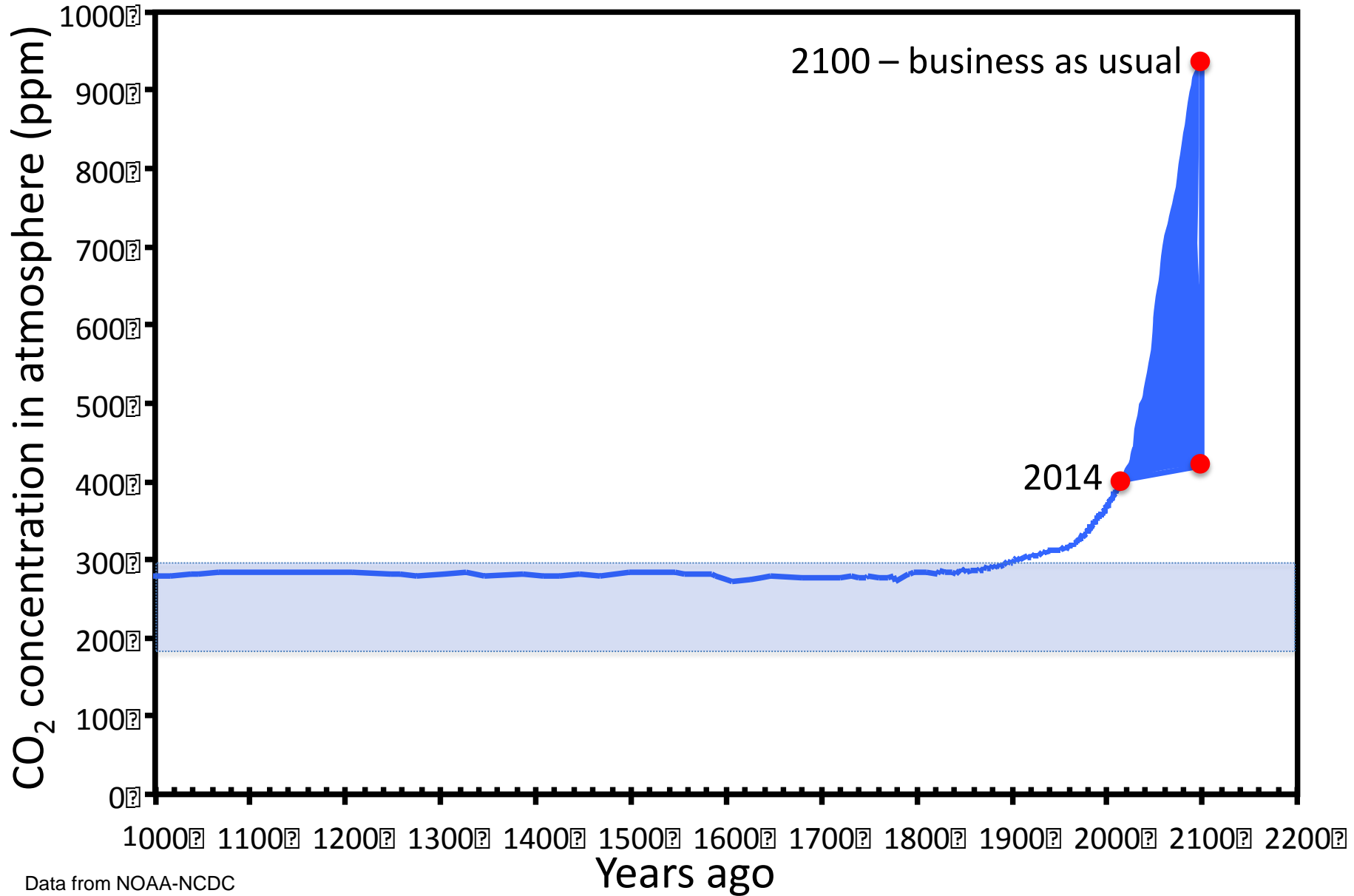


Global Warming 56 Million Years Ago & What it Means for Us

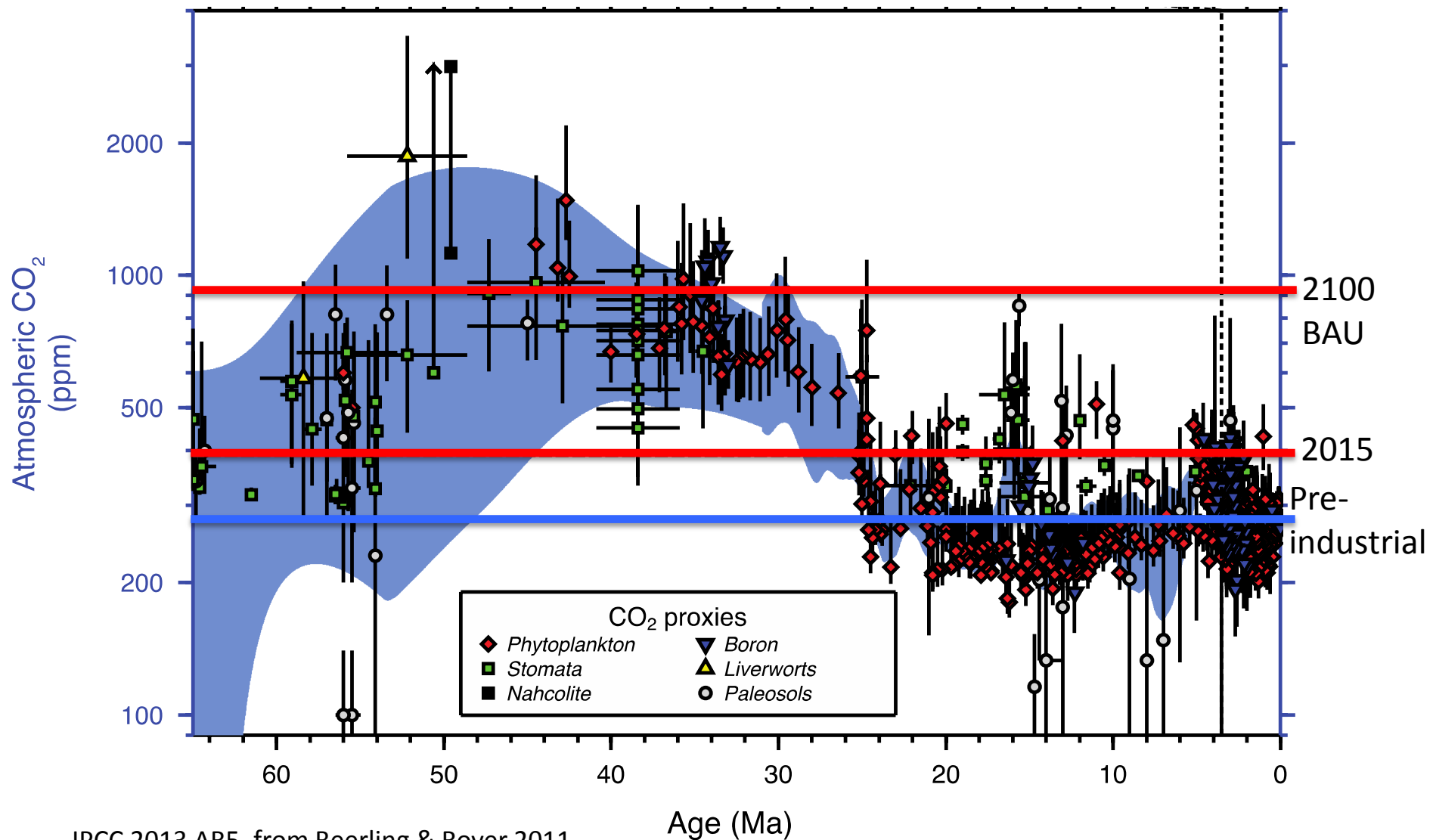


Scott Wing
Dept. of Paleobiology
Smithsonian Institution Museum of Natural History

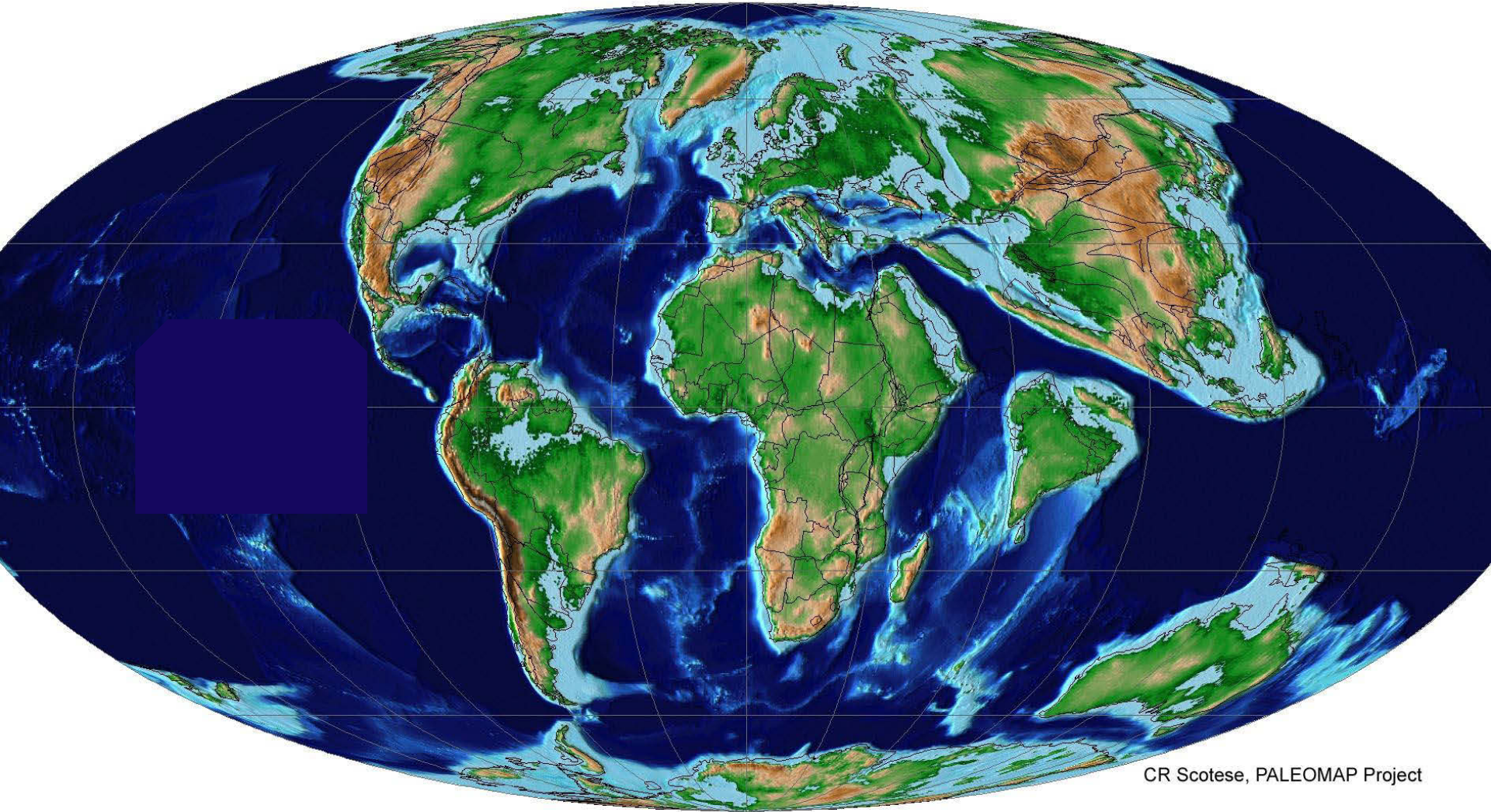
Anthropogenic increase in CO₂



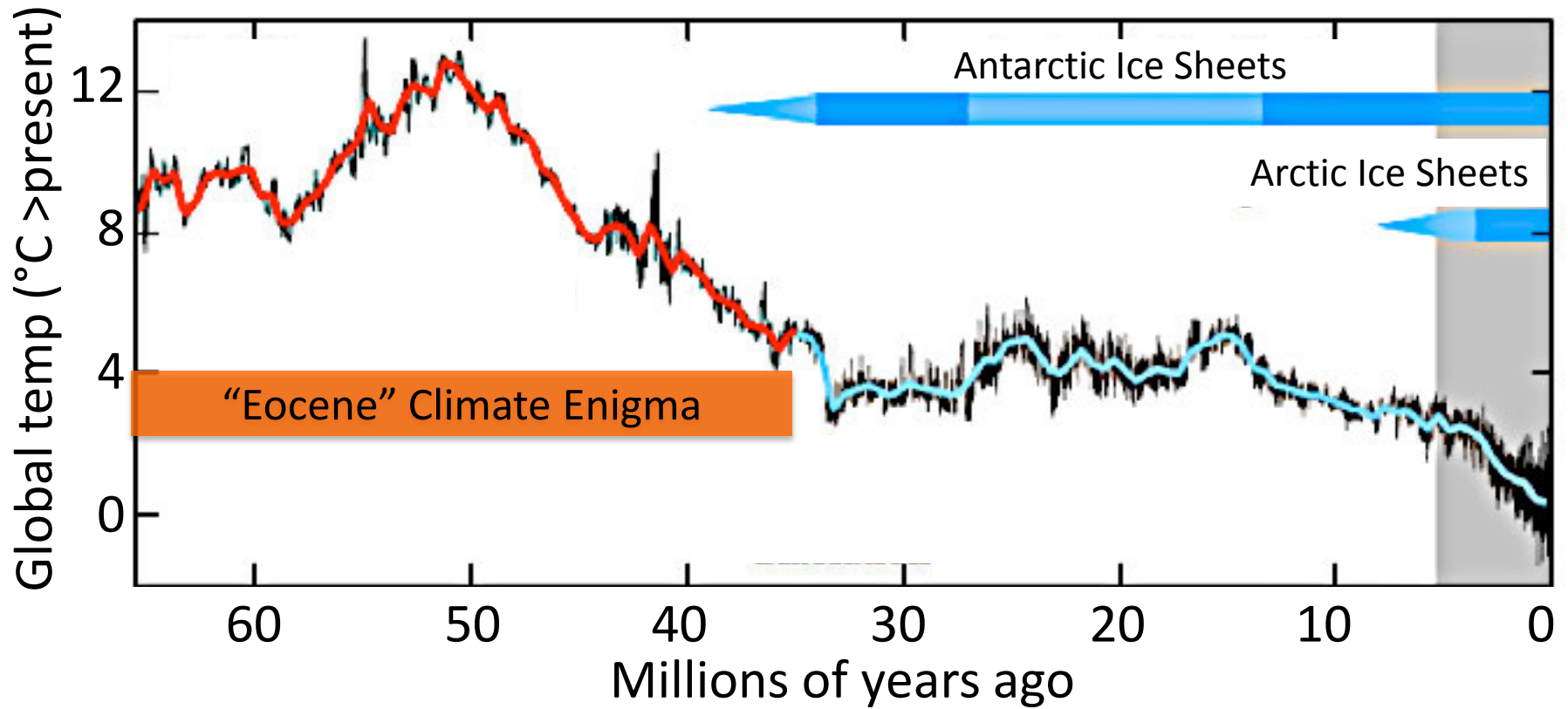
Inferred $p\text{CO}_2$



Paleogeography 56 million years ago



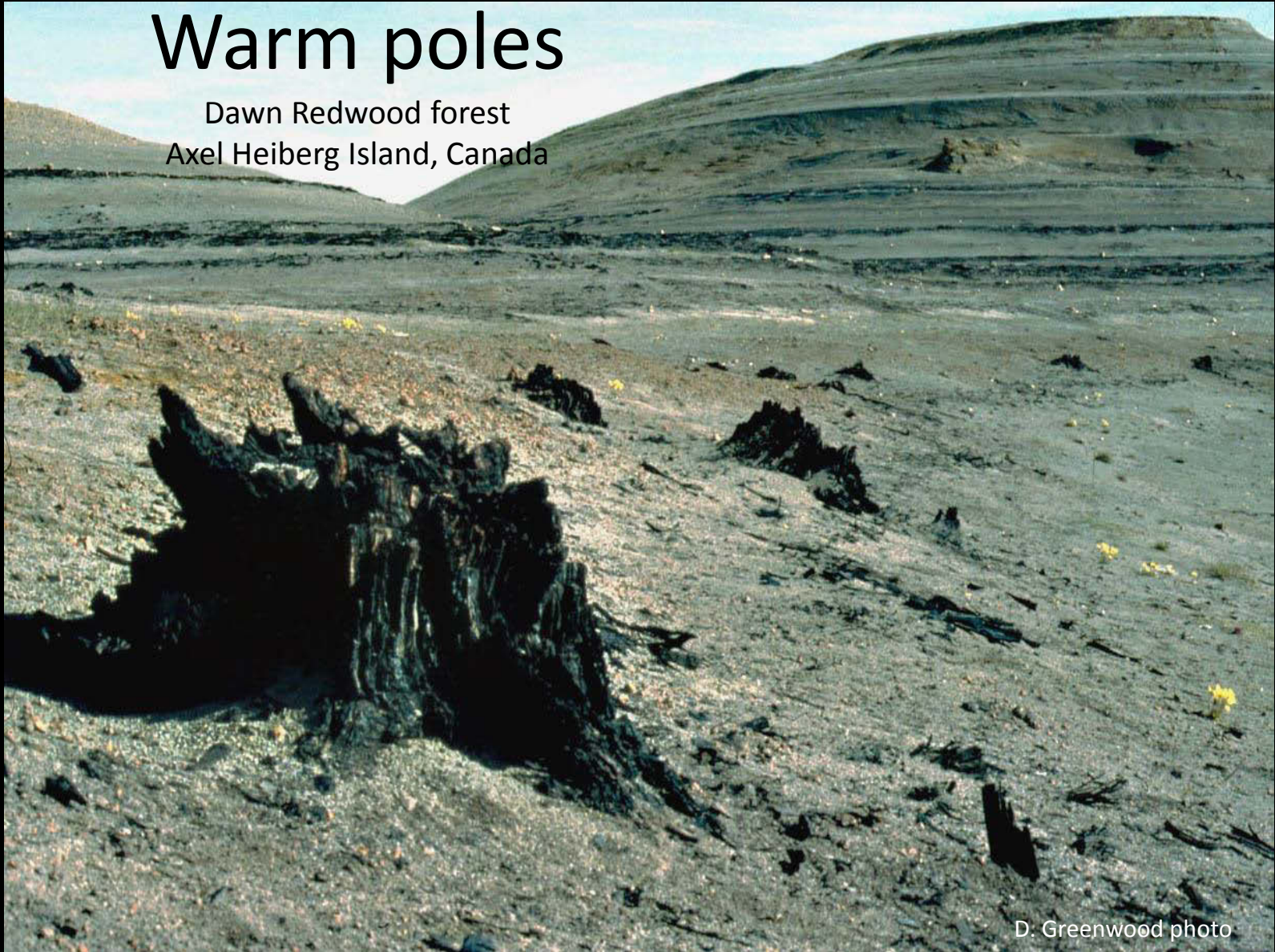
Estimated Global Mean Temperature (difference from present)



The Eocene climate enigma

Warm poles

Dawn Redwood forest
Axel Heiberg Island, Canada



D. Greenwood photo



The Eocene climate enigma



Warm winters

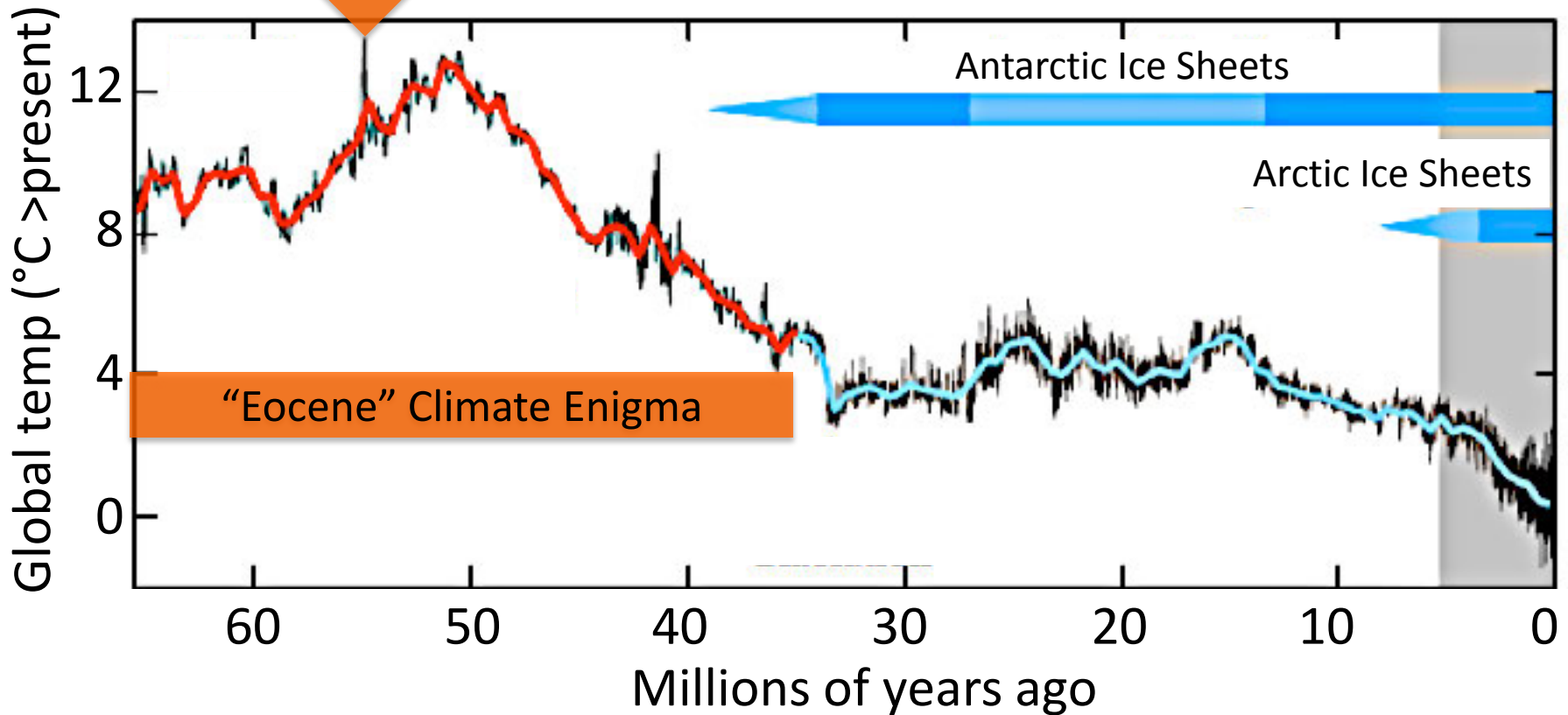
palm leaf, Wyoming, USA

Field Museum

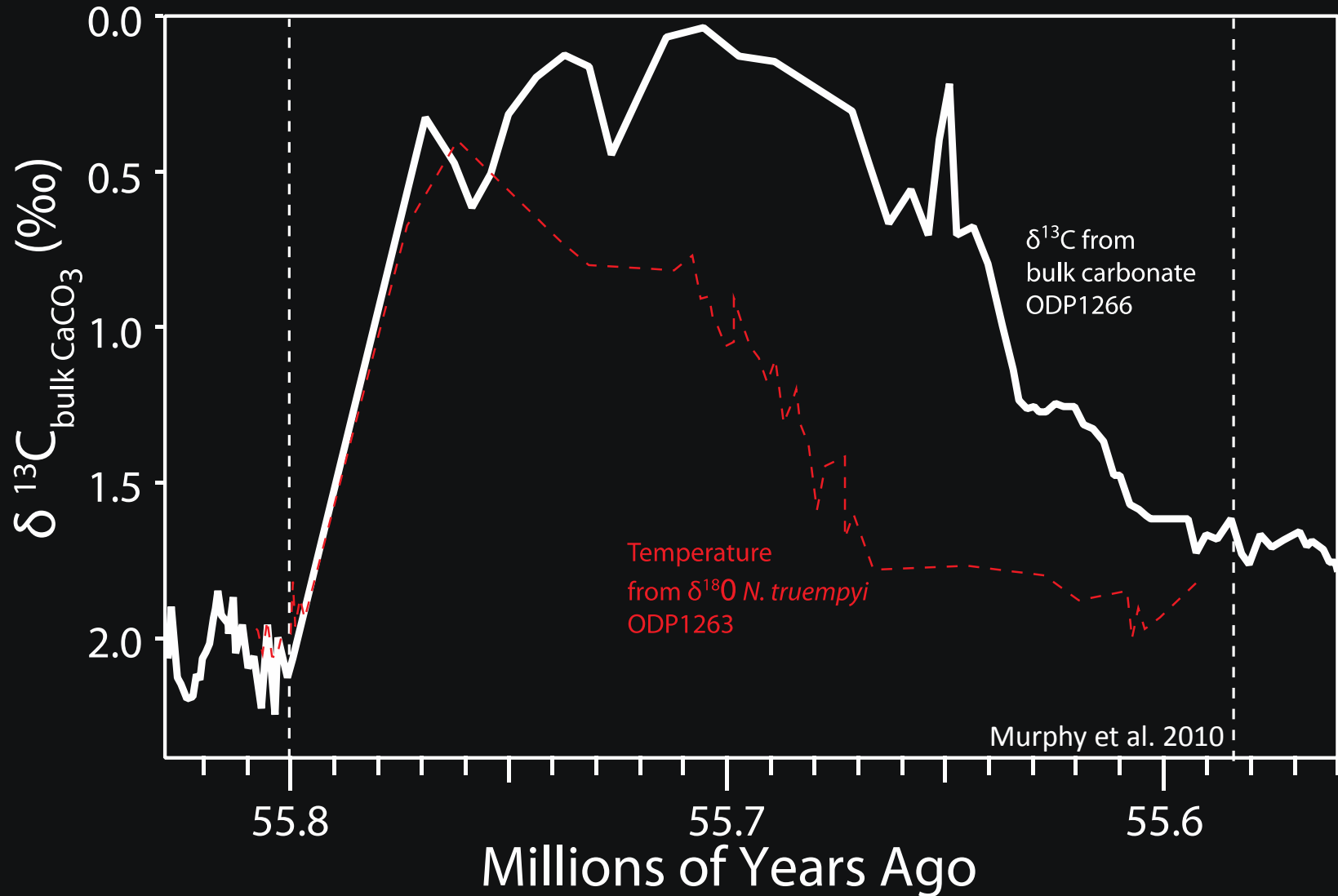


Estimated Global Mean Temperature

Paleocene-Eocene Thermal Maximum (PETM) (difference from present)



PETM carbon & temperature



Dissolution of deep ocean chalk

http://www-odp.tamu.edu/publications/208_IR/208ir.htm



Paleocene-Eocene Thermal Maximum (PETM)

- Global warming of 4 to 8 ° C
- Extensive marine carbonate dissolution
- Carbon isotope ratio shift of -4‰ to -5‰
- Total duration >100 ky

CONCLUSION

*Release of 4,000-7,000 Pg of carbon in a few
millennia or less*

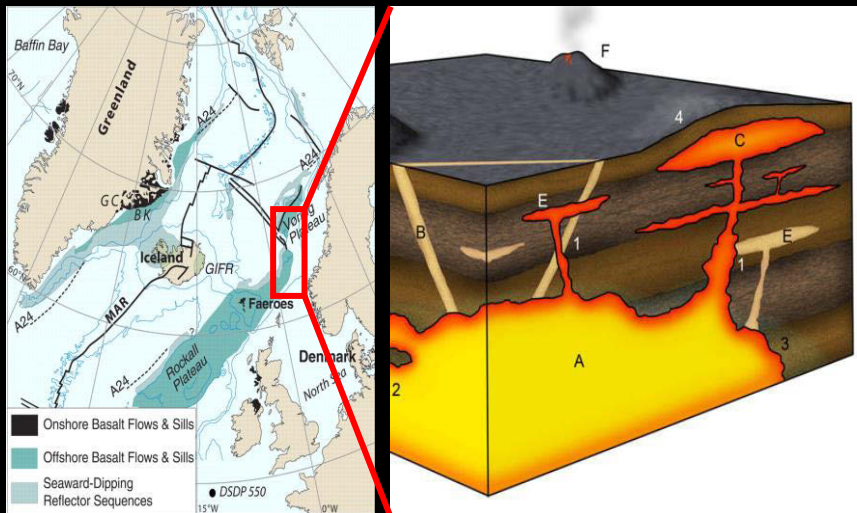
Potential carbon sources



Methane Hydrates



Wildfire

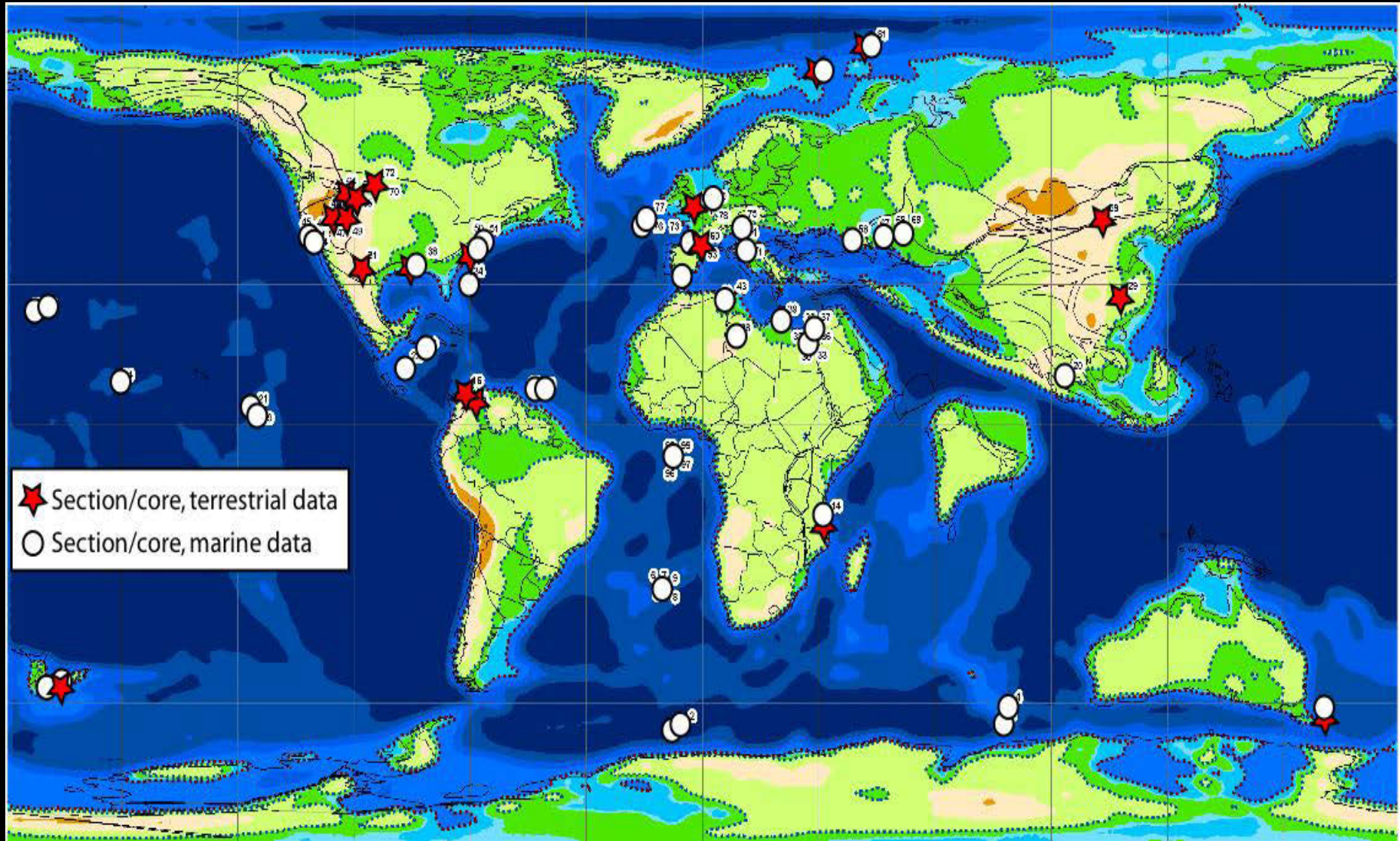


Thermogenic Methane



Permafrost

P-E boundary records



The Bighorn Basin



Tom Nash photo



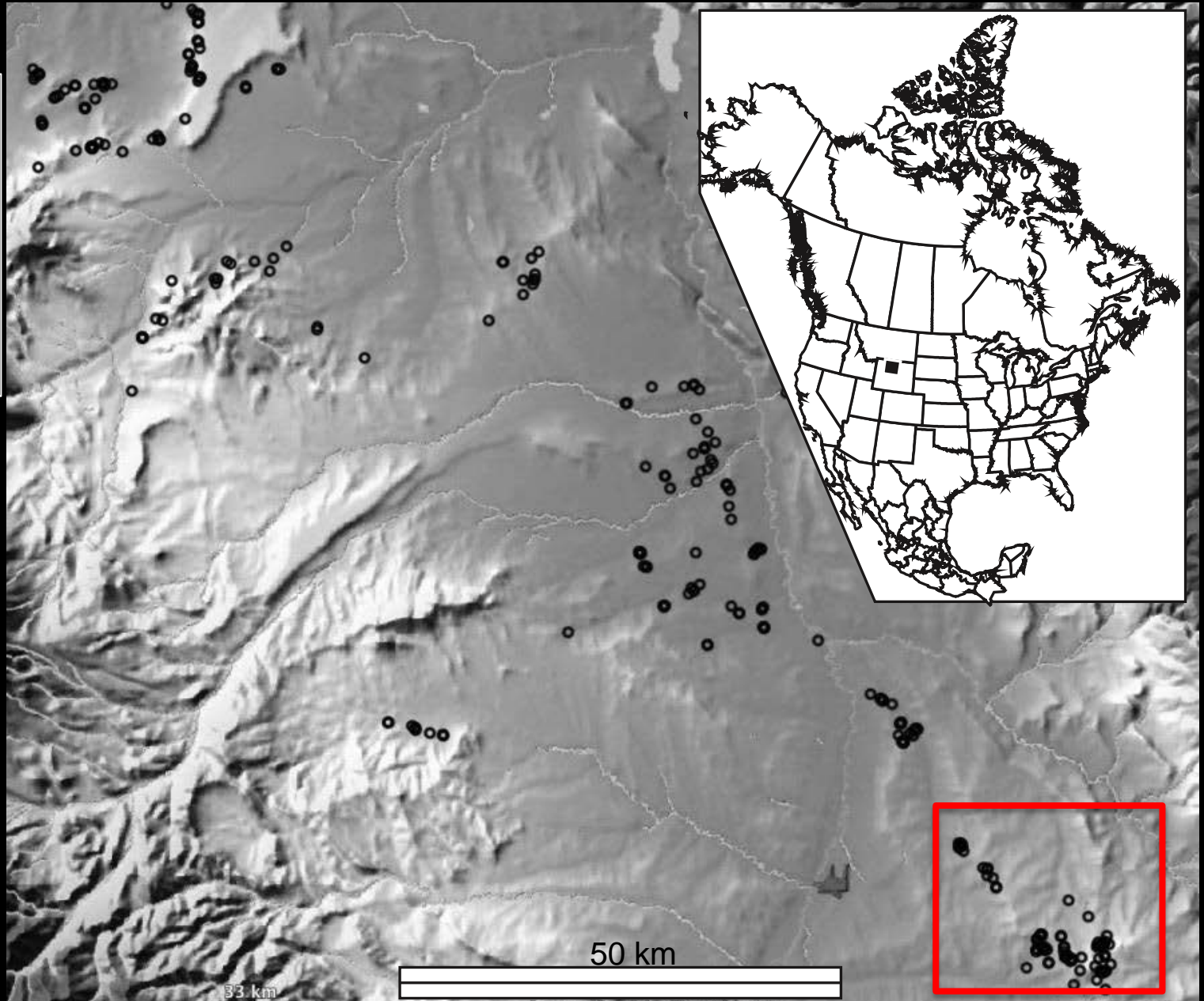
Tom Nash photo



Bighorn Basin, Wyoming, Fossil Plant Sites

225 Sites
314 Taxa

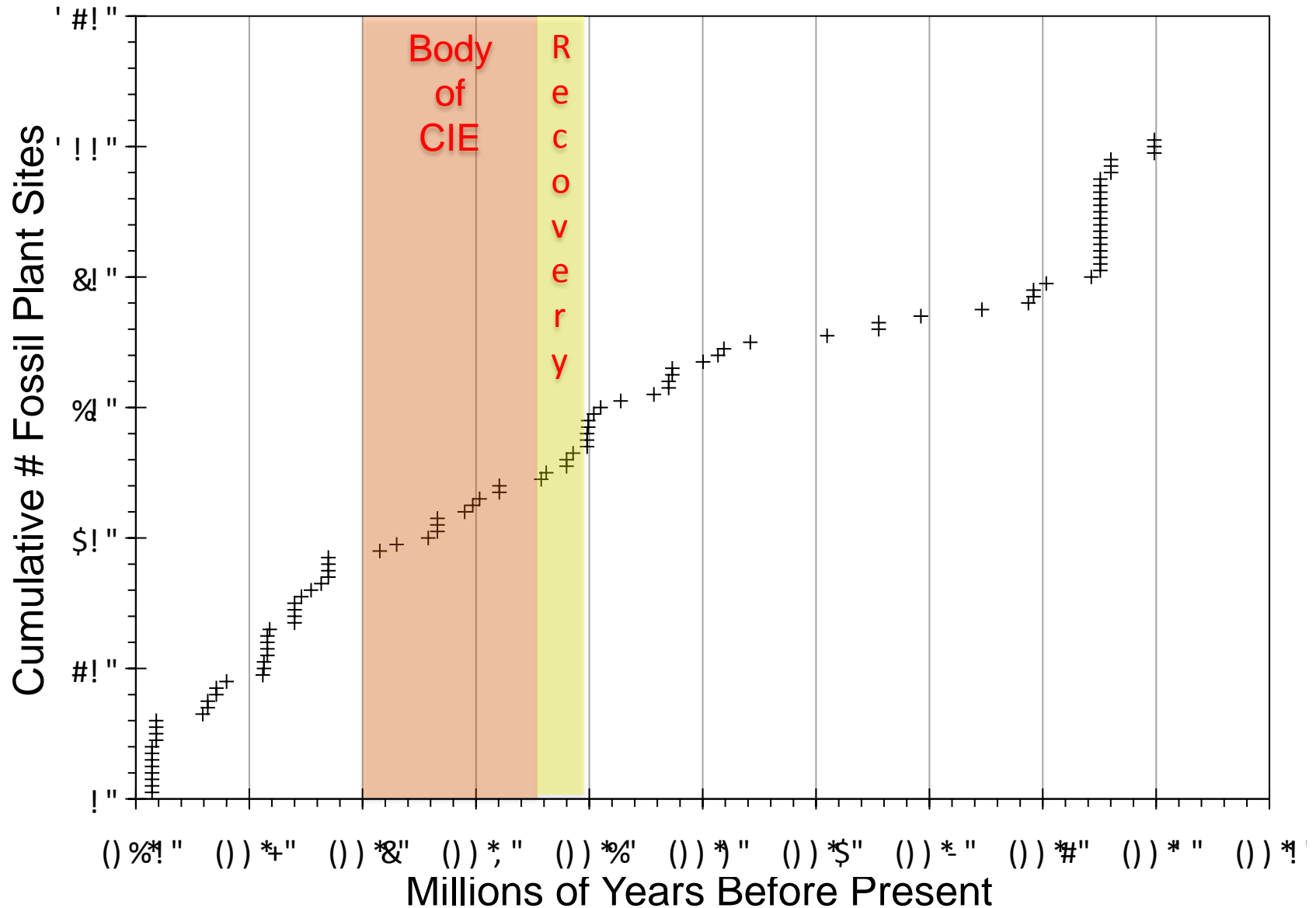
1 km strata
7 million yr



33 km

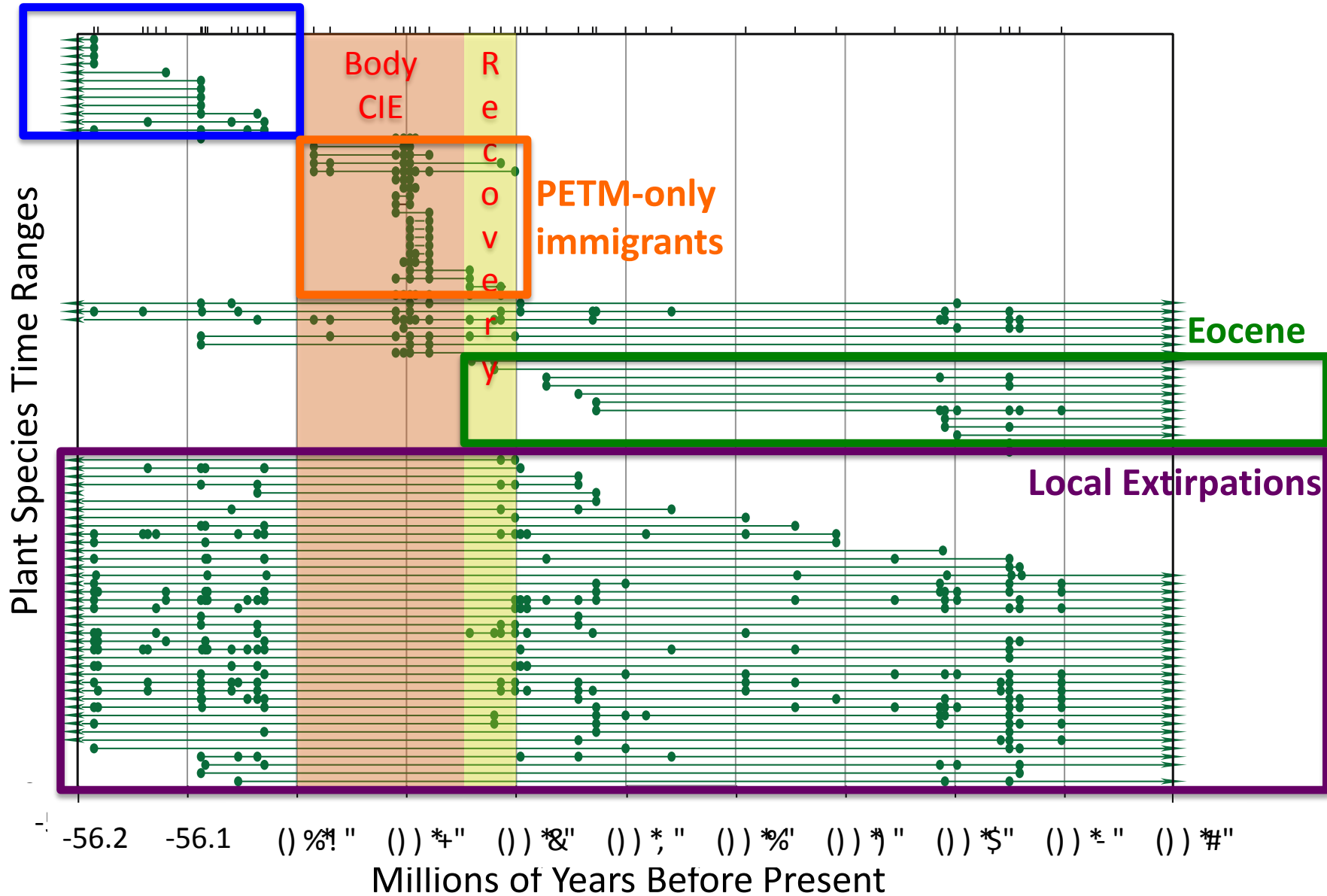
50 km

Bighorn Basin Plant Fossil Sites



Floral Change during the PETM

Possible extinctions



Possible Extinctions



Davidia antiqua
Dogwood family

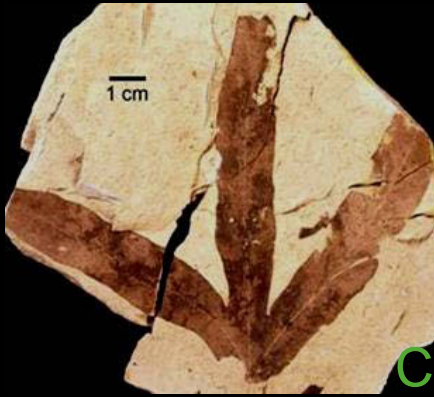


Browniea serrata
Dogwood order

PETM-only, bean family



Post-PETM Immigrants



Climbing fern



Linden family



Alder



Hickory family

Locally extirpated



Oak family



Katsura tree



Dawn redwood



Ginkgo



Birch family

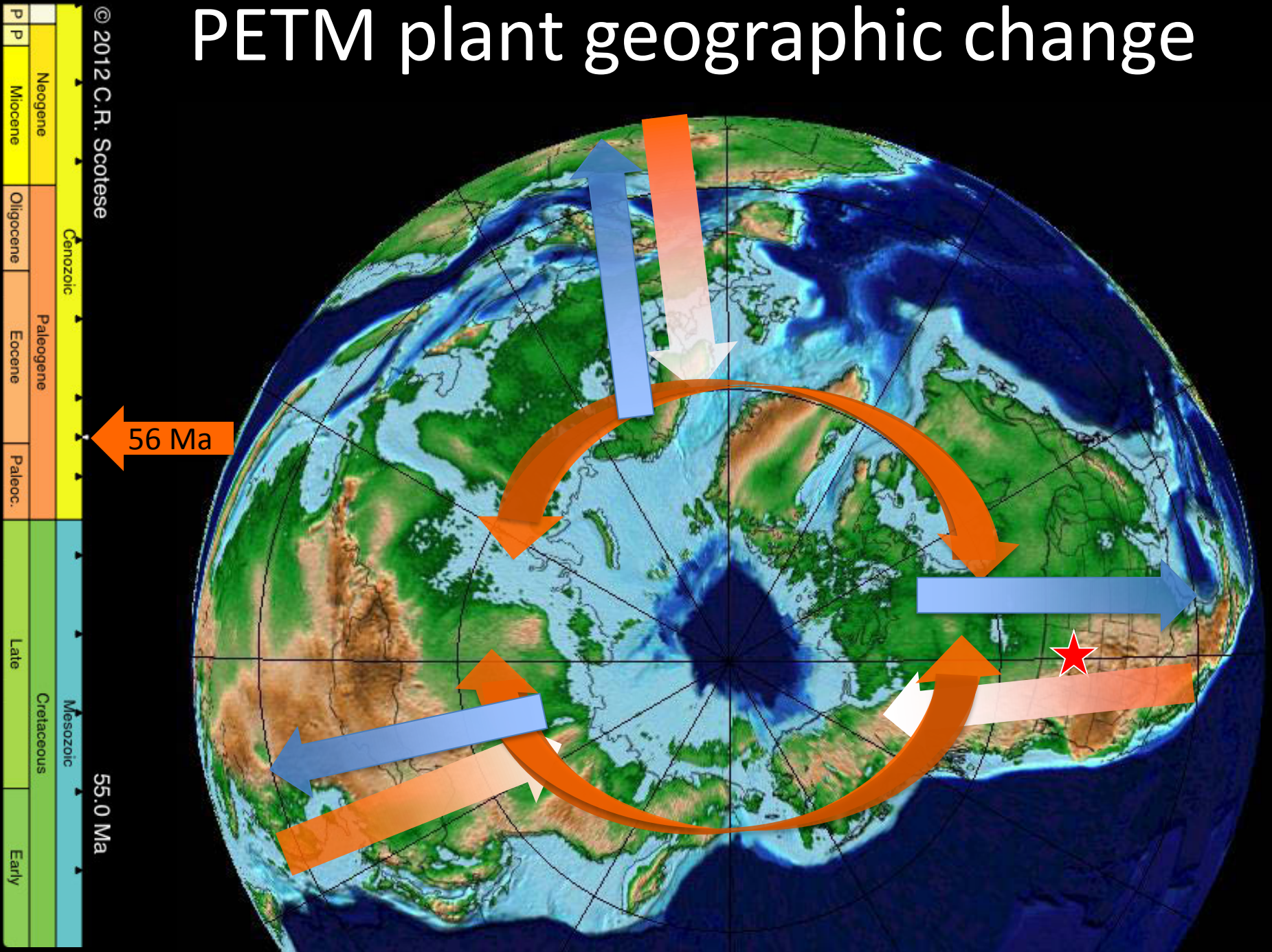


Sycamore



Sycamore

PETM plant geographic change



Floristic Change in Wyoming

1. PETM onset - local/regional EXTIRPATION of temperate deciduous plants (dawn redwood, birch, sycamore, katsura), and immigration of bean family and other dry tropical plants
2. PETM recovery - local/regional EXTIRPATION of bean family et al., return of “natives”, and intercontinental immigration of temperate plants
3. Minor EXTINCTION (~10%)



Aldo Chiappe for *National Geographic*

PETM – abundant insect damage



PETM faunal interchange

C. Clark photo



Hyracotherium - Perissodactyla

Primates

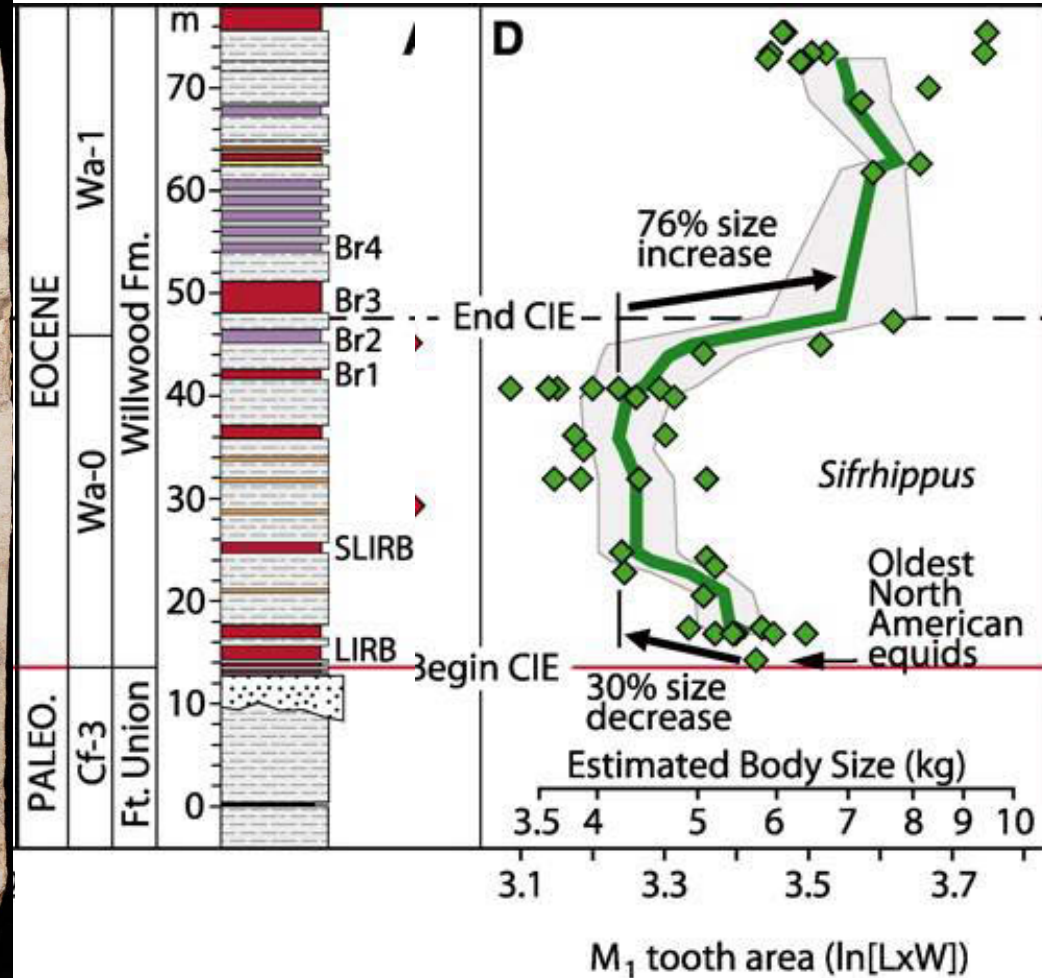


C. Clark photo



Diacodexis - Artiodactyla

Horse body size decrease during PETM



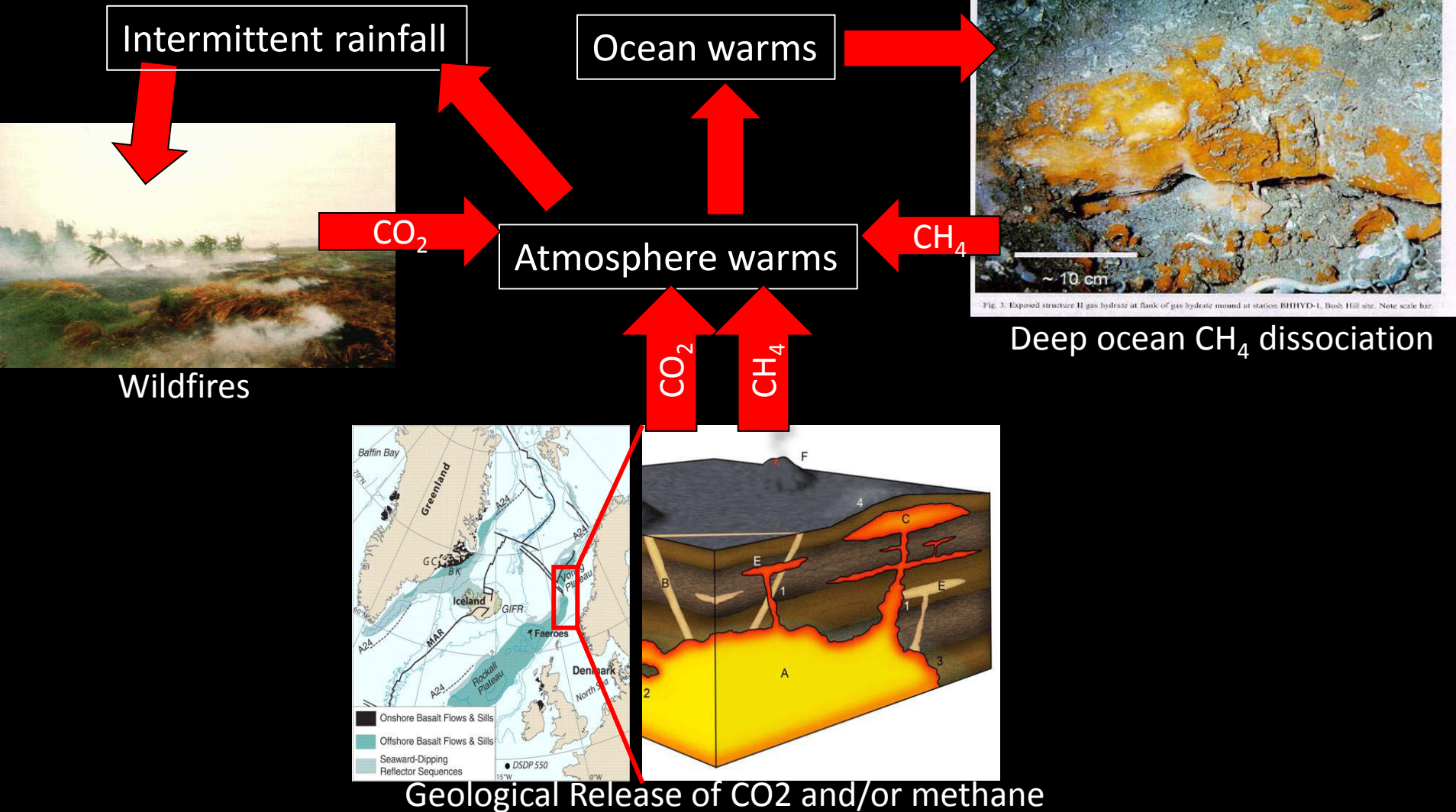
(Secord et al. 2012)

Four lessons from the PETM

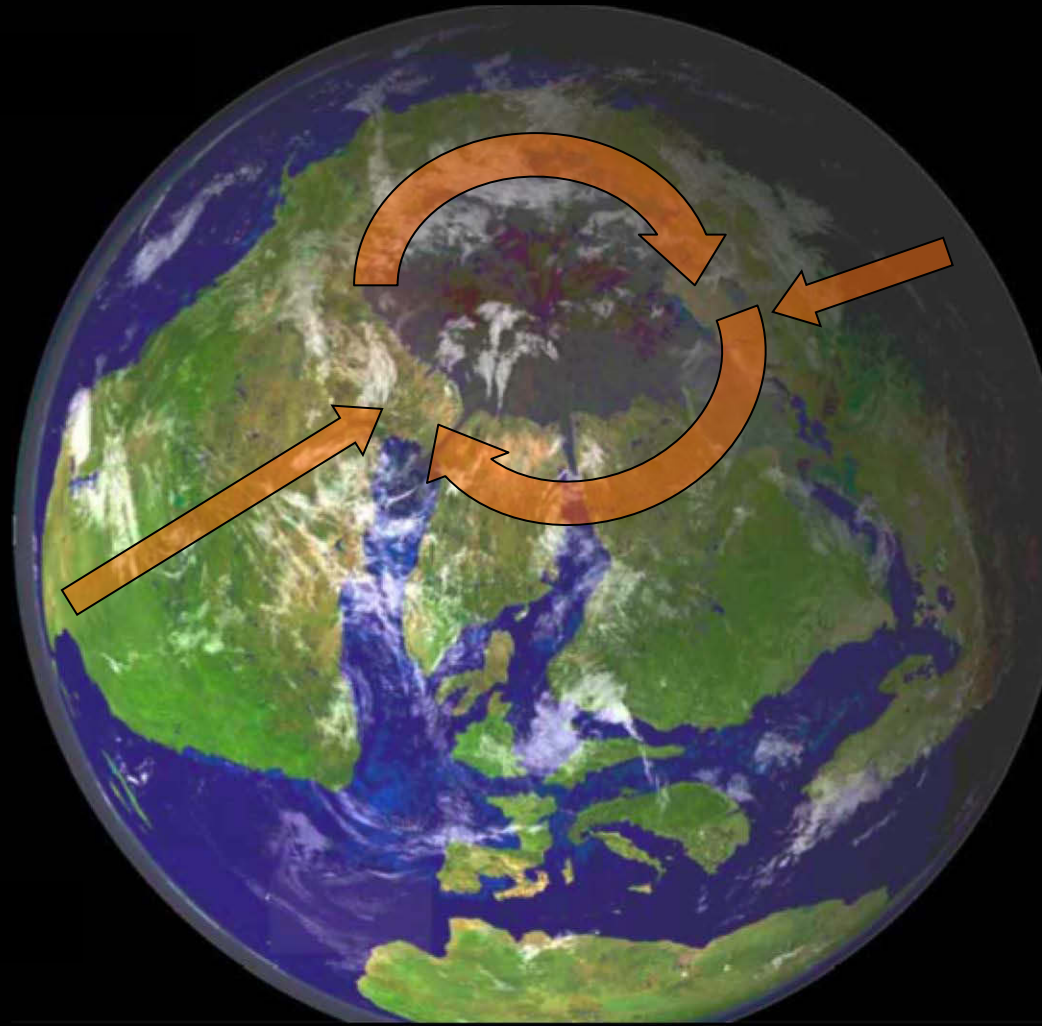
1. A big release of carbon warmed global climate and dissolved deep marine chalk



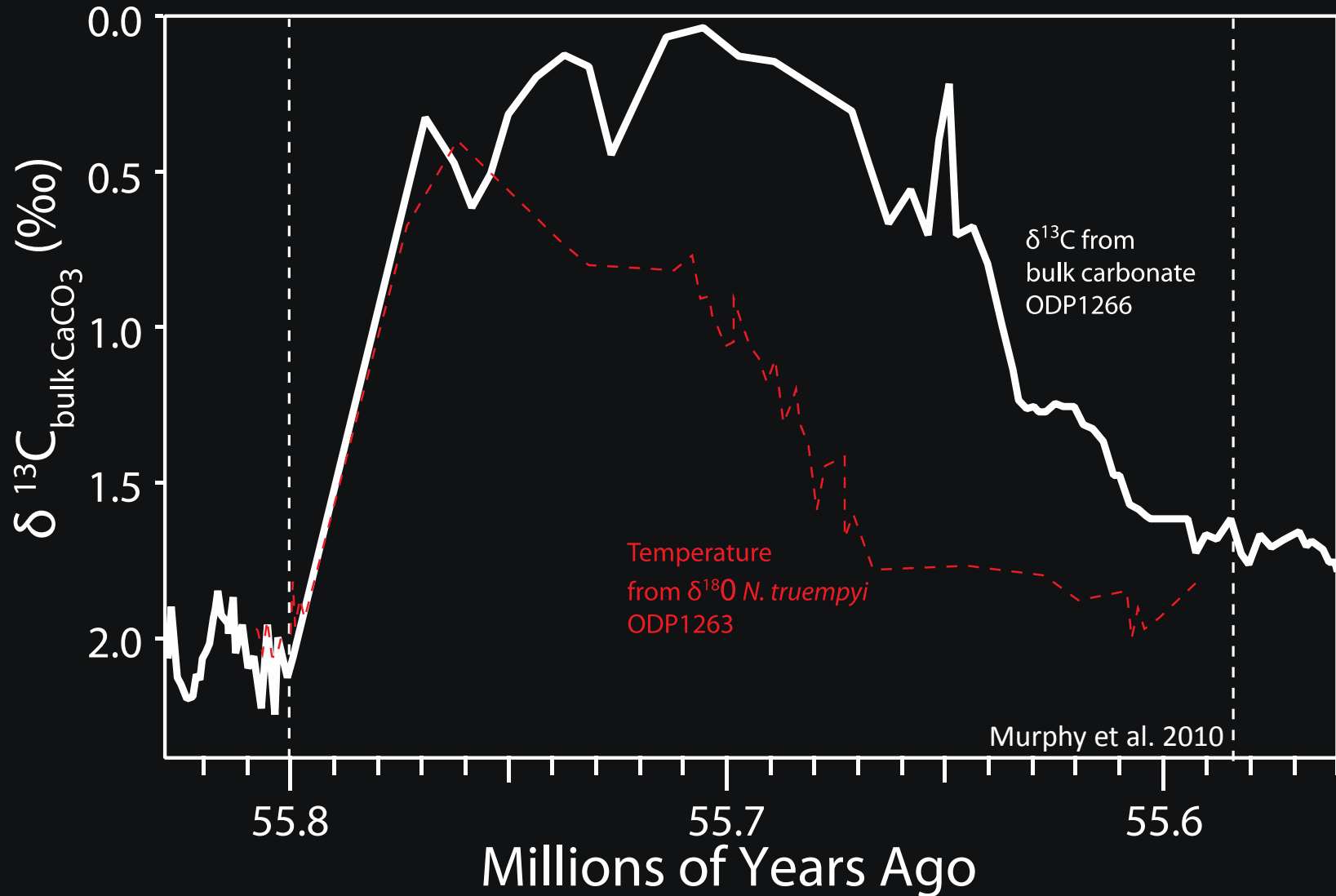
2. There was probably positive feedback – carbon release increased temperature, releasing more carbon



3. Rapid global warming changed where plants & animals lived, how they interacted, and drove rapid evolution



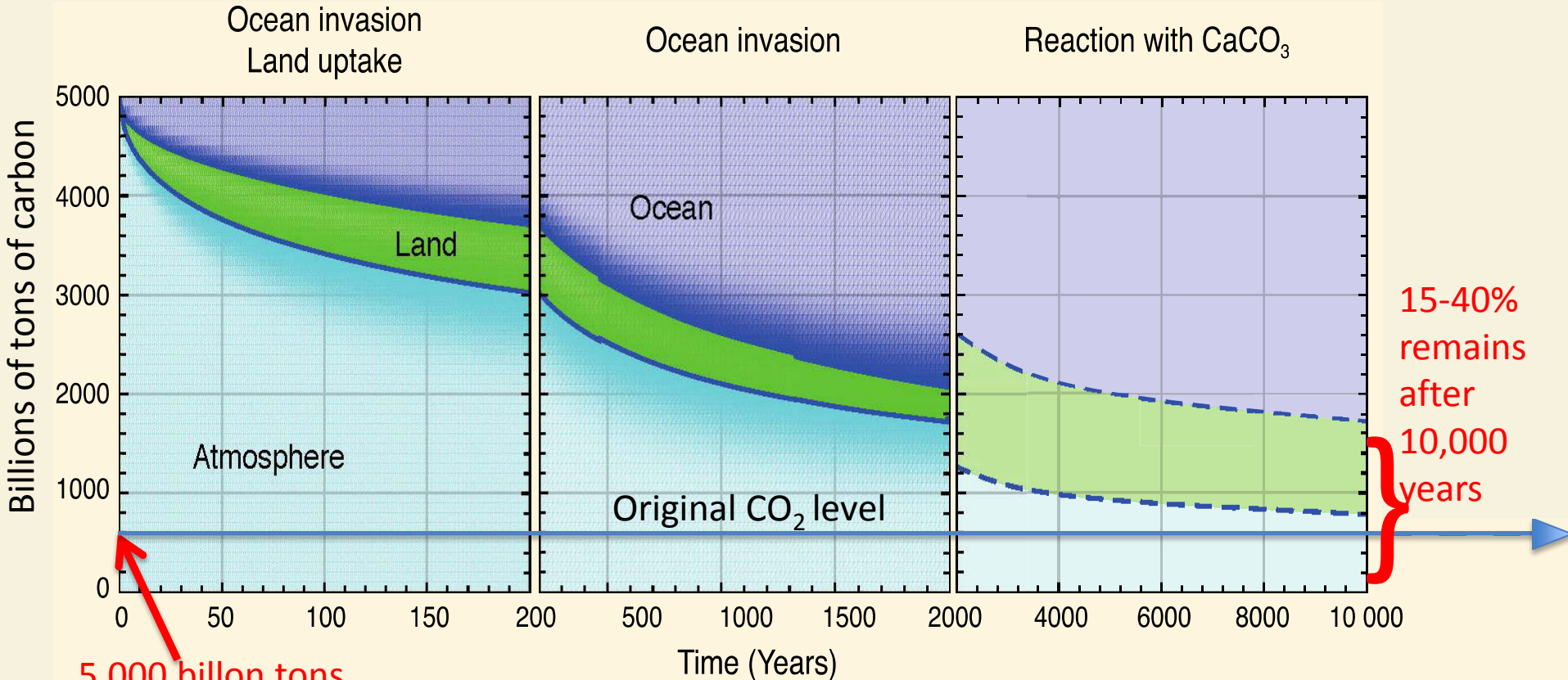
4. The effects lasted about 200,000 years





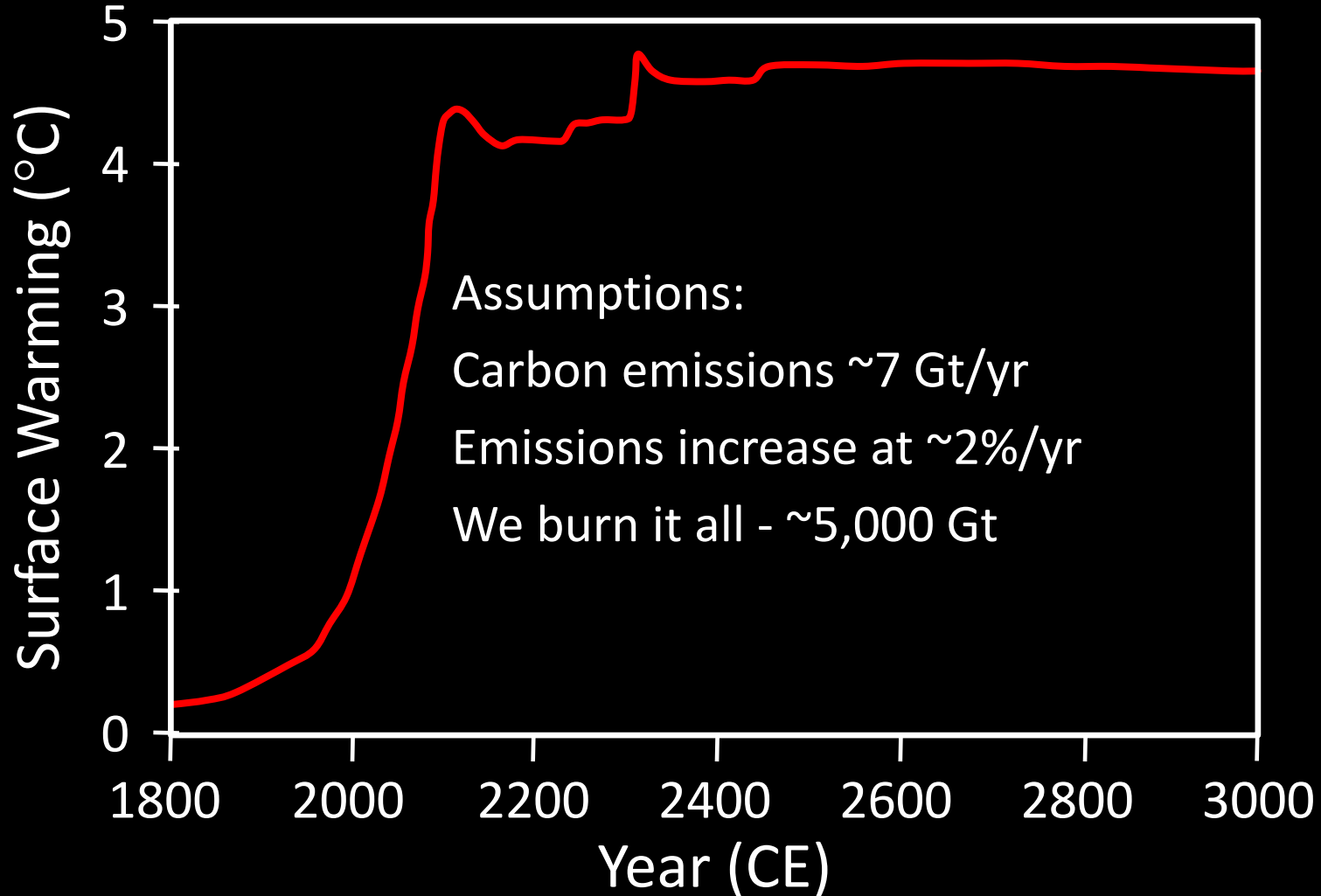
Taking the Long View

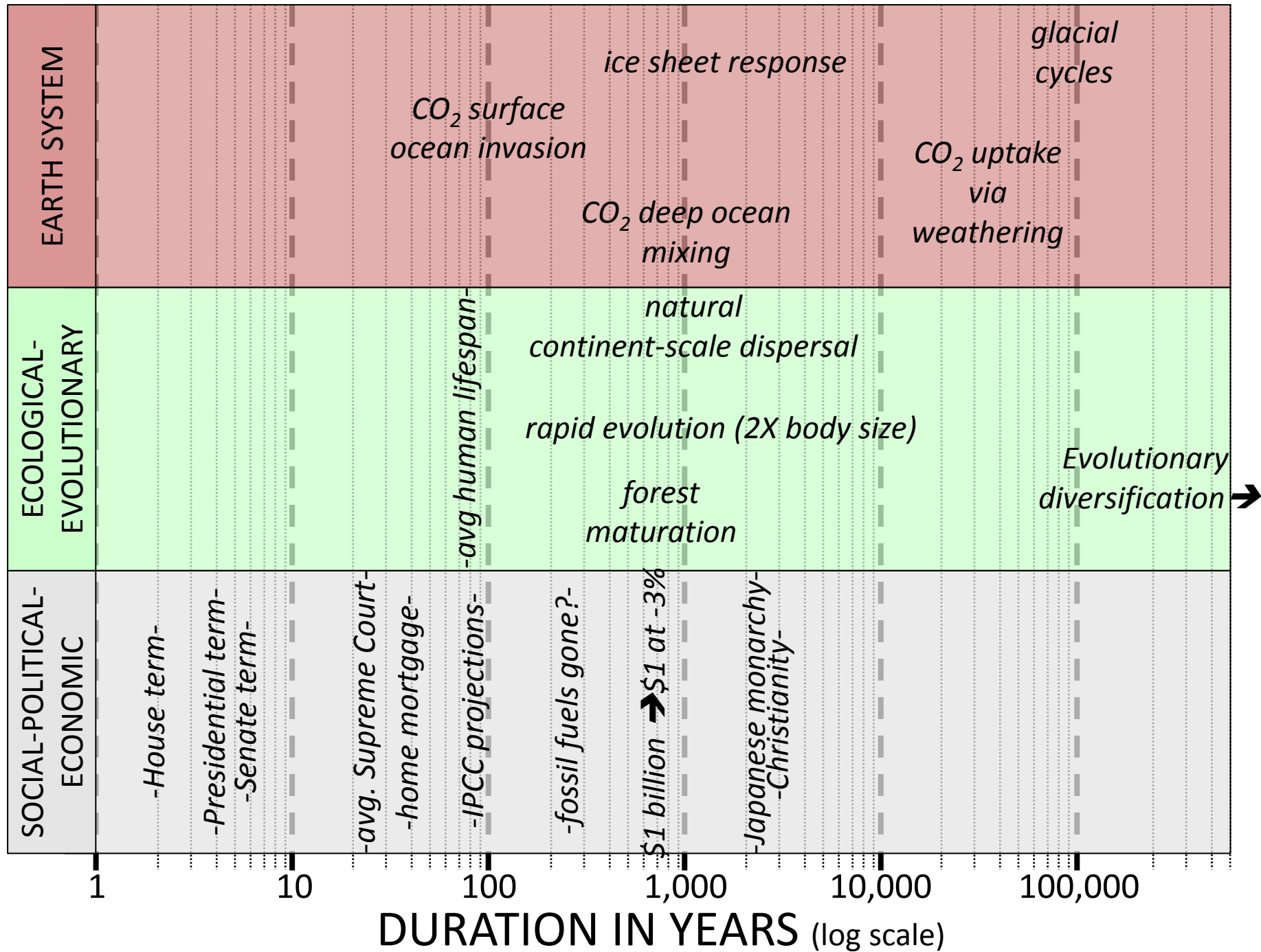
Carbon uptake is very slow



5,000 billion tons of carbon into atmosphere (the whole enchilada)

Temperature stays high





Sea level +7.5m (~25ft) – 5000 CE? (whoops! Greenland Ice Cap melted)

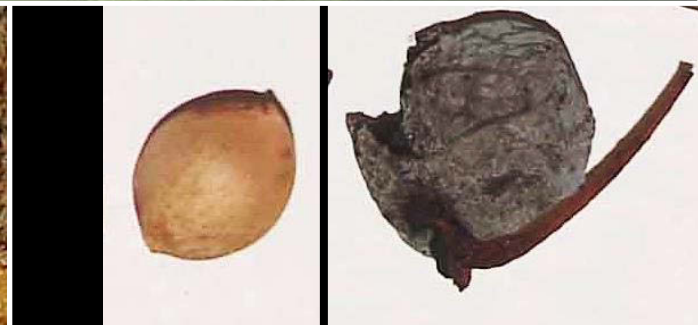


Nickolay Lamm
StorageFront.com

NYT Sunday Review
November 24, 2012
Data from Climate Central

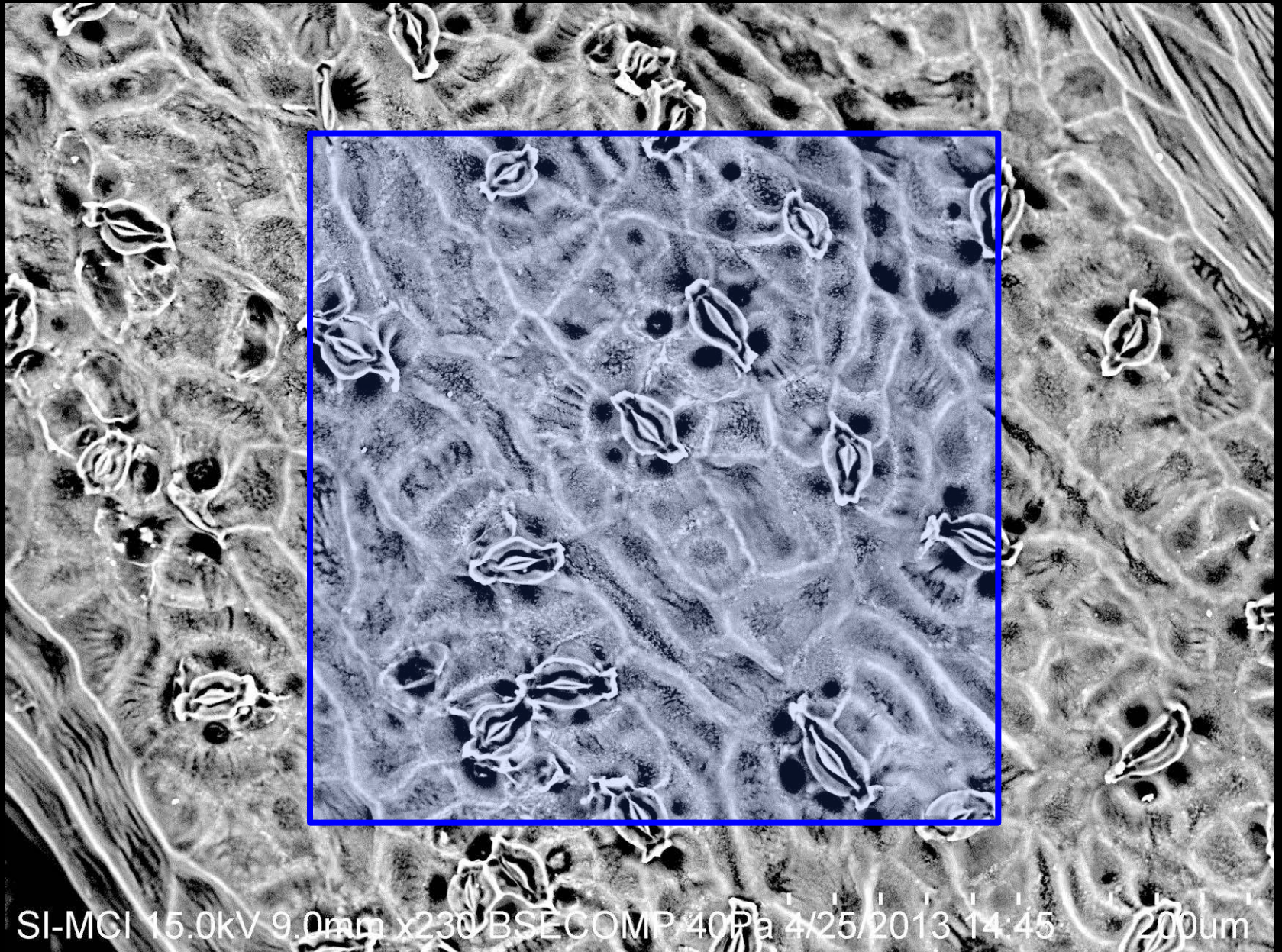


Ginkgo biloba
a “living fossil”

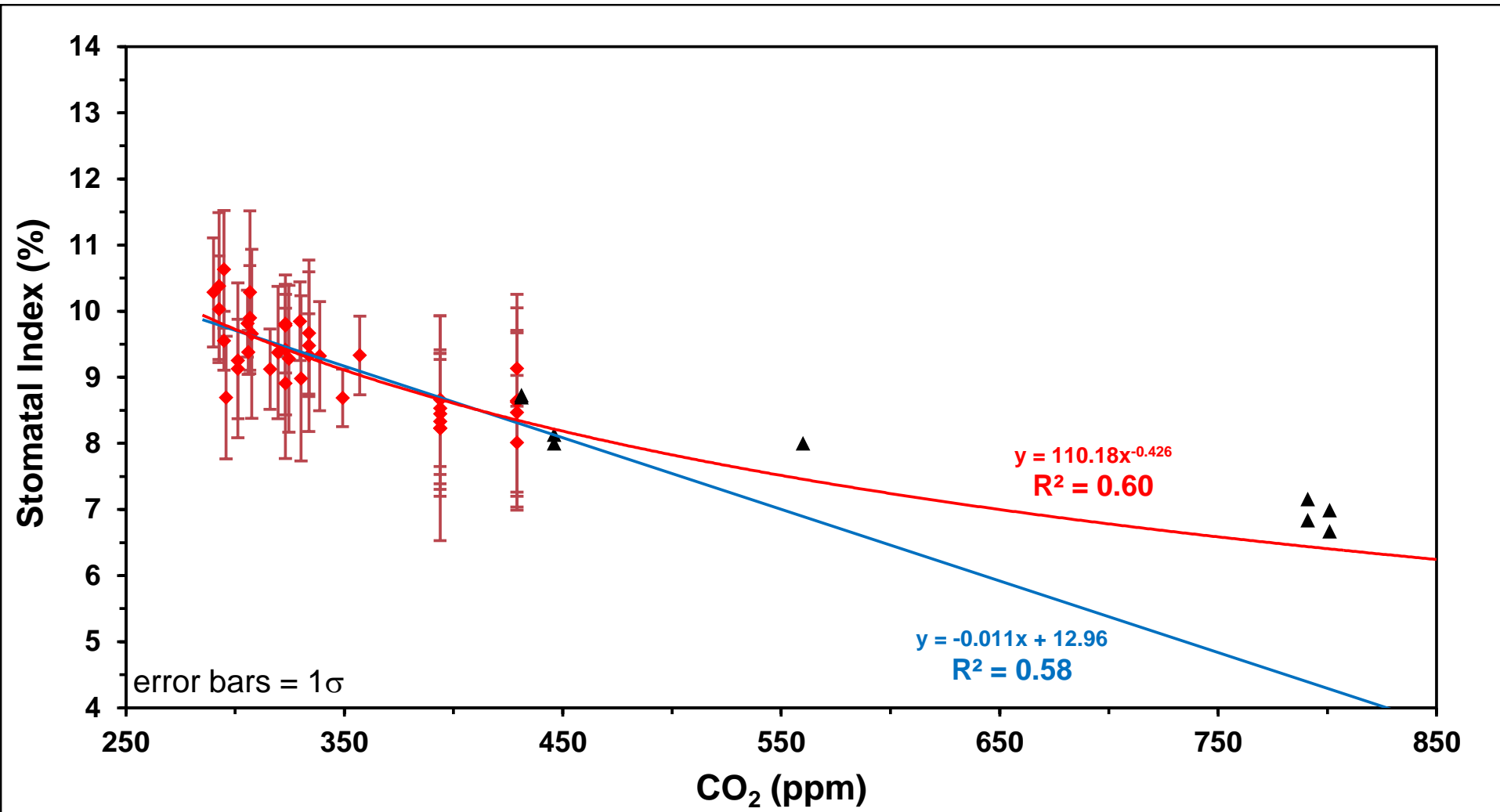


Ginkgo adiantoides
57 million years old

Ginkgo leaf surface



Stomatal Index vs. $p\text{CO}_2$ in *Ginkgo biloba*





Ginkgo adiantoides

56.1 million year old "mummified" leaf

