

Thermochronology of Mountain Belts

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Lehigh University



The 60°C isotherm! It is here!

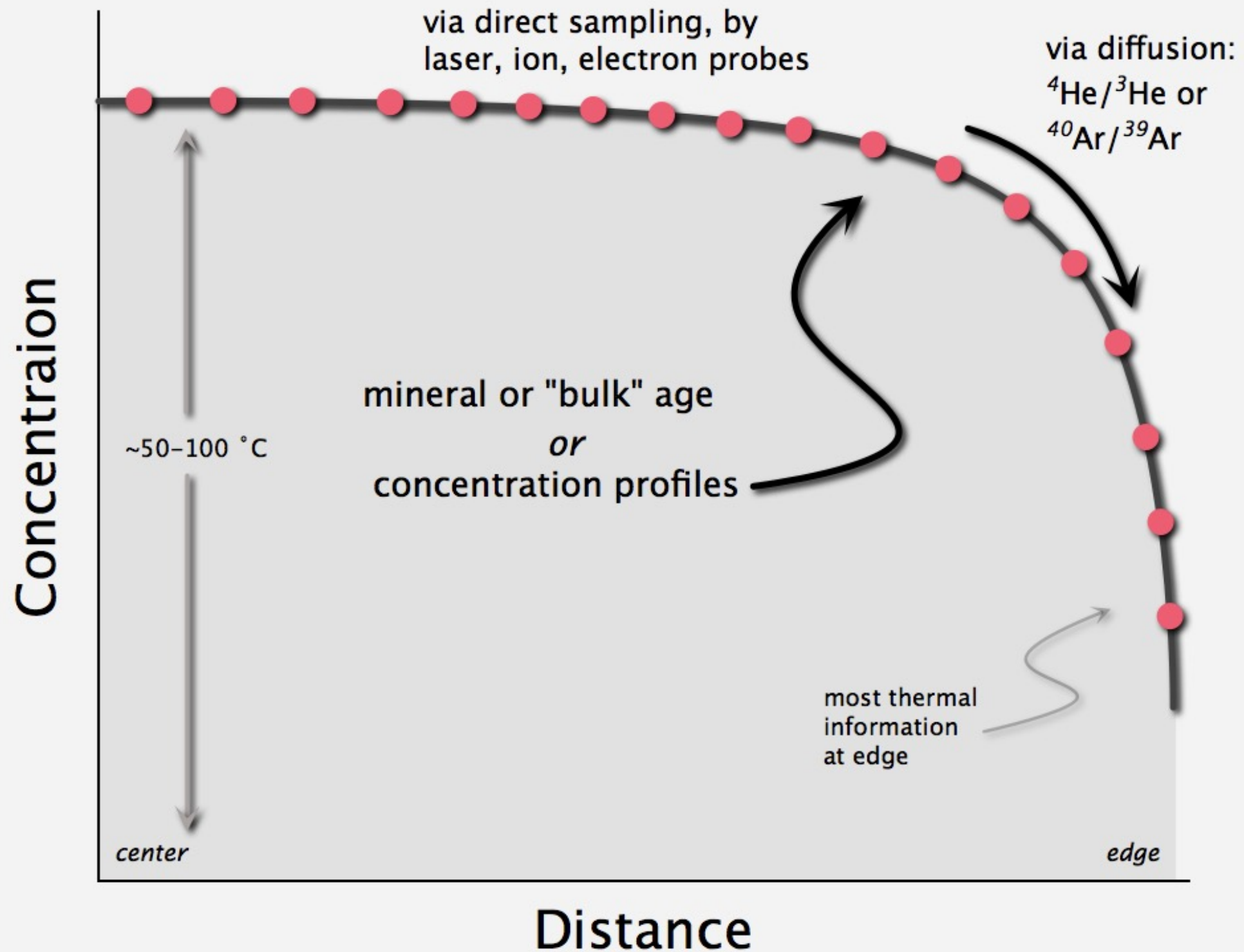


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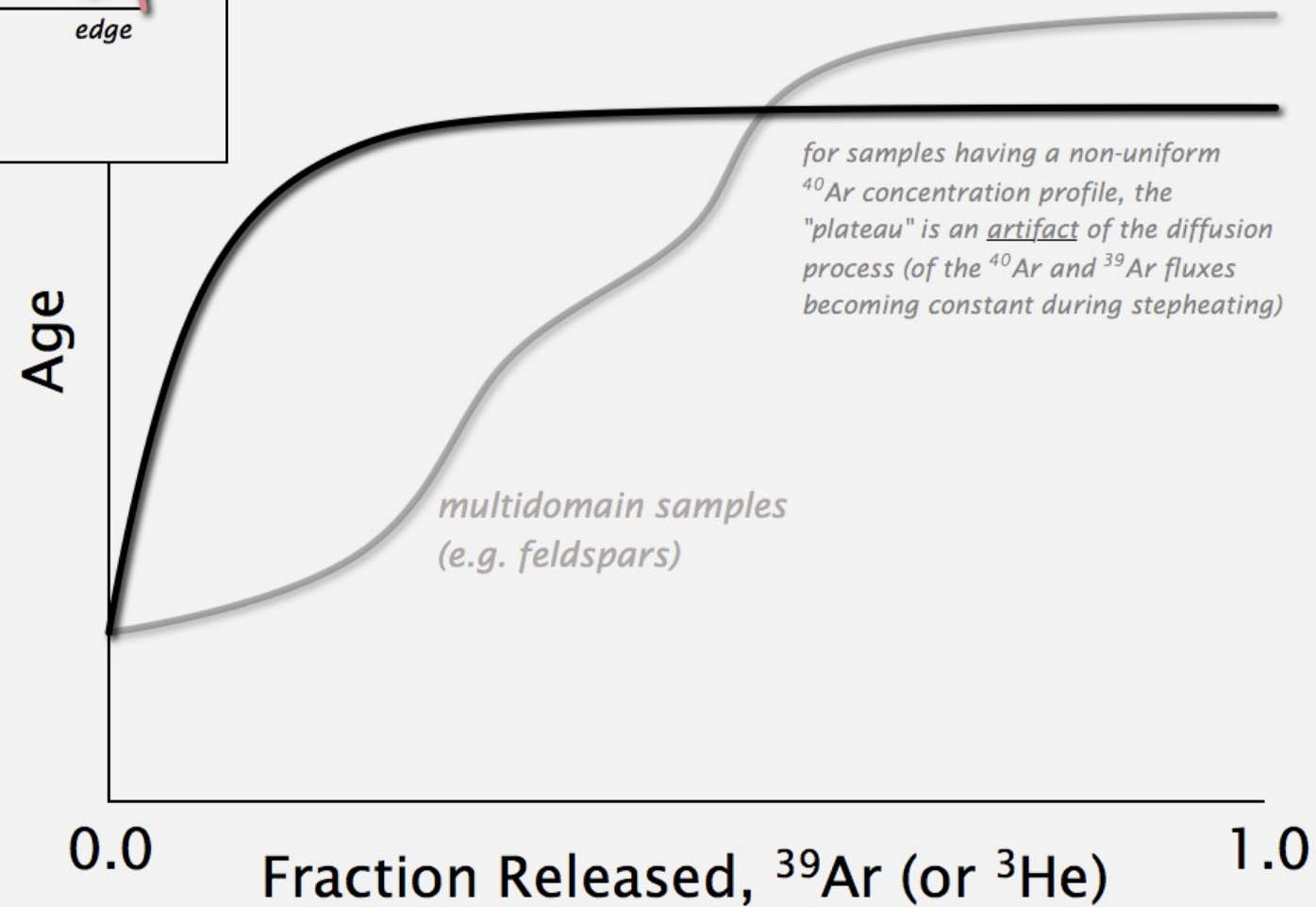
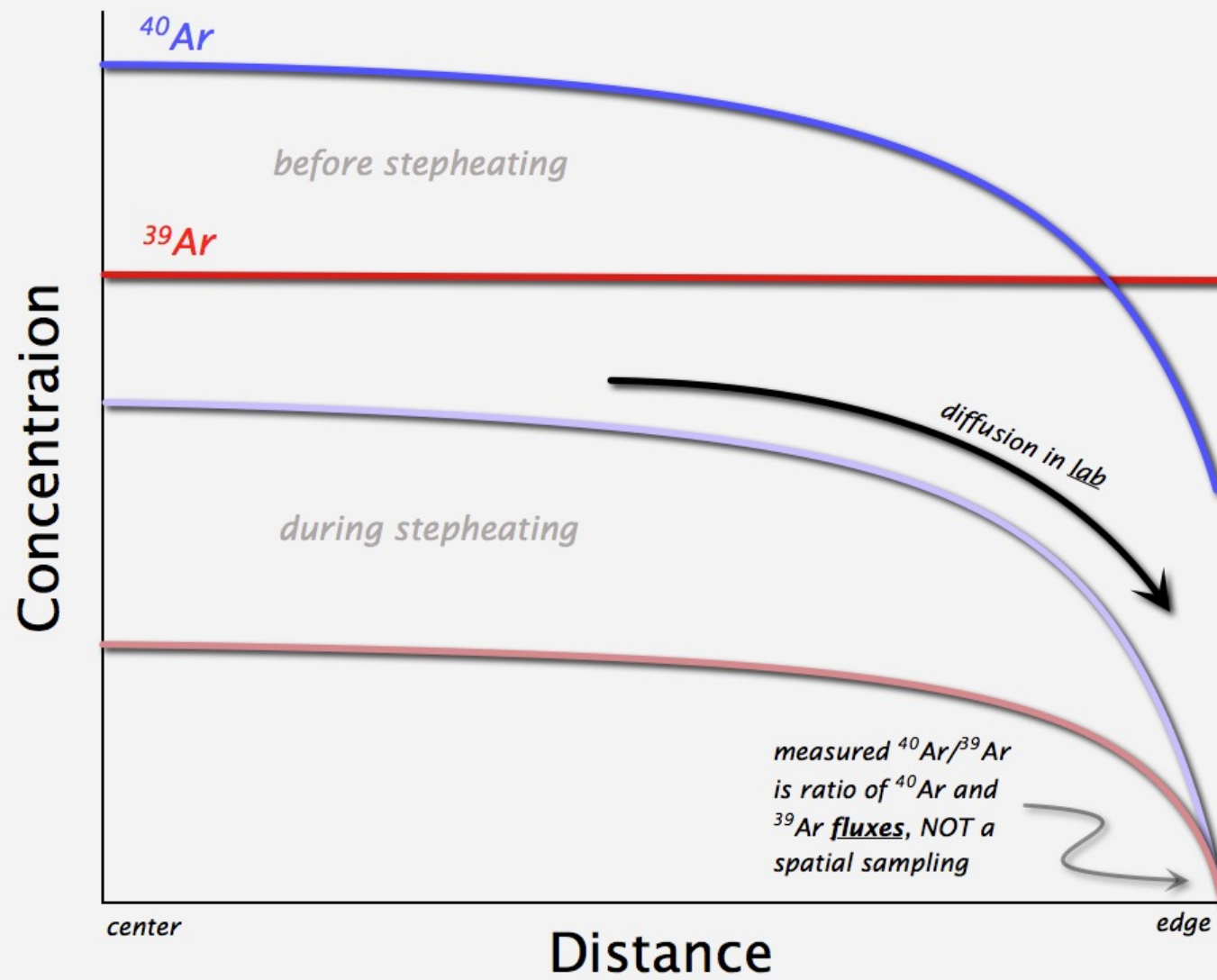
“Thermochronology of Mountain Belts”

- ◆ Quick overview
- ◆ Examples and accomplishments
- ◆ Future directions

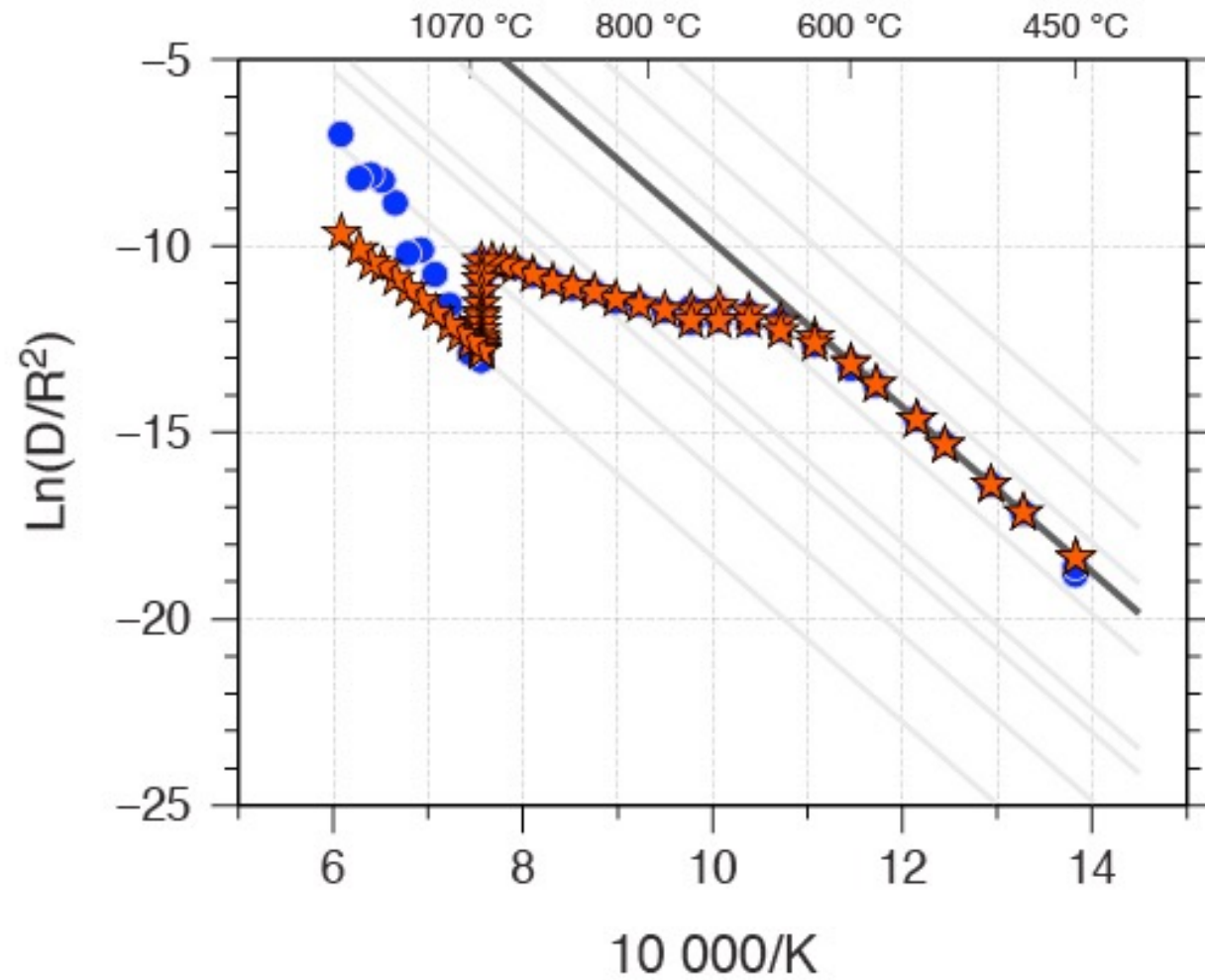
ANALYSIS



STEPHEATING



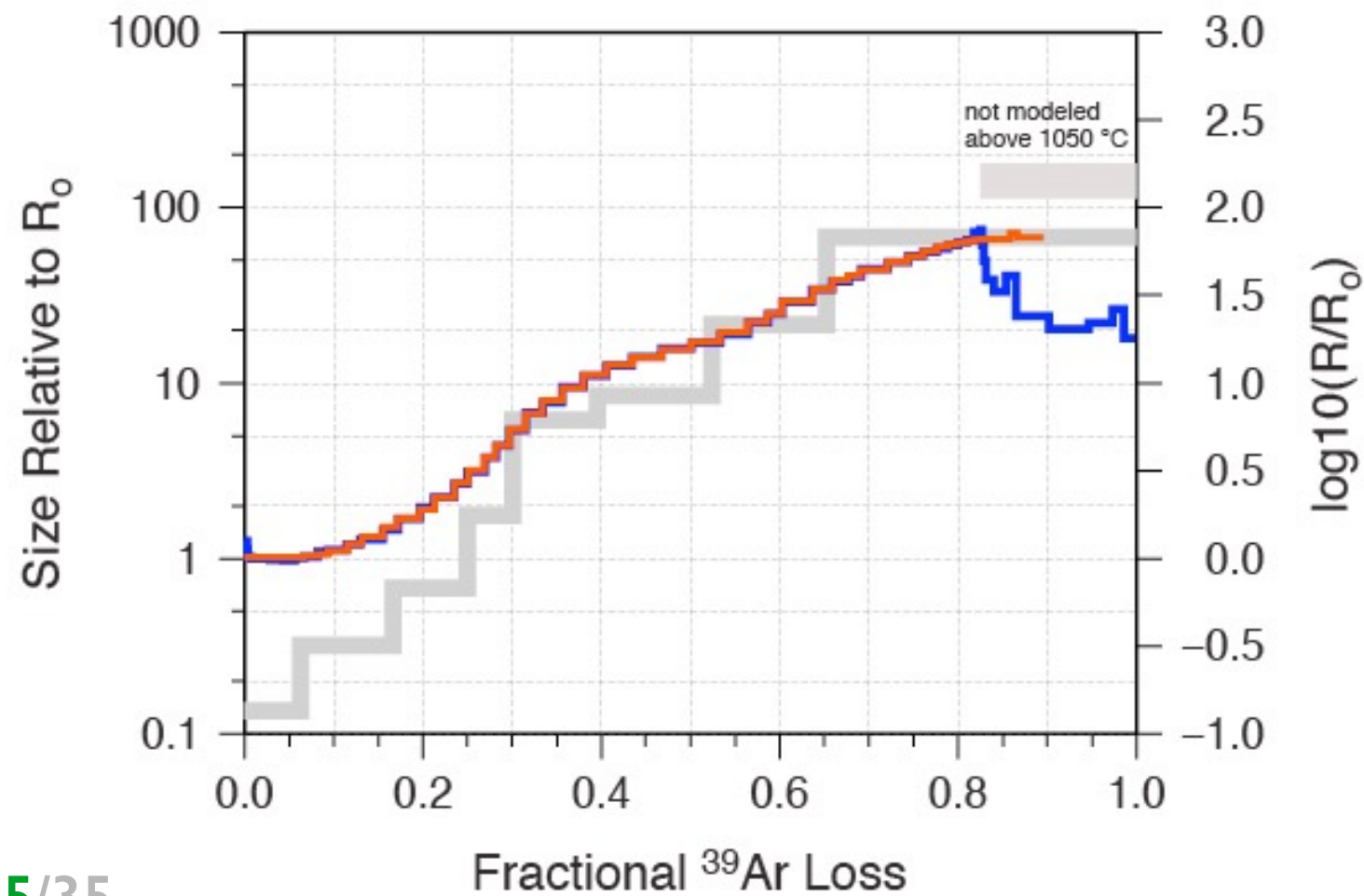
KINETICS



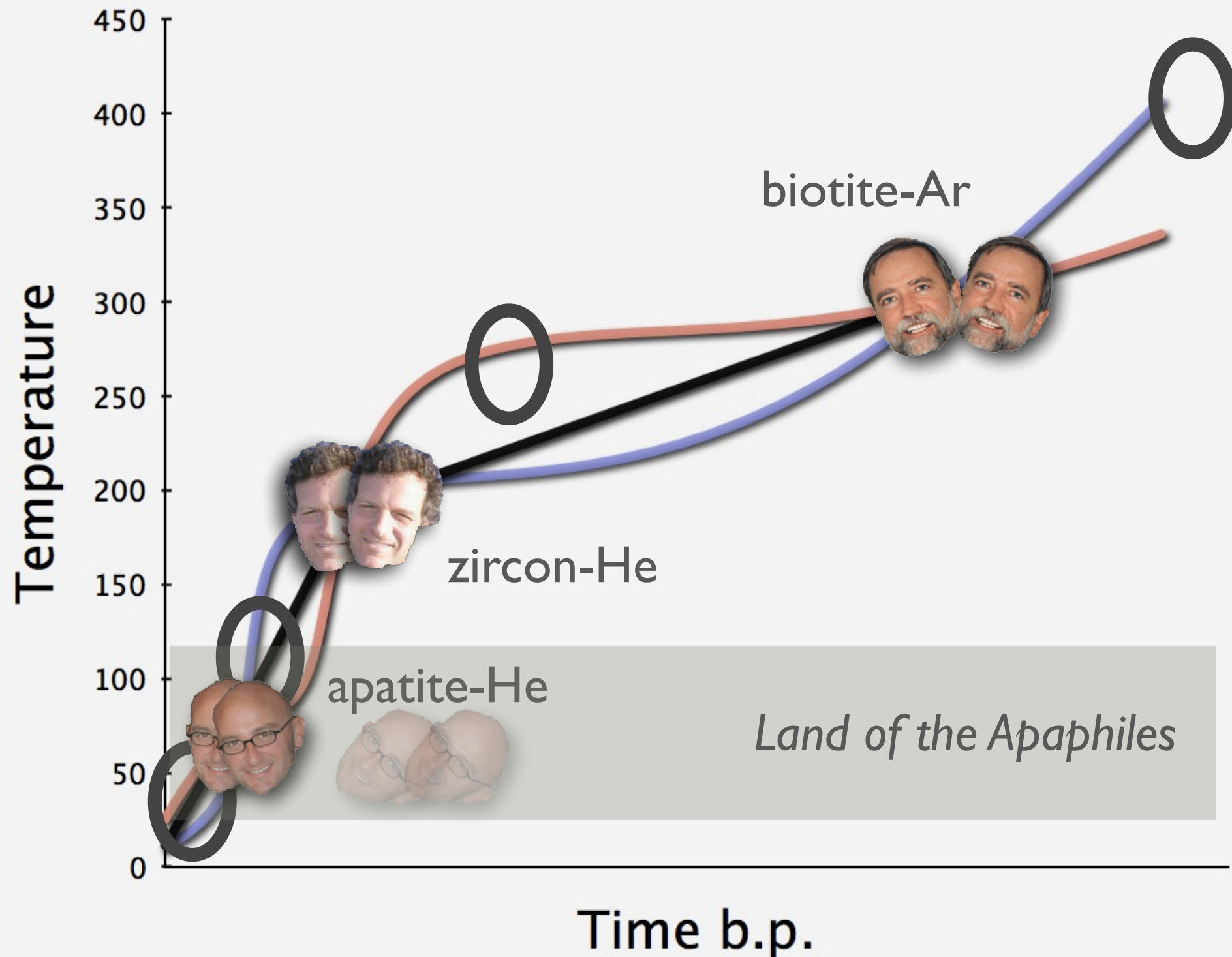
SAMPLE: lu1225
 Using steps 3 to 13:
 $E = 43.92 \pm 0.30$ kcal/mol
 $\text{Log}_{10}(D/R_0^2) = 5.314 \pm 0.081$
 Unweighted regression

8 domains:

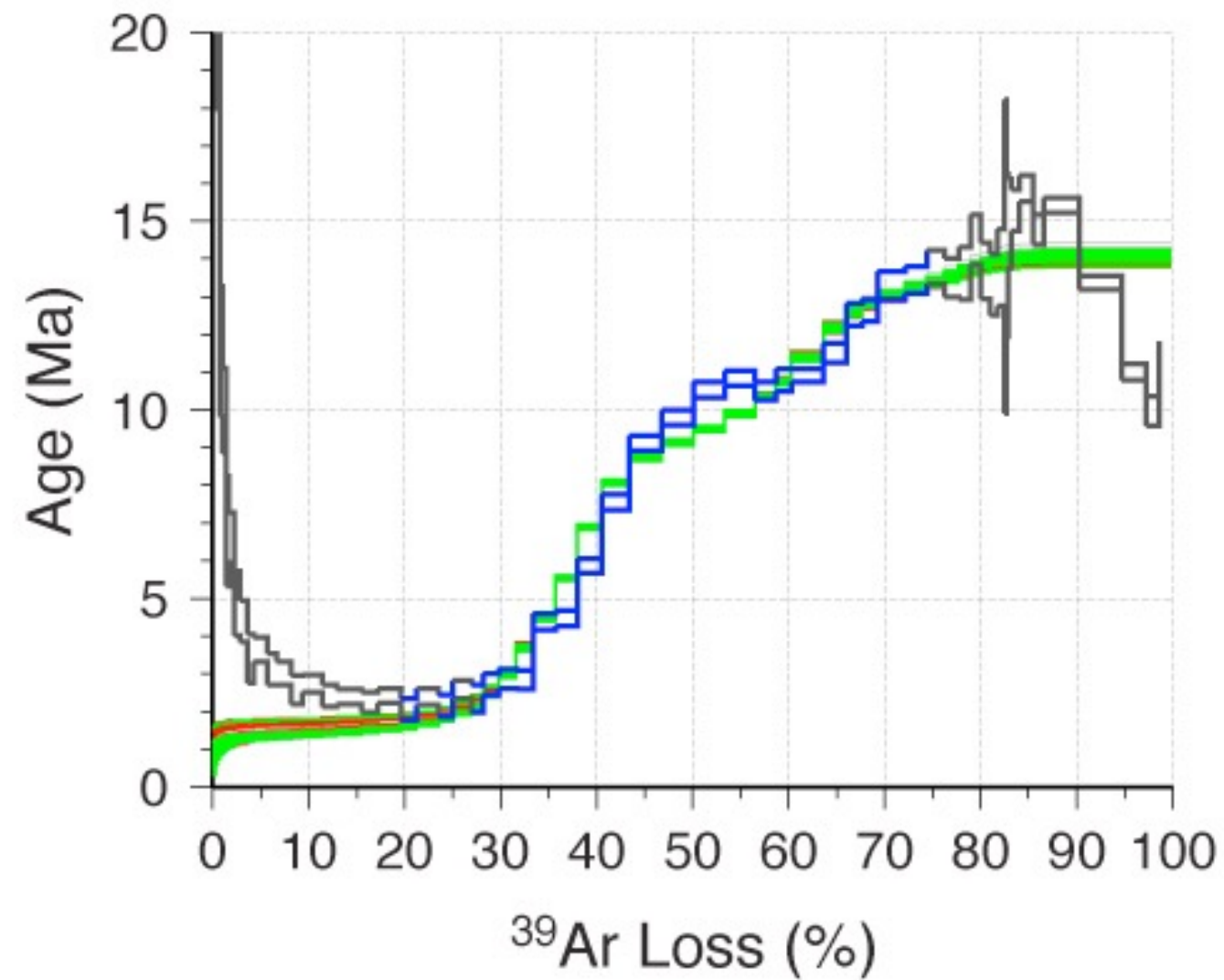
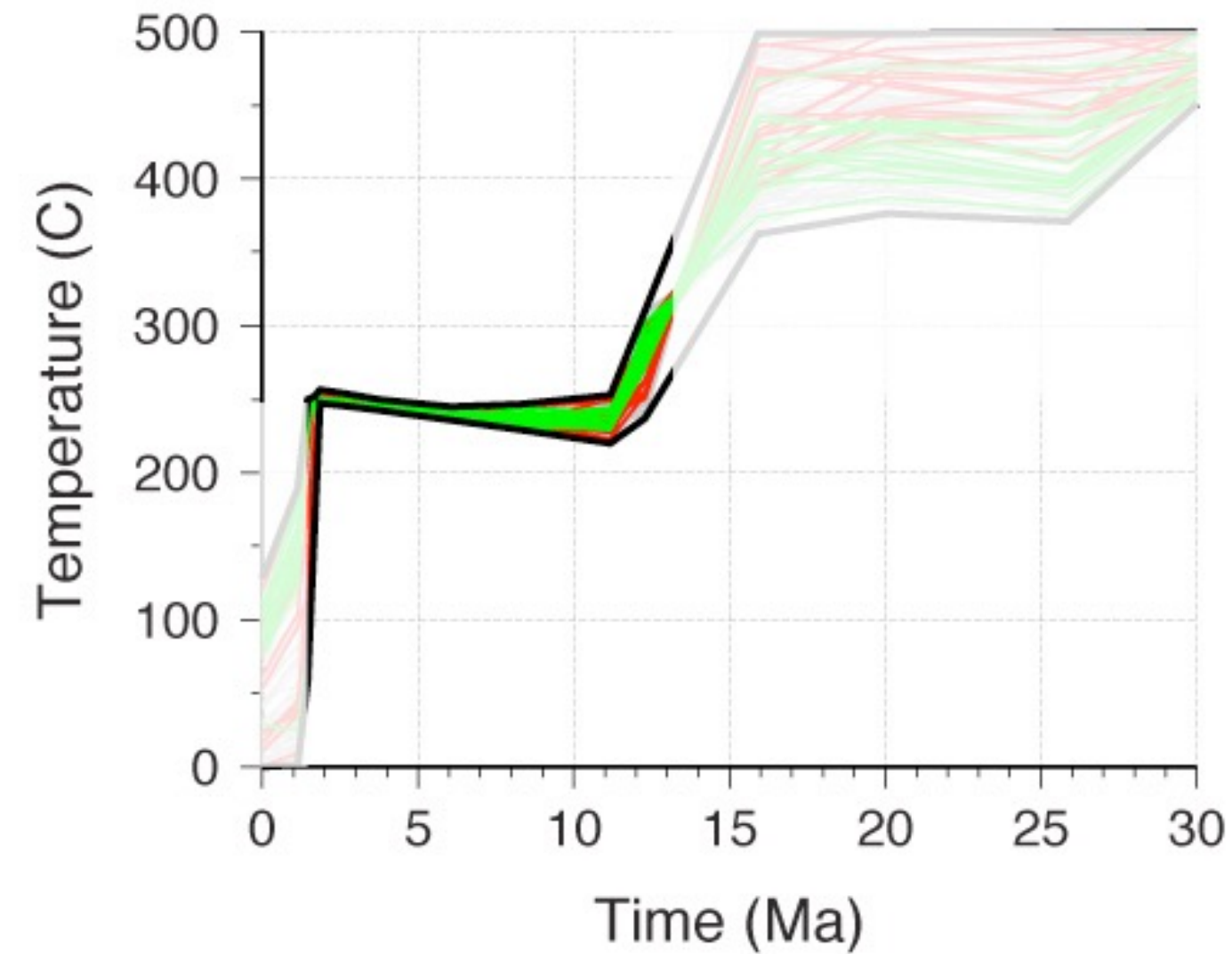
N	Vol.	Vol _T	Rel. Size
1	0.063	0.06	0.14
2	0.104	0.17	0.32
3	0.083	0.25	0.67
4	0.052	0.30	1.75
5	0.094	0.39	6.18
6	0.129	0.52	8.52
7	0.128	0.65	21.37
8	0.348	1.00	68.22



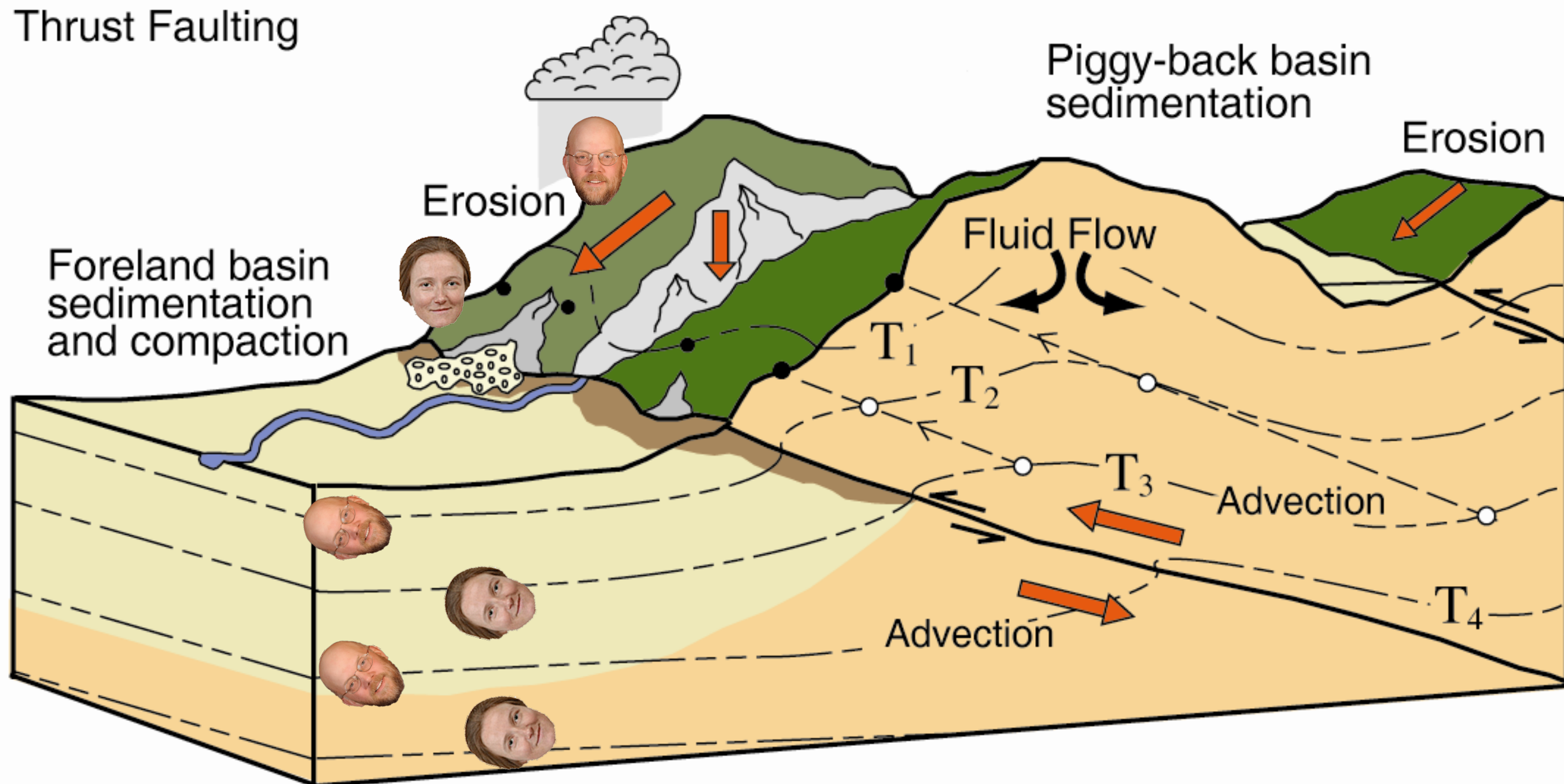
MULTIPLE SYSTEMS AVAILABLE



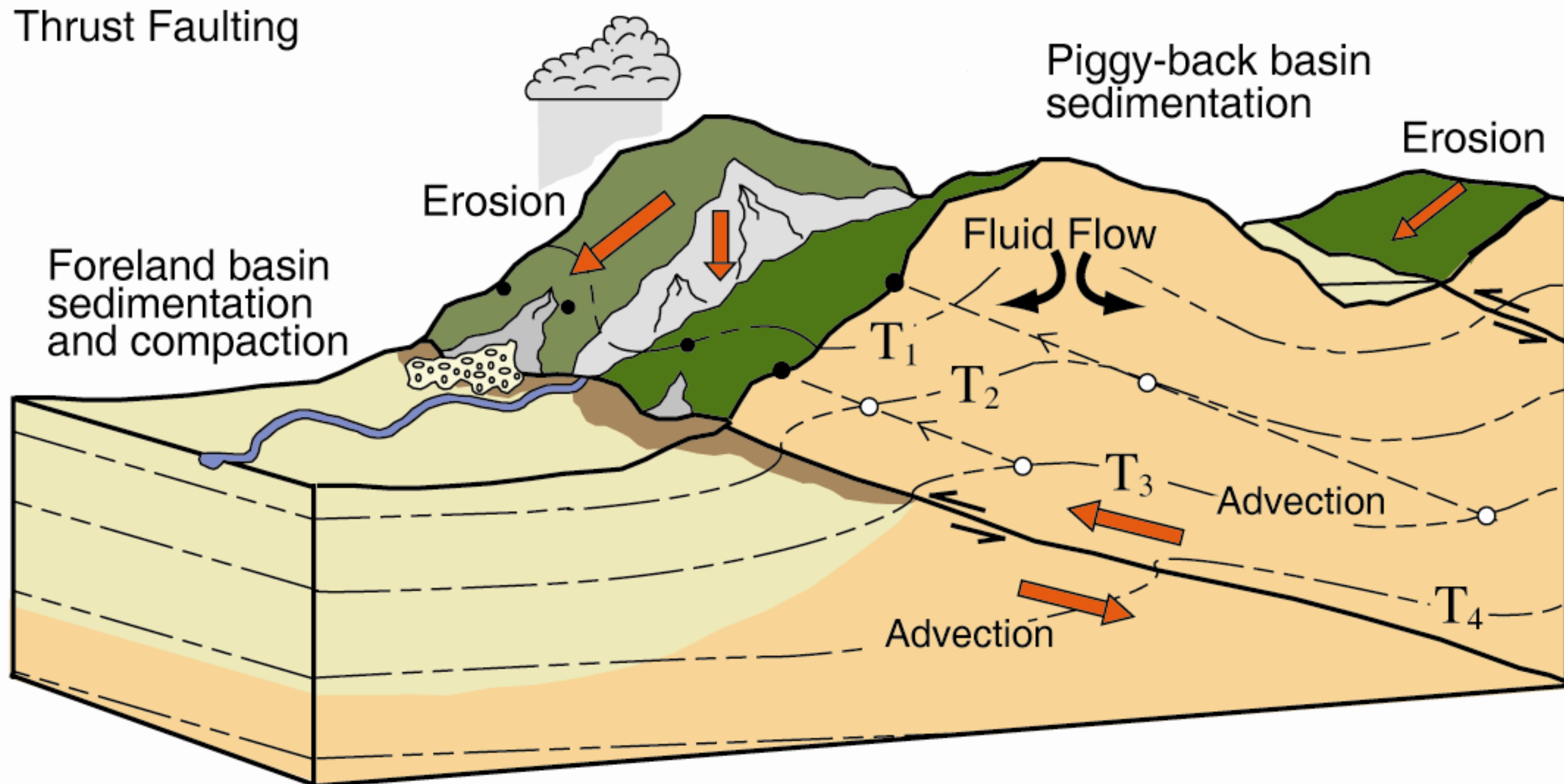
INVERSION FOR CONTINUOUS T-T PATHS



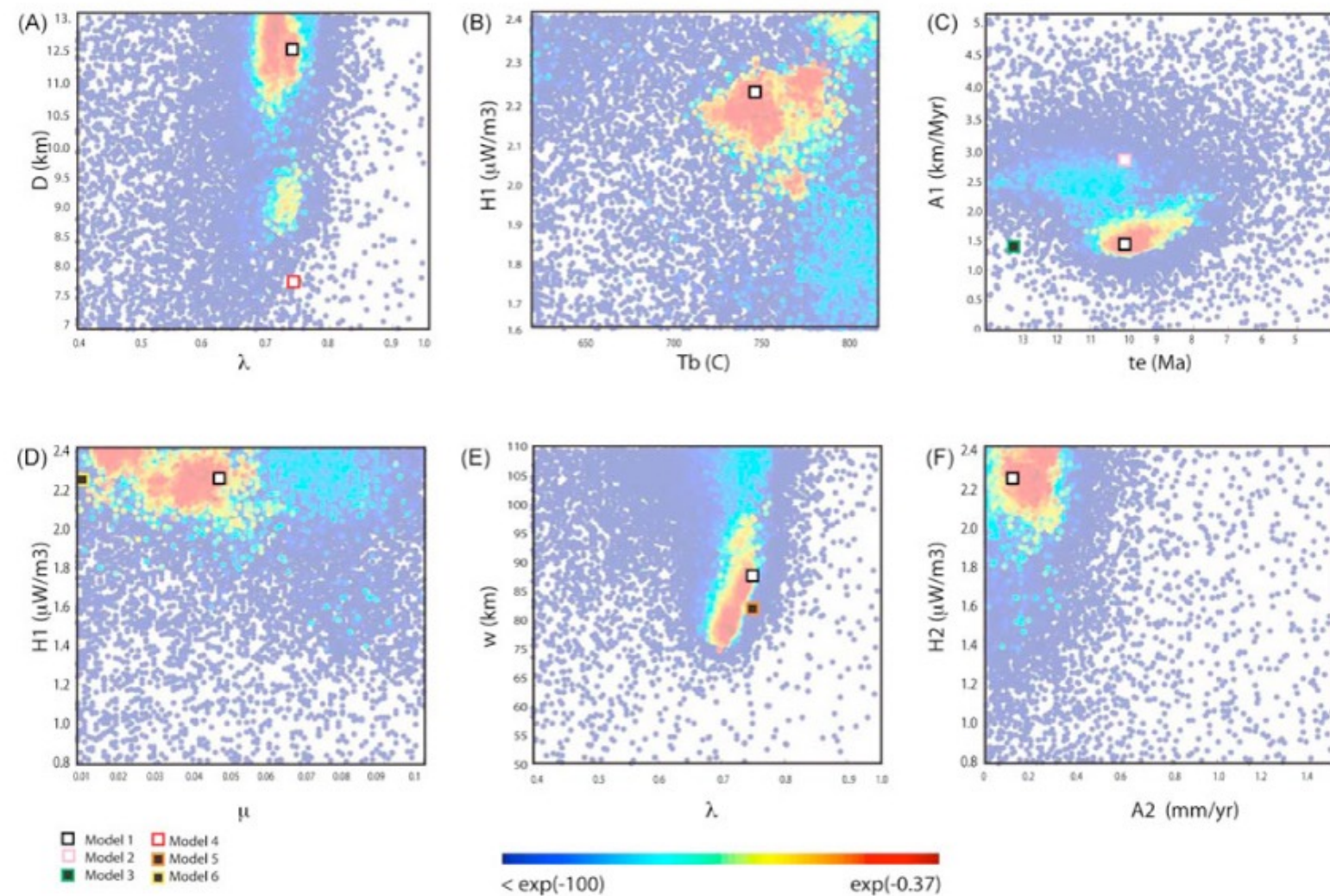
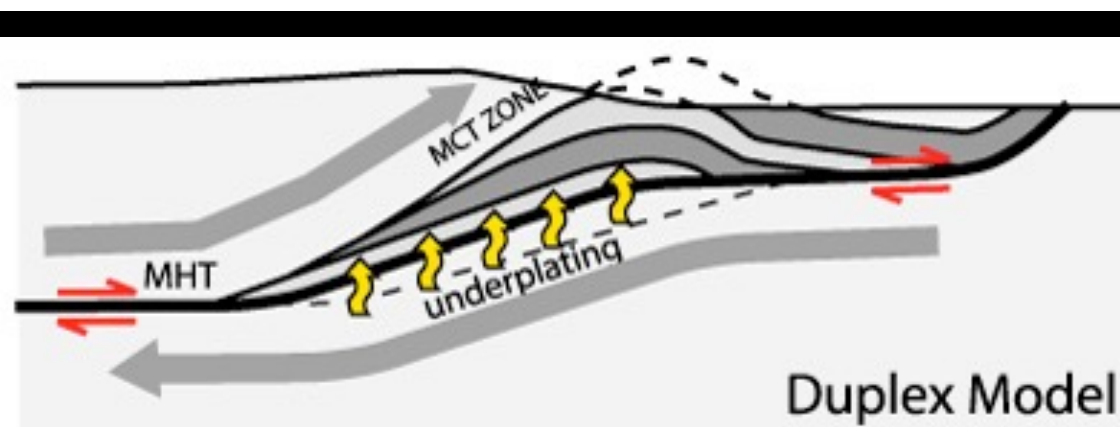
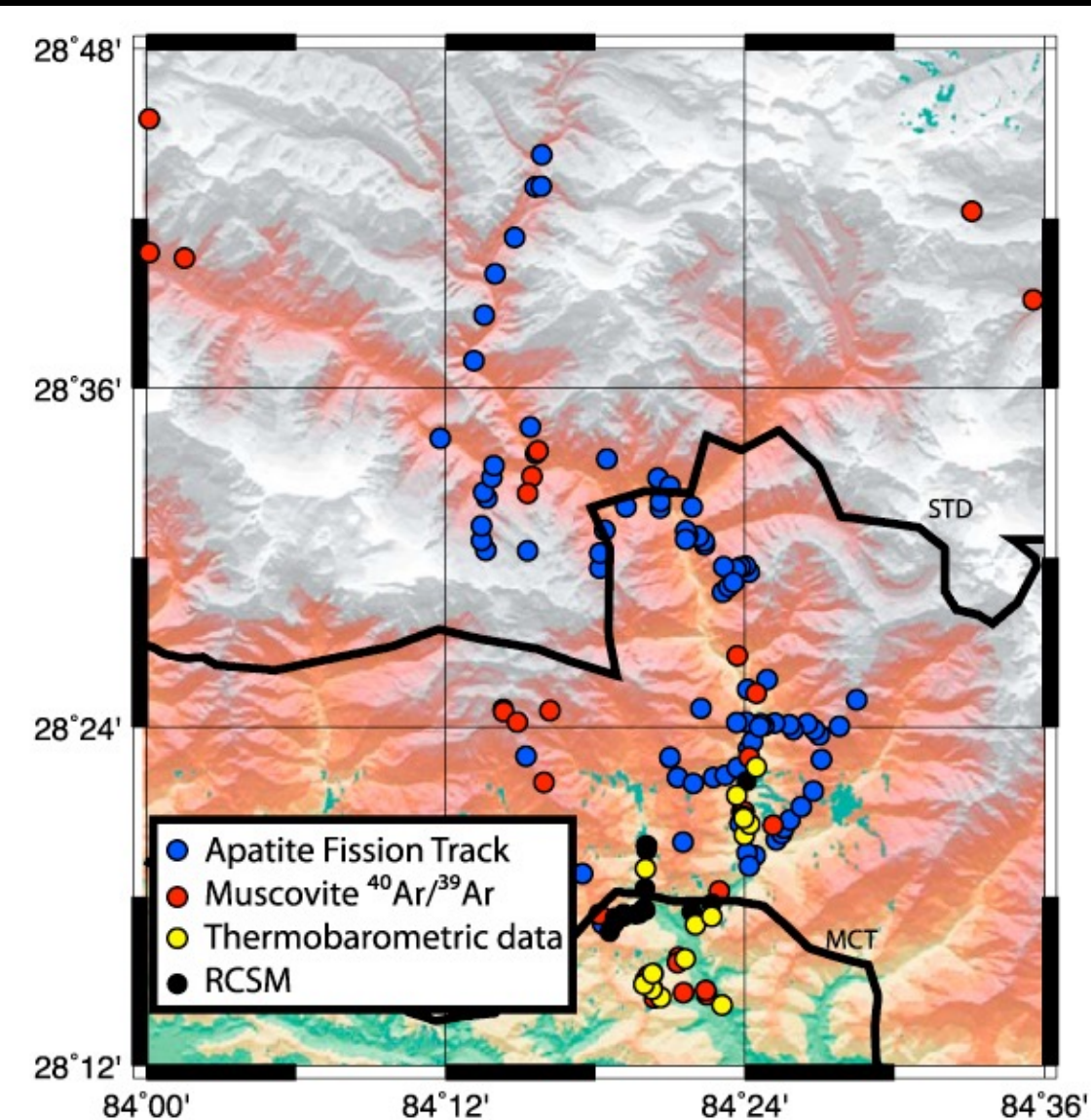
SPATIAL SAMPLING AND DETRITAL STUDIES



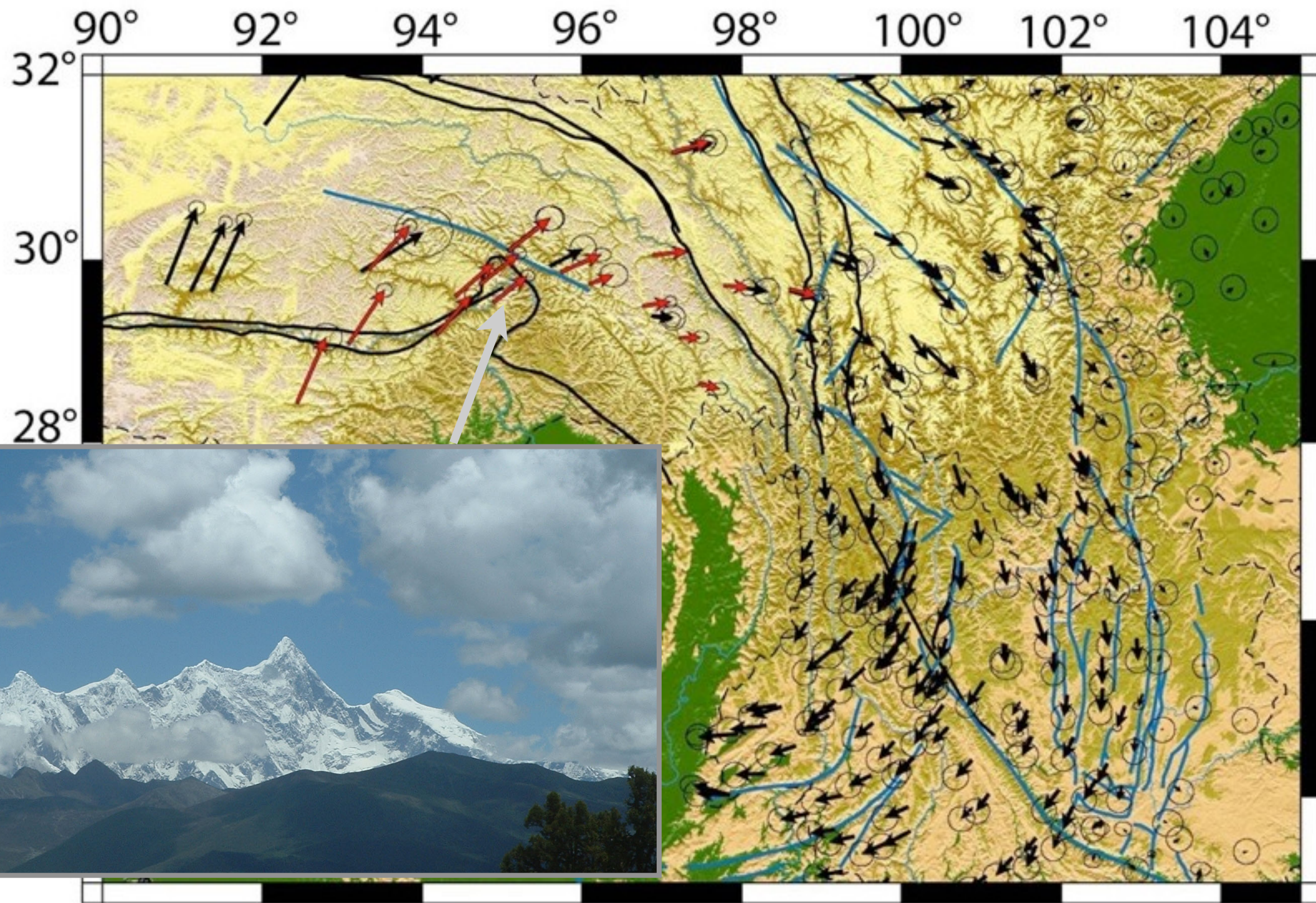
THERMAL COMPLEXITIES



DIRECT INVERSION FOR PARAMETERS OF INTEREST

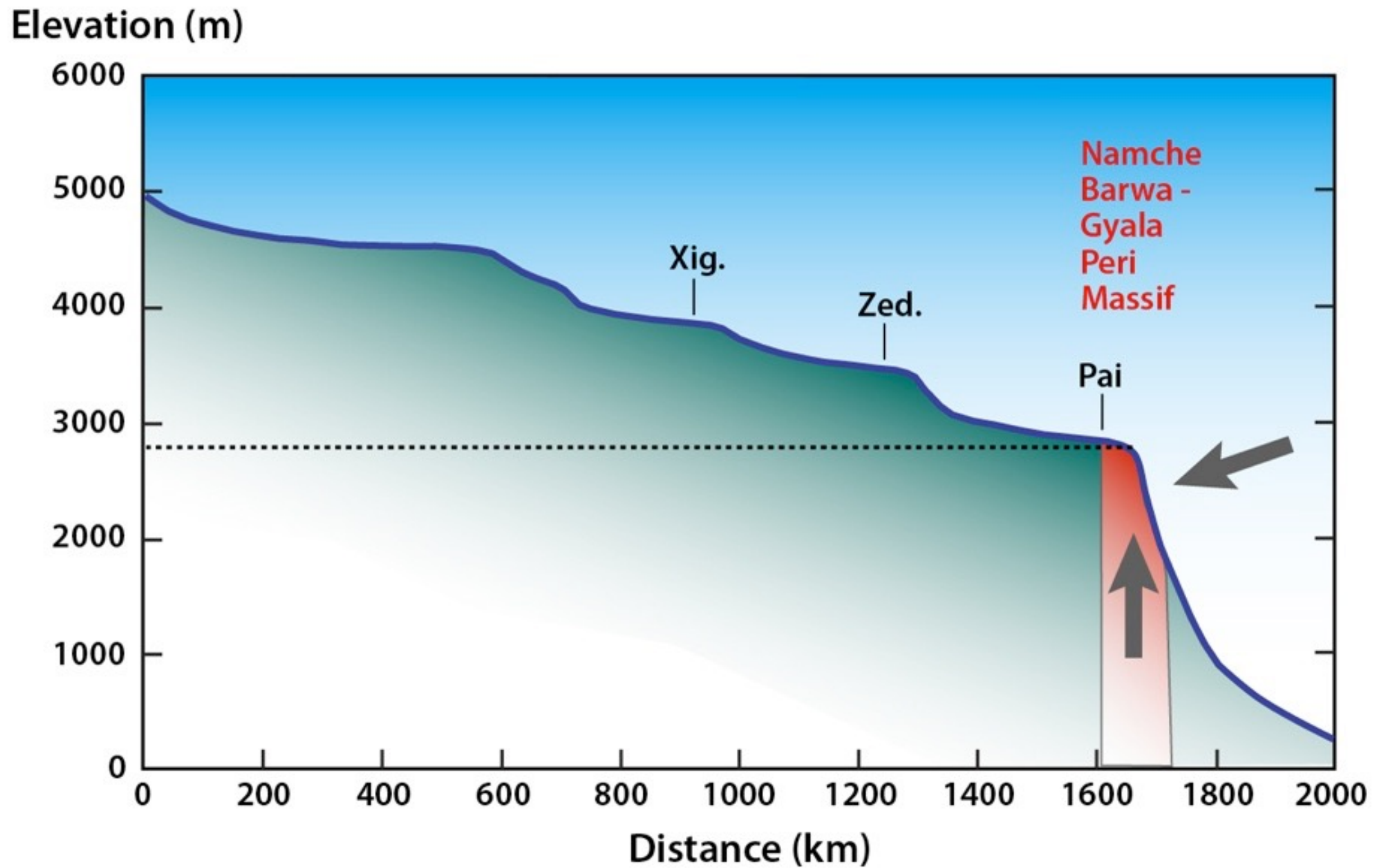


Eastern Himalaya - Namche Barwa



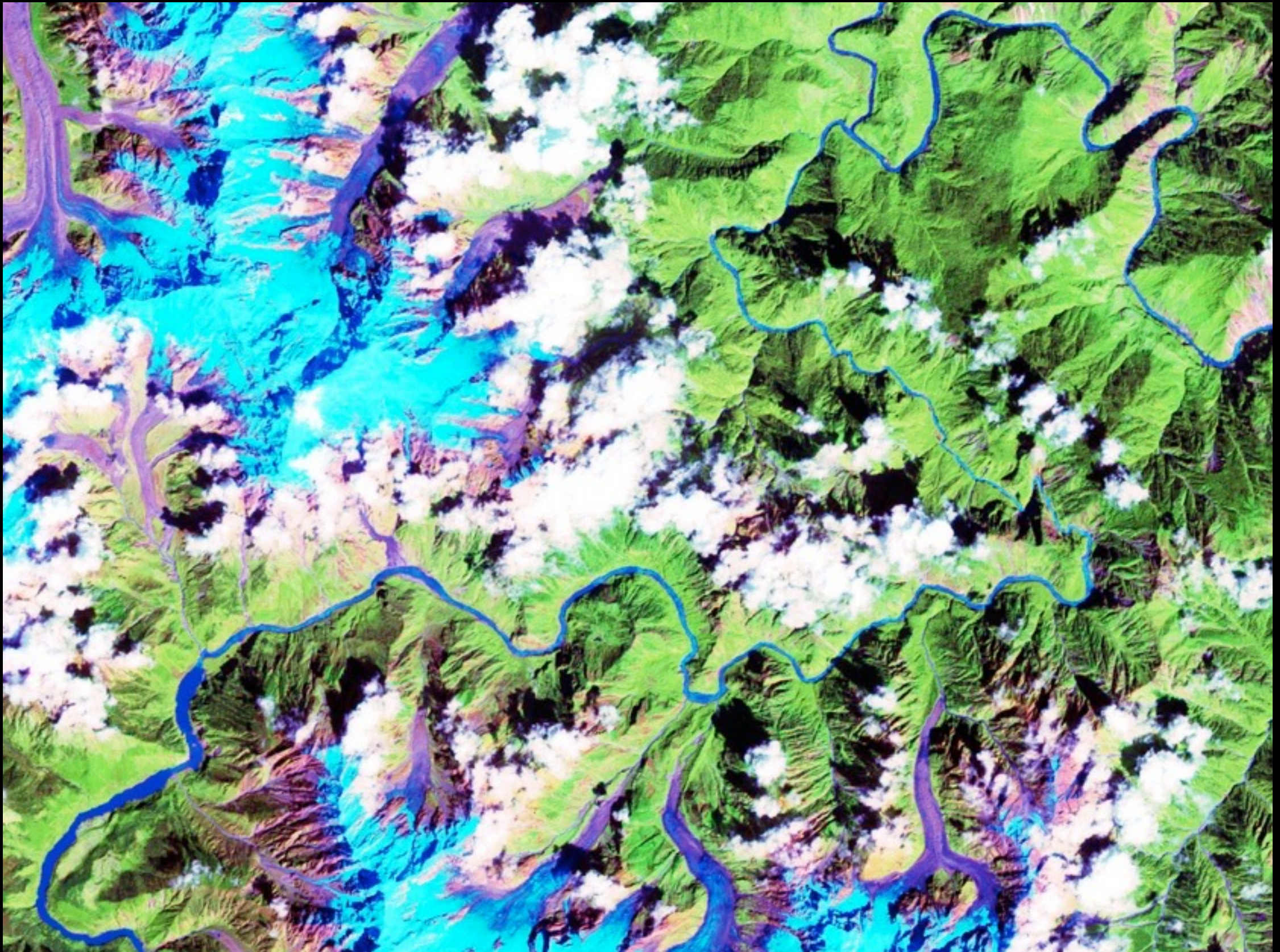
Sol et al. (2007)

Tsangpo long profile (and Mother of All Kickpoints)



*long profile after D. D. Zhang (1998); incision model
from B. Hallet*

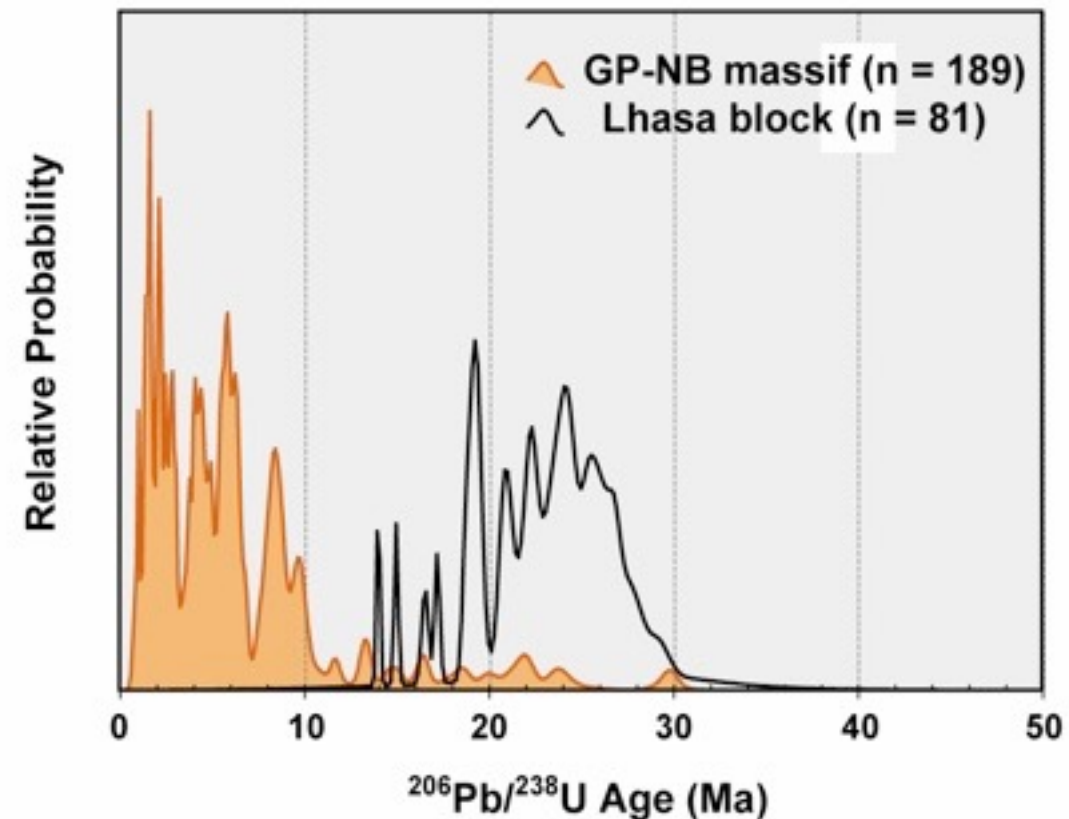
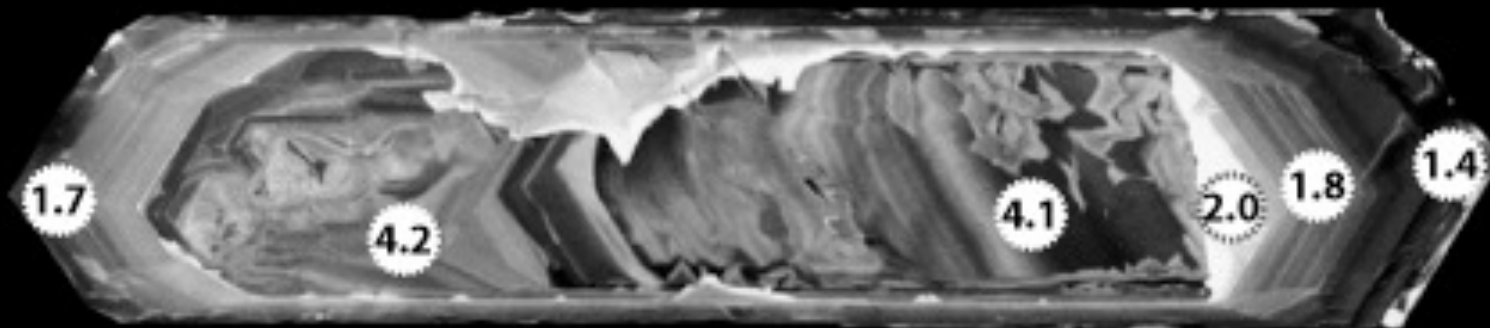
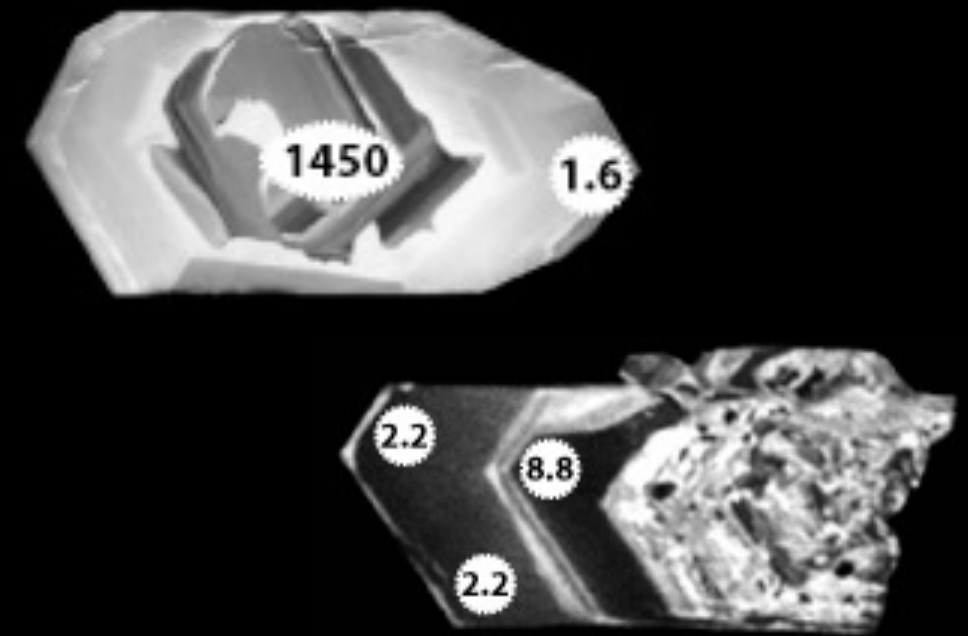
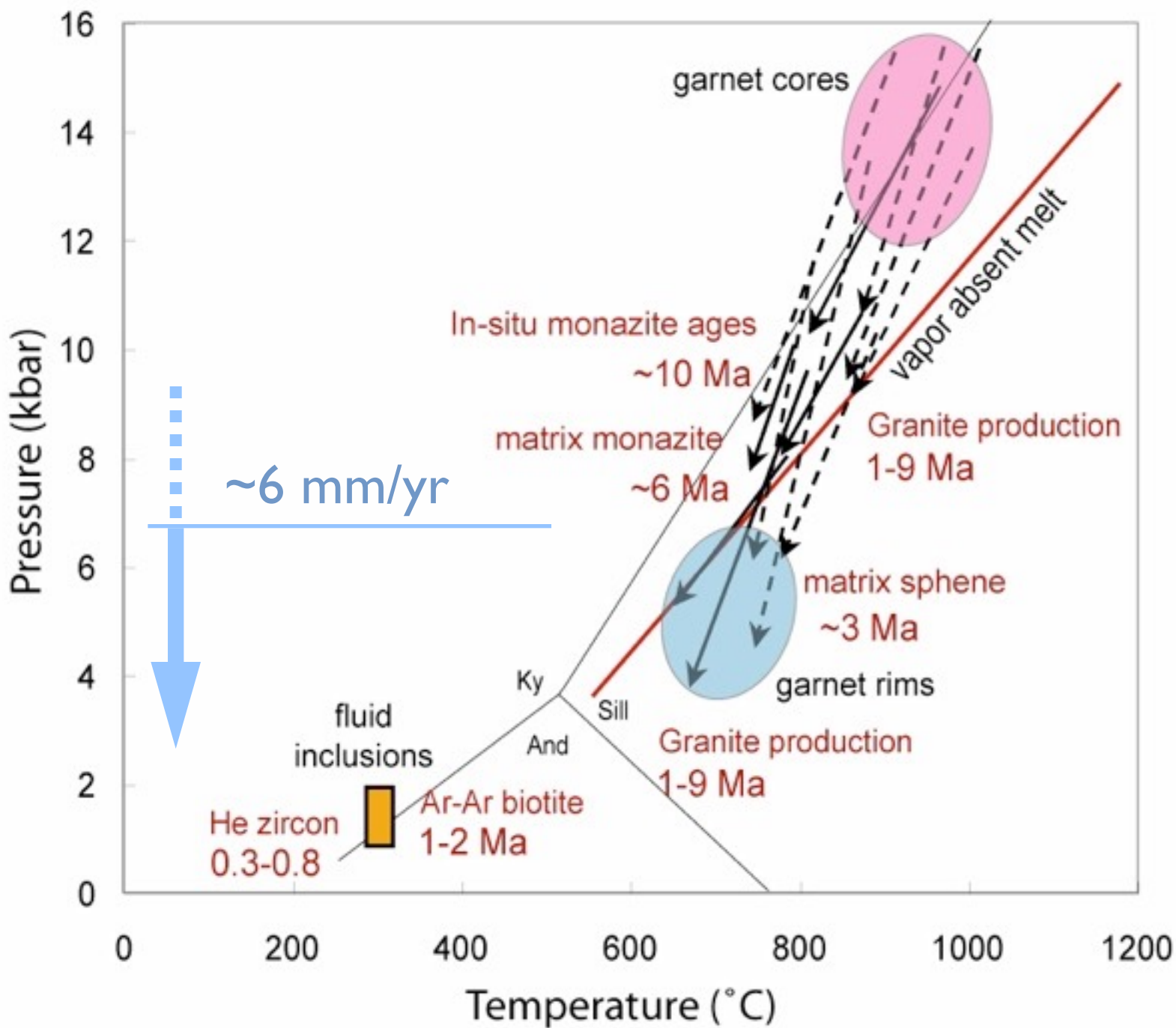
Namche Barwa, Gyala Peri, and the Big Bend Knickzone



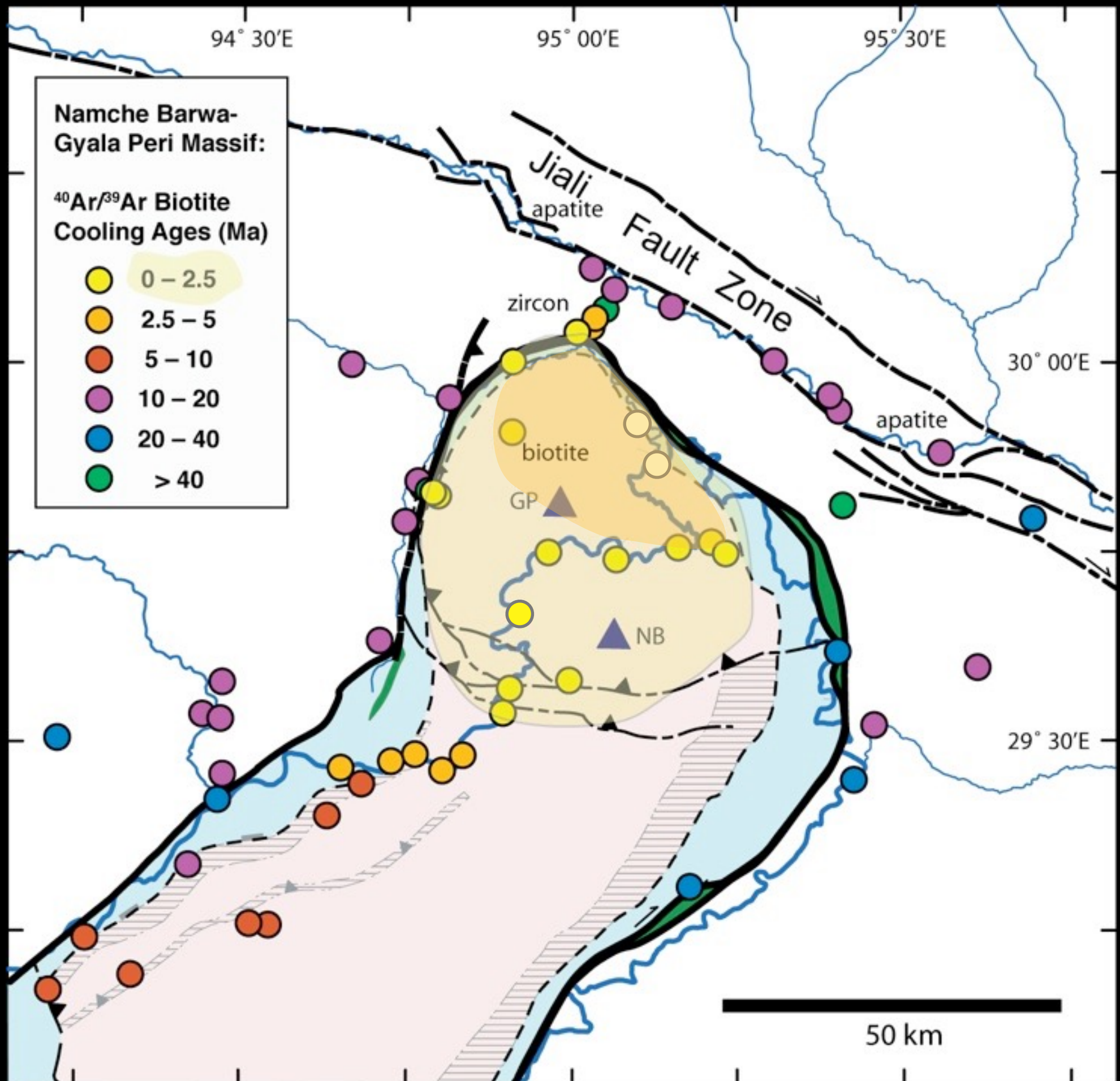
TM image
(not HeFTy model)



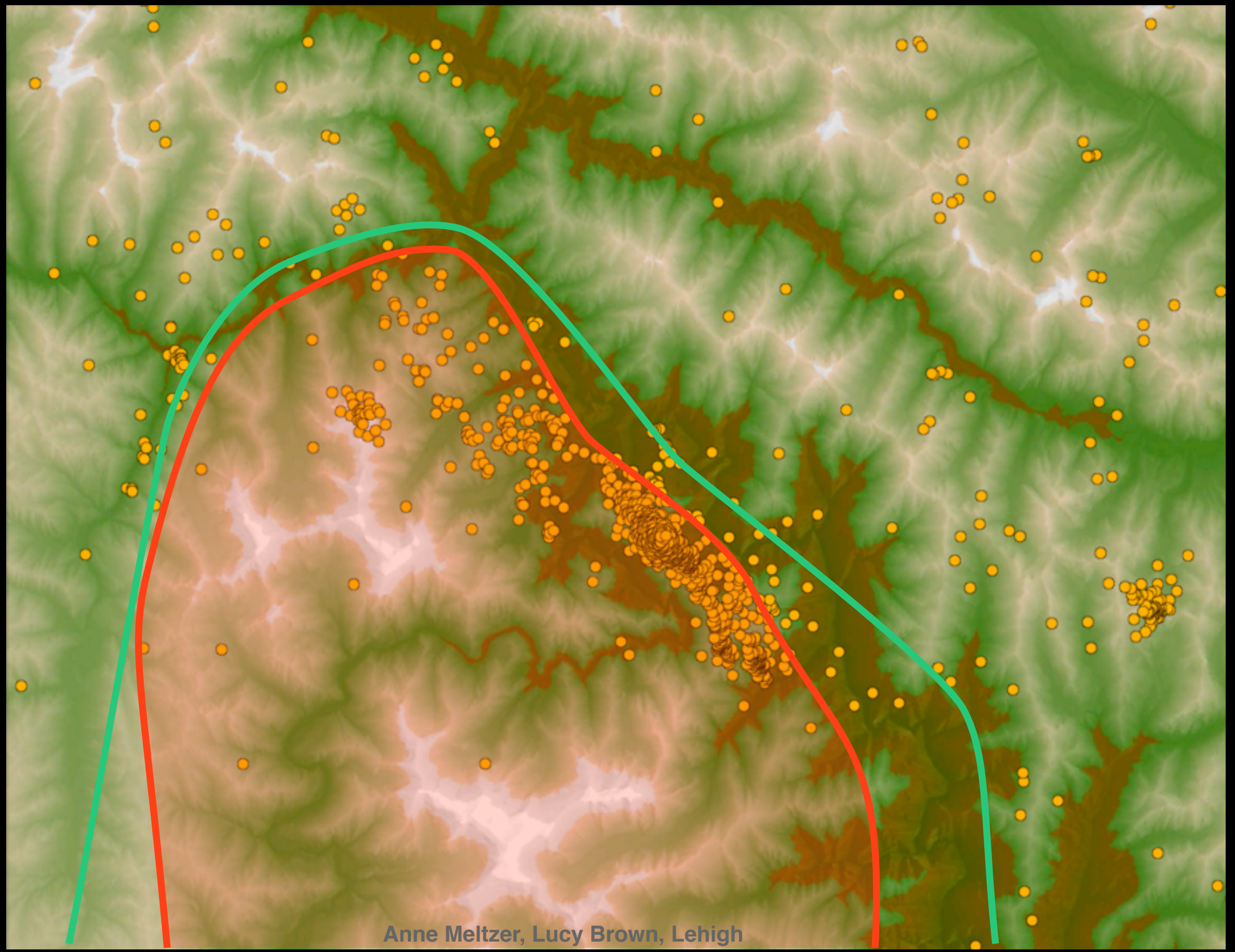
P-T-t Namche Barwa – Gyala Peri



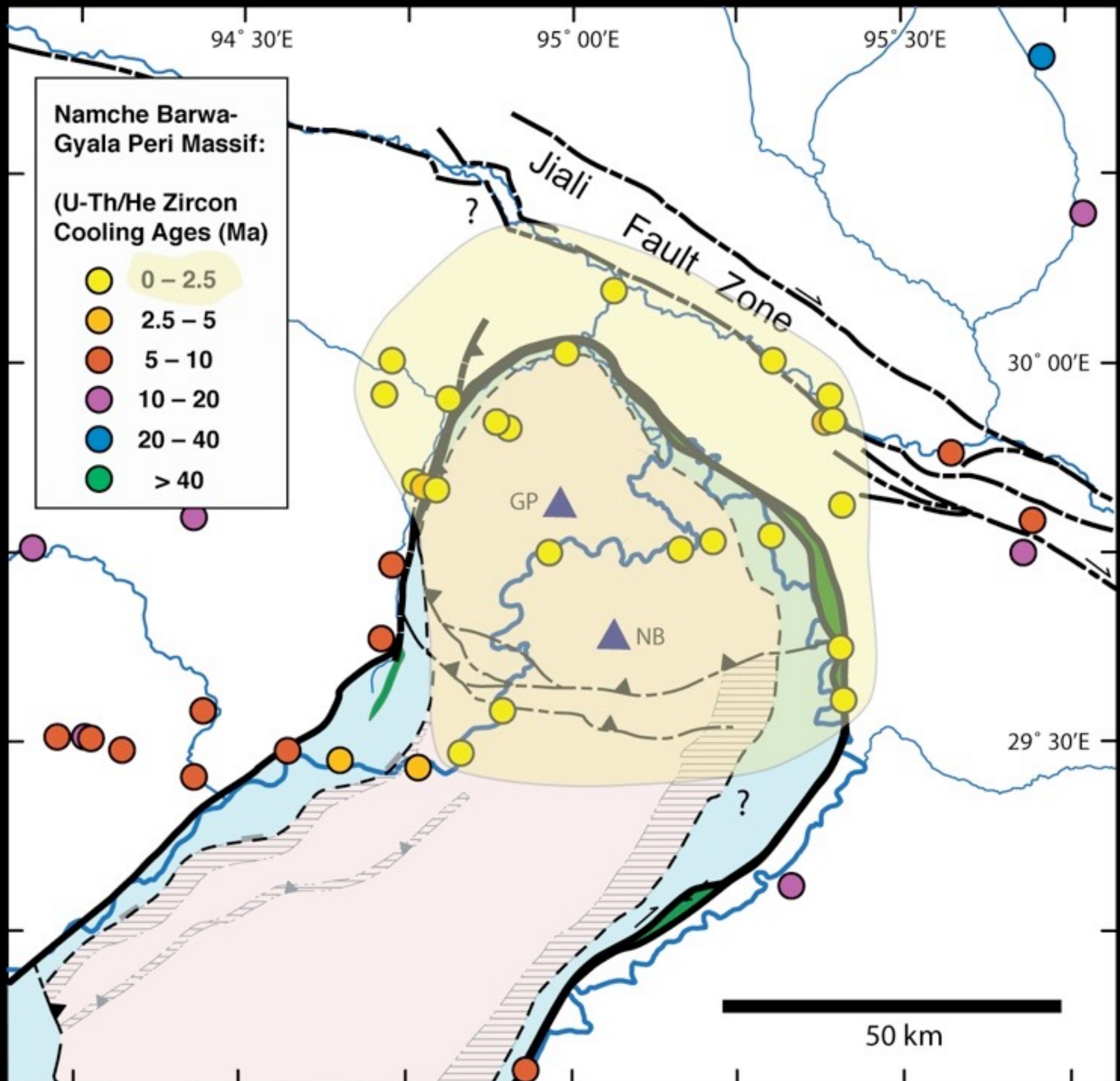
Biotite Ar-Ar cooling ages



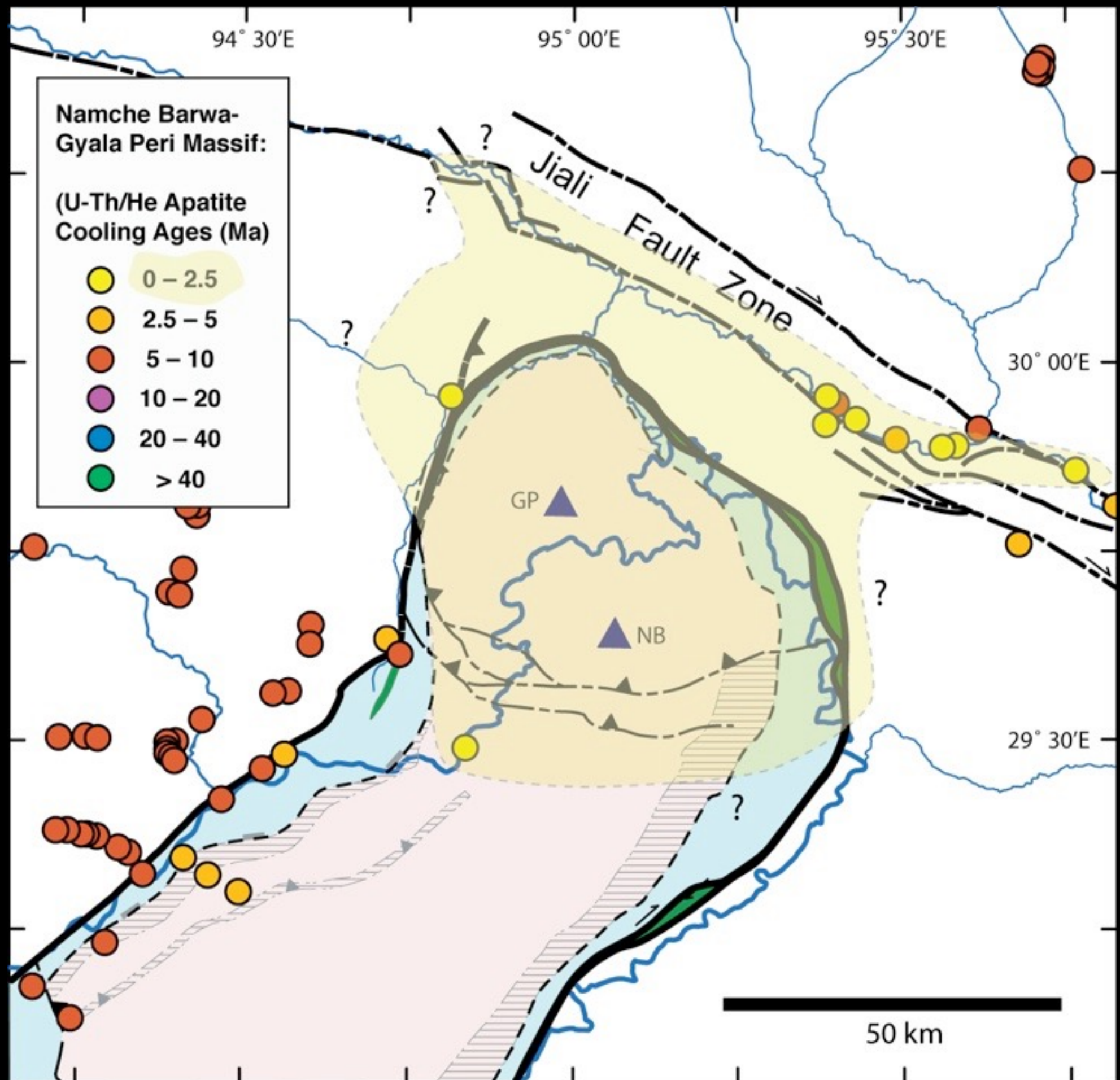
Microseismicity at Namche Barwa...



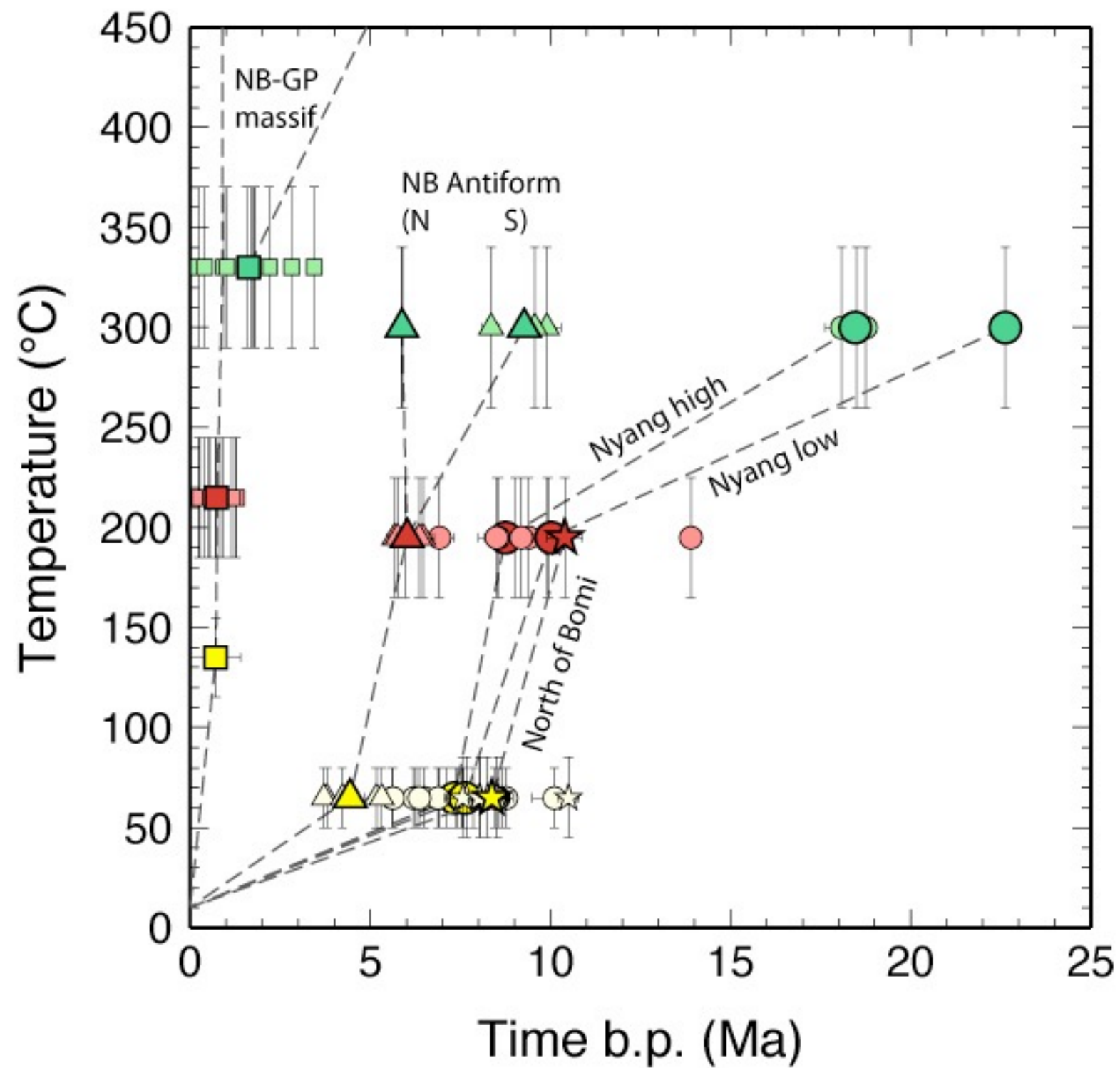
Zircon U-Th/He cooling ages



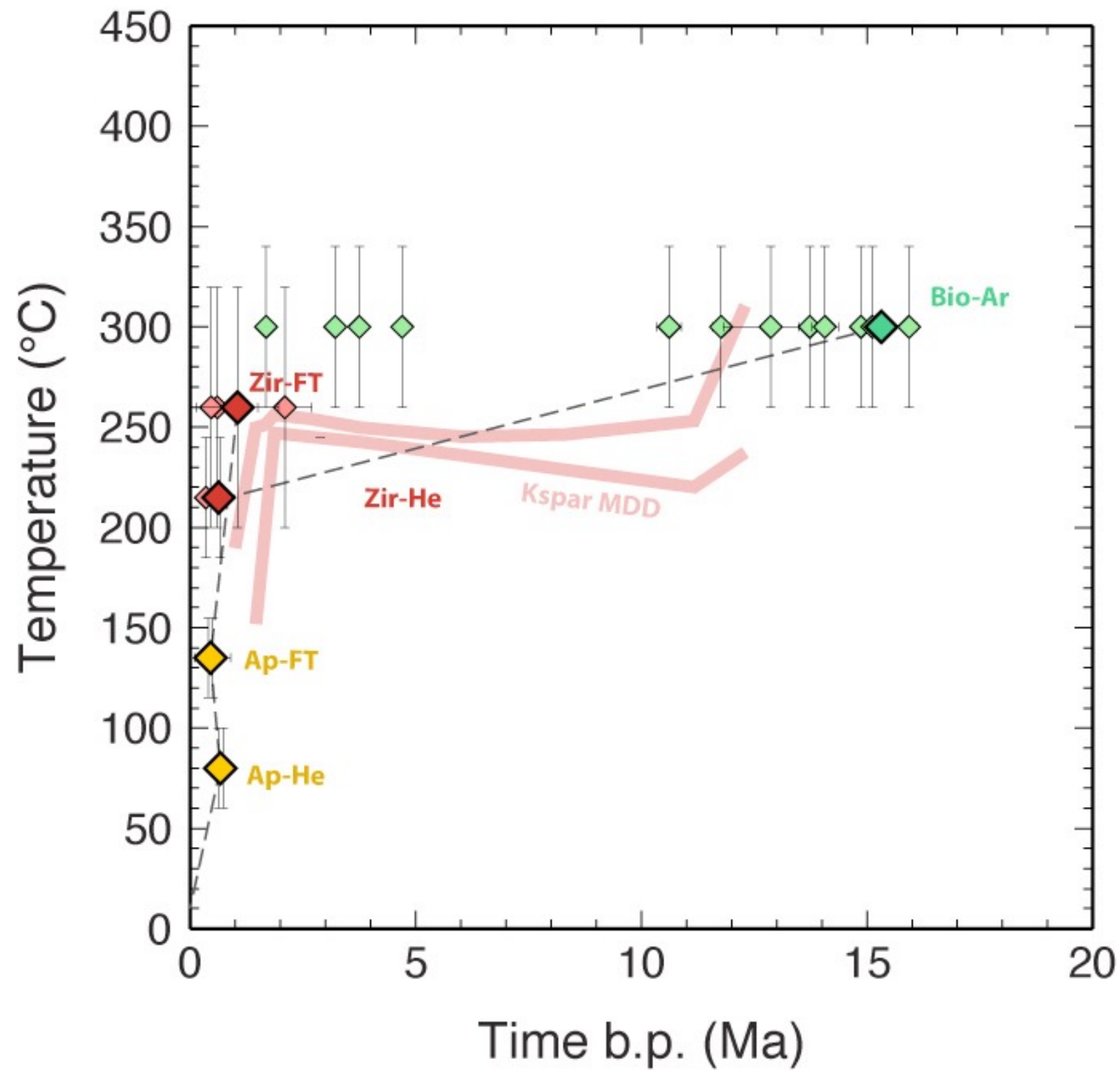
Apatite U-Th/He cooling ages

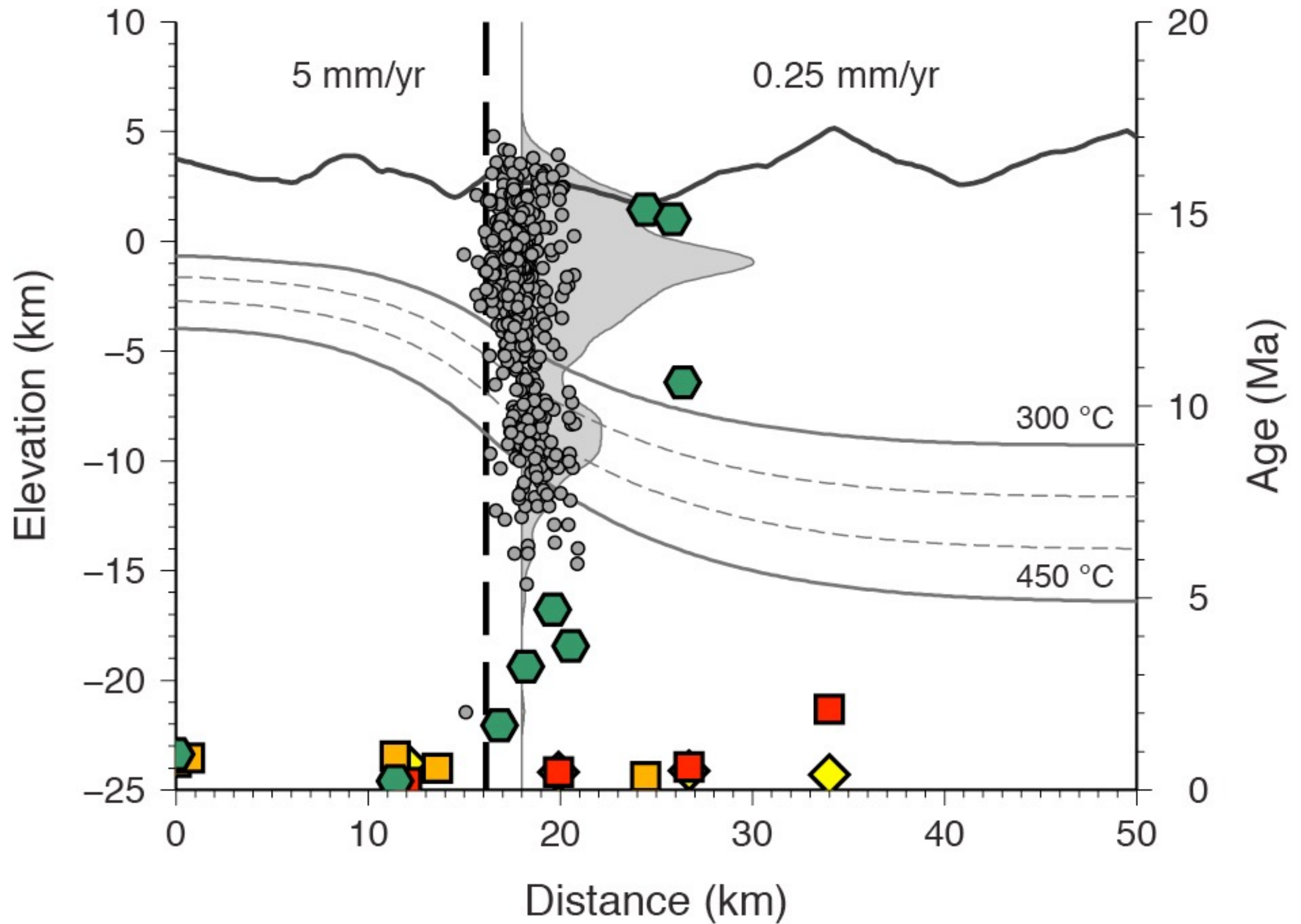


NAMCHE BARWA *T-T*

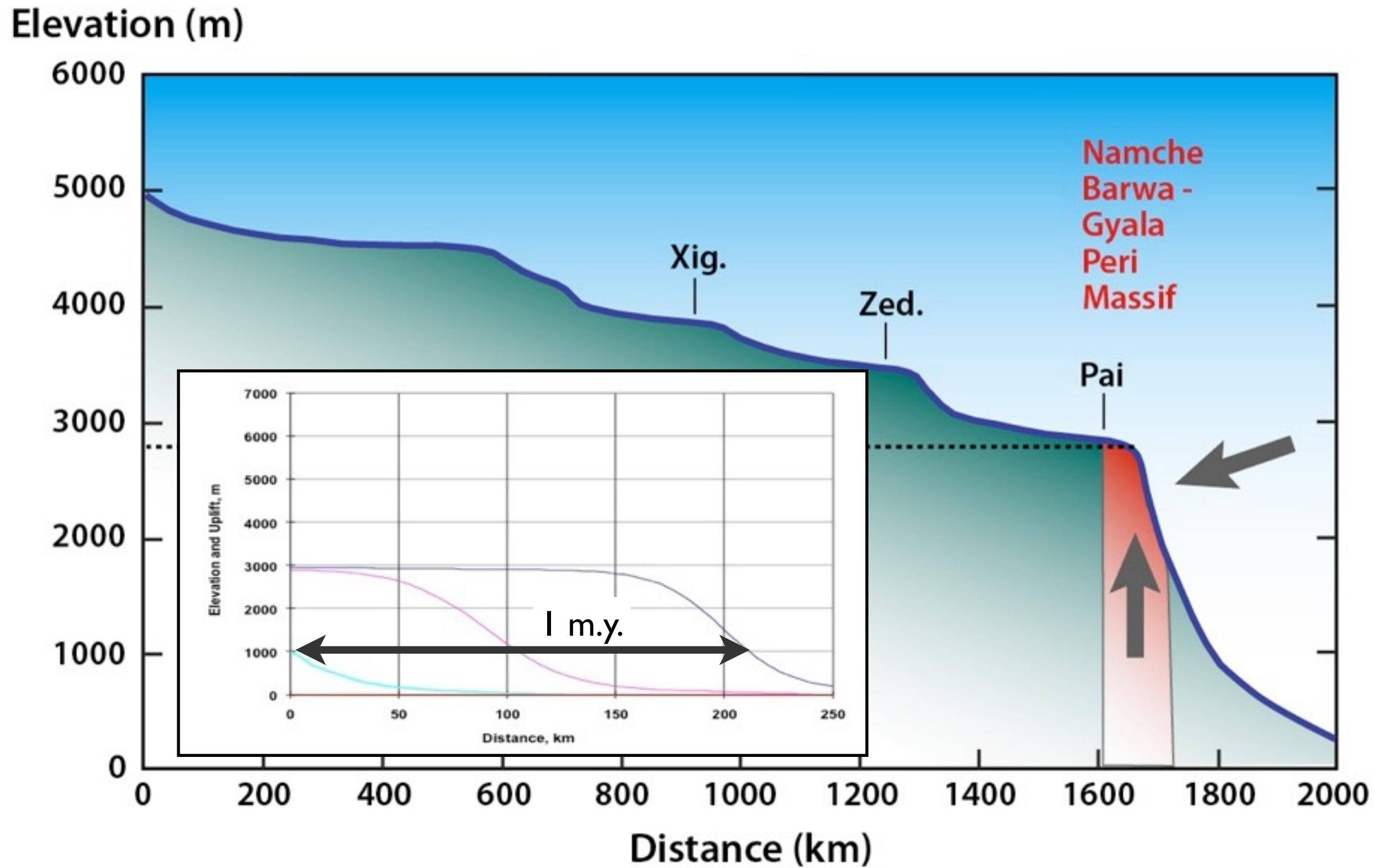


MASSIF-PROXIMAL T - T



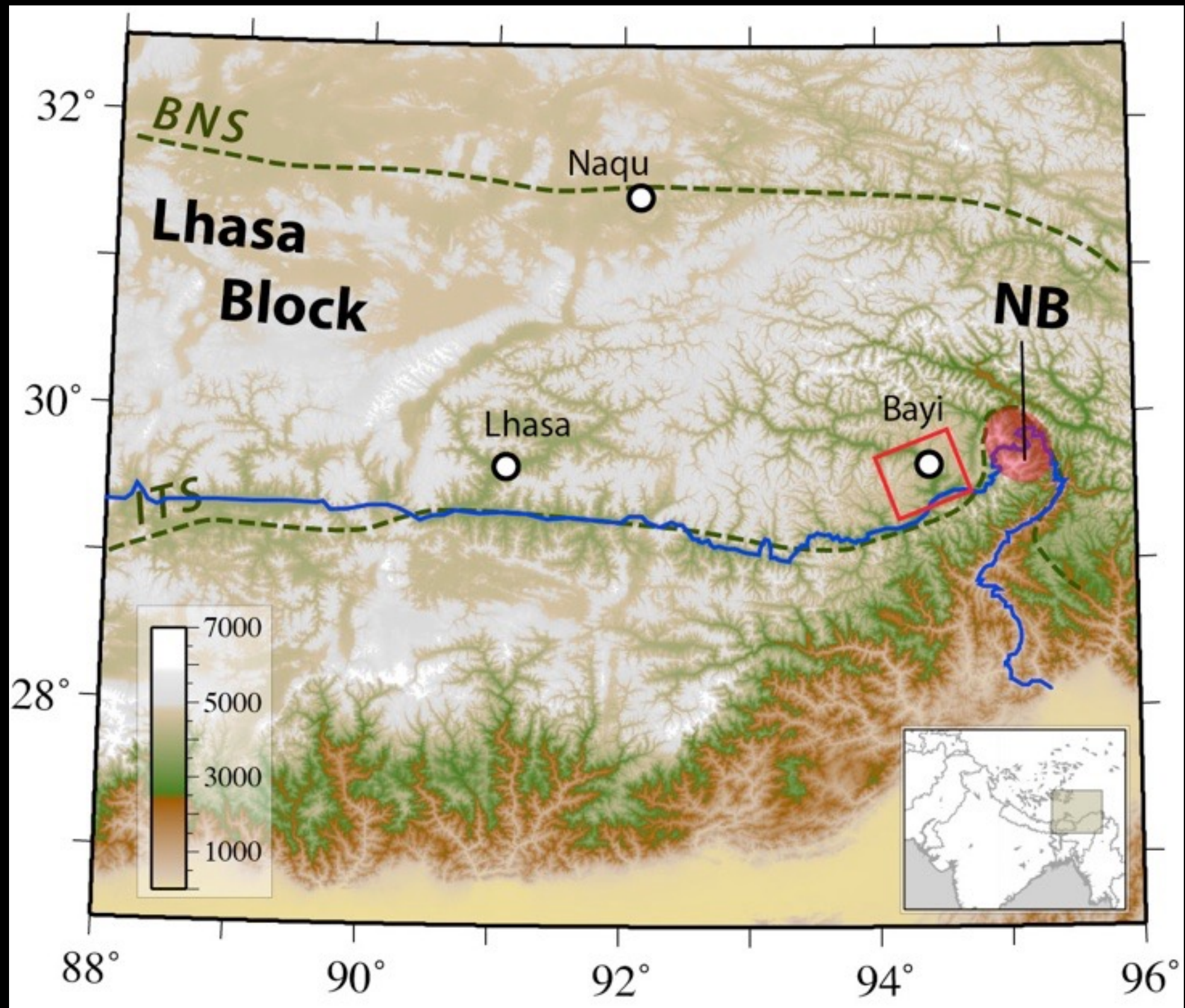


Tsangpo long profile

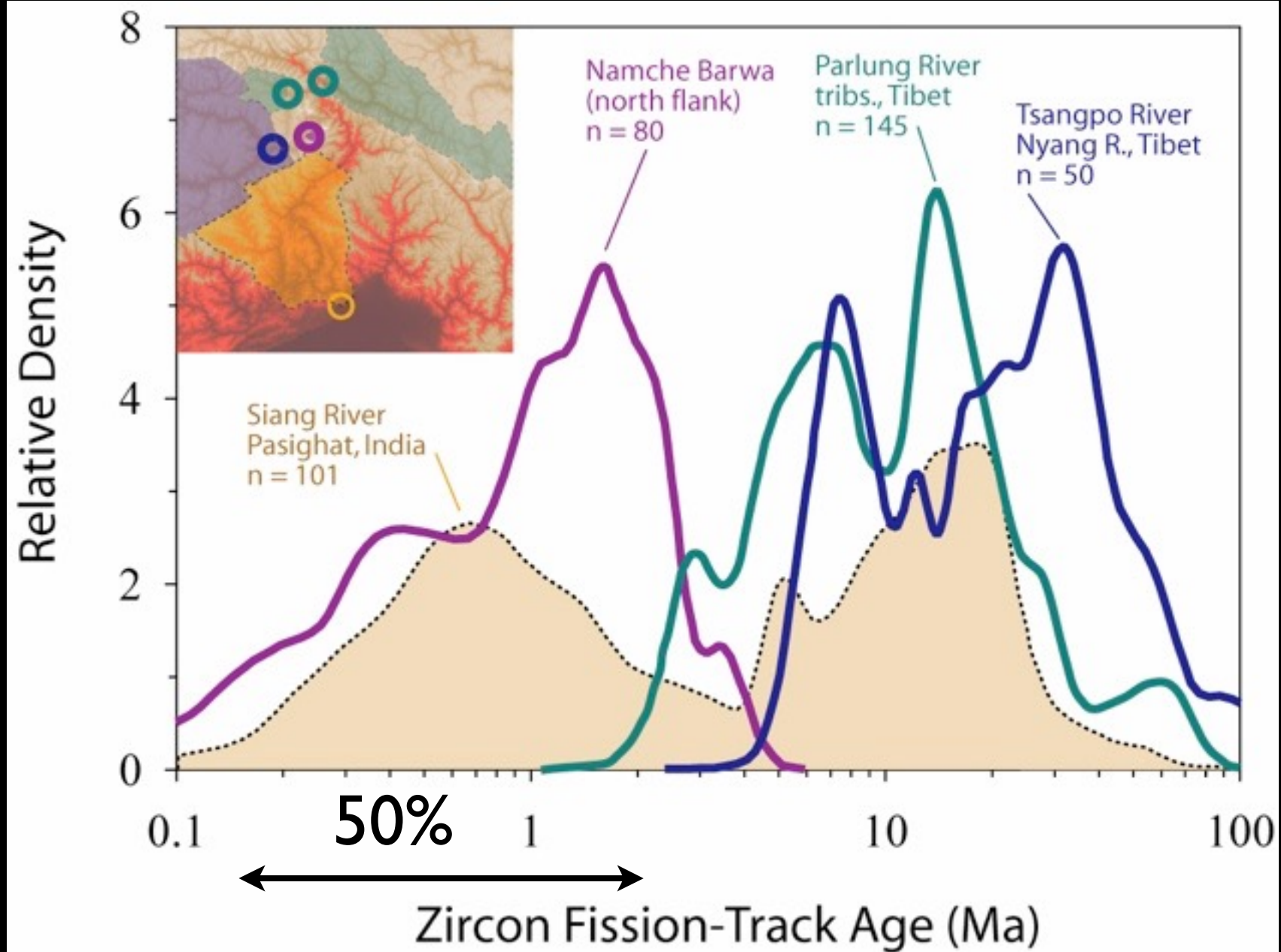
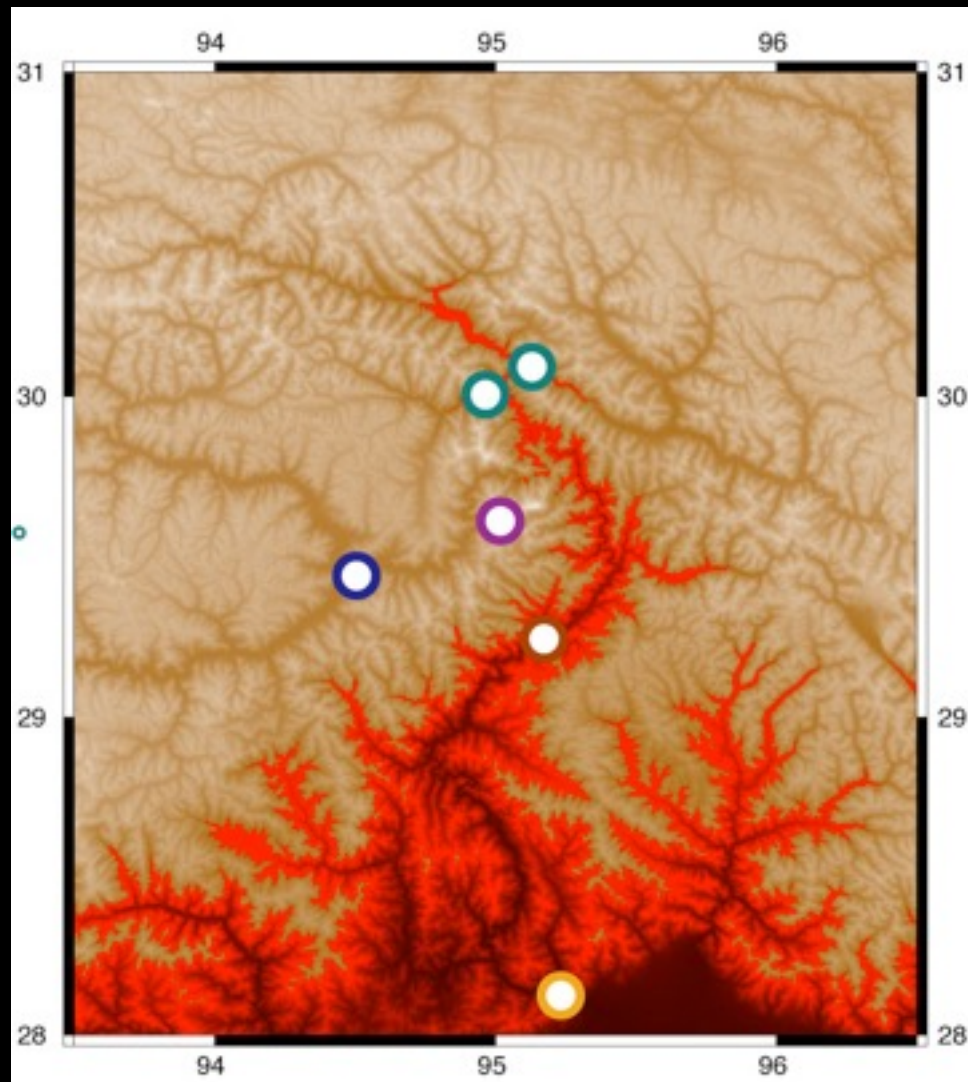


long profile after D. D. Zhang (1998); incision model from B. Hallet

Easternmost Himalaya and Namche Barwa



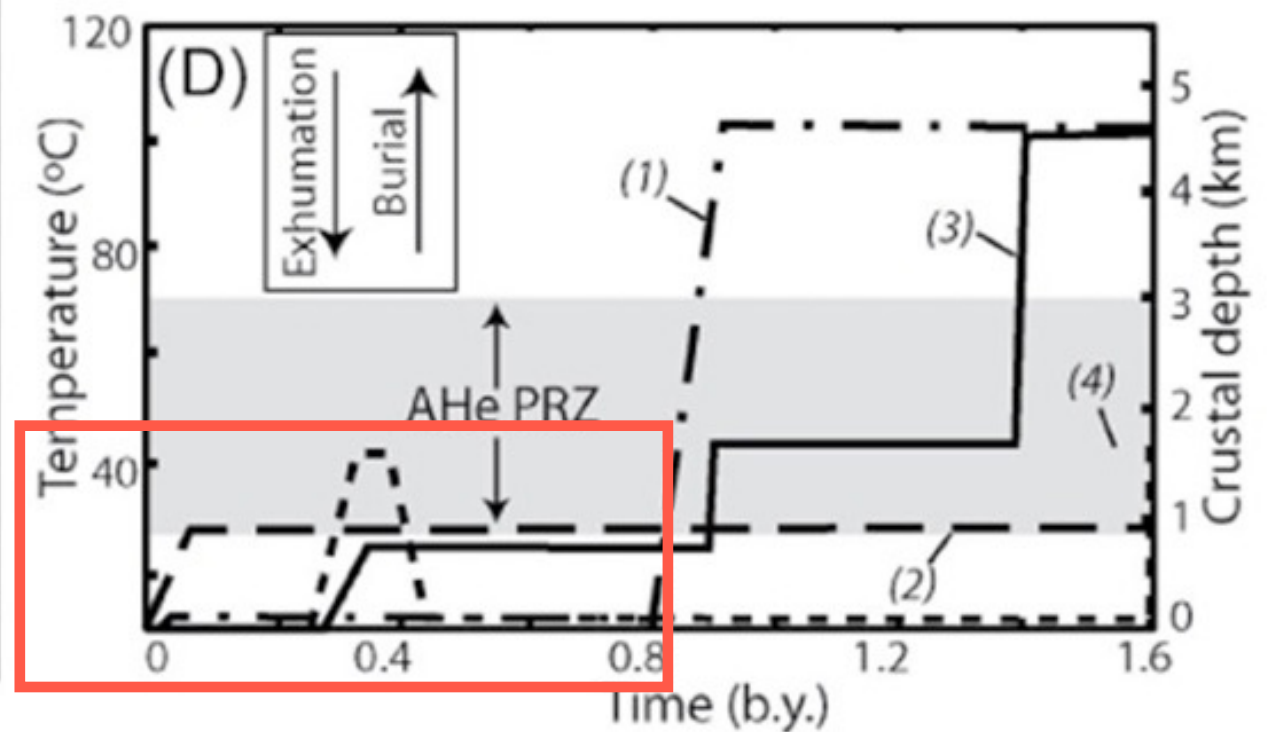
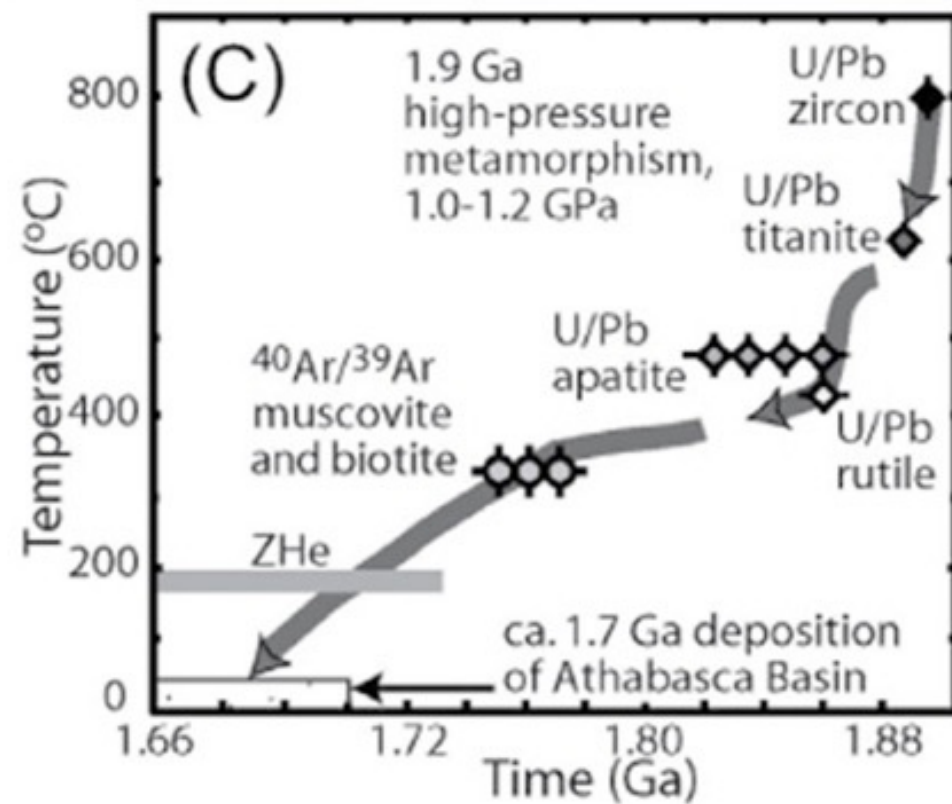
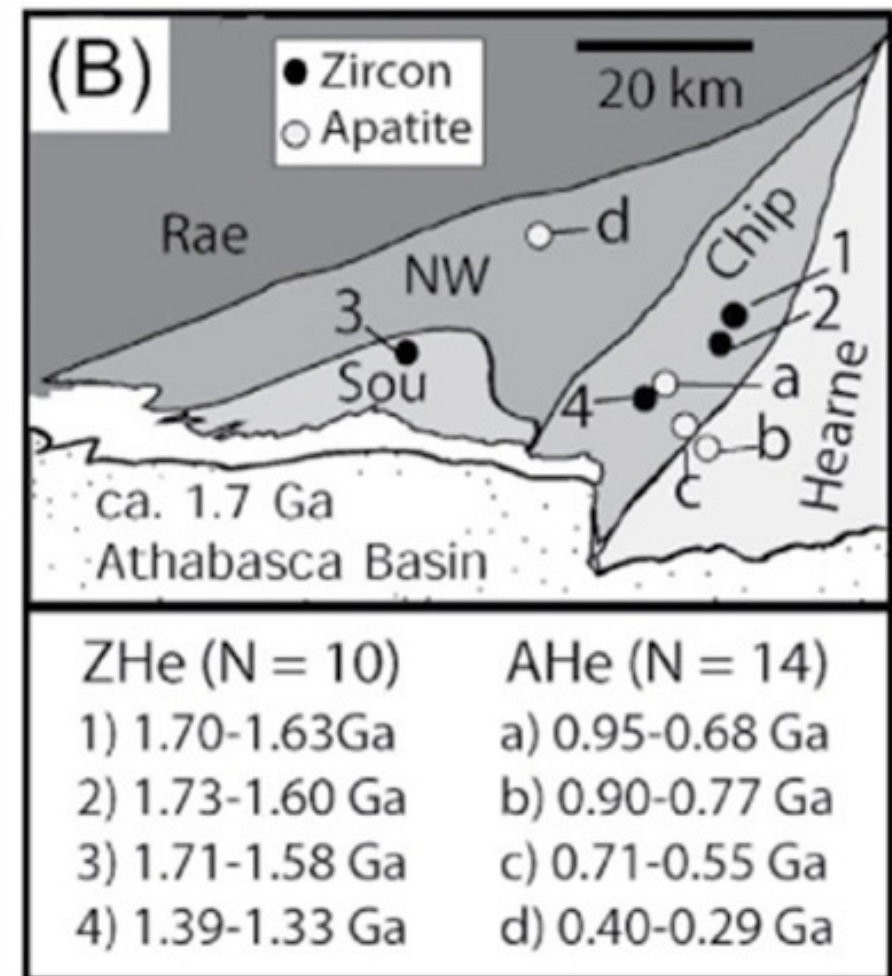
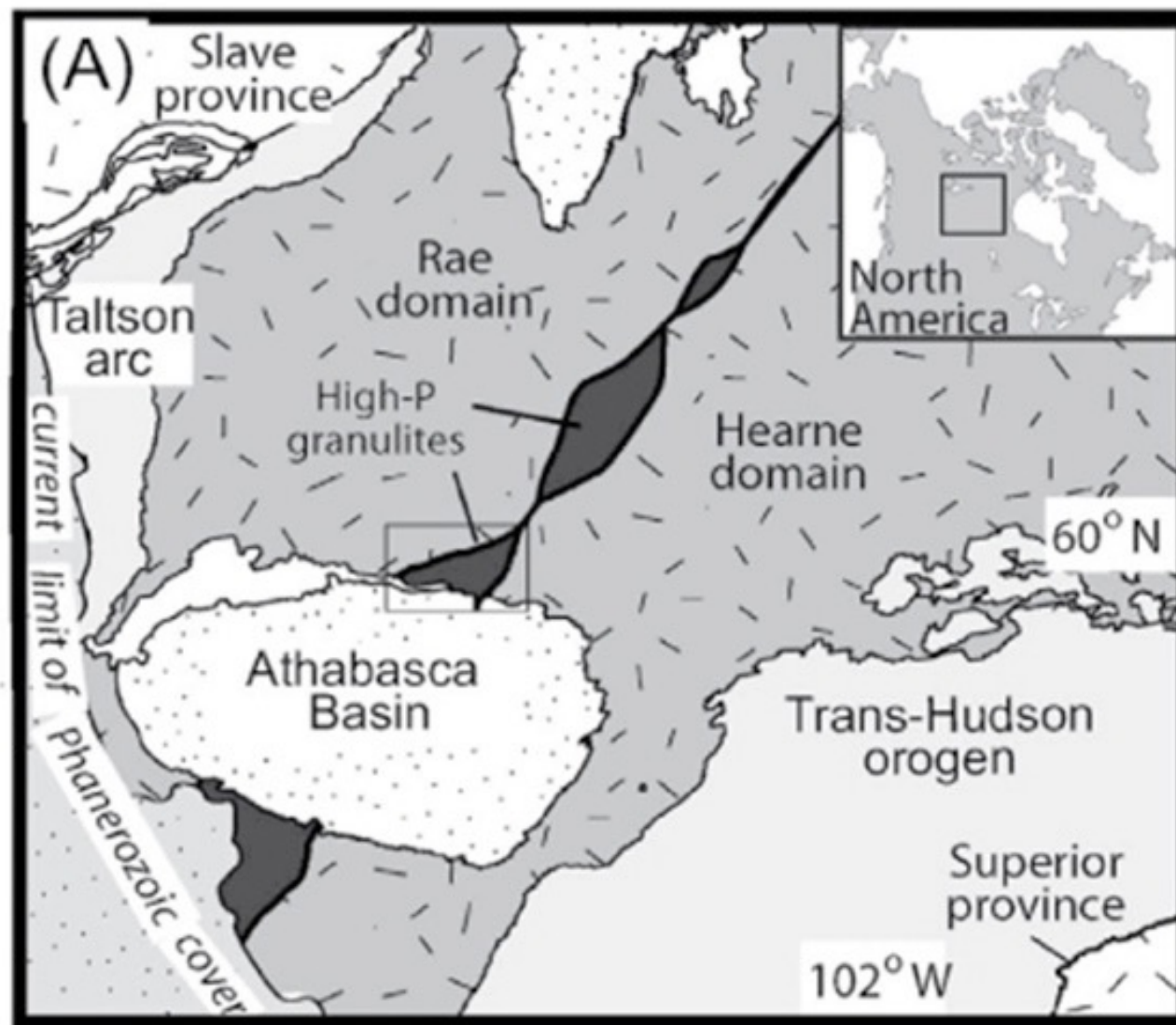
Modern Erosion Rates, Detrital Thermochronology



50% of sediment flux at Pasighat (210 Mt/yr) must be from NB-GP massif (1800-5200 km²).

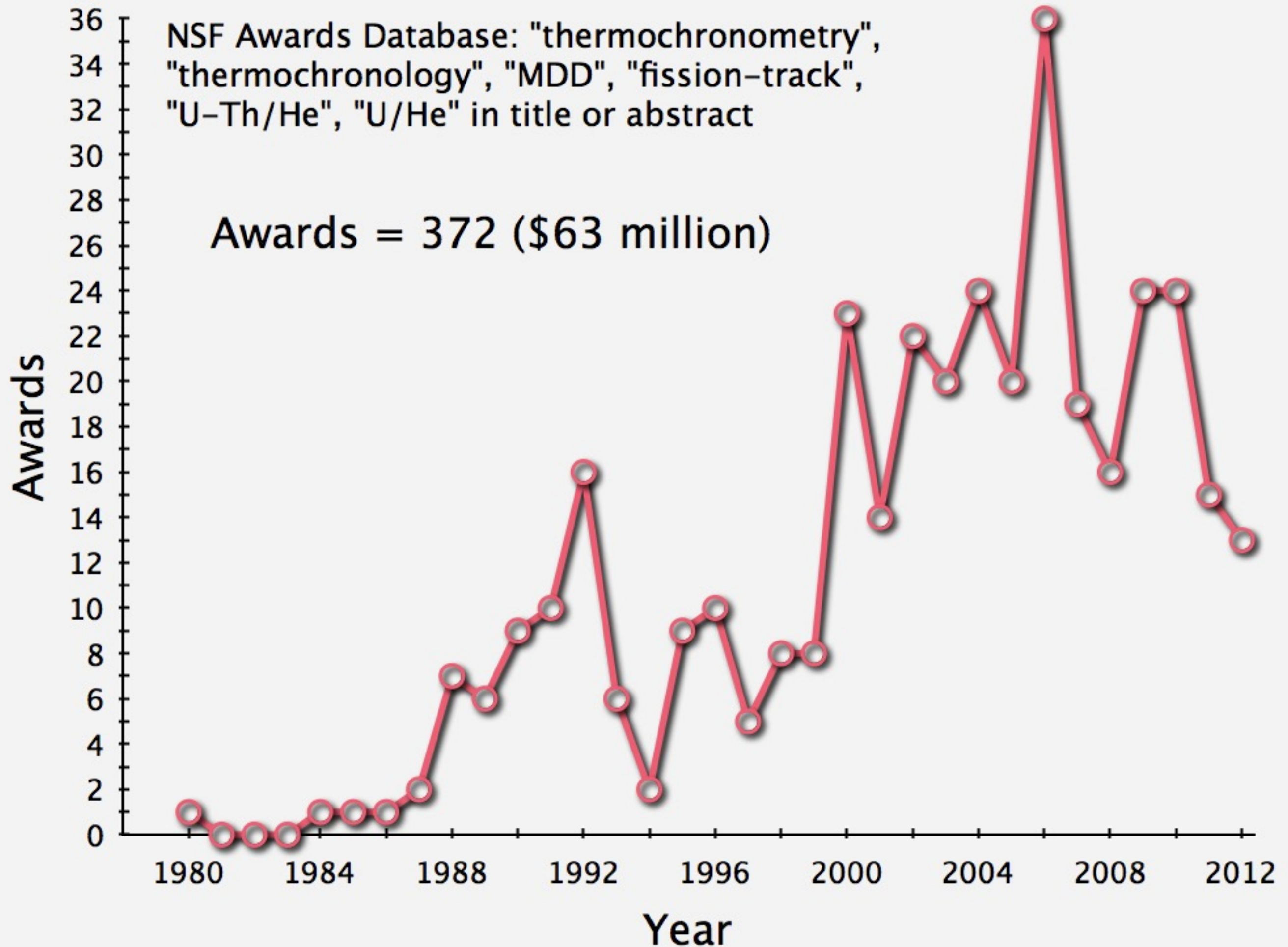
Implies ~10 mm/yr modern erosion rate (50% of 210 Mt spread over 1800-5200 km²)

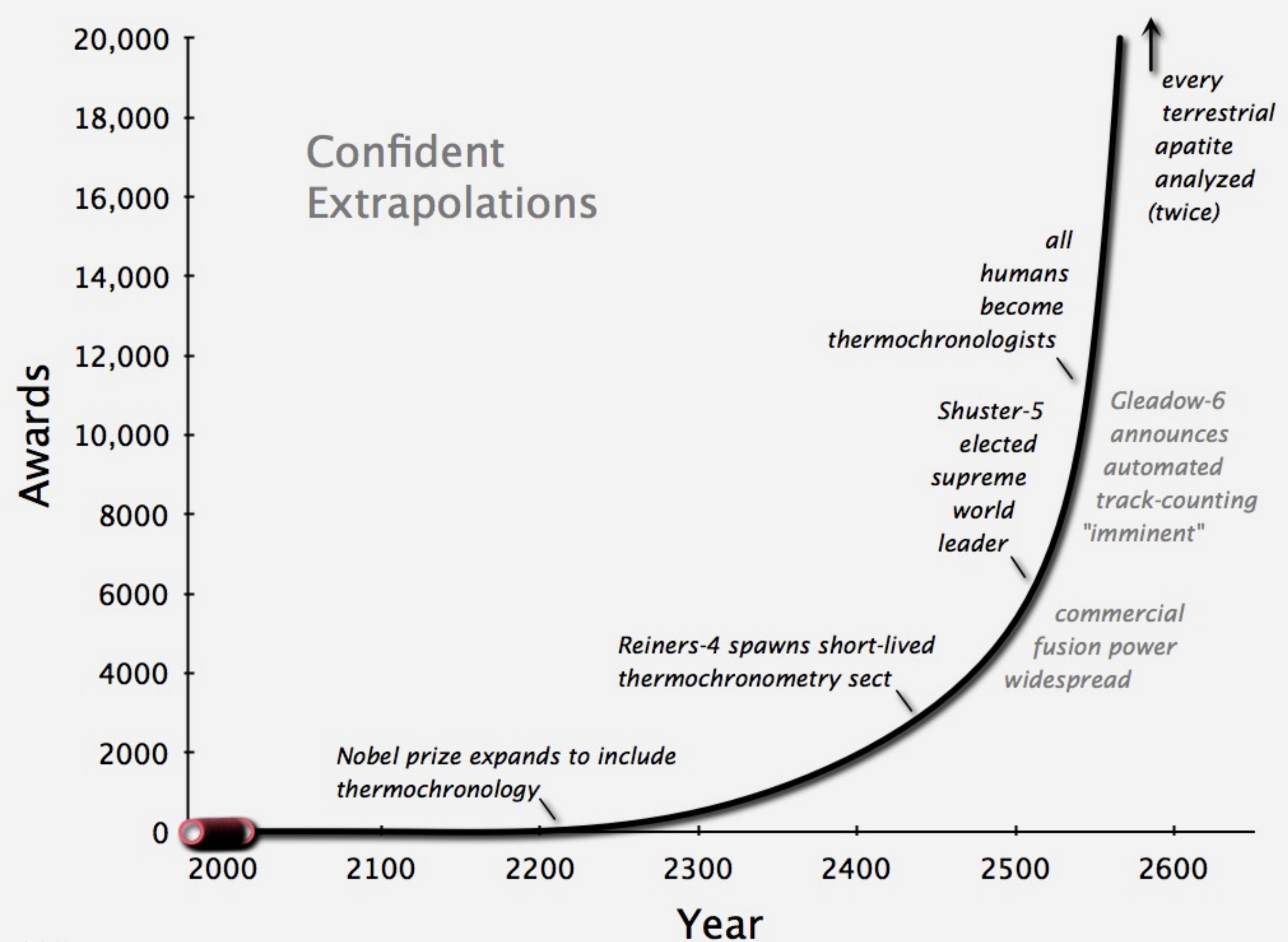
This rate about the same as thermochron estimates (1-2 m.y.) and petrological values (5+ m.y.)



NSF Awards Database: "thermochronometry",
"thermochronology", "MDD", "fission-track",
"U-Th/He", "U/He" in title or abstract

Awards = 372 (\$63 million)





QUIZ: Thermochronology's ^{Mtn. Belt} Achievements

List our game-changing outcomes:

What thermochronological measurements or ideas are in our textbooks or in the public awareness?

1.	5.
2.	6.
3.	7.
4.	8.

QUIZ: Thermochronology's ^{Mtn. Belt} Achievements

List our game-changing outcomes:

What thermochronological measurements or ideas are in our textbooks or in the public awareness?

1. <i>dates & timing</i>	5.
2. <i>rates</i>	6.
3. <i>tempo of change</i>	7.
4. <i>Earth-surface coupling</i>	8.

Accomplishments - Broader View

Thermochronology is now a standard, widely accepted tool for research in geology (including mountain belts)

Work in thermochronology has driven:

- our intuition and appreciation for the dynamics of Earth

- interest in coupling of surface processes and tectonics

- culture change in geochronology (escape from clean-room culture) - embracing of uncertainty, understanding systematics

- development of powerful models for interpretation

But what's next?

What's Next, I: Education & Outreach

More complete interpretation of data will require:

- application of the physics of heat transfer

- better knowledge of thermal (and other) crustal parameters

- geodynamic framework in which heat transfers take place

At its core, thermochronology involves the curation, development and application of methods to determine thermal histories, so continued collaboration and cross-training with other disciplines will be important

What's Next, 2: Improve Kinetics

Bring out the bombs! More lab kinetic studies. Please.

Kinetic standards for at least apatite and feldspar

Sort out radiation-damage effects

More $^4\text{He}/^3\text{He}$ and $^{40}\text{Ar}/^{39}\text{Ar}$ MDD

Community agreement on kinetic values and uncertainties, an open and updating kinetic database

What's Next, 3: Higher Throughput

You know I was going to say this. Increase output 10x.

This raises signal-to-noise for all applications

Allows us to properly address problems in exhumation or other wavelength-dependent problems in tectonics; encourages detrital studies

We should put the same enthusiasm we have for lasing things into identifying and eliminating choke points, glamorous or not

What's Next, 4: Broaden our Reach

We should better link classic lower-temperature thermochronology to higher-temperature approaches involving mineral reactions and fluids

At the very least, routinely use multiple thermochrometers

Thermochronology is fun and interesting basic research, but our community needs to keep broader goals in mind. Why are we doing what we do? Why would others care?

Talk more at meetings and workshops (like this one)