Glaciation of western United States….

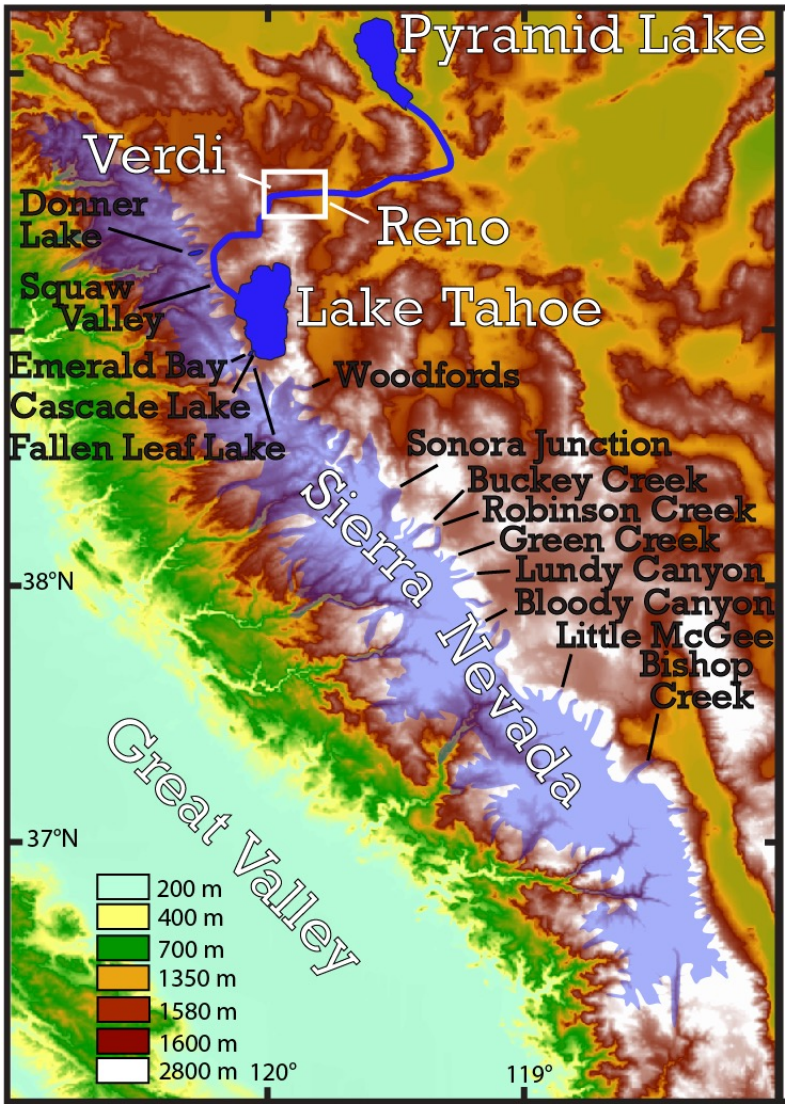
- How do we know where? And how do we know when?

Martinson, M.D. et al., 1987. Age dating and the orbital theorey of the ice ages: development of a high-resolution 0 to 3000,000 year chronostratigraphy. Quaternary Research, 27: 1-29

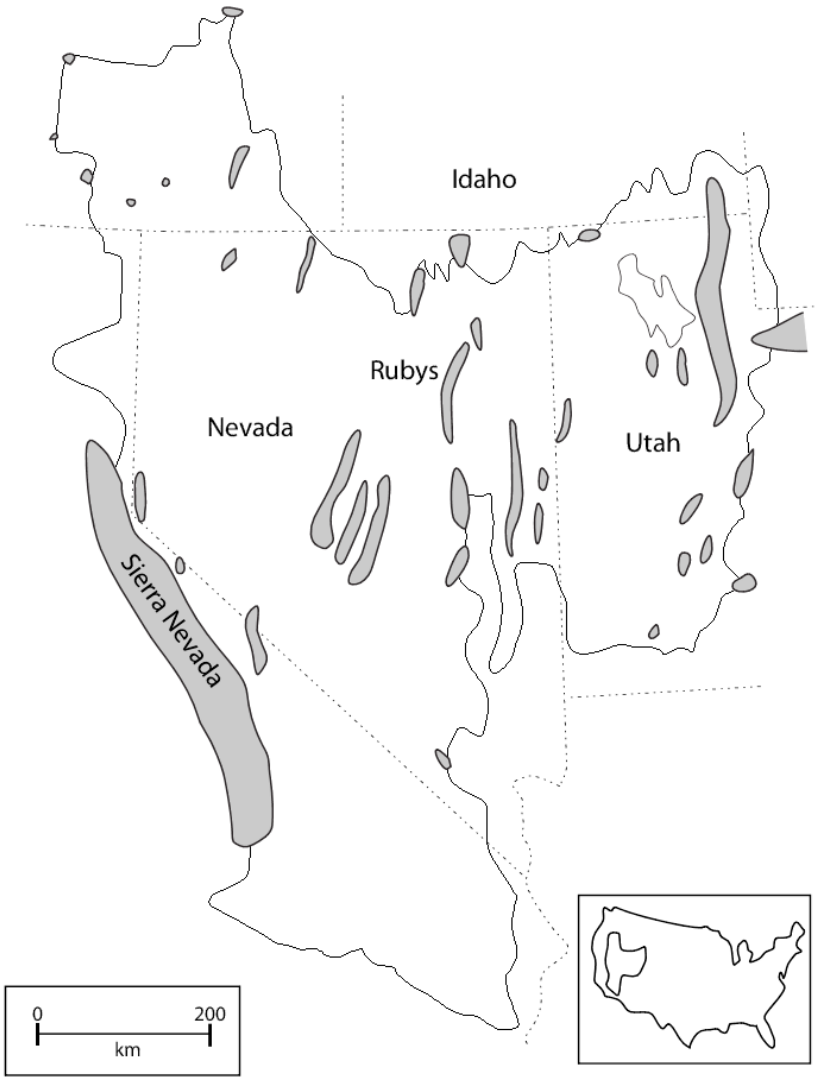
Mudelsee, M., T. Bickert, C. H. Lear, and G. Lohmann, 2014, Cenozoic climate changes: A review

Gosse, J. and Phillips, F., 2001, Terrestrial in situ cosmogenic nuclides: theory and application, Quaternary Science Reviews, 1465-1560

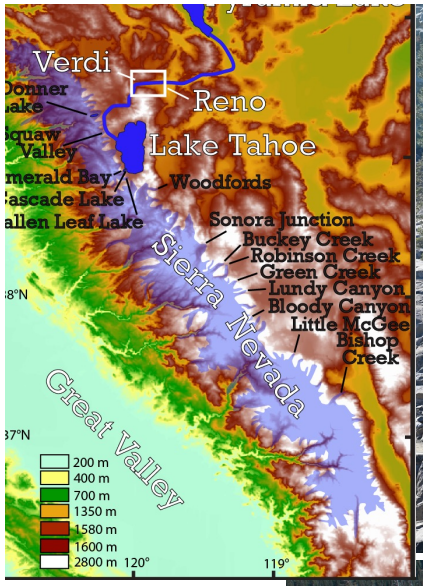
Glaciation in the Great Basin of the western United States. Quaternary Science Reviews, 13: 1377-1410.



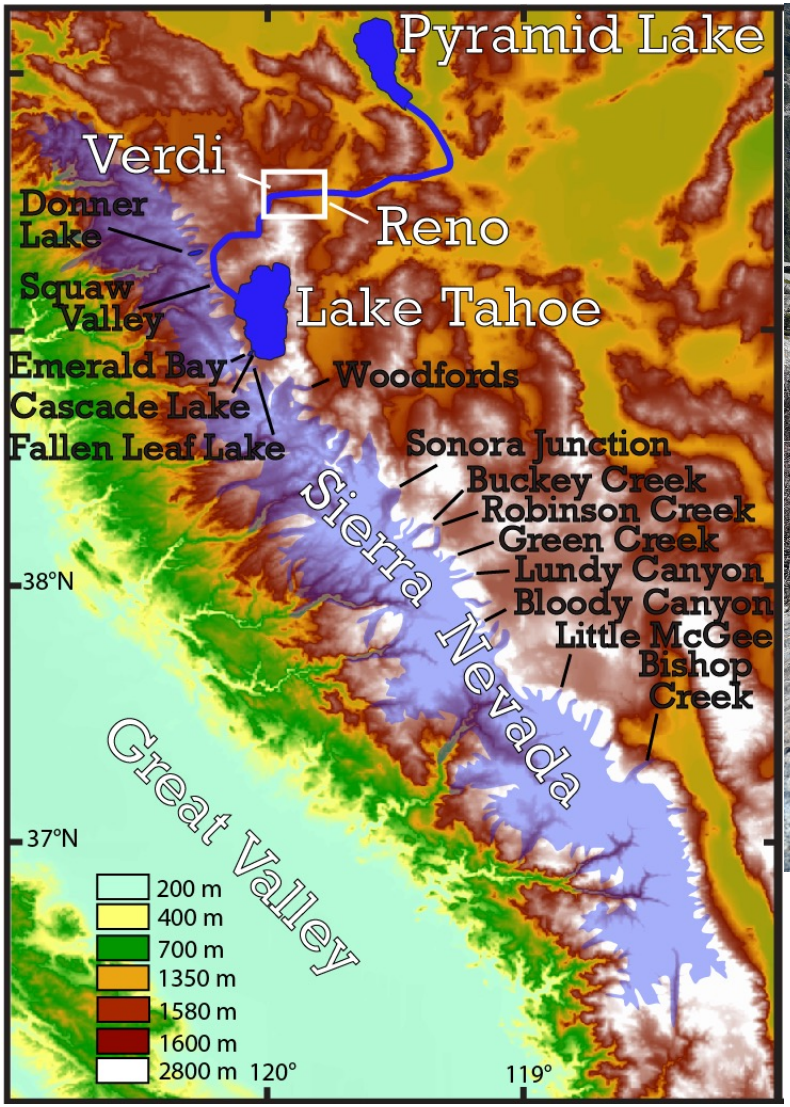
Wesnousky & Owen 2020



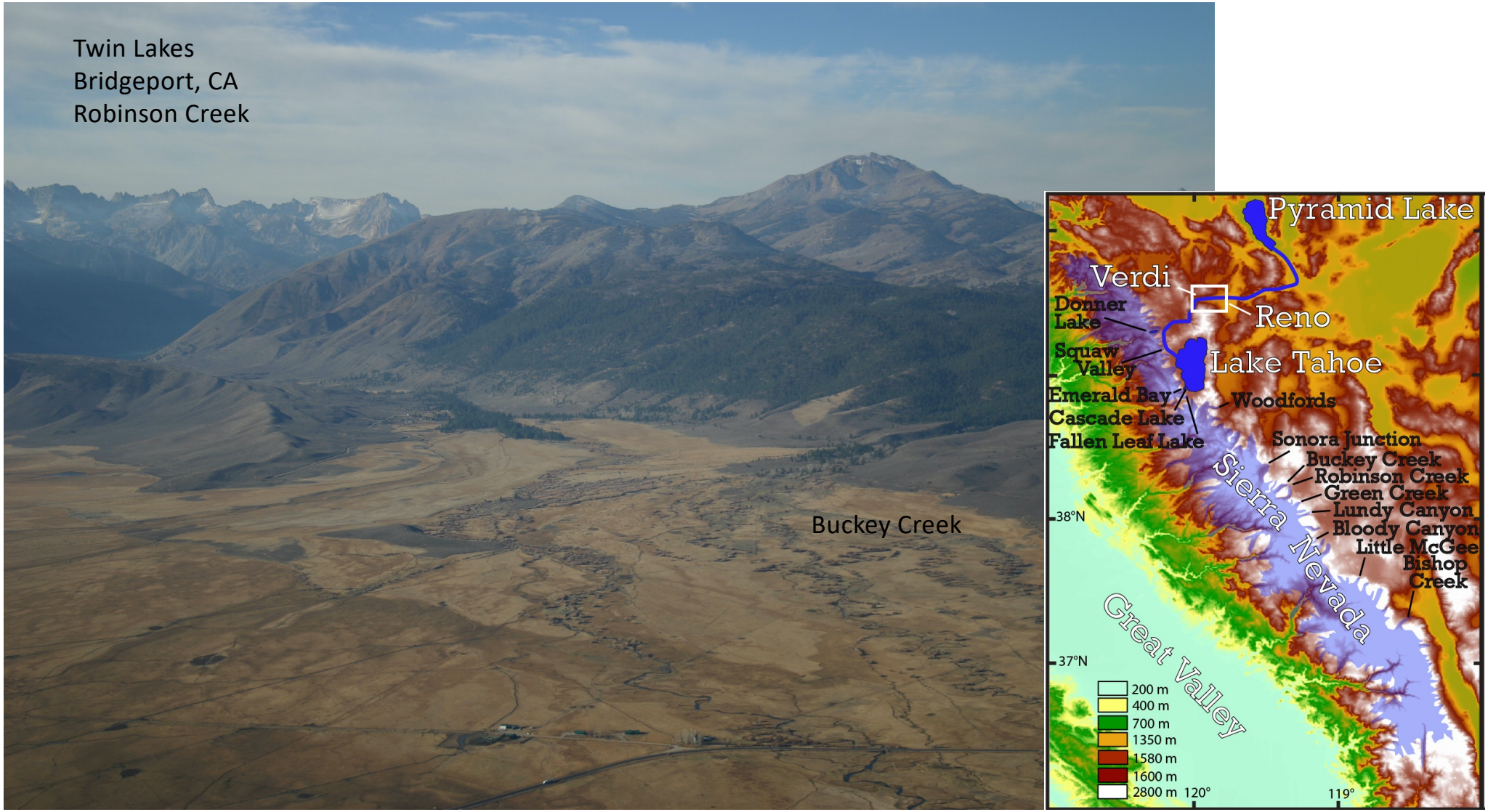
Osborne & Bevis 2001

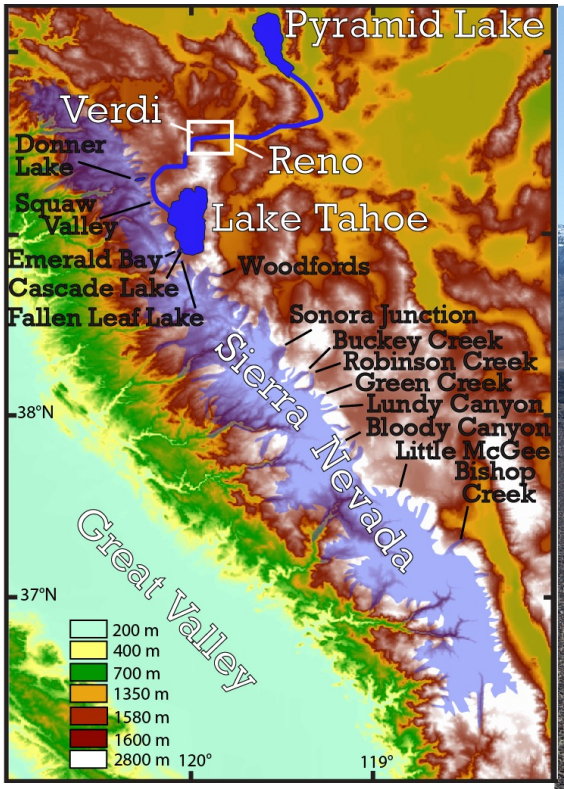


Polished, scoured, bedrock and glacial eratics….

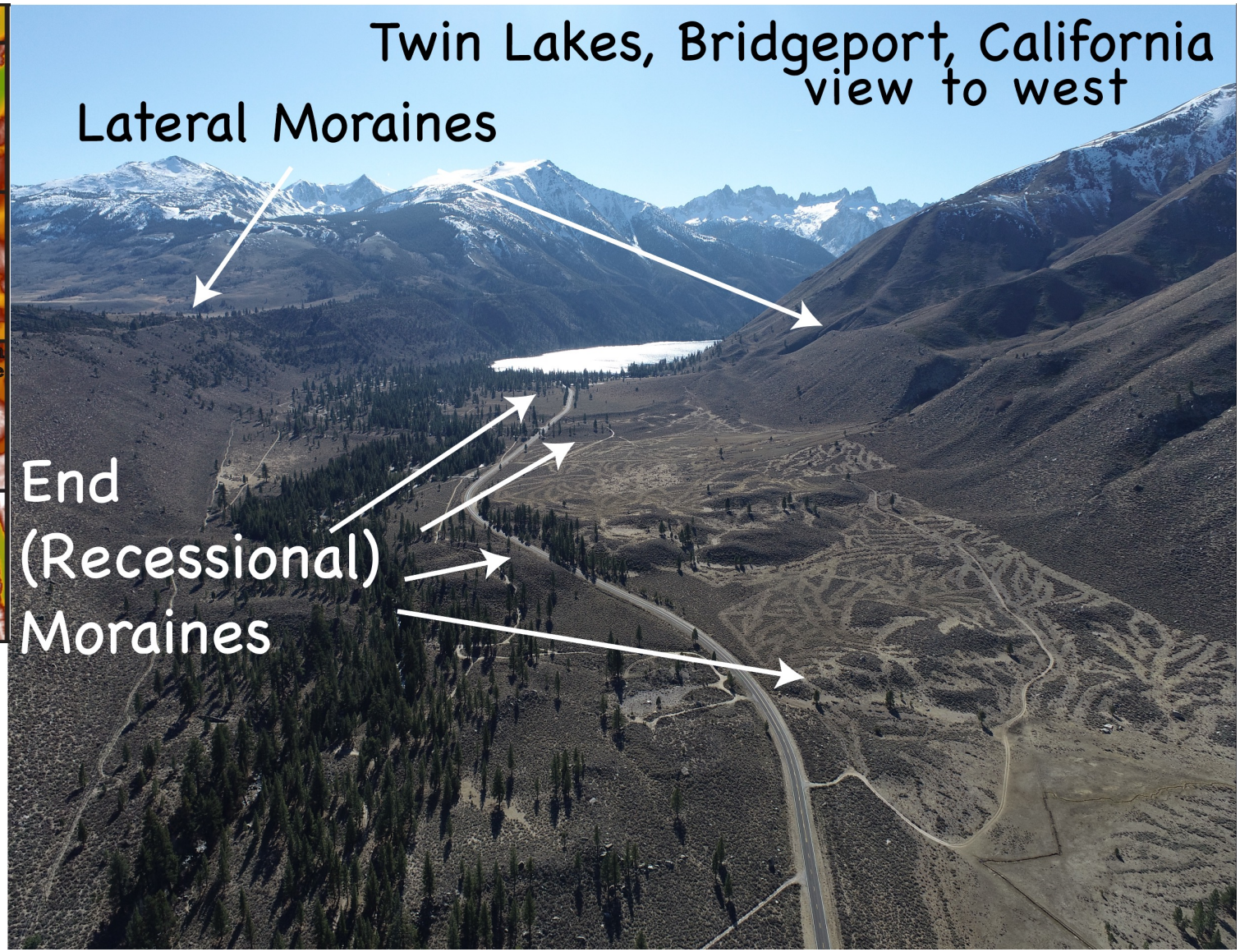


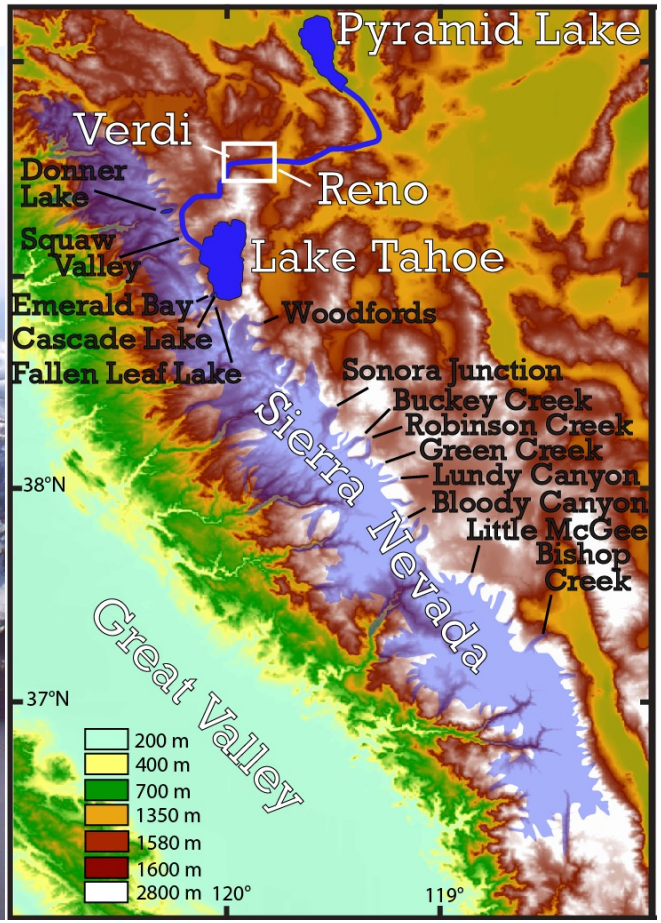
Donner Lake – view east from old hwy 50 overlook


Twin Lakes
Bridgeport, CA
Robinson Creek
Buckey Creek
Pyramid Lake
Verdi
Donner Lake
Reno
Squaw Valley
Lake Tahoe
Emerald Bay
Cascade Lake
Fallen Leaf Lake
Woodfords
Sonora Junction
Buckey Creek
Robinson Creek
Green Creek
Lundy Canyon
Bloody Canyon
Little McGee
Bishop Creek
Sierra Nevada
Great Valley
38°N
37°N
120°
119°
200 m
400 m
700 m
1350 m
1580 m
1600 m
2800 m

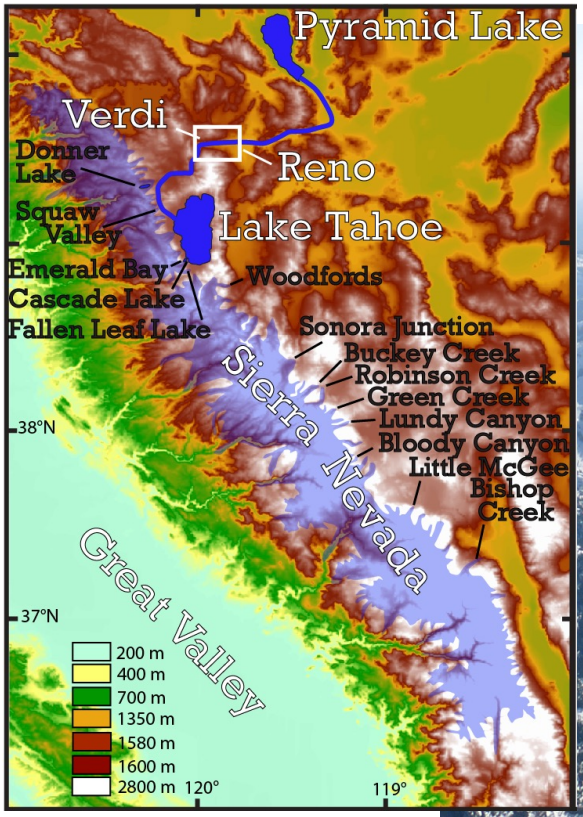


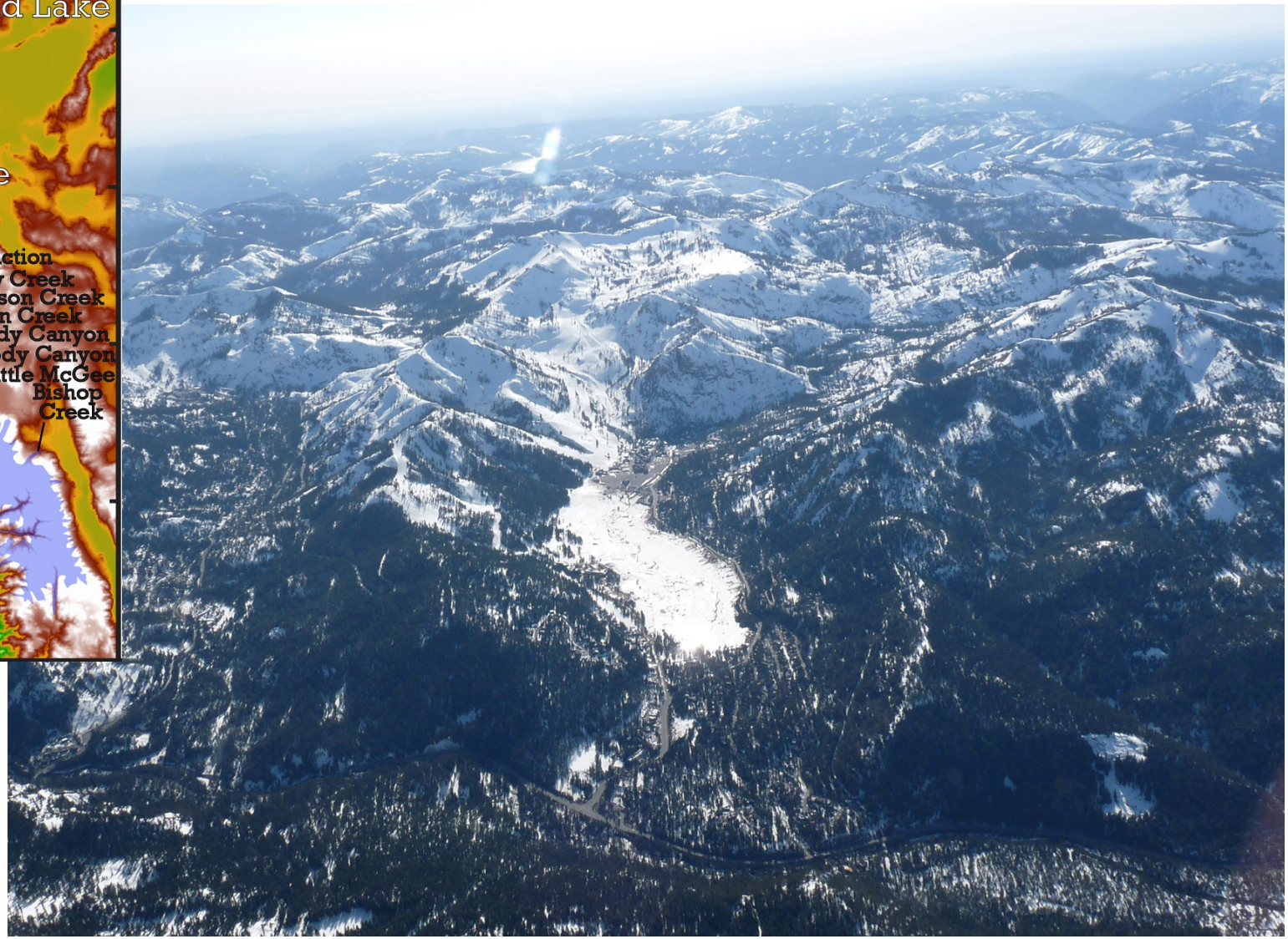
Robinson Creek



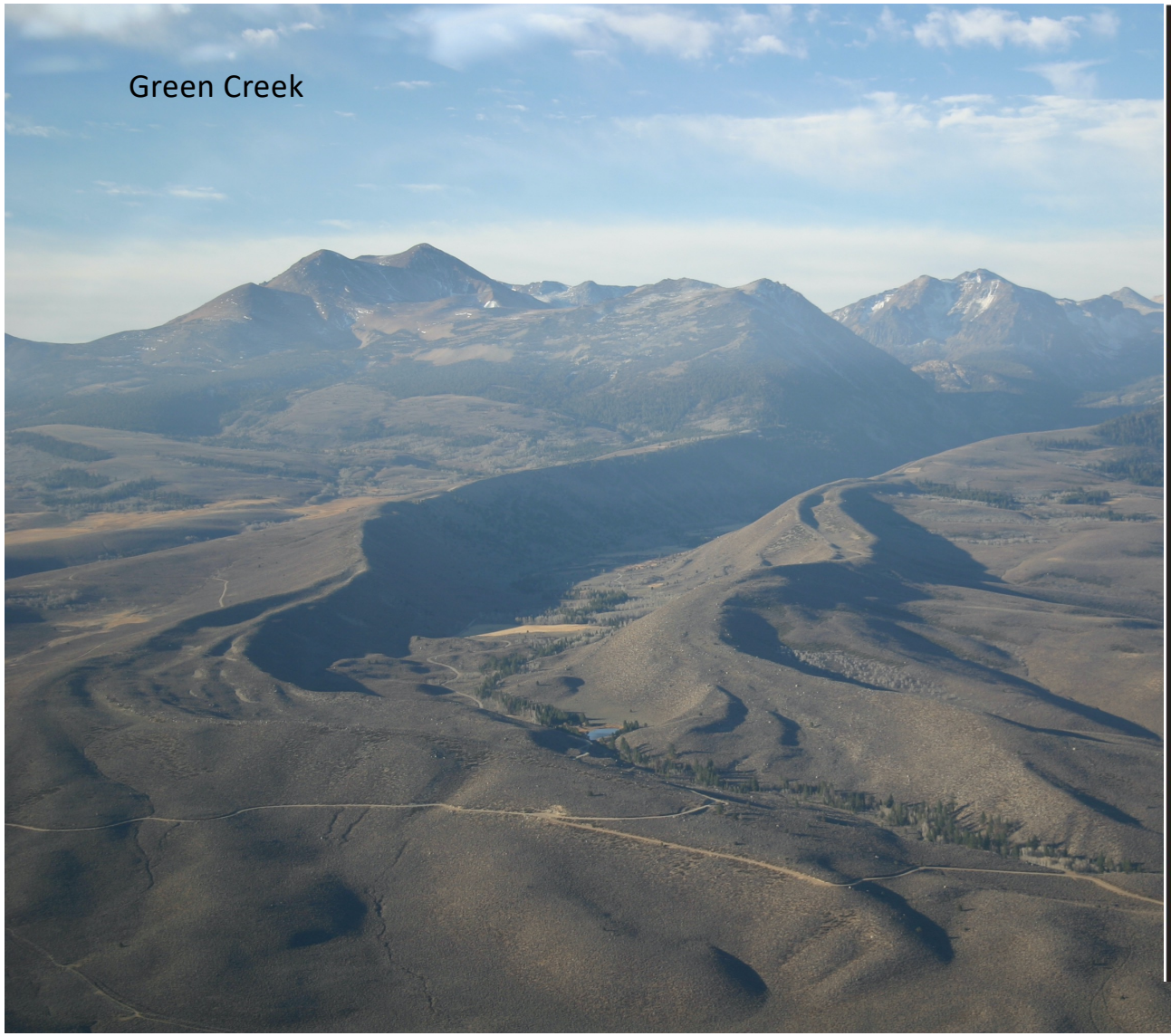


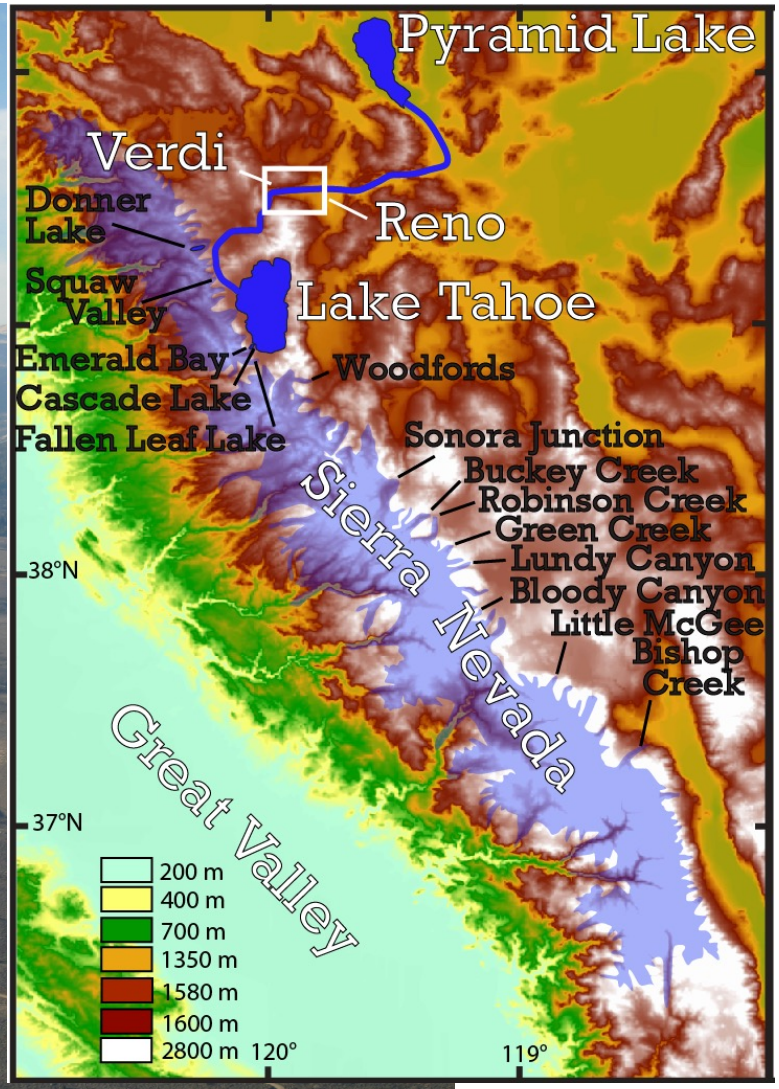
Moraine bounded lakes – South Tahoe





~~Squaw~~ Valley


Green Creek


Pyramid Lake
Verdi
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Buckey Creek
Robinson Creek
Green Creek
Lundy Canyon
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38°N
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200 m
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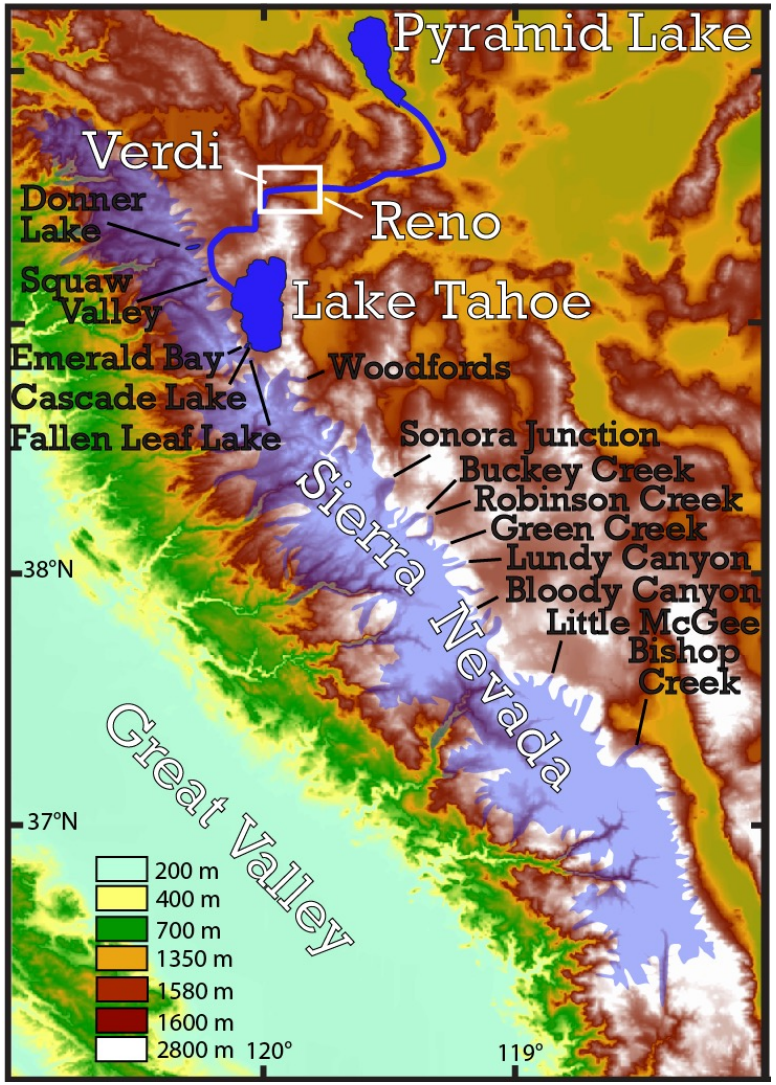
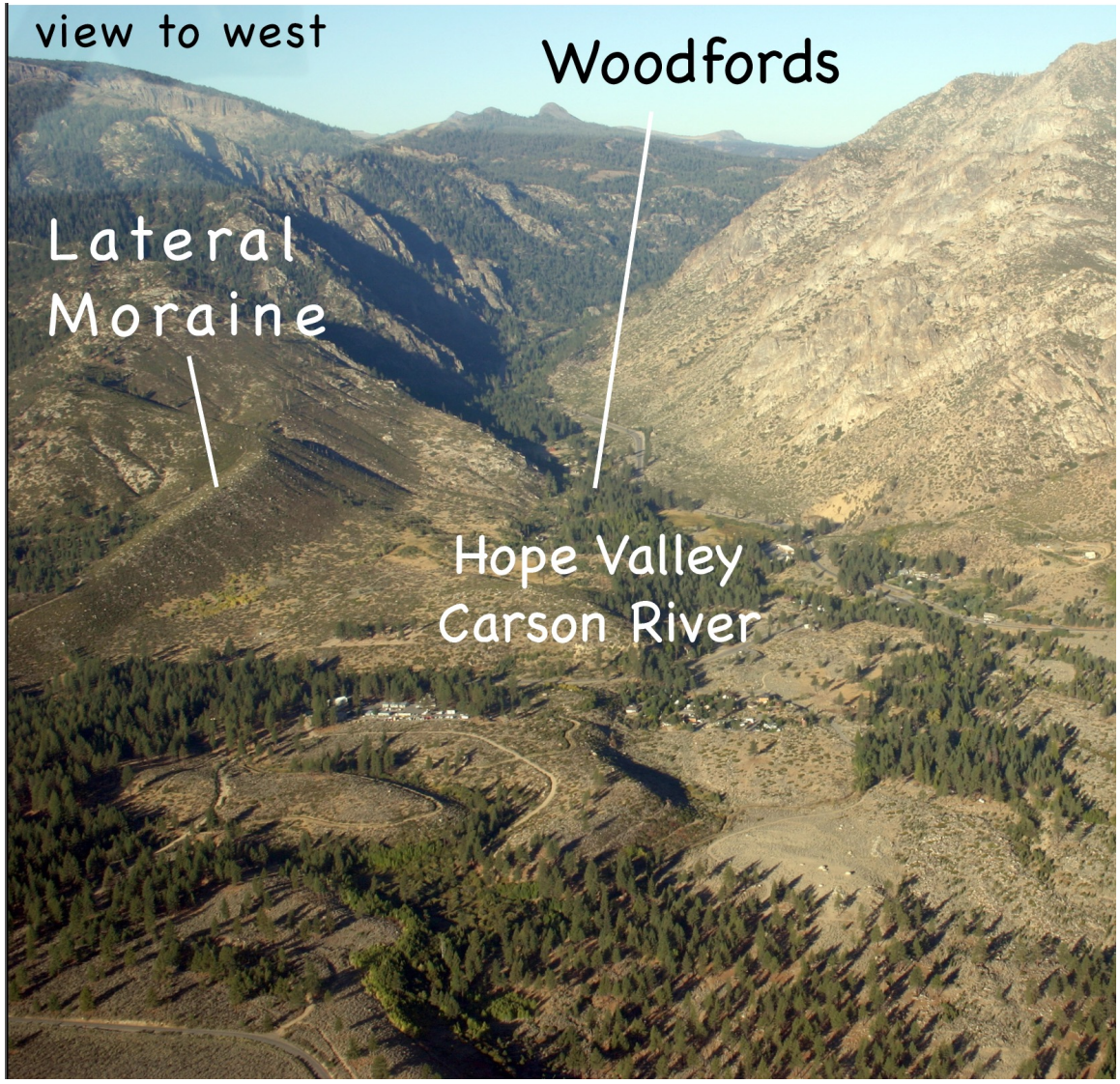
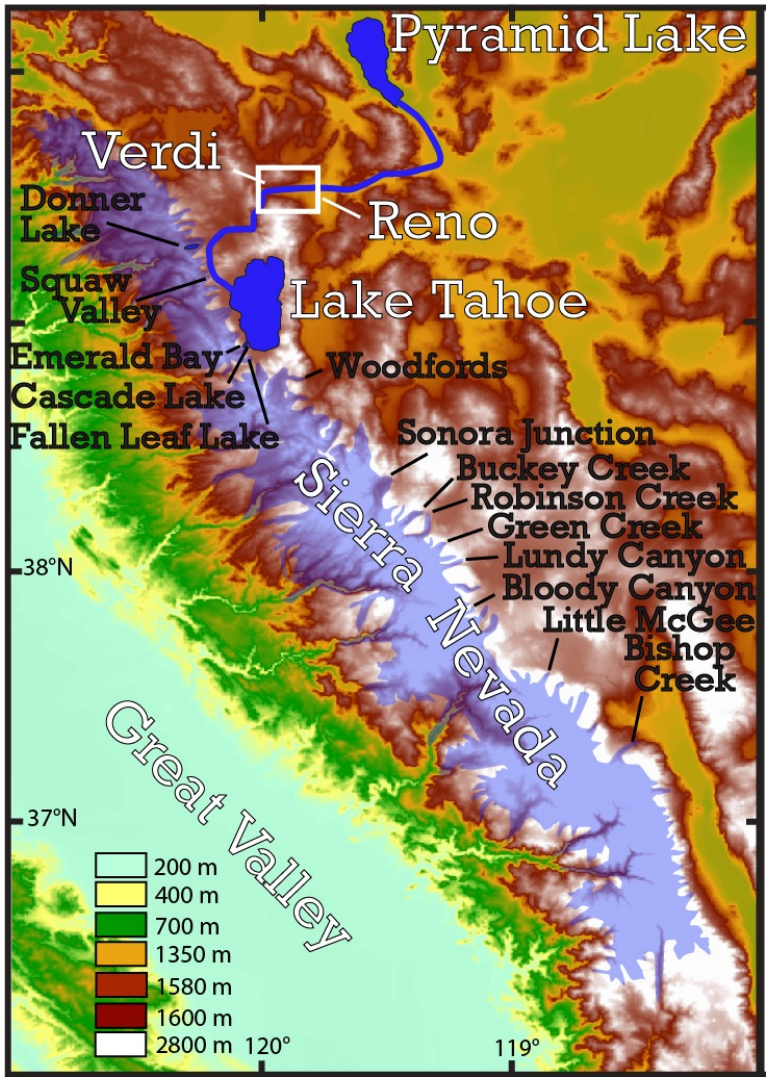
2800 m

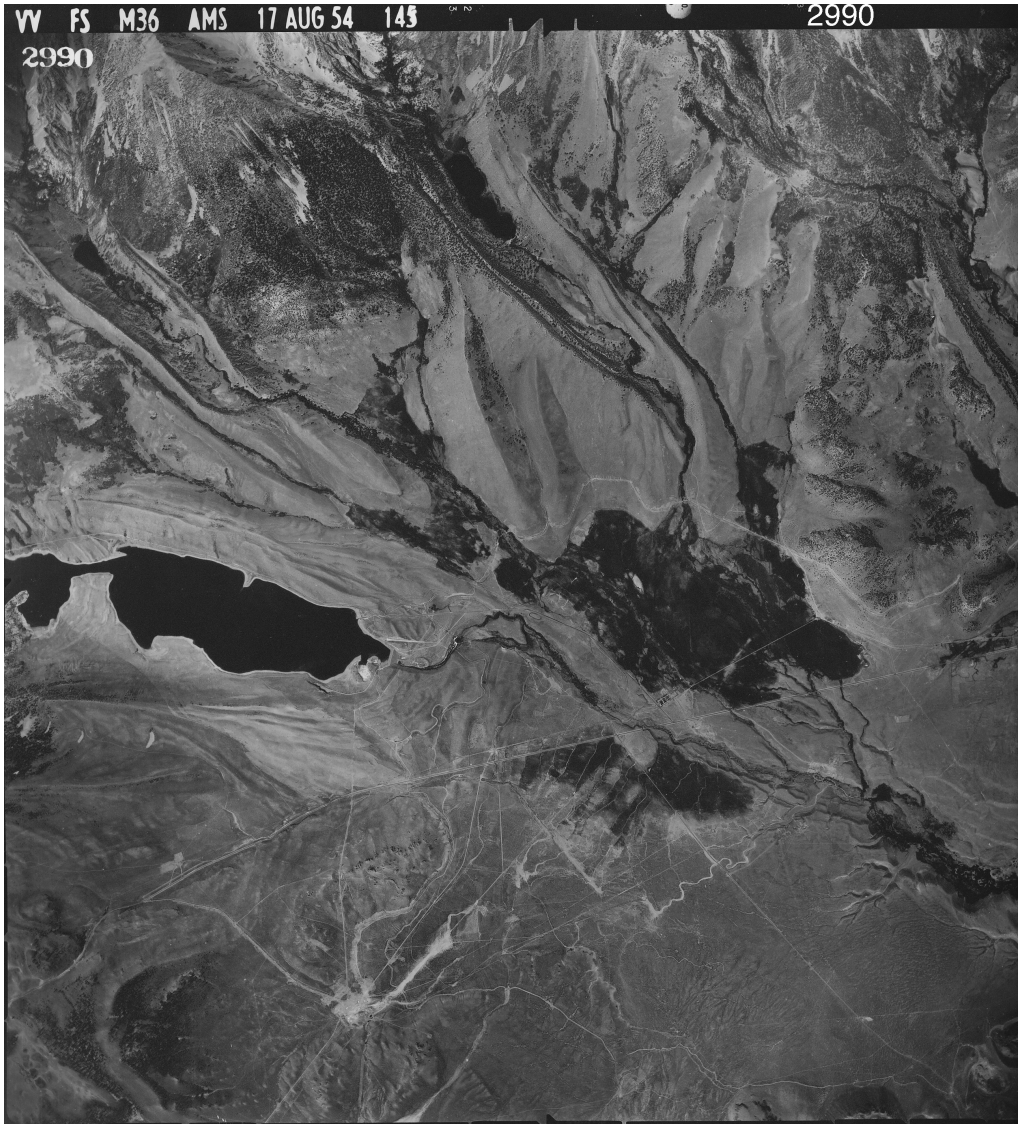


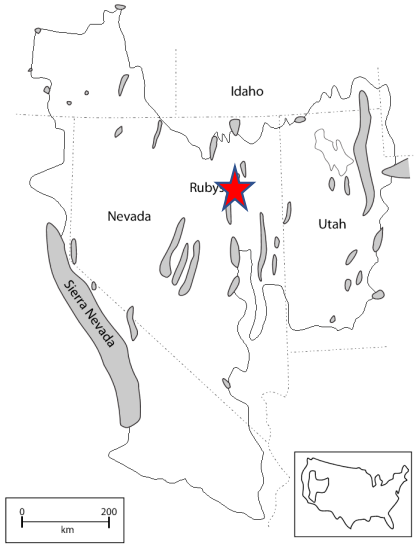


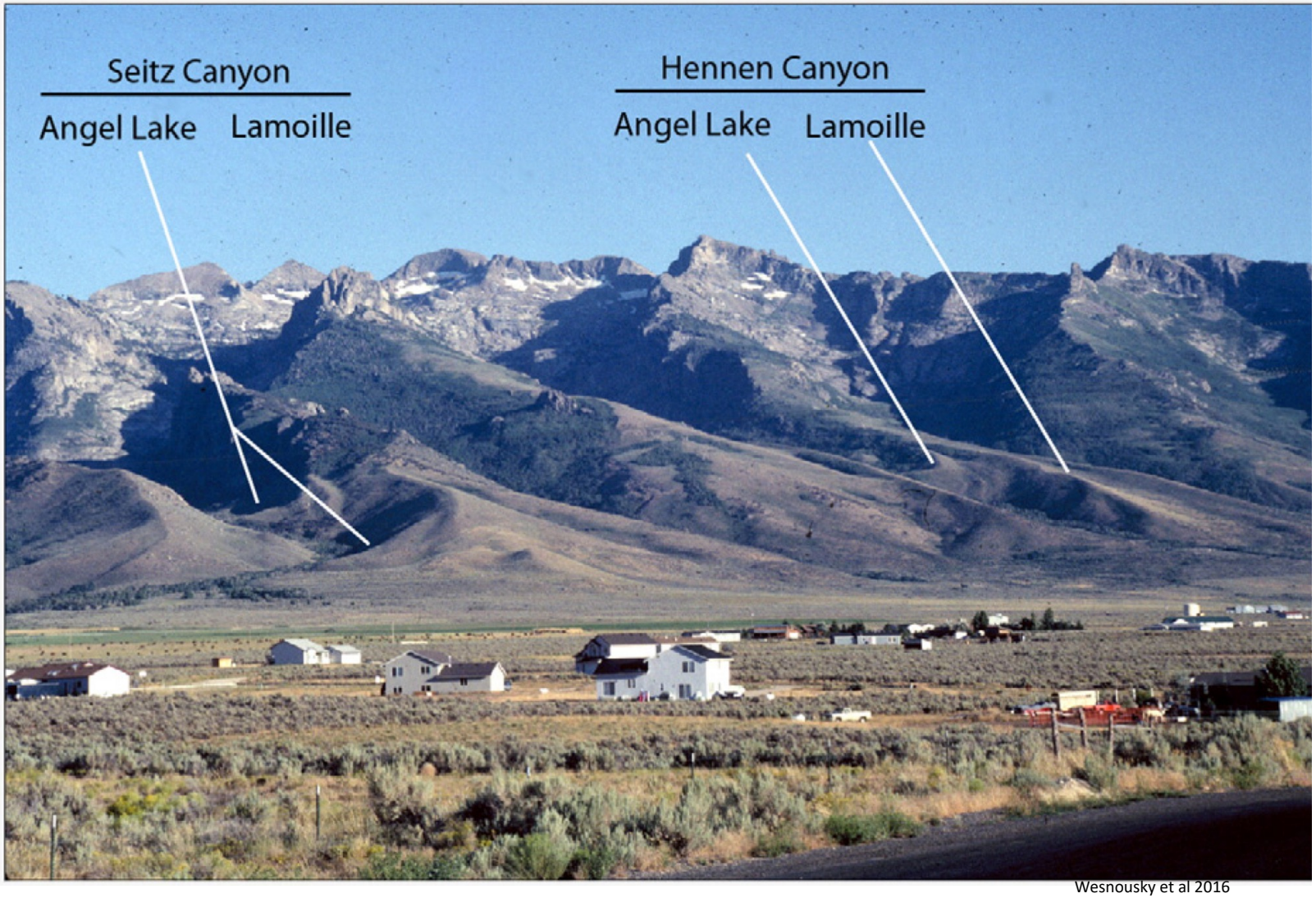
Wesnousky, S.G., R. W. Briggs, M. Caffee, R. Ryerson, R. Finkel, and L. A. Owen (2016). Glaciation in the Great Basin of the western United States. Quaternary Science Reviews, 13: 1377-1410.



Bloody Canyon





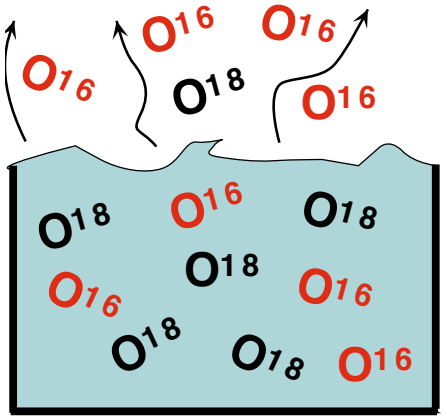


Wesnousky et al 2016

Past Climates and Dating Techniques

Two Isotopes of Oxygen

O^{18} heavier than O^{16}



With Evaporation

Water Vapor diluted in isotope O^{18}

Ocean more concentrated in the heavier isotope O^{18}

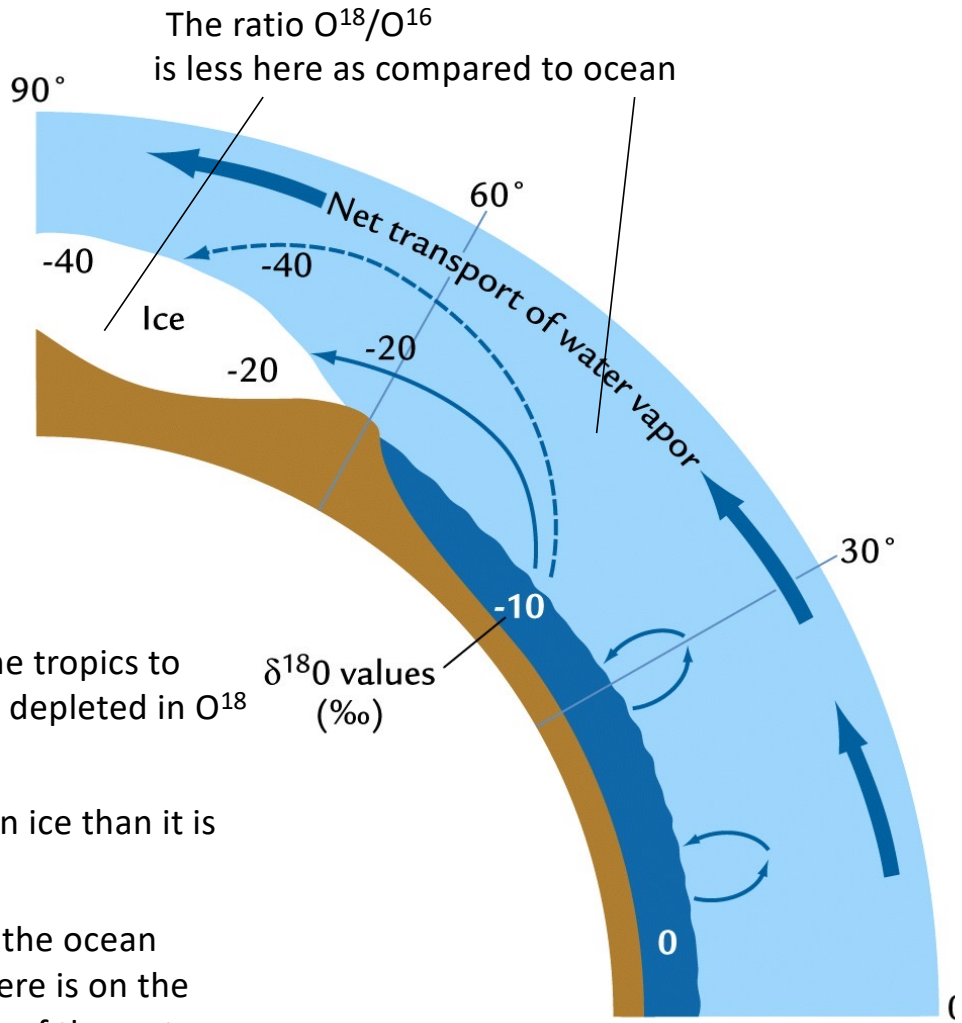
Each O^{18} and O^{16} are stable isotopes - there are on average 400 0^{16}'s for each O^{18} in atmosphere..

How do we know when it was colder - quantitatively?

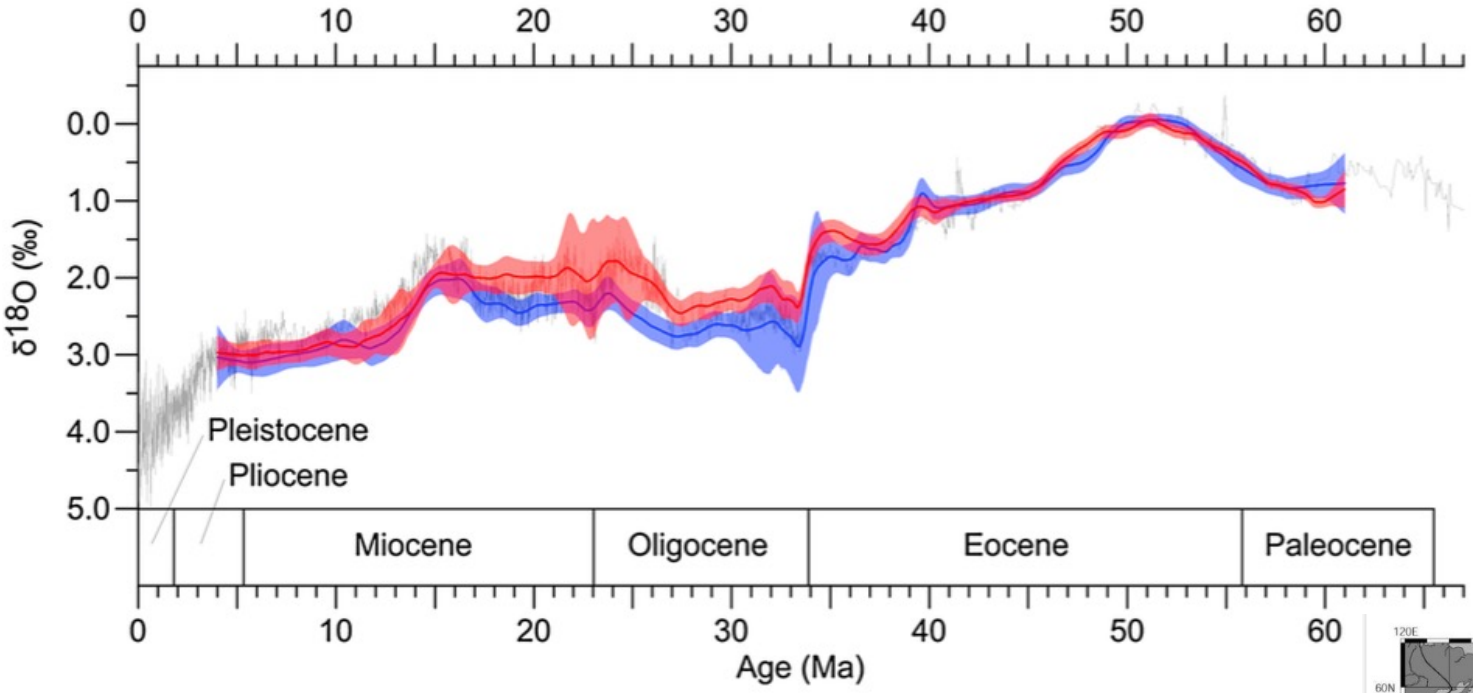
As water vapor moves from the tropics to high latitudes, it is continually depleted in O^{18} relative to O^{16} -

So the ratio of O^{18}/O^{16} is less in ice than it is in oceans…

… and the ratio will change in the ocean according to how much ice there is on the planet… (and the temperature of the water too)

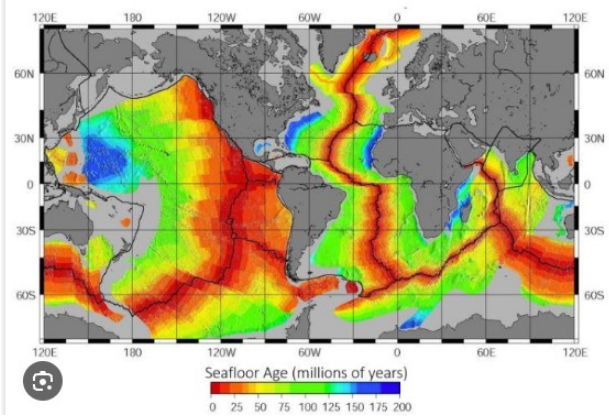


Record of delta^{18}O measured marine benthic foraminifera and shells – a ‘proxy’ for ocean temperatures



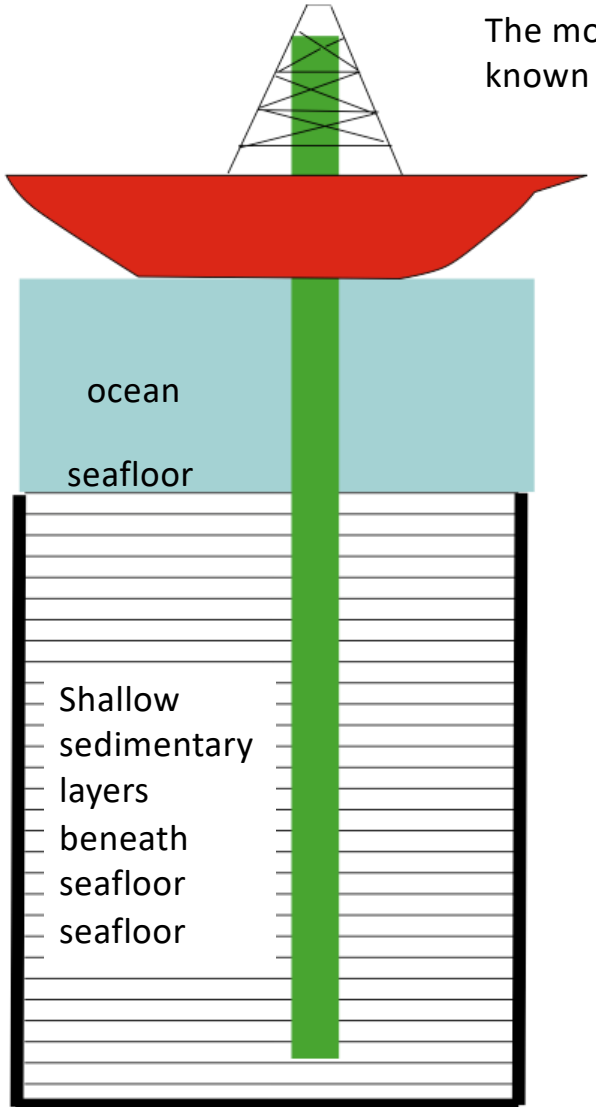
Downward trend reflects cooling climate since Paleocene-Eocene time ~50-60 Ma

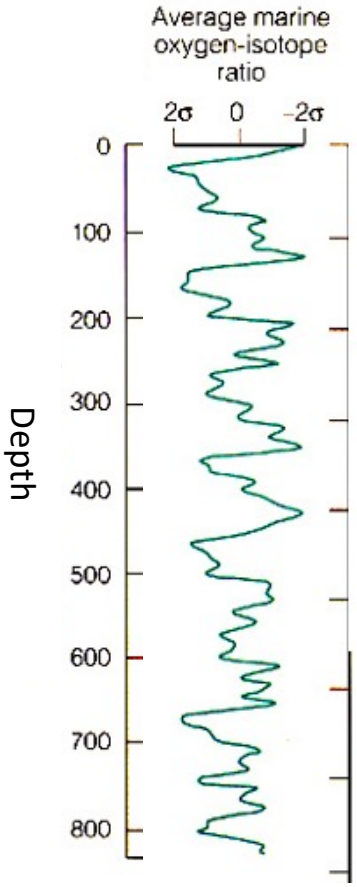
And then significant downward trend in last 2-3 m.a – the ‘ice ages’…



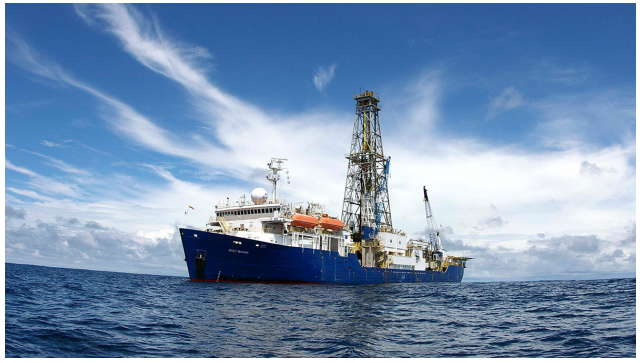
Mudalese et al. 2015

The more recent history of the climate history (i.e. delta0^{18} record) is more accurately known with sampling of sedimentary layers that have accumulated on the seafloor

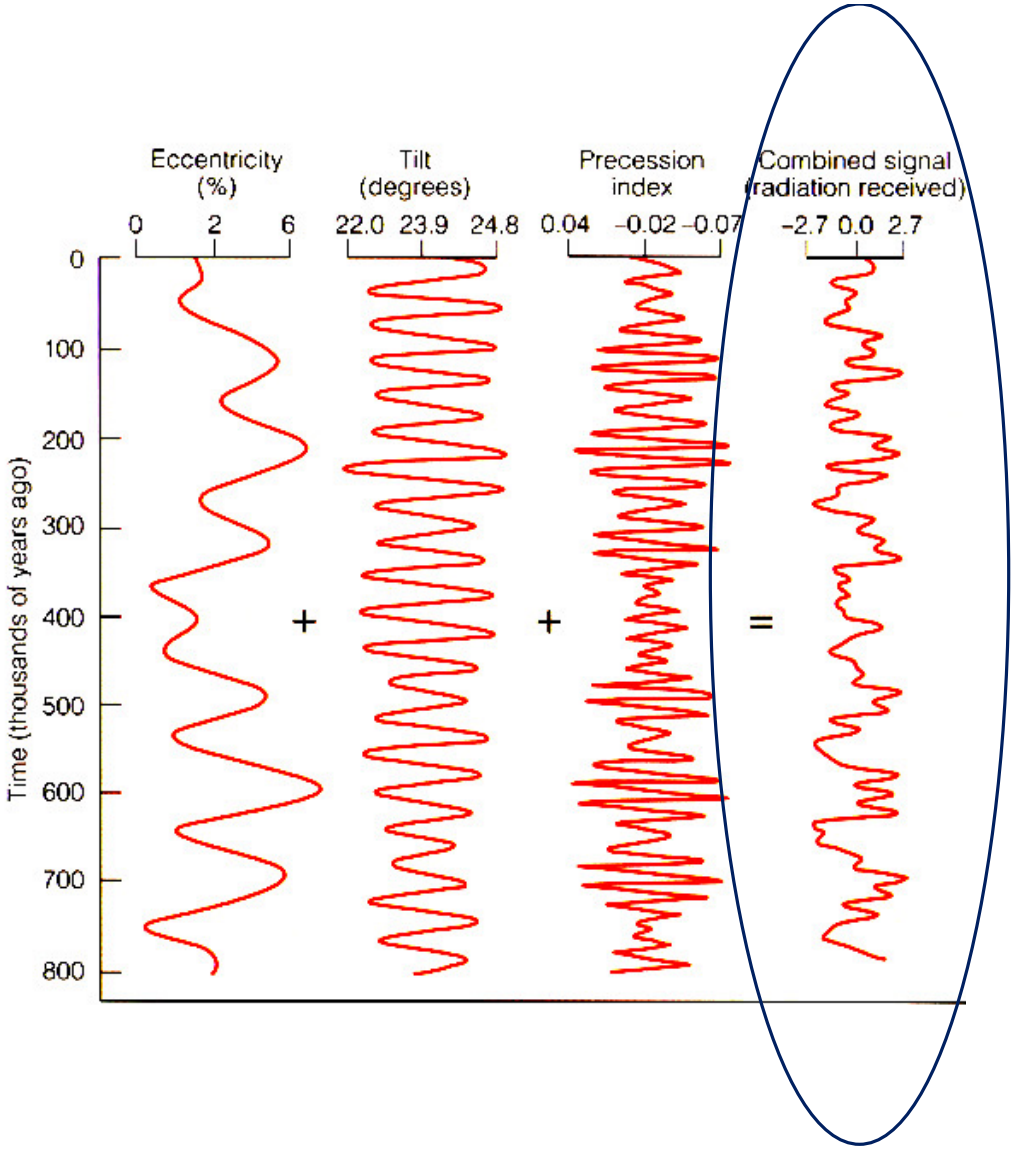


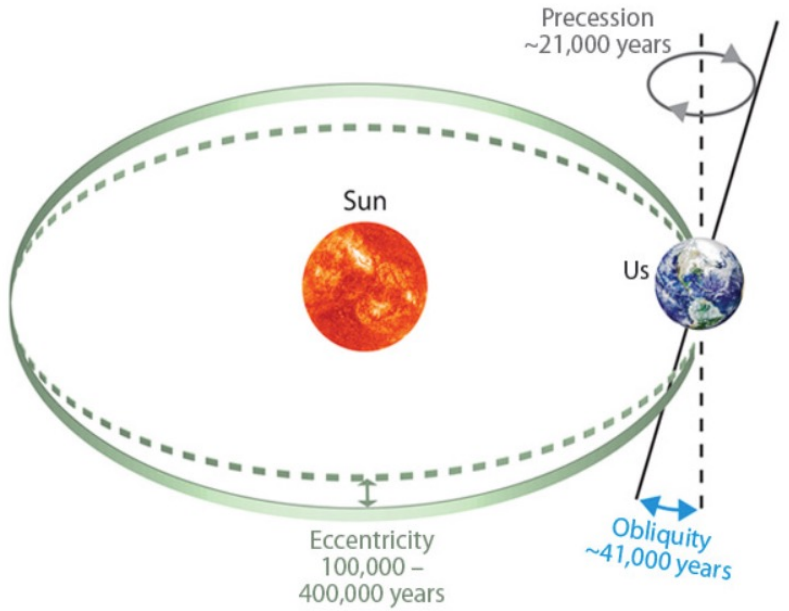


Joides Resolution – since 1978 – this year being decommissioned – more than 200 miles of core



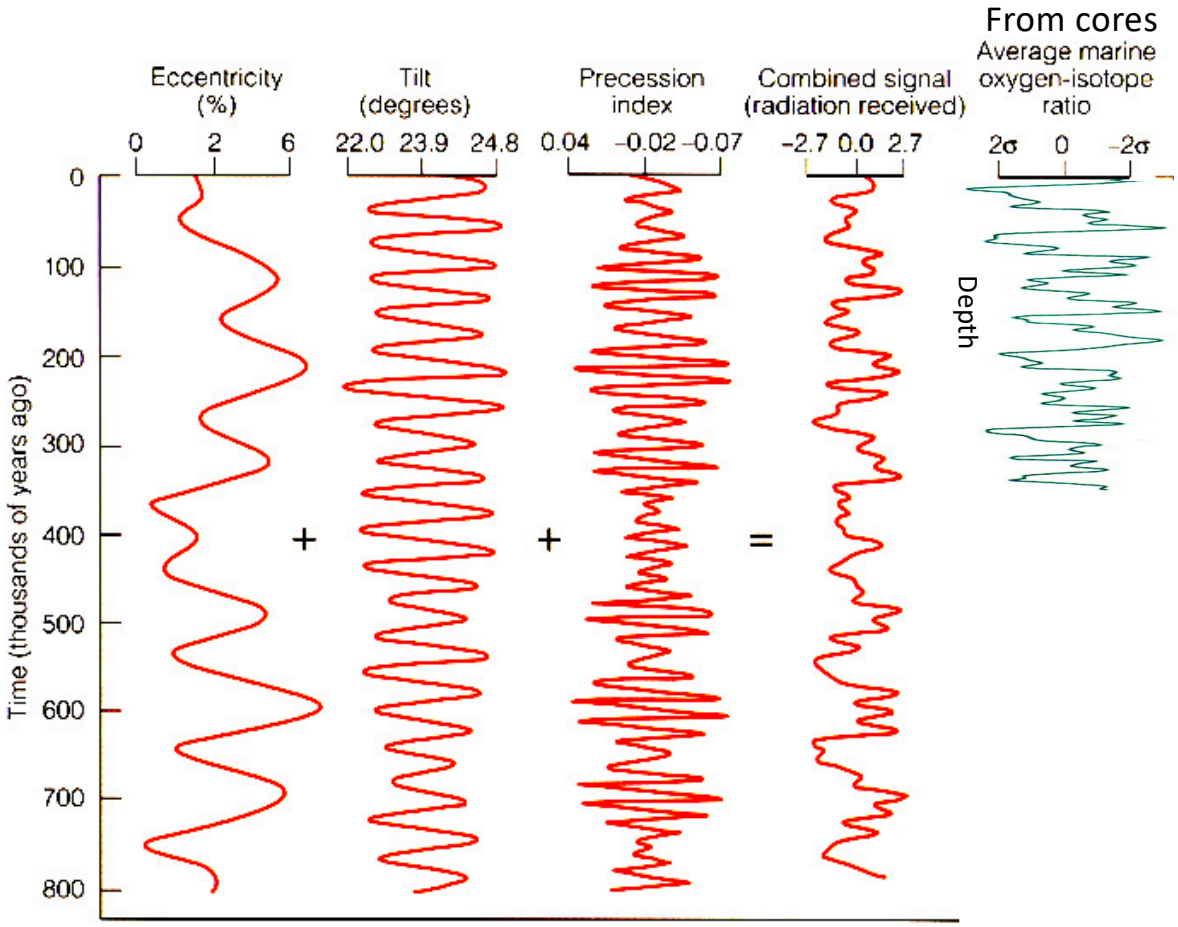
Milankovitch's Cycles



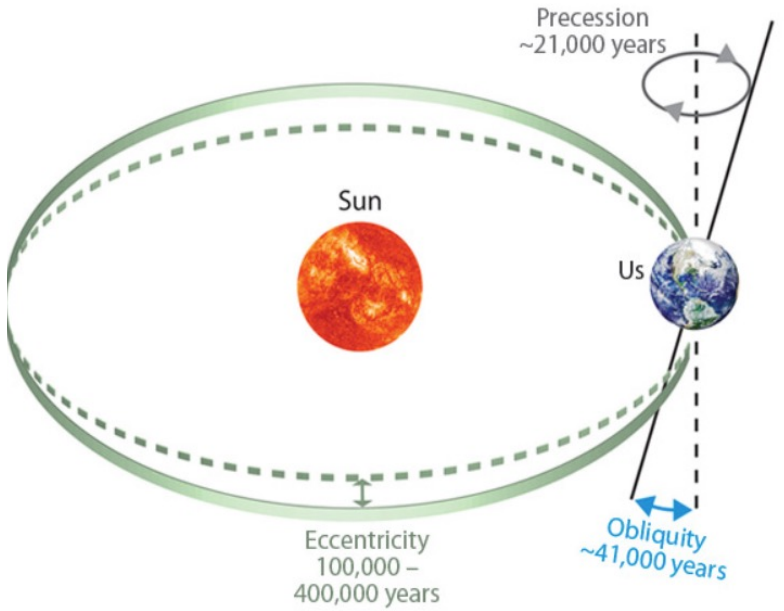


Martinson 1987

https://biocycle.atmos.colostate.edu/shiny/Milankovitch/



From cores



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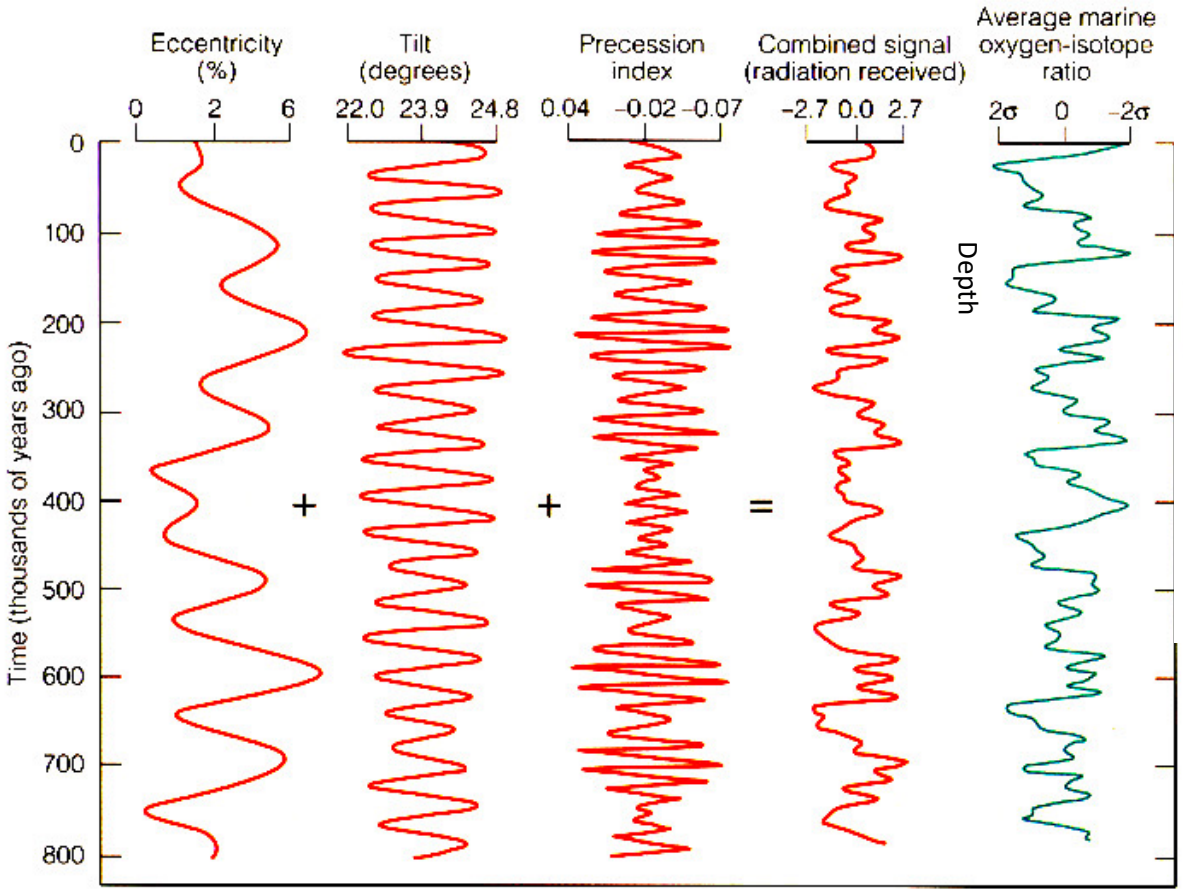

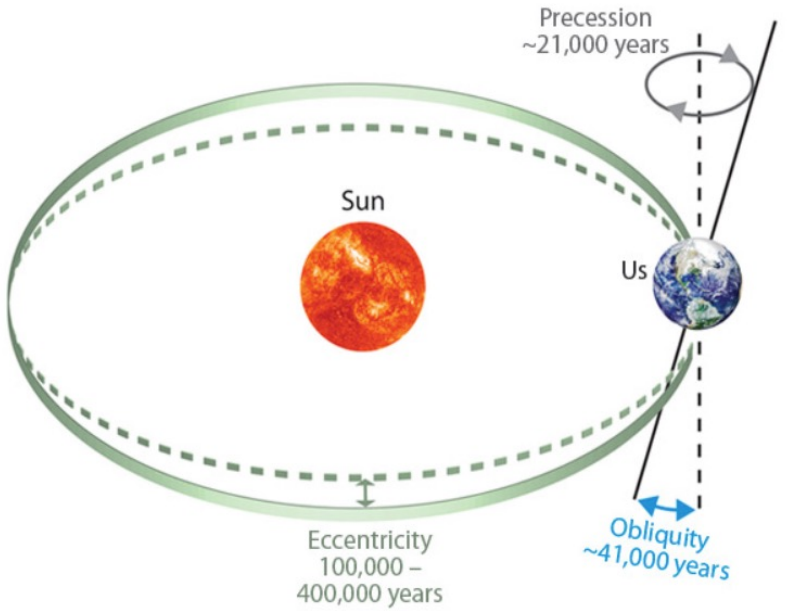

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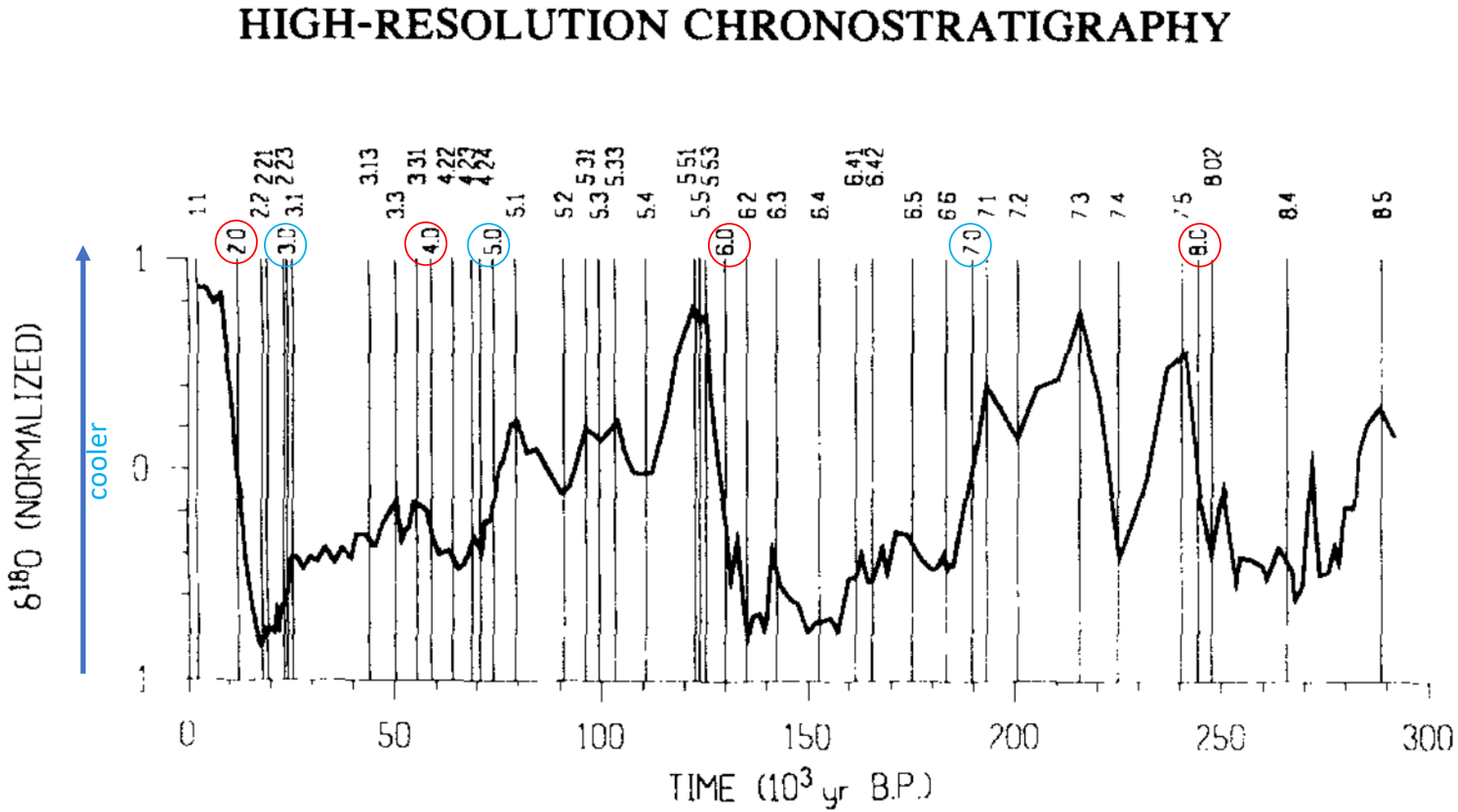
'STAGES of the Oxygen-Isotope Record - Martinson, M.D. et al., 1987. Age dating and the orbital theorey of the ice ages: development of a high-resolution 0 to 3000,000 year chronostratigraphy. Quaternary Research, 27: 1-29.



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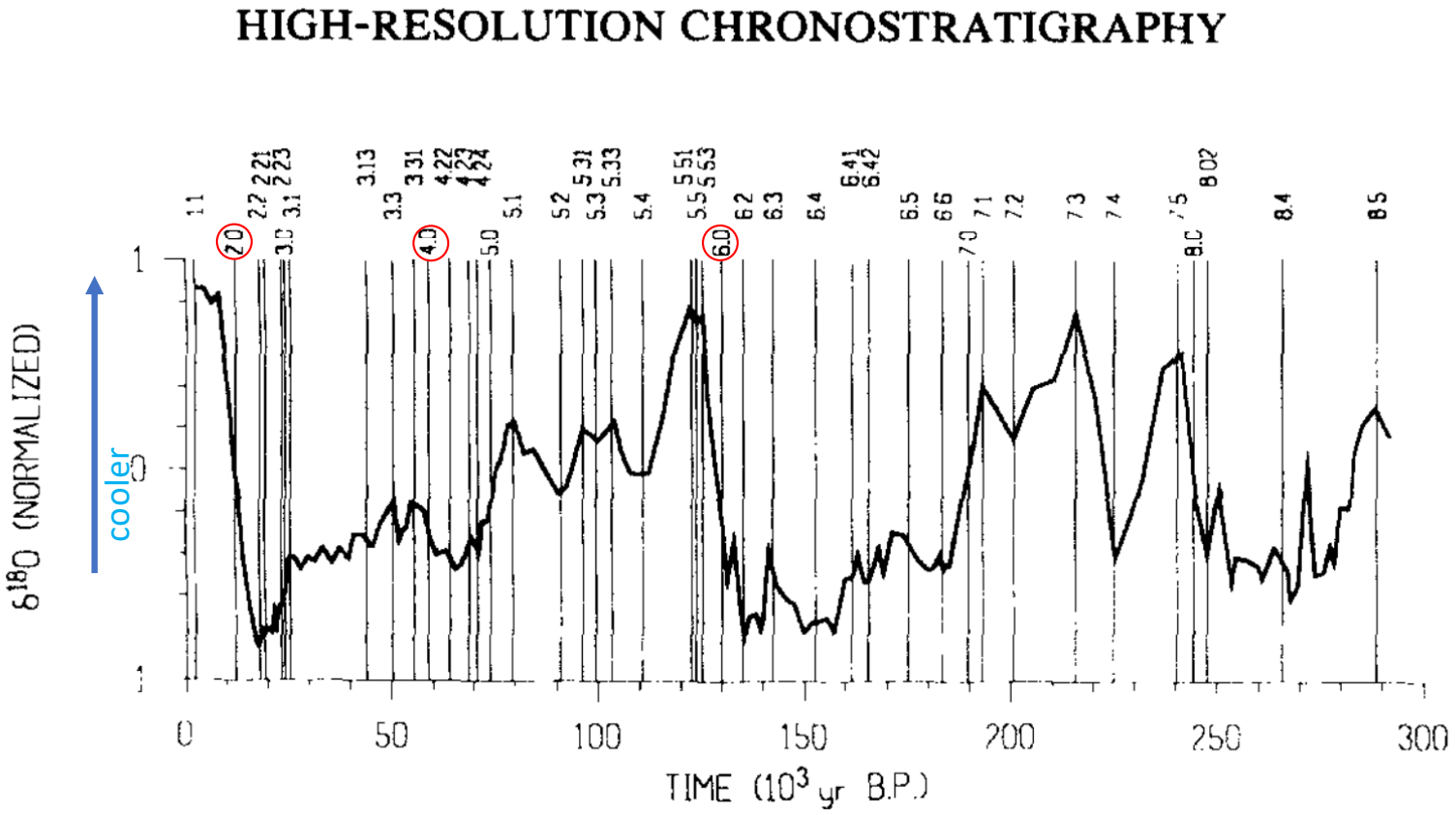
Major periods of Cooling

Stage 2 ~15 – 25 ka

Stage 4 ~55 – 65 ka

Stage 6 ~125 – 135 ka



This tells us when things were cold but does not tell us directly the age of glacial deposits like we looked at earlier

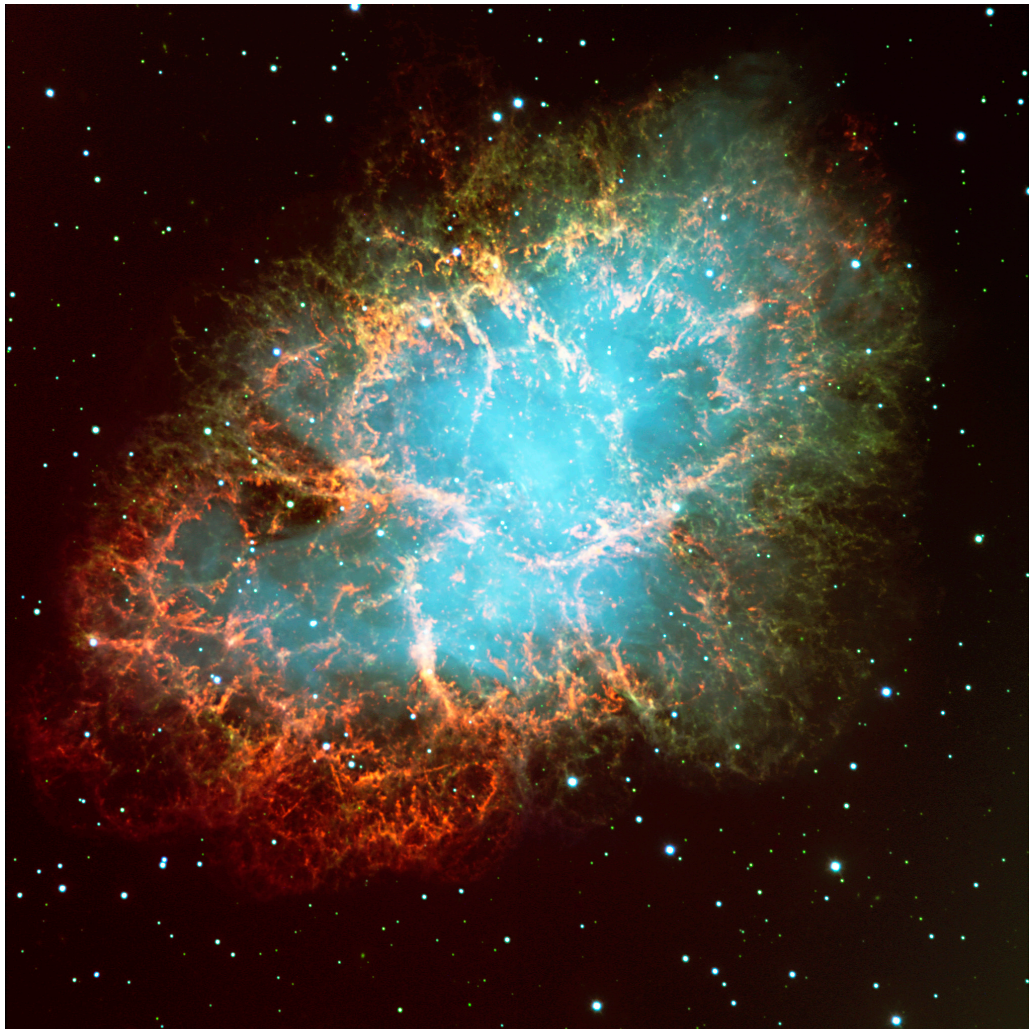
Quantitative Dating of Glacial Deposits and Surfaces

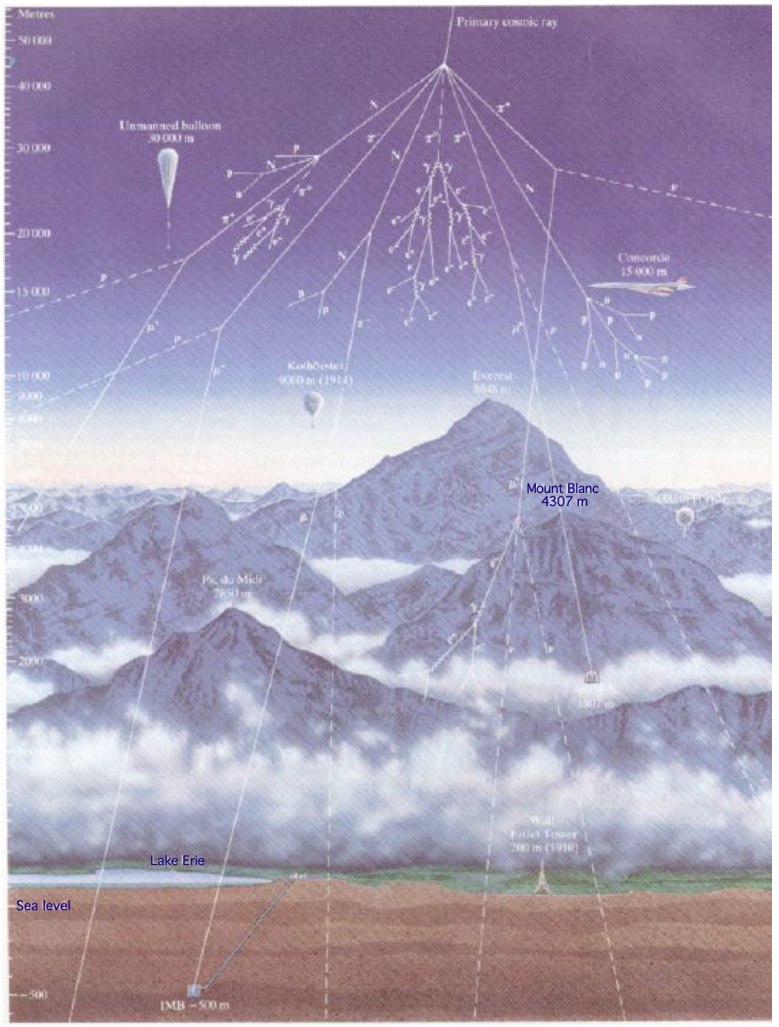
Radiocarbon gets one back to ~40k

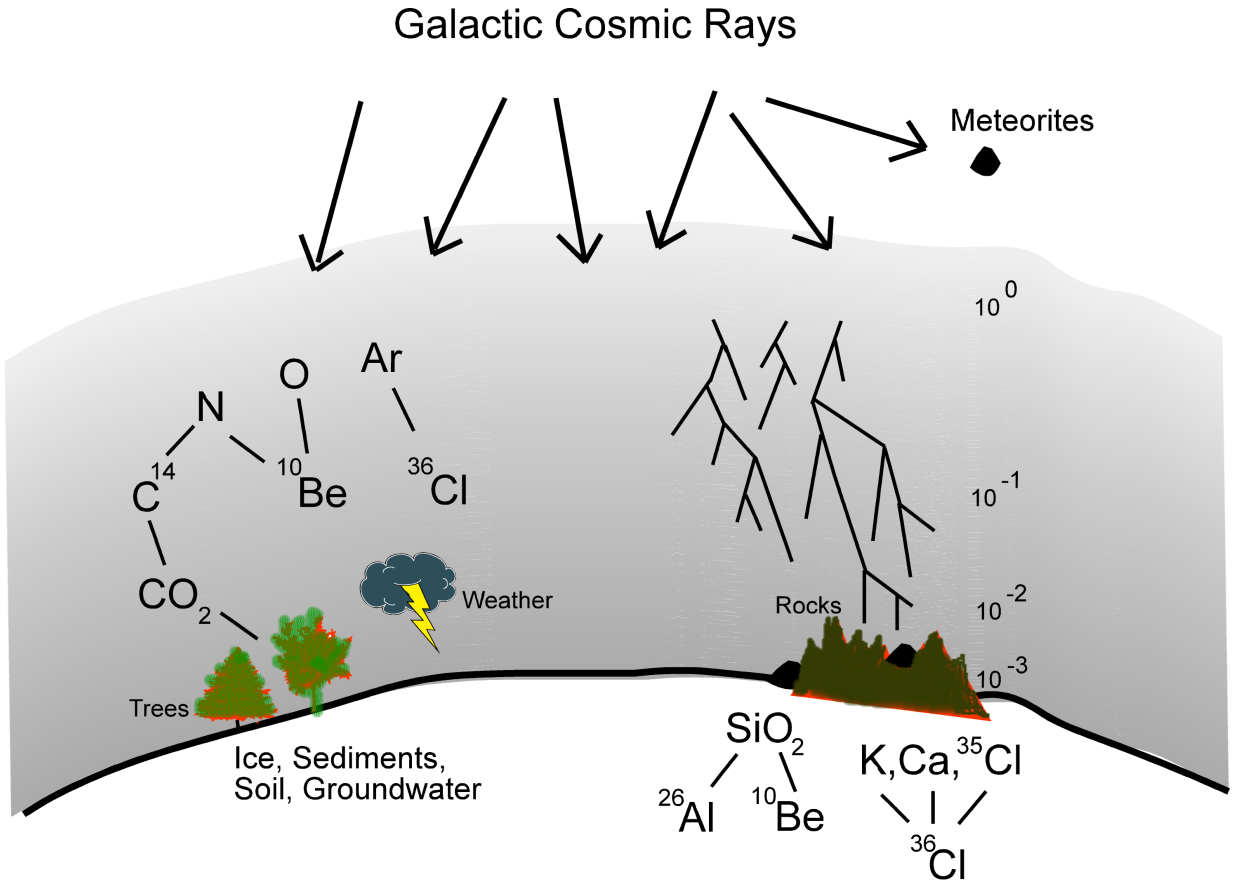
Glacial isotope record shows cold periods prior to that time

Terrestrial Cosmogenic Dating (TCN) dating methods allow dating of rocks back to several hundreds of thousands of years – with caveats..

Most are familiar with radiocarbon dating – and that is used when organic material is found in geologic deposits – but it only is useful to about 40ky – for older deposits – Cosmogenic rays offer another approach is applicable to older deposits





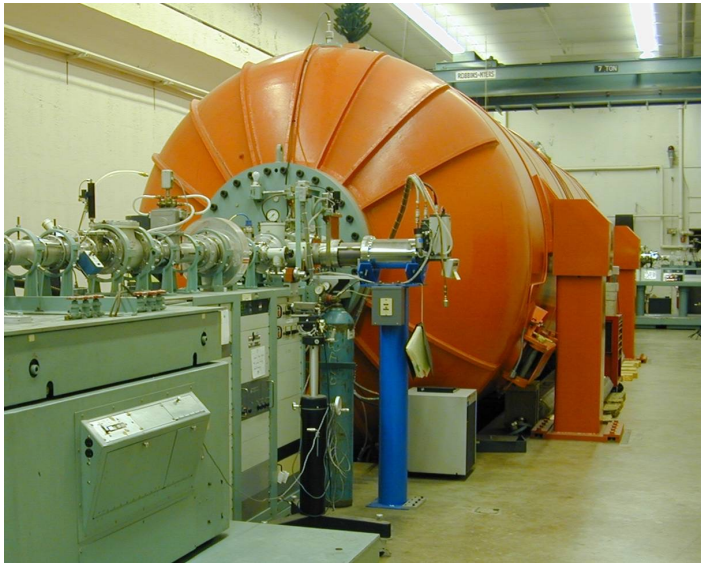


Garden Variety

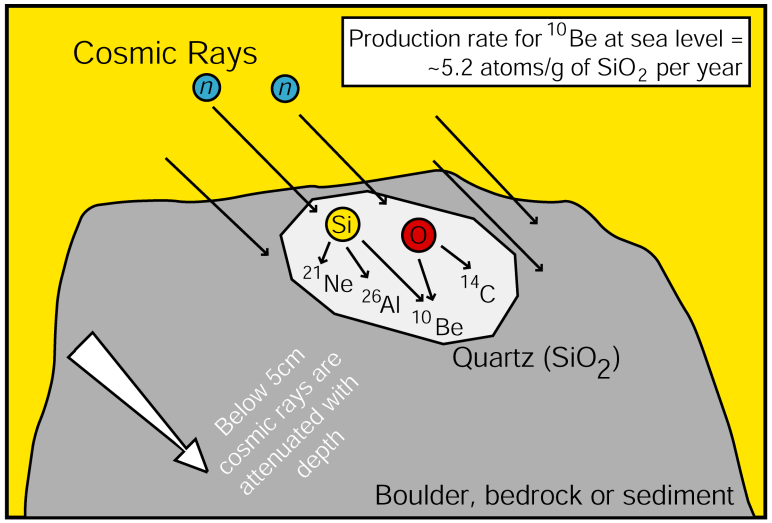
produced in the atmosphere

In-situ Variety

produced on the Earth's surface



Terrestrial Cosmogenic Nuclide (TCN) Dating of Rocks on Surface.



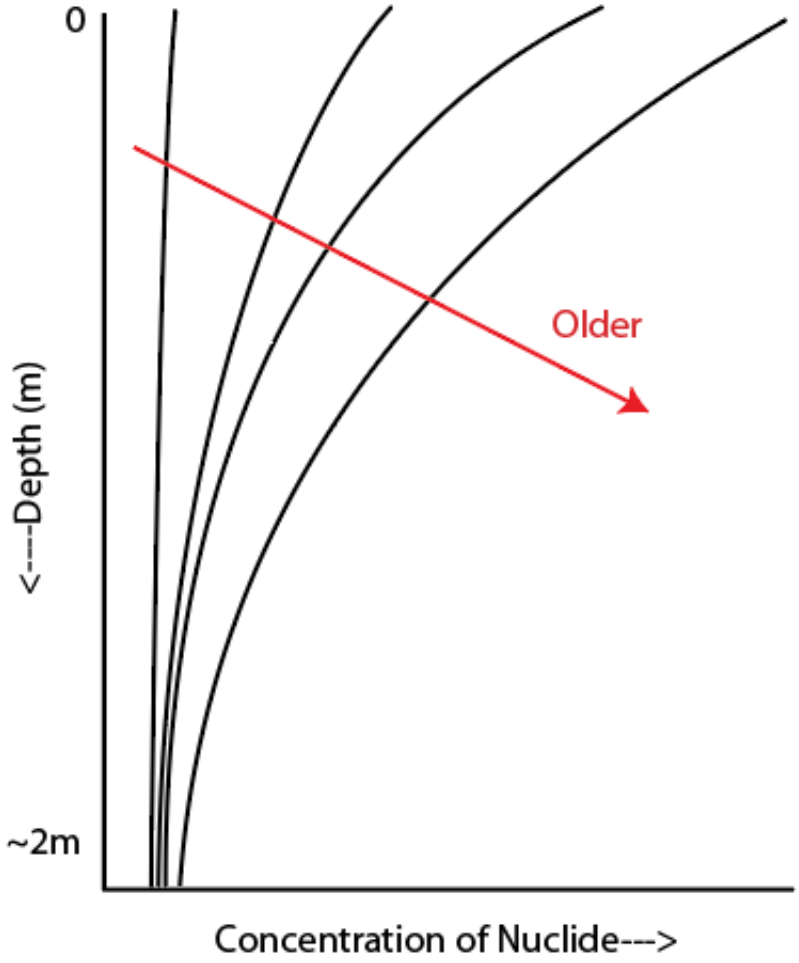
About 500g of rock chiseled/drilled form outer 5 cm of exposed rock.

To first order – isotopes accumulate increase with time – so concentrations of isotopes are measure of how long rock is exposed on surface.

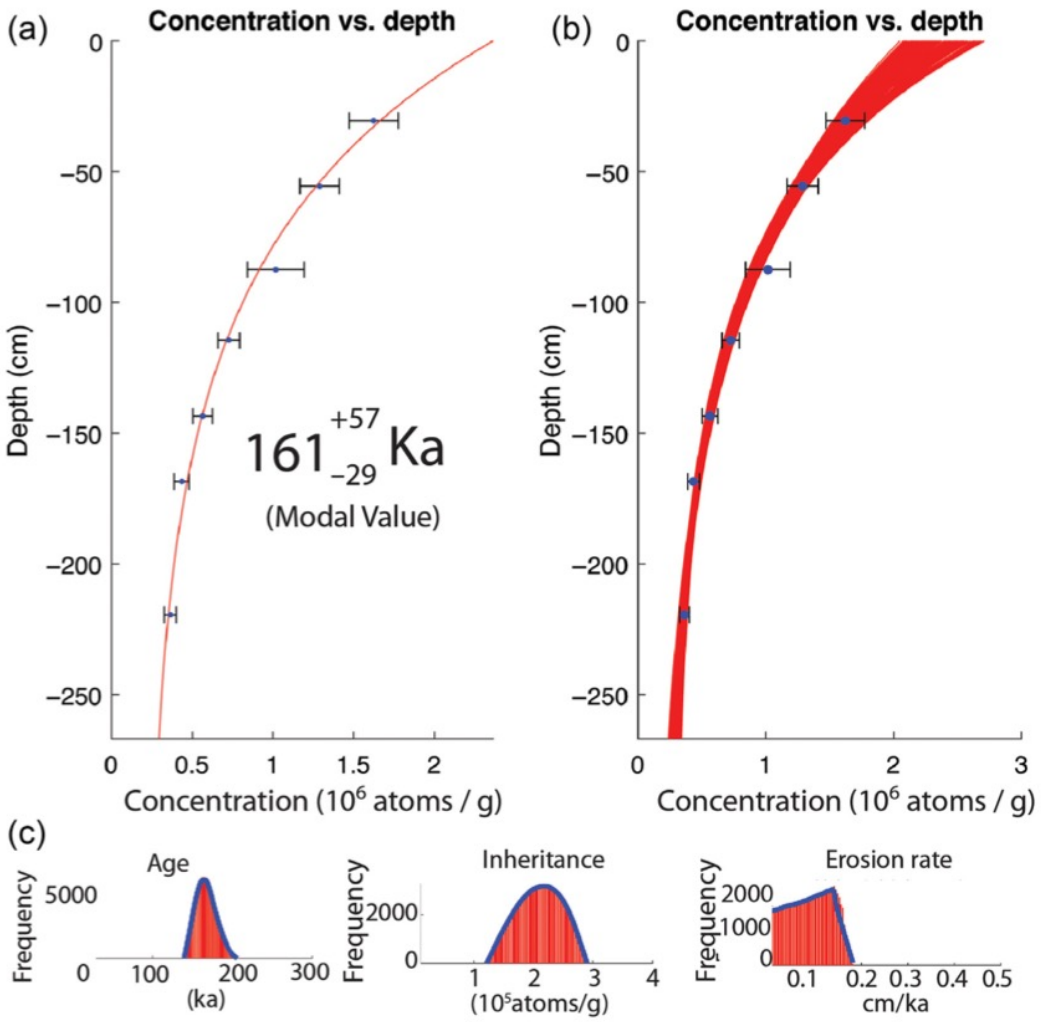
Other geologic factors that effect the concentration and thus age determination are
-weathering
-process of exhumation – rapid/gradual
-prior exposure before being deposited at place of sampling (inheritance)
-shielding of surface by sediment or snow and topography

Terrestrial Cosmogenic Nuclide (TCN)

Dating of Sediments deposited on surface – applicable to alluvial surfaces that have been 'abandoned' and absent of erosion for some period of time- in alluvium, cosmogenic radiation generally reaches no more than about 2 m (more than solid rock)




(a)
Qff2
A
Pit
Qf1
B
vs 2.5m
vs 20m


(a)
Concentration vs. depth
Depth (cm)
0
−50
−100
−150
−200
−250
0
0.5
1
1.5
2
Concentration (10^6 atoms / g)
161 +57 −29 Ka
(Modal Value)
(b)
Concentration vs. depth
Depth (cm)
0
−50
−100
−150
−200
−250
0
1
2
3
Concentration (10^6 atoms / g)
(c)
Age
Frequency
5000
0
100
200
300
(ka)
Inheritance
Frequency
2000
0
1
2
3
4
(10^5atoms/g)
Erosion rate
Frequency
2000
1000
0
0.1
0.2
0.3
0.4
0.5
cm/ka


Glacial moraine
Scarp and trailhead
Mt Rose Highway