



Berkeley  
Geochronology Center  
2455 Ridge Road, Berkeley CA 94709 USA  
<http://www.bgc.org>

**INTERCALIBRATED  
RADIOCARBON  
AND EXPOSURE-AGE  
CHRONOLOGIES  
FOR  
THE LAST GLACIAL MAXIMUM  
AND INITIAL DEGLACIATION  
IN  
SOUTHERN NEW ENGLAND**

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**GREG BALCO** Berkeley Geochronology Center

**PAUL BIERMAN** University of Vermont

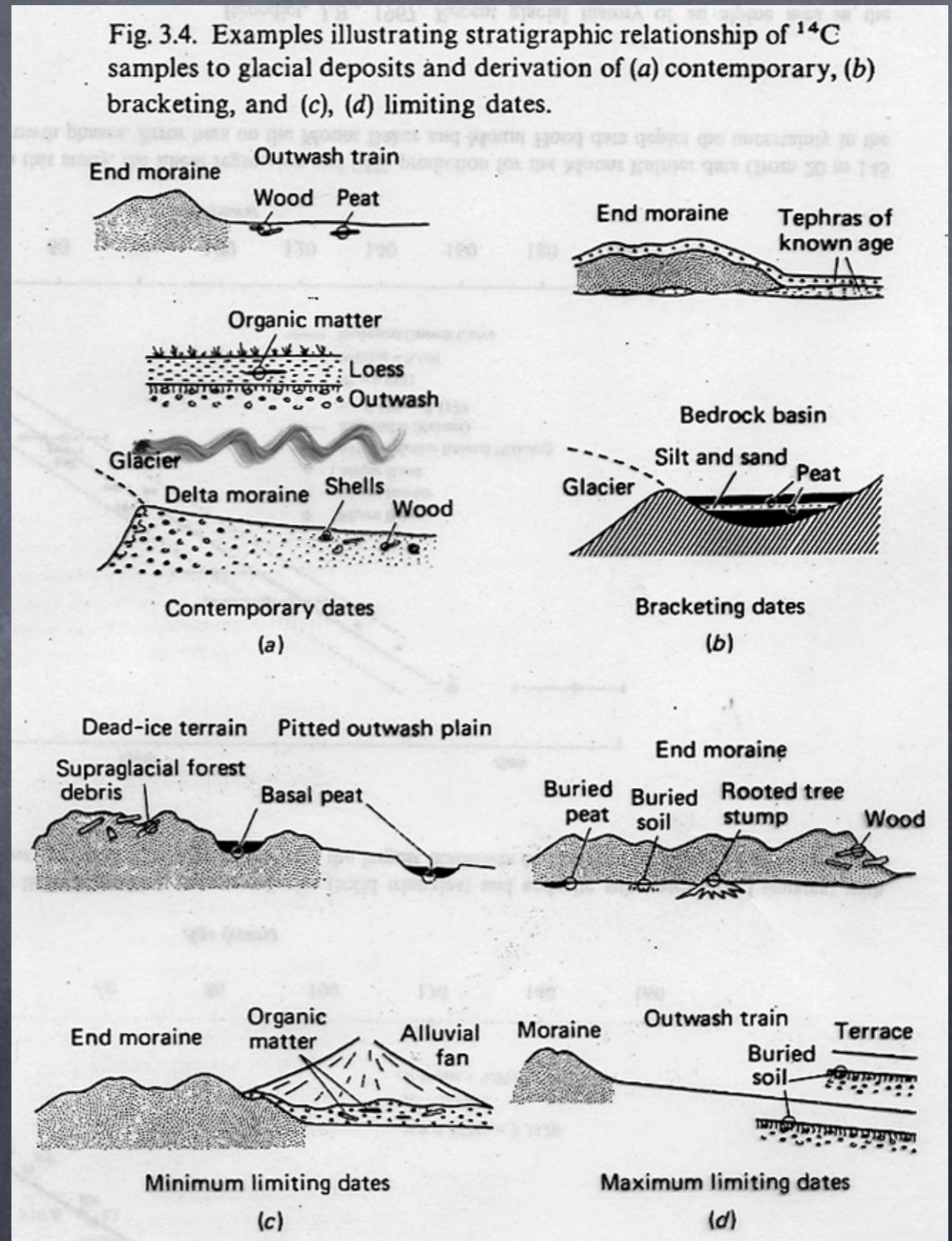
**JOERG SCHAEFER** Lamont-Doherty Earth Observatory

**with assistance from many others to be named later in the talk.**

# Deglaciation chronology of New England

Basically, in New England there are four ways to figure out when deglaciation happened.

## 1. Terrestrial C-14 ages.



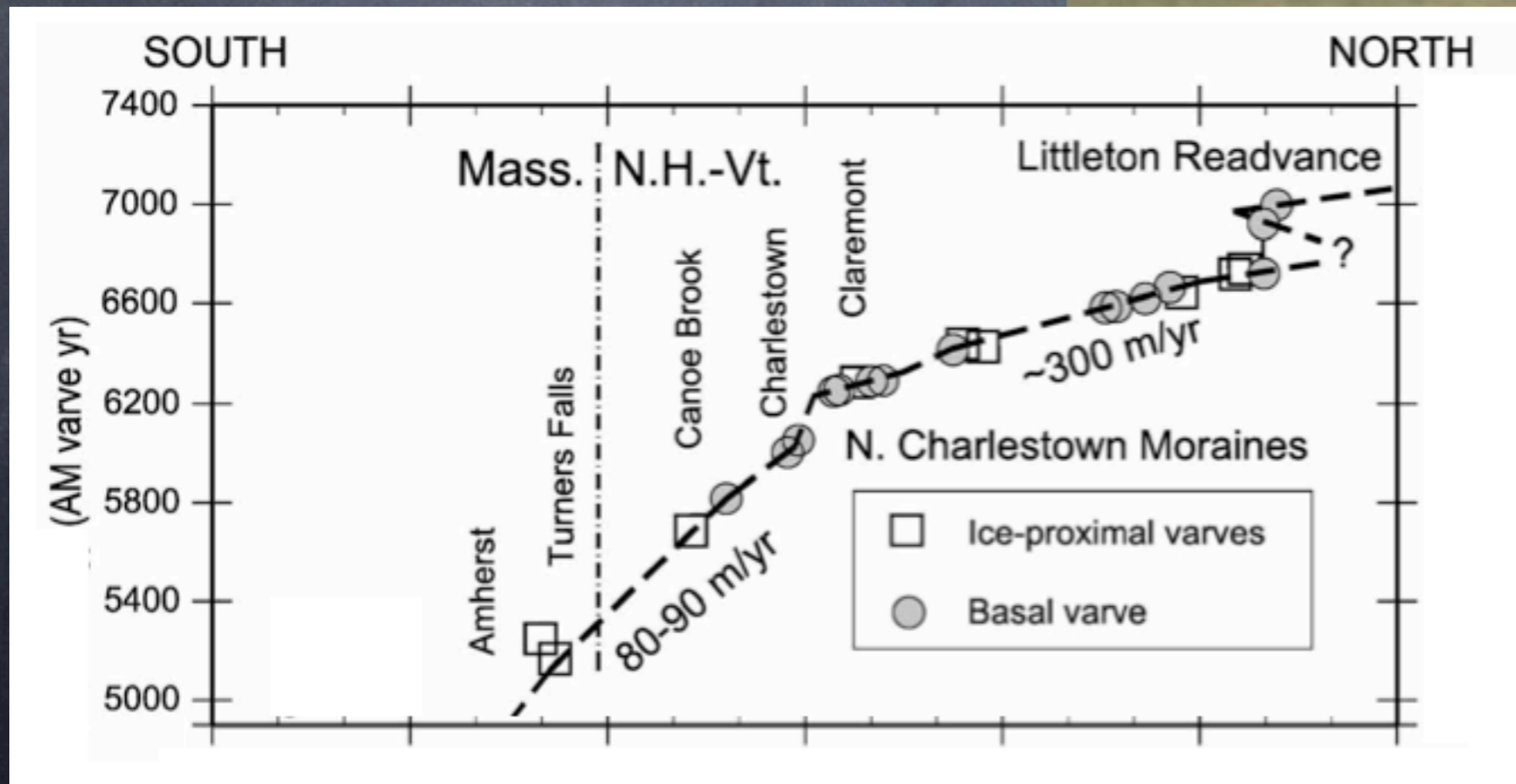
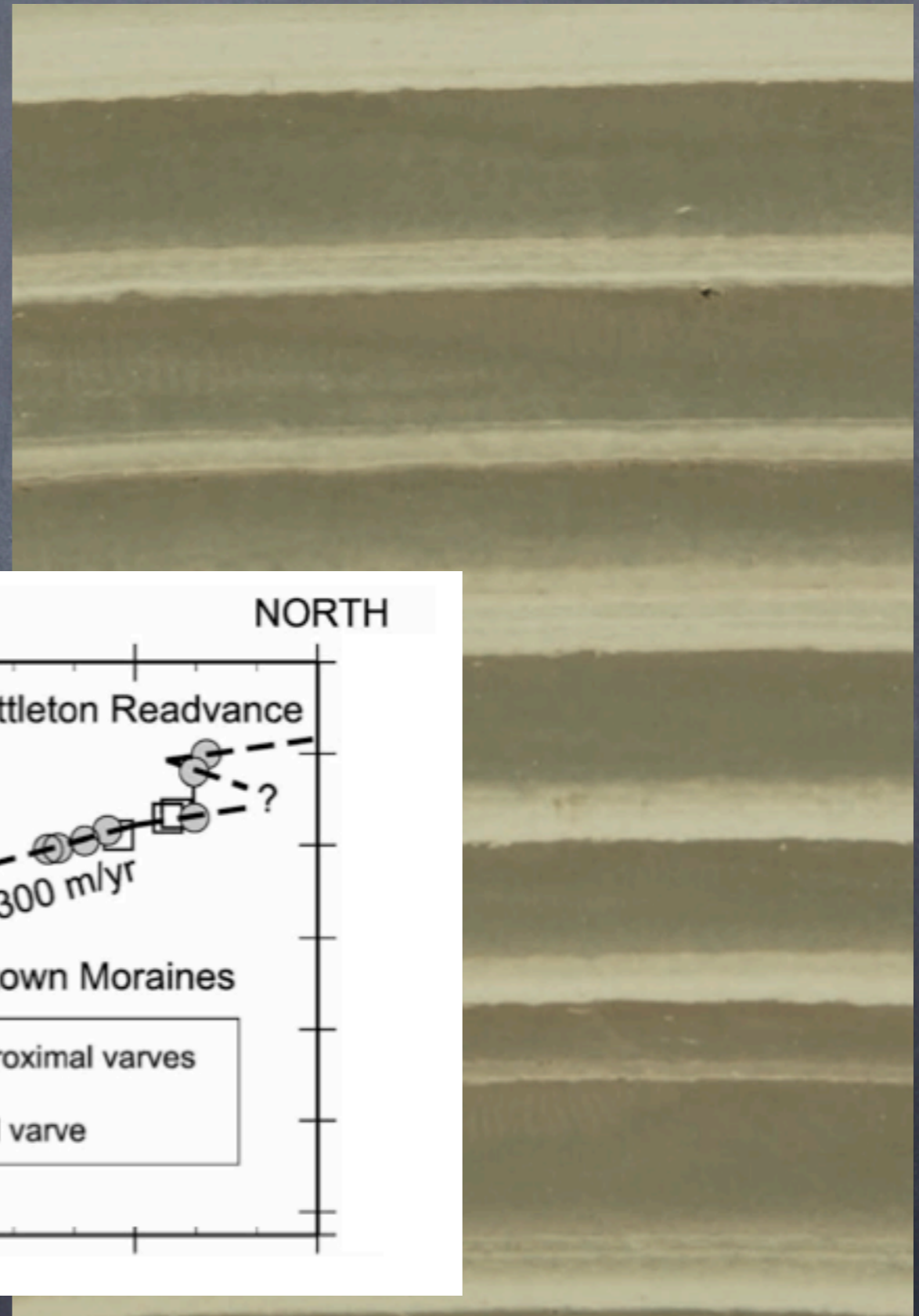
from Steve Porter

# Deglaciation chronology of New England

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1. Terrestrial C-14 ages.

2. Varve chronology



# *Deglaciation chronology of New England*

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- 1. Terrestrial C-14 ages.*
- 2. Varve chronology*
- 3. Marine C-14 ages.*



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- 1. Terrestrial C-14 ages.*
- 2. Varve chronology*
- 3. Marine C-14 ages.*
- 4. Cosmogenic-nuclide exposure dating.*



# *Deglaciation chronology of New England*

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*Basically, in New England there are four ways to figure out when deglaciation happened.*

- 1. Terrestrial C-14 ages.*
- 2. Varve chronology*
- 3. Marine C-14 ages.*
- 4. Cosmogenic-nuclide exposure dating.*

*Each one of these has their own independently calibrated parameter(s) to calibrate observations to absolute ages.*

- 1. Atmospheric calibration curve*
- 2. Varve year - cal yr offset*
- 3. Atmospheric calibration curve PLUS marine reservoir age*
- 4. Cosmogenic-nuclide (e.g., Be-10) production rate.*

# What we are trying to do here

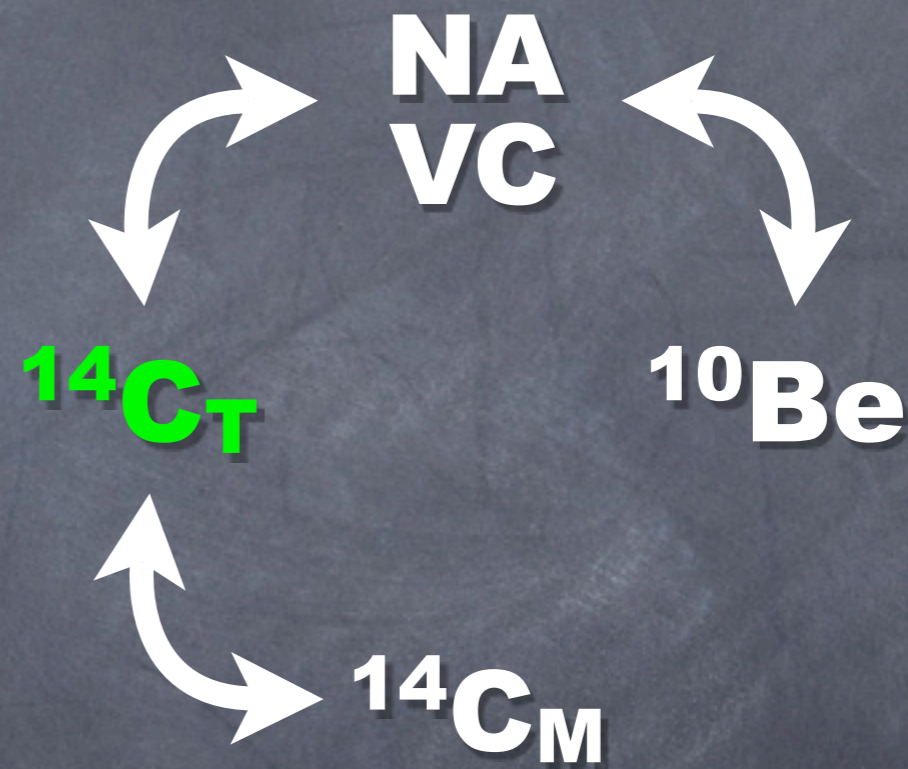
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*Is intercalibrate all these different chronometers*

*so we can apply them all to obtain*

*one single and internally consistent chronology*

*for what happened here in the LGM and late glacial.*

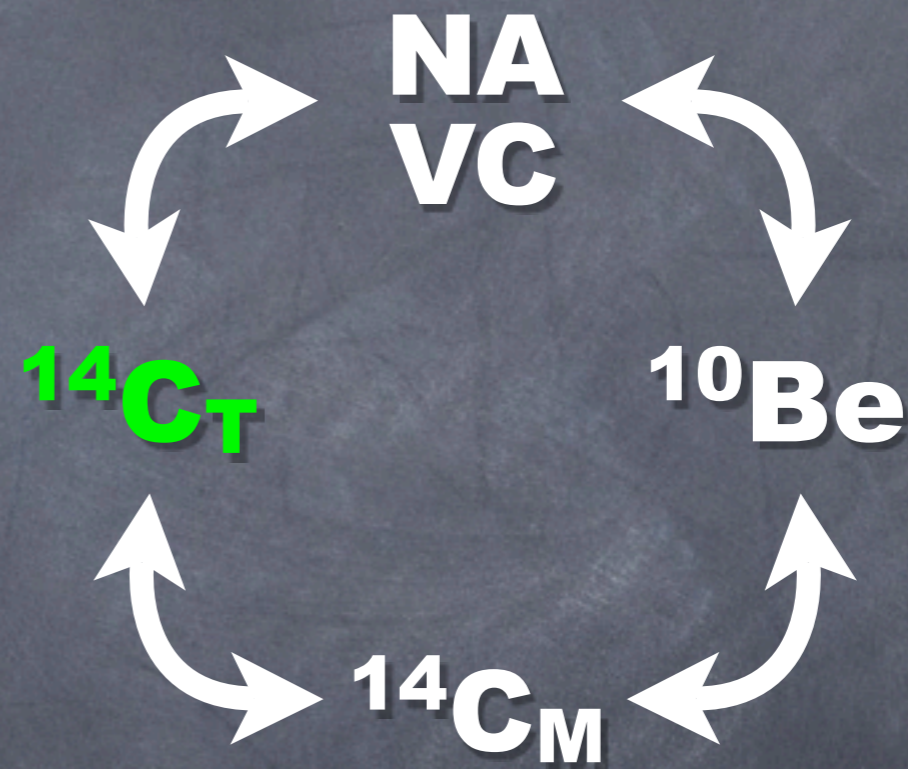


## What we are trying to do here

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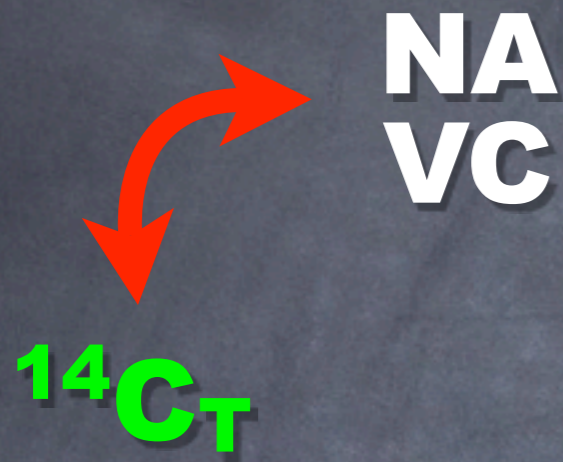
*And what we really want to do is close the loop so we can get the same result going in any direction.*

*So let's see how close we are to that.*

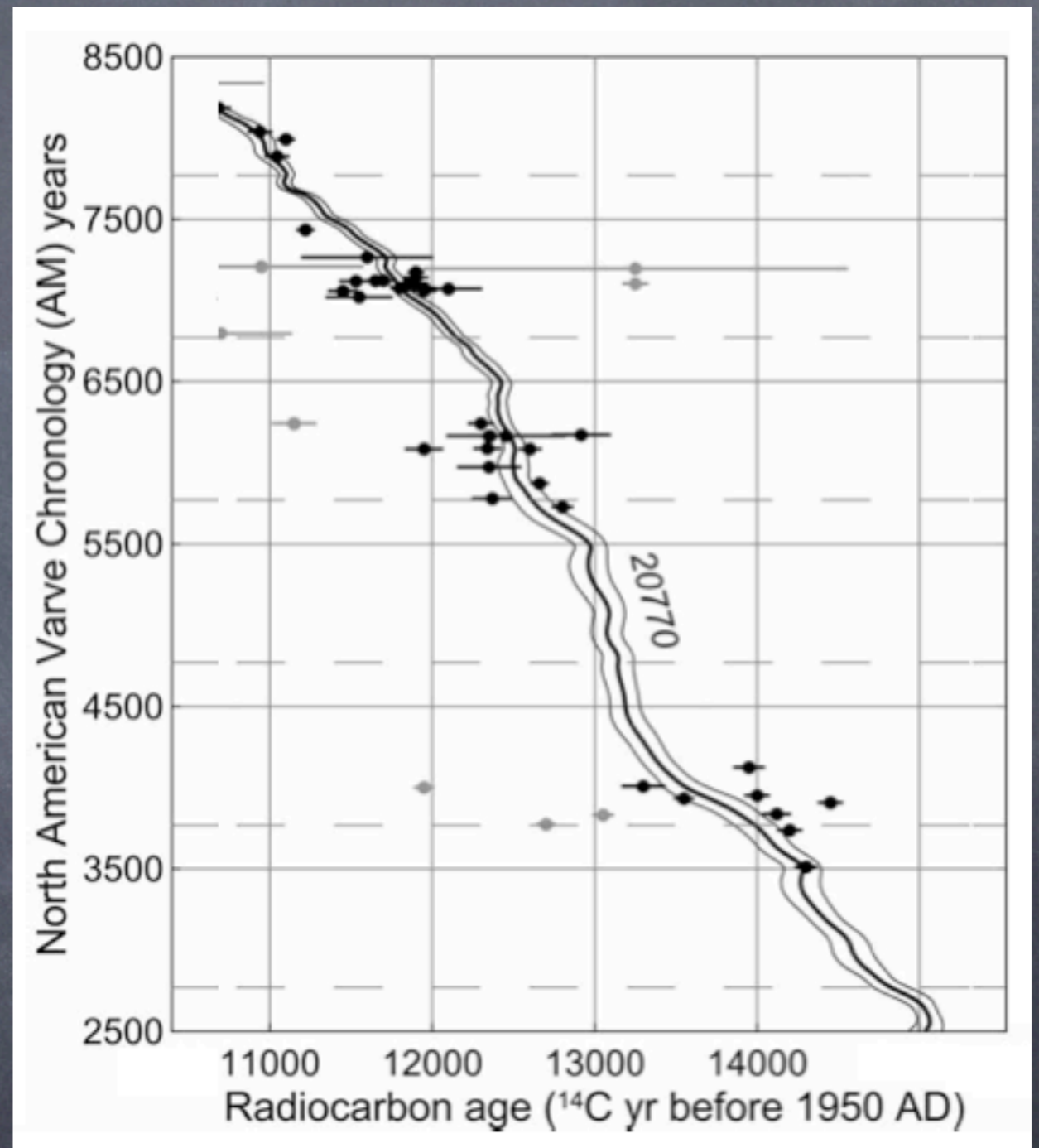




# 1. Terrestrial radiocarbon to NAVC.



*This has been accomplished by Jack Ridge and co-authors by C-14 dating of (many) terrestrial plant macrofossils within individual varves.*



*C-14 ages from NAVC vs. INTCAL09  
(Ridge et al., 2013)*

## 2. Terrestrial radiocarbon and NAVC to Be-10.

*Terminal moraines in southern coastal New England:*

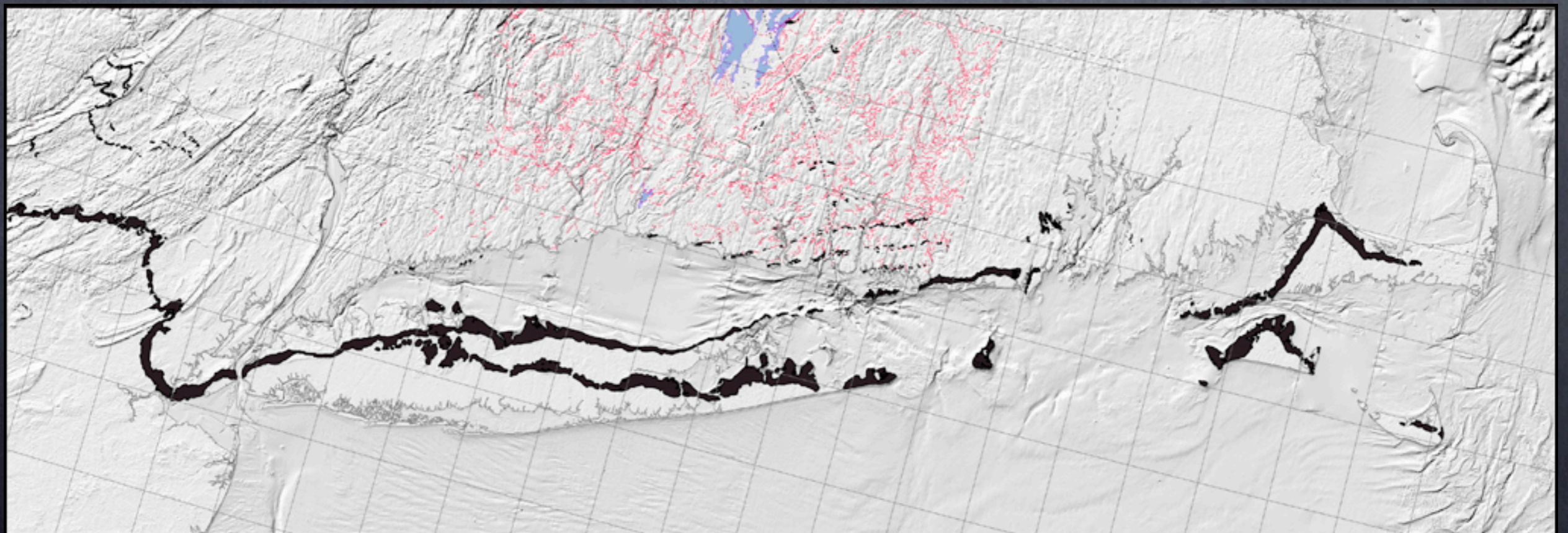
**NA  
VC**



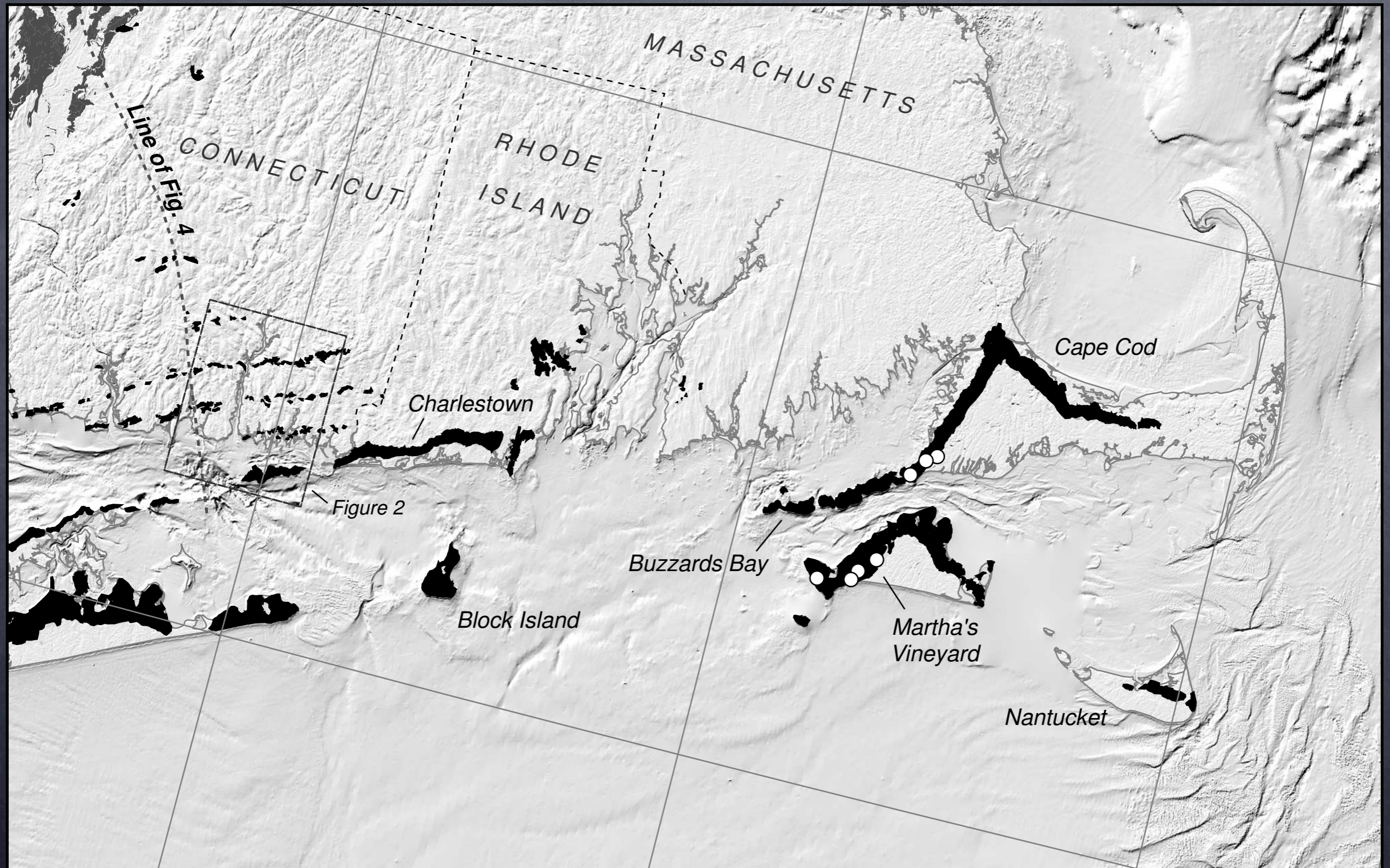
*South/below/older than oldest correlated varves by an unknown amount*

*Only widely bracketed by radiocarbon ages (ca. 17-30 ka)*

*Lots of boulders.*



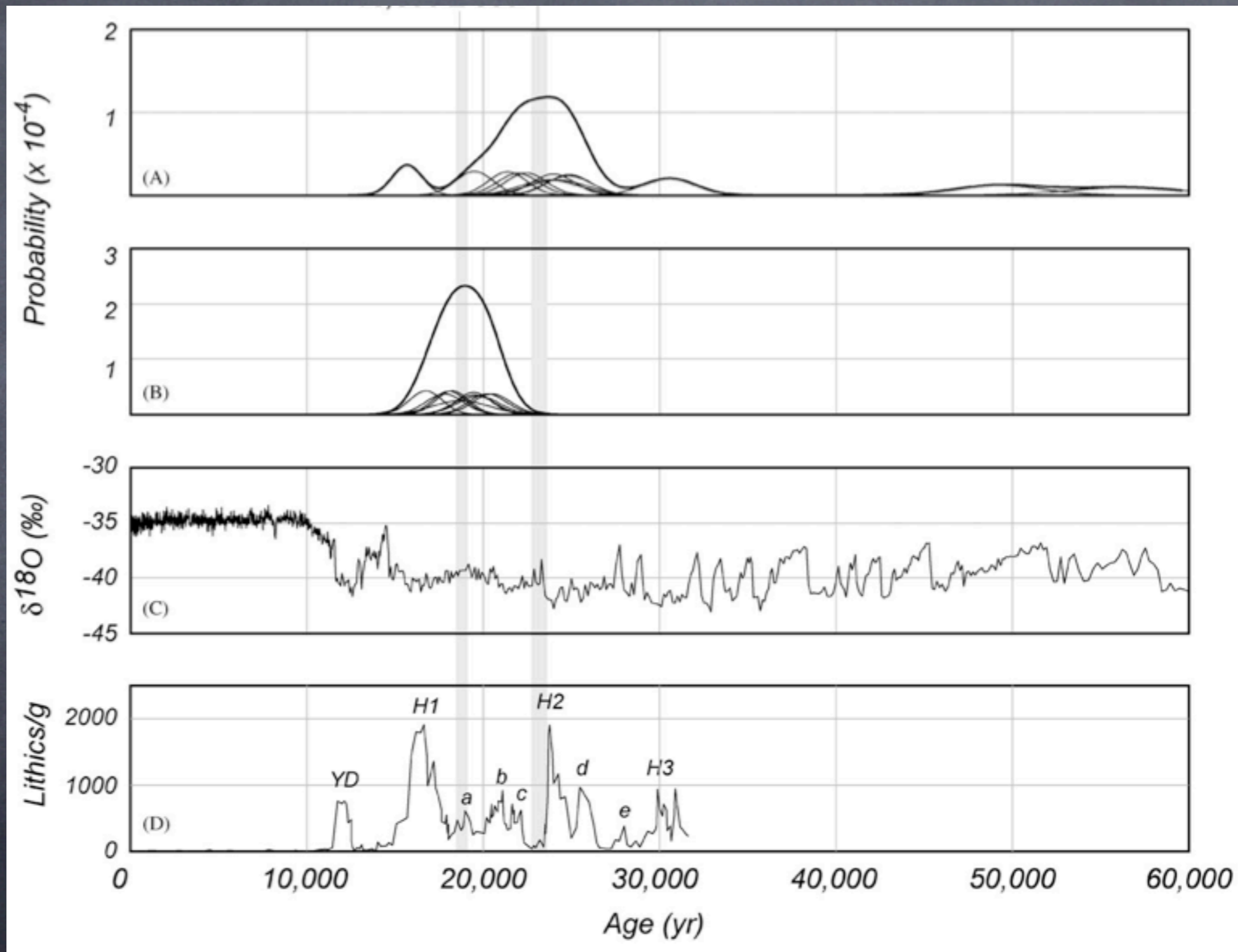
## 2. Terrestrial radiocarbon and NAVC to Be-10.



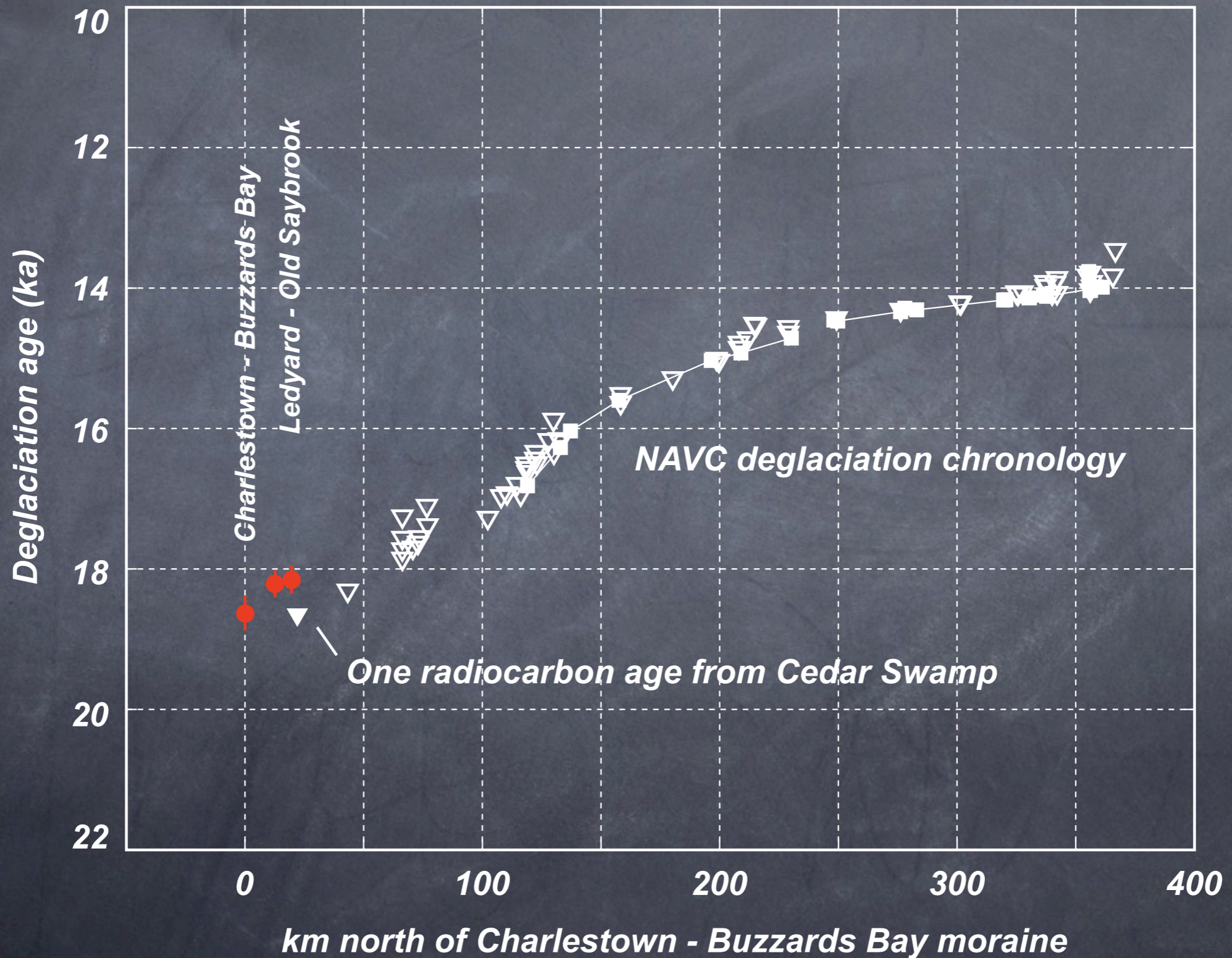
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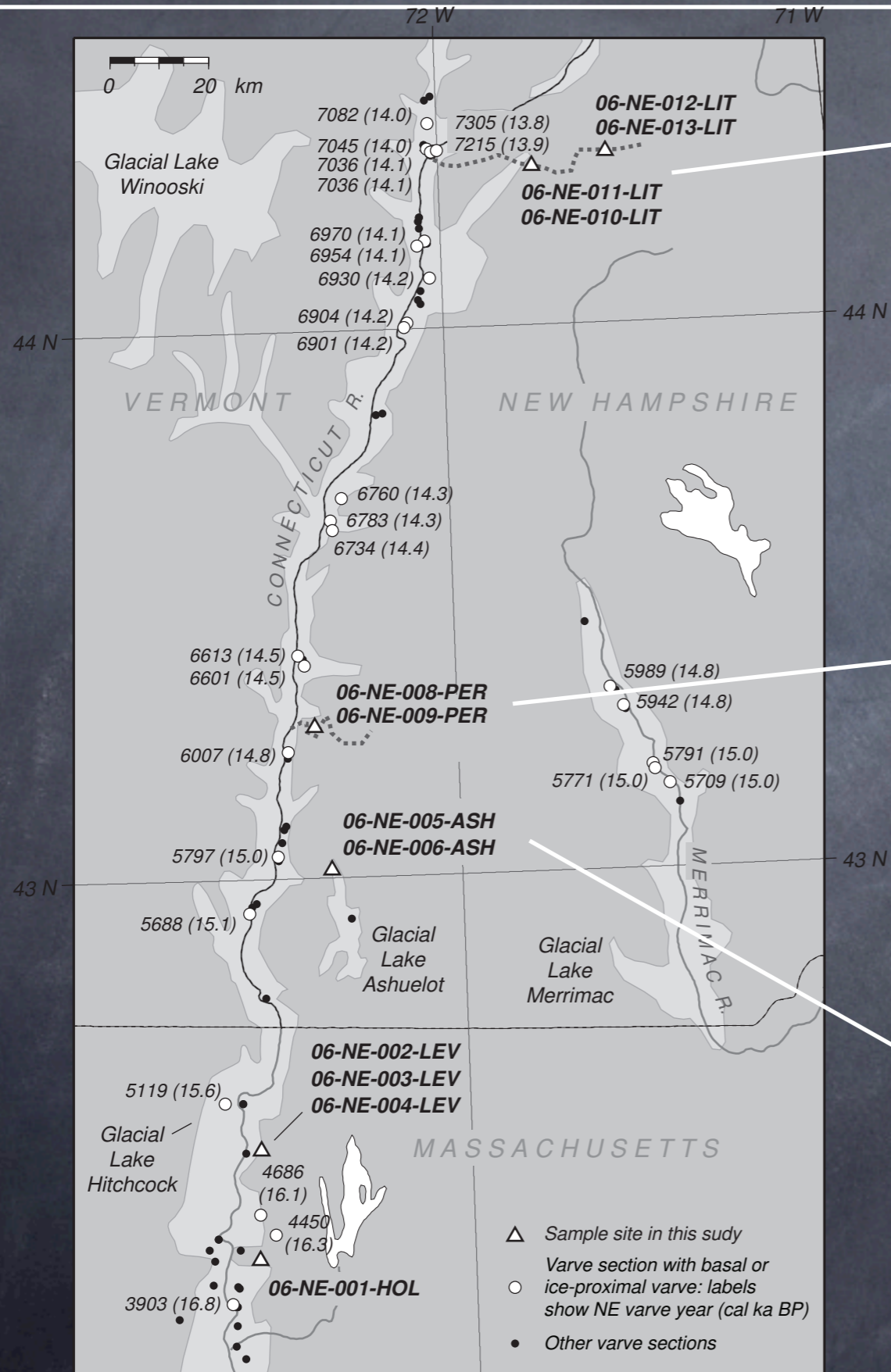
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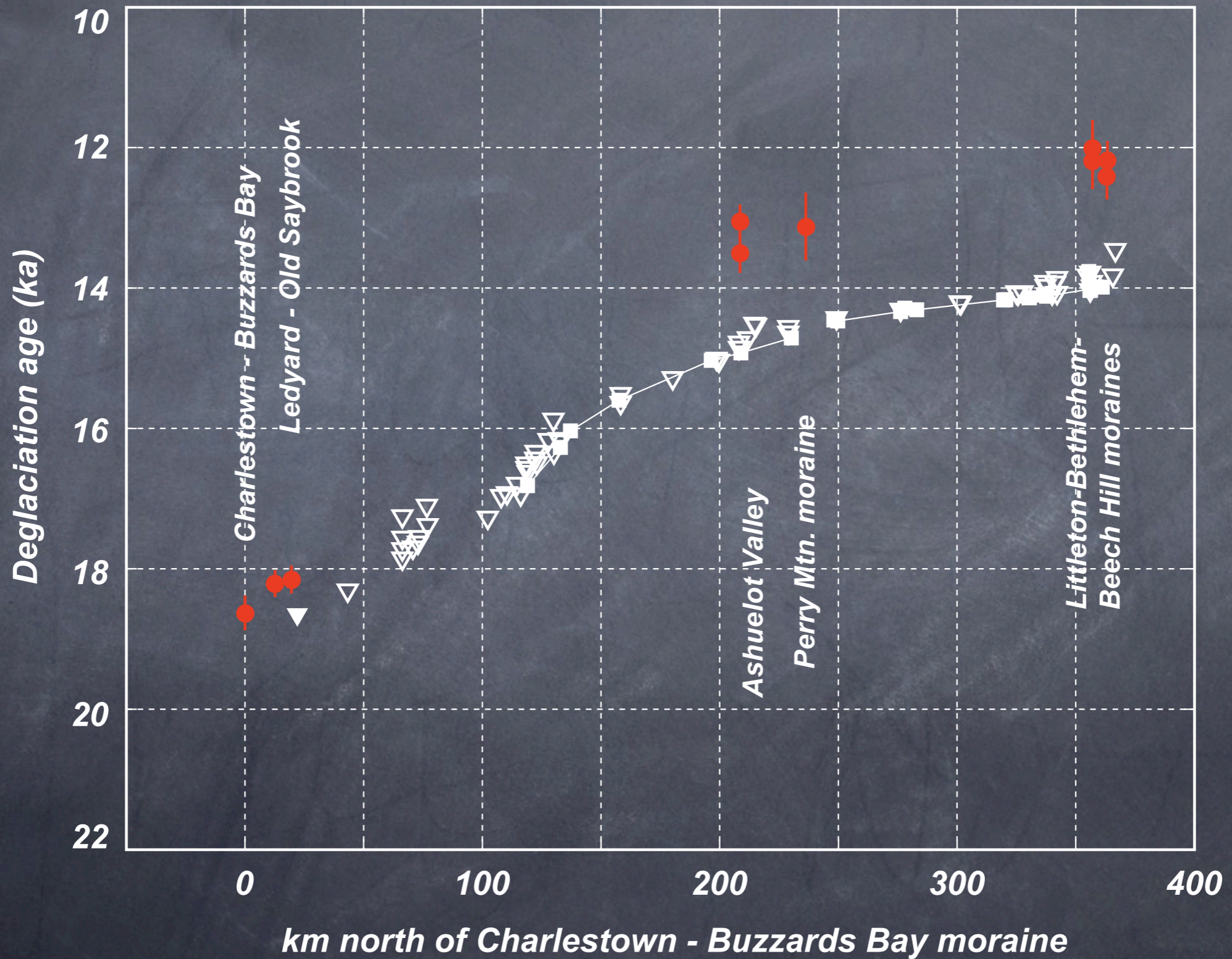
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# 2. Terrestrial C-14 / NAVC to Be-10.

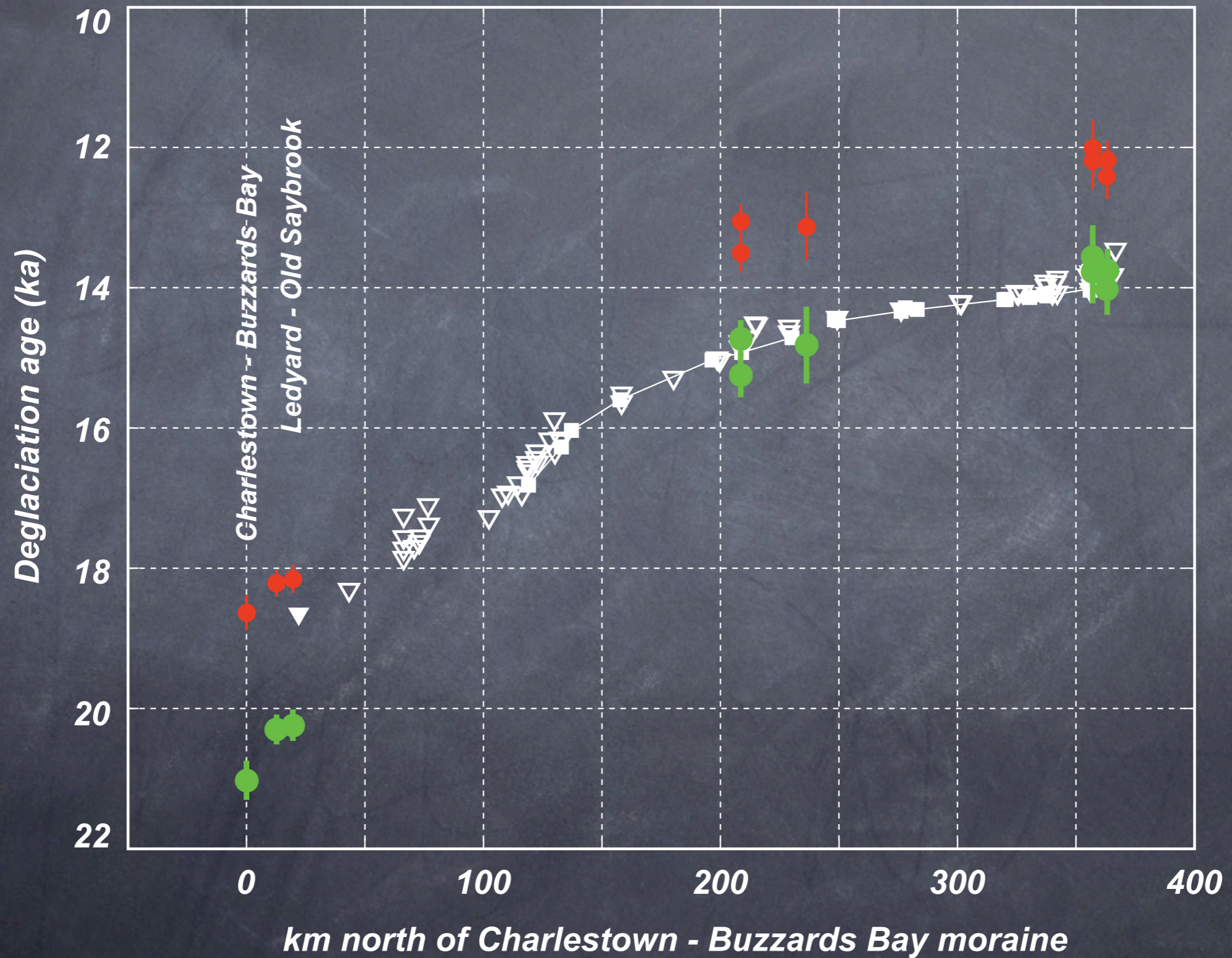


## 2. Terrestrial C-14 / NAVC to Be-10.

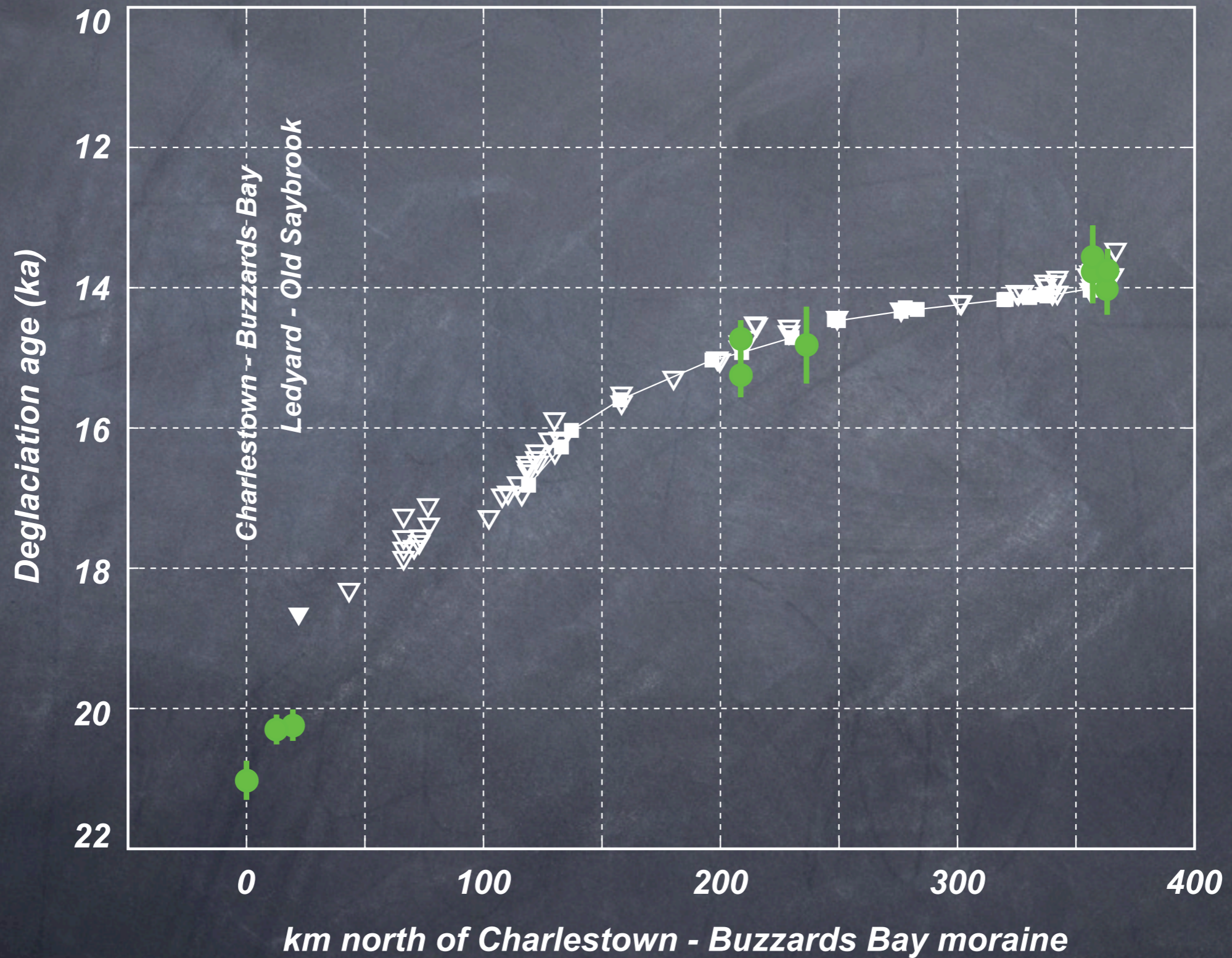




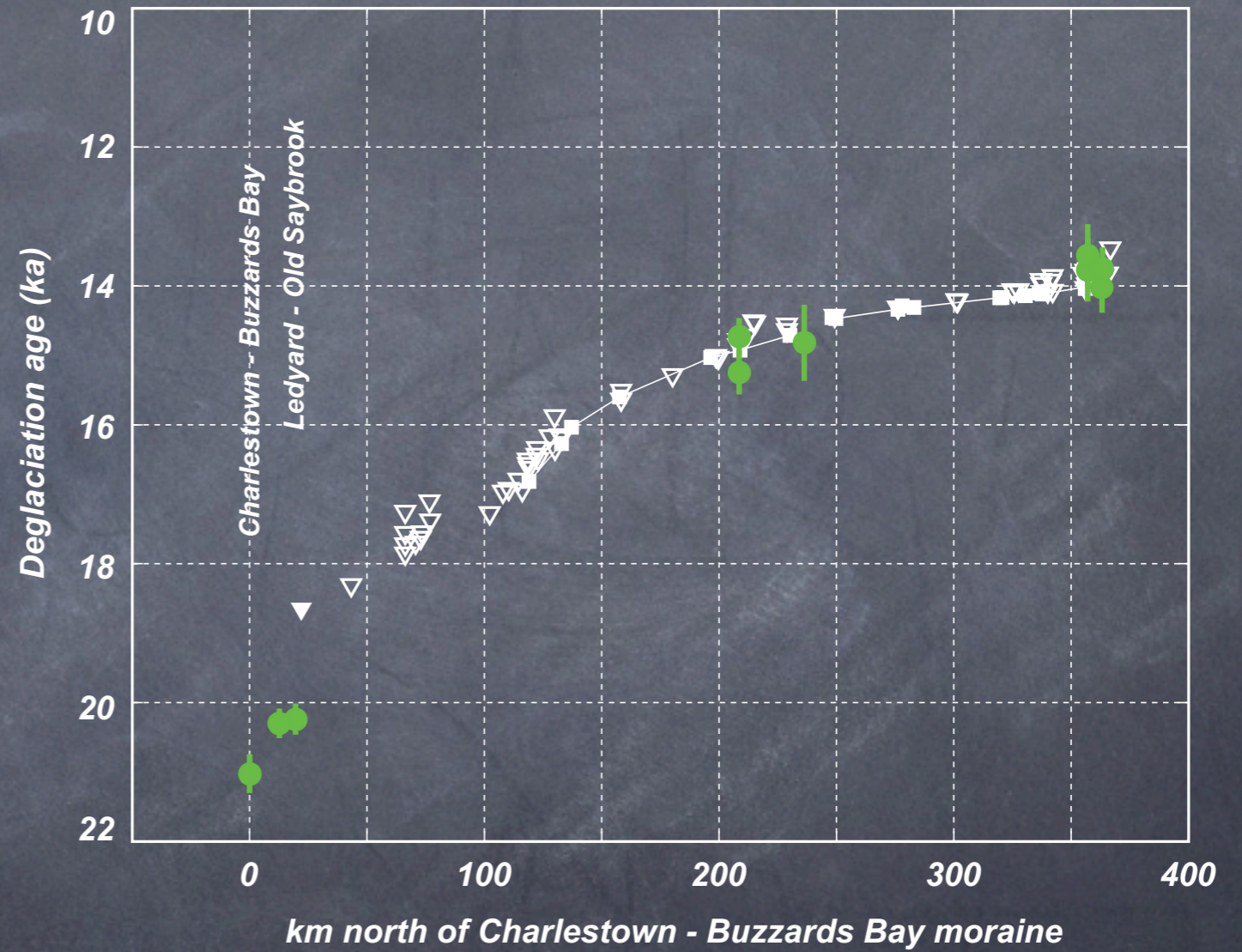
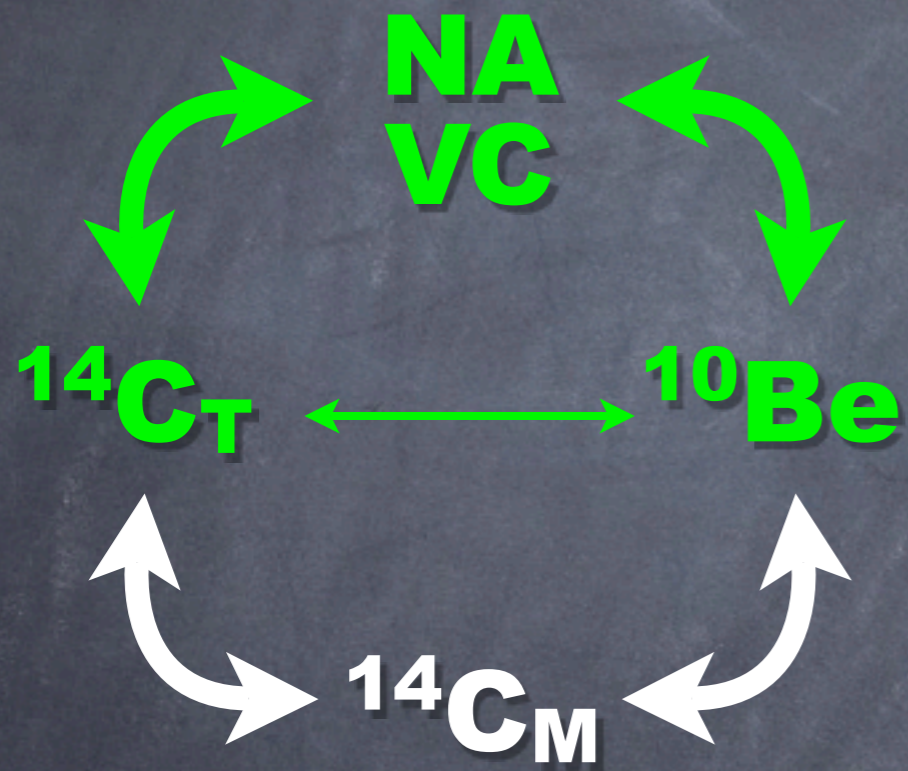
## 2. Terrestrial C-14 / NAVC to Be-10.



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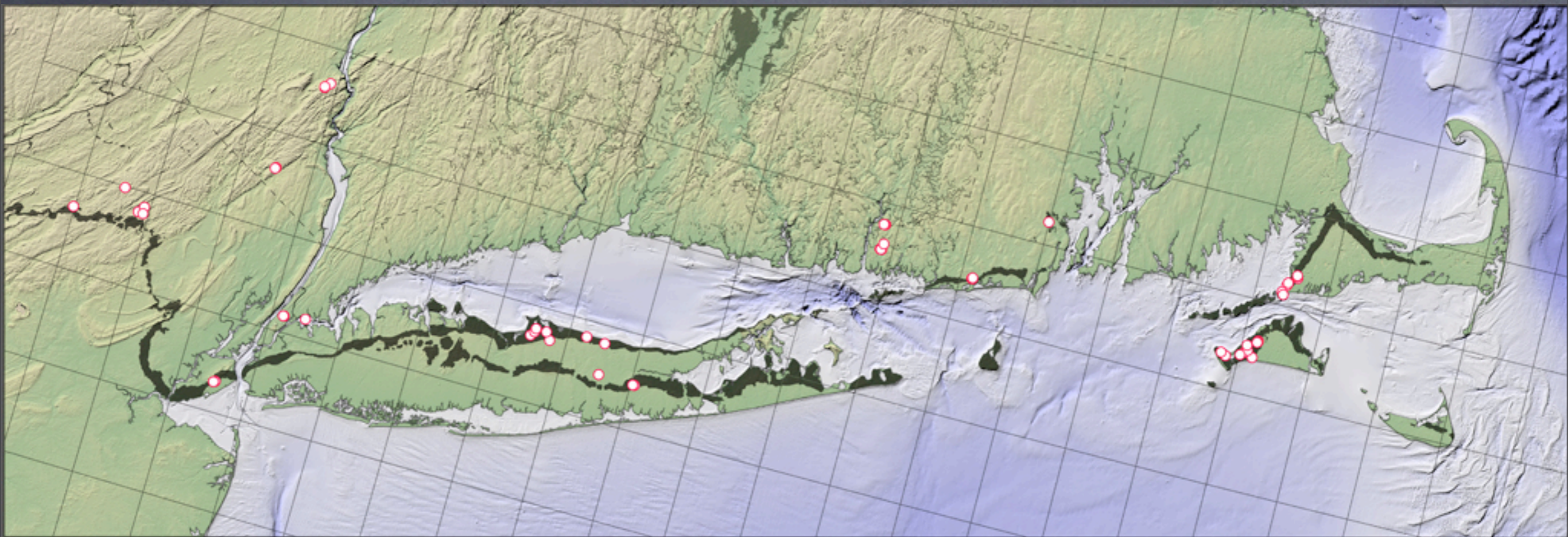
## 2. Terrestrial C-14 / NAVC to Be-10.



### *3. Exposure age chronology for terminal moraine complex.*

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*Various published and unpublished data*



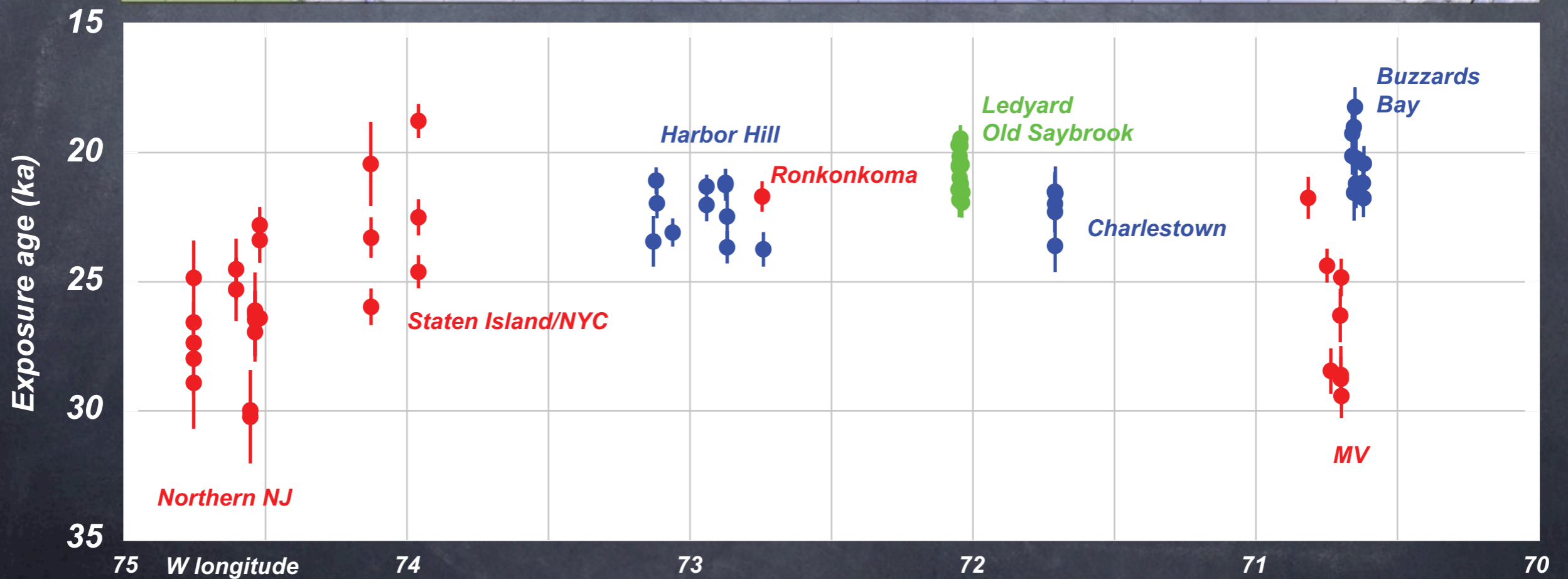
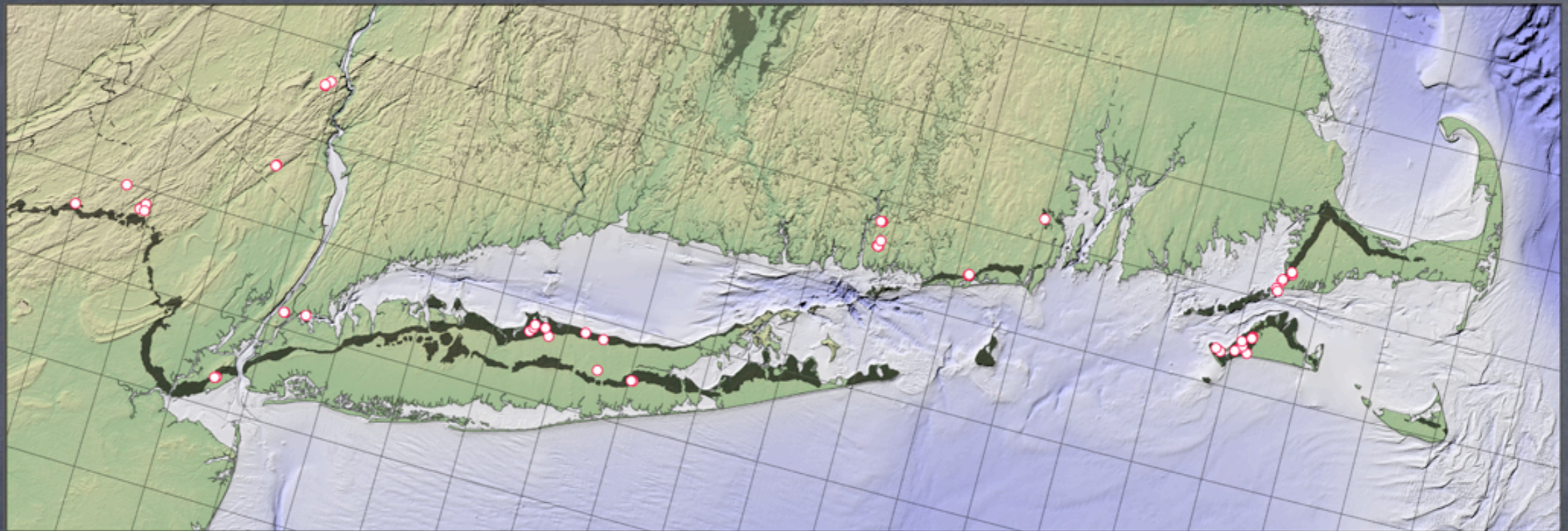
*MV, Cape Cod, eastern CT: published -- Balco, Schaefer, others*

*Northern NJ: semi-published -- Bierman, Larsen, others*

*Charlestown Moraine: unpublished -- Balco, Boothroyd, Oakley*

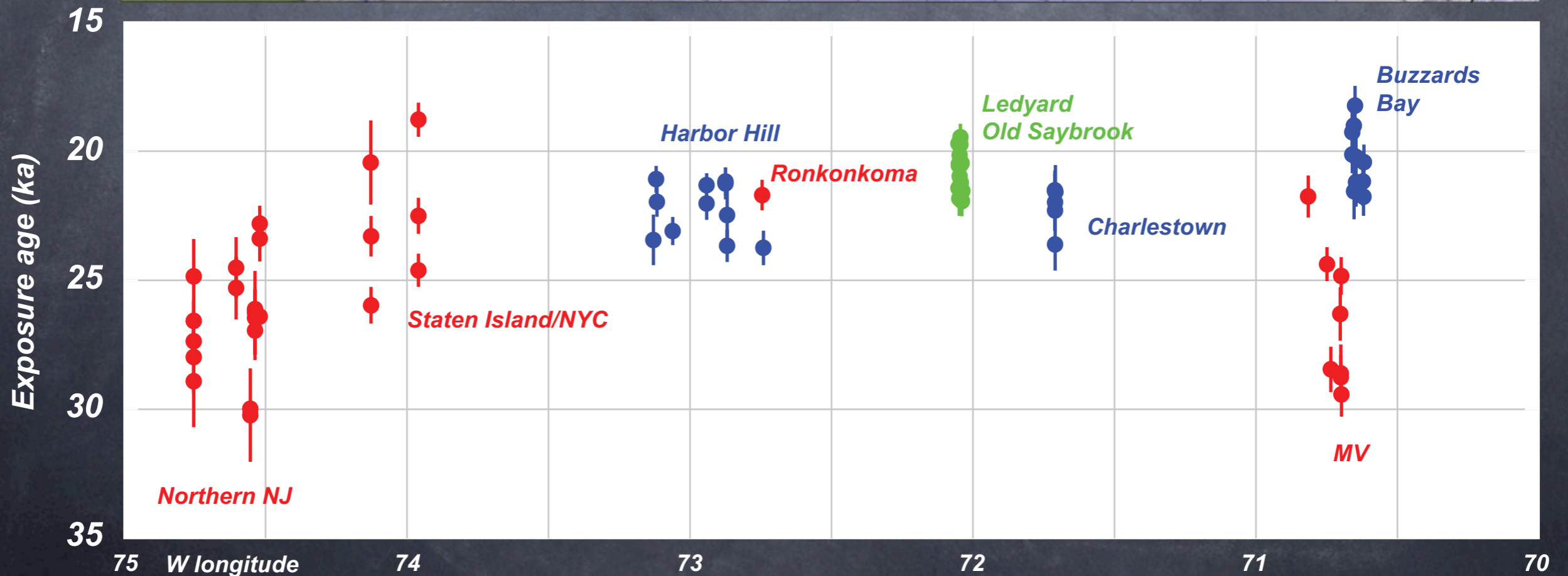
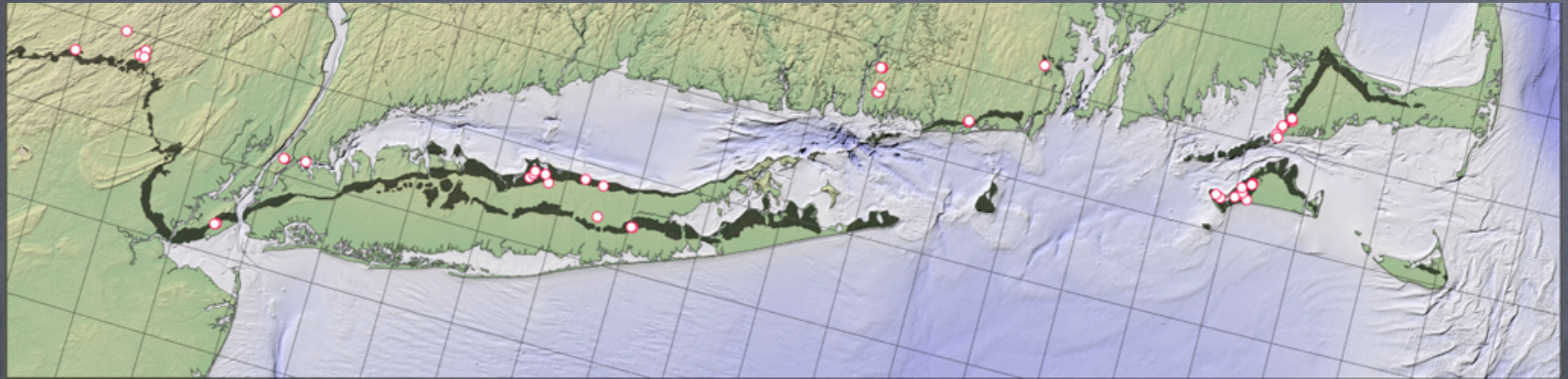
*Long Island: unpublished -- Schaefer, others*

### 3. Exposure age chronology for terminal moraine complex.



# 4. What do we learn from this?

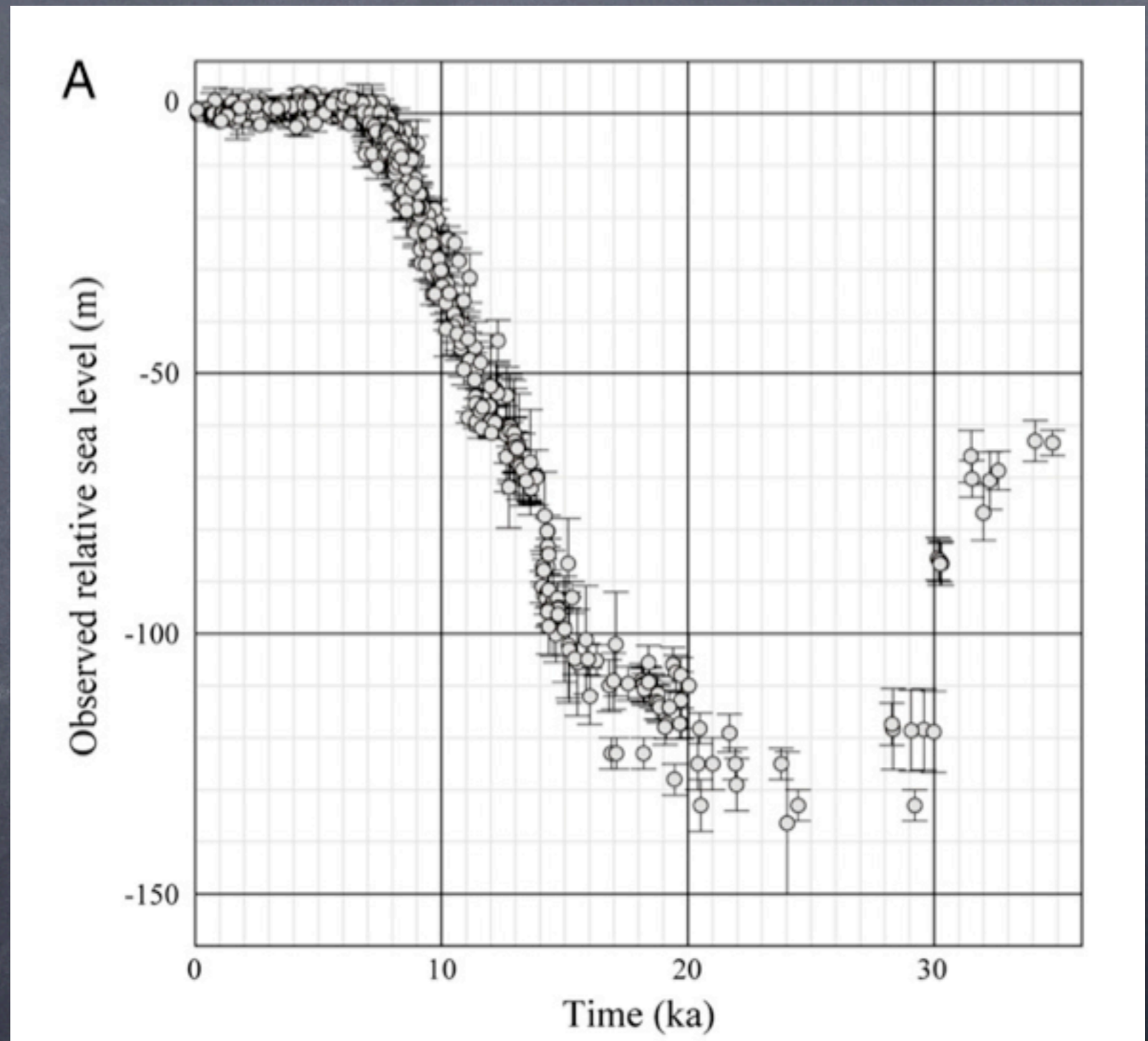
1. Exposure ages from the terminal moraine complex span almost 10 ka.



## 4. What do we learn from this?

1. Exposure ages from the terminal moraine complex span almost 10 ka.

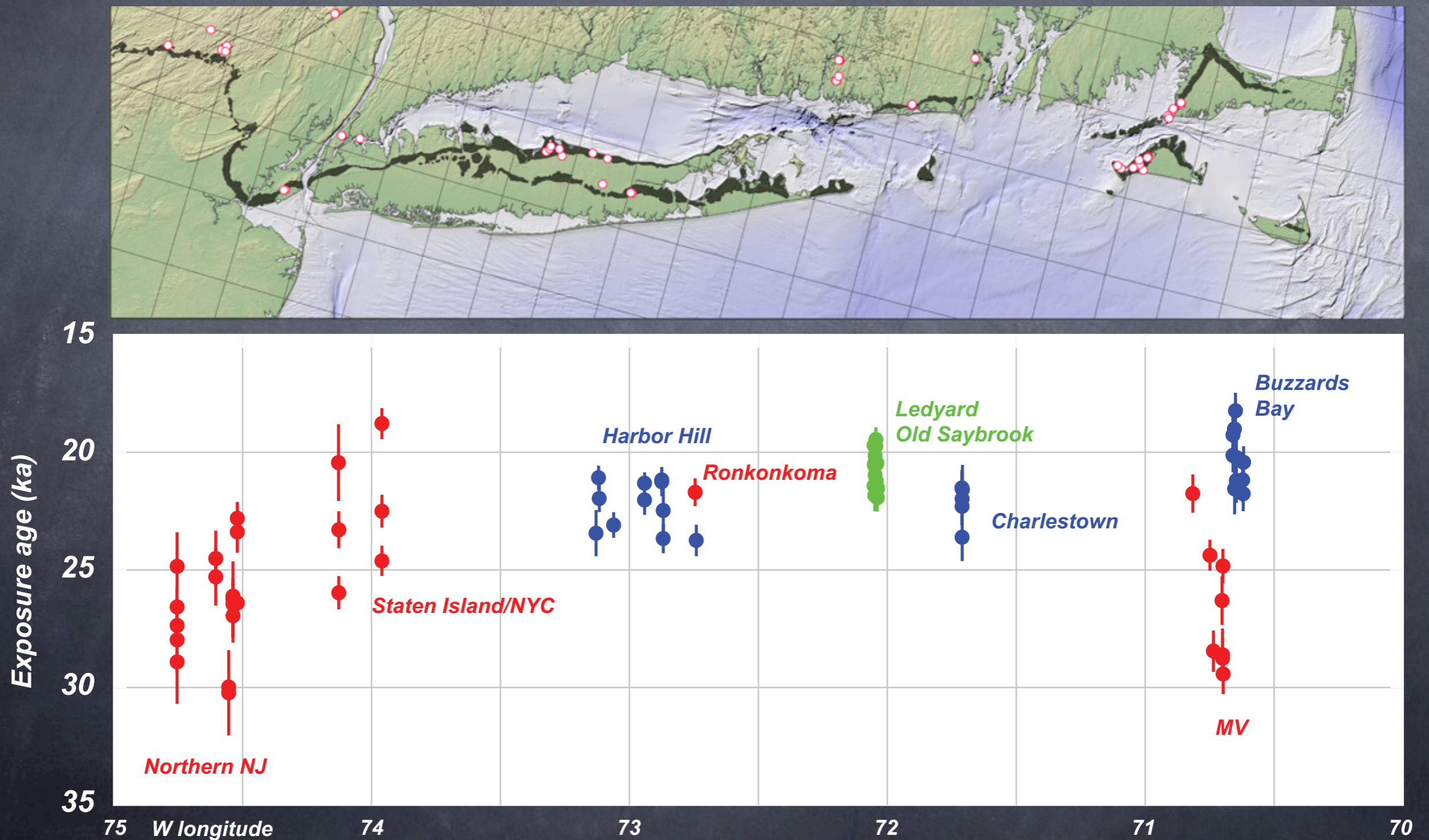
*This is in complete agreement with sea level data.*



*Lambeck et al., 2014 PNAS*

## 4. What do we learn from this?

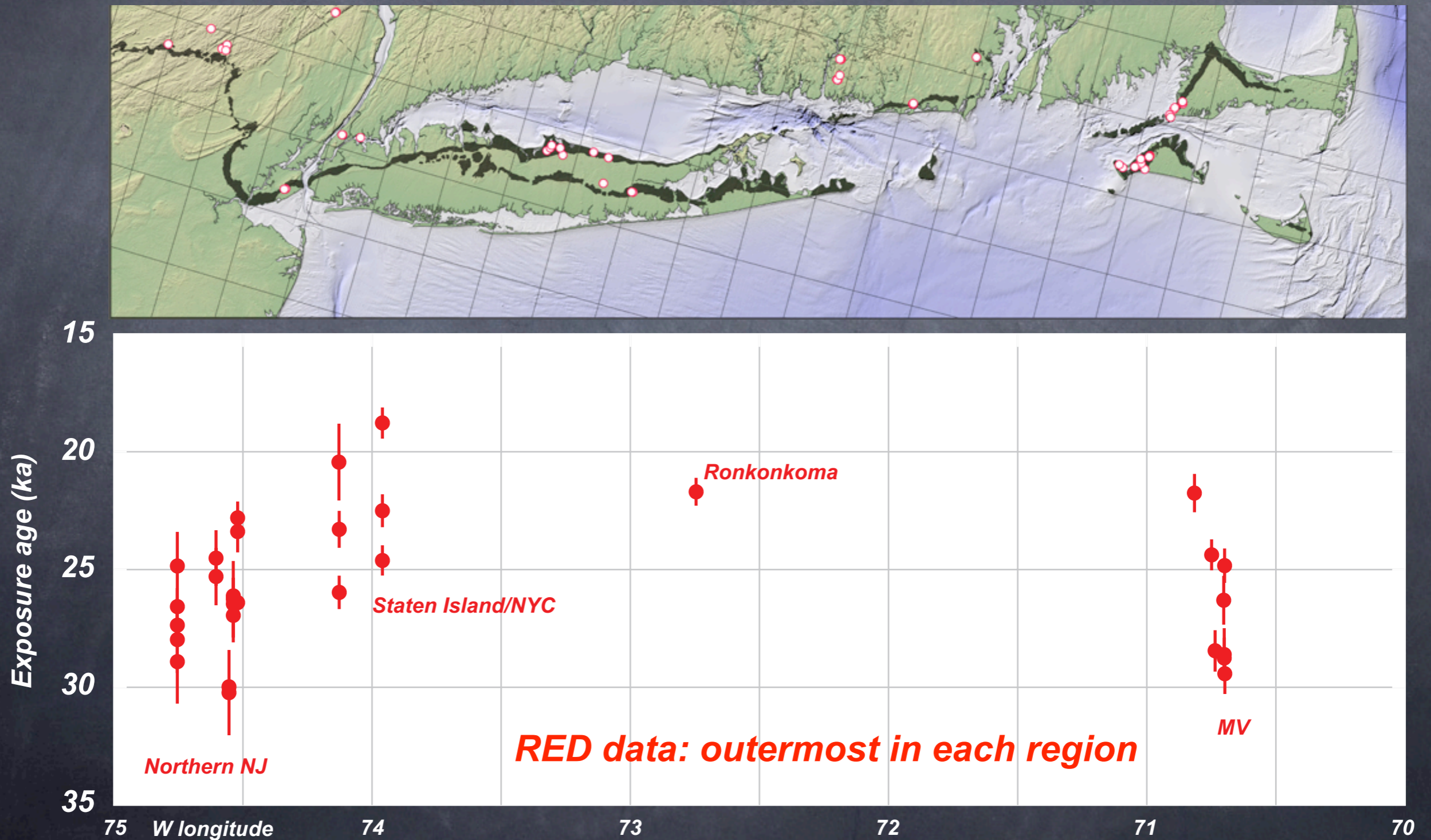
2. The exposure ages are not consistent with synchronous emplacement of the outer terminal moraine belt.





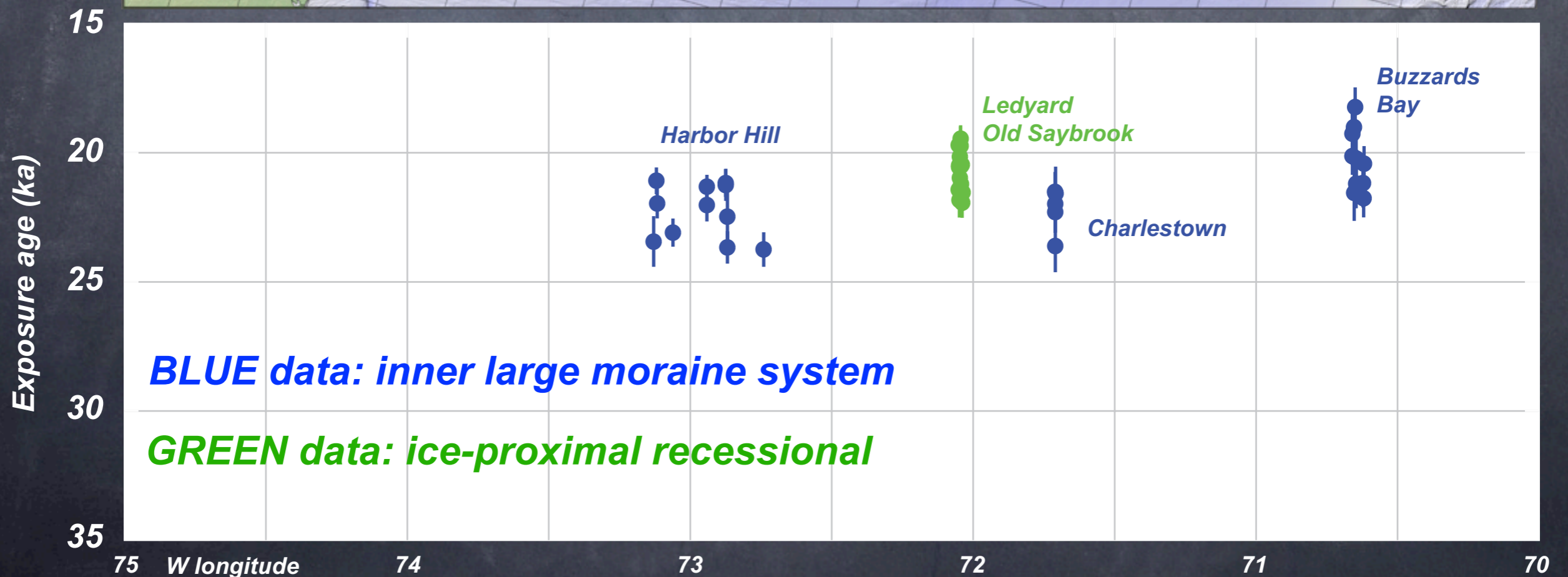
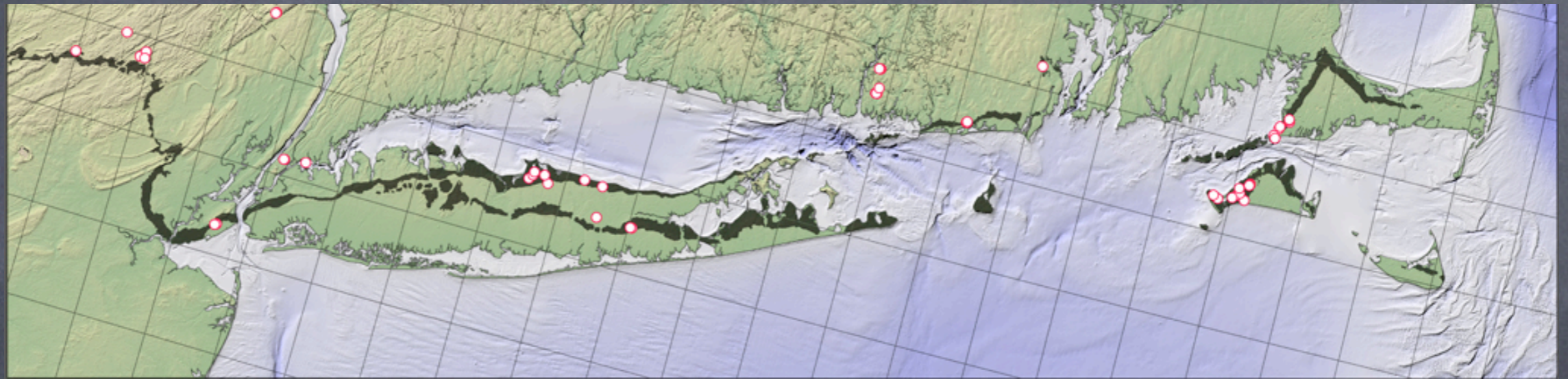
## 4. What do we learn from this?

2. The exposure ages are not consistent with synchronous emplacement of the outer terminal moraine belt.

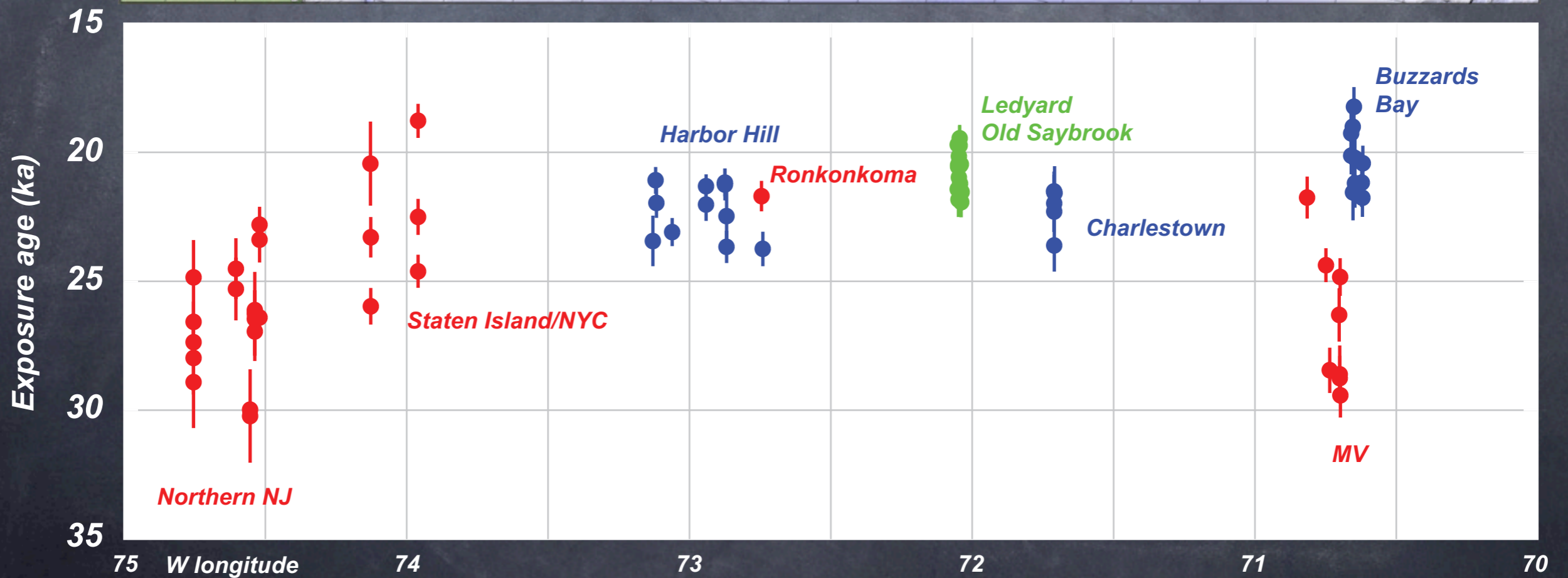
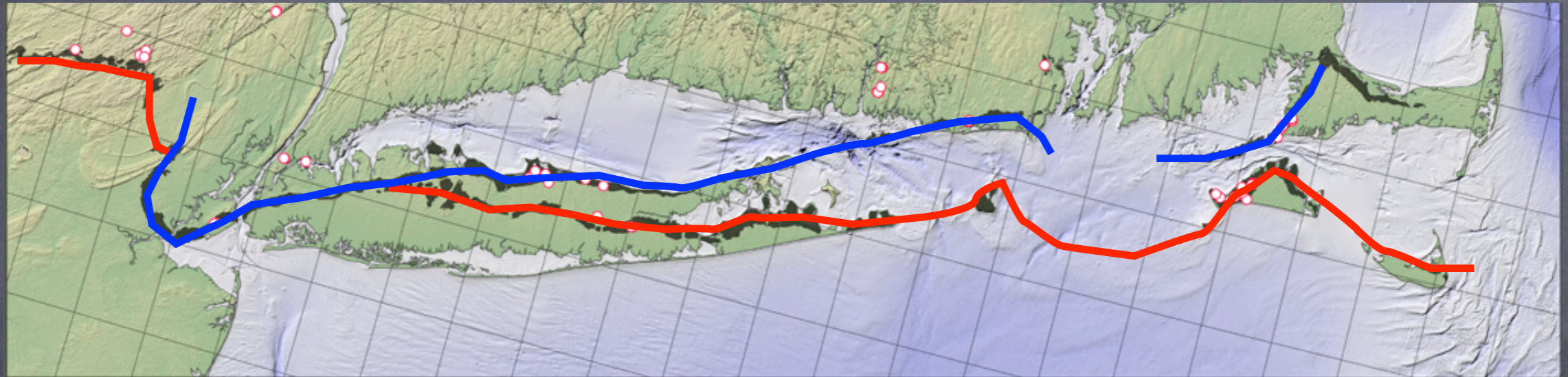


## 4. What do we learn from this?

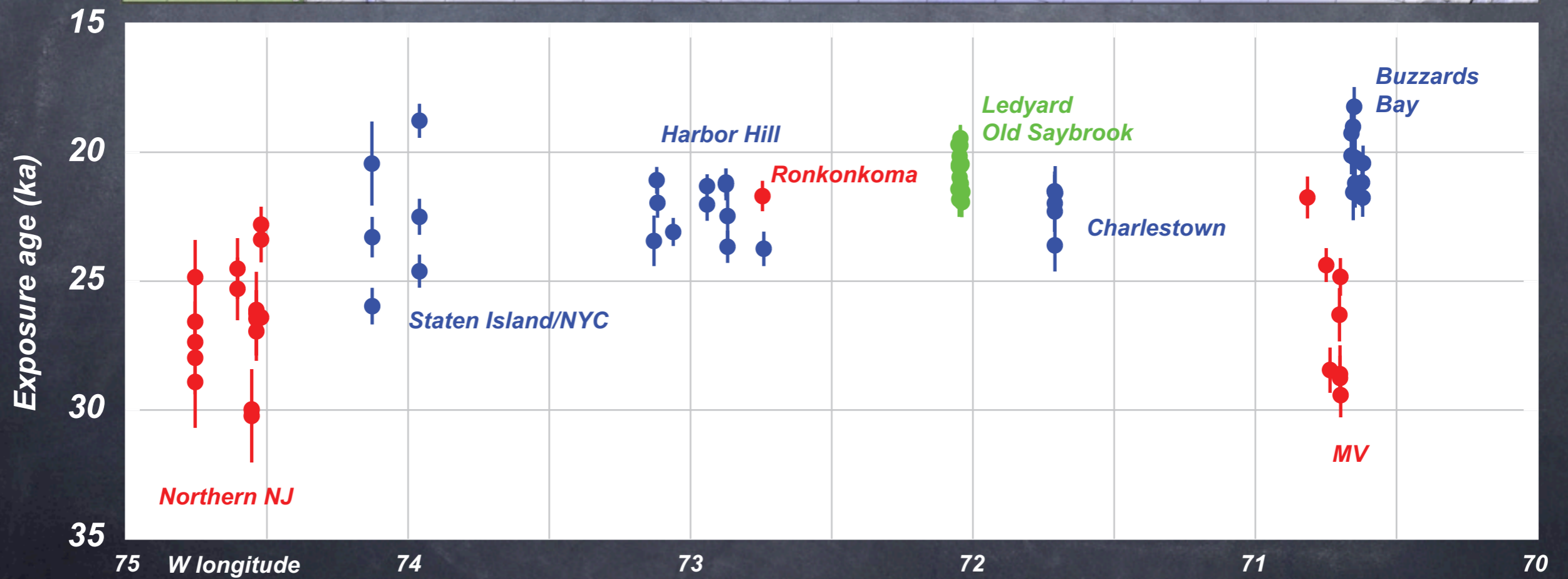
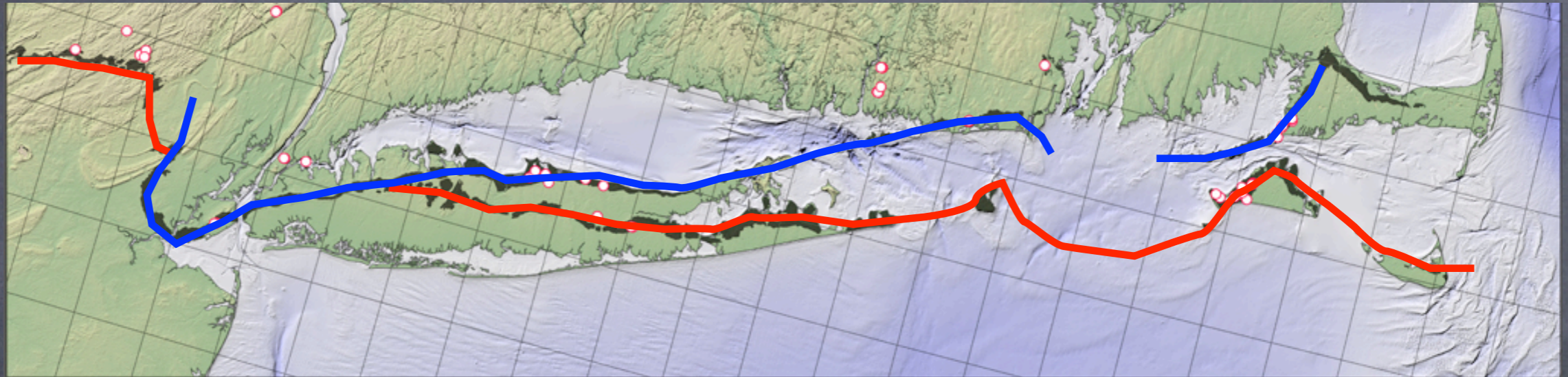
3. However, they are consistent with the inner moraine belt being synchronous across its length.



# 4. What do we learn from this?

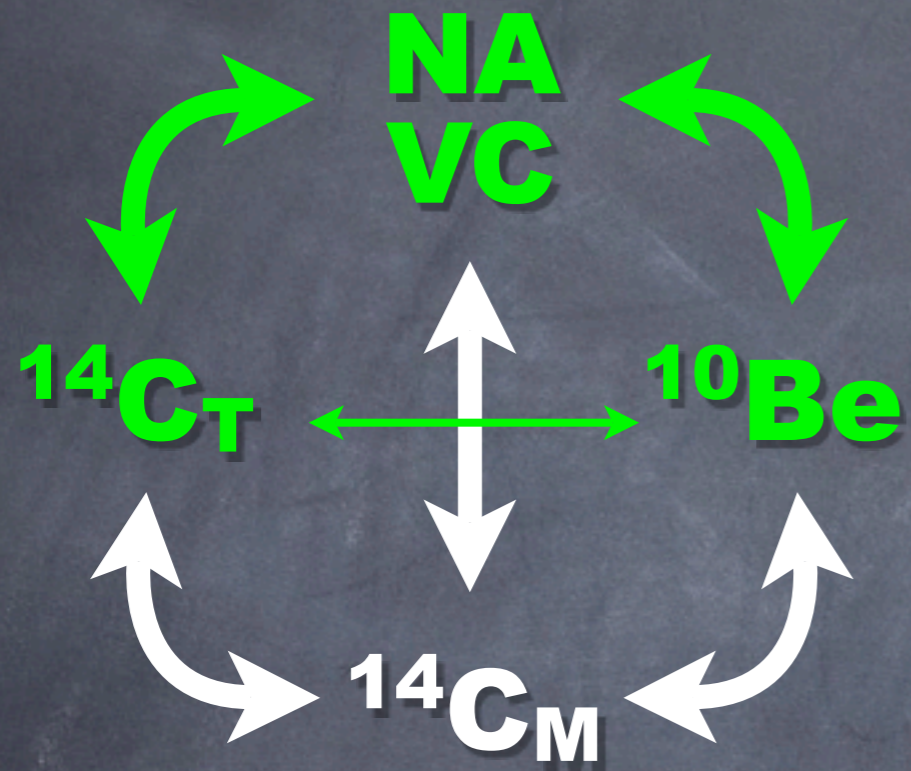


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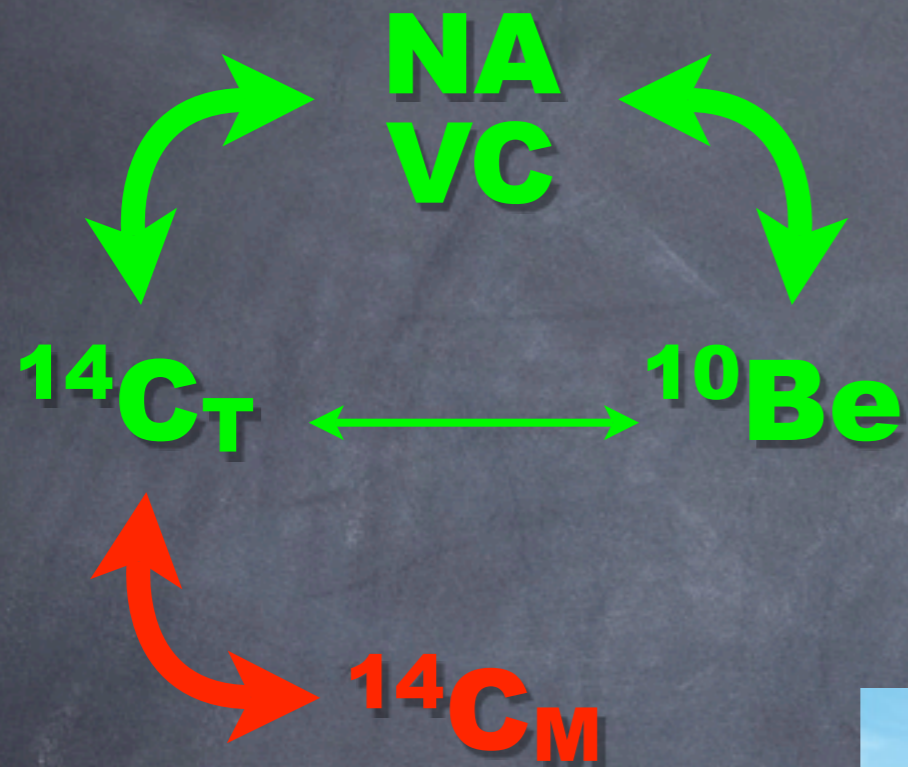


## 5. Close the loop

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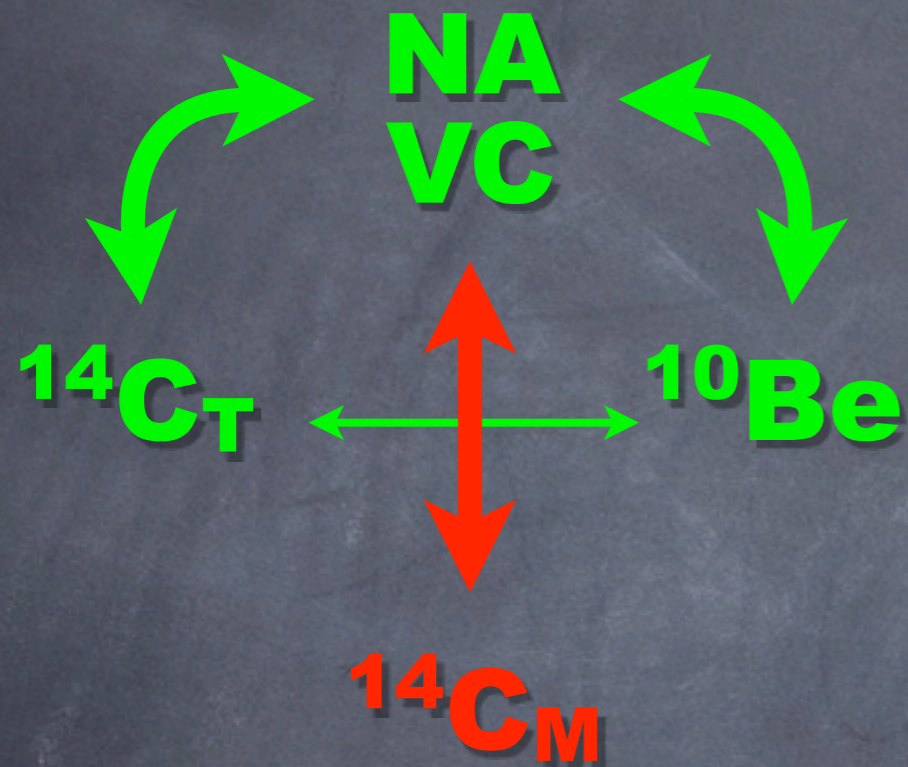
## 5. Close the loop



*Co-occurring marine and terrestrial organic material in postglacial marine sediments*



# 5. Close the loop

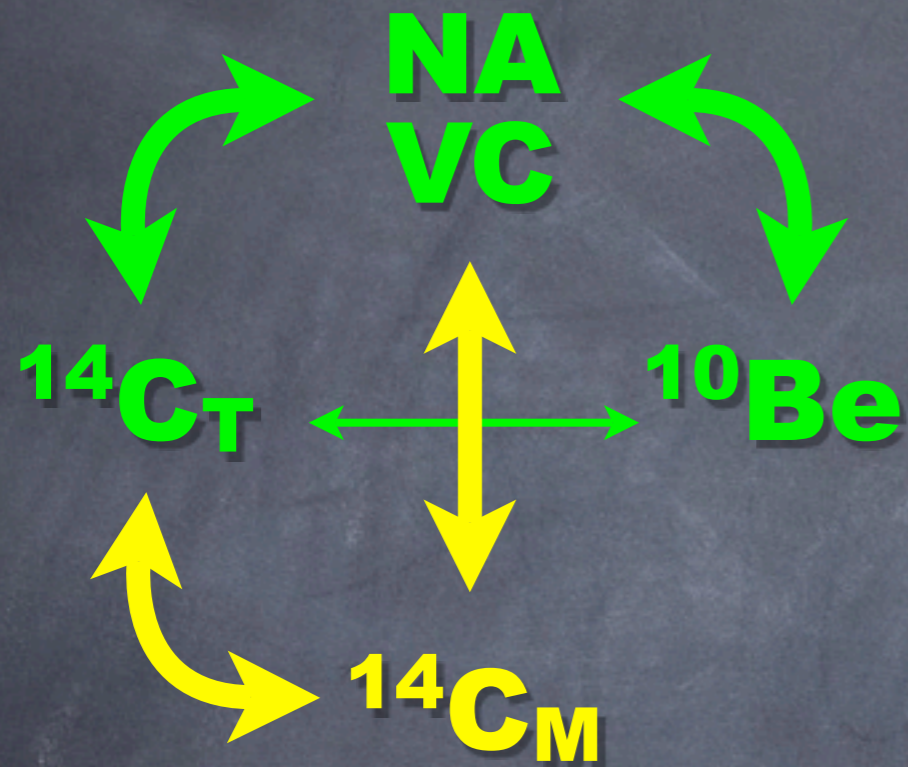


*Matching ice-marginal positions inferred from NAVC (NH) and marine radiocarbon ages (Maine)*

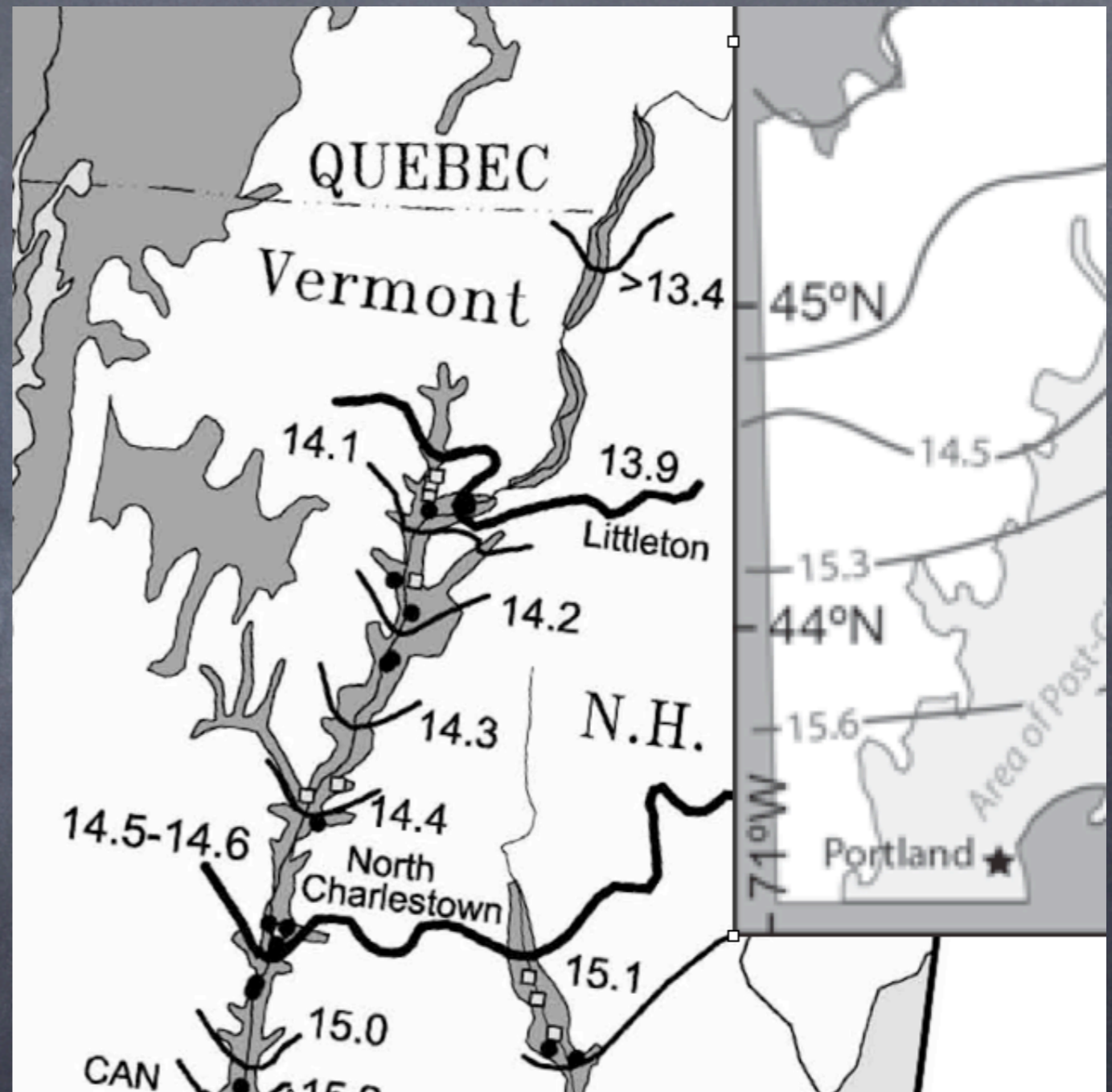


*“D\*\*\* state lines!”*

## 5. Close the loop

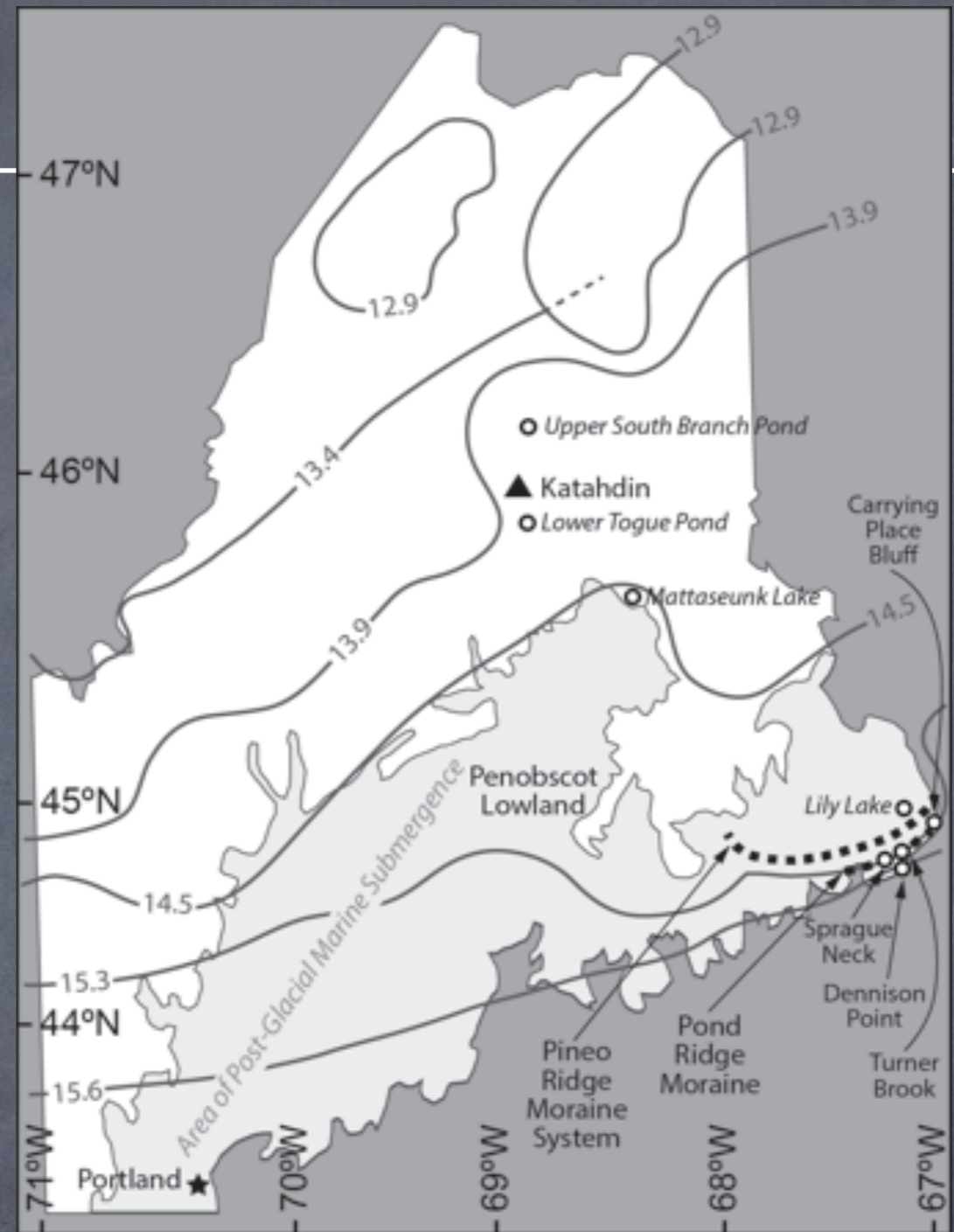
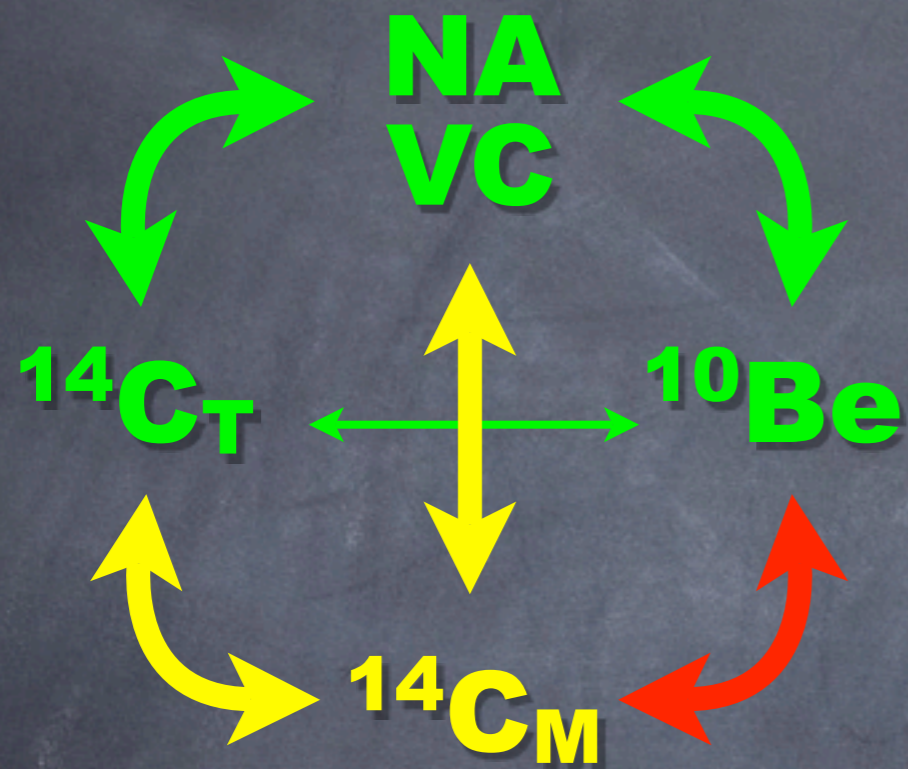


*Matching ice-marginal positions inferred from NAVC (NH) and marine radiocarbon ages (Maine)*





## 5. Close the loop



*Davis, Bierman, Corbett: rapid ice surface lowering at Mt. Katahdin (dated by exposure ages) happened at the same time as rapid ice margin retreat across the Penobscot Lowland (dated by marine radiocarbon ages).*