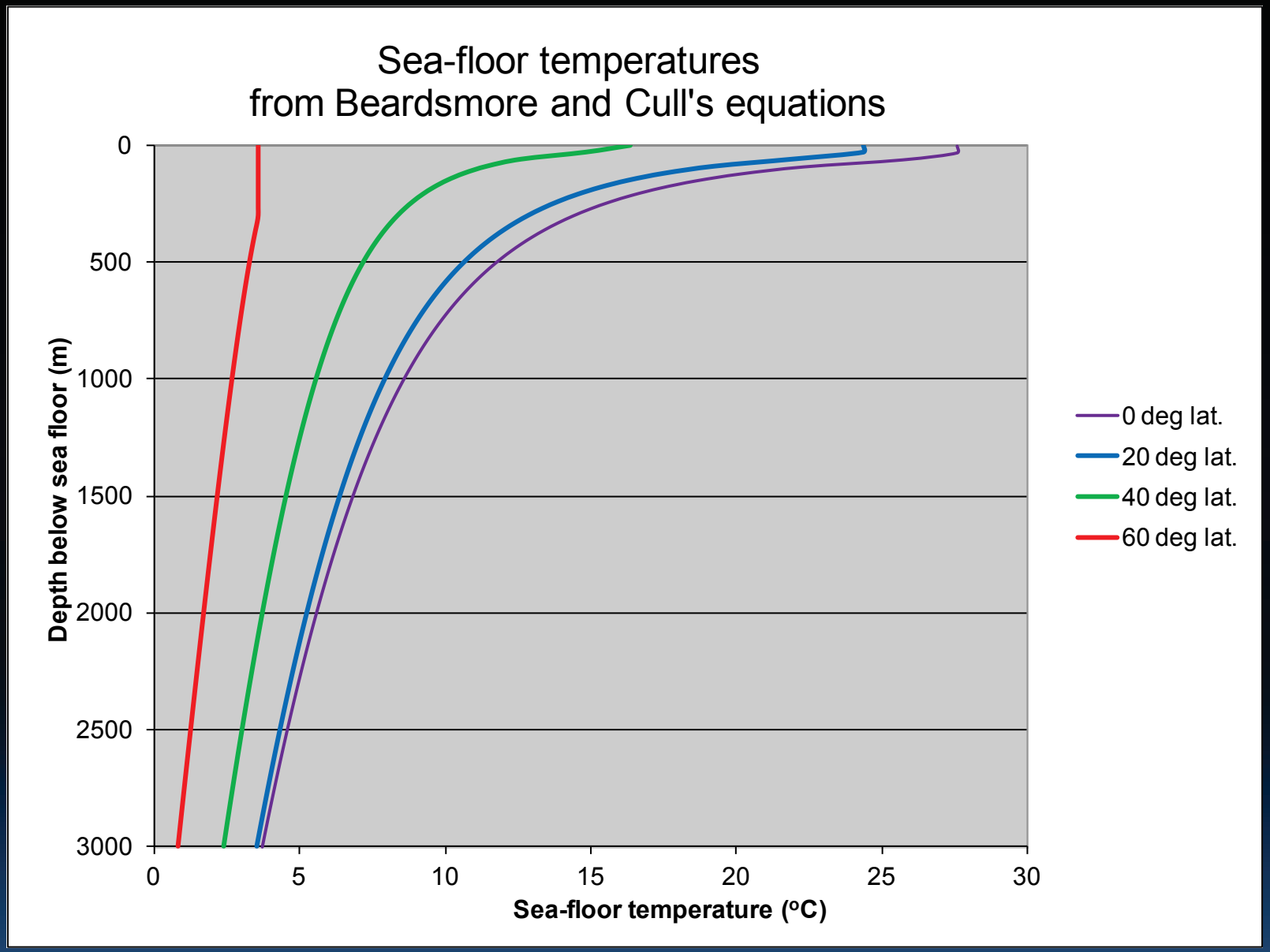


Figure 3.11. BWT (°C) as a function of water depth (m) and latitude (°), as predicted by Equations (3.19)–(3.21). Contour interval = 2°C.


Sea-floor temperatures
from Beardsmore and Cull's equations
Depth below sea floor (m)
0
500
1000
1500
2000
2500
3000
0
5
10
15
20
25
30
Sea-floor temperature (°C)
0 deg lat.
20 deg lat.
40 deg lat.
60 deg lat.

Potential issues

Shallow water

Sea-floor temperature cannot be higher than air temperatures

Isolated bodies of water

???

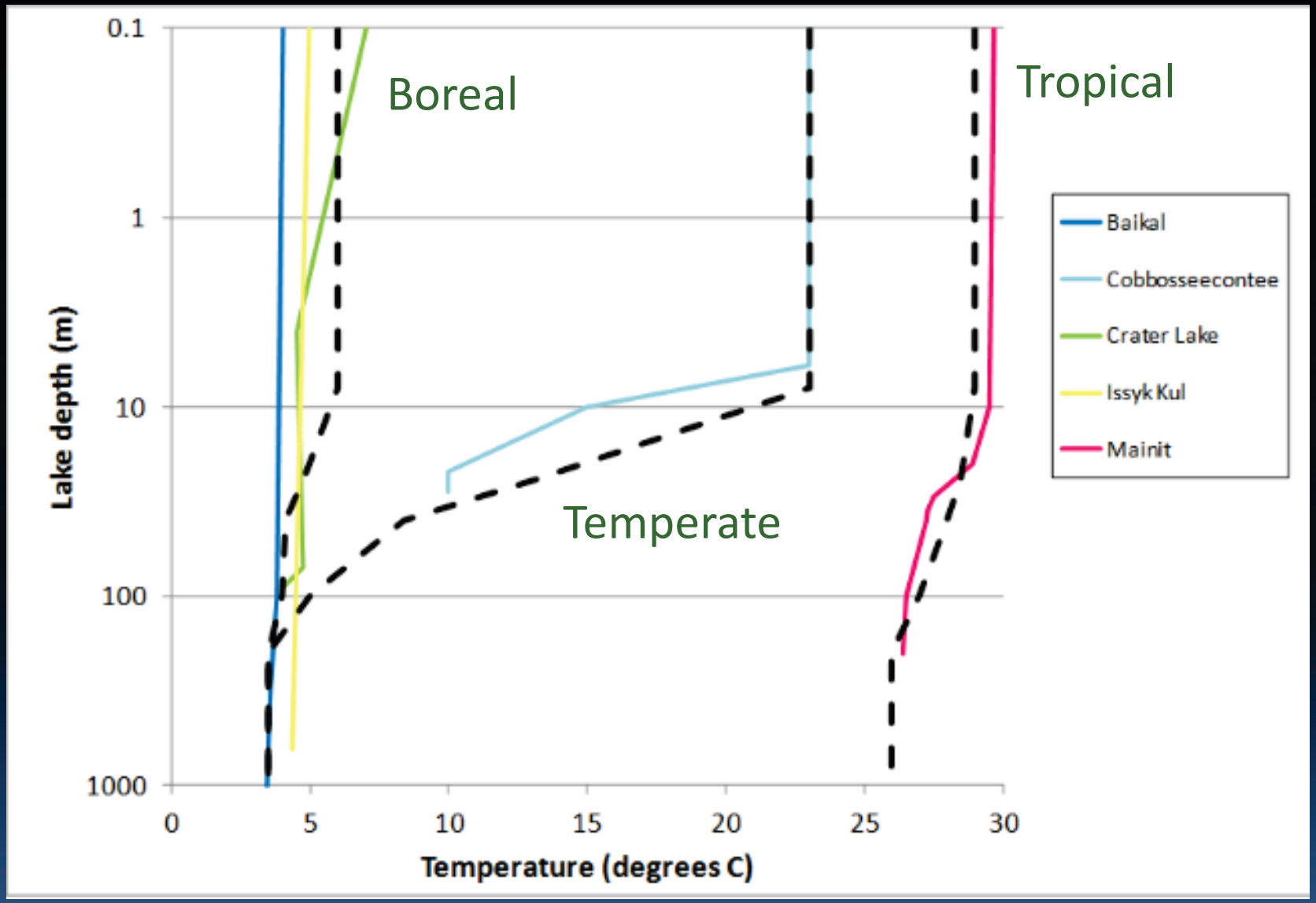
Use of measured bottom-water temperatures

Correction for depth?

Geographic relevance?

Changes in water circulation?

Modern lakes



Paleosurface temperatures

Onshore and offshore

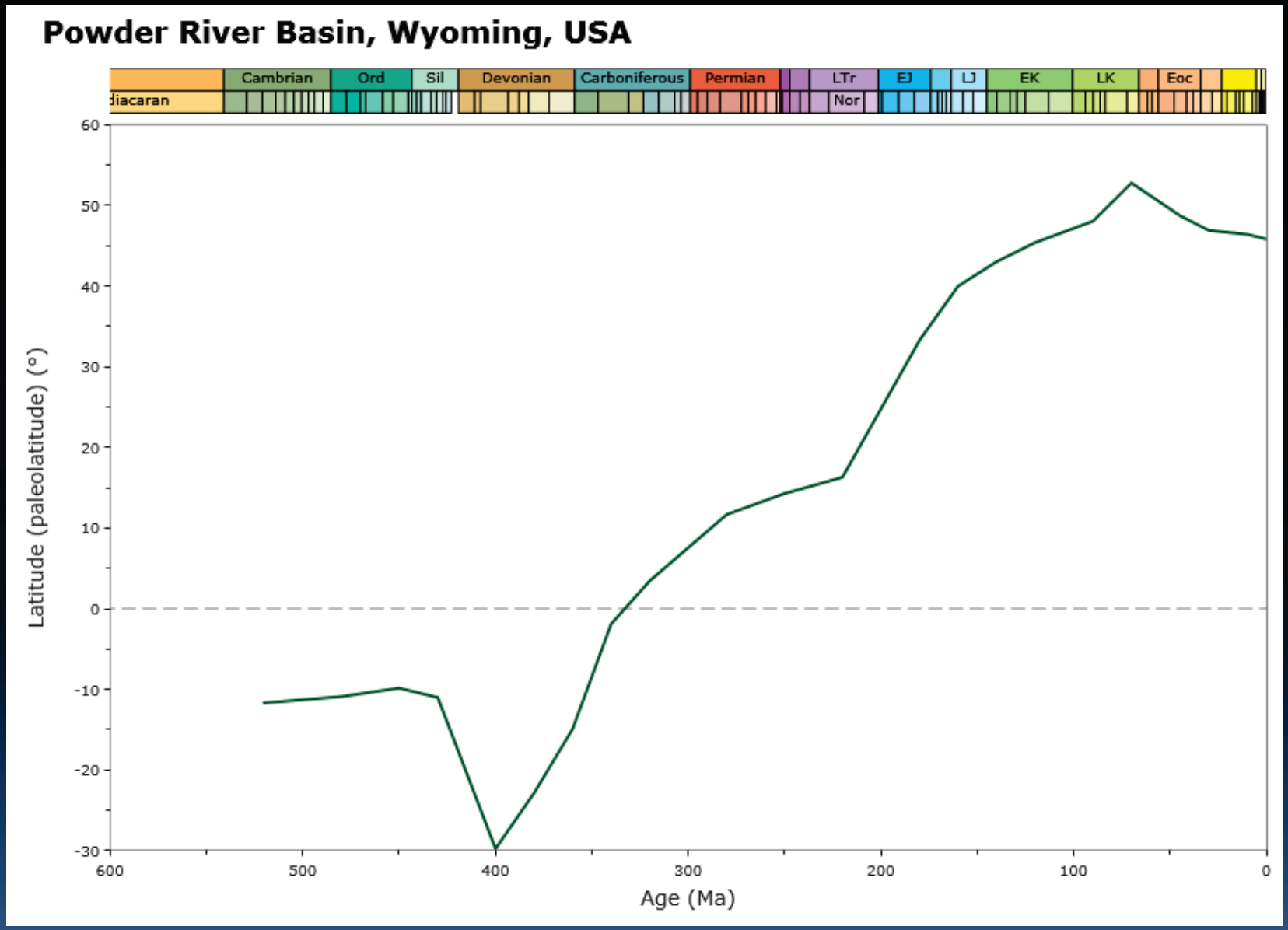
Paleolatitude

Paleoclimate

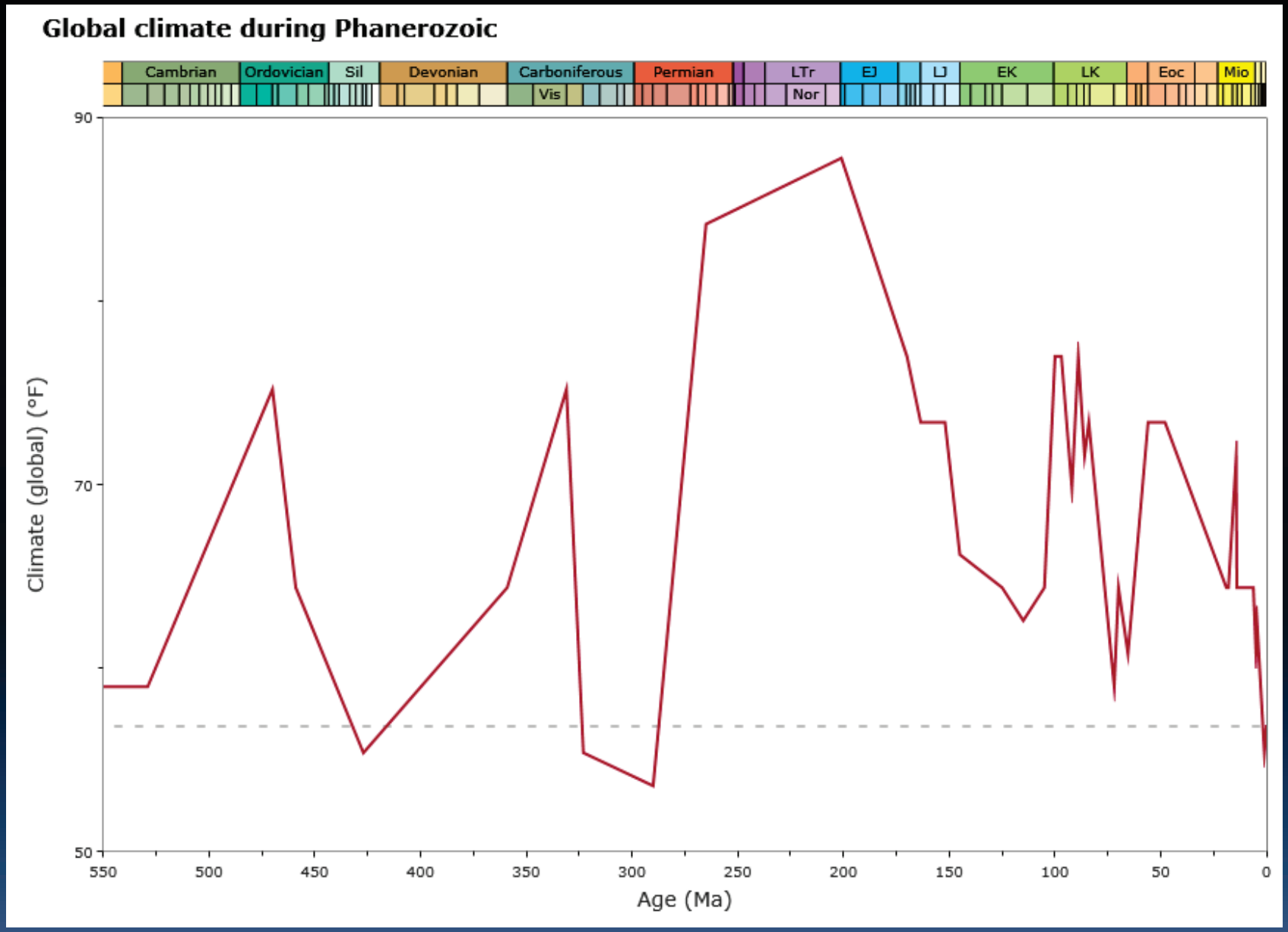
Paleoelevation

Paleobathymetry

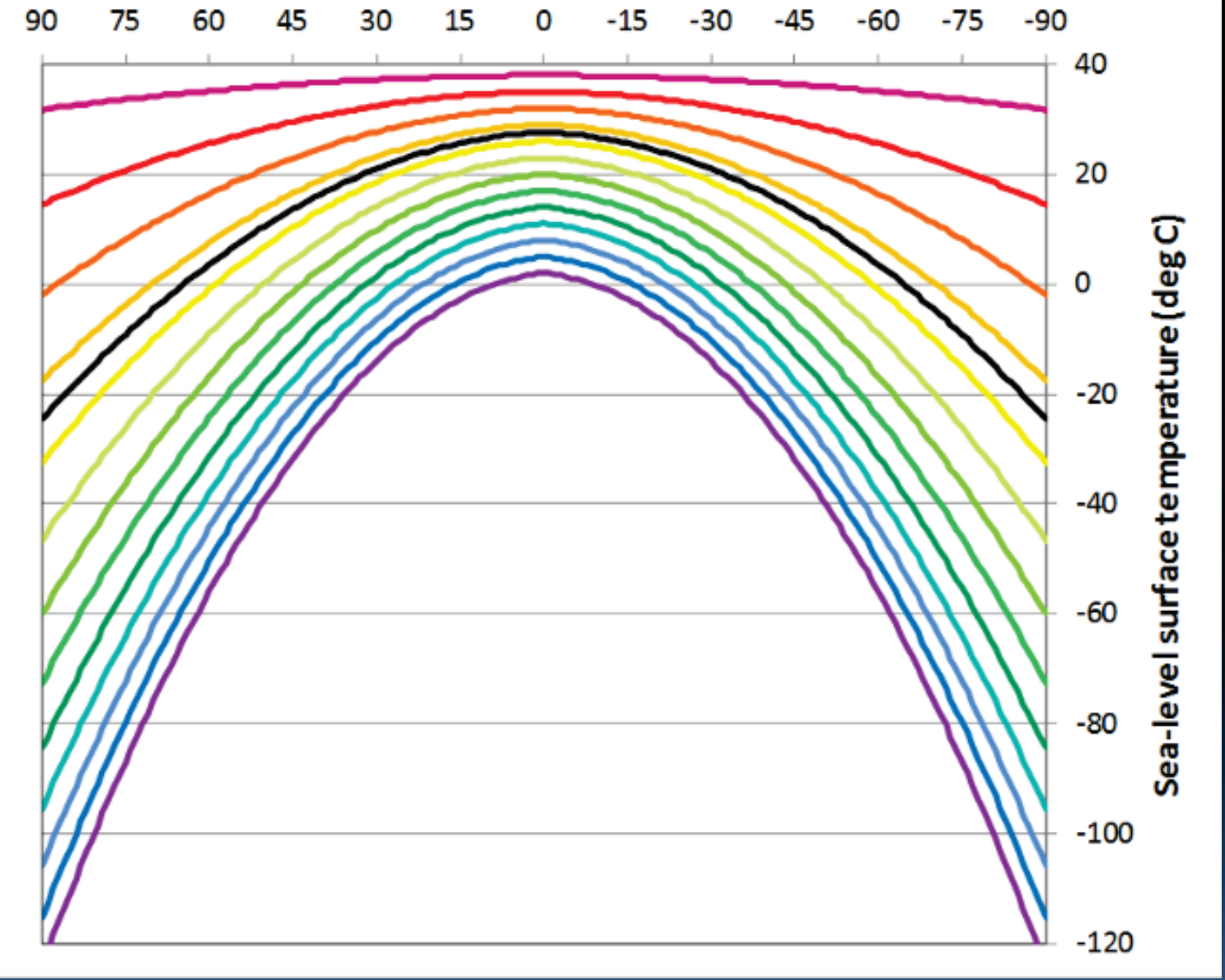
Paleolatitude



Paleoclimate



Latitudinal dependence of effects of paleoclimate



Paleoelevation

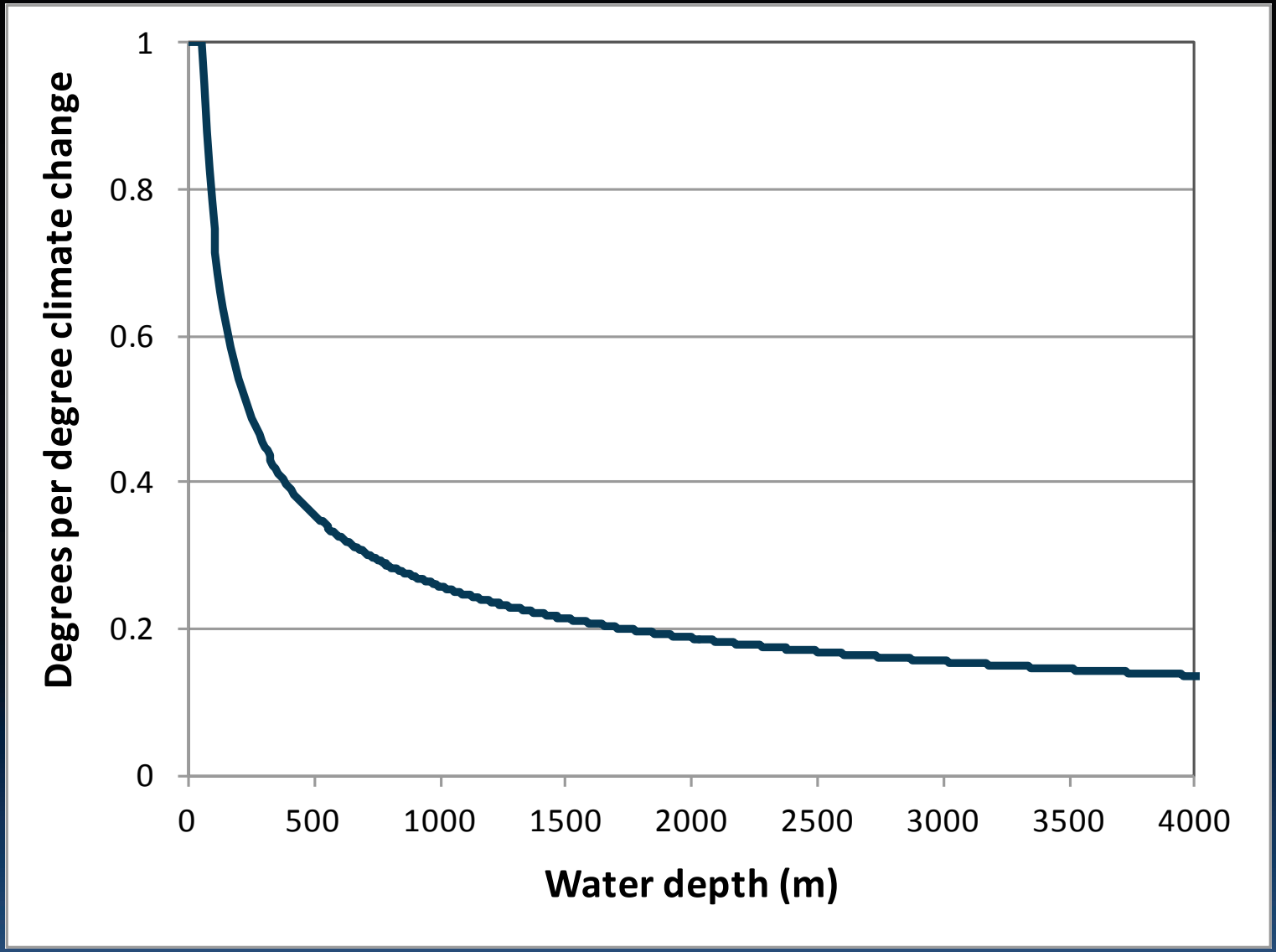
Adiabatic lapse rate assumed to be the same as today's

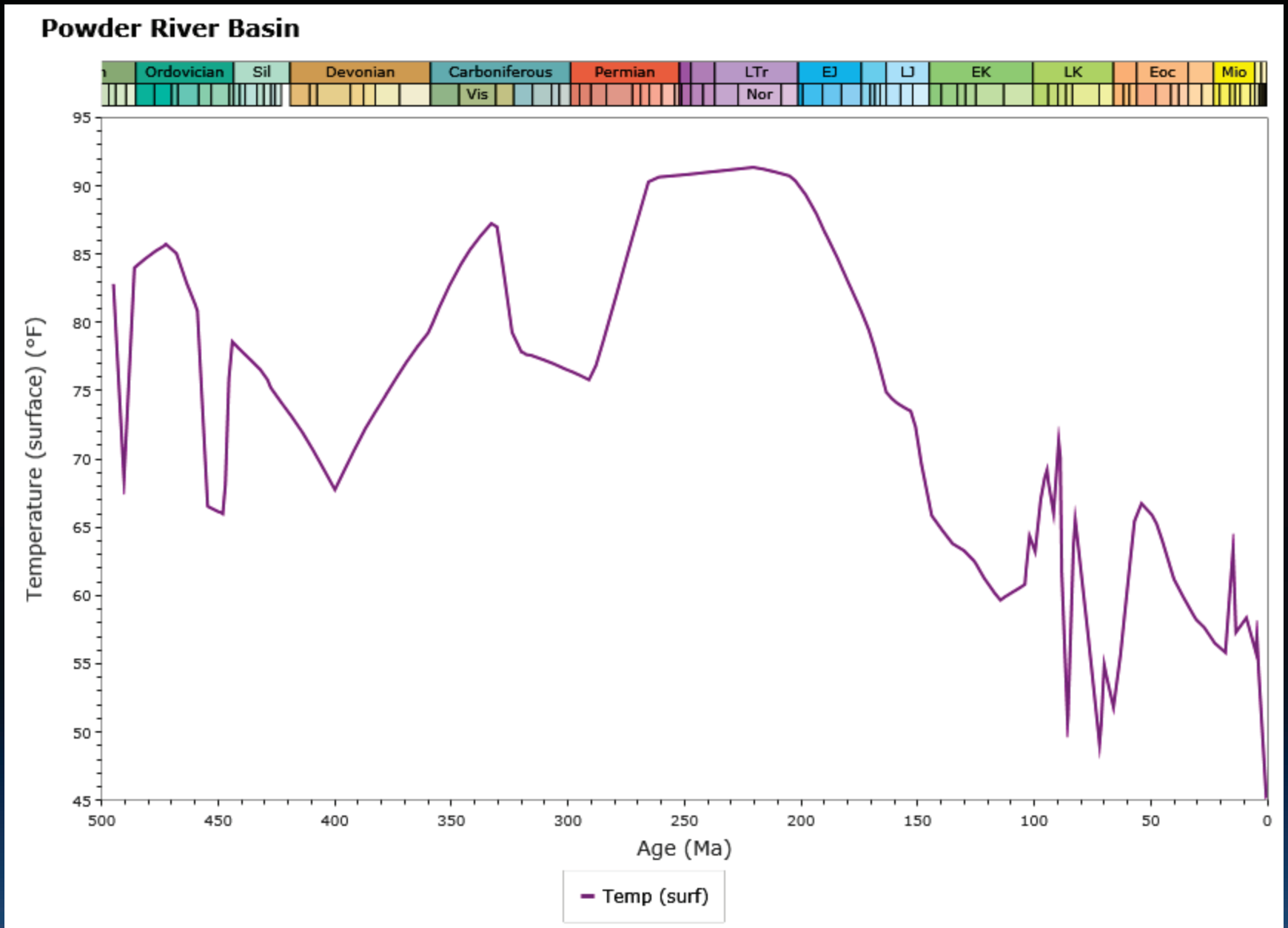
Paleobathymetry

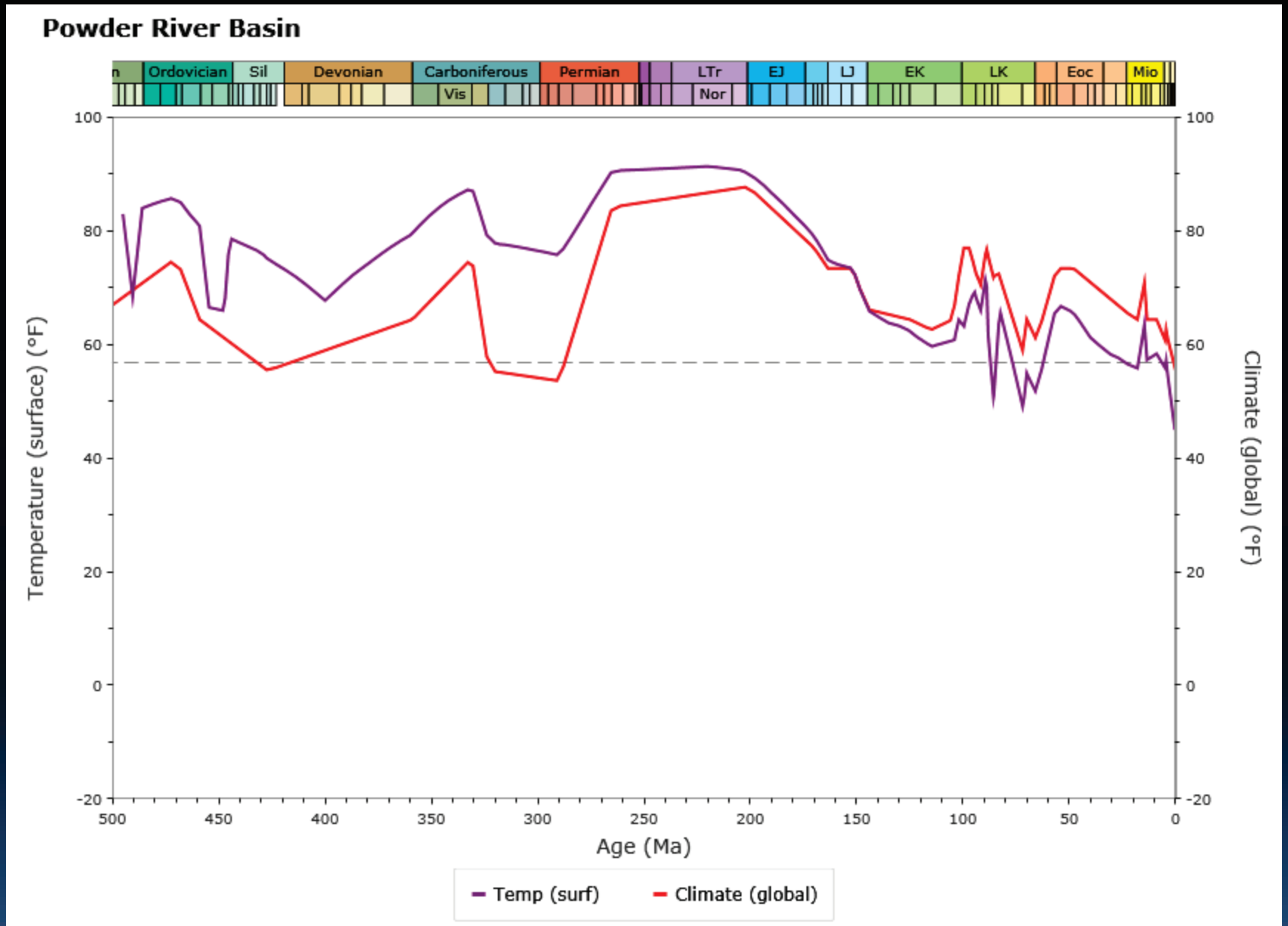
Based on Beardsmore/Cull algorithm using paleolatitude and paleobathymetry

Adjustment for climate change

Effect of paleoclimate on seafloor temperatures




Powder River Basin
Ordovician
Sil
Devonian
Carboniferous
Vis
Permian
LTr
Nor
EJ
LJ
EK
LK
Eoc
Mio
Temperature (surface) (°F)
95
90
85
80
75
70
65
60
55
50
45
500
450
400
350
300
250
200
150
100
50
0
Age (Ma)
Temp (surf)


Powder River Basin
Ordovician
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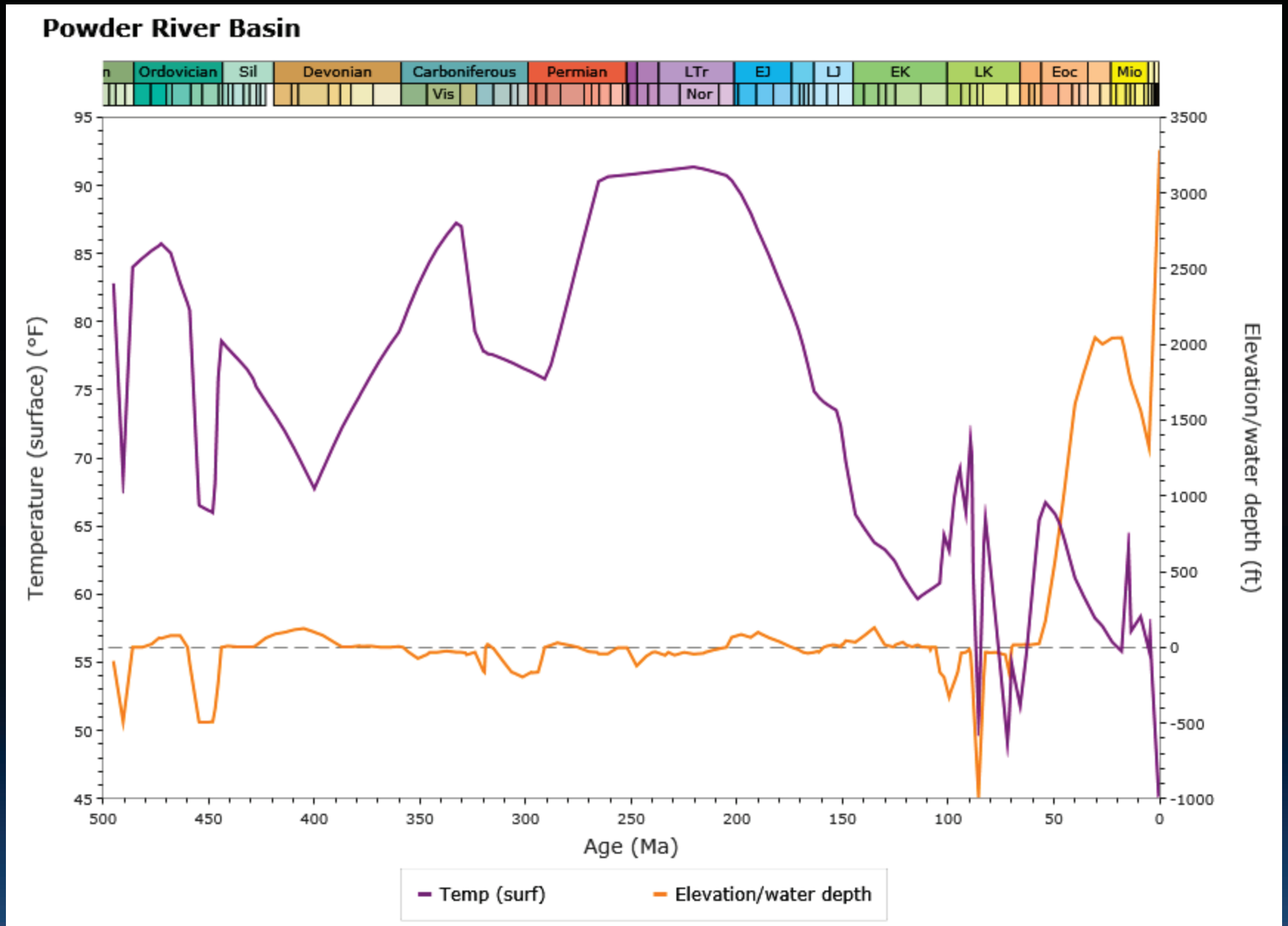
Mio
Temperature (surface) (°F)
Climate (global) (°F)
Age (Ma)
Temp (surf)
Climate (global)


Powder River Basin
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Ordovician
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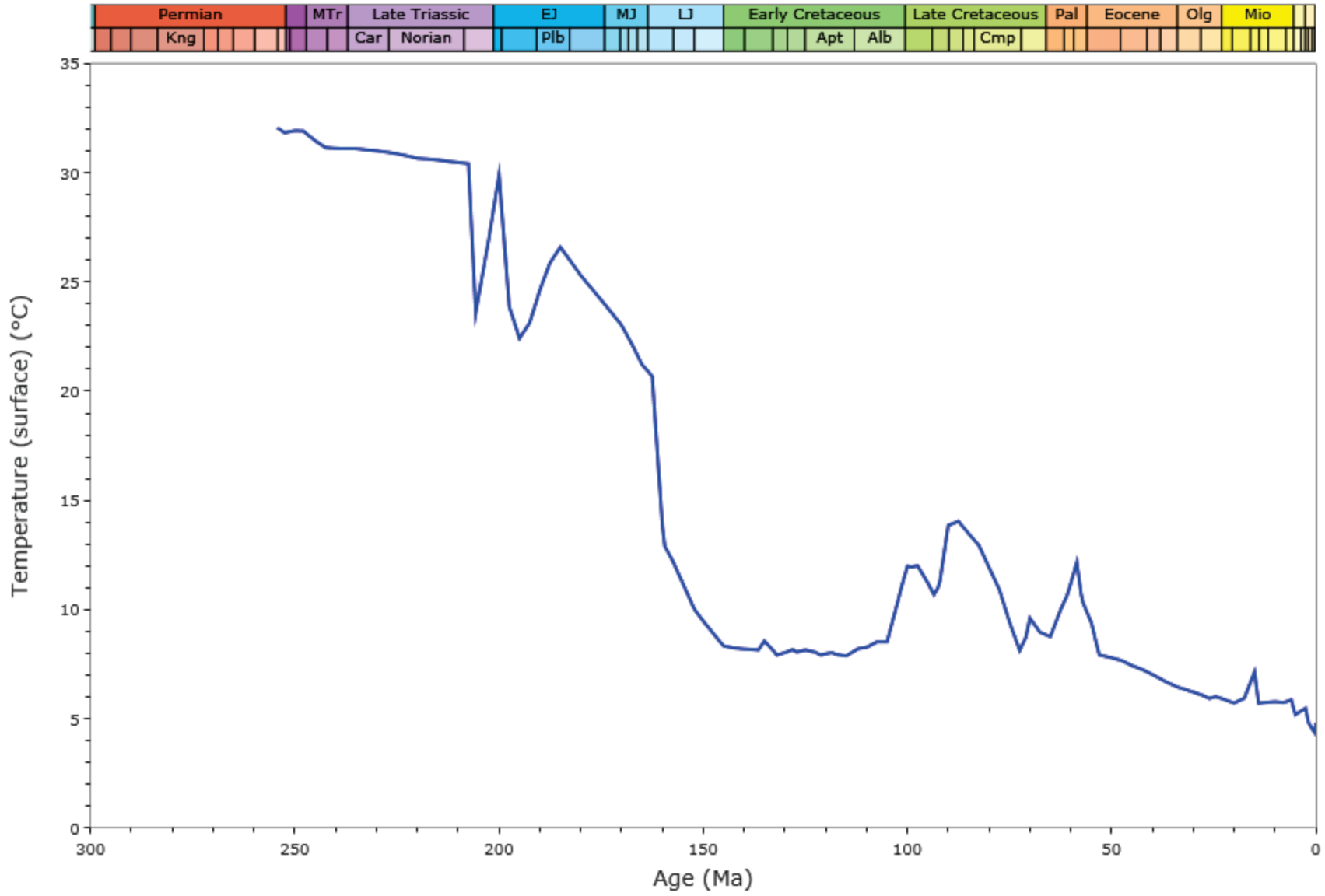
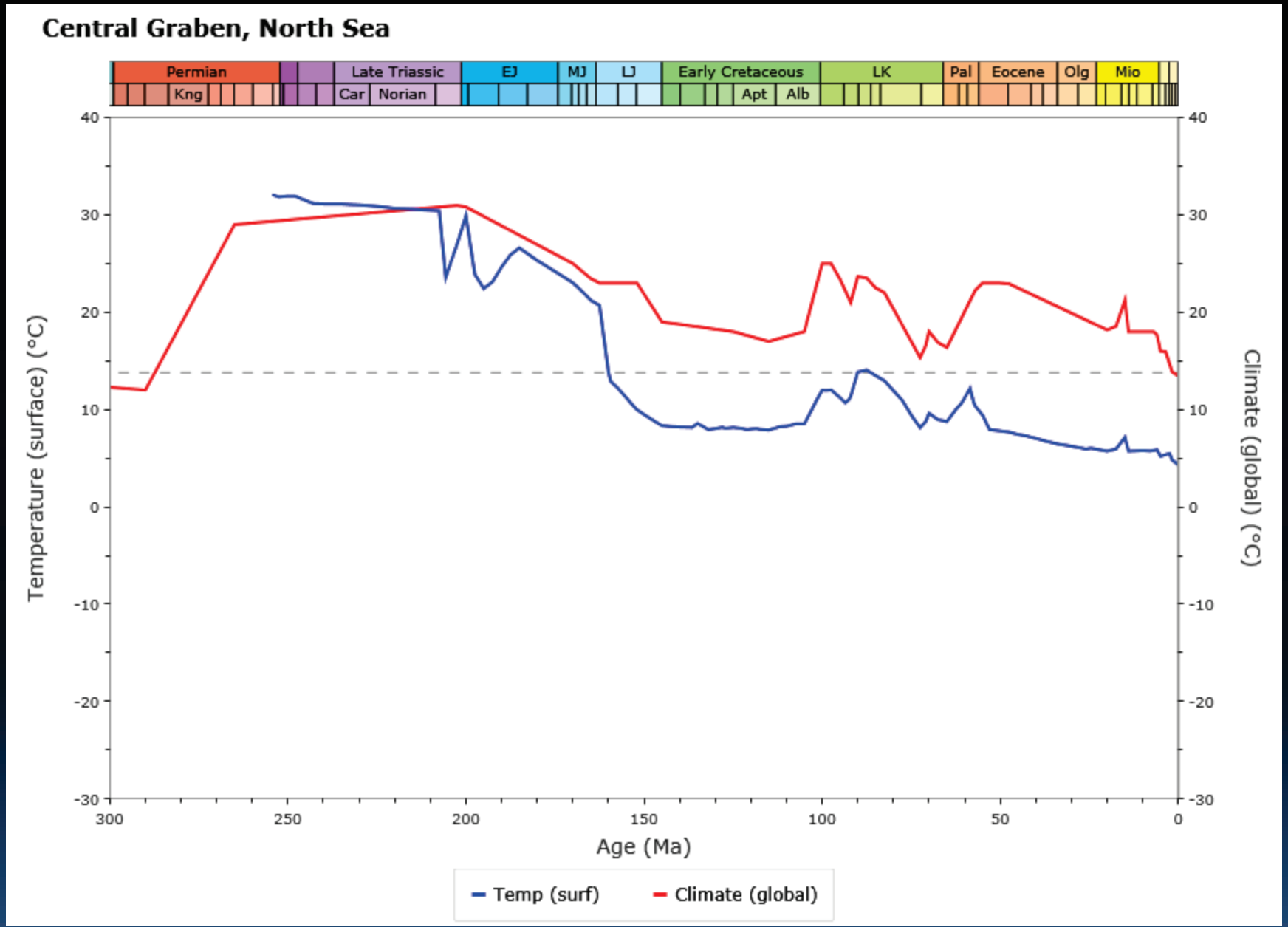
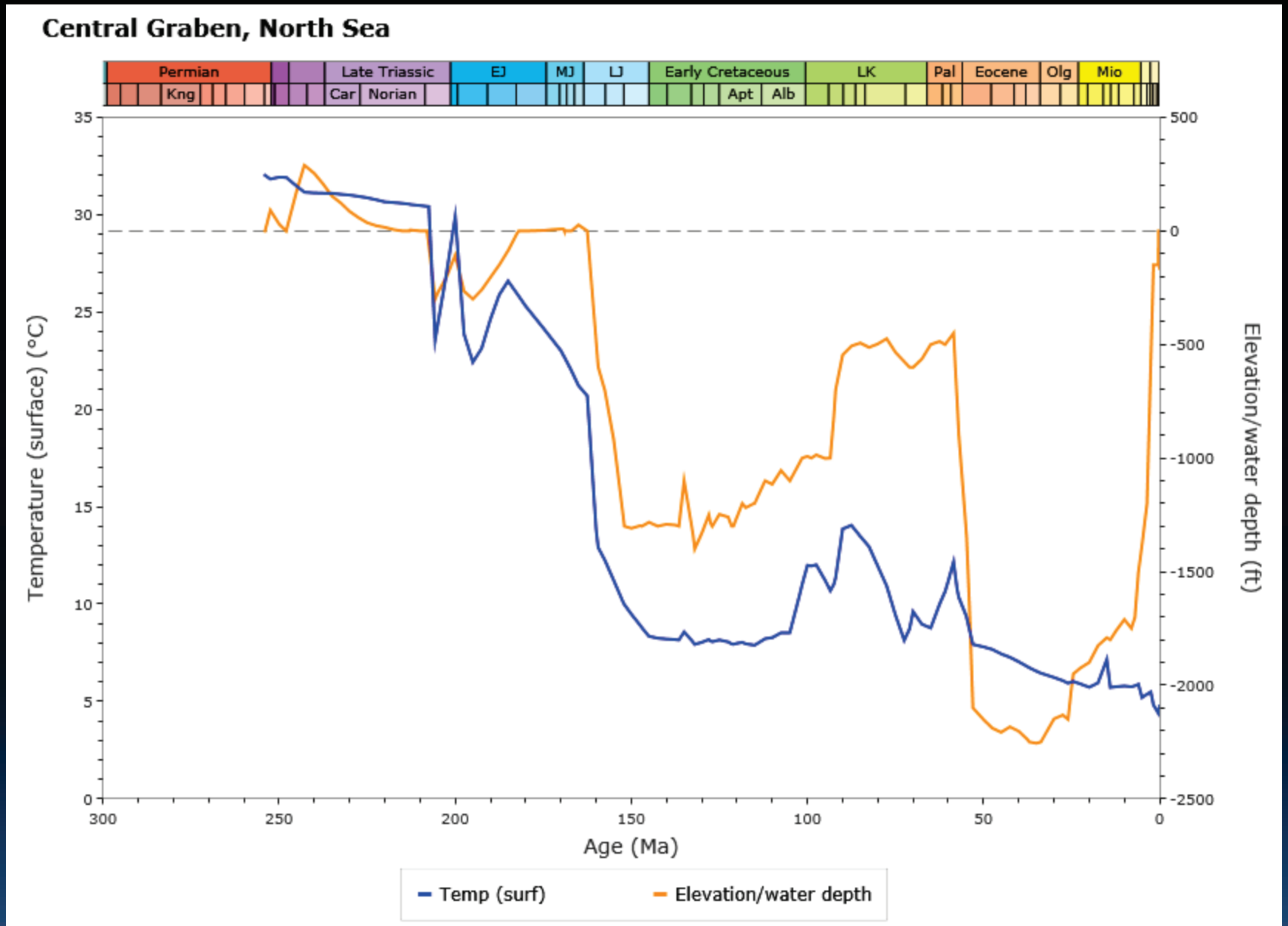
Eoc
Mio
Temperature (surface) (°F)
95
90
85
80
75
70
65
60
55
50
45
Elevation/water depth (ft)
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
500
450
400
350
300
250
200
150
100
50
0
Age (Ma)
Temp (surf)
Elevation/water depth

Central Graben, North Sea




Central Graben, North Sea
Permian
Kng
Late Triassic
Car
Norian
EJ
MJ
LJ
Early Cretaceous
Apt
Alb
LK
Pal
Eocene
Olg
Mio
Temperature (surface) (°C)
Climate (global) (°C)
40
30
20
10
0
-10
-20
-30
300
250
200
150
100
50
0
Age (Ma)
Temp (surf)
Climate (global)


Central Graben, North Sea
Permian
Kng
Late Triassic
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Norian
EJ
MJ
LJ
Early Cretaceous
Apt
Alb
LK
Pal
Eocene
Olg
Mio
Temperature (surface) (°C)
Elevation/water depth (ft)
Age (Ma)
Temp (surf)
Elevation/water depth

Summary

"Surface" temperatures depend on many factors

Past, present

Concepts are simple but application is complex

Enabled by appropriate software

Of direct and indirect benefit