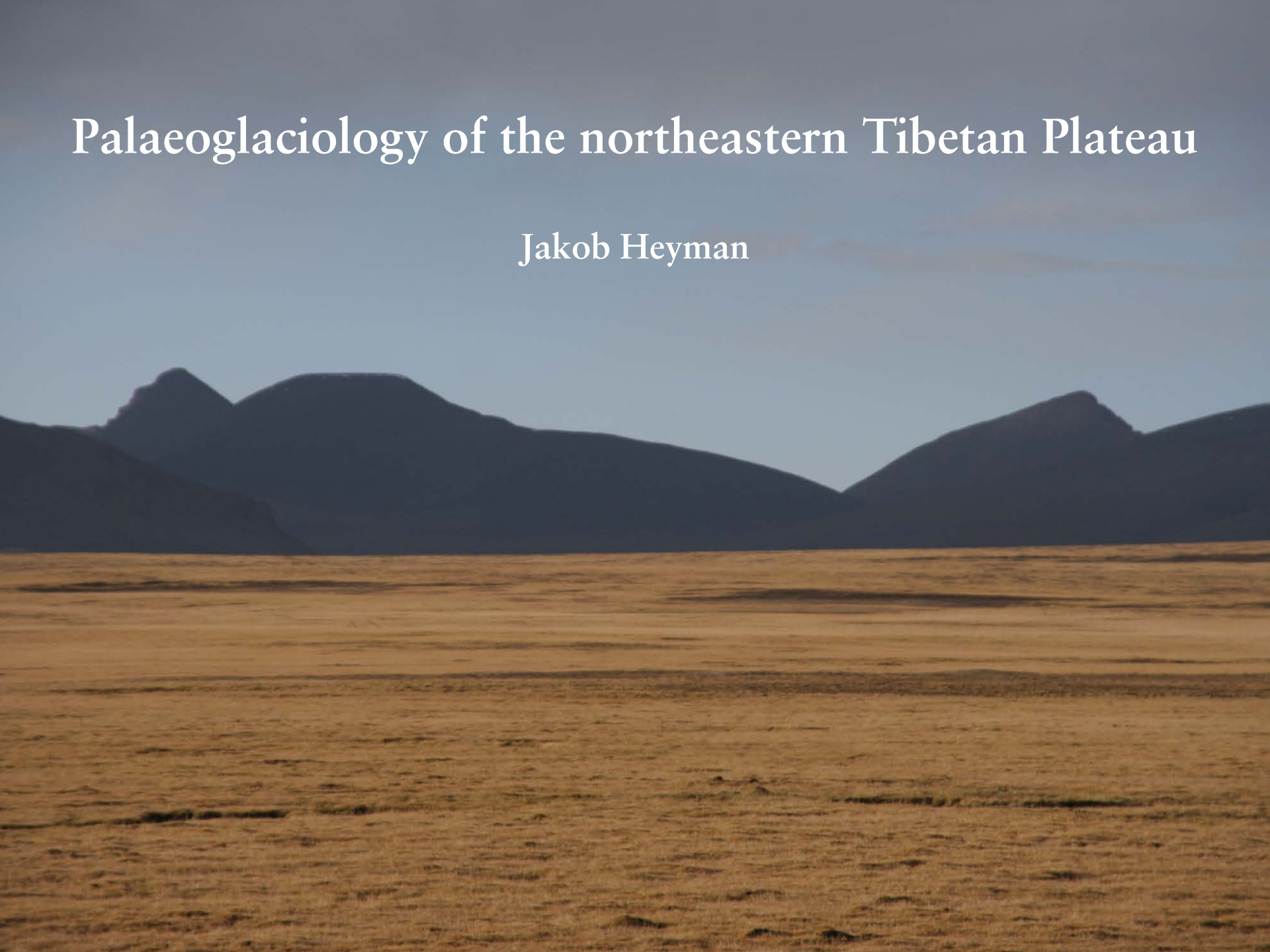
Palaeoglaciology of the northeastern Tibetan Plateau

Jakob Heyman



Acknowledgement

Arjen Stroeven

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Liping Zhou

Gengnian Liu

Jianyi Dong

Luyi Ma

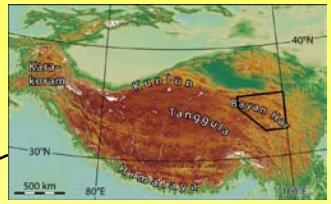
Martin Machiedo

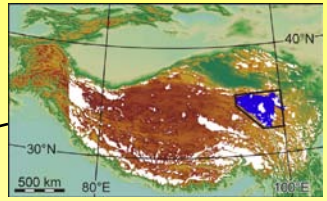
Feng Liu

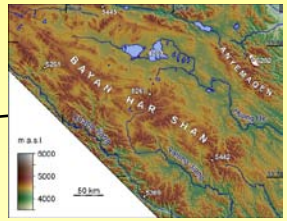
Daniel Veres

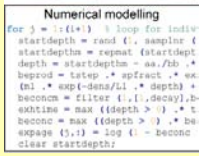
Alun Hubbard

Outline

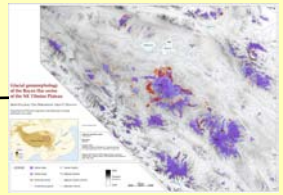




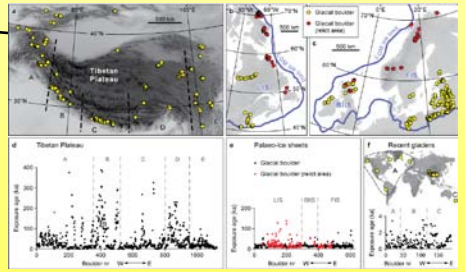




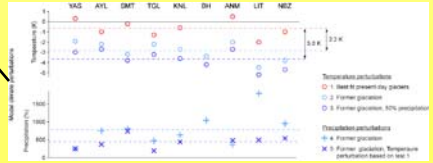
Introduction
- Palaeoglaciology
- Tibetan Plateau
- Glacial reconstructions
- Bayan Har Shan
- Aim and methods



Paper I
Paper II
Paper III
Paper IV
Paper V



Thesis summary



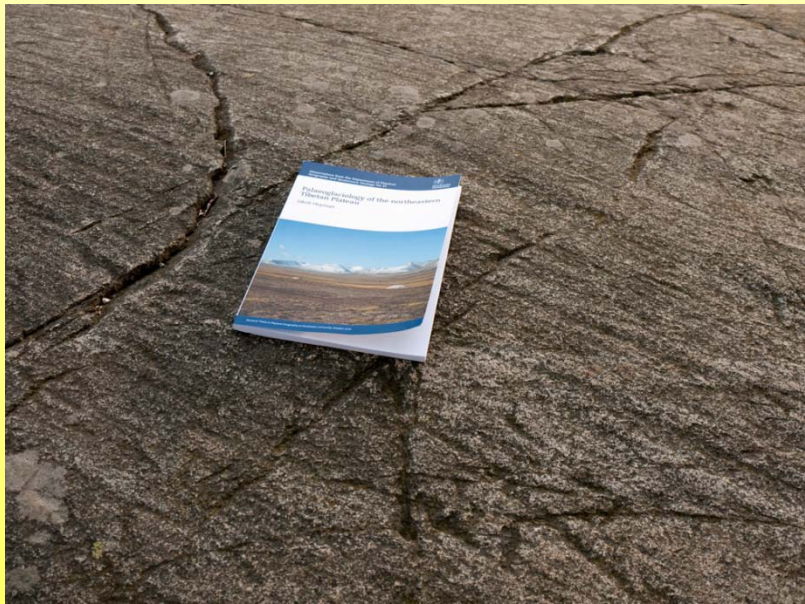
Conclusions

Palaeoglaciology – study of past glaciers

Size of past glaciers based on landform and sediment record

Timing of past glaciers based on physics/chemistry methods

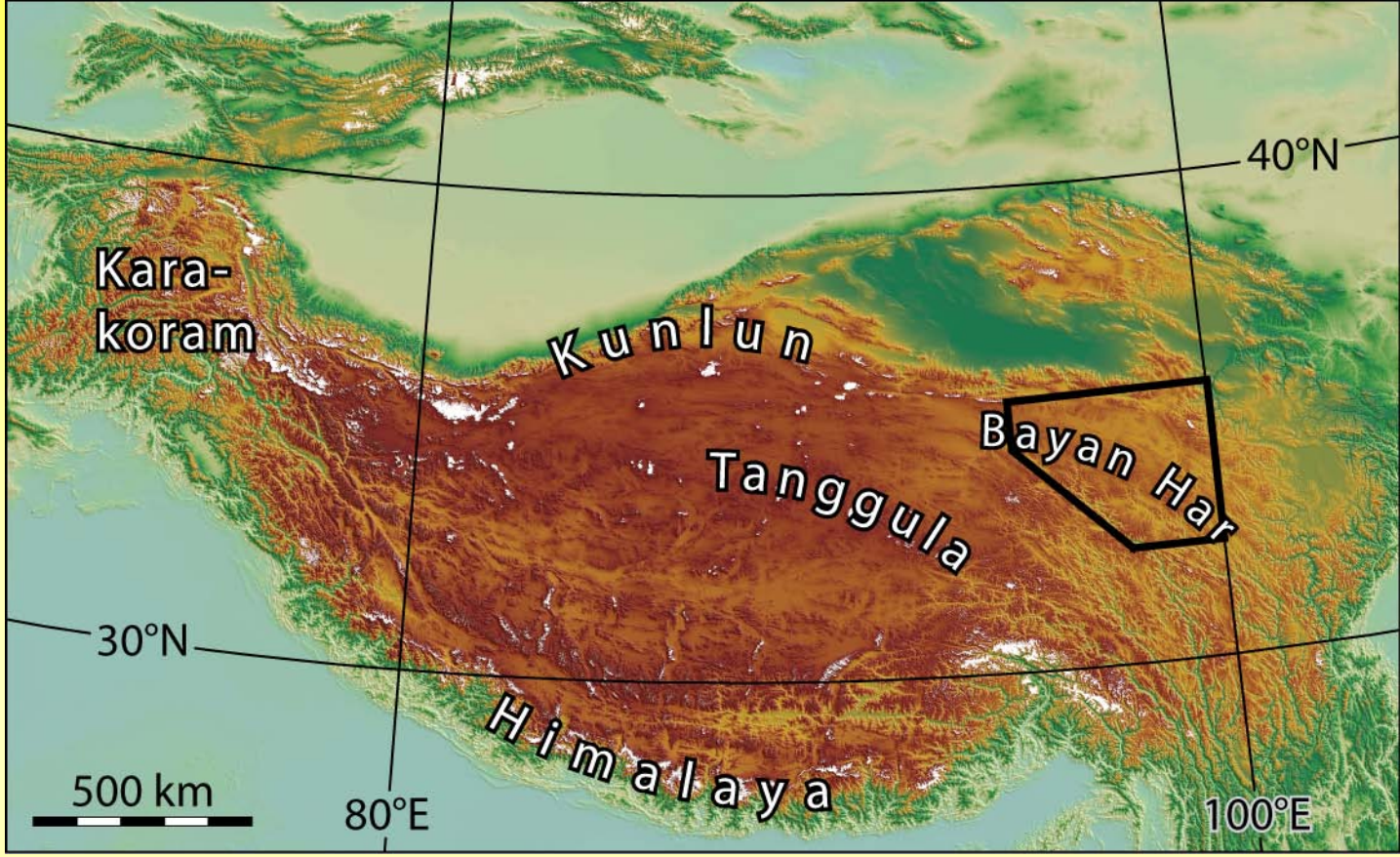
<u>Challenge</u>
Time obscures the spatial and temporal record

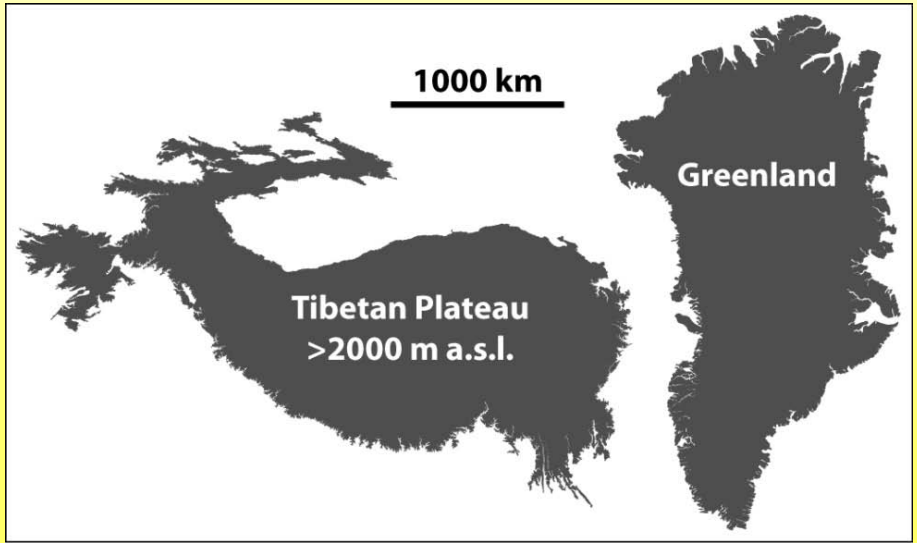


Tibetan Plateau

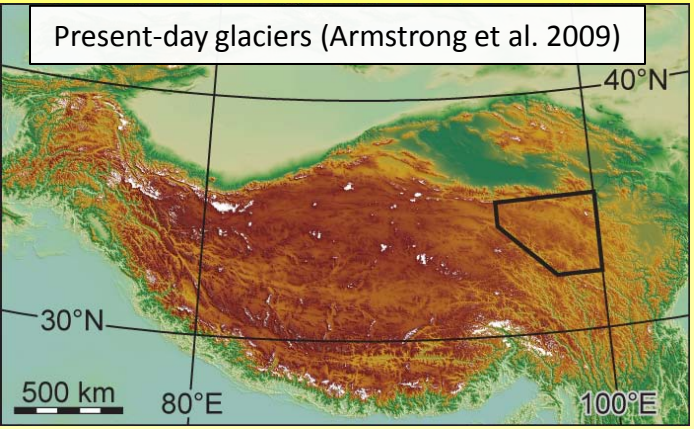
”Roof of the world”

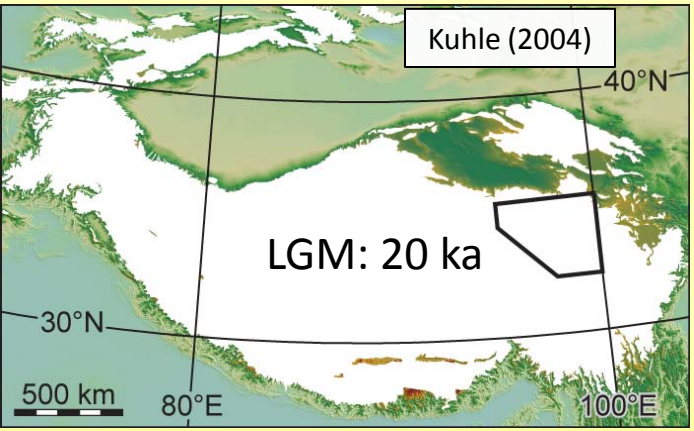
”Third pole”

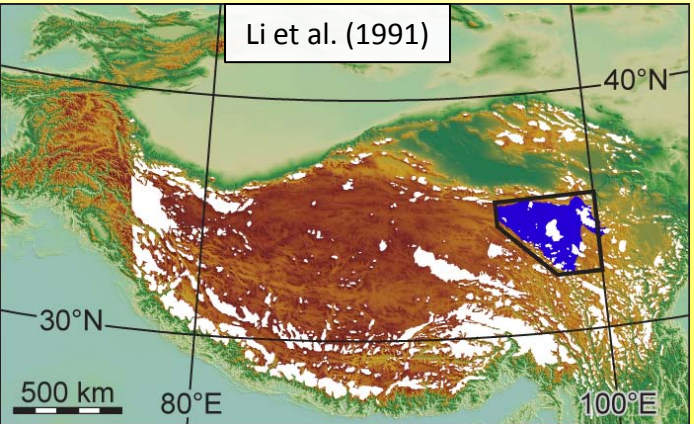


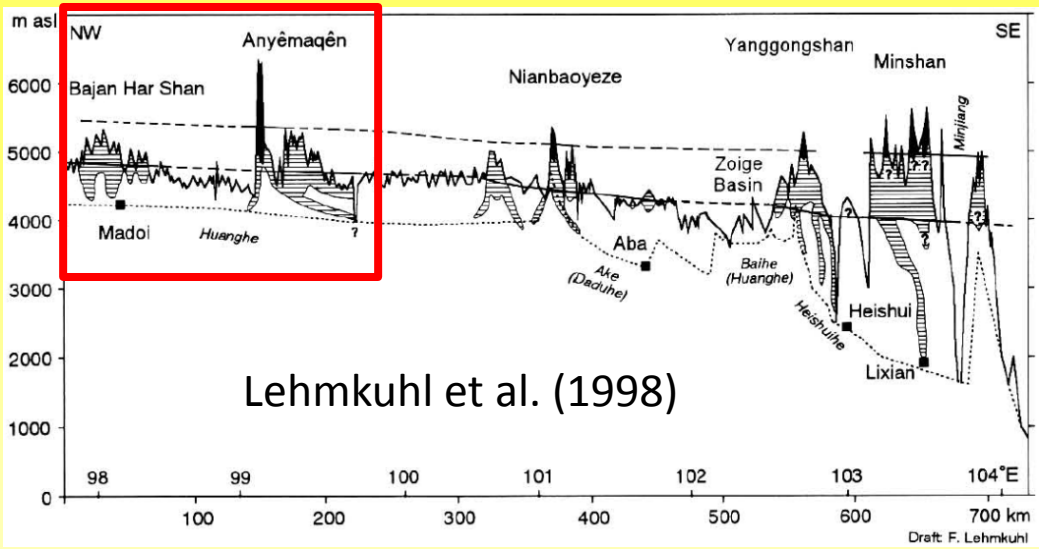


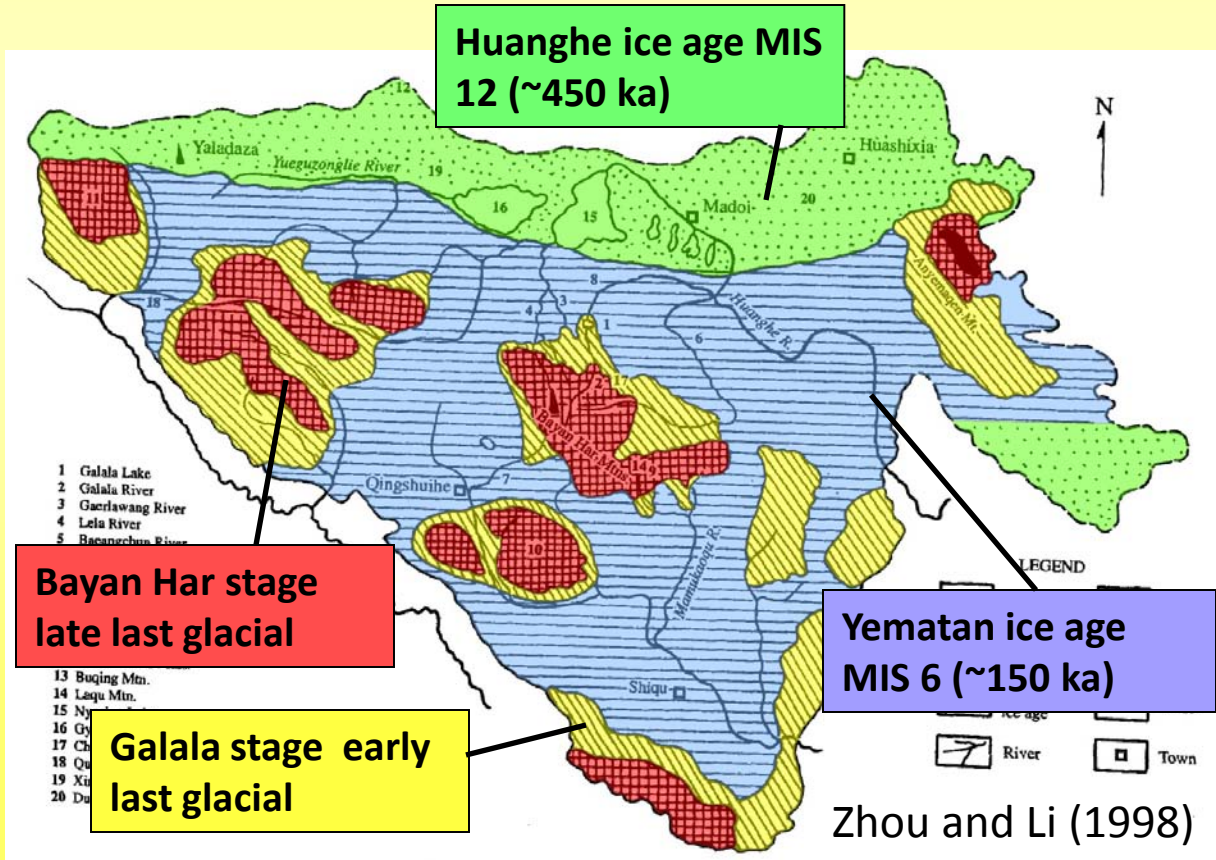
Glacial reconstructions



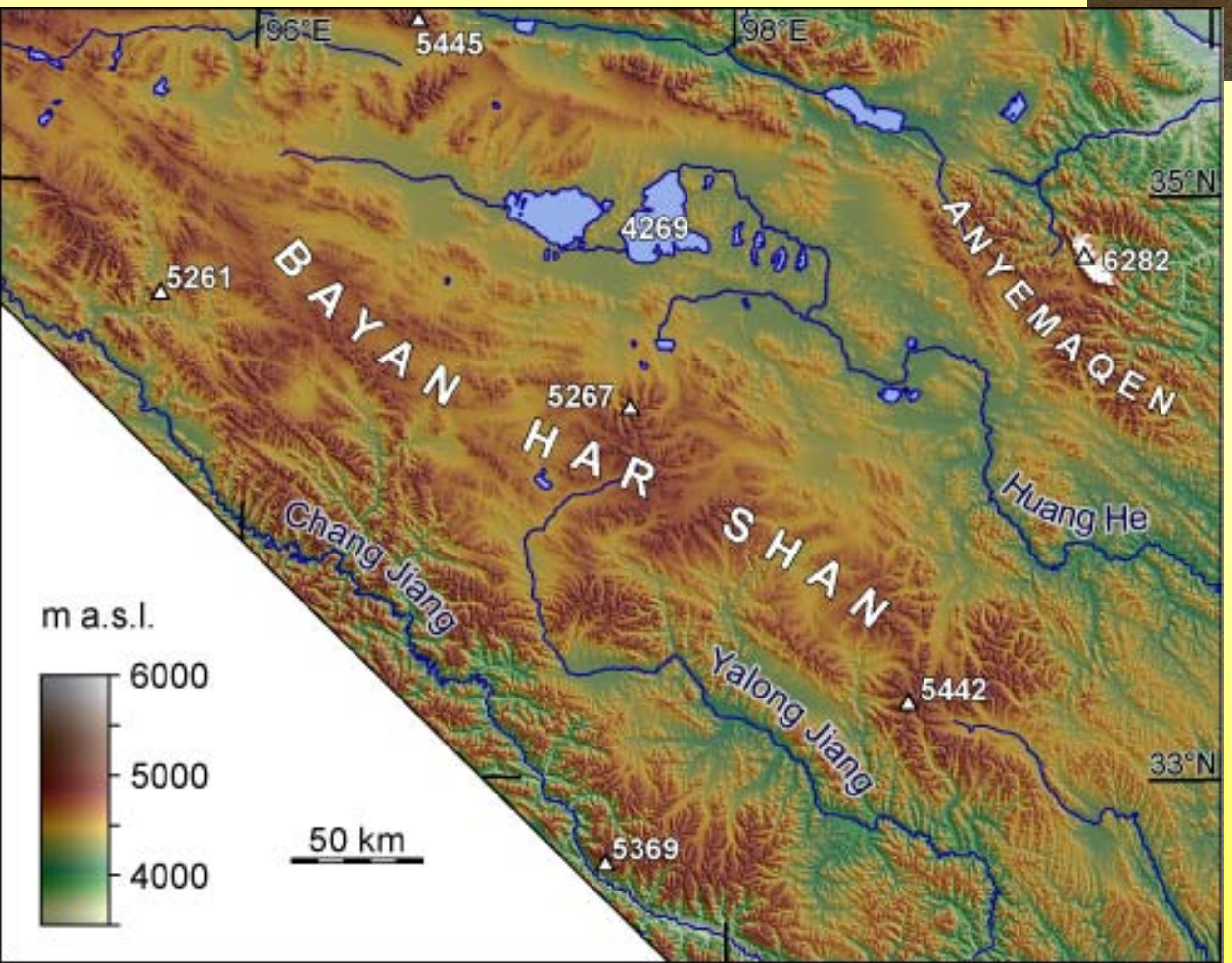








The NE sector: Bayan Har Shan



Aim and methodology

How extensive have past glaciers in Bayan Har Shan been and when did they exist?

Paper I
Heyman J, Hättestrand C, Stroeven AP, 2008. Glacial geomorphology of the Bayan Har sector of the NE Tibetan Plateau. *Journal of Maps* 2008, 42-62.

Paper II
Stroeven AP, Hättestrand C, **Heyman J**, Harbor J, Li YK, Zhou LP, Caffee MW, Alexanderson H, Kleman J, Ma HZ, Liu GN, 2009. Landscape analysis of the Huang He headwaters, NE Tibetan Plateau – patterns of glacial and fluvial erosion. *Geomorphology* 103, 212-226.

Paper III
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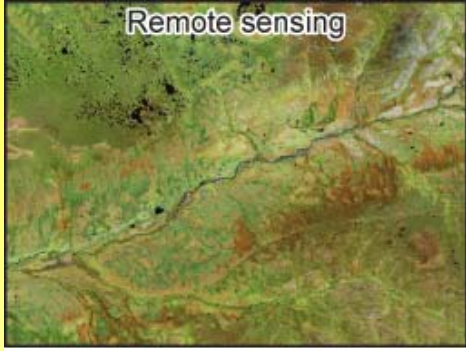
Paper IV
Heyman J, Stroeven AP, Harbor J, Caffee MW, submitted. Boulder cosmogenic exposure ages as constraints for glacial chronologies. *Earth and Planetary Science Letters*.

Paper V
Heyman J, Stroeven AP, Caffee MW, Hättestrand C, Harbor J, Li YK, Alexanderson H, Zhou LP, Hubbard A, manuscript. Palaeoglaciology of Bayan Har Shan, NE Tibetan Plateau: the case of a missing LGM expansion.



Numerical modelling

```
for j = 1:(i+1)  % loop for indiv
  startdepth = rand (1, samplnr (
  startdepthm = repmat (startdept
  depth = startdepthm - aa./bb .*
  beprod = tstep .* spfract .* ex
  (m1 .* exp(-dens/L1 .* depth) +
  beconcm = filter (1,[1,decay],b
  exhtime = max ((depth > 0) .* t
  beconc = max ((depth > 0) .* be
  expage (j,:) = log (1 - beconc
  clear startdepth;
```

Paper I

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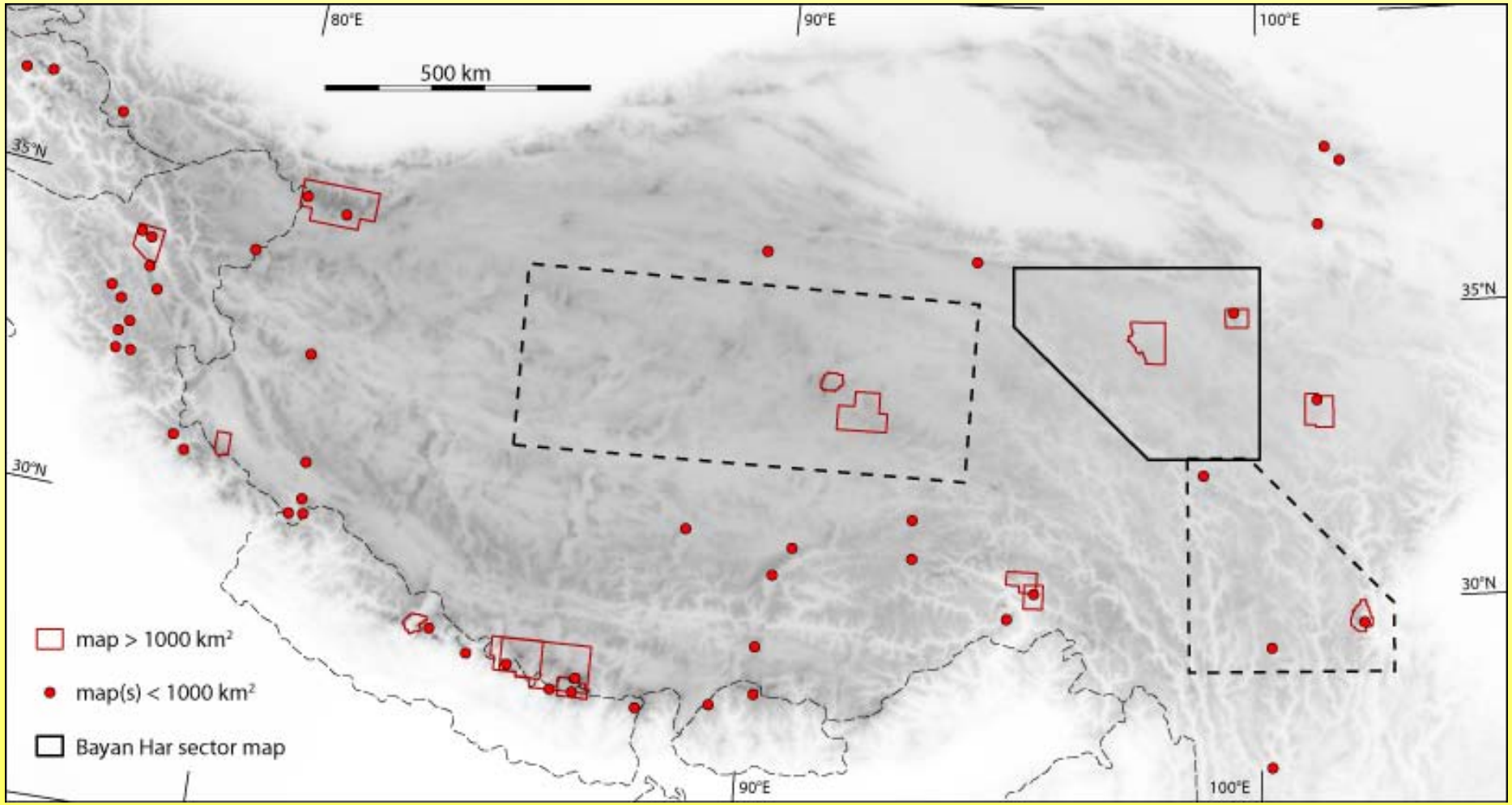
Detailed glacial geomorphological maps



Glacial geomorphology of the Bayan Har sector of the NE Tibetan Plateau

Jakob Heyman, Clas Hättestrand, Arjen P. Stroeven

Department of Physical Geography and Quaternary Geology
Stockholm University

Projected coordinate system
UTM zone 47

Map datum
WGS 84

Elevation data
Holefilled seamless SRTM data V3, International Center for Tropical Agriculture (CIAT), (http://srtm.csi.cgiar.org)

Mapped 2005-2007 from SRTM digital elevation model and Landsat ETM+ satellite imagery. Field checked during fieldwork in 2005, 2006, 2007.

LEGEND

- Glacial valley
- Glacial trough
- Hummocky terrain
- Contemporary glacier
- Glacial lineation
- Marginal moraine
- Marginal moraine remnant
- Meltwater channel

6000
Elevation (m a.s.l.)
3500

50 km

Paper II

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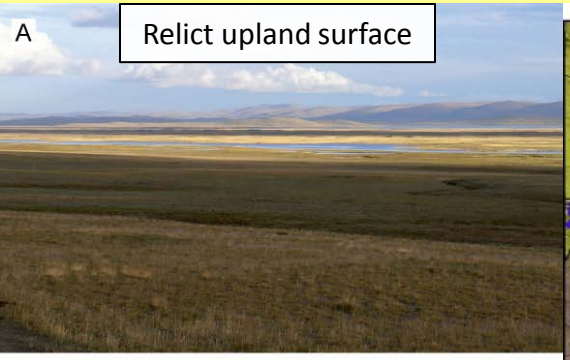
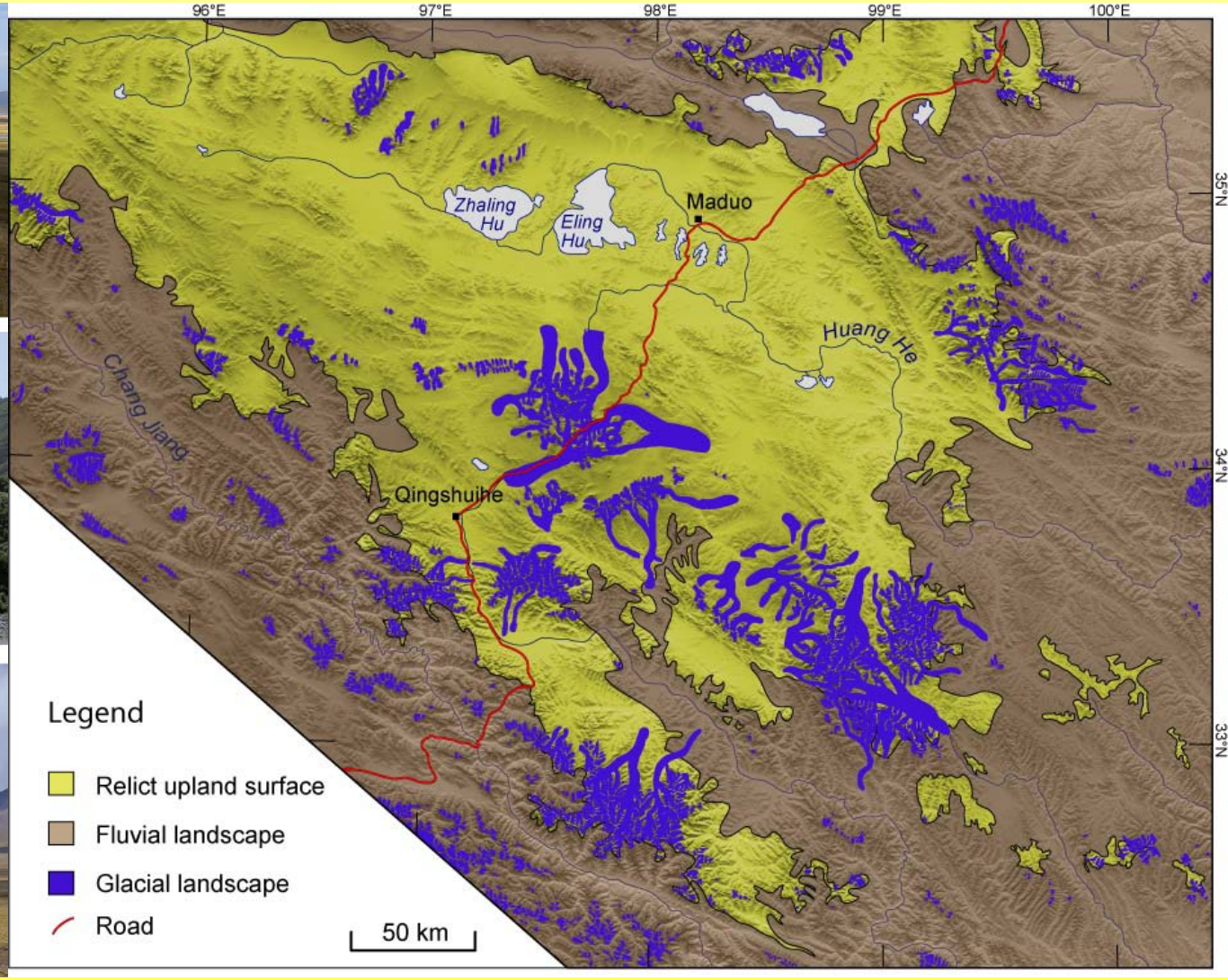
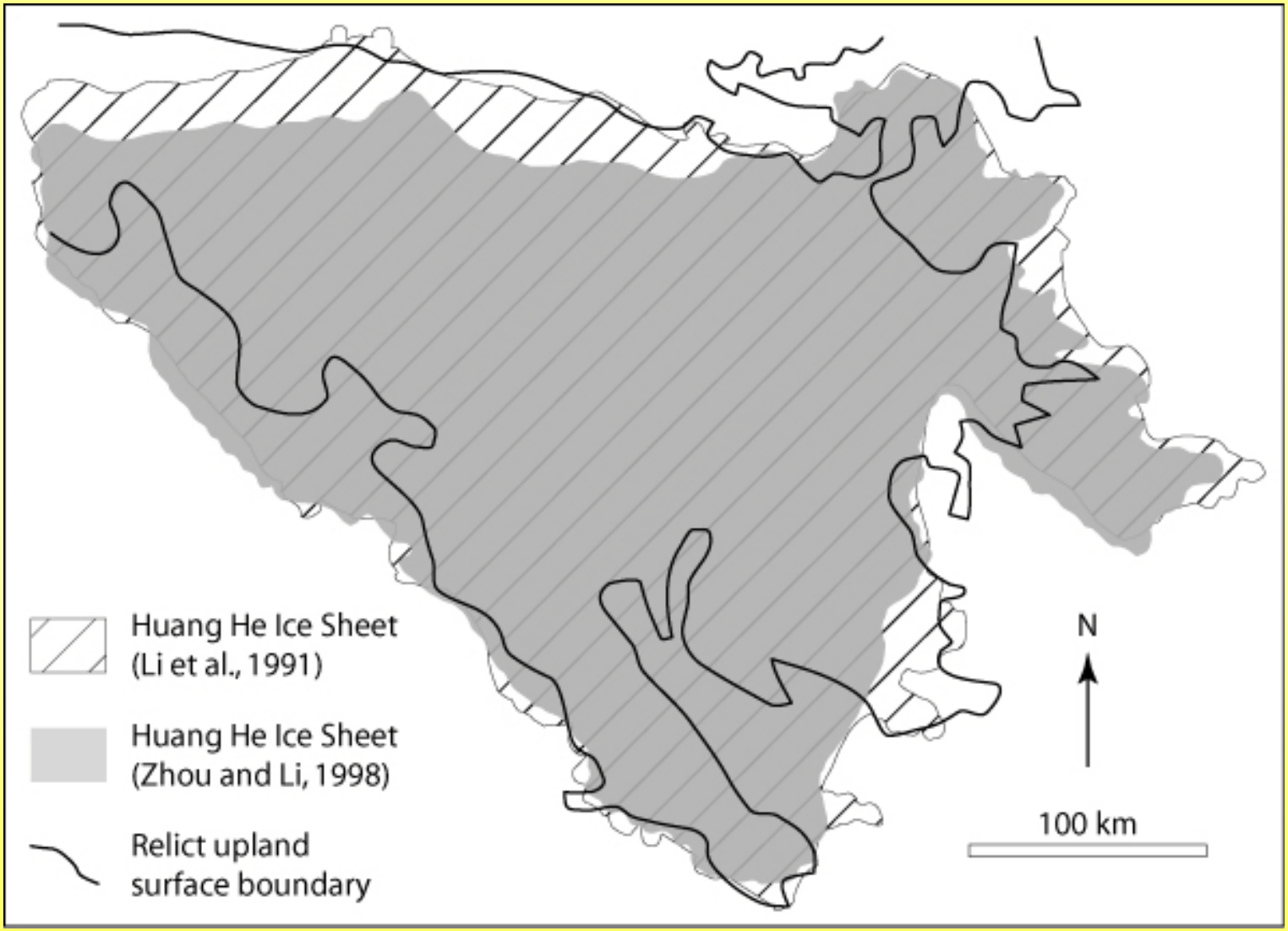




Paper II

Comparison: Relict upland surface – Huang he ice sheet



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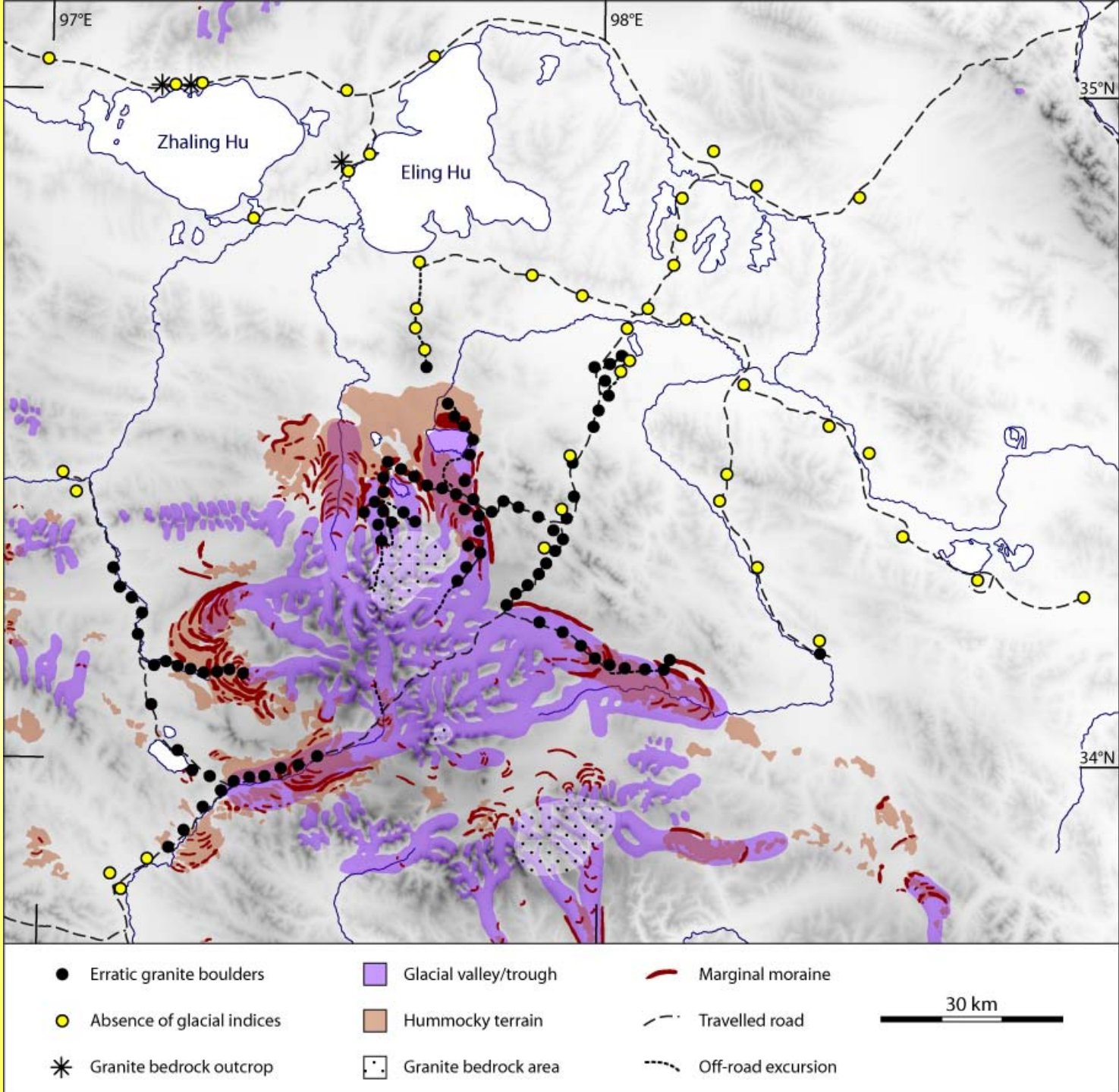
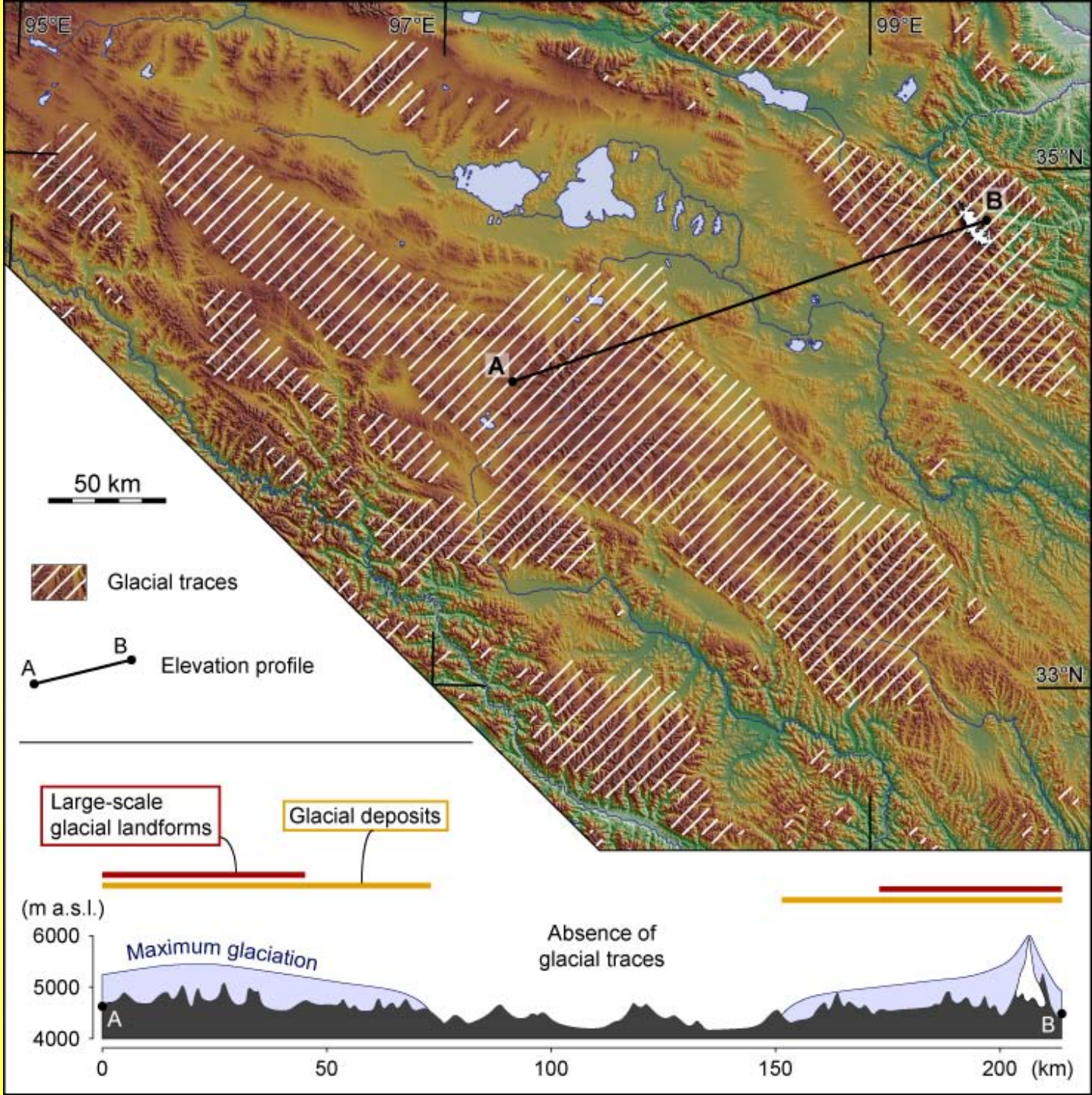
Field data paper

Comparison field data – remote sensing data



Minimum extent of maximum glaciation



Paper IV

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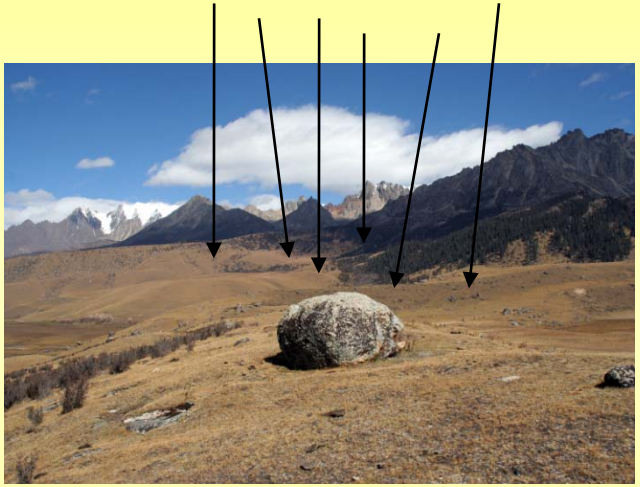
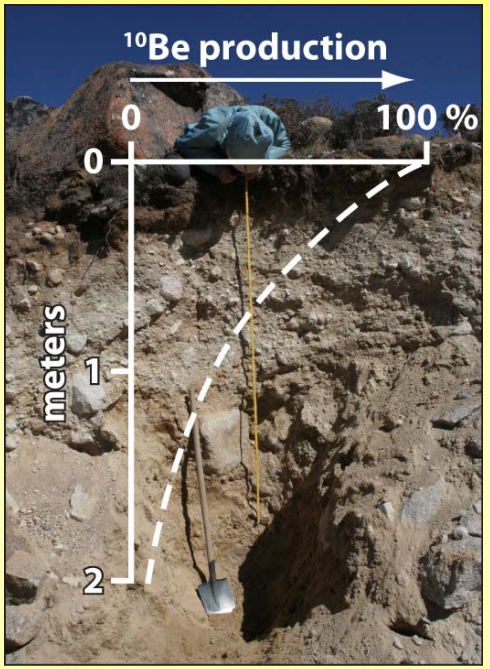
Cosmogenic exposure dating

Exposure to cosmic rays produces cosmogenic nuclides (^{10}Be) in quartz





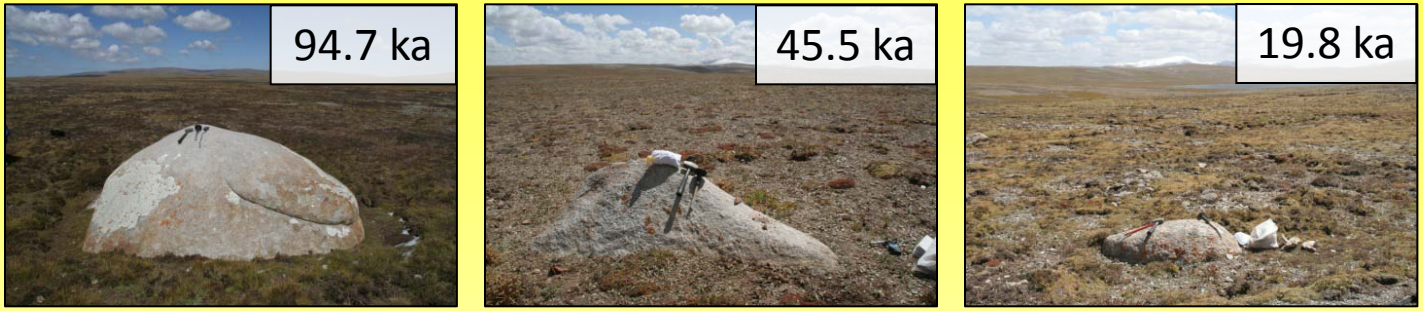
Glacial erosion and deposition

Sampling and ^{10}Be measurement

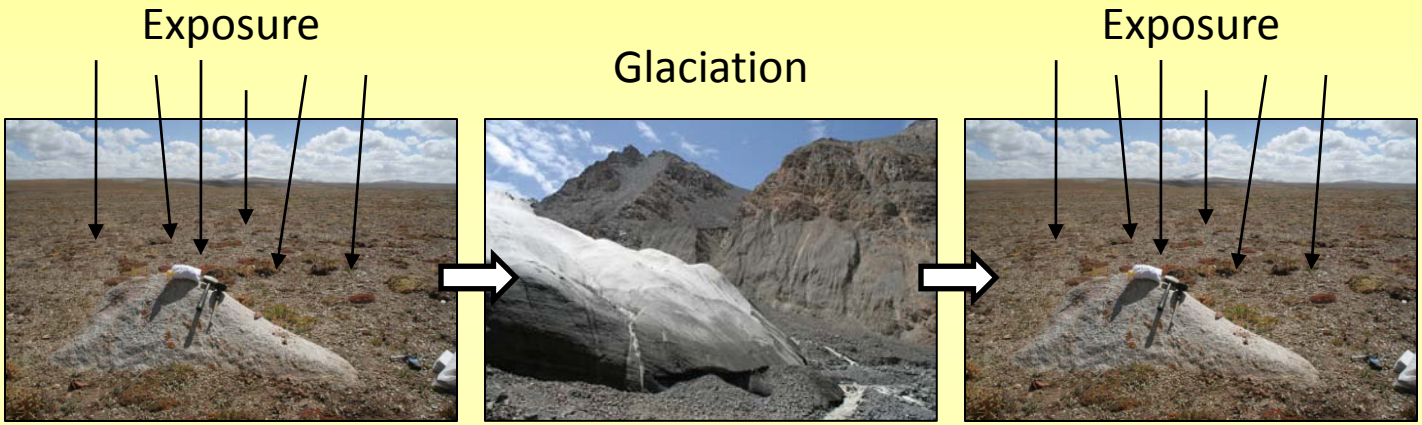
Absolute measurement of **exposure to cosmic rays**

⇩

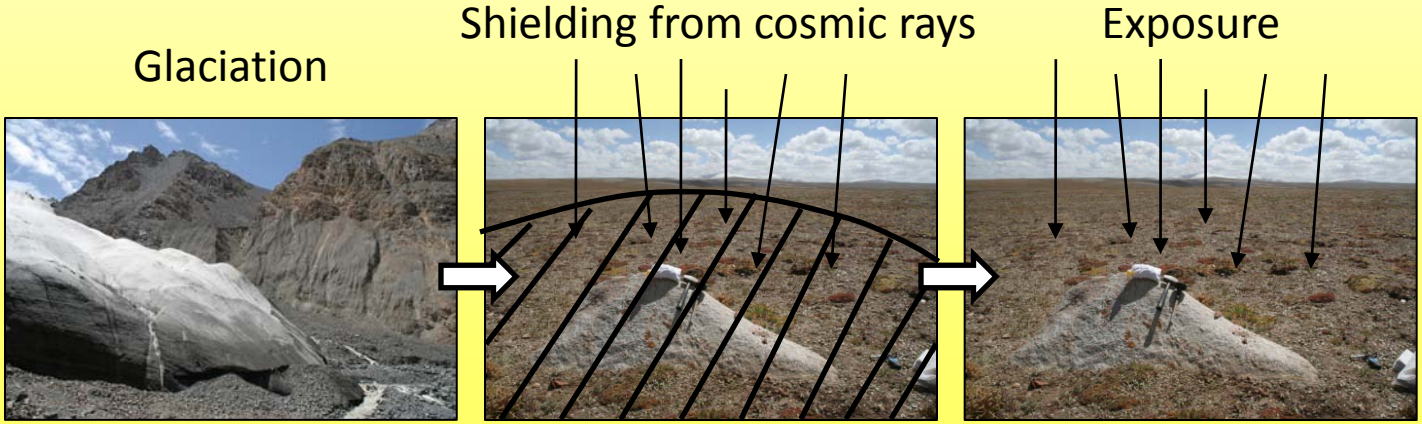
Exposure age



Deglaciation age???



Too old
exposure age



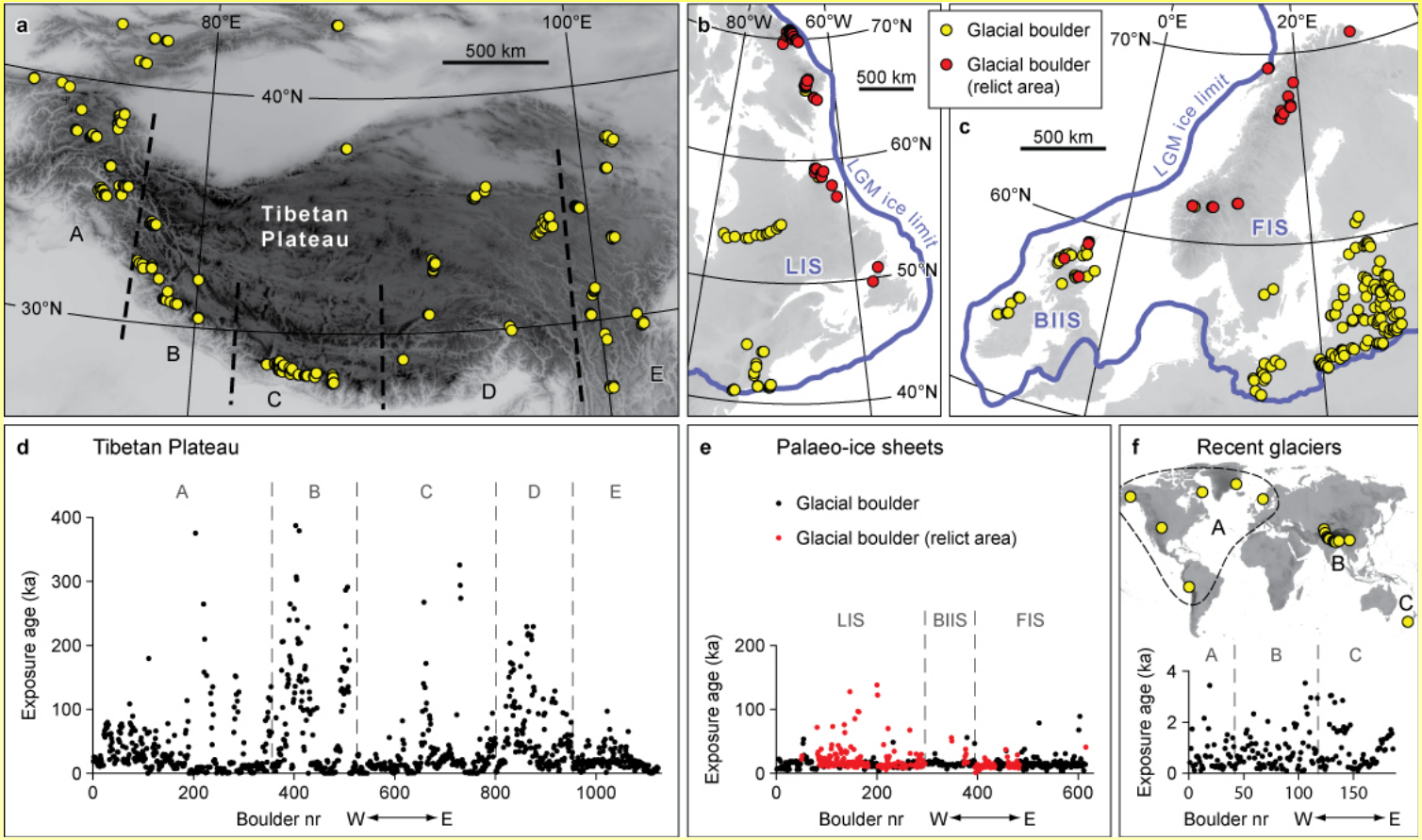
Too young
exposure age

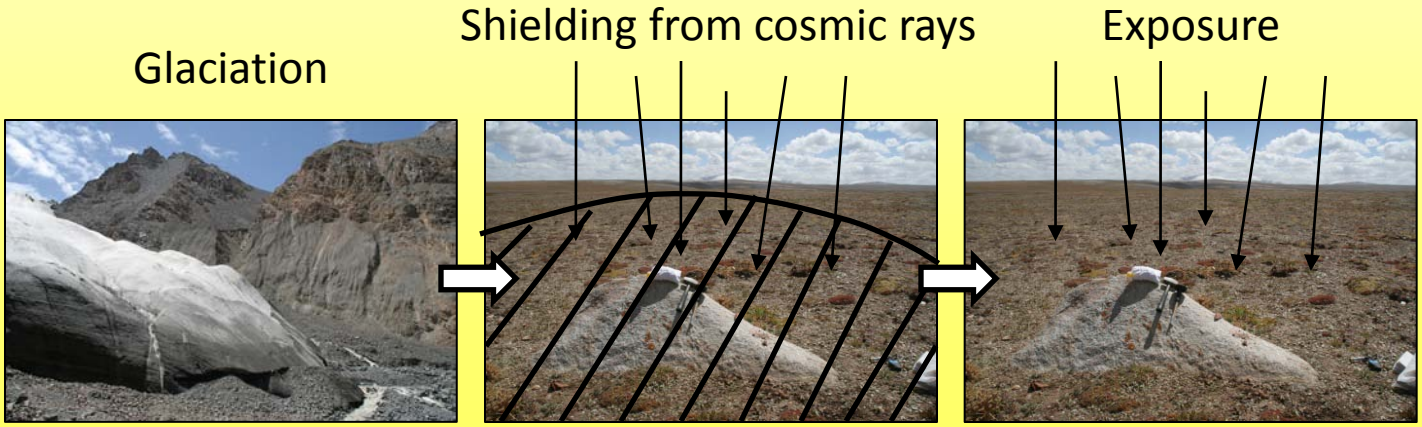
Exposure age compilation

Tibetan Plateau:
1123 boulders

Palaeo-ice sheets:
615 boulders

Present glaciers:
186 boulders





Minimum age

Paper V

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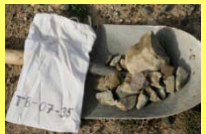
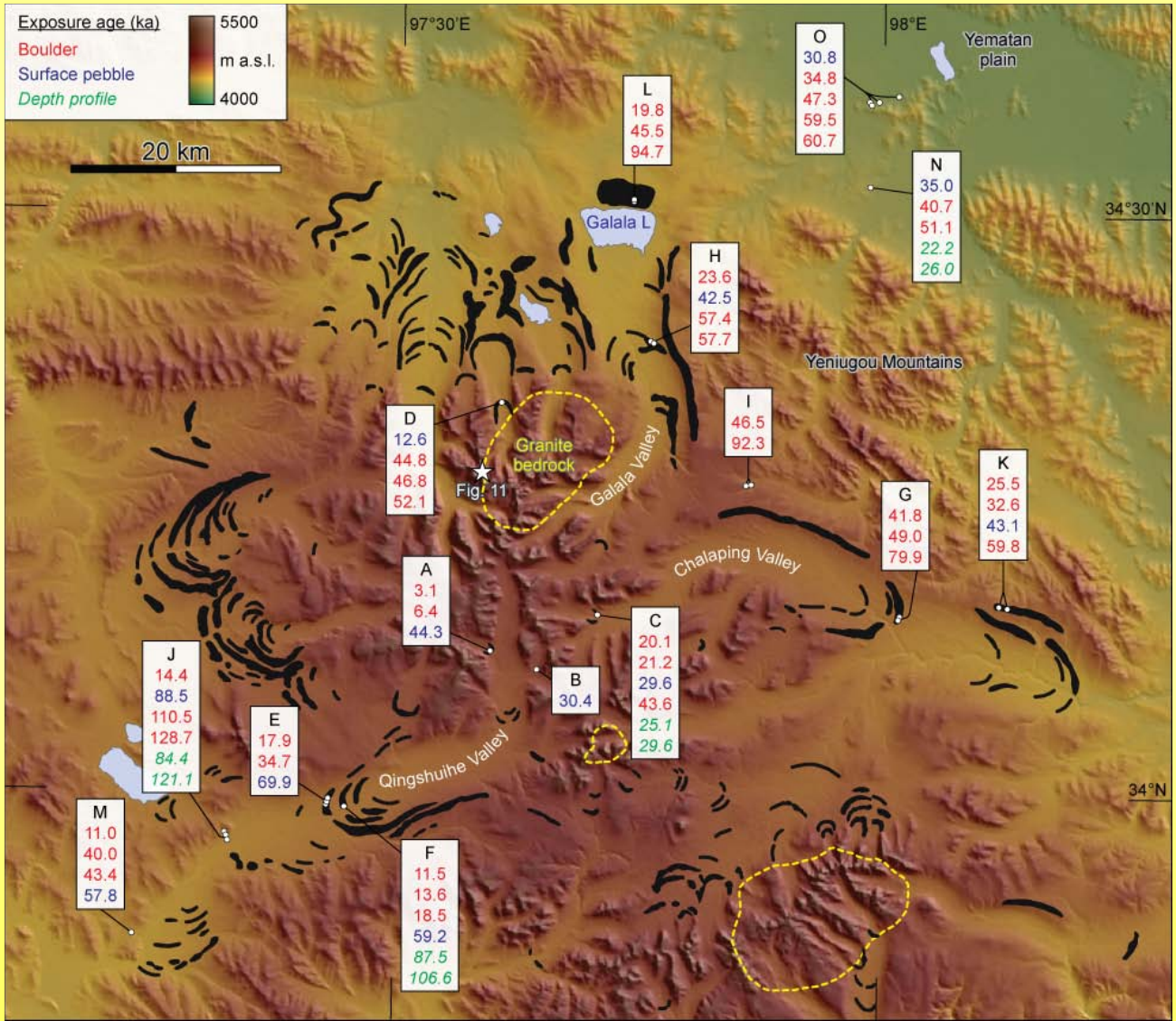
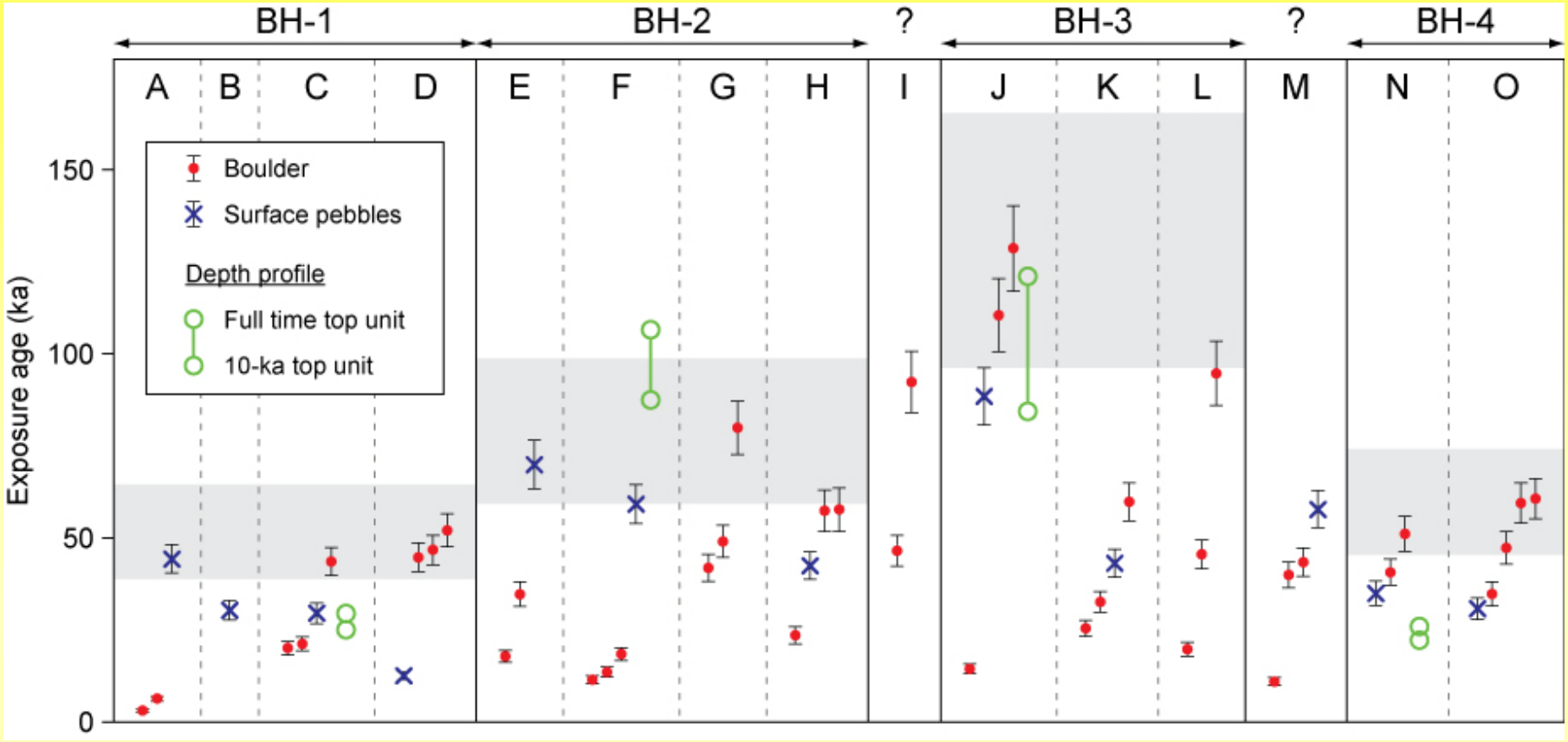
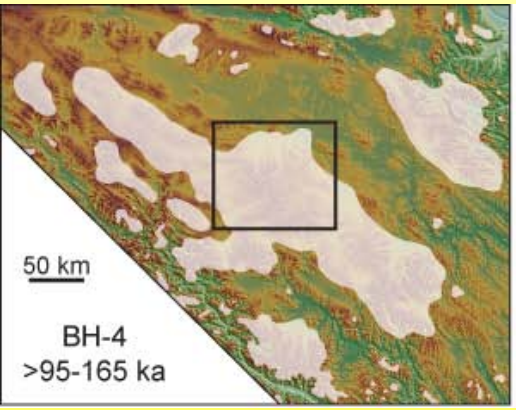
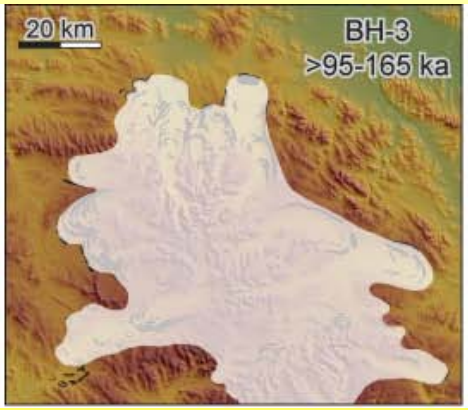


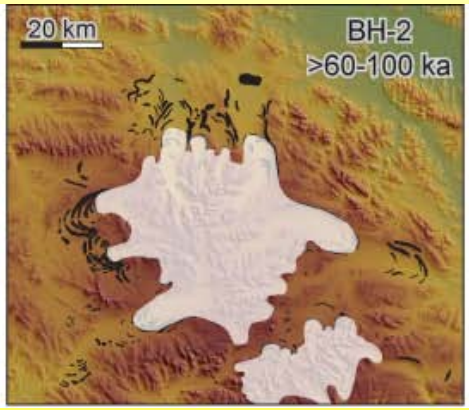


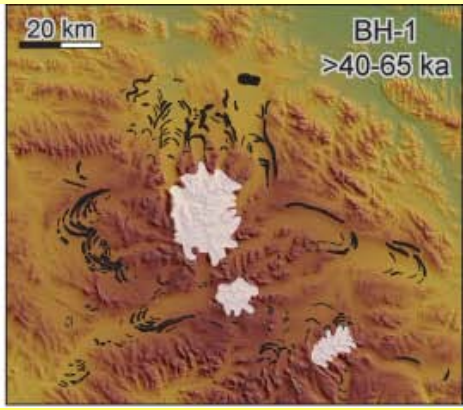


How extensive have past glaciers in Bayan Har Shan been and when did they exist?

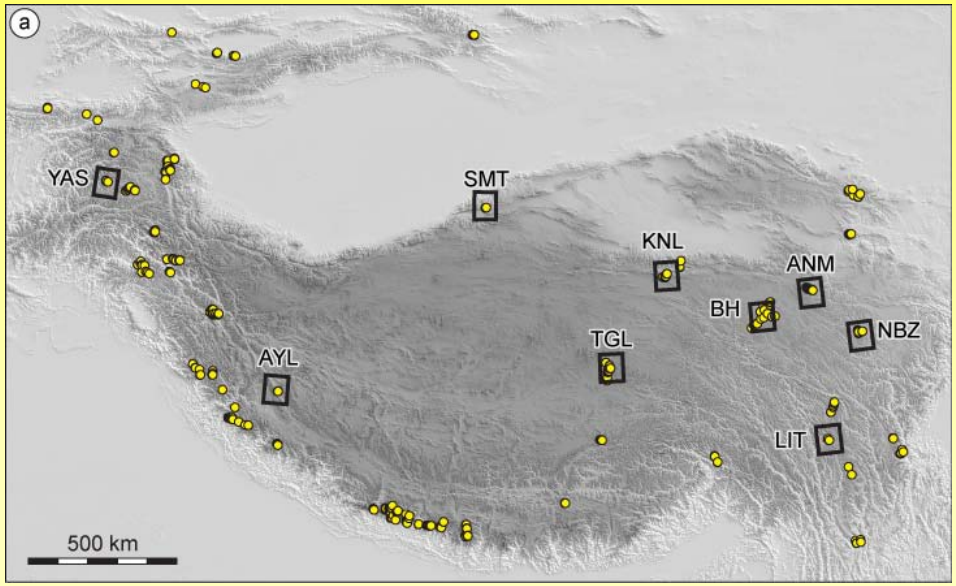






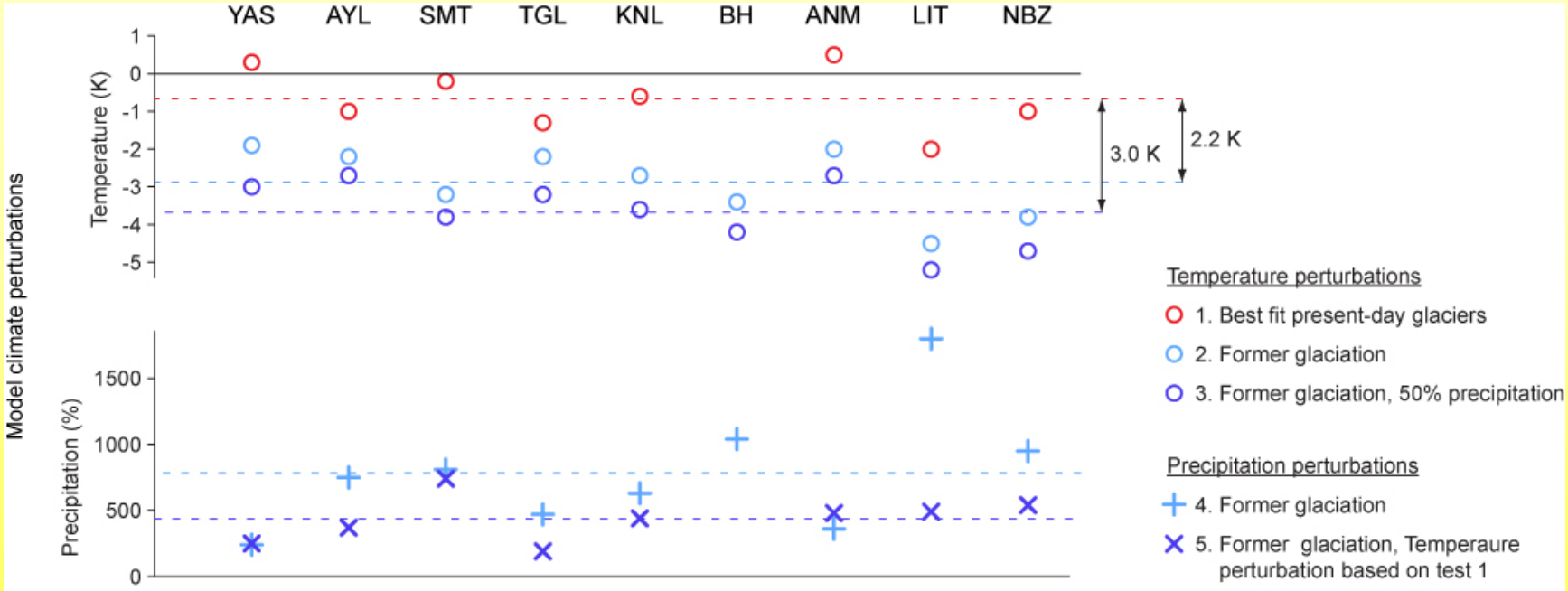


Thesis summary

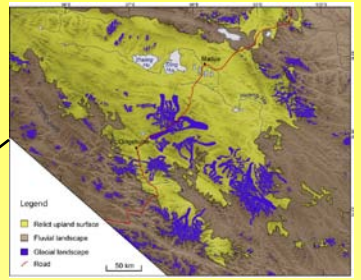


3D glacier modelling

Modest cooling (2-4 K) enough to produce glaciers larger than during the LGM

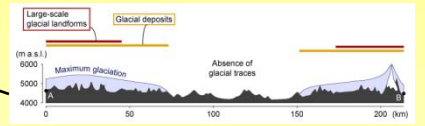


Conclusions

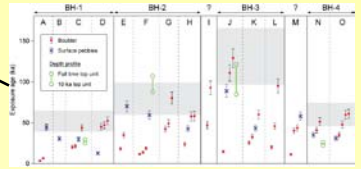


Bayan Har Shan

- In the mountains: glacial erosion more effective than fluvial erosion
  Along the plateau margin: fluvial erosion more effective than glacial erosion
- Multiple glaciations with alpine style valley glaciers and ice fields

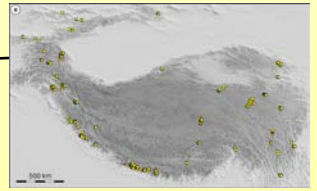


- All dated landforms are significantly older than the global LGM

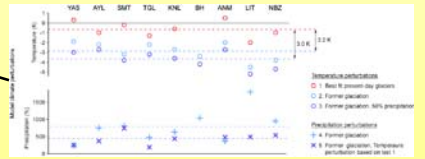


Tibetan Plateau

- Generally restricted glaciations during the LGM

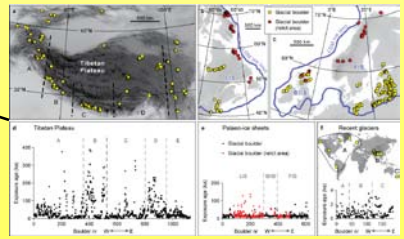


- Modelling indicate modest cooling during the LGM



Cosmogenic exposure ages

- Exposure ages should, in the absence of other evidence, be viewed as minimum deglaciation ages



Take-home message

Glaciers on the Tibetan Plateau have been small for a long time

Thank you!

Funding

Swedish Research Council/Swedish International Development Cooperation Agency (VR/SIDA) to Arjen Stroeven

Royal Swedish Academy of Sciences (KVA)

Swedish Society for Anthropology and Geography (SSAG)

Helge Ax:son Johnsons stiftelse

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Gerard De Geers stiftelse.