# Paleoclimate and Paleoelevation in the Western US Cordillera, ~80 Ma to Present

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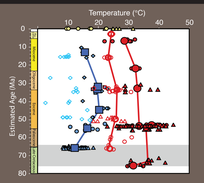
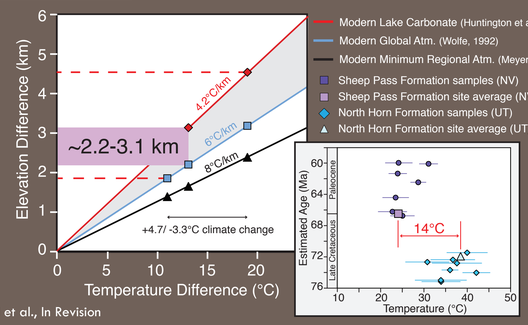



Late Cretaceous:
Central Nevada ~2-3 km




Snell et al., In Revision

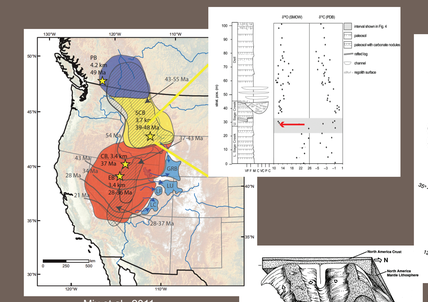
## When did the "Nevadaplano" achieve peak elevations?

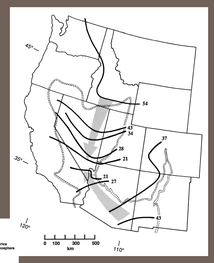
Traditional stable isotope paleoaltimetry suggests peak elevations of the Nevadaplano occured during the early Cenozoic and that prior elevations were not high

- -This assumes $\delta^{18}O$ shifts in carbonate reflect ~1:1 shifts in the $\delta^{18}O$ of water
- -Recent work suggests elevations were also high in the Late Cretaceous, however

How does temperature constraint affect the SWEEP hypothesis?
What does temperature constraint teach us about $\delta^{18}O$ of water?
How can we control for the effects of climate change on paleoelevation estimates from climate proxy data?

Paleocene-Oligocene
Northern US Cordillera: 3.4 - 4.2 km

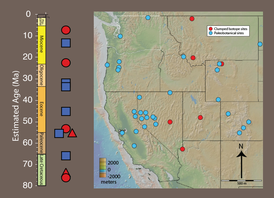


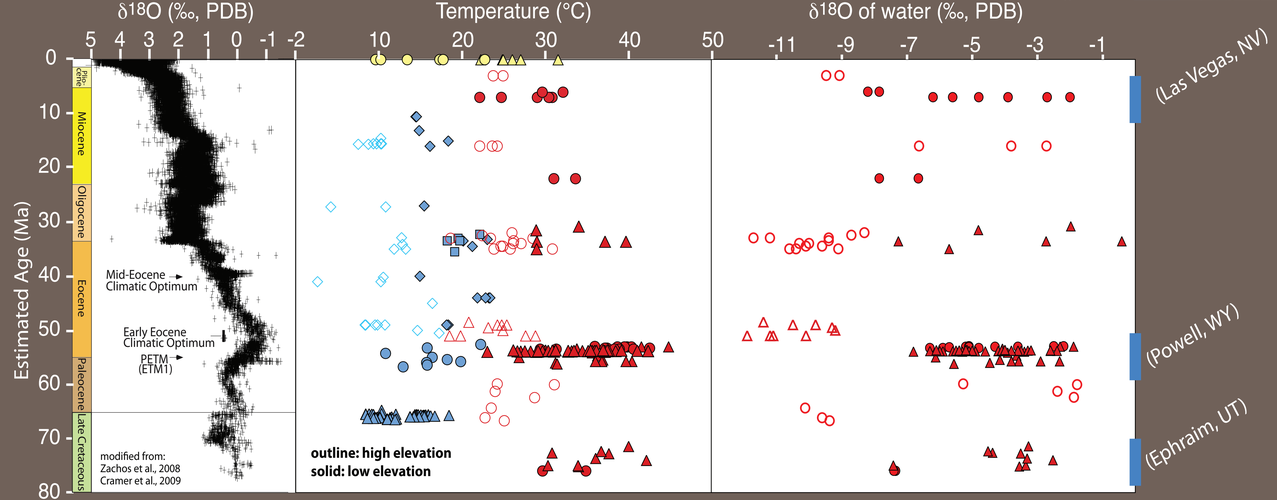




## Paleoclimate Framework and $\delta^{18}O$ of water

MAT and seasonal range of Temp for sites close to samples

- (Powell, WY)
- (Ephraim, UT)
- (Las Vegas, NV)




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

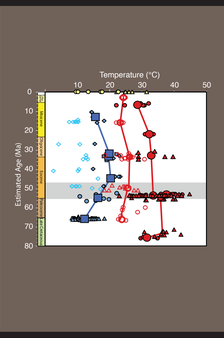
**Clumped T**
- lacustrine carbonate
  Huntington et al., 2010, Snell et al., In Review/new data
- Modern lacustrine carbonate
  (Huntington et al., 2010)
- Paleosol carbonate
  Snell et al., 2013, Snell et al., In Review/new data
- Modern pedogenic carbonate
  (Passey et al., 2010)

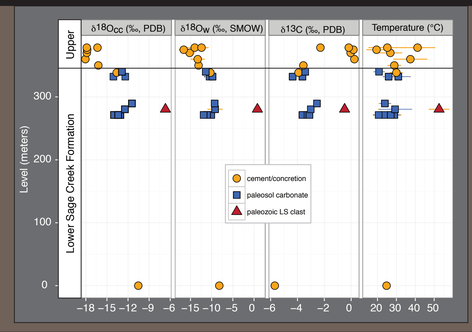
Paleobotany-based MAT and clumped isotopes appear to match the general trend of climate change through time

The $\delta^{18}O$ of water is more variable in lakes than in soils but with a larger spread overall after 40 Ma
-May be the result of increased aridification?

Most of the sites thought to be at high elevation (based on colder temperatures) also have low $\delta^{18}O$ values

## How does temperature constraint affect the SWEEP hypothesis?



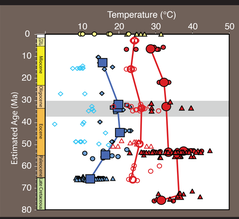

Clumped isotope temperatures show no cooling
-expect temperature drop if the basin was uplifted

$\delta^{18}O_W$ shift to lower values of ~3-5‰
-could indicate a change in the relief structure of the regio
-could include basin down drop and/or no change in mean elevation

Shift is restricted to carbonate cements/concretions
-NOT in carbonate nodules
-harder to be certain of origin /meaning of the d18O values

Average temperatures of the nodules are cooler than ~contemporaneous samples from the nearby Bighorn Basin
-Lapses rate of ~4-6°C suggest an elevation difference between the two sites of ~2.5-1.7 km.

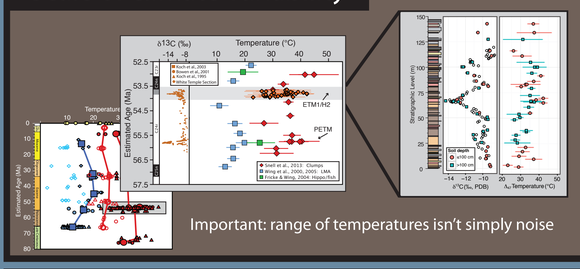
## Further work: House Range




Clumped isotope temperatures from the House Range in central Utah are cooler than temperatures from the Great Plains
-need more data from the Great Plains

Lapses rate of ~4-6°C suggest an elevation difference between the two sites of ~1.7-1.1 km.

## Scale of climate variability




Important: range of temperatures isn't simply noise

## General Conclusions

The Cordillera was high in the Late Cretaceous
-What are elevations in the Paleocene?

Temperatures suggest the Early Eocene was similar to lightly lower than Late Cretaceous
-If cements reflect depositional conditions, $\delta^{18}O$ may reflect relief changes or changes in moisture source or trajectories
-Doesn't rule out slab rollback, but no strong evidence for it from isotopic data

Preliminary data suggest slightly lower elevation into the Oligocene

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