GEOLOGY | THE GEOLOGICAL SOCIETY OF AMERICA®

https://doi.org/10.1130/G47196.1

Manuscript received 28 August 2019
Revised manuscript received 12 November 2019
Manuscript accepted 18 November 2019

Diachronous Tibetan Plateau landscape evolution derived from lava field geomorphology

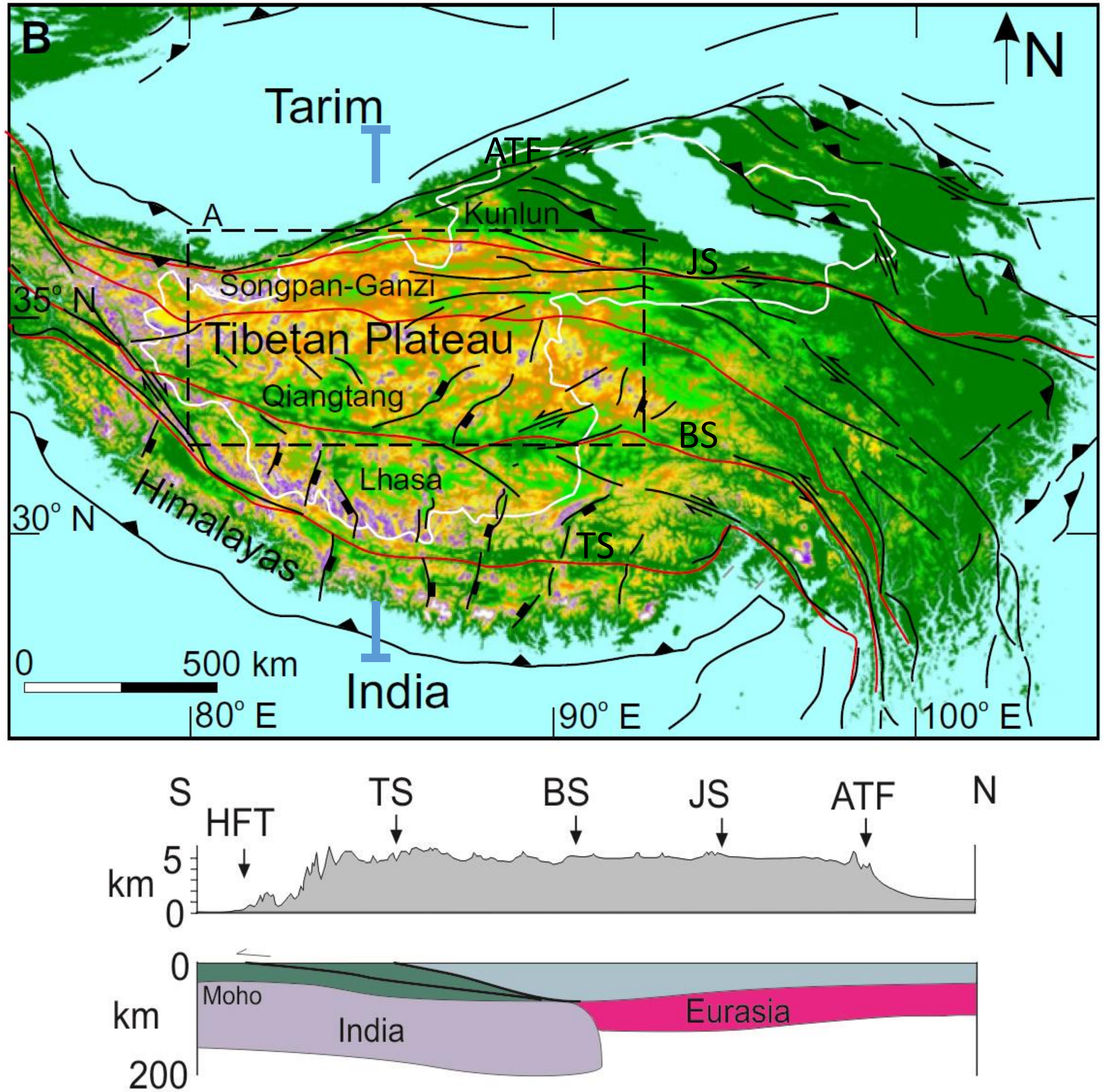
Robert Law[1,2] and Mark B. Allen[2]
[1]Scott Polar Research Institute, Department of Geography, Cambridge University, Cambridge CB2 1ER, UK
[2]Department of Earth Sciences, Durham University, South Road, Durham DH1 3LE, UK

The paper on which this study is based was published in Geology in March 2020 (and is Open Access).

Traditional starting point:

The crust of the Tibetan Plateau is ~70 km thick, and elevation are commonly ~5 km above sea level. So if we don't understand how it evolved, we can't claim to understand continental tectonics.

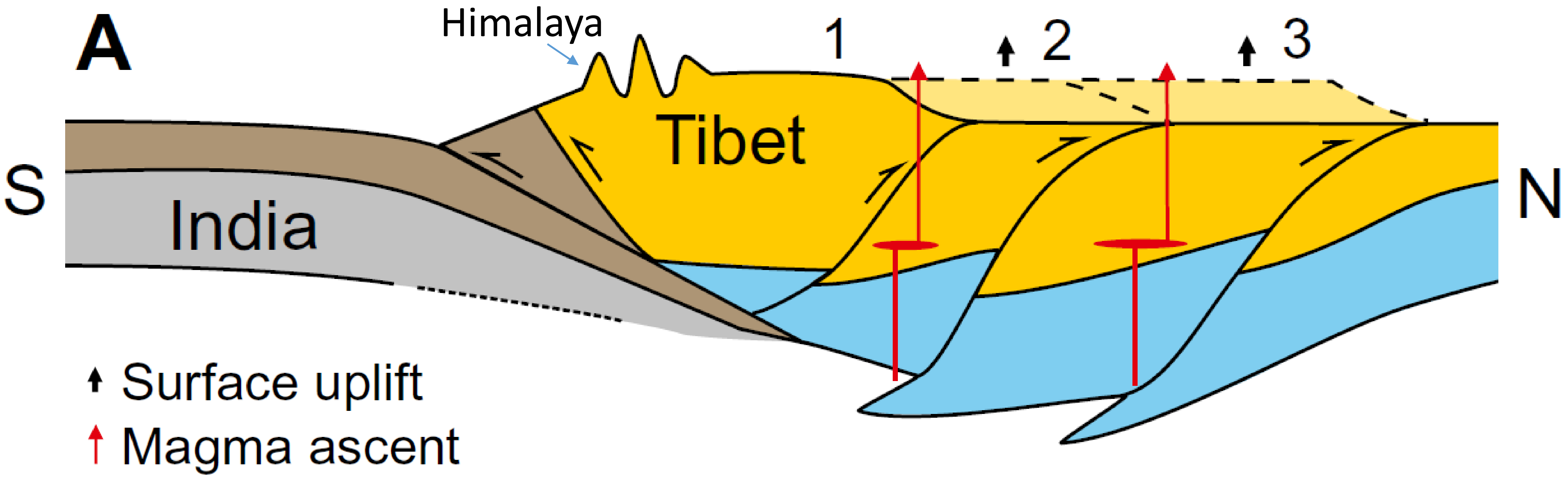
This study looks at the geomorphology of lava fields that post-date the initial India-Eurasia collision (~50 Ma).



White line: Limit of internal drainage

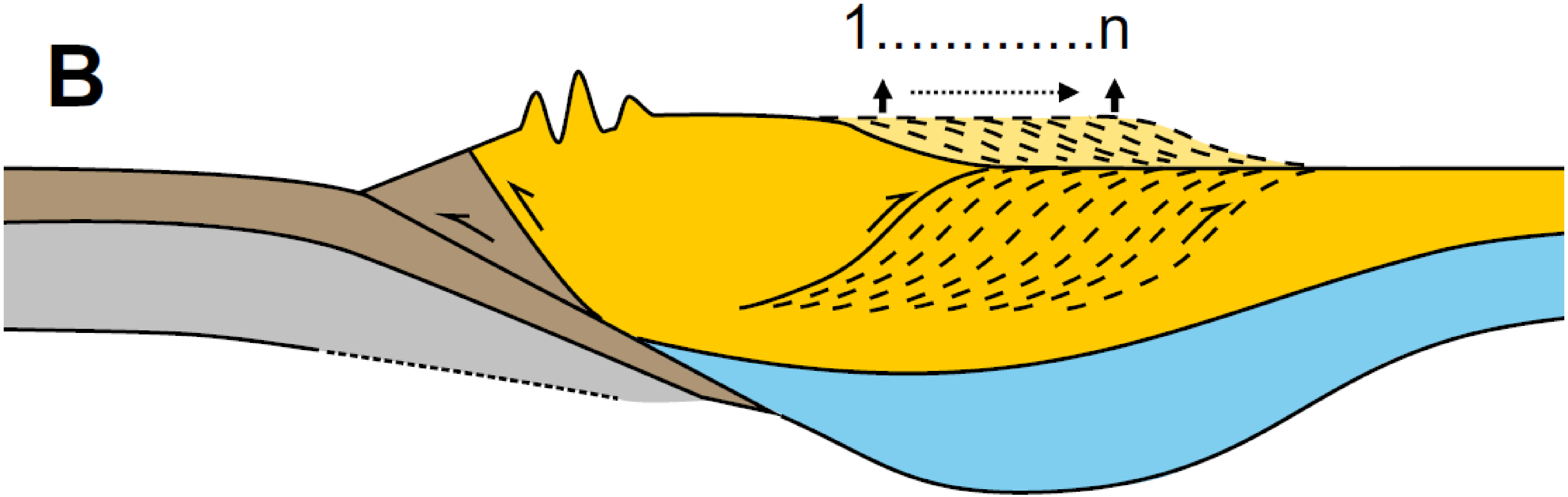
Red lines: Sutures

Several end-member models have been proposed for evolution of the Tibetan Plateau, north of the Himalaya. These include stepwise, crustal shortening and thickening, above continental subduction:



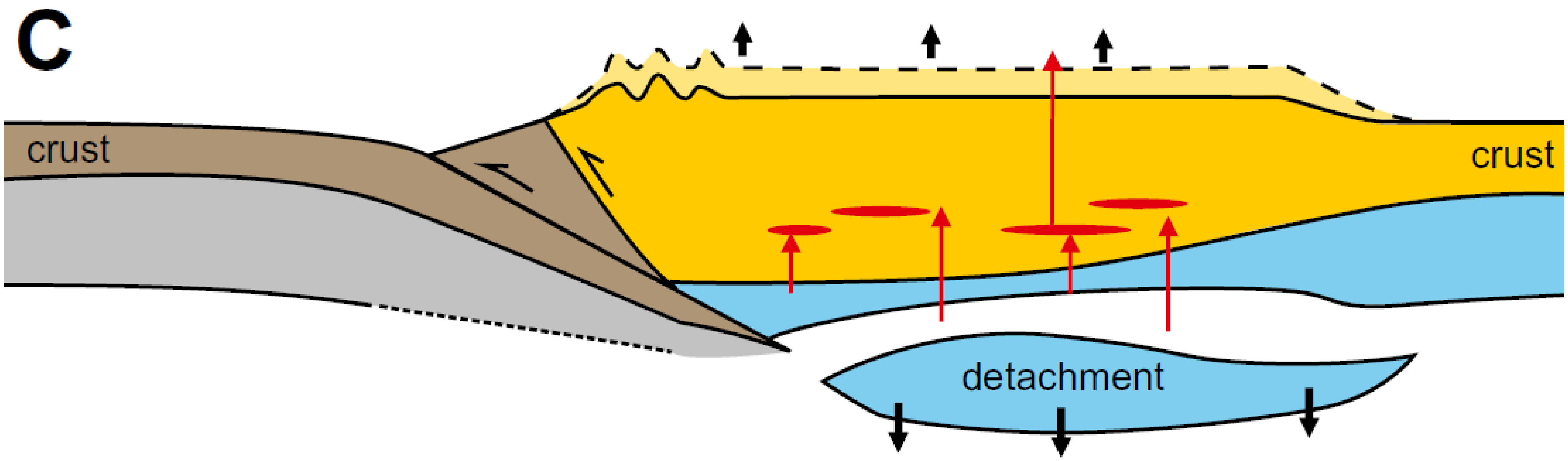
Ref: Tapponnier et al 2001

In contrast, northwards crustal shortening and thickening has been proposed to be incremental (and early deformation may have taken place far north of eventual plateau development):



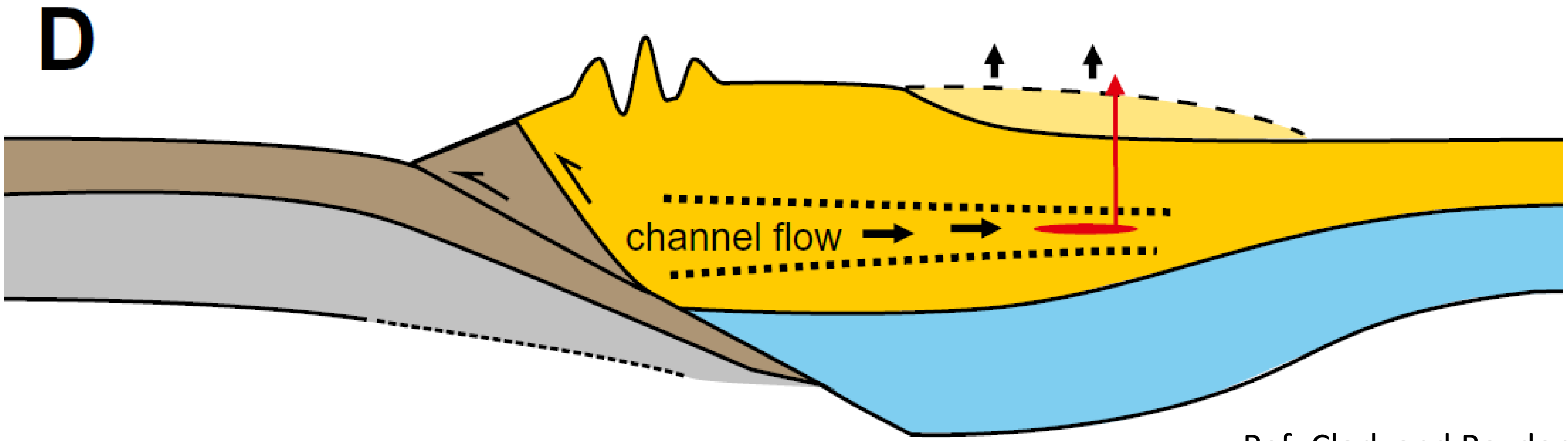
Ref: England and Houseman 1986

Surface uplift and plateau growth has been proposed to be rapid and regional in response to lower lithosphere delamination:



Ref: England and Houseman 1989

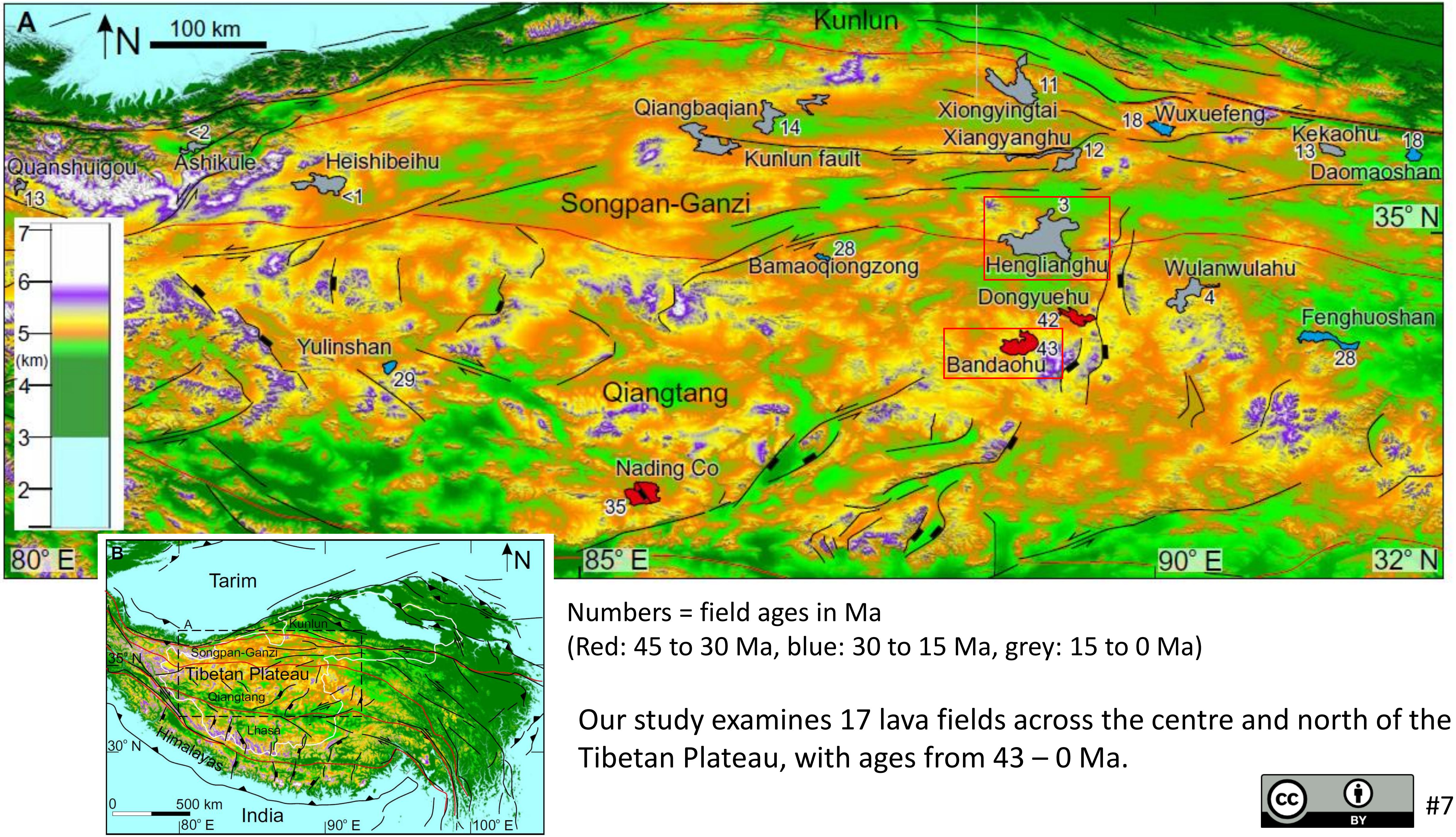
Plateau growth has been linked to outward flow of hot, low viscosity lower crust, in the type example of “channel flow”:



Ref: Clark and Royden 2000

Not all of these end-member models are mutually exclusive; combinations are possible.

In this study we try to distinguish between these different models using the geomorphology of lava fields that postdate the initial collision. The rationale is that these fields give information about the landscapes they flowed over, and act as markers for later deformation and erosion.



Numbers = field ages in Ma
(Red: 45 to 30 Ma, blue: 30 to 15 Ma, grey: 15 to 0 Ma)

Our study examines 17 lava fields across the centre and north of the Tibetan Plateau, with ages from 43 – 0 Ma.

~60 km

Henglianghu field: ~3 Ma (located on slide #7)

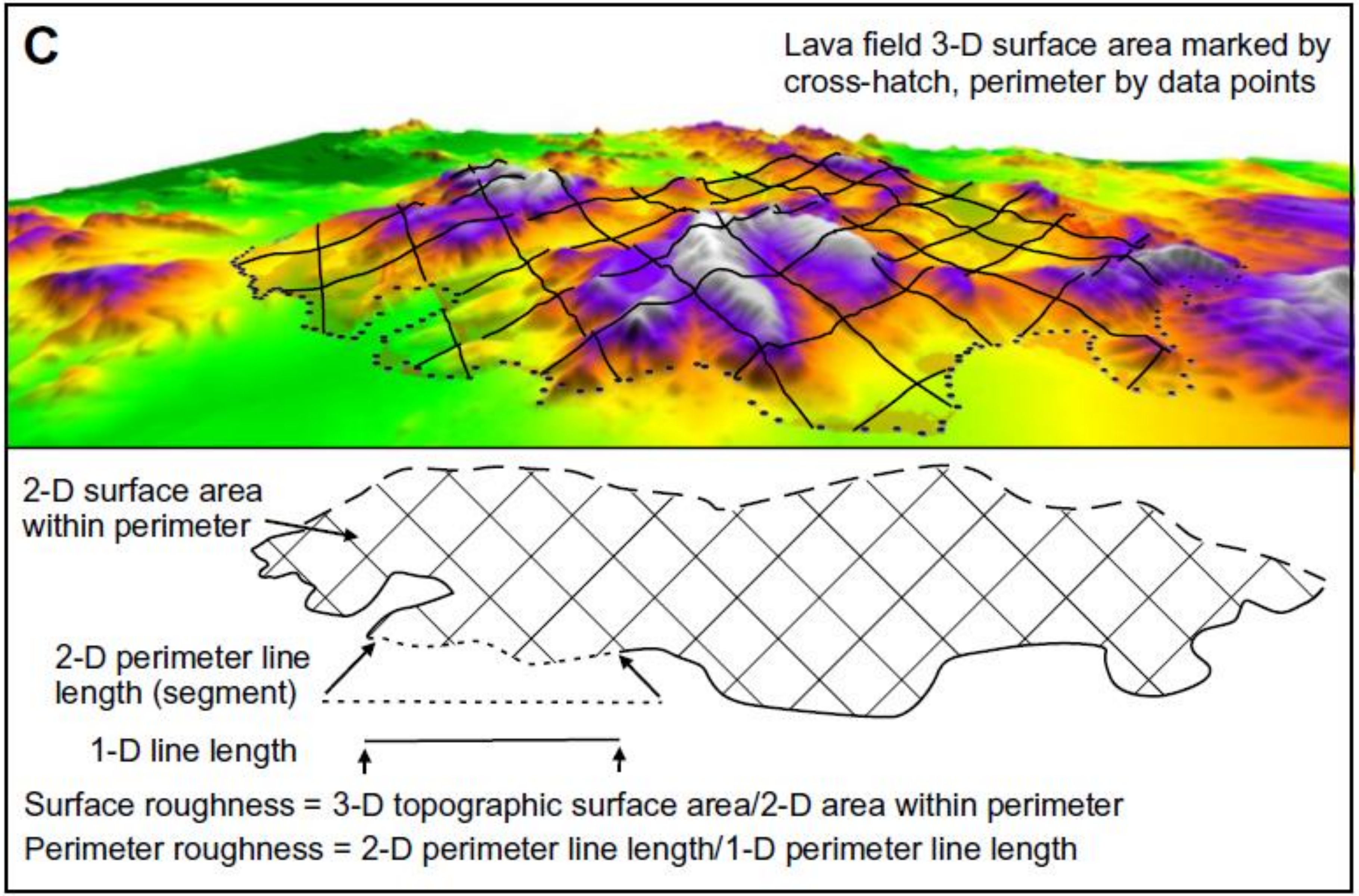
Unsurprisingly, very young fields are draped across the landscape

Oblique view of the Henglianghu field

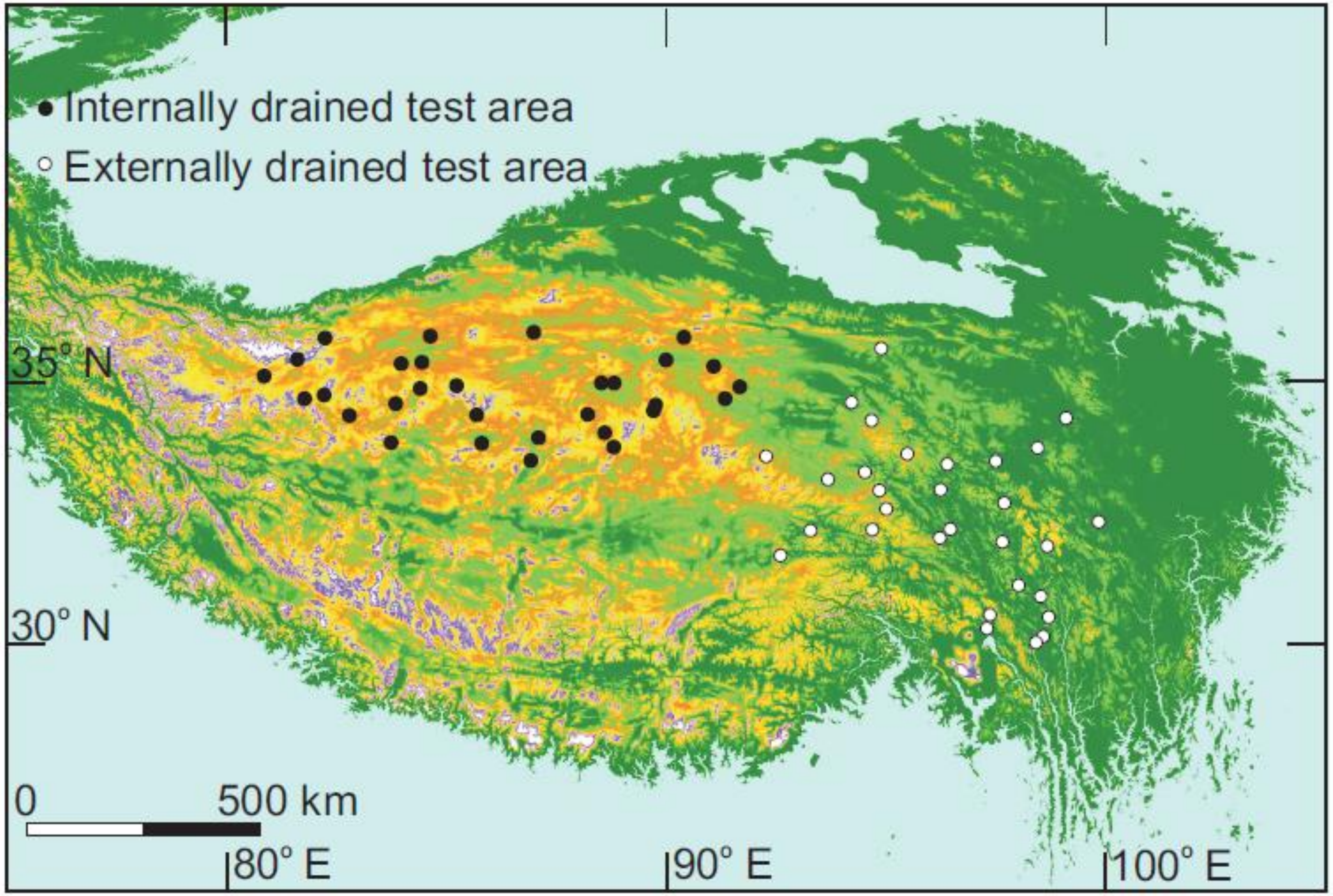
~30 km

Bandaohu field: ~43 Ma

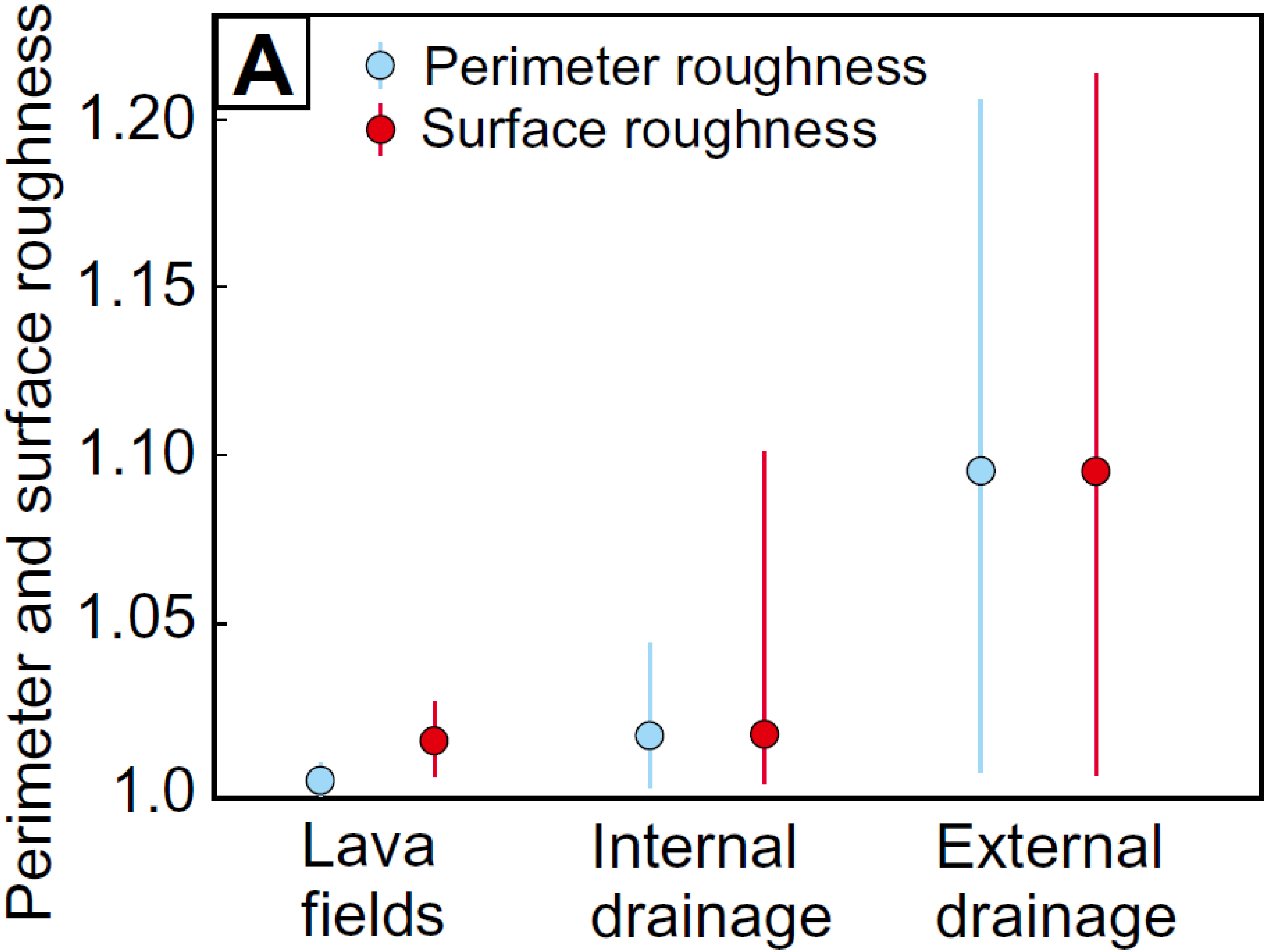
But, much older fields appear to have comparable geomorphology



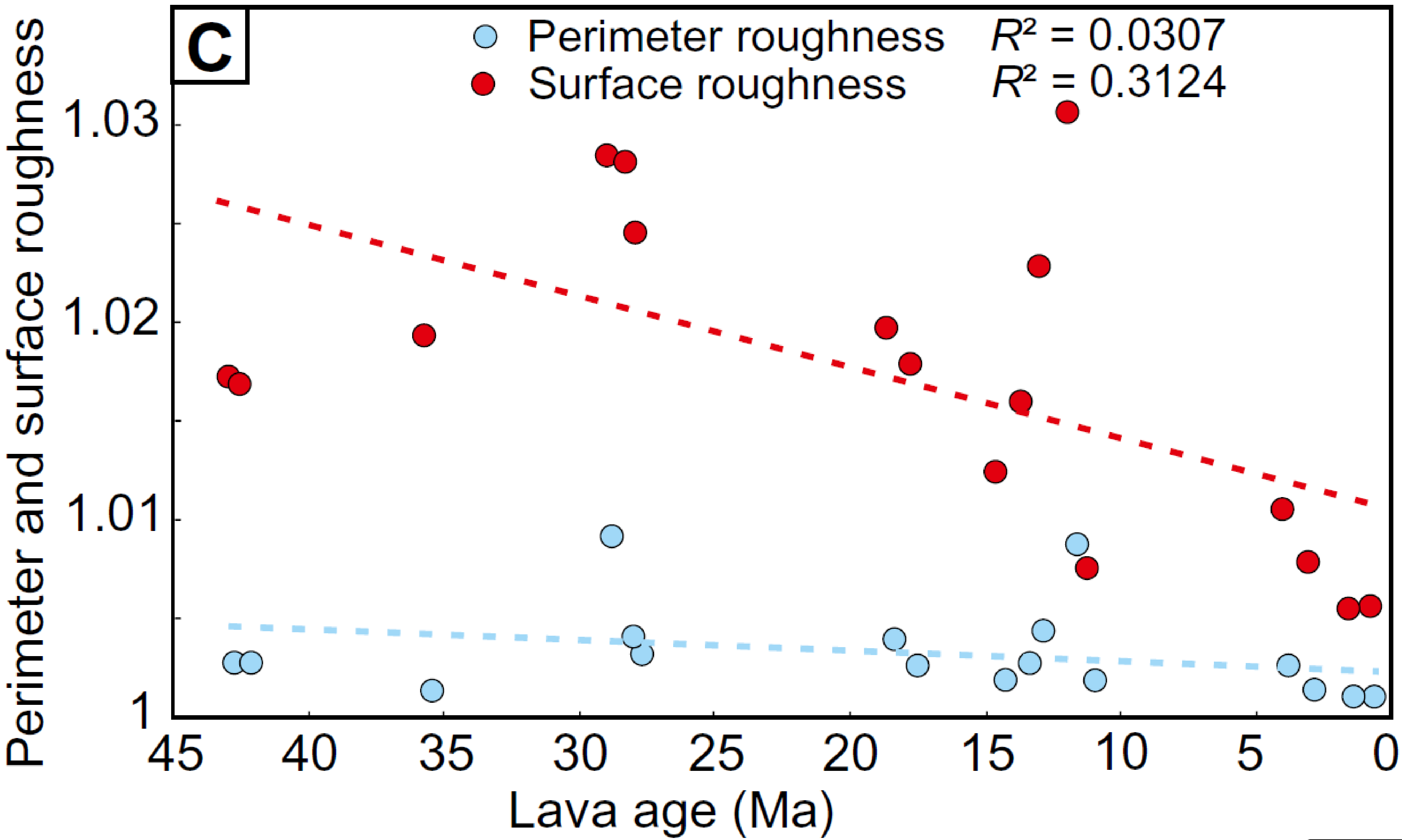
We quantify field geomorphology in terms of surface roughness and perimeter roughness (this is the best possible look at the base of each field)



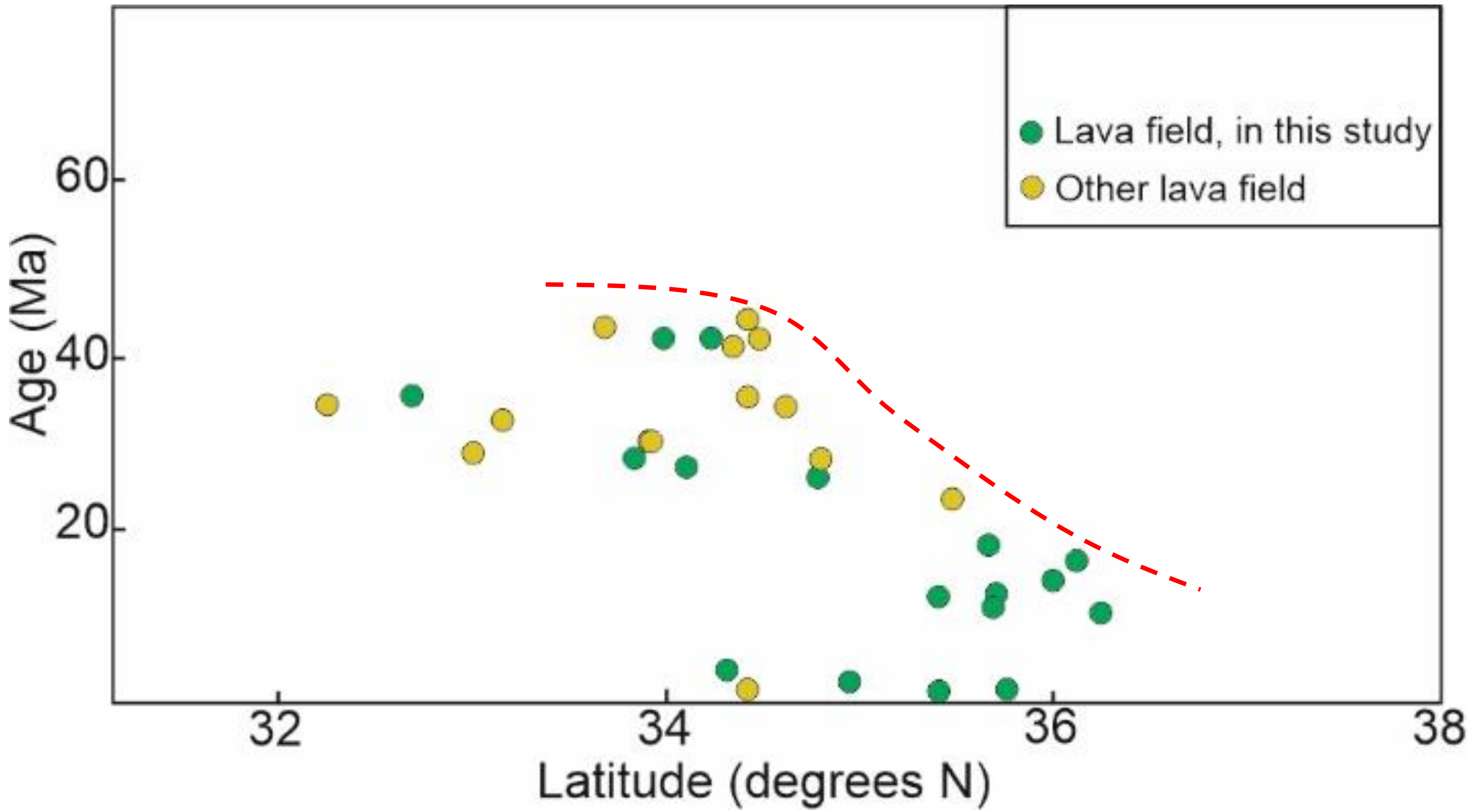
Results are somewhat abstract (no one carries SR values around in their heads…) so we compare our results to 60 test areas, randomly selected around the plateau, with 30 inside the limit of internal drainage and 30 outside.



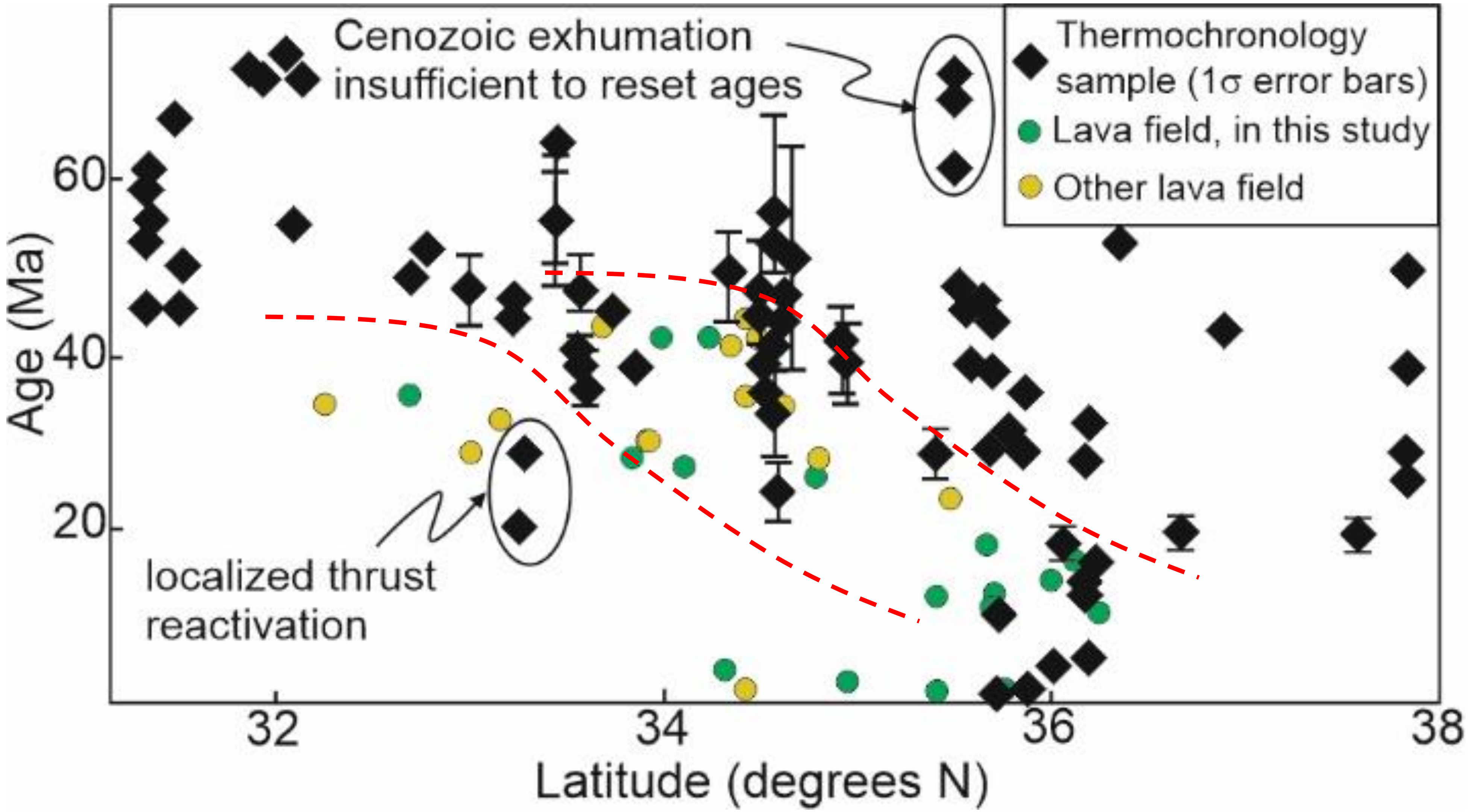
Lava fields resemble the modern internally-drained parts of the plateau, not externally-drained regions



There is a weak correlation between lava field SR and age, and none for PR and age



Oldest lava field ages at any latitude become younger northwards (red dashed line)



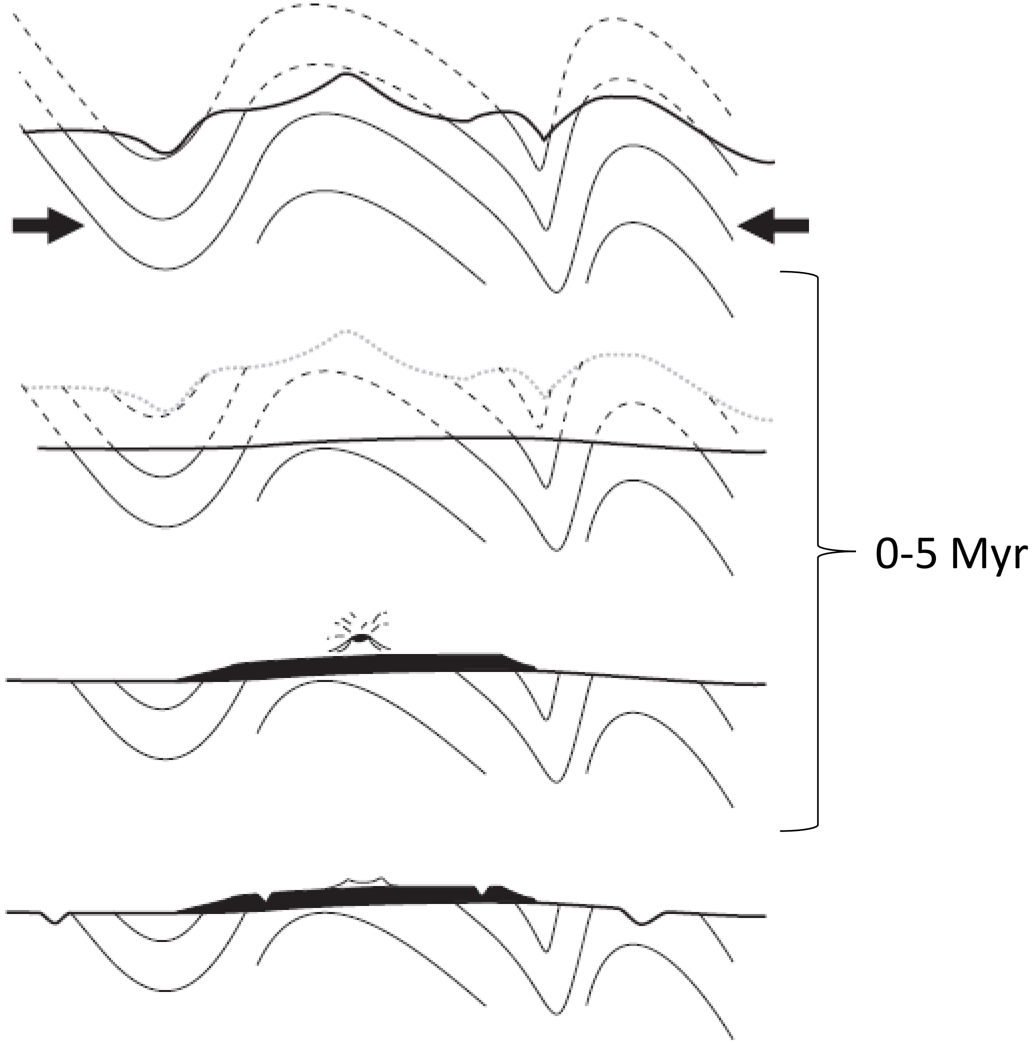
Published low temperature thermochronology data show the same northwards younging for the youngest ages at each latitude. Neither dataset shows a step-change

Stage 1: Compressional deformation, crustal thickening and syn-tectonic relief

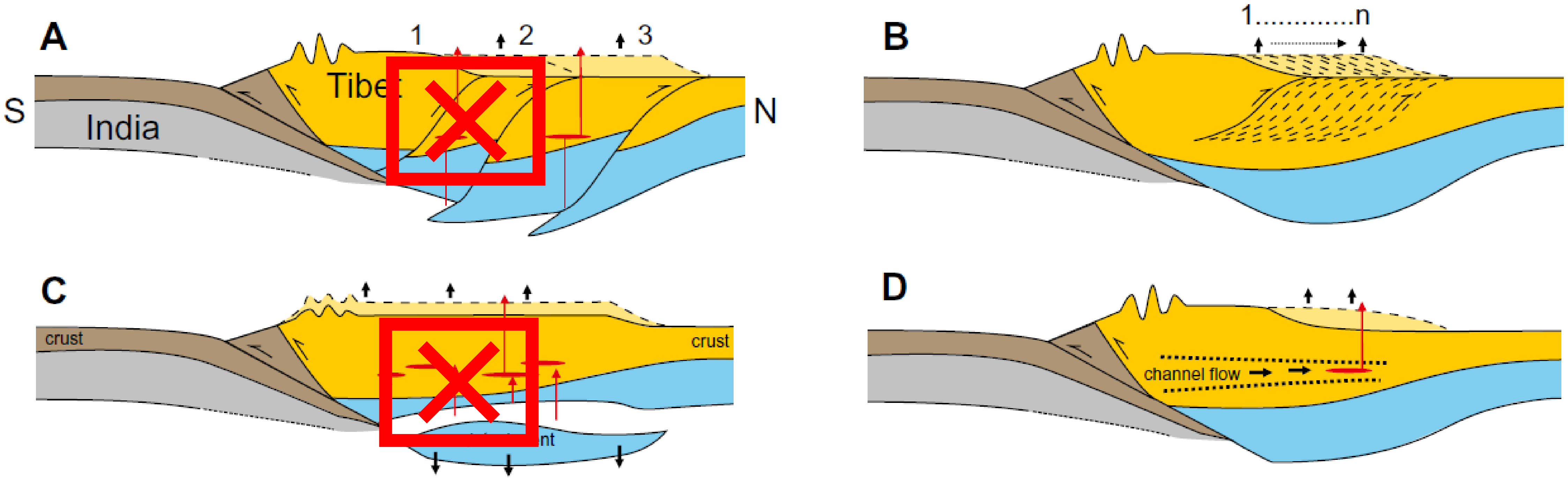
Stage 2: Erosion ~~Peneplanation~~ and plateau formation

Stage 3: Eruption of K-rich lava

Stage 4: Limited post-eruption erosion and relief generation



We interpret relatively rapid formation of plateau landscapes after the end of crustal thickening in each area, advancing northwards at ~15 km/Myr between ~40 and 10 Ma



These results and conclusions are consistent with northwards incremental growth of the plateau by crustal thickening, not stepwise growth or regional uplift.

Conclusions

Tibetan Plateau lavas preserve a record of underlying low relief bedrock landscapes at the time they were erupted, which have undergone little change since

Thermochronology ages and the oldest lava in each area overlap

Plateau landscapes grew between ~32.5^{o} - ~36.5^{o} N between ~40 and ~10 Ma, advancing northwards at a long-term rate of ~15 km/Myr

Results are consistent with incremental northwards growth of the plateau, rather than a stepwise evolution or synchronous uplift.