Glacial boulder exposure ages from the Tibetan Plateau

old deposits and postglacial shielding

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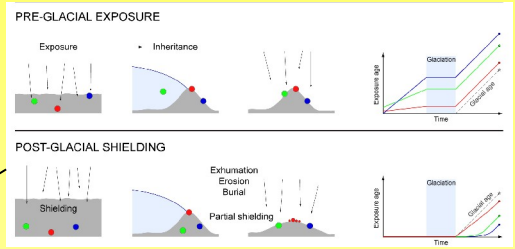
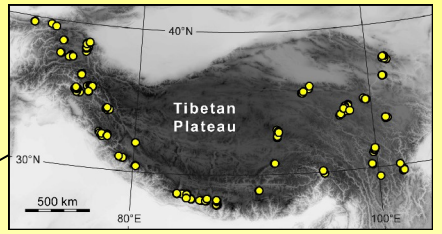
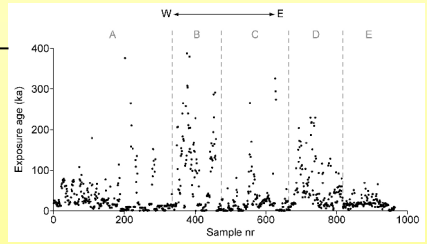
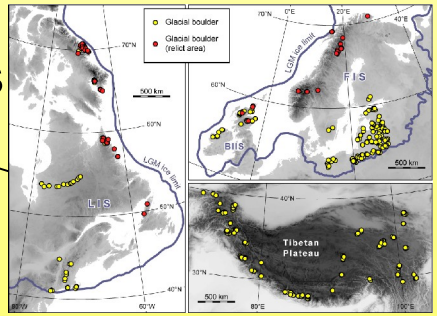
Presentation outline

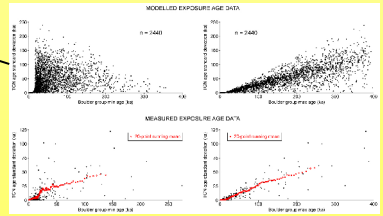
- Cosmogenic exposure dating
  - Introduction
  - Geological sources of error
- Age distribution investigation – aim and strategy
- Tibetan TCN age distributions – results
- Explaining the TCN age distributions
  - Testing inheritance and post-glacial shielding
  - Comparison with paleo-ice sheet boulder ages
  - Numerical model
- Conclusions
- References

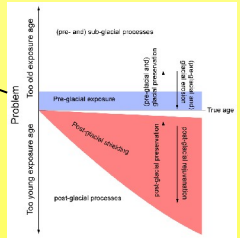




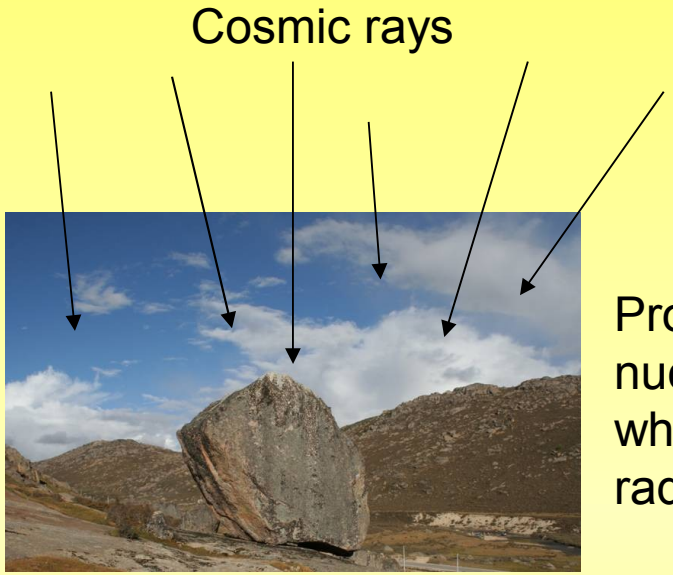








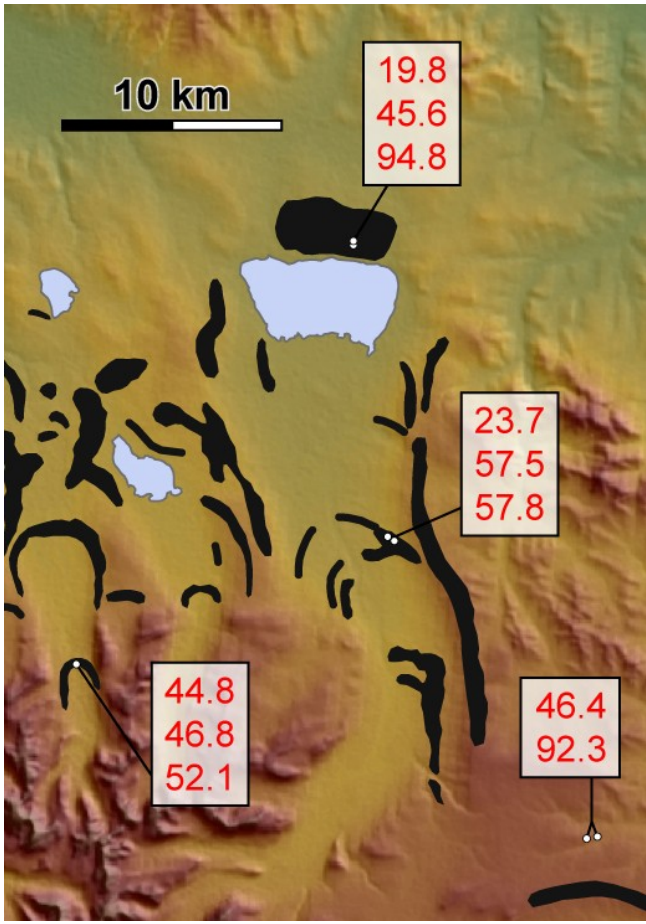
Cosmogenic exposure dating

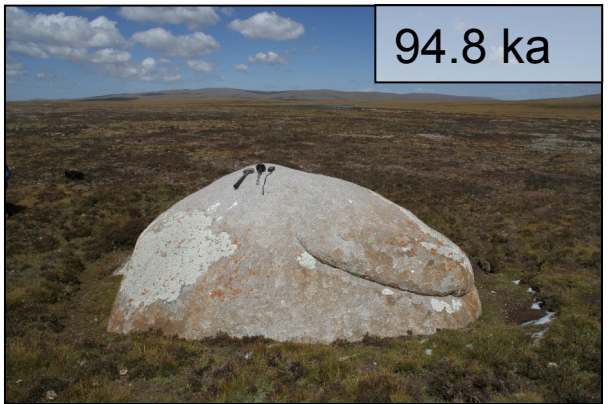


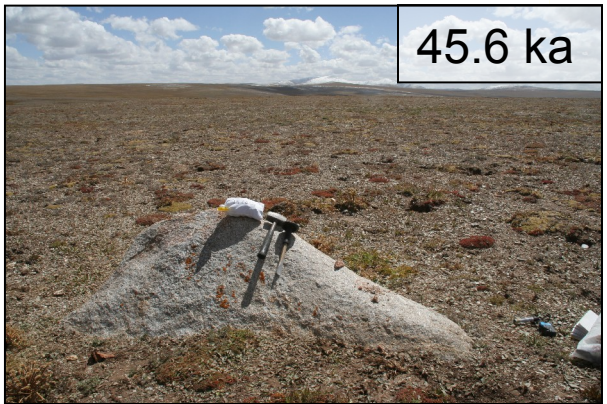
Production of cosmogenic nuclides (^{10}Be) in quartz when exposed to cosmic radiation

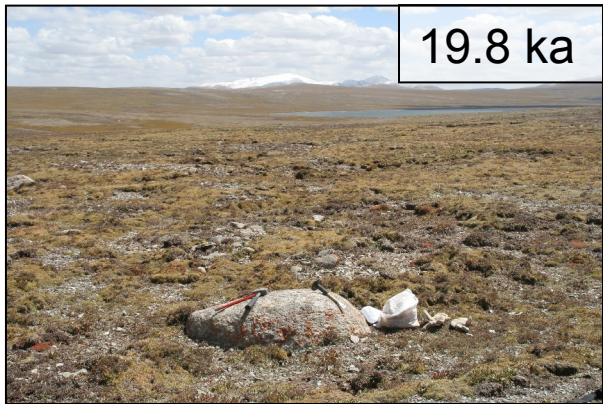
Absolute measurement of **exposure age**

The problem:



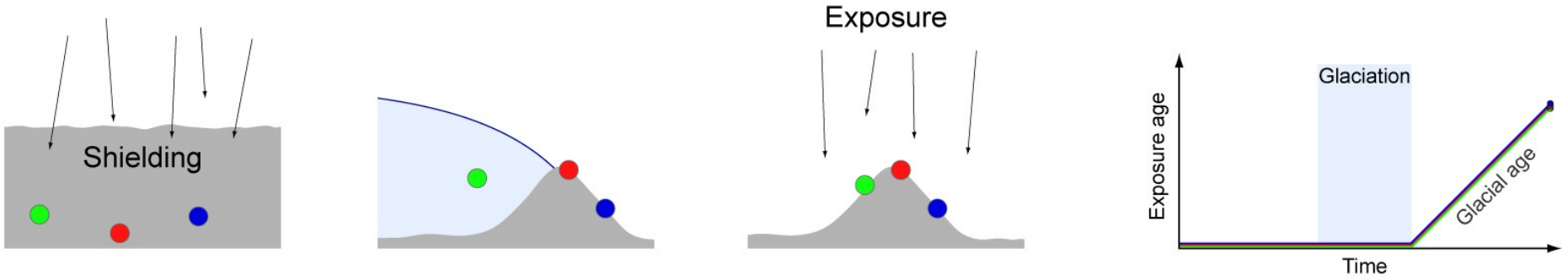




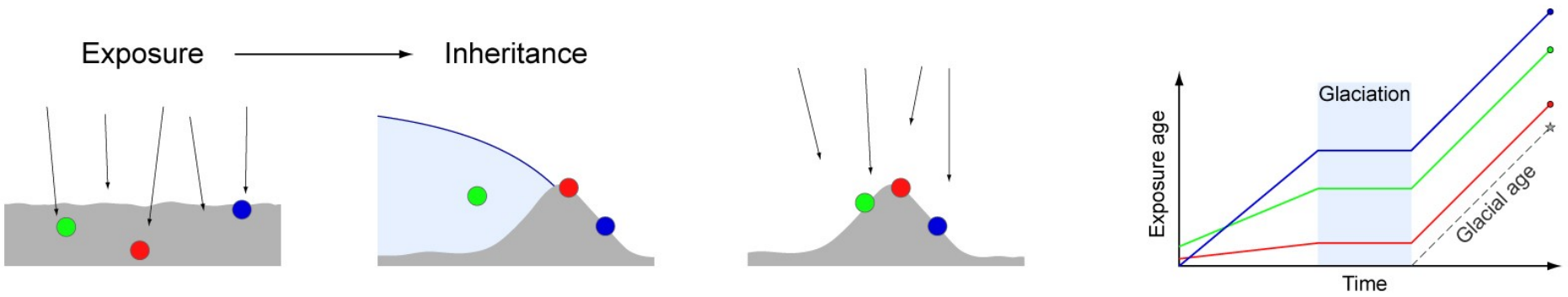


Geological sources of error

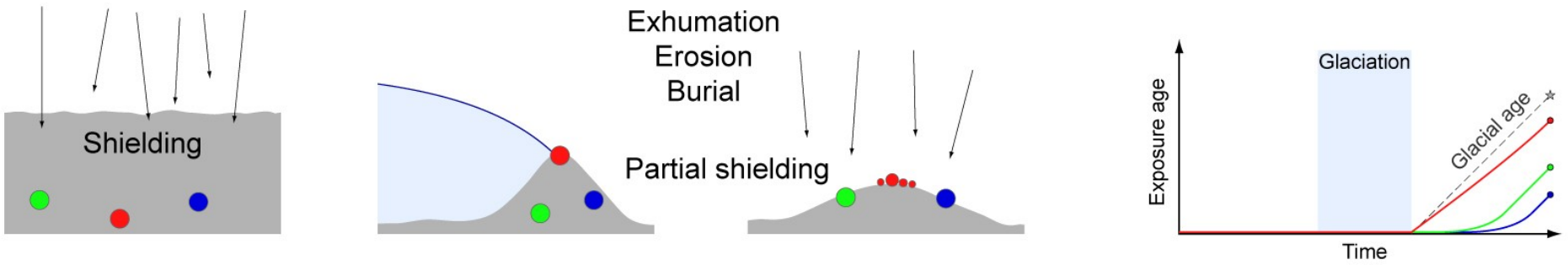
IDEAL CASE



PRE-GLACIAL EXPOSURE



POST-GLACIAL SHIELDING



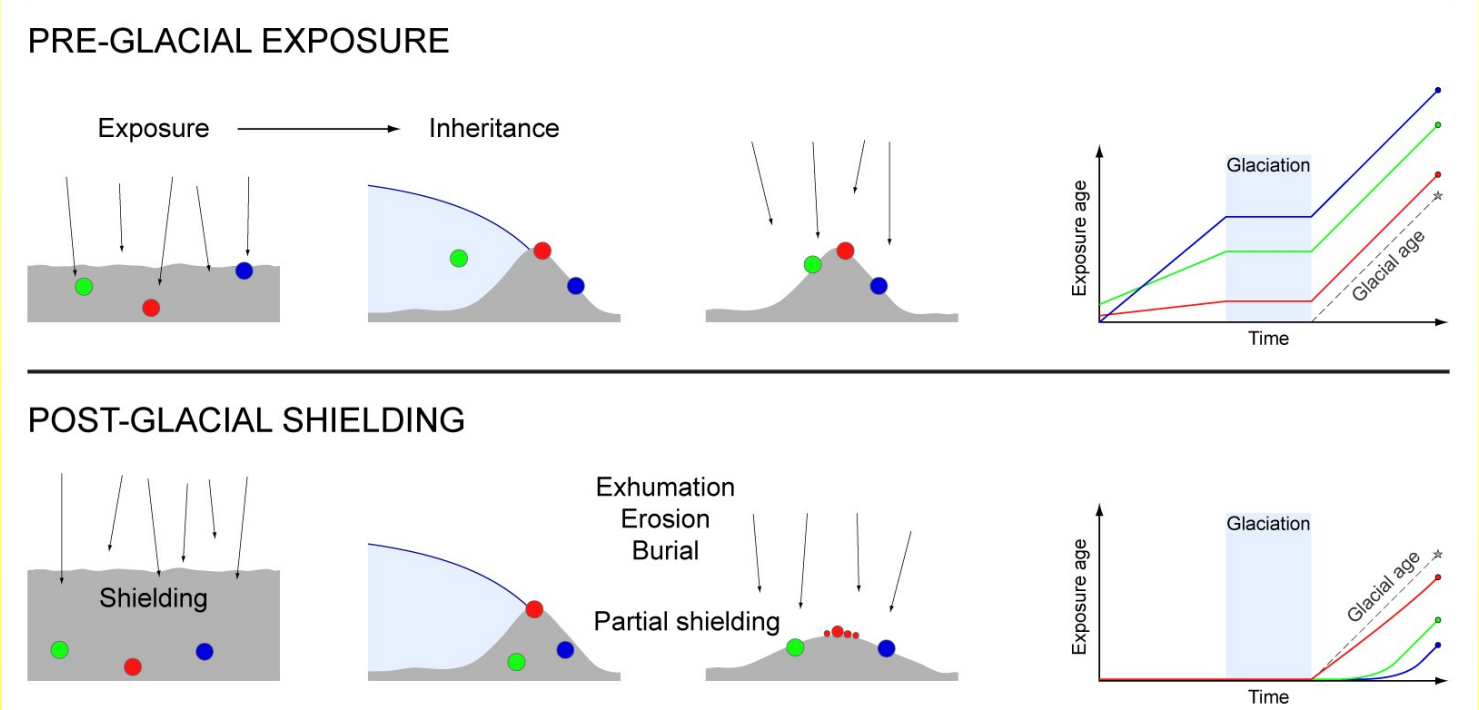
Reseach question:

How to interpret the often widely diverging Tibetan TCN boulder ages?

Strategy:

Meta-analysis of large set of glacial boulder ^{10}Be TCN ages from the Tibetan Plateau

Can pre-glacial exposure or post-glacial shielding alone explain the Tibetan boulder TCN age distribution?



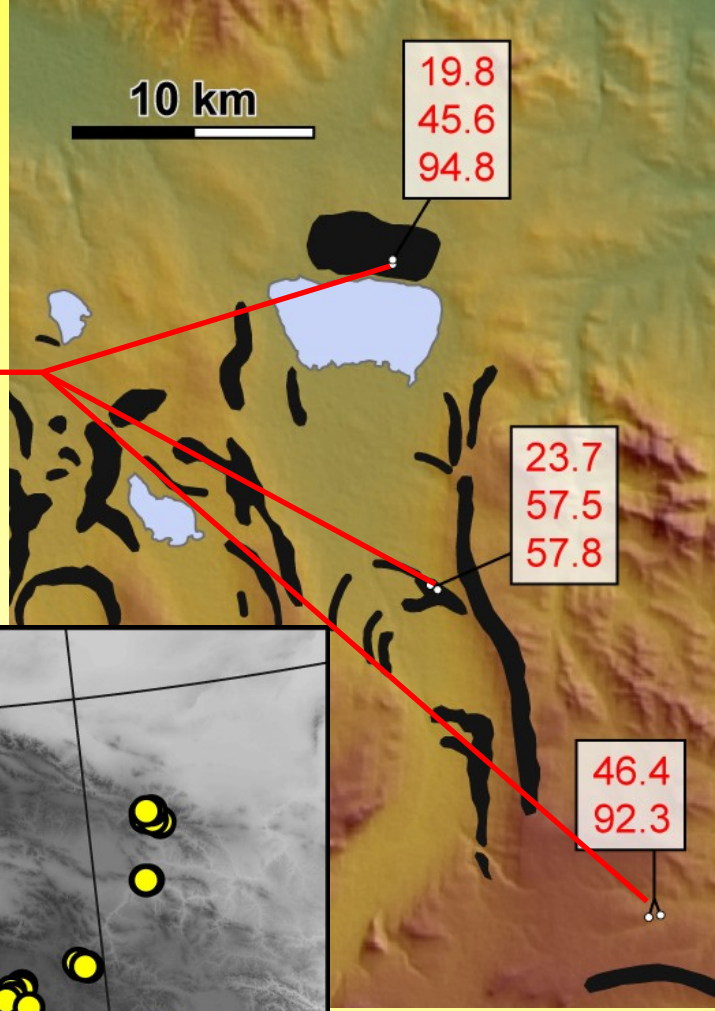
Data compilation

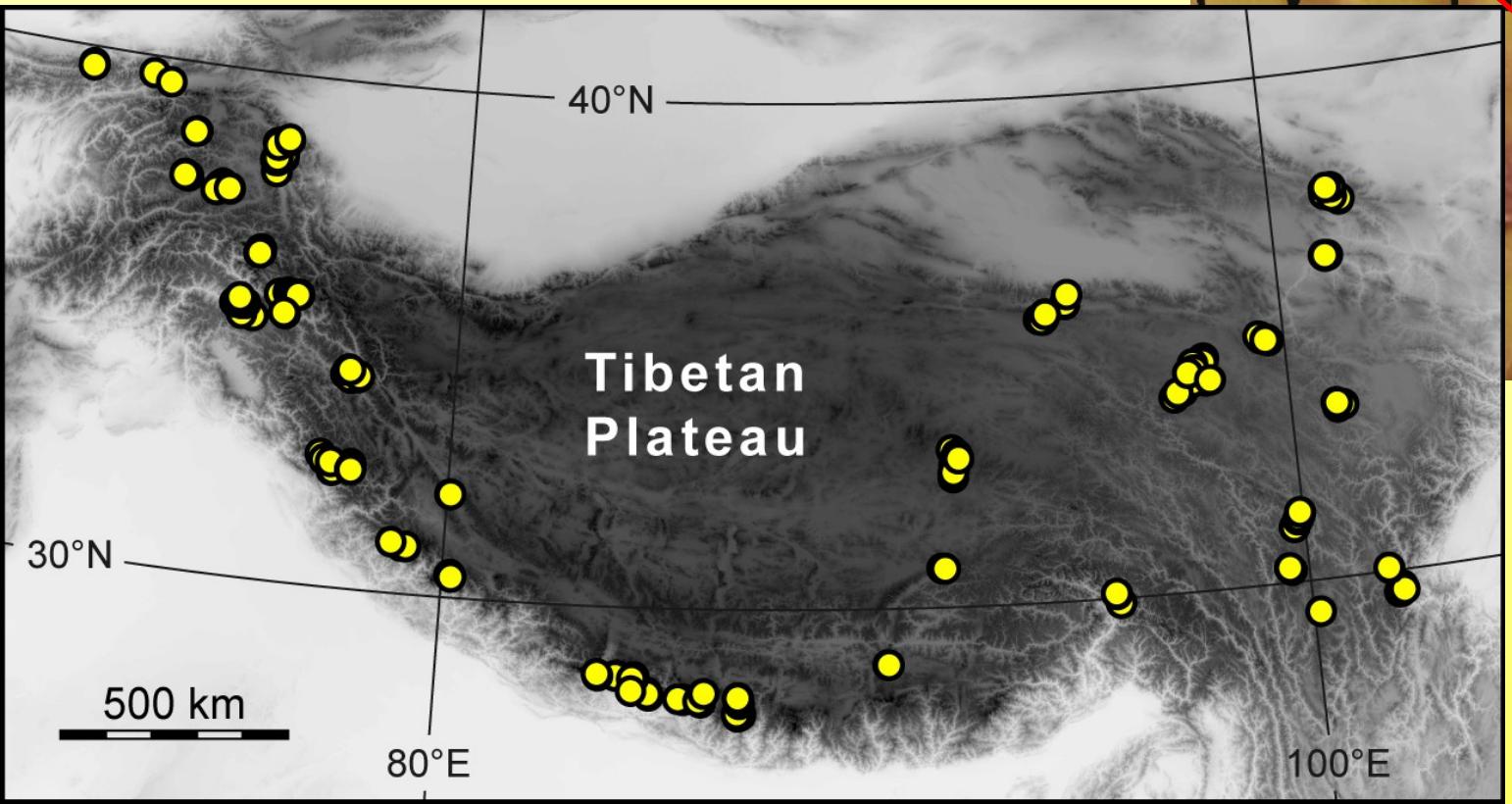
All available glacial boulder ^{10}Be TCN ages included:

964 boulders from 244 boulder groups (35 references)

1 boulder group = 1 glacial deposit (1 true age)

TCN ages calculated using CRONUS online calculator version 2.2 (Balco et al. 2008: http://hess.ess.washington.edu/)

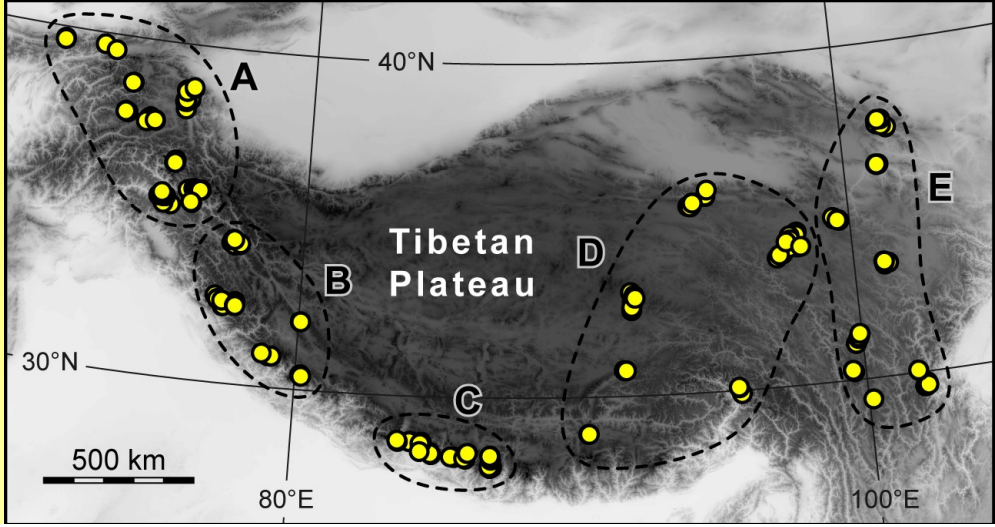


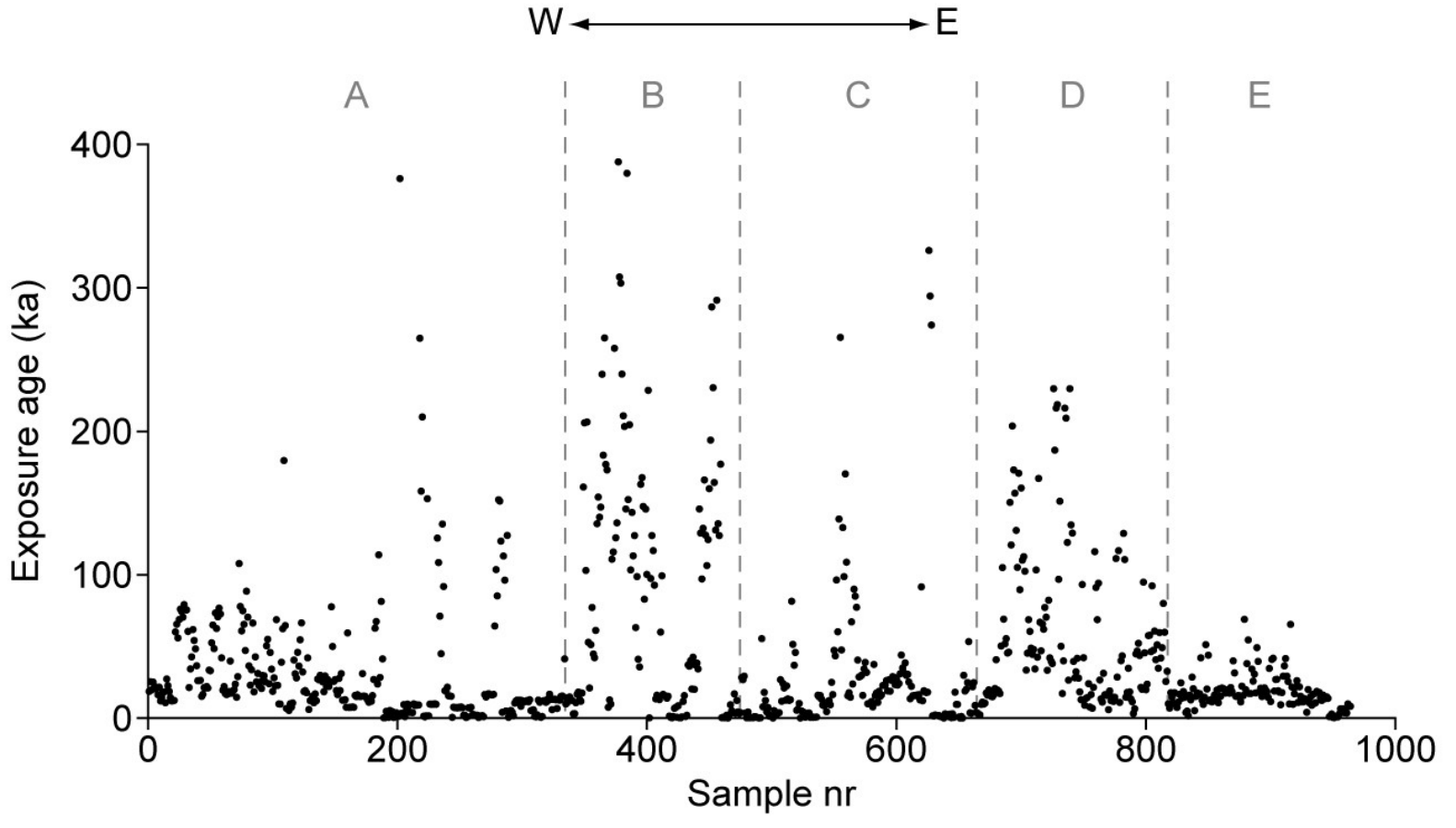


Tibetan Plateau exposure ages

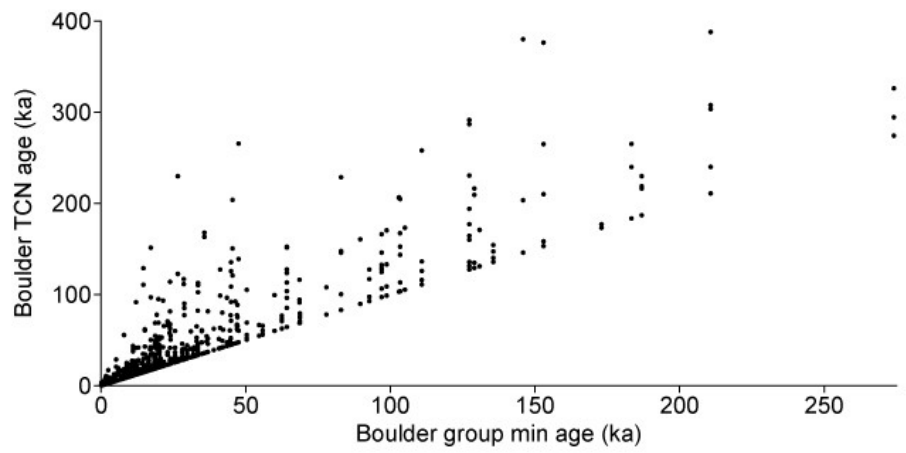
All presented exposure ages are CRONUS Lm ages (Balco et al. 2008)

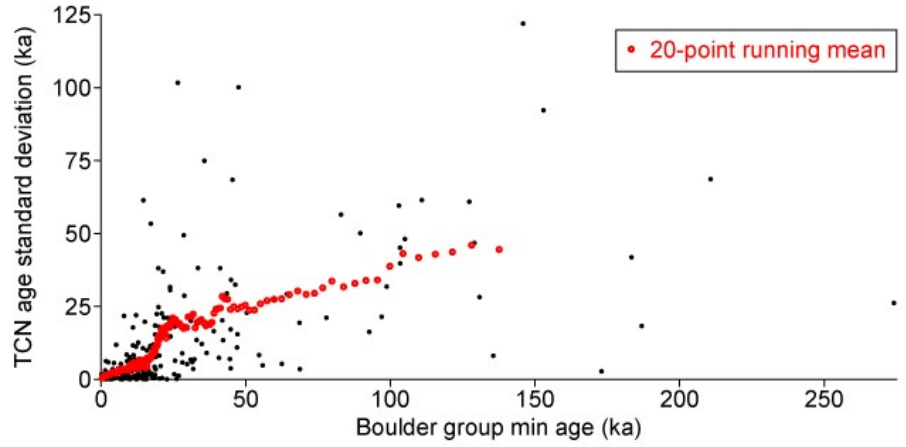
<u>Conclusions valid for all CRONUS production rate scaling schemes</u>

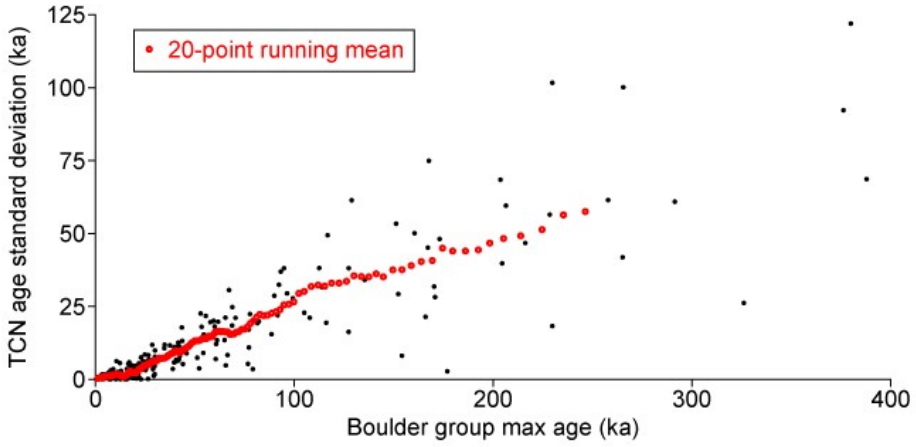




Boulder group TCN ages



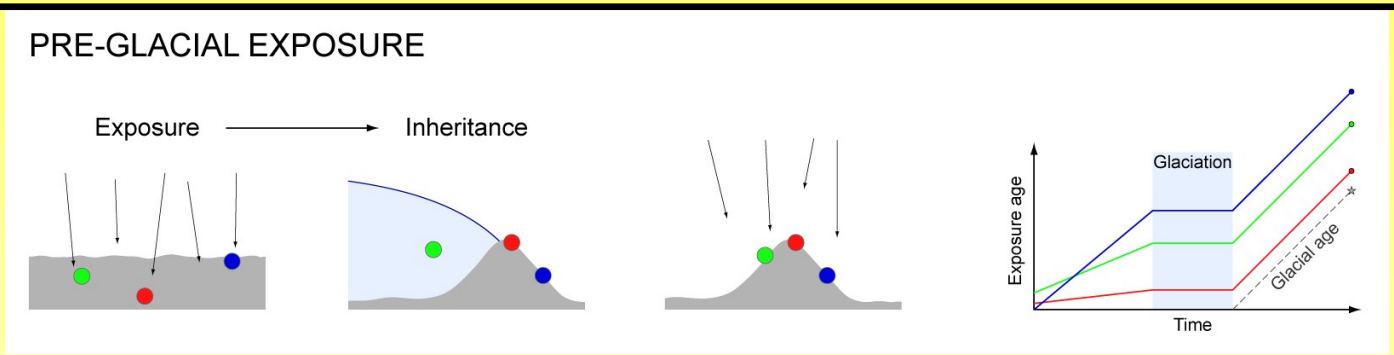




Older boulder groups → wider age spread

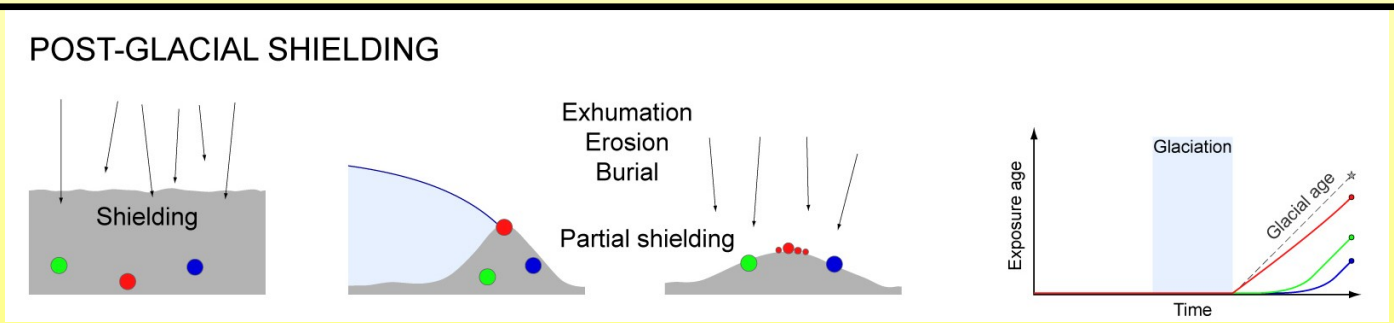
Significant step in age spread from c. 15 ka

Explaining older boulder groups → wider age spread



Older glacial deposits → more cosmogenic inheritance

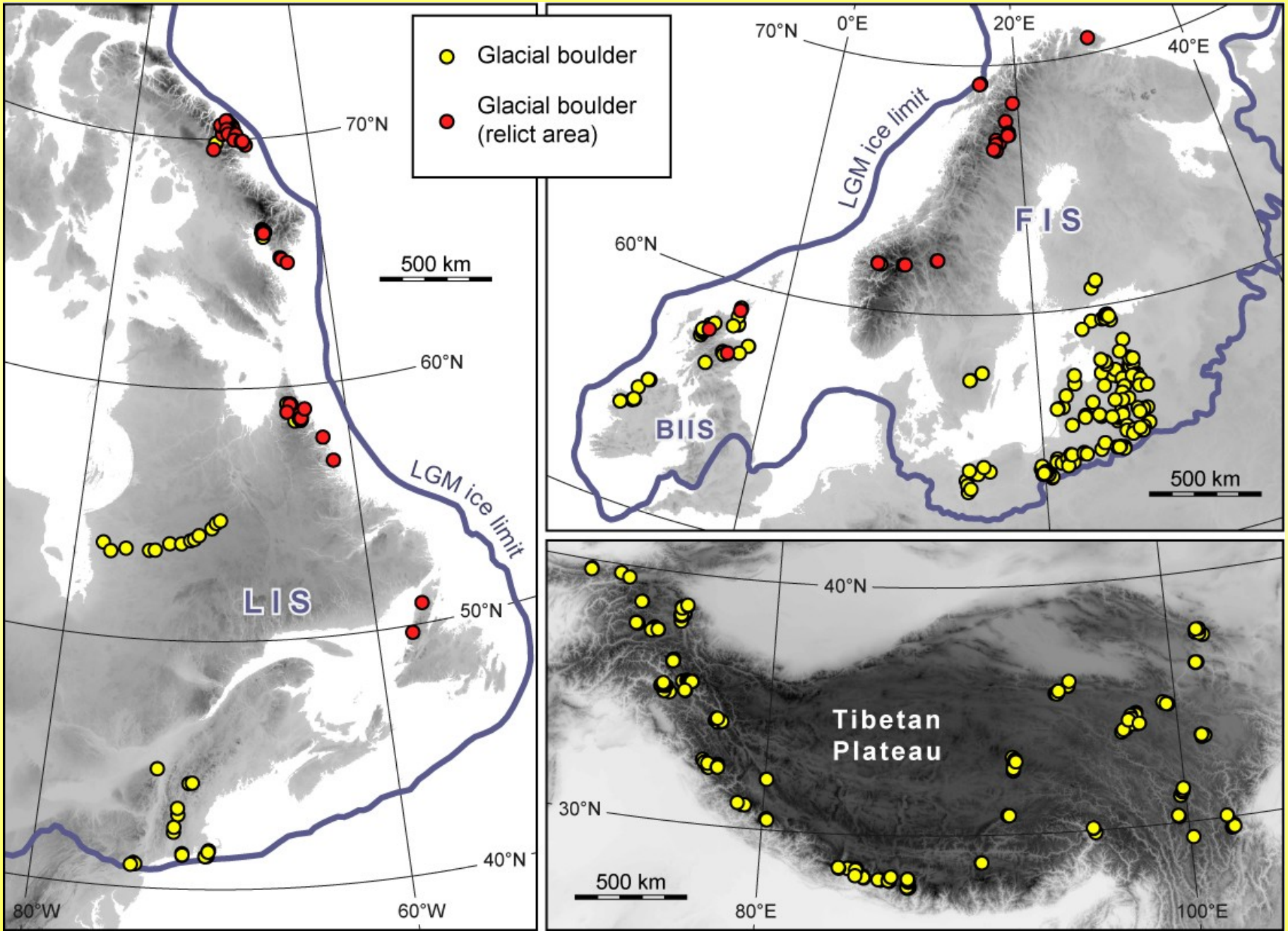
No obvious relationship: glacial age – inheritance

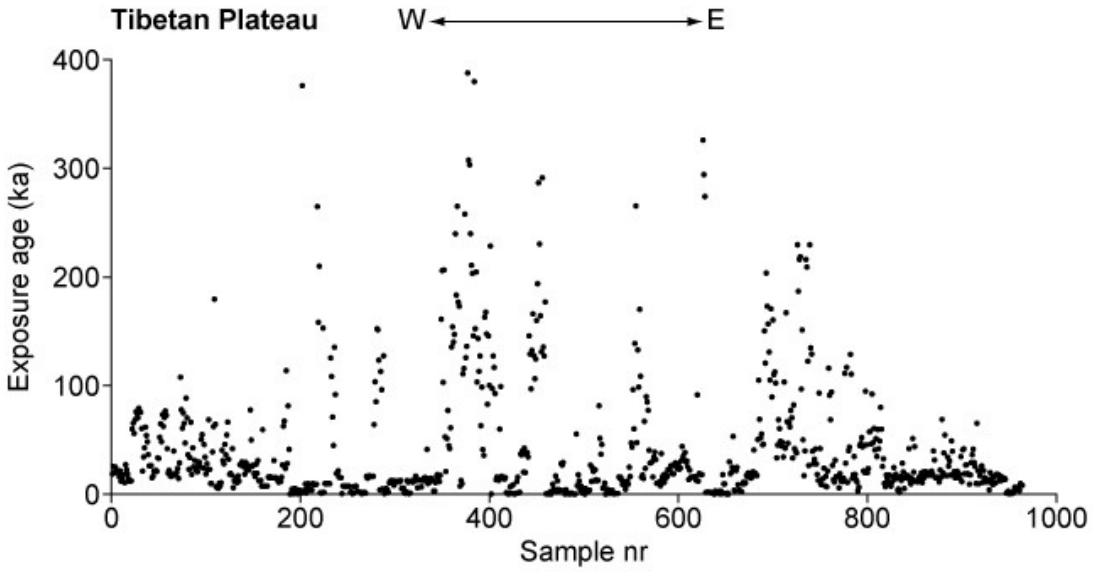


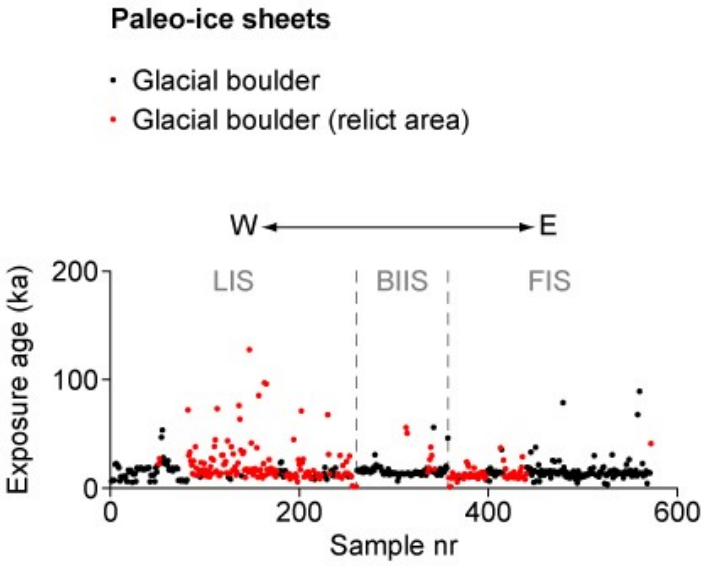
Older glacial deposits → more post-glacial shielding

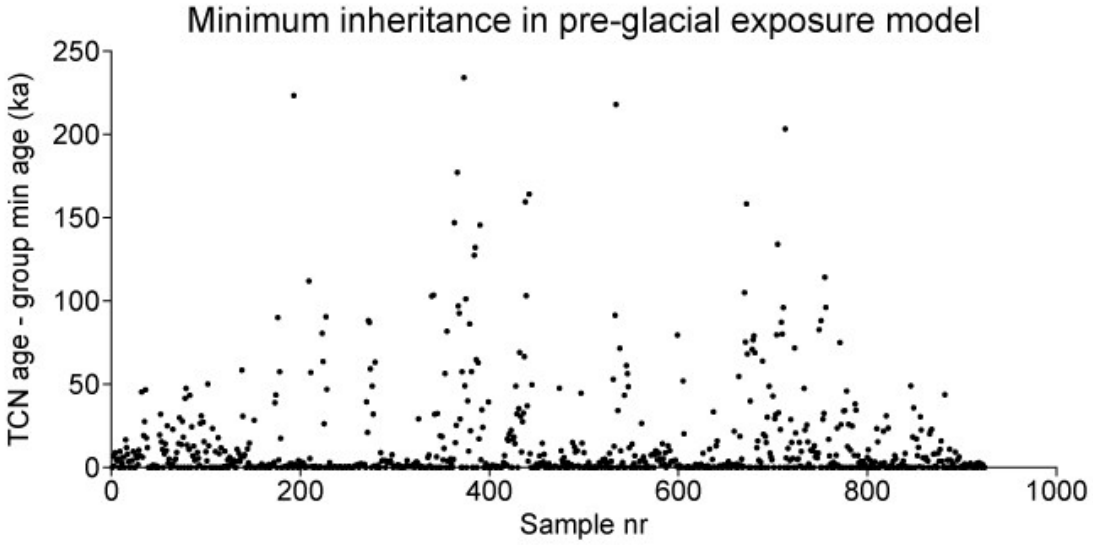
Direct relationship: glacial age – potential post-glacial shielding

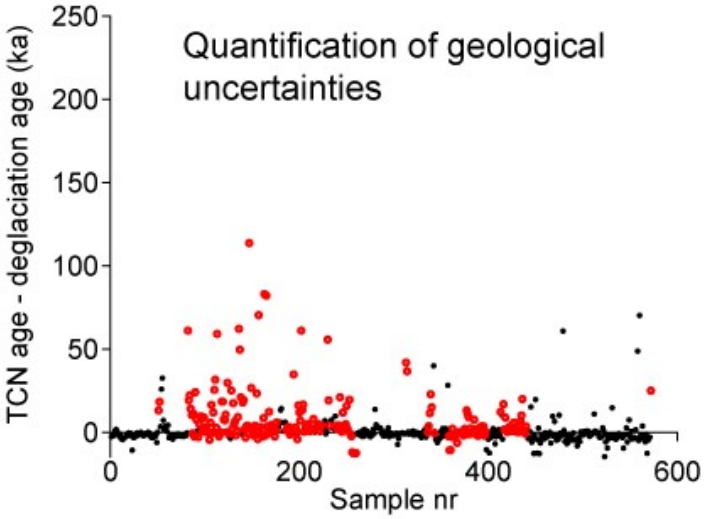
Comparison with northern hemisphere paleo-ice sheet boulders







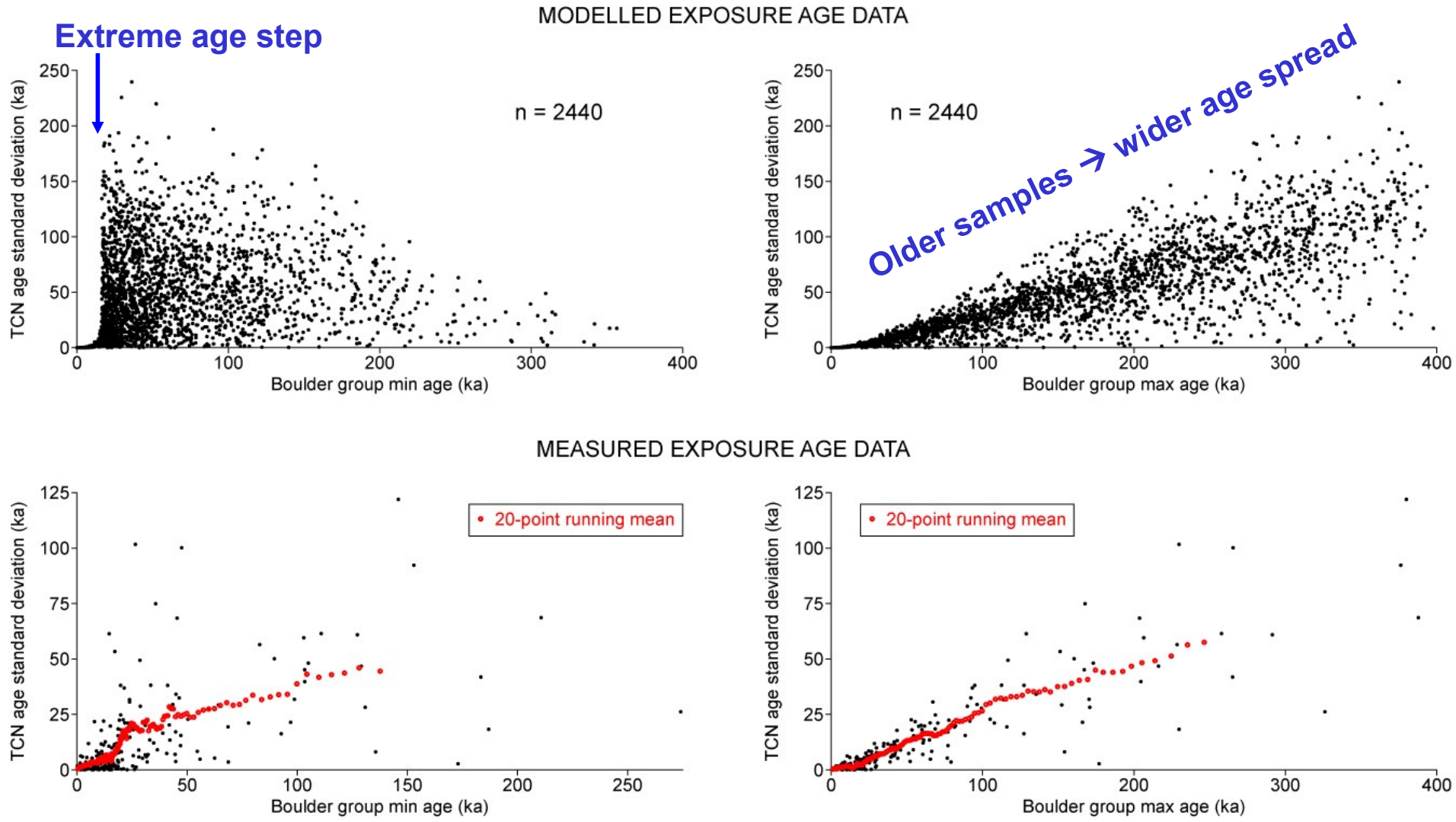




Significantly more TCN inheritance than in the paleo-ice sheet boulders needed to explain the Tibetan boulder group age spreads

Post-glacial shielding by boulder exhumation

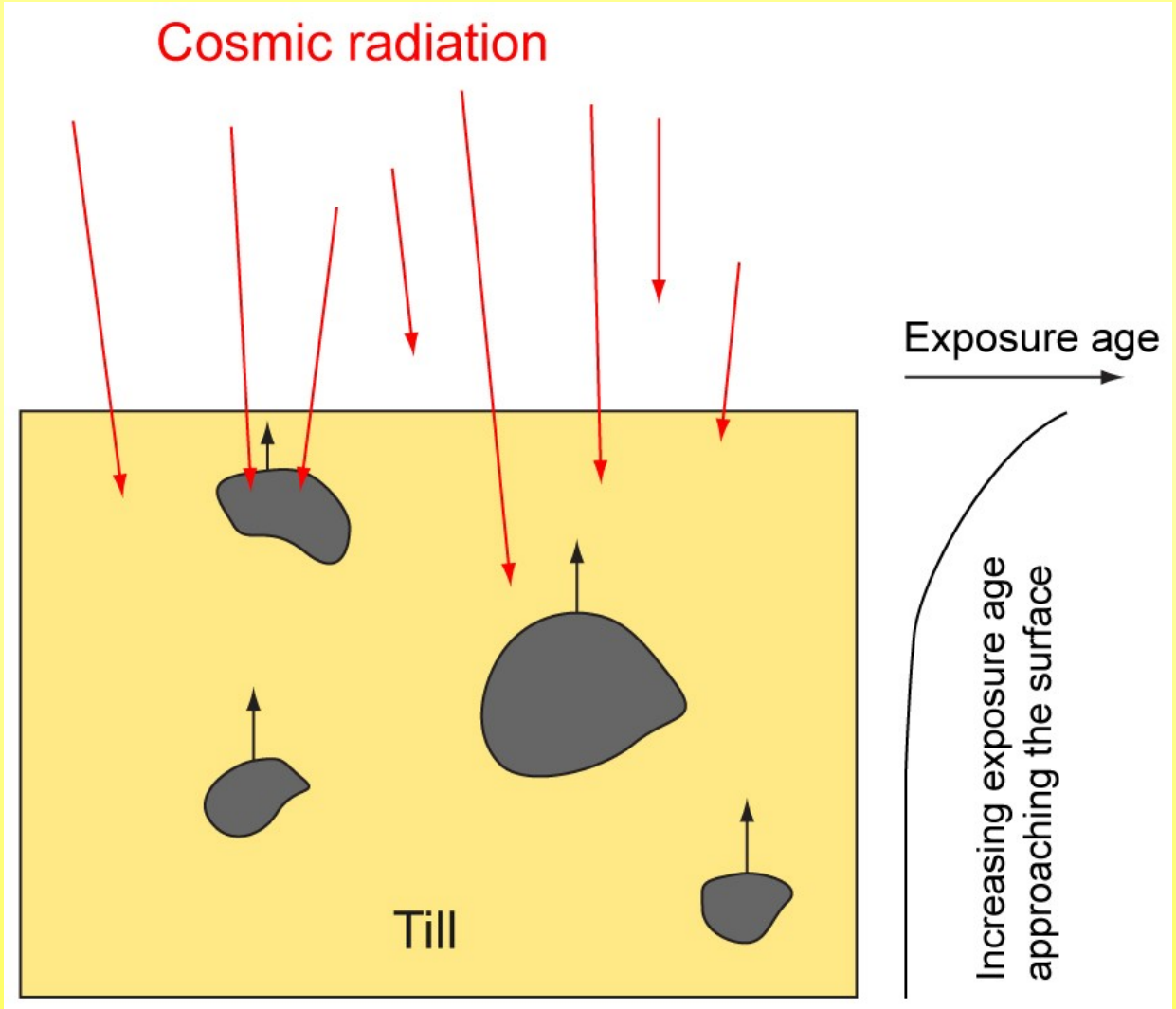
Numerical model assuming constant boulder exhumation
(5 cm/ka) through till (2.0 g/cm^3, 165 g*cm^{-2})

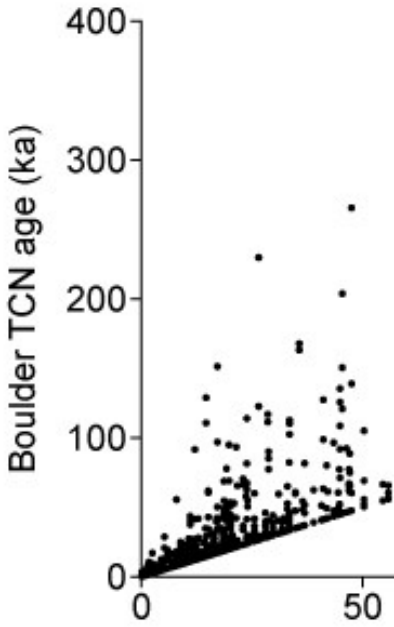


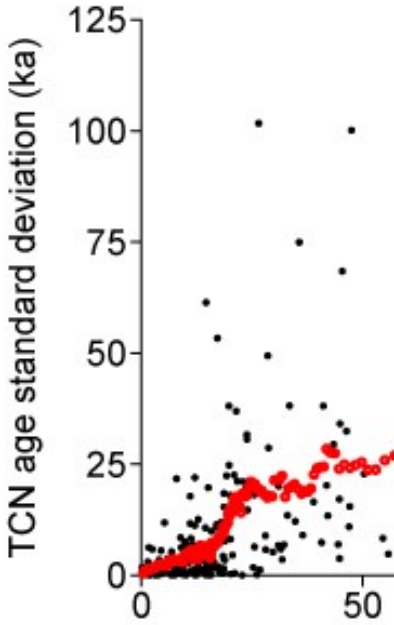
Captures both main characteristics of the TCN age distribution

Post-glacial shielding by boulder exhumation

All types of post-glacial shielding not disrupted abruptly will result in age steps

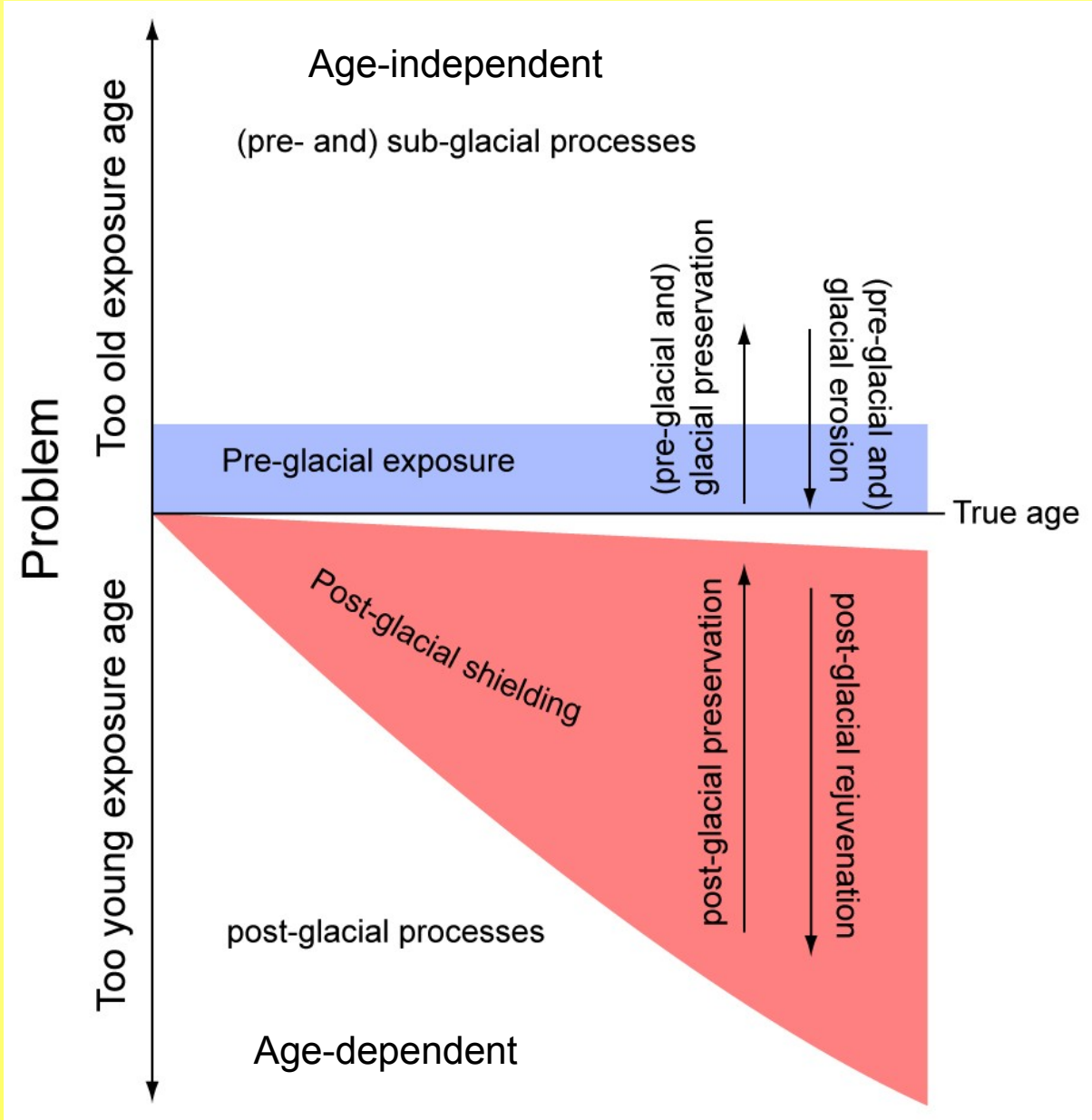






Summary

Post-glacial shielding has a stronger explanatory power than pre-glacial exposure for the wide Tibetan glacial boulder age spreads



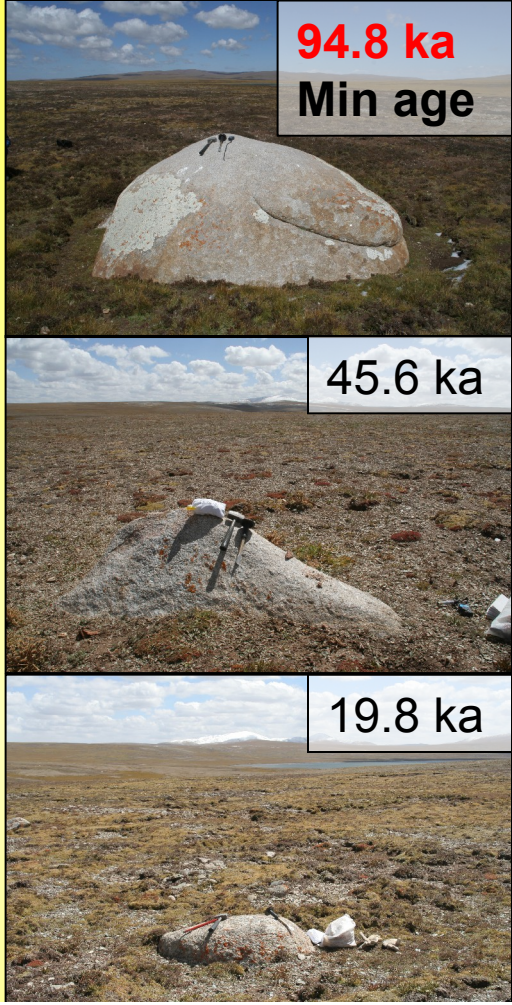
Conclusions

- Post-glacial shielding can explain the ^{10}Be TCN age distribution of the entire set of glacial boulder groups from the Tibetan Plateau

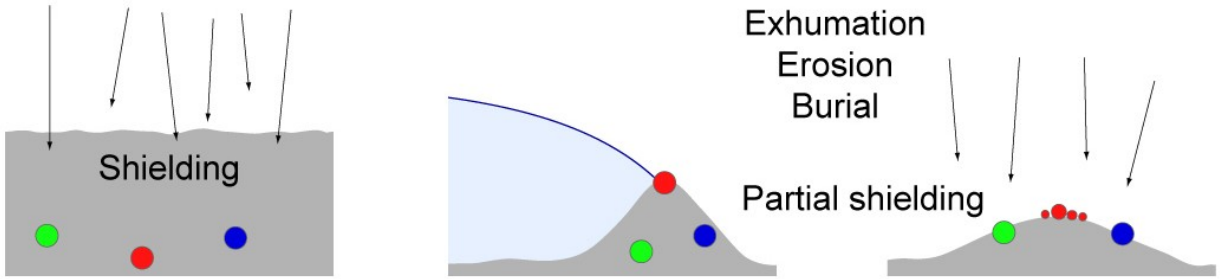
- Inheritance cannot explain the TCN age distribution set without extreme assumptions

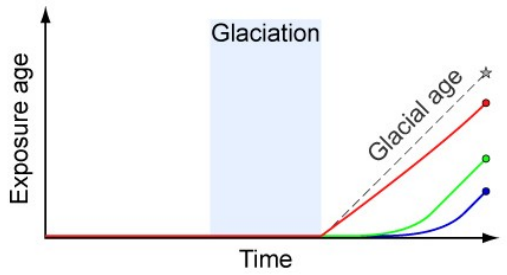
- If there are no special circumstances indicating inheritance, the oldest sample of a group of boulders should be interpreted as a minimum age

(cf. Putkonen and Swanson 2003: *QR*)



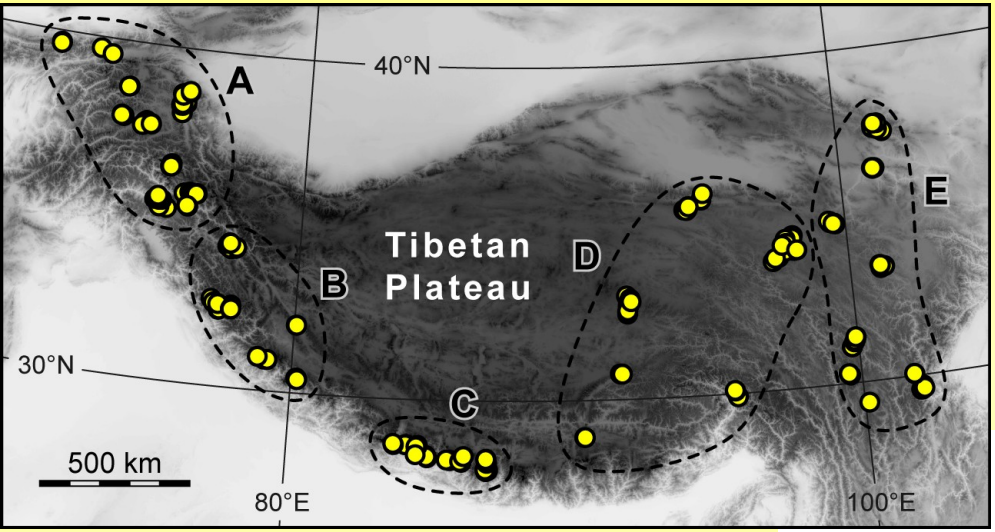
POST-GLACIAL SHIELDING

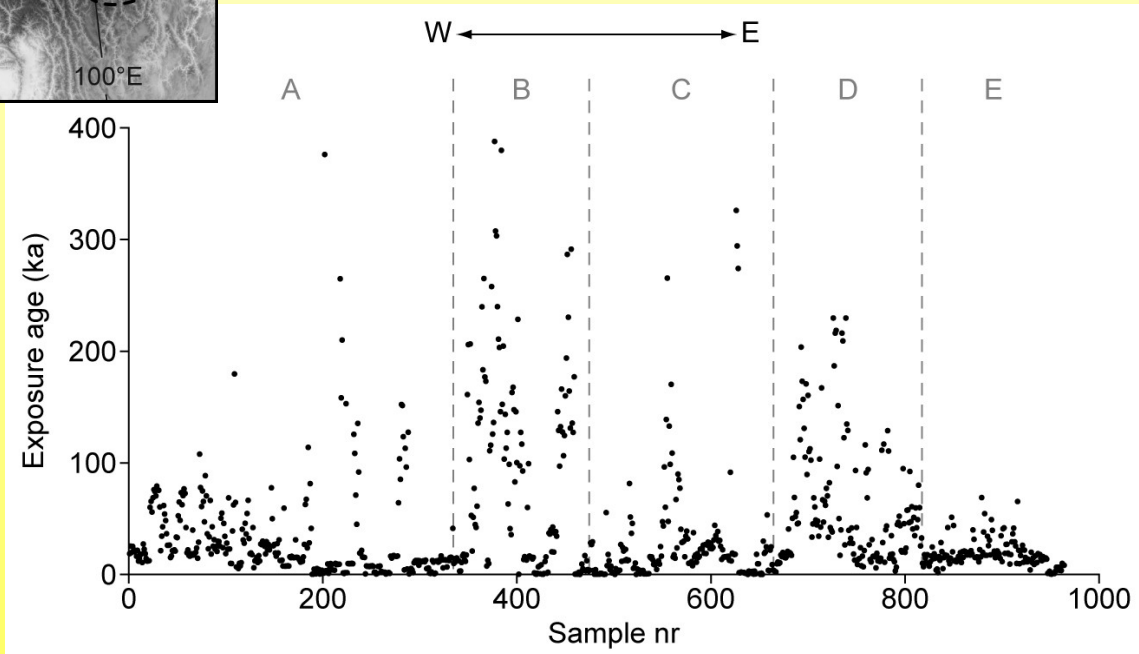




Implications for Tibetan paleoglaciology

The Tibetan Plateau holds a glacial geological record that is significantly older than what is normally found in the northern hemisphere






Thank you!

Tibetan plateau TCN data

Reference	boulders	boulder groups
Abramowski (2004): *PhD Thesis*	28	7
Abramowski et al. (2006): *QSR*	83	19
Aoki and Imamura (1999): *Proceedings*	2	1
Barnard et al. (2004a): *Sedimentary Geology*	15	4
Barnard et al. (2004b): *Geomorphology*	15	5
Barnard et al. (2006): *QSR*	11	4
Brown et al. (2002): *JGR*	4	1
Chevalier et al. (2005): *Science*	27	3
Colgan et al (2006): *QR*	3	-
Finkel et al. (2003): *Geology*	38	12
Gayer et al. (2006): *EPSL*	4	1
Graf et al. (submitted): *Quaternary Geogchron*	17	6
Heimsath and McGlynn (2008): *Geomorphology*	10	2
Heyman et al. (in prep)	39	14
Owen et al. (2001): *JQS*	24	9
Owen et al. (2002): *GSAB*	28	9
Owen et al. (2003a): *GSAB*	65	20
Owen et al. (2003b): *Zeitschrift f Geomorph*	15	4
Owen et al. (2003c): *Boreas*	18	6
Owen et al. (2005): *QSR*	67	19
Owen et al. (2006a): *GSAB*	55	16
Owen et al. (2006b): *QI*	46	12
Owen et al. (2009): *QSR*	59	10
Phillips et al. (2000): *Geology*	14	3
Schaefer et al. (2008): *QSR*	21	7
Schäfer (2000): *PhD Thesis*	1	-
Schäfer et al. (2002): *EPSL*	9	2
Seong et al. (2007): *QSR*	65	10
Seong et al. (2009): *GSAB*	124	25
Strasky et al (2009): *J of Asian Earth Sciences*	5	1
Tschudi et al. (2003): *J of Asian Earth Sciences*	2	1
Wang et al. (2003): *Acta Geologica Sinica*	1	-
Zech et al. (2005): *QR*	20	4
Zech et al (2009): *QSR*	17	5
Zhou et al. (2007): *Chinese Science Bulletin*	12	2
Sum	964	244

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http://people.su.se/~jahe5887/
including CRONUS input and
Google Earth kml files