Paleoclimate and paleoelevation in the western US Cordillera, ~80 Ma to Present

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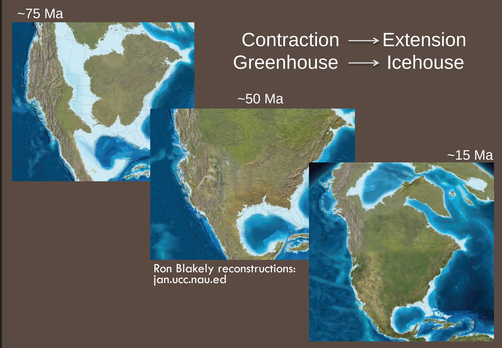
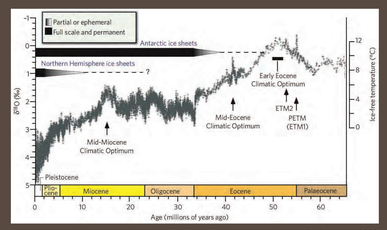
Scientific questions for a multi-proxy paleotemperature compilation: (paleobotany and clumped isotopes)

Terrestrial paleoclimate:
-Does the pattern of climate change on land match the marine record?
-What do terrestrial temperatures respond to globally warm conditions?
-What happens to seasonality temperature ranges on land at mid-latitudes during globally warm periods?

Paleoelevation:
-When did the cordillera achieve peak elevations?
-Did early-mid Cenozoic topography record slab rollback/mantle delamination/lower crustal flow?
-Did the western US maintain pre-existing topography until Miocene collapse?

Background:





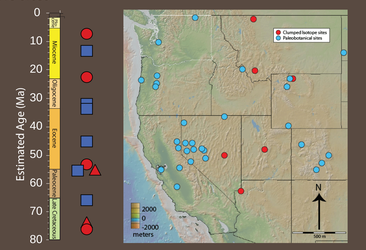
Zachos et al., 2008

-Despite years of study, quantitative paleotemperature and paleoelevation are still uncertain for the western Cordillera
-Our knowledge of climate change through the Cenozoic is based on the marine $\delta^{18}O$ record; we have no equivalent for the terrestrial record

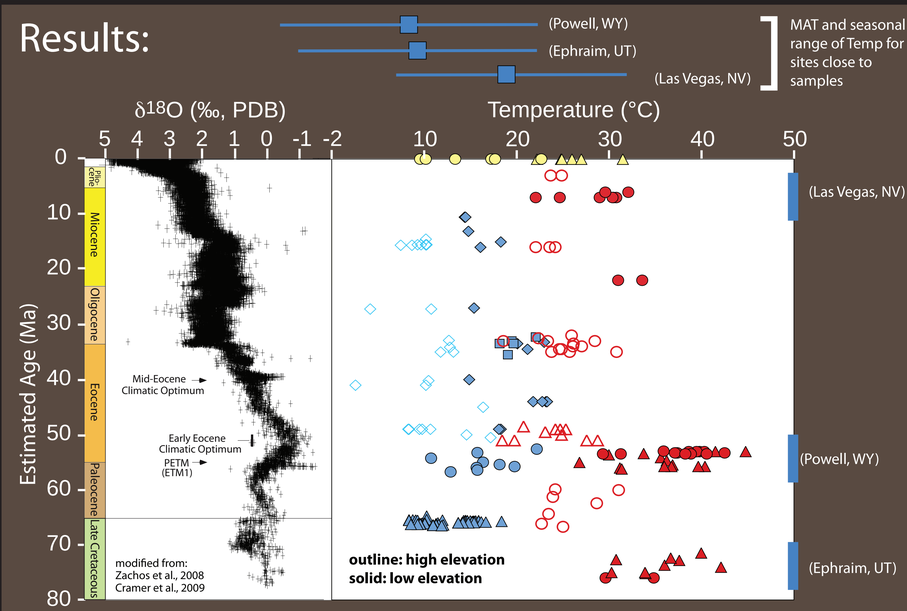
What we've done.....

Compiled paleobotanical and clumped isotope temperature data from the Late Cretaceous to the present
-From paleoclimate and paleoelevation studies

Binned data according to relative paleoelevation of the sites



Results:



Paleobotanical T
- Wolfe et al., 1997; 1998
- Wing et al., 2000; 2005
- Gregory-Wodzicki, 1997
- Wilf et al., 2003

Clumped T
- lacustrine carbonate
  Huntington et al., 2010
  Snell et al., in prep & new data
- Modern lacustrine carbonate
  (Huntington et al., 2010)
- Paleosol carbonate
  Snell et al., submitted
  Snell et al., in prep & new data
- Modern pedogenic carbonate
  (Passey et al., 2010)

General Conclusions

Paleobotany-based MAT and clumped isotopes appear to match the general trend of climate change through time

The Cordillera was high in the Late Cretaceous AND Early Eocene (and maybe early Oligocene?)
-What are elevations in the Paleocene?

Terrestrial paleotemperature compilation can discriminate between climatic and tectonic effects

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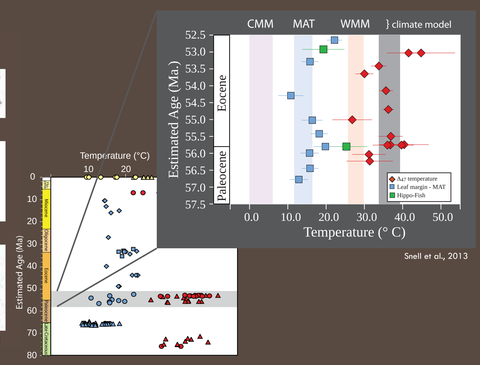
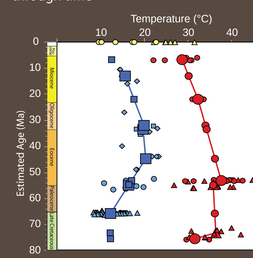
Acknowledgements:

We want to thank Brady Foreman and Jeff Thompson for providing samples, Nami Kitchen for assistance in the lab, Jay Quade and the Eiler lab for helpful discussions, and funding from the Gordon and Betty Moore Foundation, the National Science Foundation and the UC Santa Cruz Waters Award foundation.

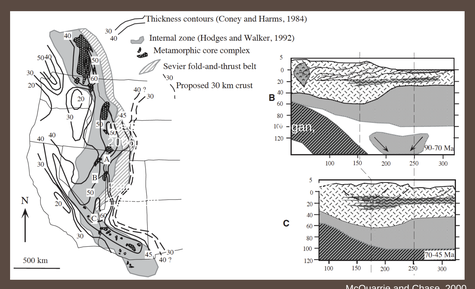
Terrestrial Seasonality: more "equable" during greenhouse climate conditions? Change through time?



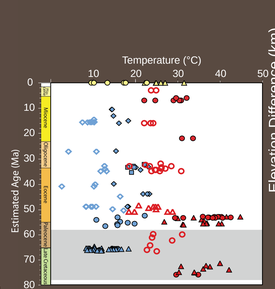
-Clumped isotopes generally reflect summer temperatures
-All seasons were warmer, but not more equable
-Paleobotany-based MAT and clumped isotopes appear to match the general trend of climate change through time

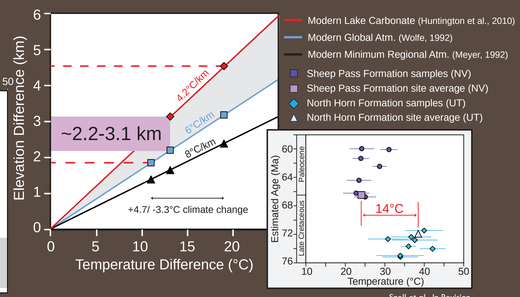


How high was central Nevada during the Late Cretaceous?



McQuarrie and Chase, 2000



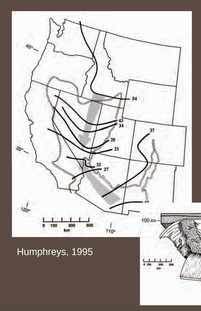


The Nevadaplano was likely 2-3 km high (at minimum) during the Late Cretaceous

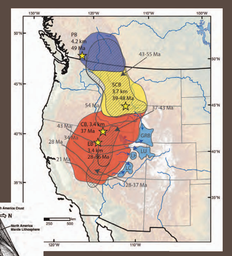
If the plateau had more relief than originally thought, then average elevation might be higher

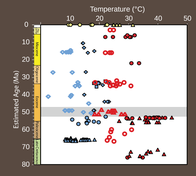
This datum is consistent with crustal thickness estimates and provides support for geodynamic models for Cenozoi tectonics events that require overthickened crust and high elevation as drivers

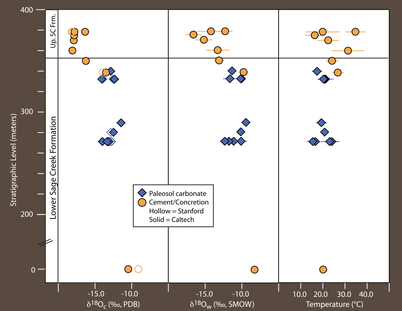
Can clumped isotopes provide new insight on traditional $\delta^{18}O$ studies? What were Paleogene elevations?



Humphreys, 1995







Clumped isotope temperatures show no change/slight warming, rather than a temperature drop (expect if uplift of the basin caused the d18Oc shift)

$\delta^{18}O_W$ shift reduces to ~3‰, rather than 5-7‰ as originally interpreted from the $\delta^{18}O_C$ record alone

Average temperatures overall are much cooler than ~contemporaneous samples from the nearby Bighorn Basin
-suggests higher relative elevation througout deposition of the Sage Creek Fm.