Thomas R. Worsley and the Supercontinent Cycle

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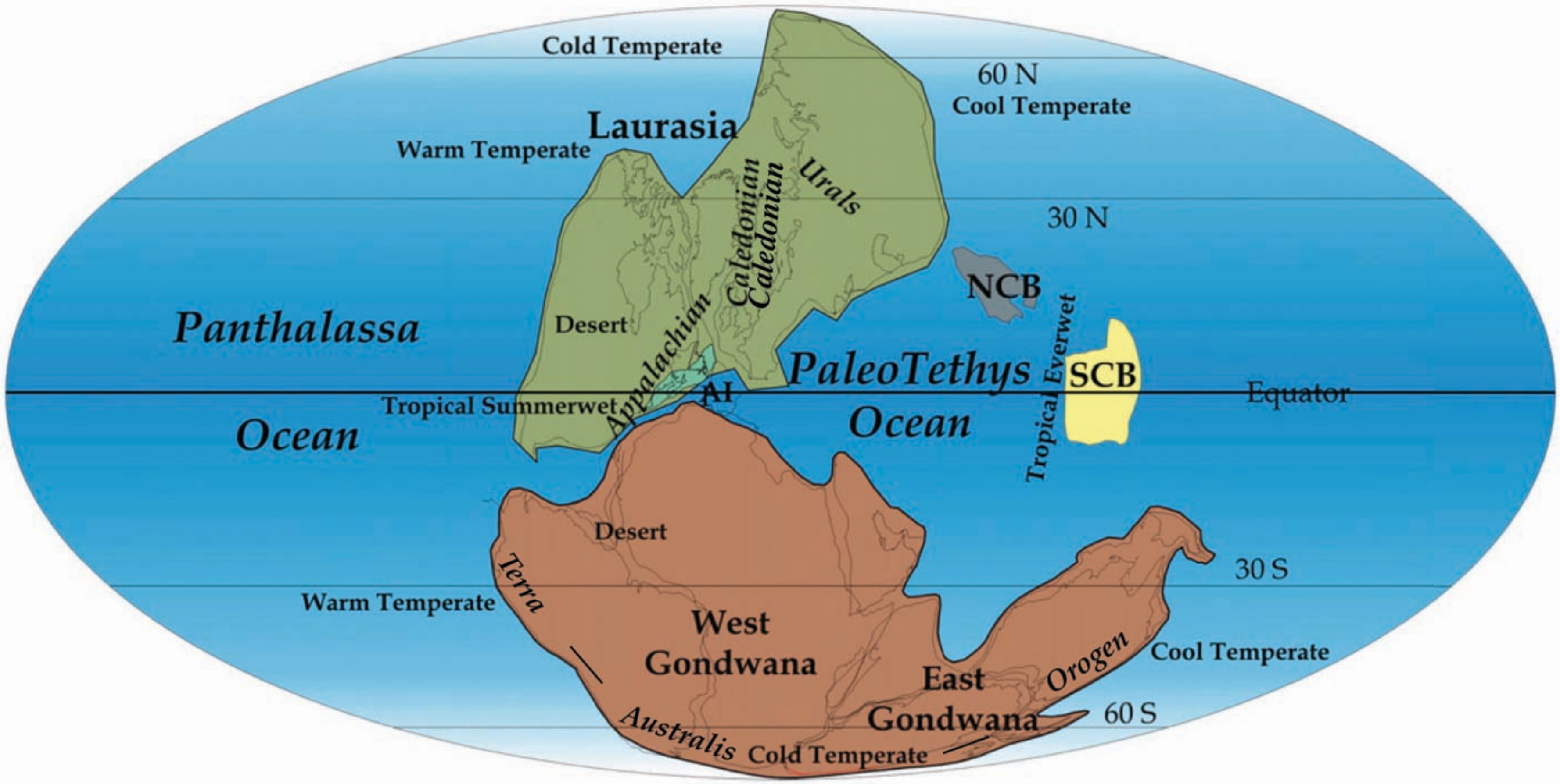
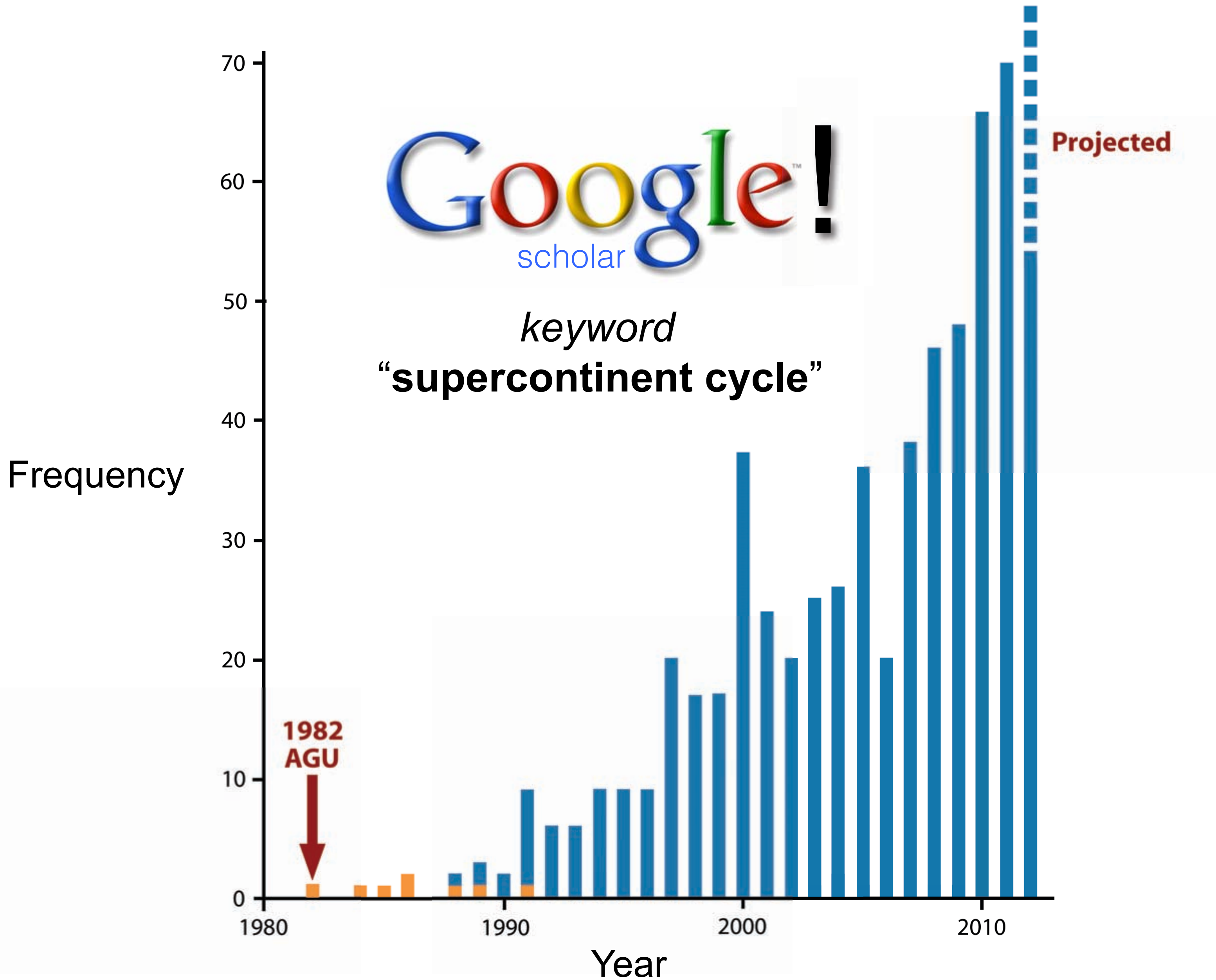
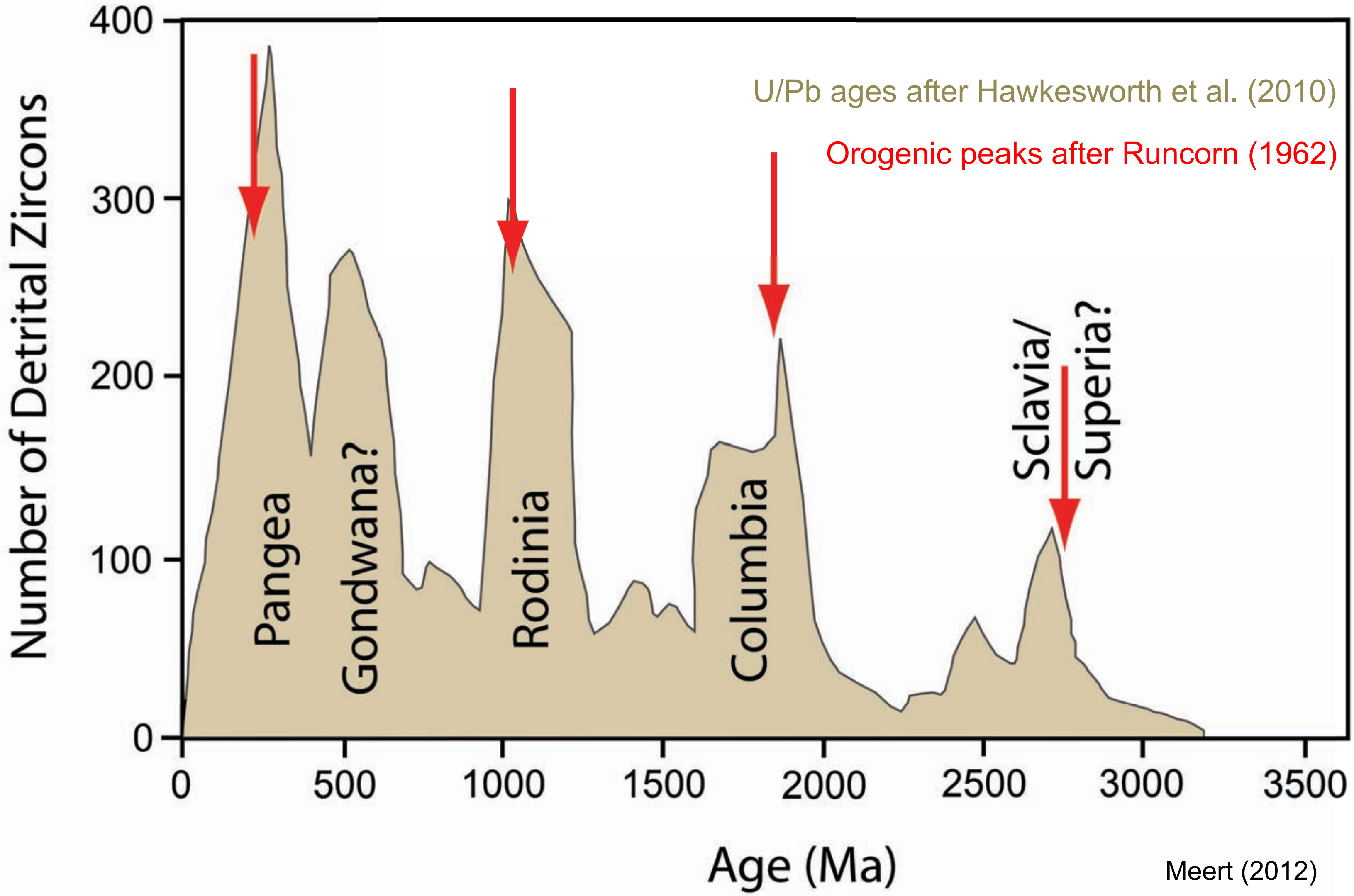
Pangaea (~260 Ma)



Meert (2012)



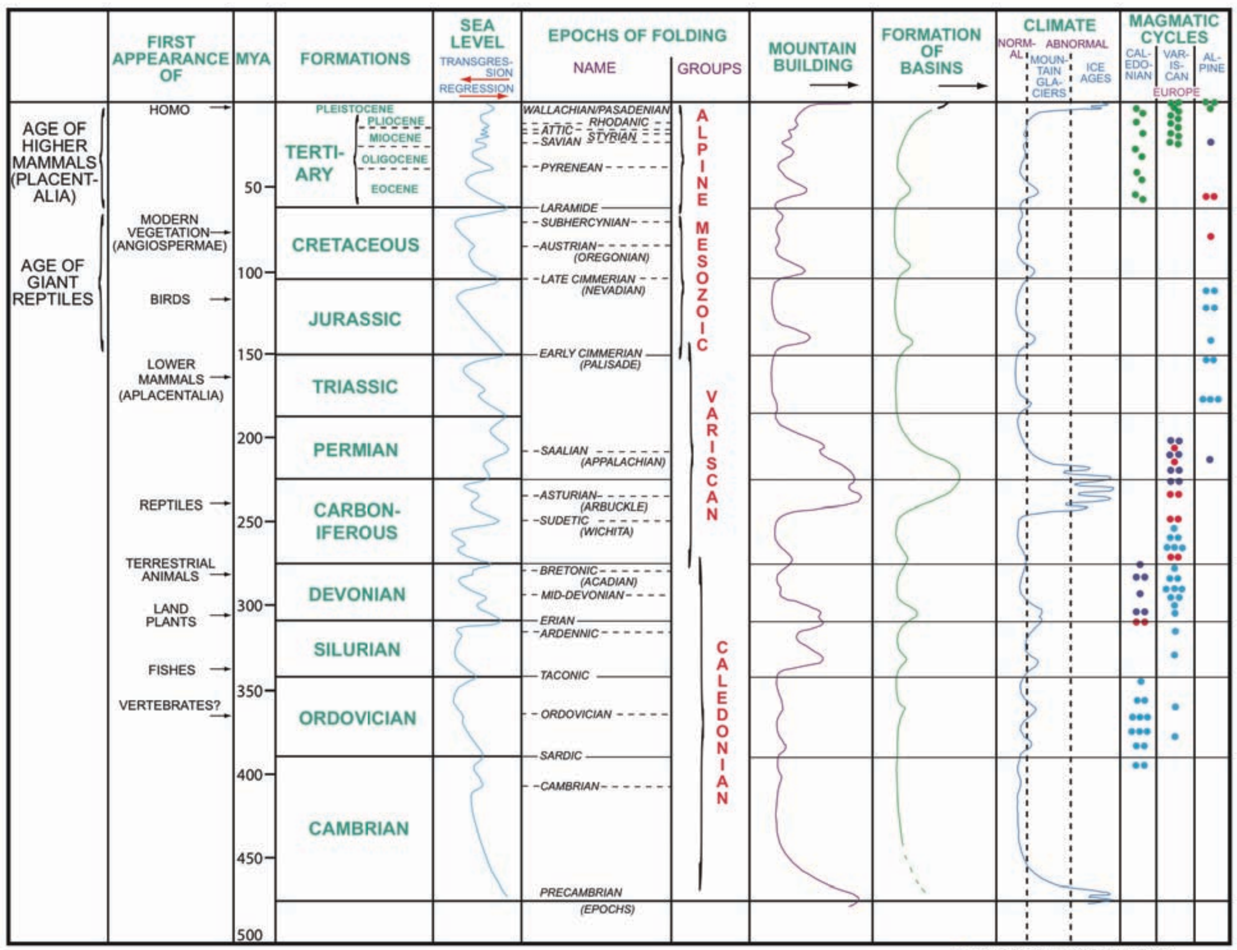
Google!
scholar
keyword
"supercontinent cycle"
Projected
1982
AGU
Frequency
Year
0
10
20
30
40
50
60
70
1980
1990
2000
2010



Number of Detrital Zircons
400
300
200
100
0
U/Pb ages after Hawkesworth et al. (2010)
Orogenic peaks after Runcorn (1962)
Pangea
Gondwana?
Rodinia
Columbia
Sclavia/
Superia?
0
500
1000
1500
2000
2500
3000
3500
Age (Ma)

Meert (2012)

Early Advocates for Tectonic Episodicity



Umbgrove (1947)

~250 m.y. “pulse” in Phanerozoic sea level, orogeny, basin formation, climate and magmatism.

Early Advocates for Tectonic Episodicity

Holmes (1951); Wilson et al. (1960); Burwash (1963)

Orogenic episodicity in Precambrian fold belts

Holmes (1954); Gastil (1960)

Episodicity in continental crust formation

Voitkevich (1958); Vinogradov & Tugarinov (1962); Runcorn (1962); Dearnly (1966)

Episodicity in radiometric age data

Sloss (1963)

Tectonic episodicity inherent in recognition of cratonic sequences

Sutton’s (1963) “Chelogenic Cycles”

(global-scale shield-forming events)

- Called for an episodic clustering of continents
- Rather than producing a supercontinent, cycle resulted in periodic recurrence of two antipodal continental clusters, the assembly and breakup of which were responsible for the record of orogenic episodicity
- Cycle was thought to occur because small subcontinental convection cells first resulted in continental clustering and orogeny in continental interiors, but then coaslesced into larger cells that fostered continental breakup, orogenic quiescence, and the later regrouping of the disrupted continental masses into two new antipodal clusters
- Cycle had periodicity of 750-1250 m.y. and had been repeated at least four times during Earth history

Tectonic Episodicity and Plate Tectonics

Wilson (1966)

Wilson cycles of ocean opening and closure

Valentine and Moores (1970), Hallam (1974)

Tectonic cycles applied to evolutionary biogenesis

Mackenzie and Pigott (1981)

Episodicity in pattern of Phanerozoic sedimentary cycling

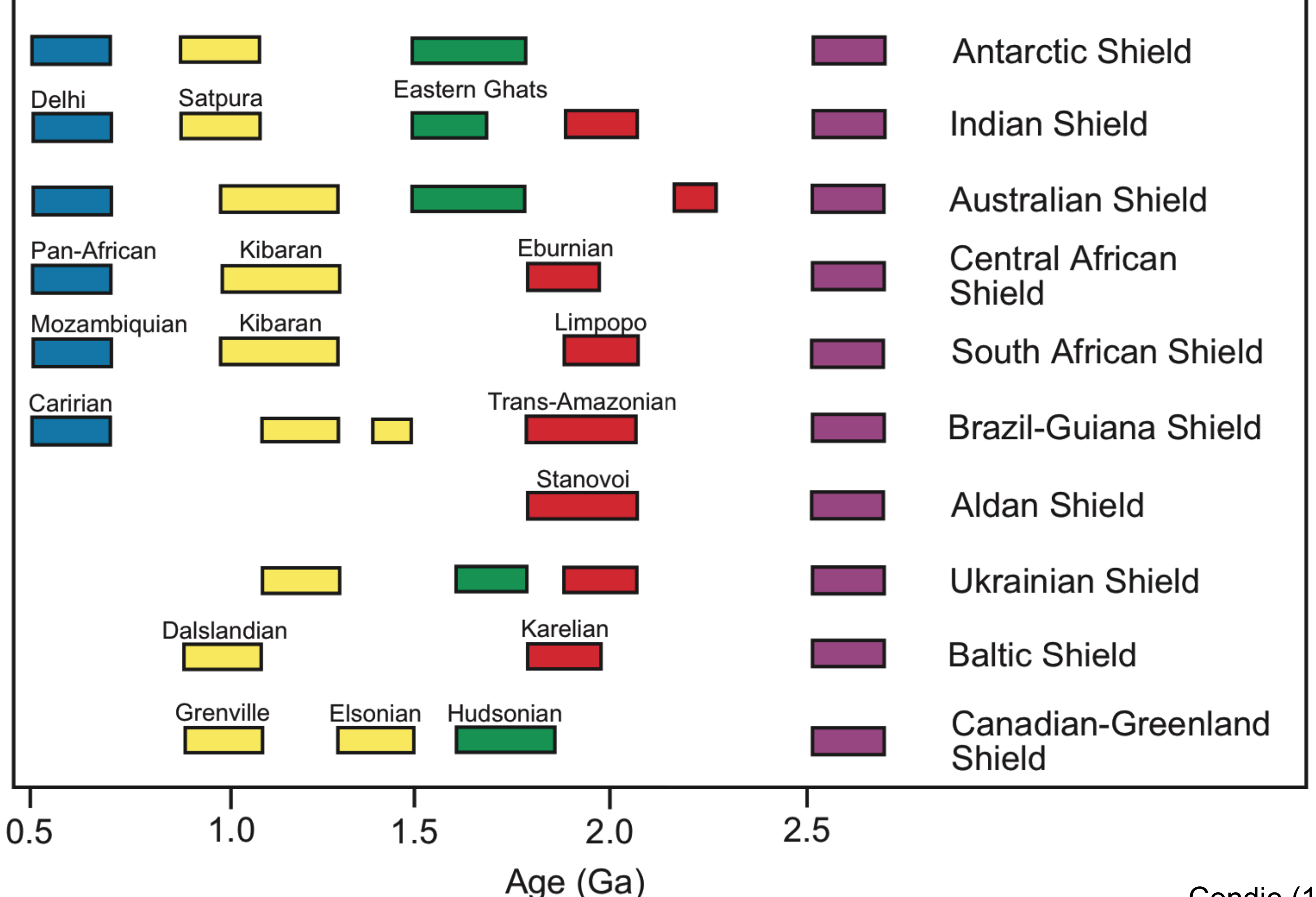
Meyer (1981)

Episodicity in distribution of ore-forming processes through time

Condie (1982)

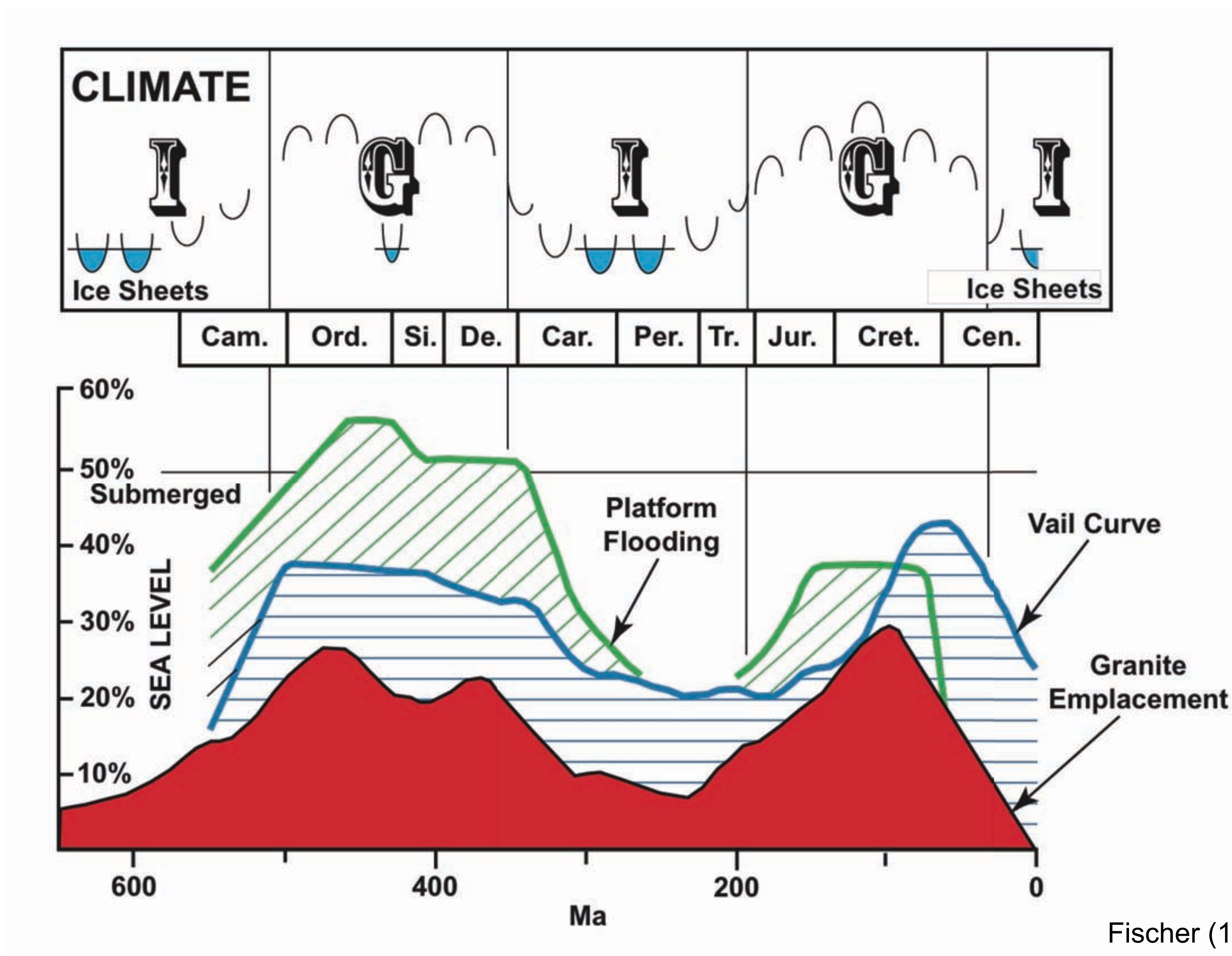
Orogenic episodicity supported by increasingly precise radiometric ages

Radiometric Ages for Periods of Major Orogenesis

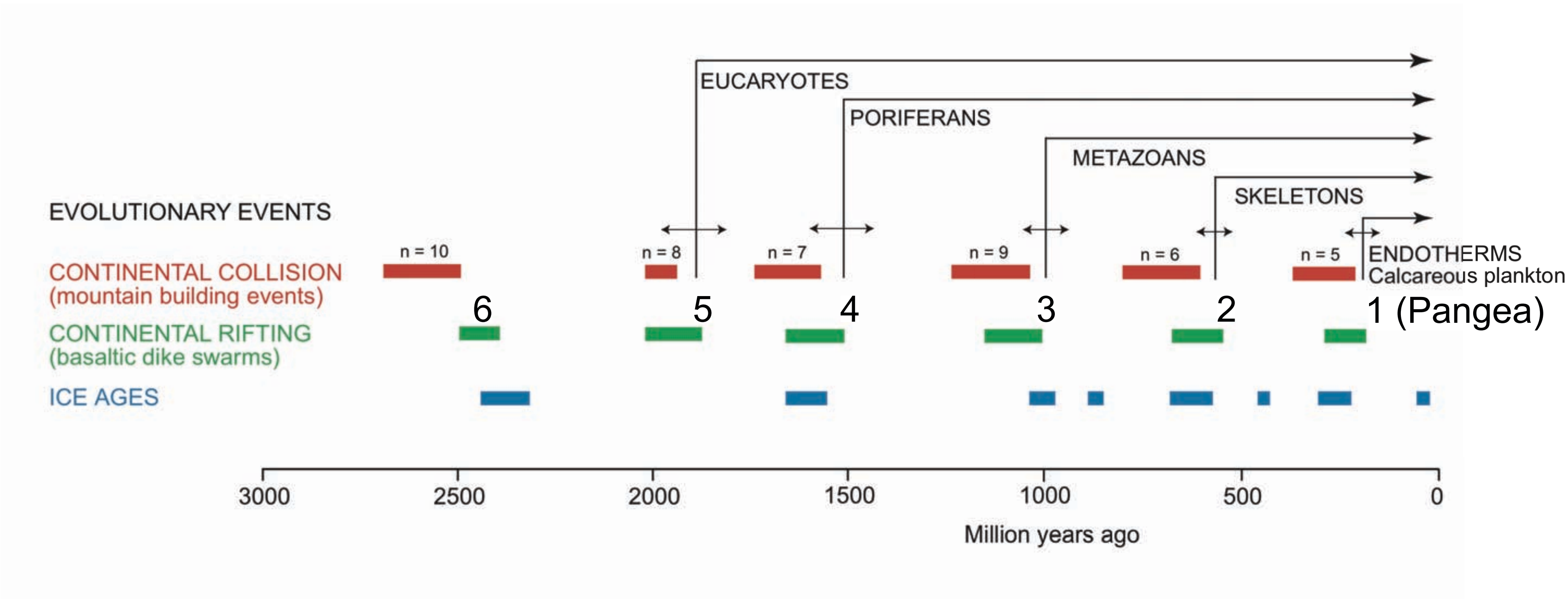


Condie (1982)

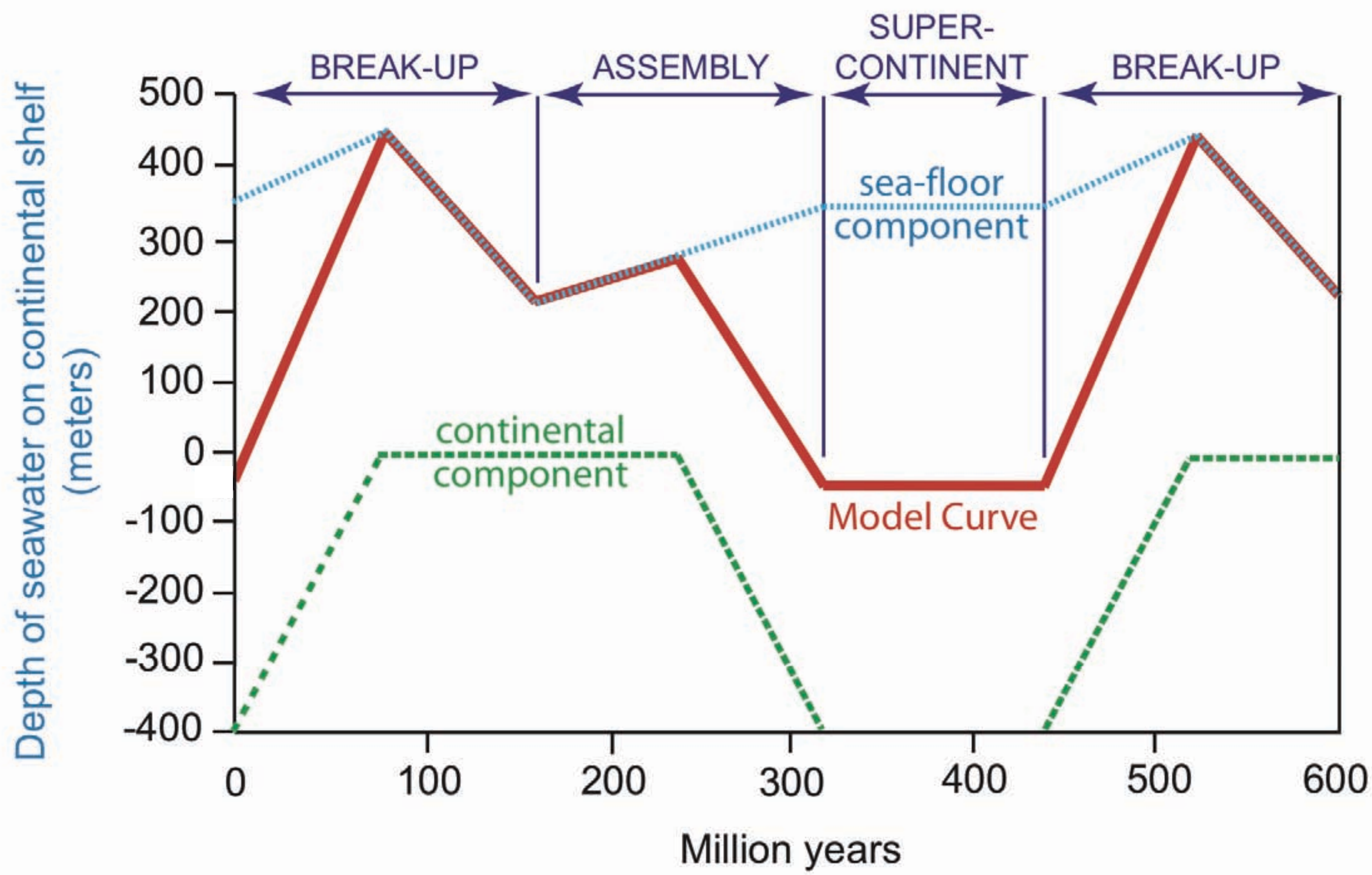
Two ~300 m.y. Supercycles in Phanerozoic Record of Climate, Sea Level and Granitoid Magmatism.



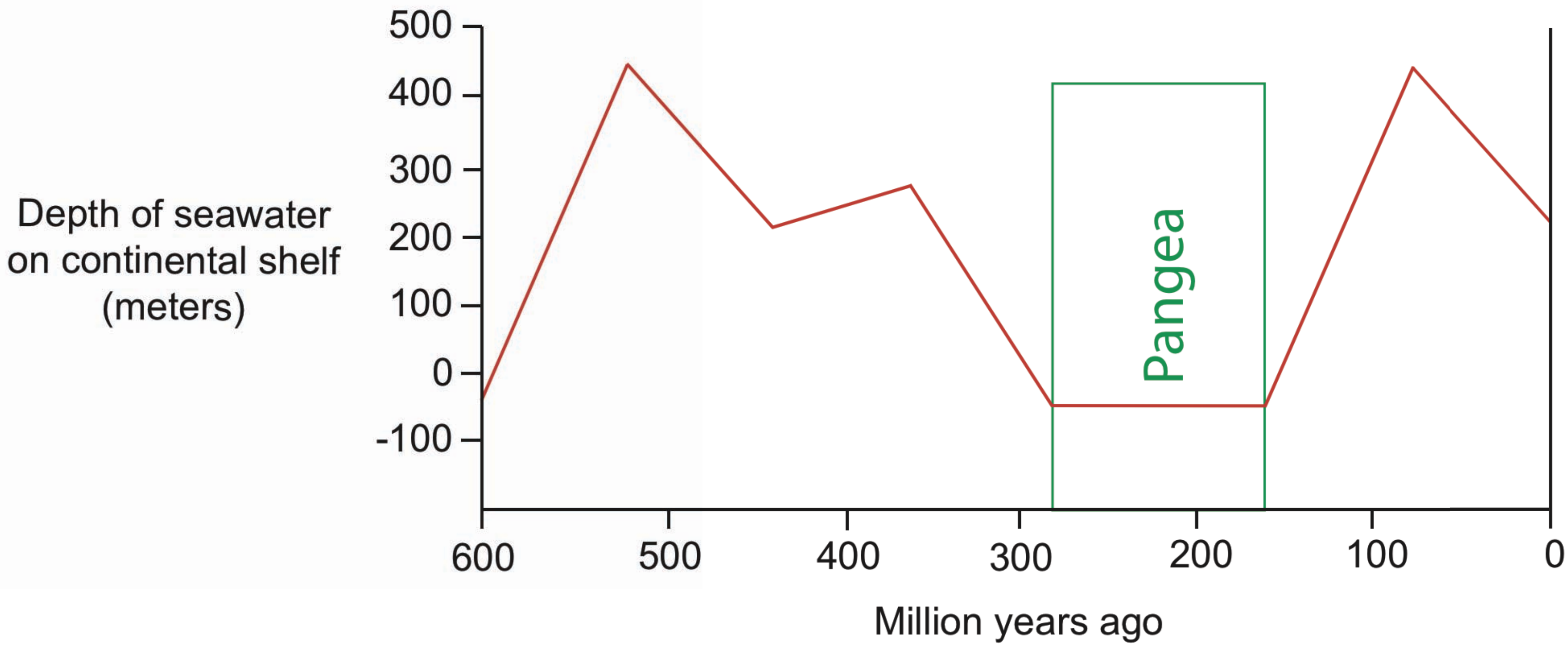
Fischer (1982)



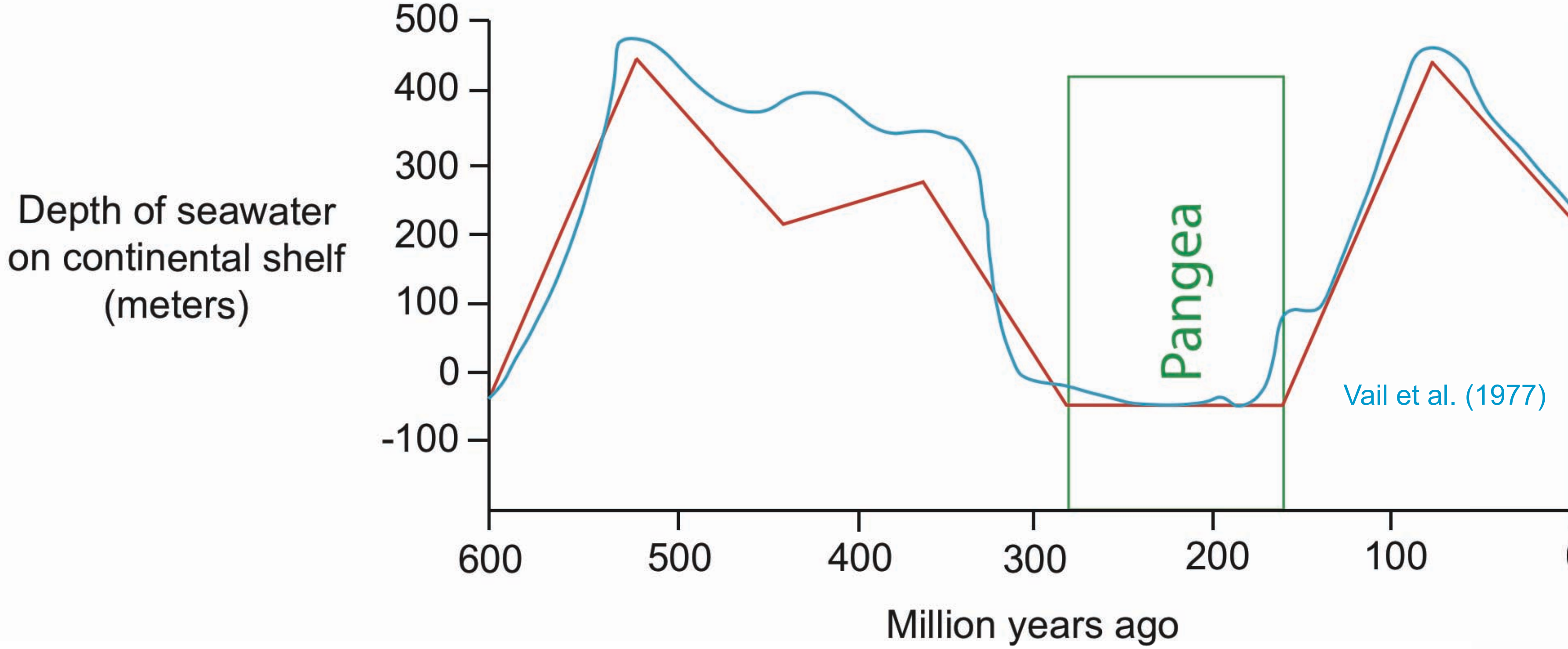
Worsley et al. (1984, 1985)



Worsley et al. (1984)

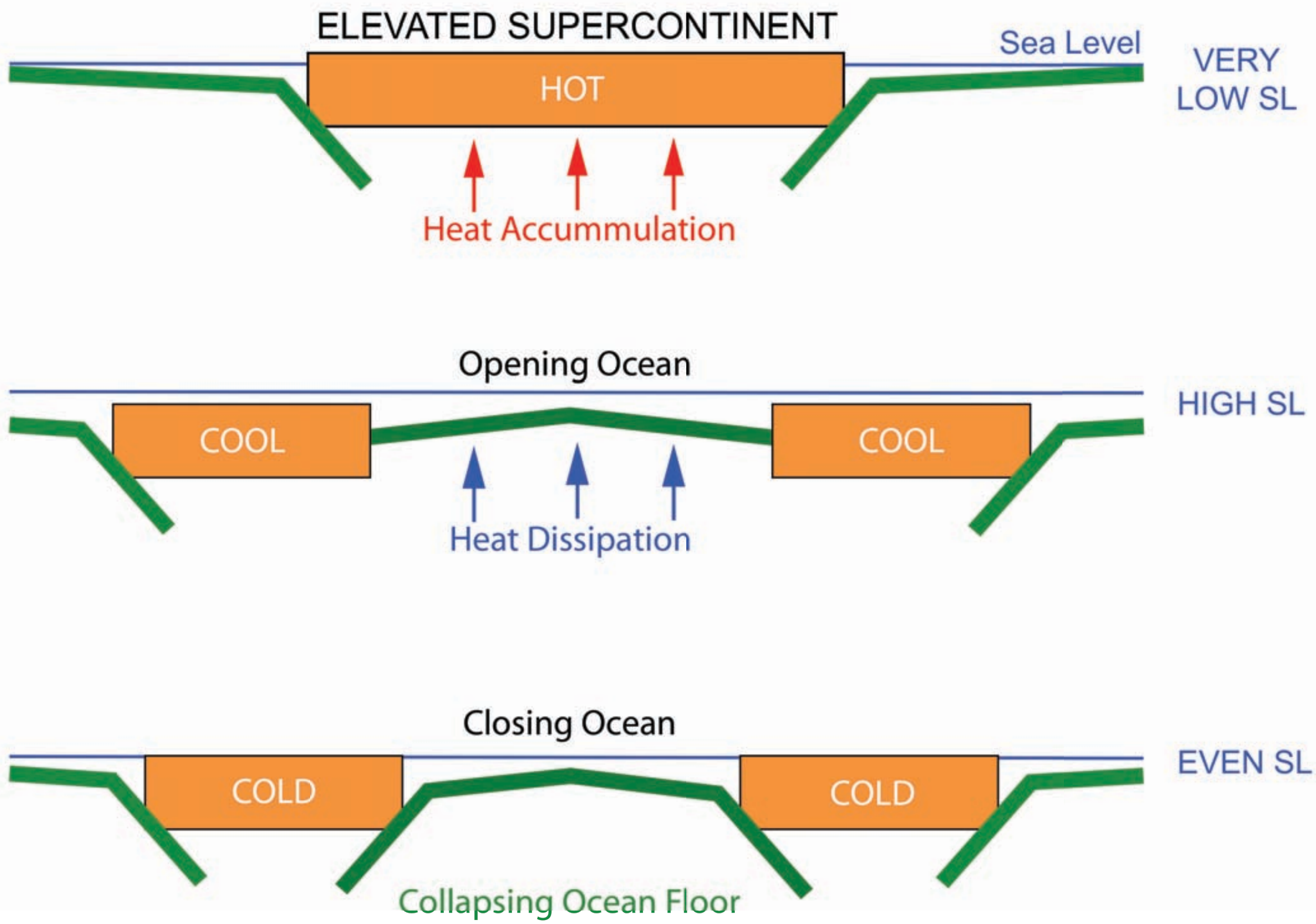


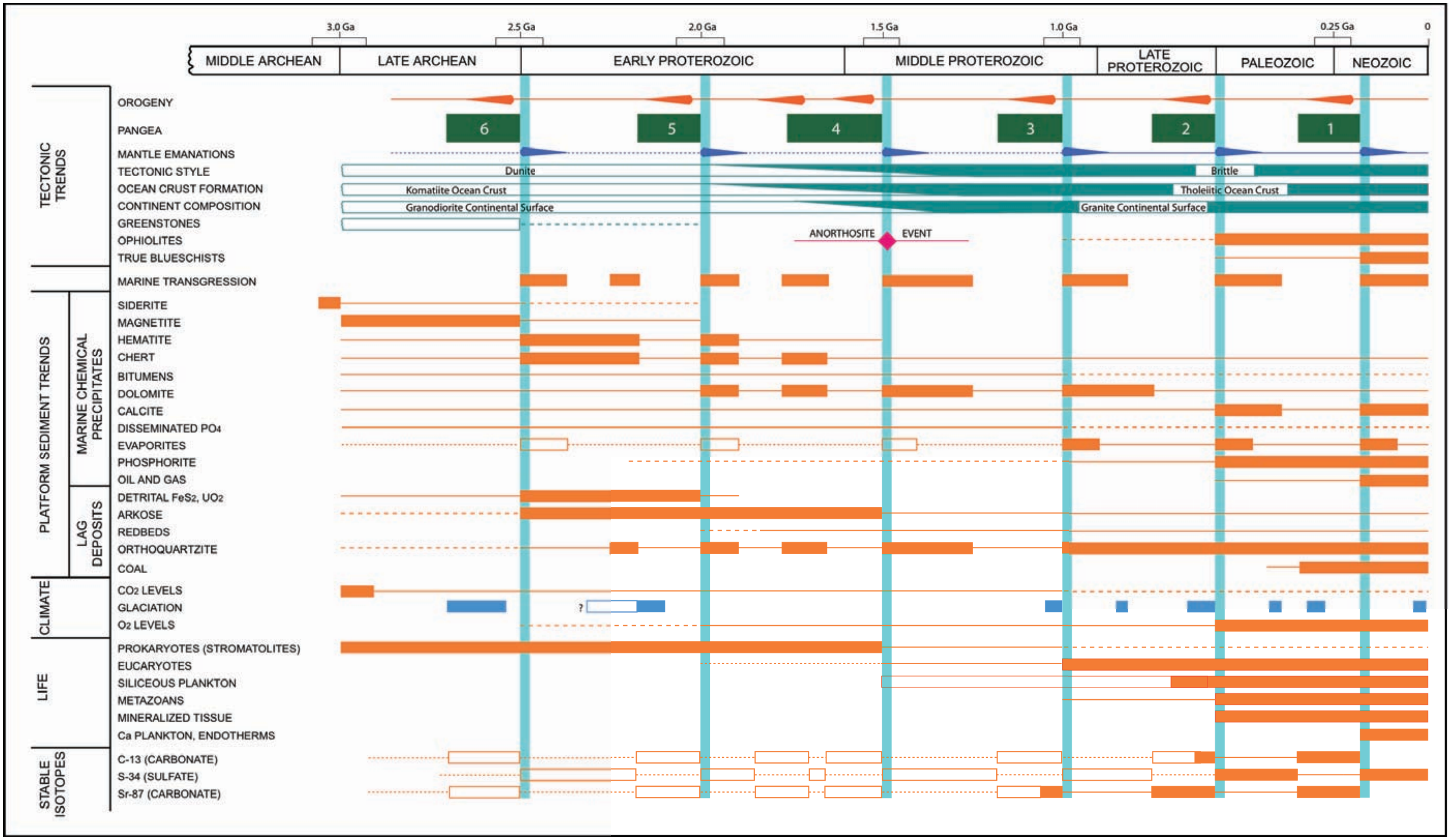
Worsley et al. (1984)



Worsley et al. (1984)

Proposed Driving Mechanism





Worsley et al. (1985)

Supercontinentality

- Tectonic activity dominated by epeirogenic uplift as trapped mantle heat accumulates beneath largely stationary supercontinent

- Accretionary orogeny expected at margins of exterior (Panthalassic) ocean, now at its largest size

- With sea level at its lowest elevation, terrestrial deposition enhanced

- Sequestering of isotopically light carbon in non-marine and organic-rich sediments, and heavy sulfur in evaporites, expected to produce a record of low $\delta^{13}C$ and $\delta^{34}S$ in reciprocal marine platform reservoir

- Massive extinctions expected to accompany loss of shallow marine habitat

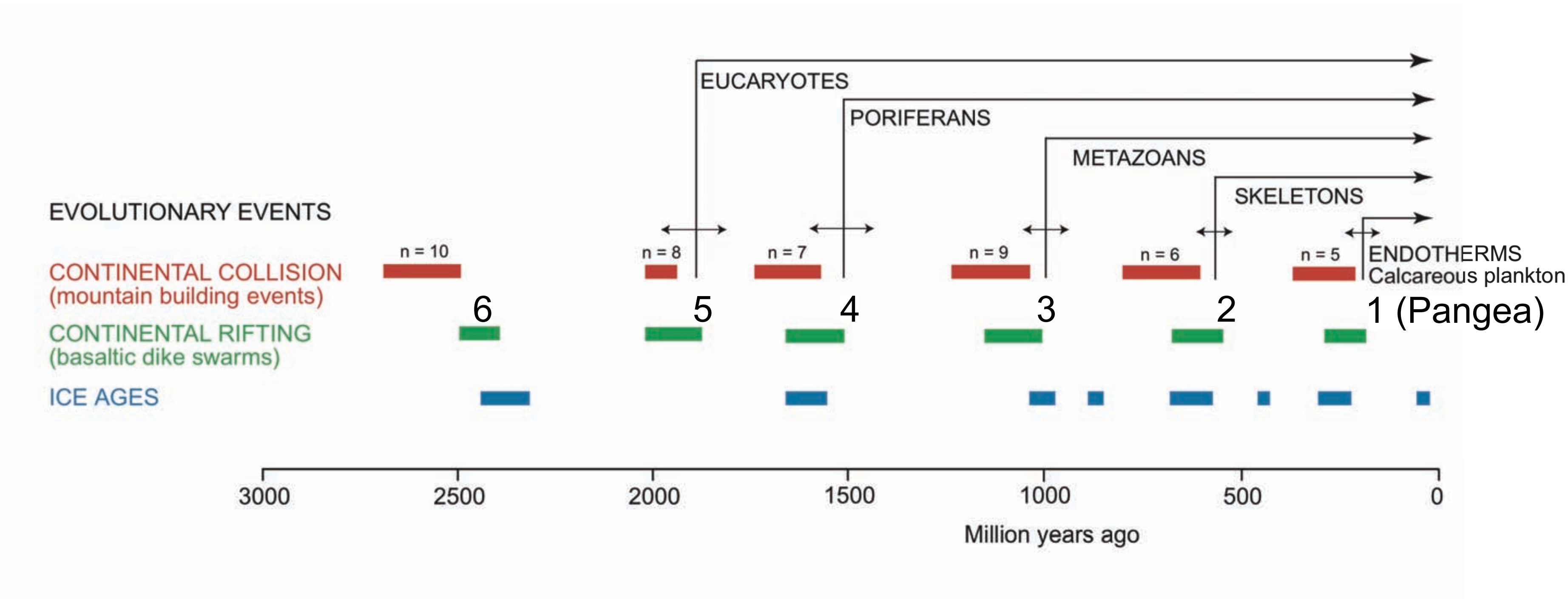
- Cold climates (potentially leading to continental glaciation) expected to develop as CO_2 is removed from the atmosphere by weathering of large areas of subaerially exposed continental crust

Supercontinent Breakup and Dispersal

- Younging of world ocean floor through rifting and opening of new (interior) ocean basins, coupled with subsidence of dispersing continental fragments, should raise sea level to its maximum elevation
- Collisional orogeny minimal, although accretionary orogeny and terrane accretion expected on exterior ocean margins
- Rapid biotic diversification and enhanced preservation of platform sediments with increasing high values of $\delta^{13}C$ and $\delta^{34}S$ should accompany continental drowning
- Warm, equable climates should develop as continental flooding allows atmospheric CO_2 levels to build

Supercontinent Assembly

- Accretionary and collision orogenesis should increase to a maximum
- Global sea level should first rise and then fall as subduction consumes first the old and then the young floor of interior oceans (opening and then closing back-basins along their margins)
- Active margin sedimentation should increase
- Atmospheric CO_2 levels should fall, causing global climates to deteriorate



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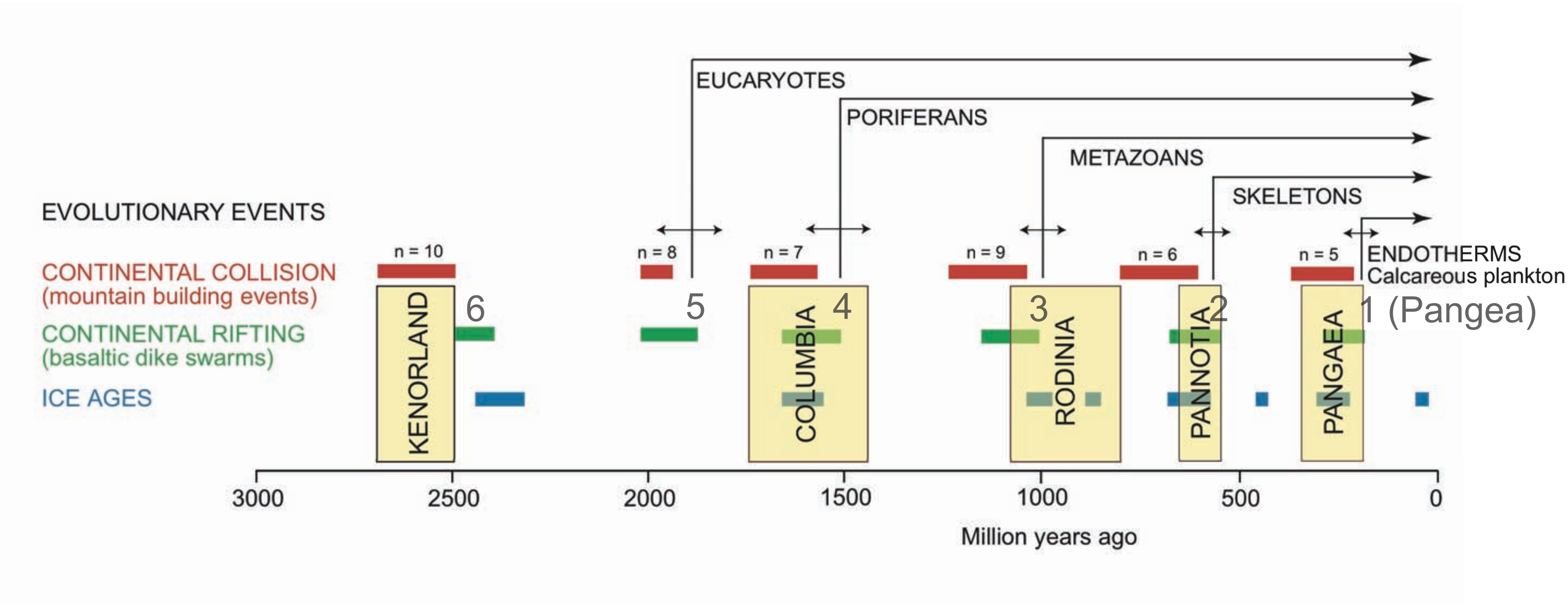

Worsley et al. (1984, 1985)