Cosmogenic nuclide concentrations in Neogene rivers of the Great Plains reveal the evolution of fluvial storage and recycling

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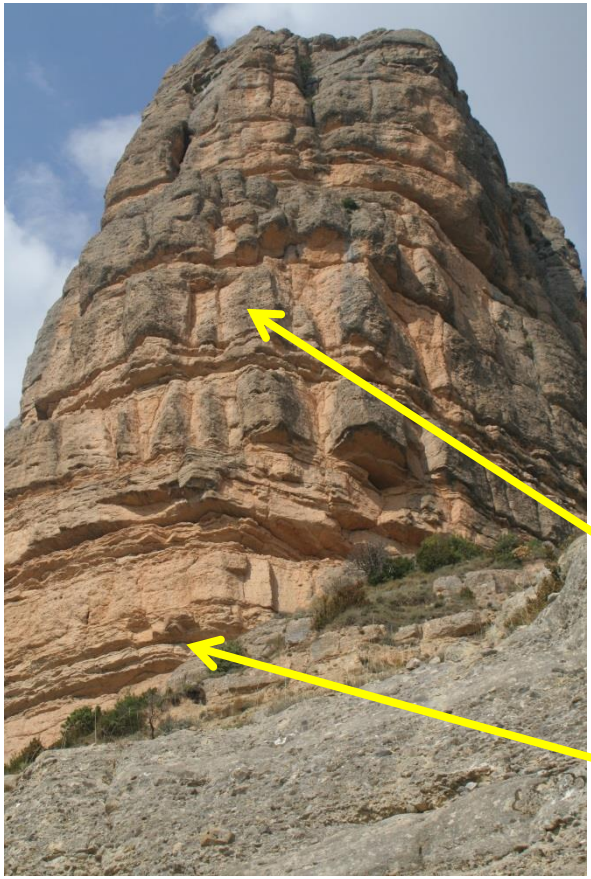
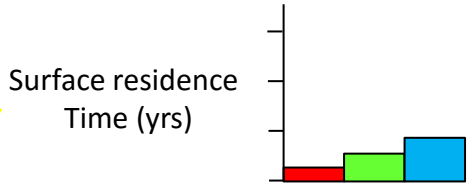
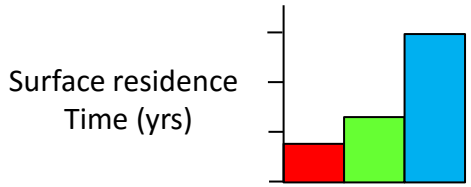
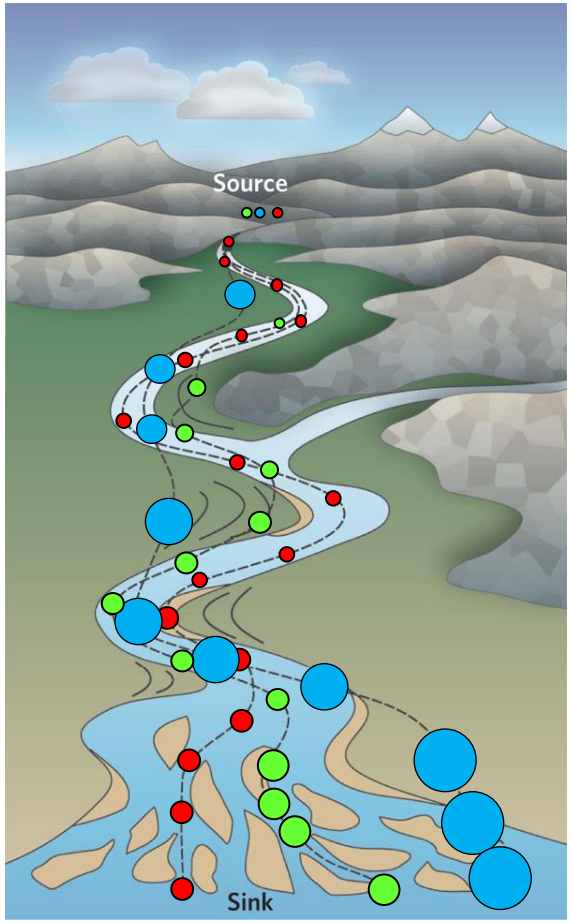
[2] – Scottish Universities Environmental Research Centre (SUERC), East Kilbride, UK

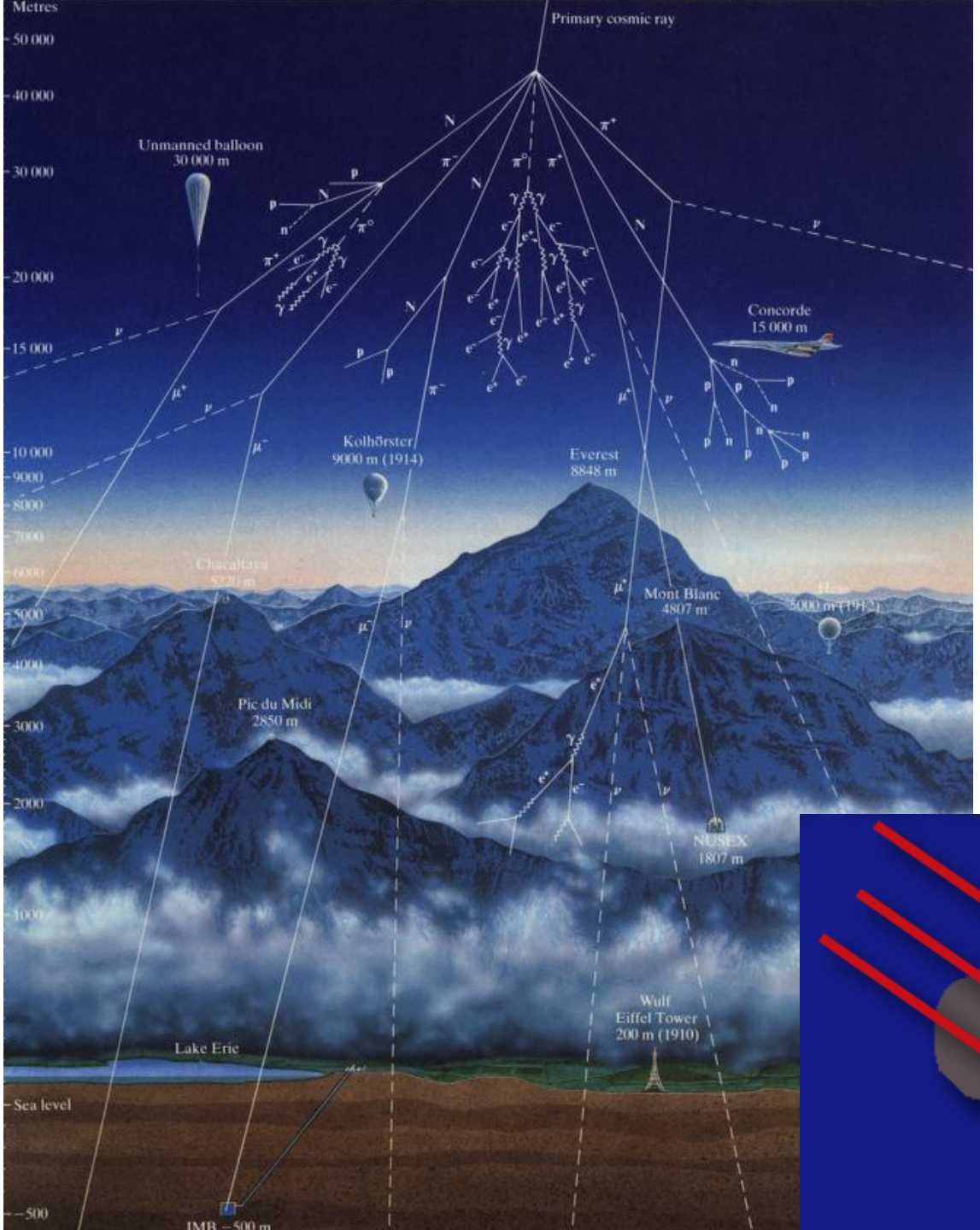


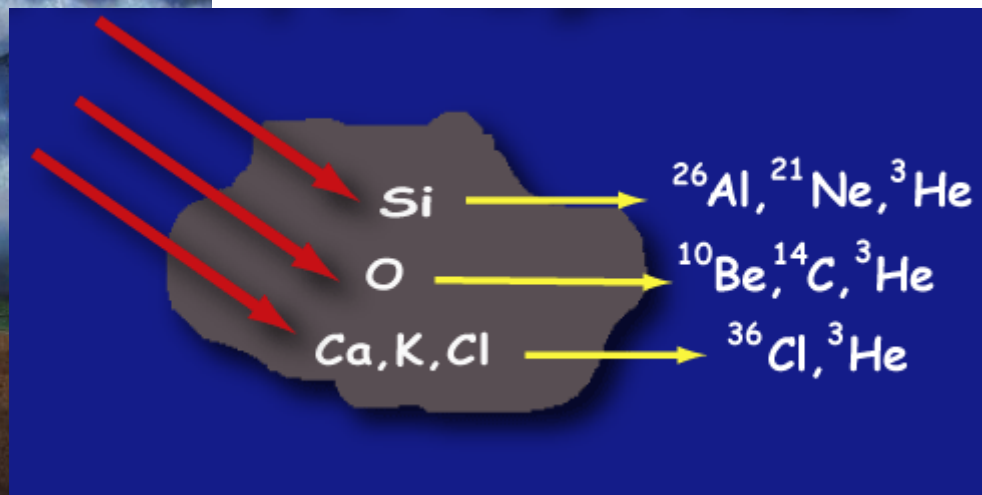




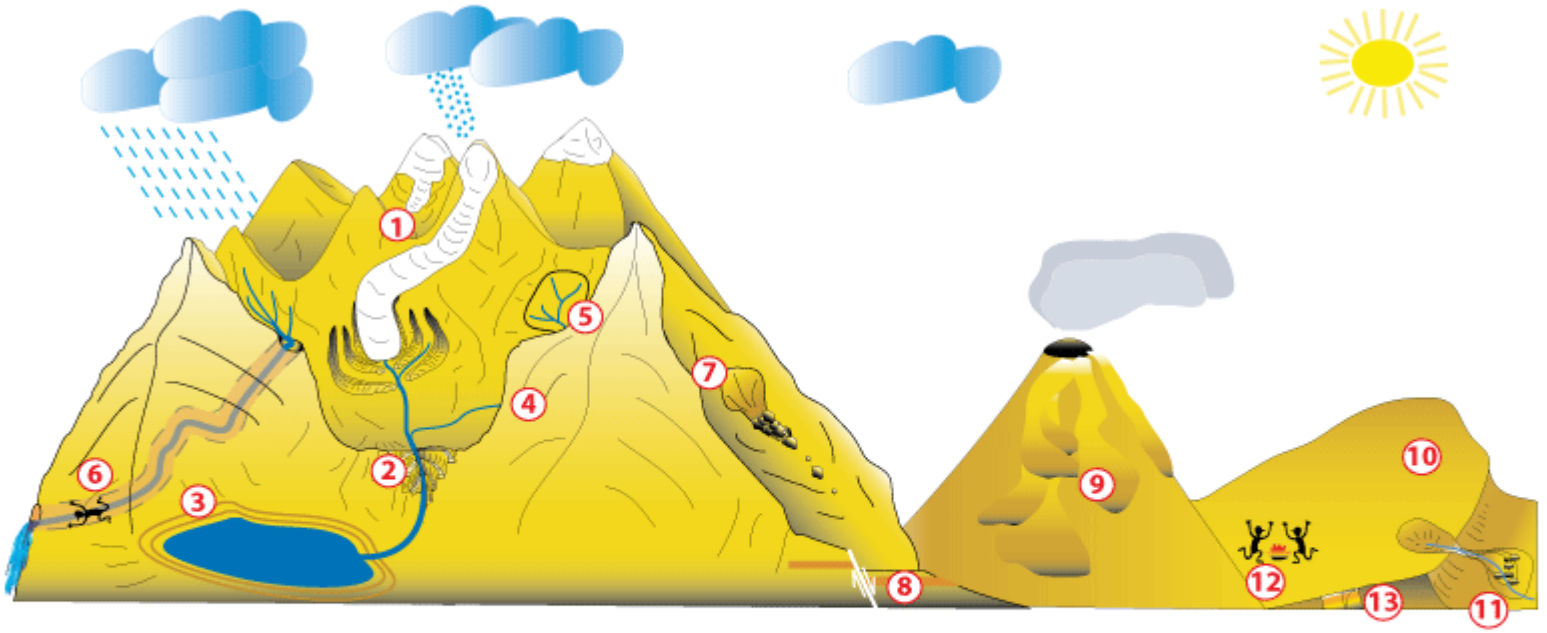


Cosmogenic nuclides generated by interaction of cosmic rays with the nucleus of the atom



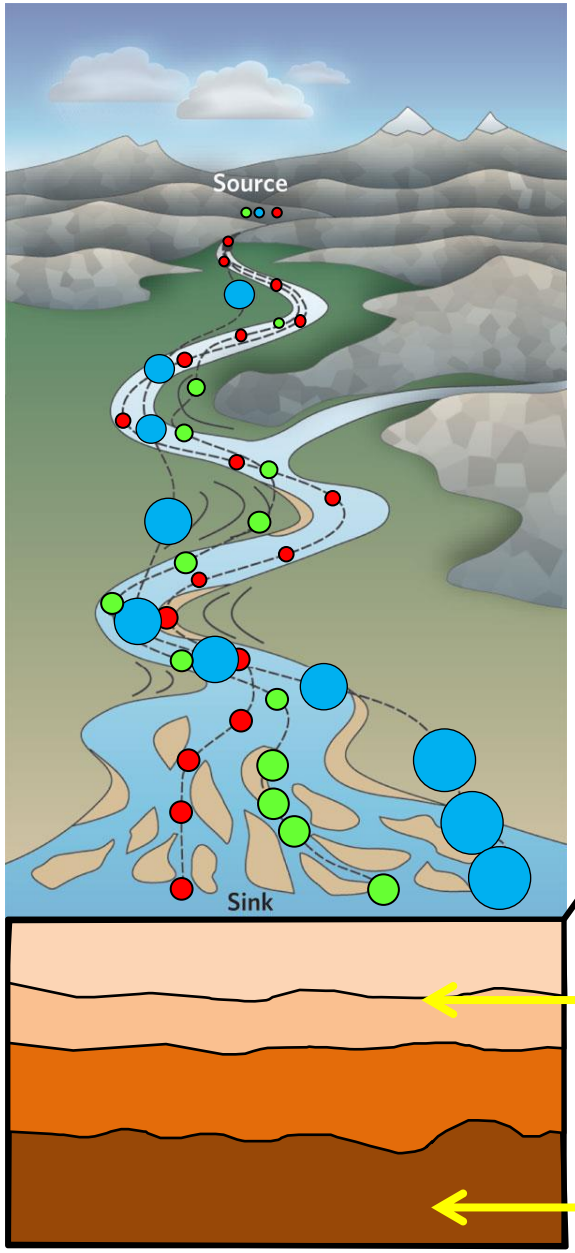


Widespread application in geomorphology and Quaternary geology



1. glacial chronologies (alpine, ice-sheets)
2. fluvial chronologies (terraces, incision)
3. shoreline chronologies (terraces, lacustrine, marine)
4. hillslope rates
5. catchment wide denudation rates
6. burial chronologies (caves, terraces, paleosols)
7. landslide chronologies
8. fault scarp chronologies
9. volcanic eruption chronologies
10. desert chronologies
11. alluvial fan chronologies
12. archeology
13. pedogenic chronologies

http://www.ams.ethz.ch/research/ams/insitu/source.png?hires

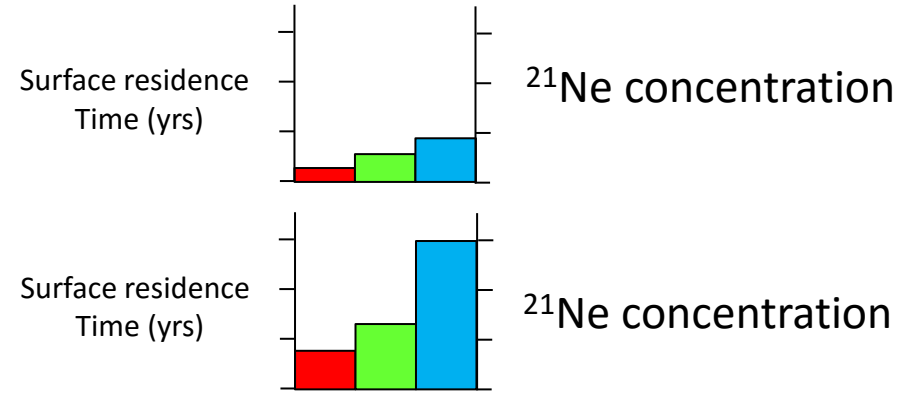


Modern and Quaternary processes

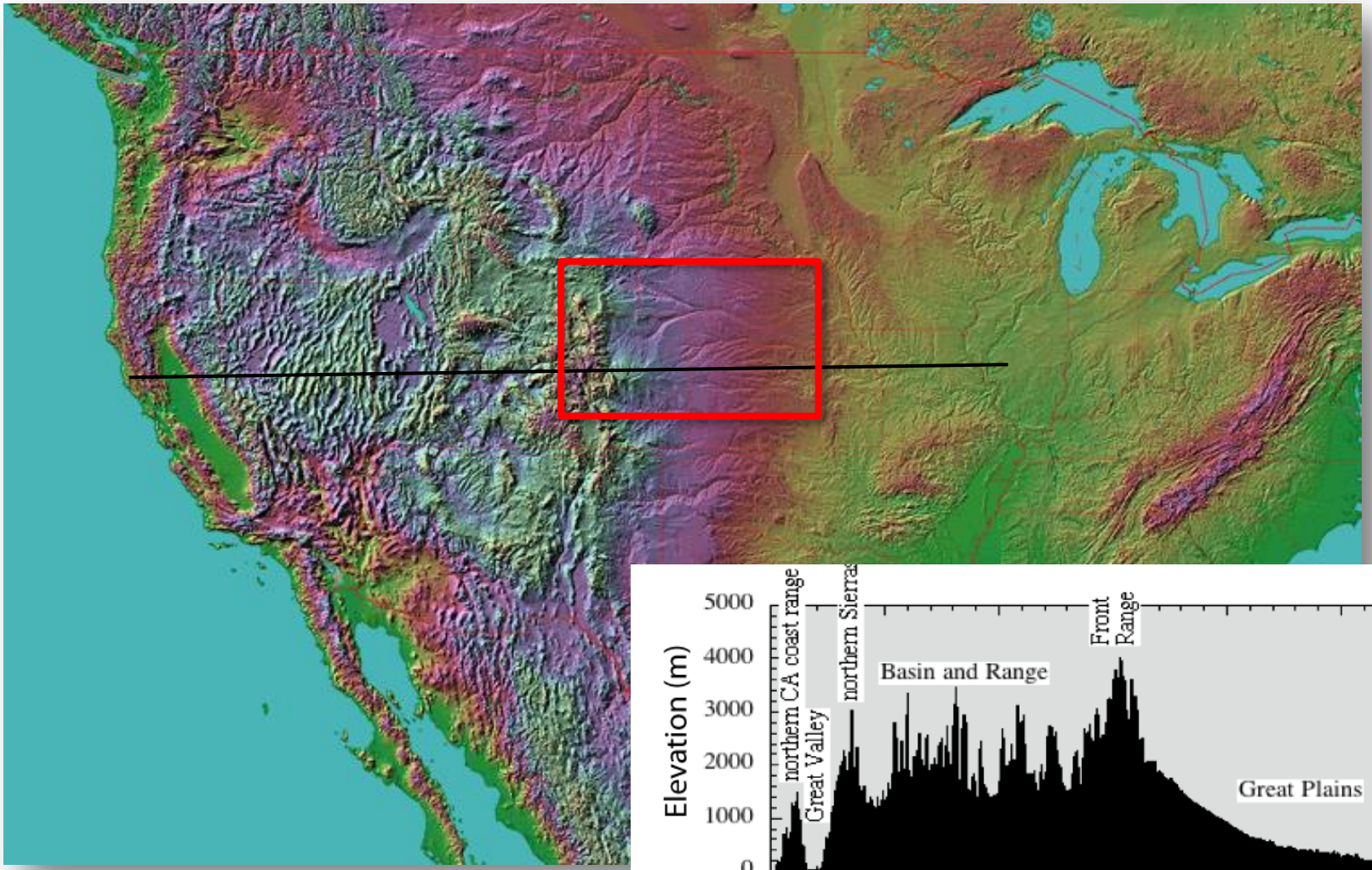
Radiogenic nuclides mainly ^{10}Be and ^{26}Al

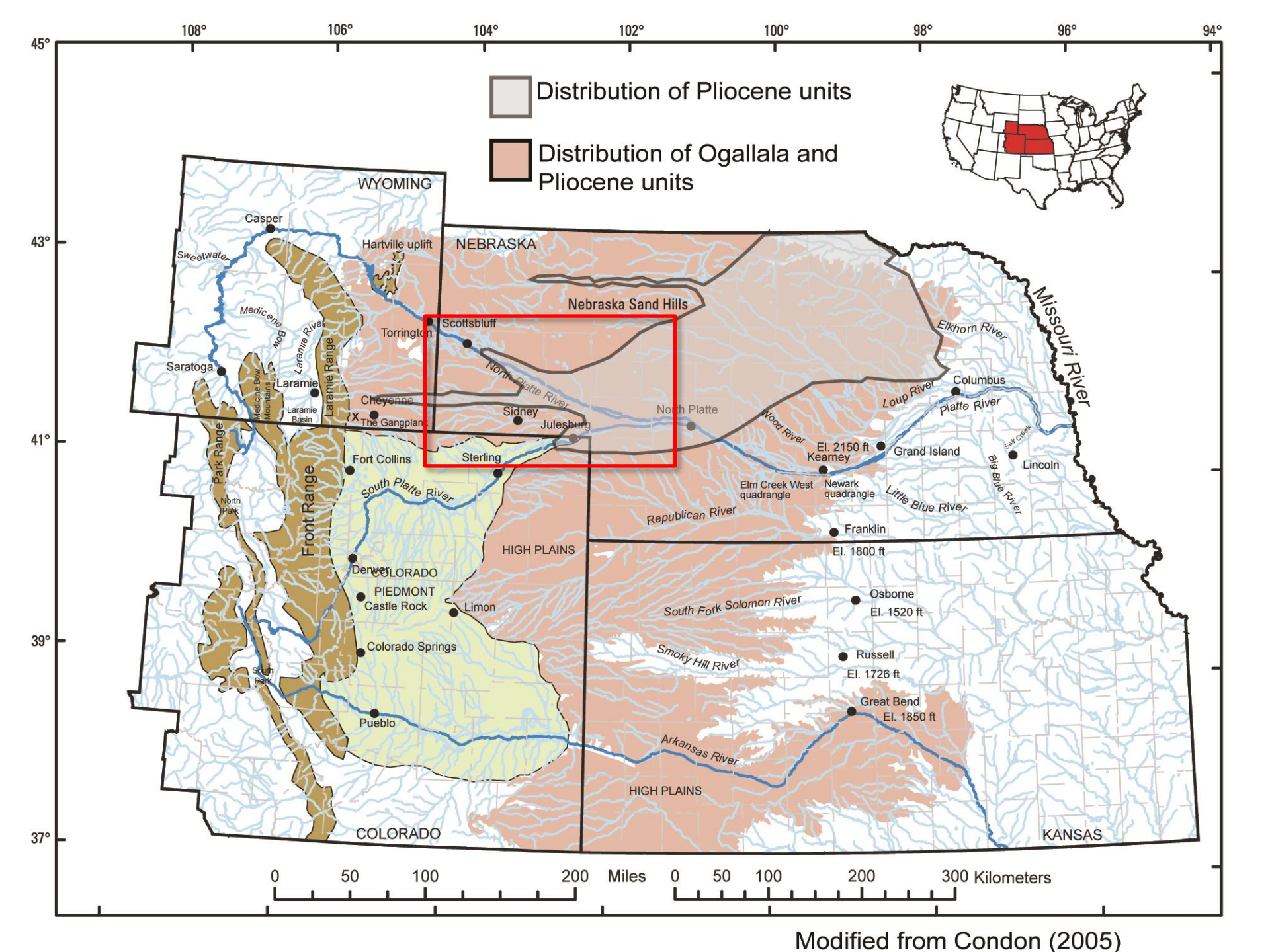
Stratigraphic record throughout Earth history

Stable nuclides such as ^{21}Ne

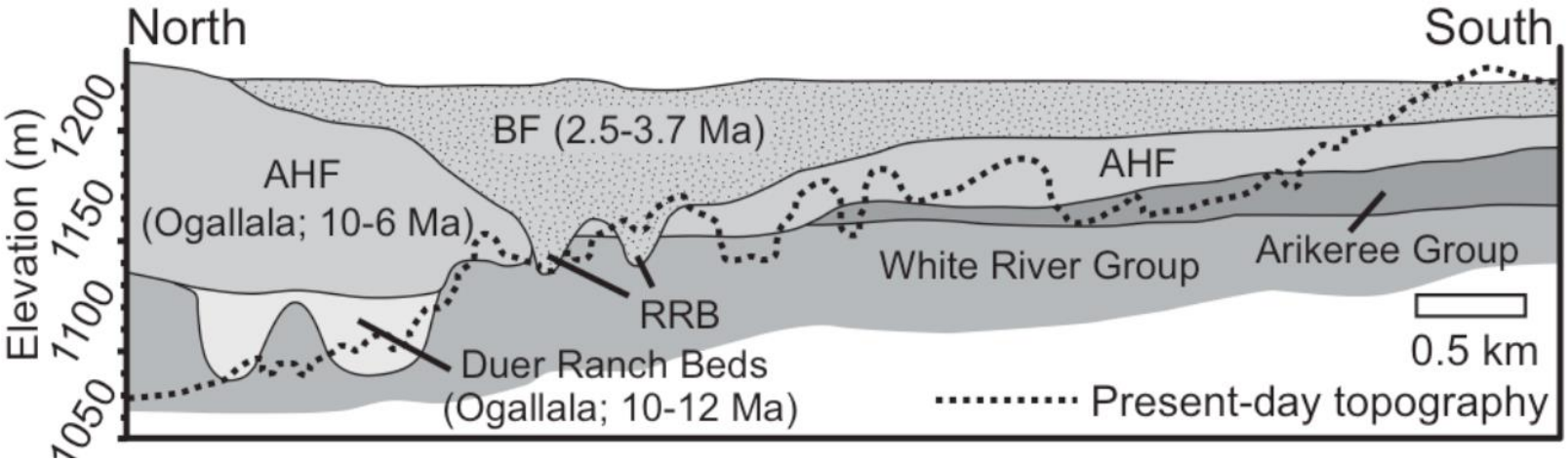


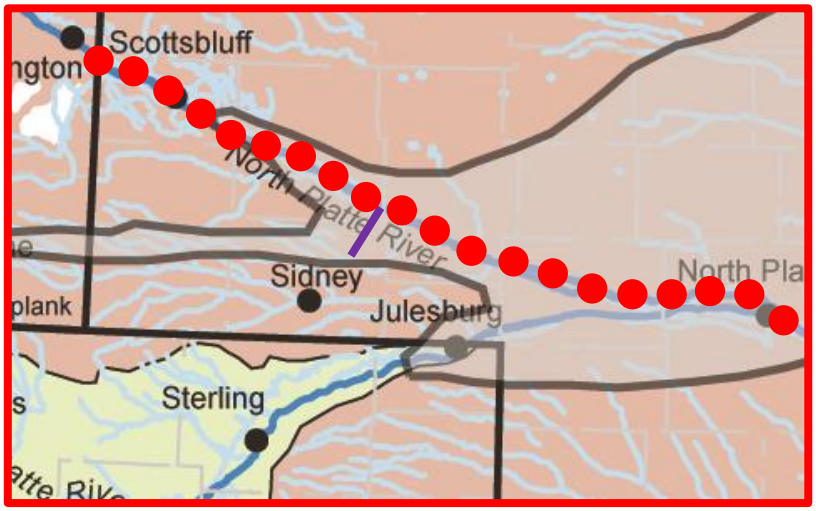
Neogene of Great Plains - a thin (~100m) succession of fluvial sediments known as the Ogallala Group sourced from the Rockies. Modern rivers incised into Plains.

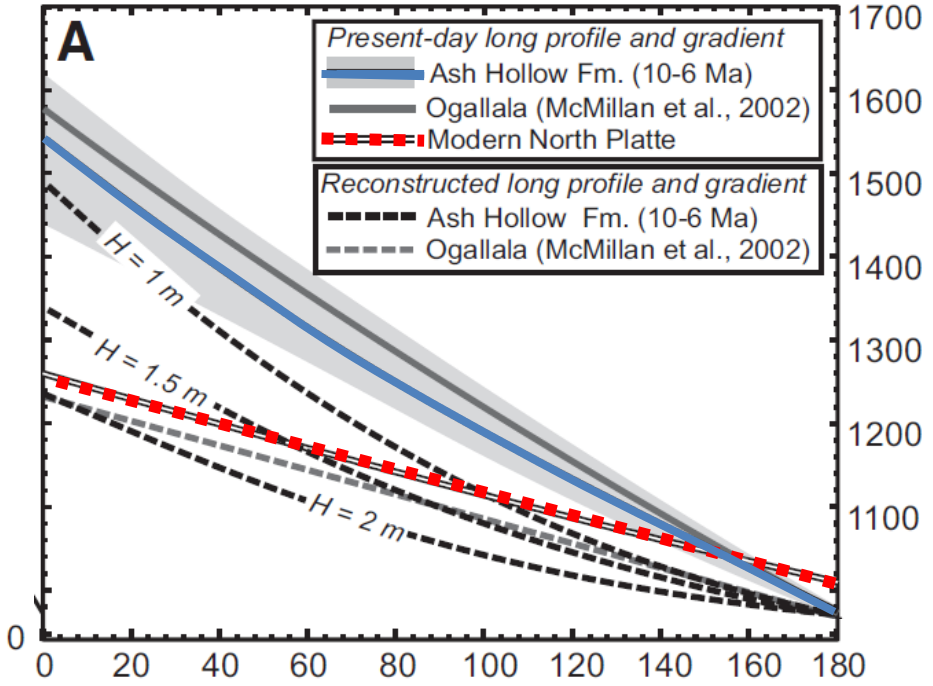




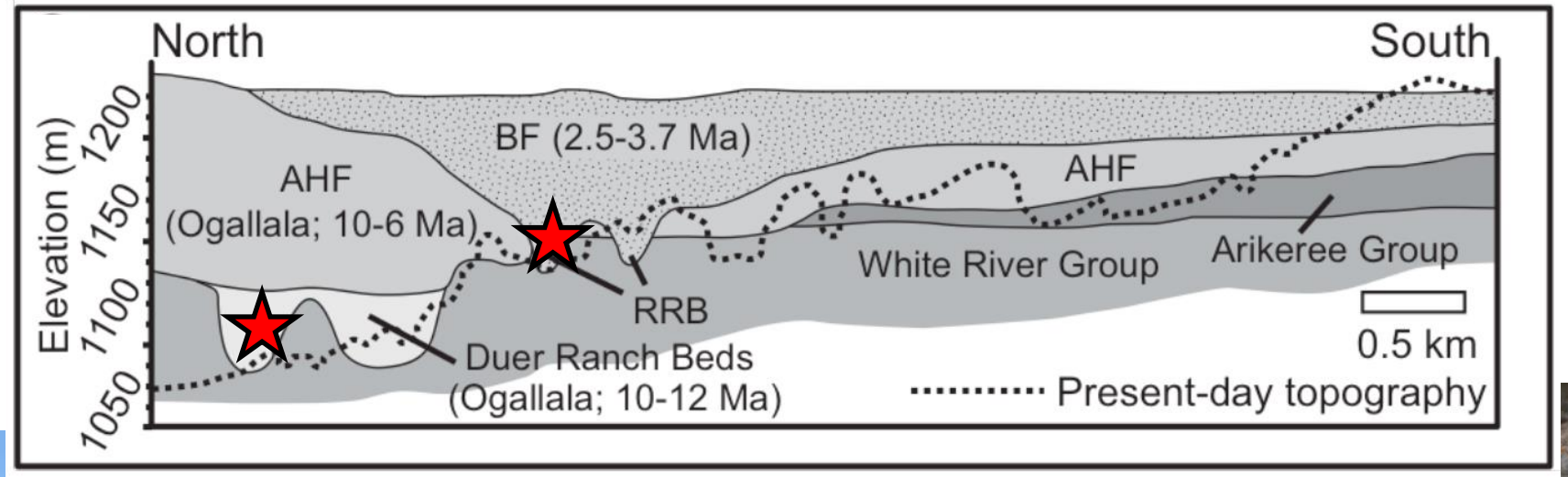
Modified from Condon (2005)





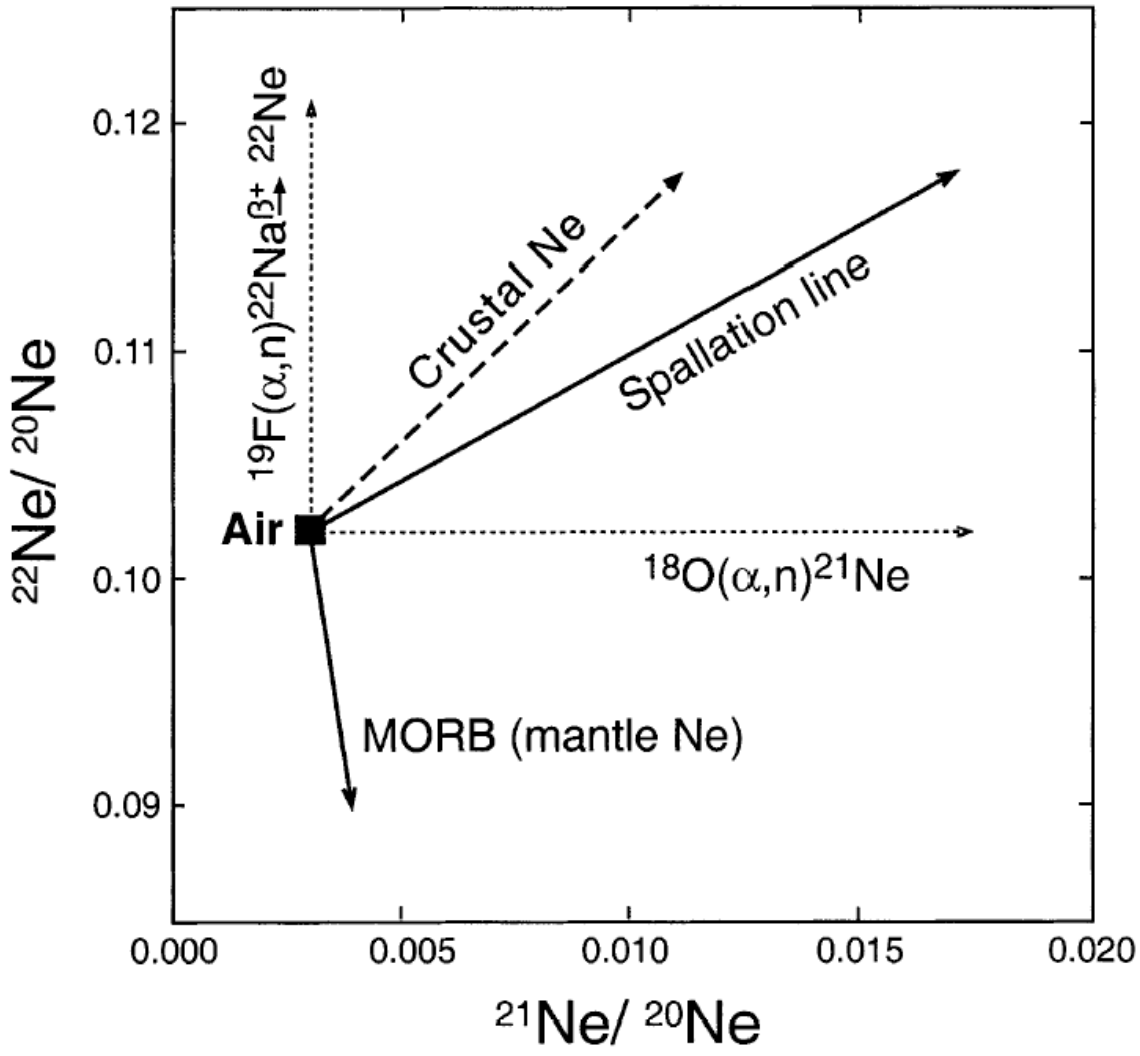


Duller et al., 2012. Geology.


North
South
Elevation (m)
1200
1150
1100
1050
BF (2.5-3.7 Ma)
AHF
(Ogallala; 10-6 Ma)
AHF
White River Group
Arikeree Group
RRB
Duer Ranch Beds
(Ogallala; 10-12 Ma)
0.5 km
Present-day topography

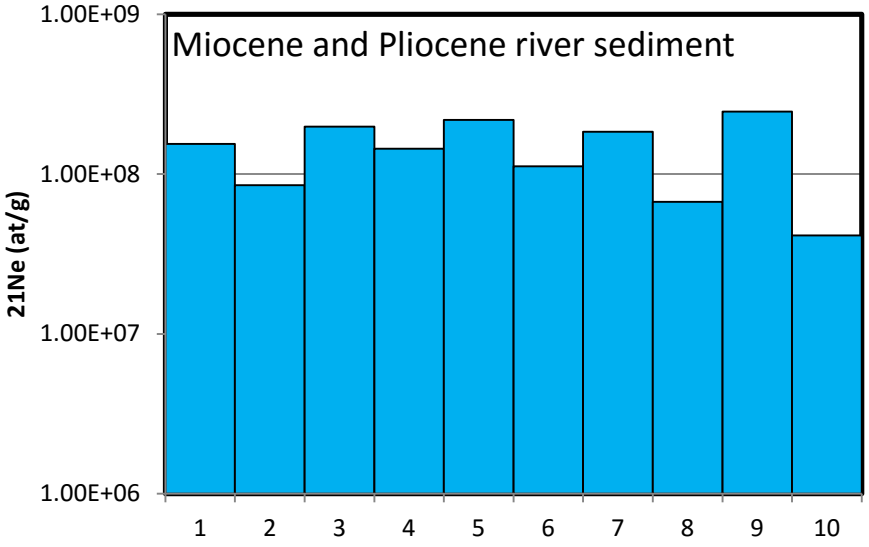

Modern North Platte

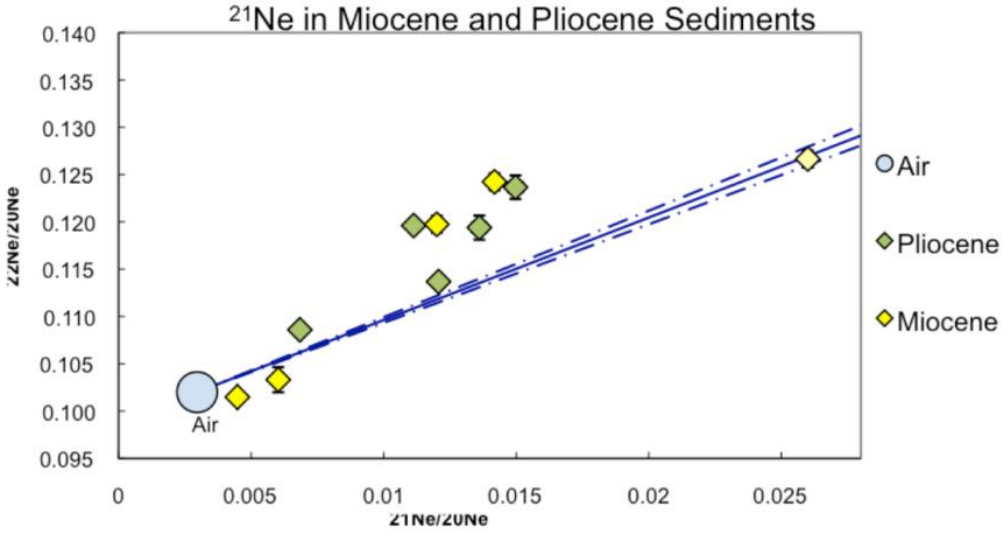
Non-cosmogenic 21Ne can be identified using a three isotope plot of ^{20}Ne, ^{21}Ne and ^{22}Ne.



Modern and ancient river sediment

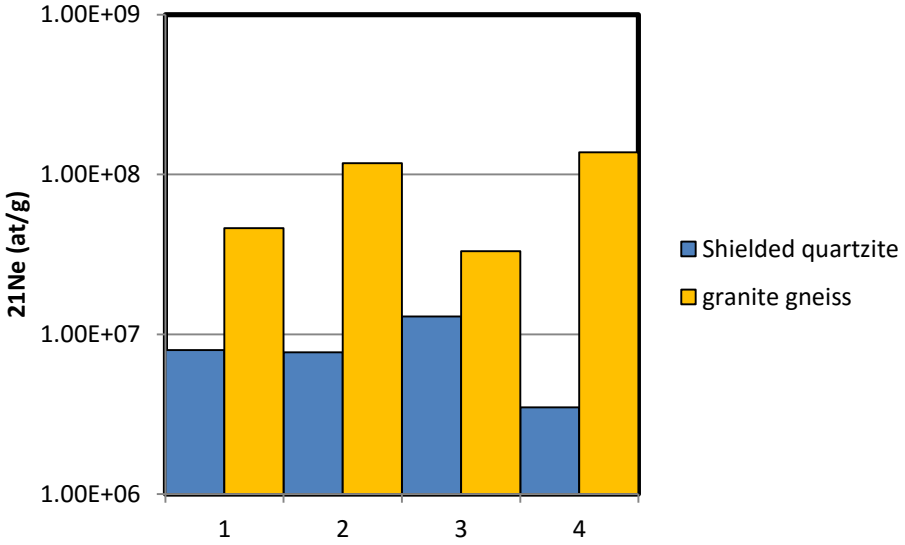
Mean sediment concentration – **1.5E+08**

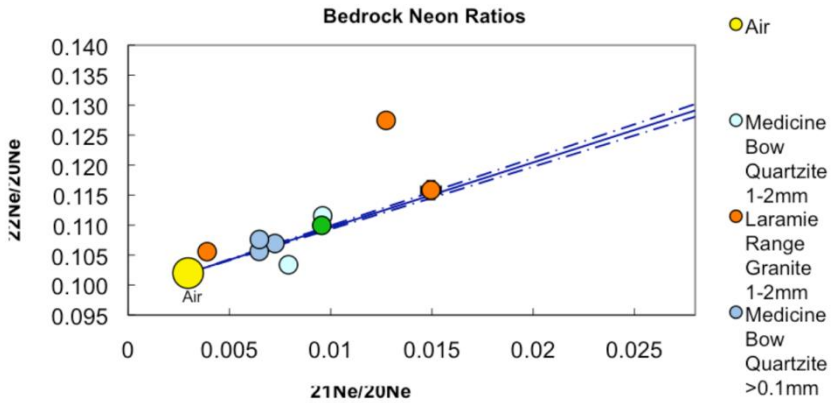


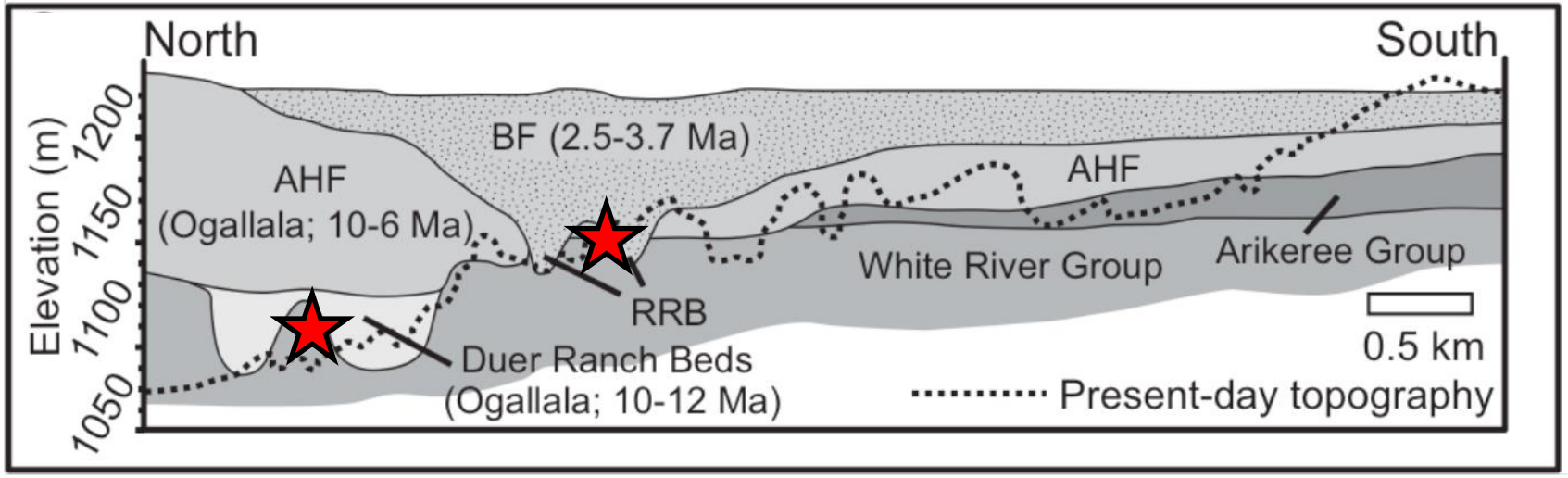


‘Shielded’ bedrock samples of source area eg. roadcuts

Mean granite concentration - **8.3E+07**
Mean quartzite concentration - **8.0E+06**

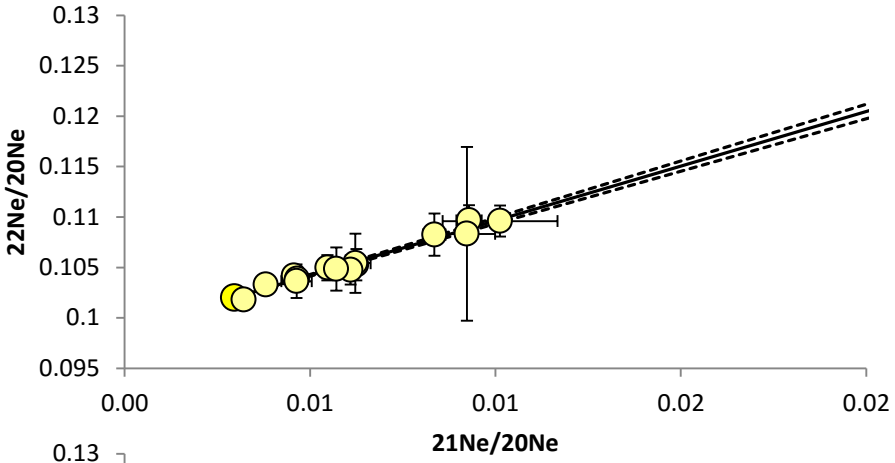




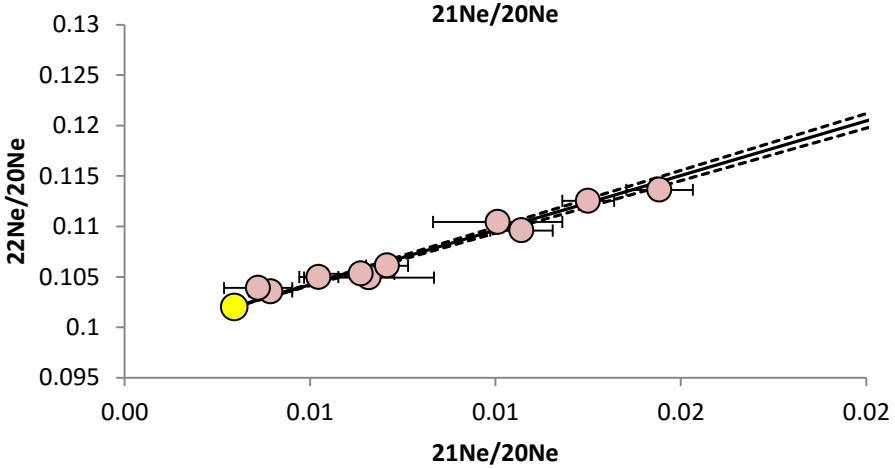

North
South
Elevation (m)
1200
1150
1100
1050
BF (2.5-3.7 Ma)
AHF
(Ogallala; 10-6 Ma)
AHF
White River Group
Arikeree Group
RRB
Duer Ranch Beds
(Ogallala; 10-12 Ma)
0.5 km
Present-day topography

Canon

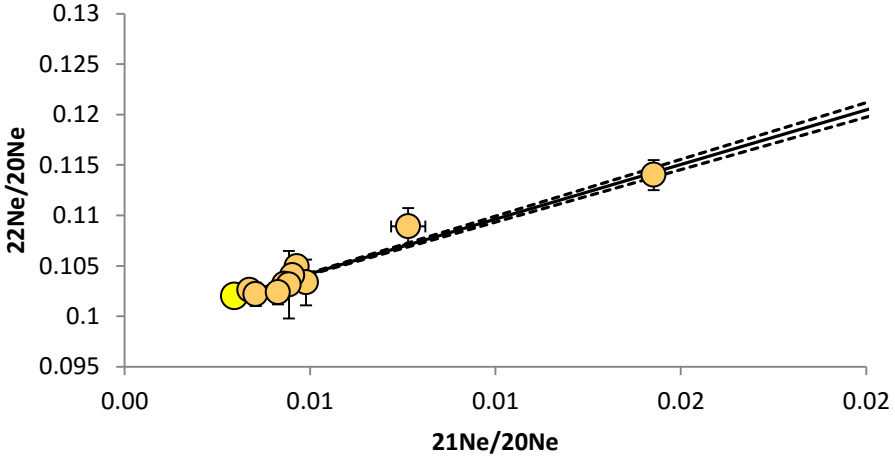
Modern



Pliocene



Miocene

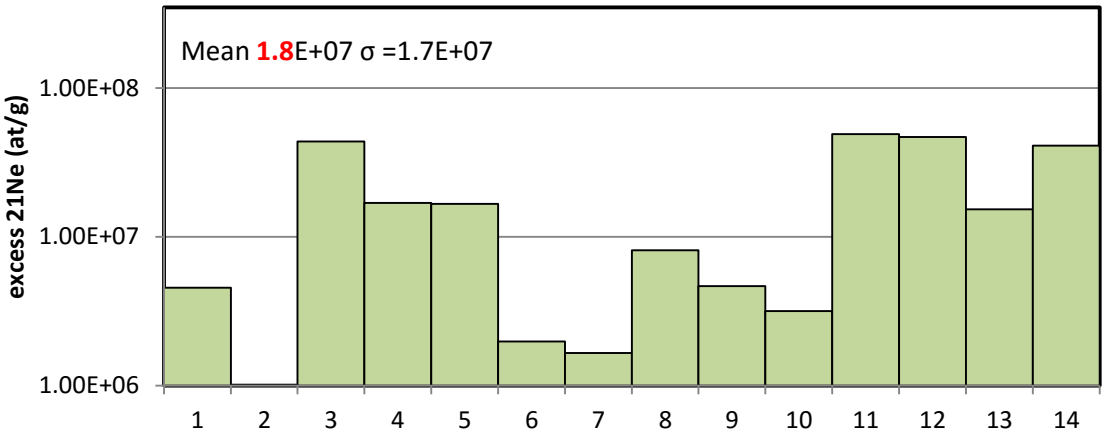


Extra ^{21}Ne above source rock values

Surface residence times

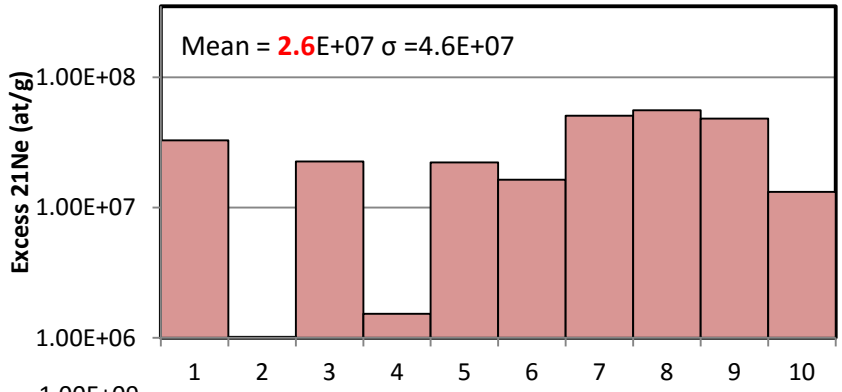
Modern

Mean 400 Kyr
Range 242-1380 Kyr



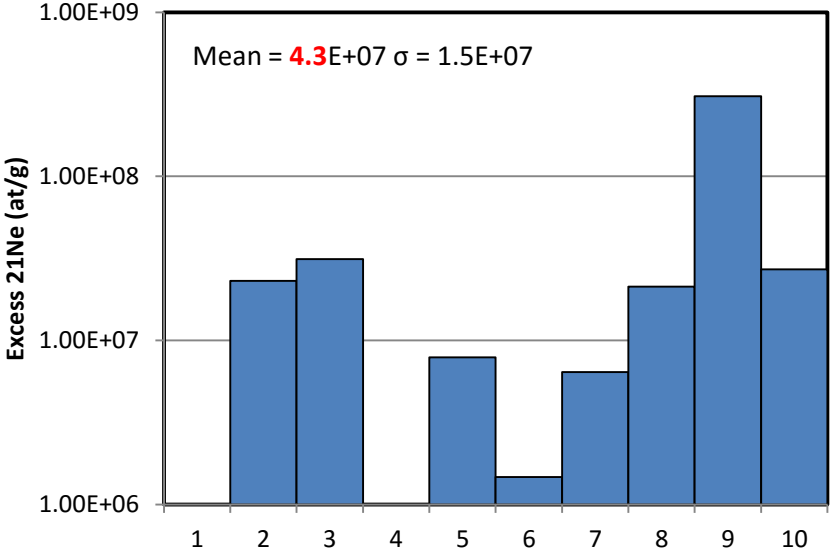
Pliocene

Mean 580 Kyr
Range 0-1520 Kyr



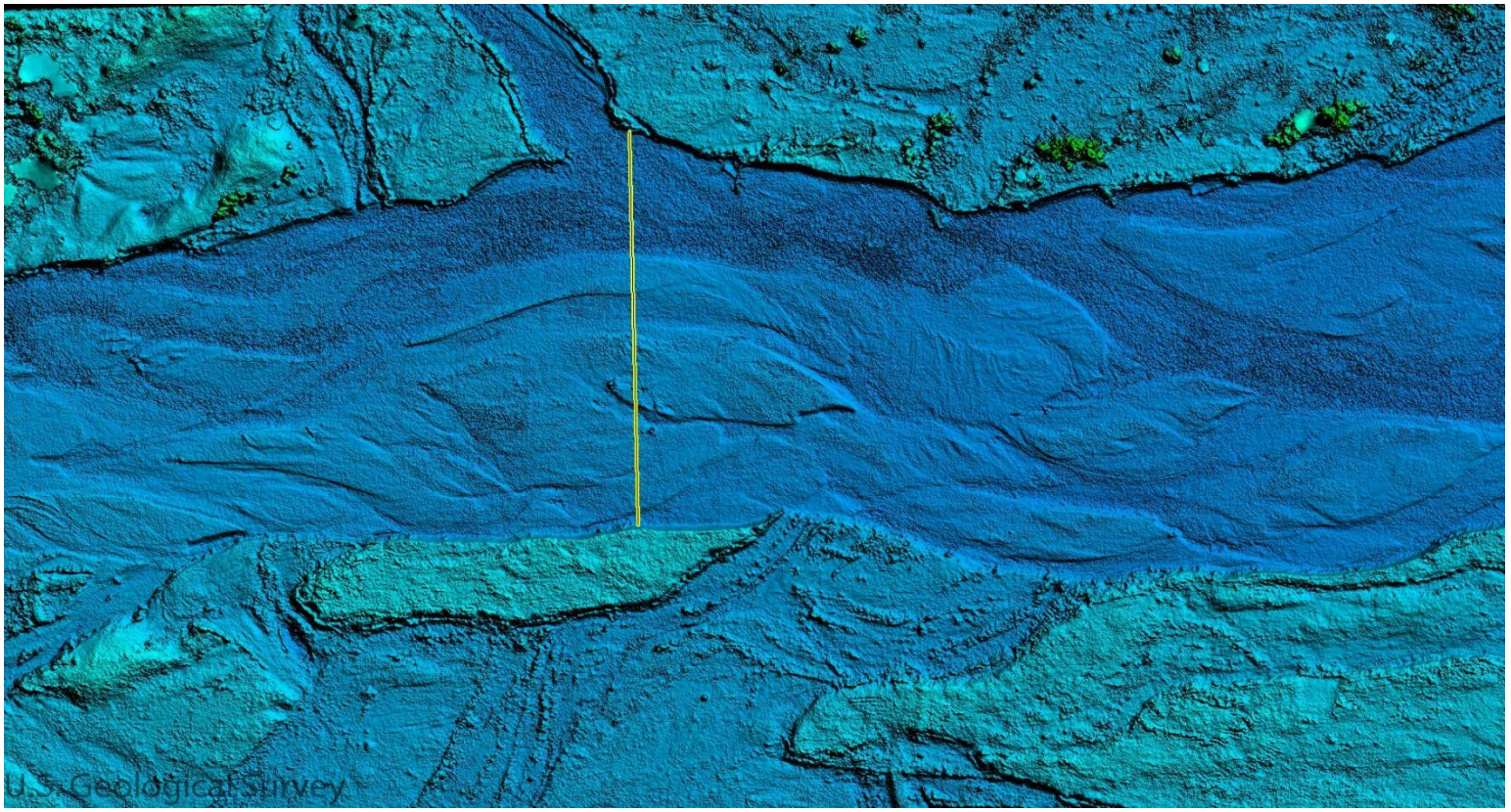
Upper Miocene

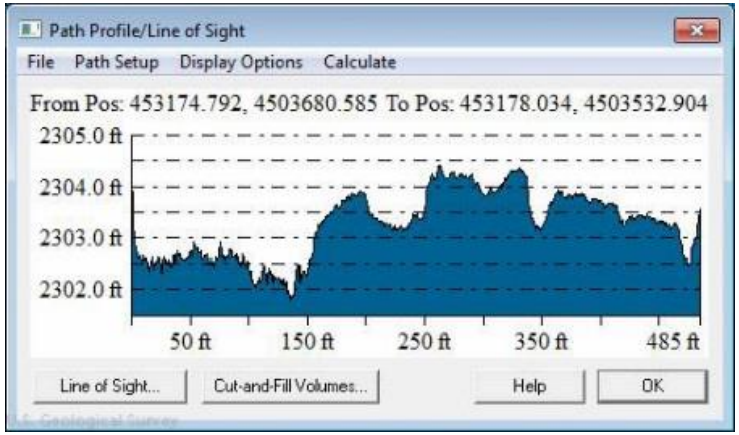
Mean 950 Kyr
Range 240-7100 Kyr



Conclusions

- Stable cosmogenic nuclides such as ^{21}Ne can be used to derive palaeo-surface residence times of sediment throughout the stratigraphic record
- In the Great Plains of Nebraska sampled pebbles indicate a reduction in surface residence times from Miocene to present
- Pebbles resided near the surface for up to 7 Myr in Miocene times





http://rmgsc.cr.usgs.gov/uas/products.shtml


W Shoemaker Island Rd
River Rd
28
32
110th Rd
735 m
© 2016 Google
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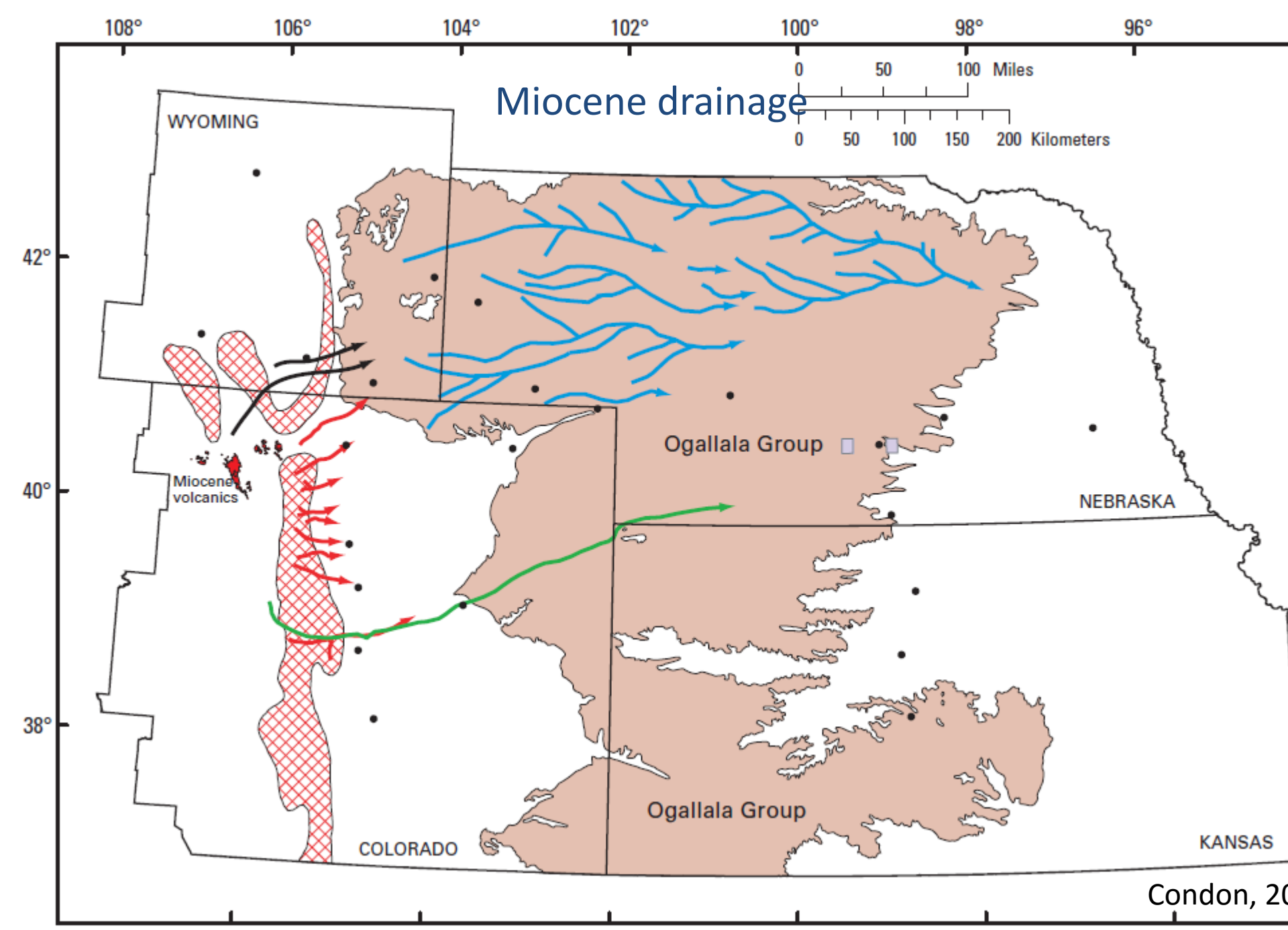
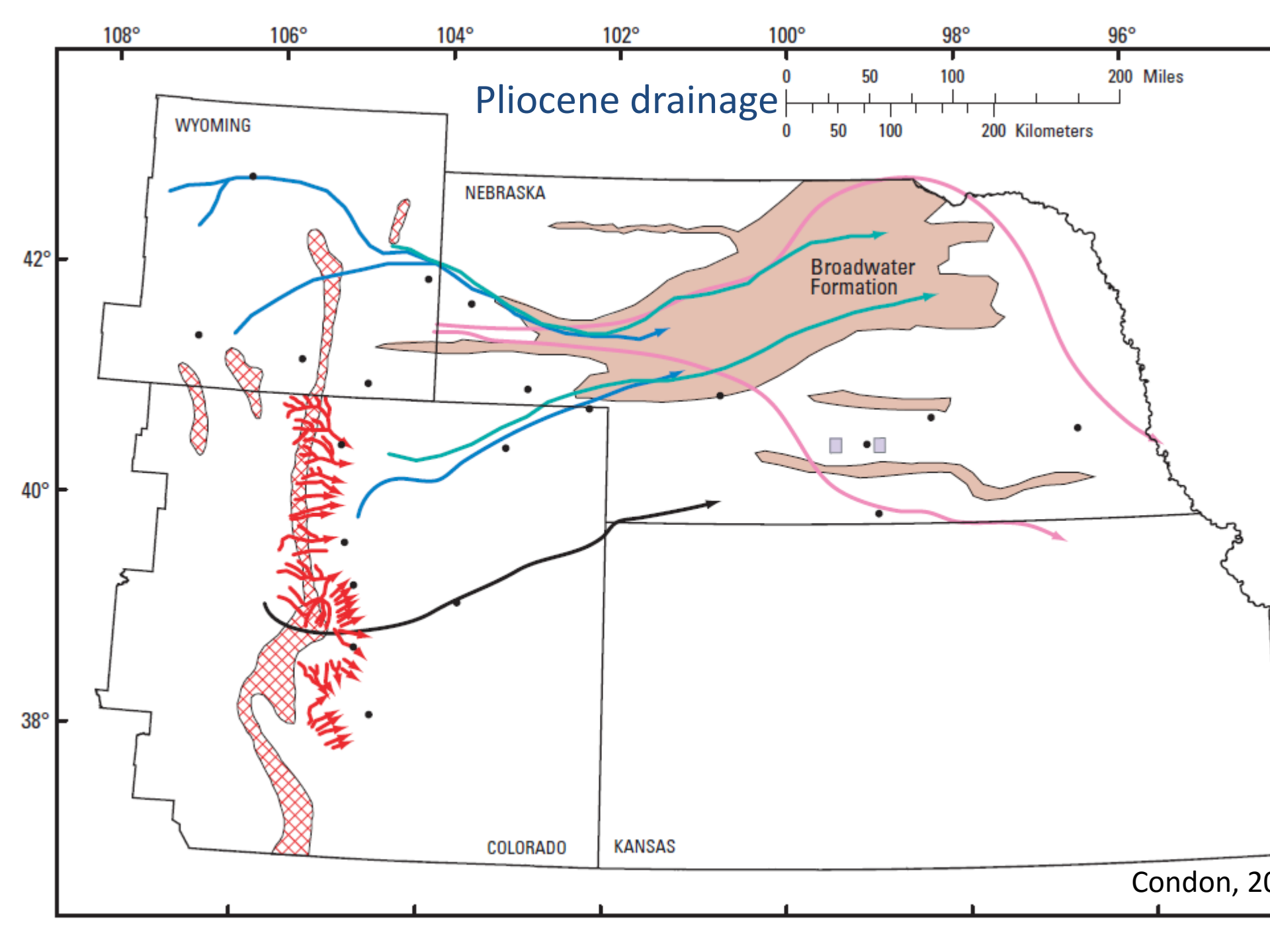
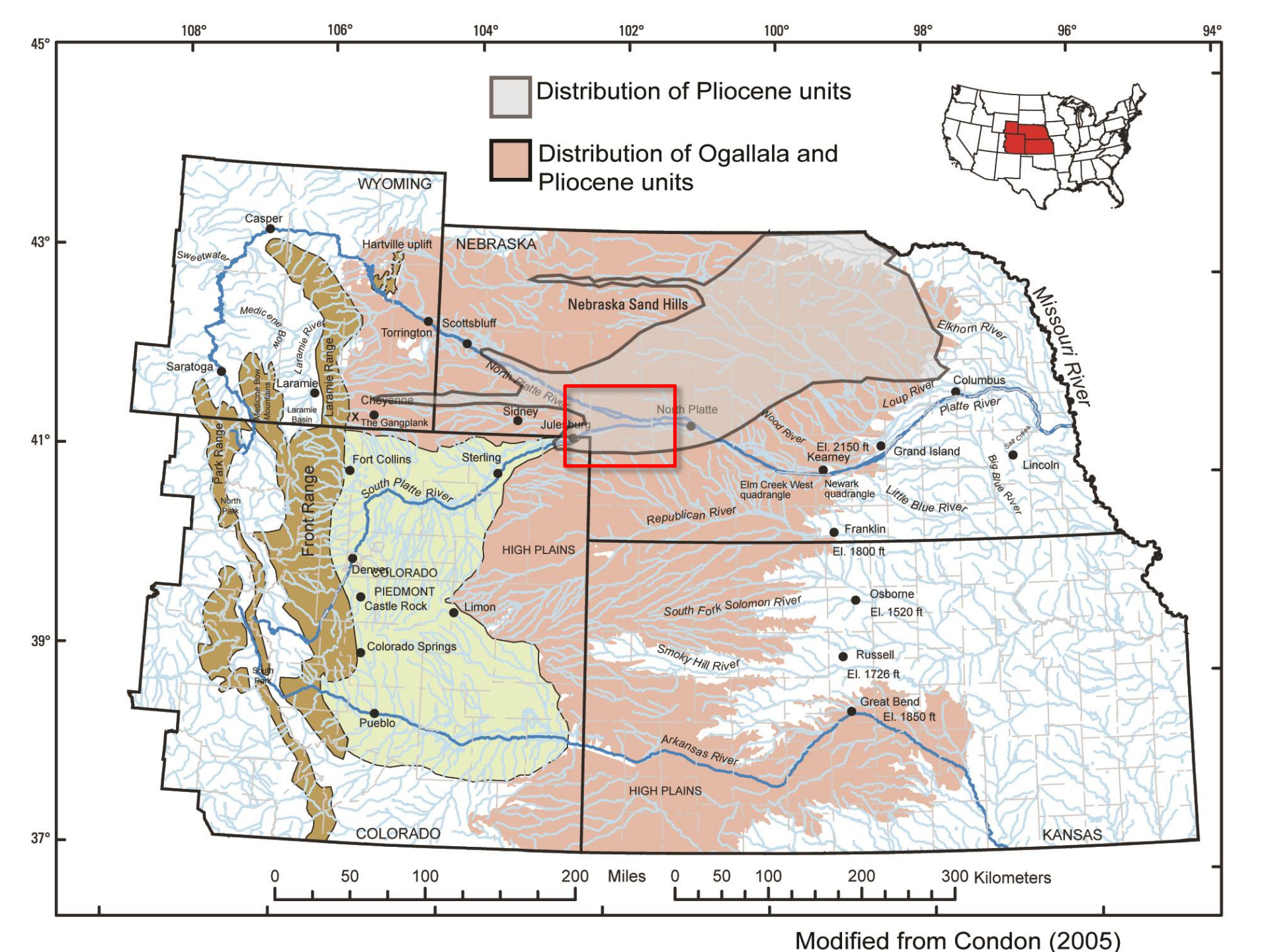
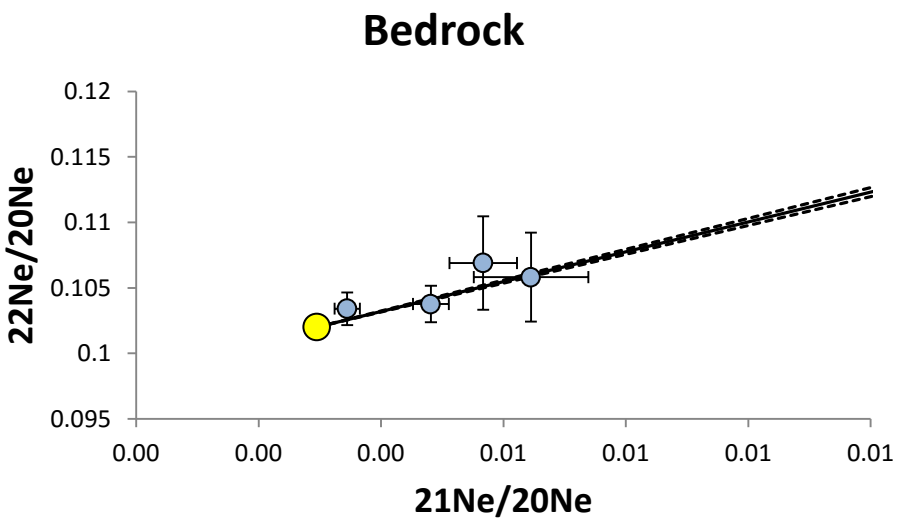
Imagery Date: 4/22/2016
lat 40.754305° lon -98.531902° elev 591 m
Eye alt 3.77 km

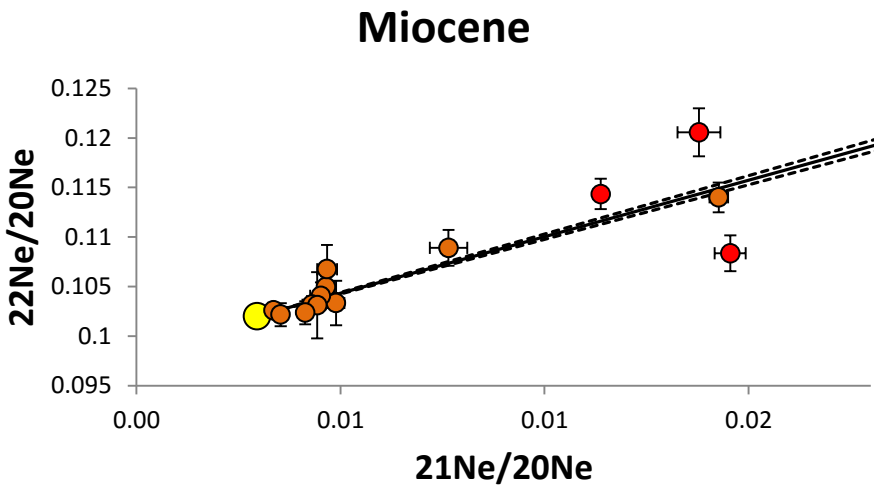

Miocene drainage
108°
106°
104°
102°
100°
98°
96°
42°
40°
38°
0 50 100 Miles
0 50 100 150 200 Kilometers
WYOMING
Ogallala Group
Miocene volcanics
NEBRASKA
COLORADO
Ogallala Group
KANSAS
Condon, 20

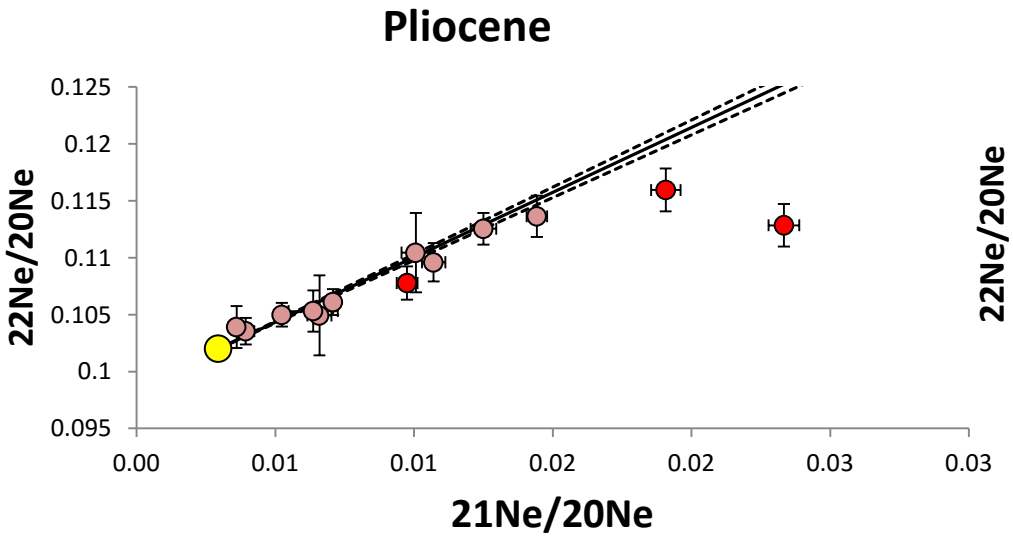

Pliocene drainage
108°
106°
104°
102°
100°
98°
96°
42°
40°
38°
0 50 100 200 Miles
0 50 100 200 Kilometers
WYOMING
NEBRASKA
Broadwater Formation
COLORADO
KANSAS
Condon, 20

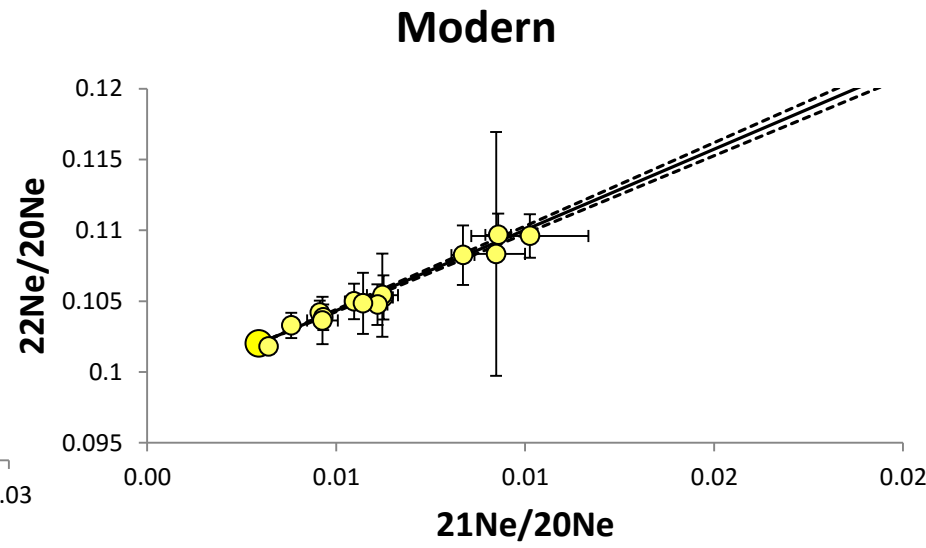

Distribution of Pliocene units
Distribution of Ogallala and Pliocene units
108°
106°
104°
102°
100°
98°
96°
94°
45°
43°
41°
39°
37°
WYOMING
NEBRASKA
COLORADO
KANSAS
Casper
Hartville uplift
Nebraska Sand Hills
Scottsbluff
Torrington
Saratoga
Laramie
Cheyenne
The Gangplank
Sidney
Julesburg
North Platte
Columbus
Grand Island
Kearney
Lincoln
Fort Collins
Sterling
Denver
Castle Rock
Limon
Colorado Springs
Pueblo
Franklin
El. 1800 ft
Osborne
El. 1520 ft
Russell
El. 1726 ft
Great Bend
El. 1850 ft
El. 2150 ft
Elm Creek West quadrangle
Newark quadrangle
Front Range
Park Range
Laramie Range
Medicine Bow Mountains
Laramie Basin
North Park
South Park
HIGH PLAINS
PIEDMONT
Sweetwater
Medicine Bow
Laramie River
North Platte River
South Platte River
Republican River
Loup River
Platte River
Wood River
Elkhorn River
Missouri River
Salt Creek
Big Blue River
Little Blue River
South Fork Solomon River
Smoky Hill River
Arkansas River
0 50 100 200 Miles
0 50 100 200 300 Kilometers
Modified from Condon (2005)

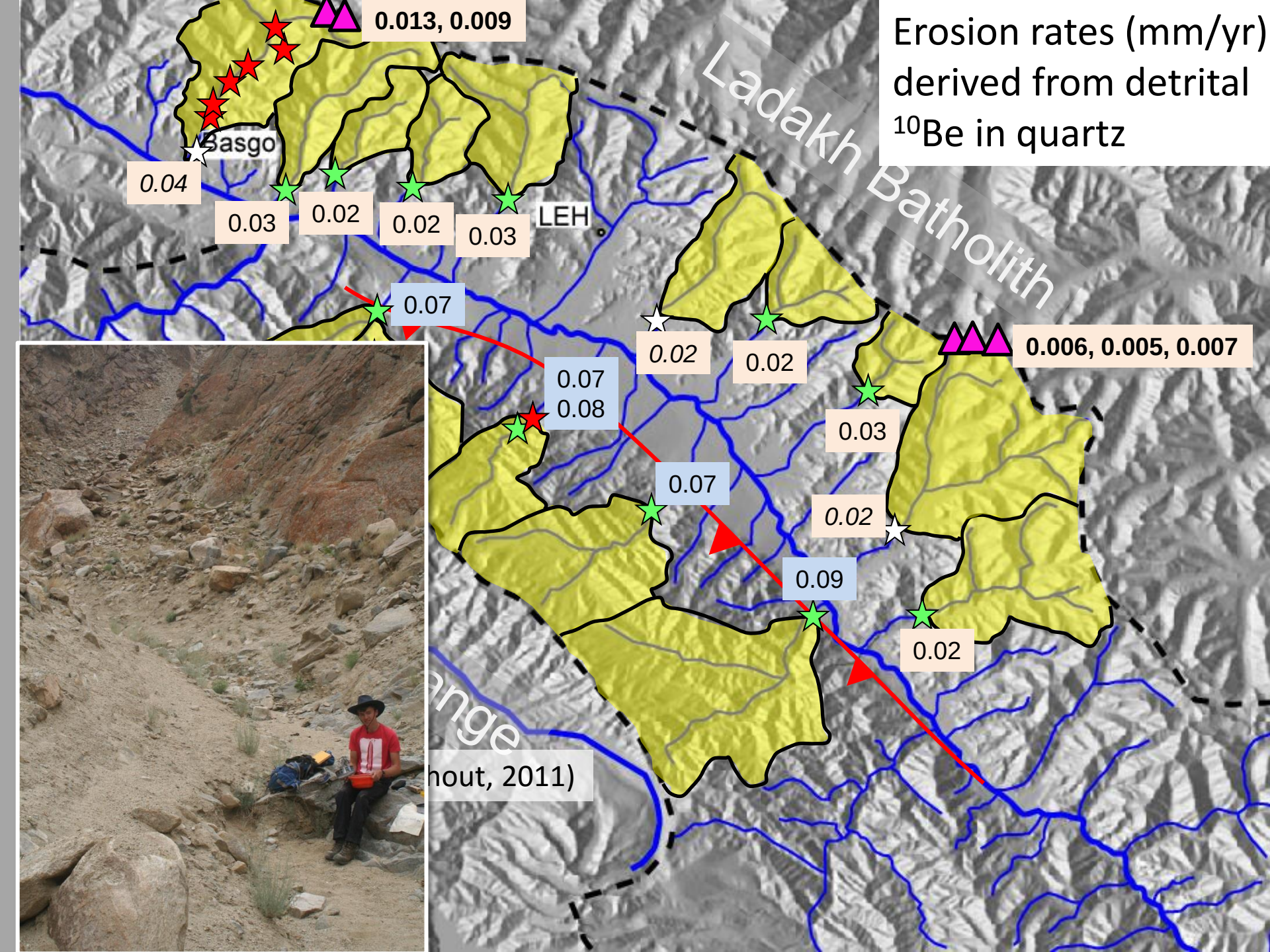
Results


Bedrock
22Ne/20Ne
21Ne/20Ne
0.12
0.115
0.11
0.105
0.1
0.095
0.00
0.00
0.00
0.01
0.01
0.01
0.01


Miocene
22Ne/20Ne
21Ne/20Ne
0.125
0.12
0.115
0.11
0.105
0.1
0.095
0.00
0.01
0.01
0.02


Pliocene
22Ne/20Ne
21Ne/20Ne
0.125
0.12
0.115
0.11
0.105
0.1
0.095
0.00
0.01
0.01
0.02
0.02
0.03
0.03


Modern
22Ne/20Ne
21Ne/20Ne
0.12
0.115
0.11
0.105
0.1
0.095
0.00
0.01
0.01
0.02
0.02


Erosion rates (mm/yr) derived from detrital ^{10}Be in quartz
Ladakh Batholith
0.013, 0.009
Basgo
0.04
0.03
0.02
0.02
0.03
LEH
0.07
0.07
0.08
0.02
0.02
0.006, 0.005, 0.007
0.03
0.07
0.02
0.09
0.02
hout, 2011)