Mineral-scale constraints on the geodynamics of extension

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Acknowledgements

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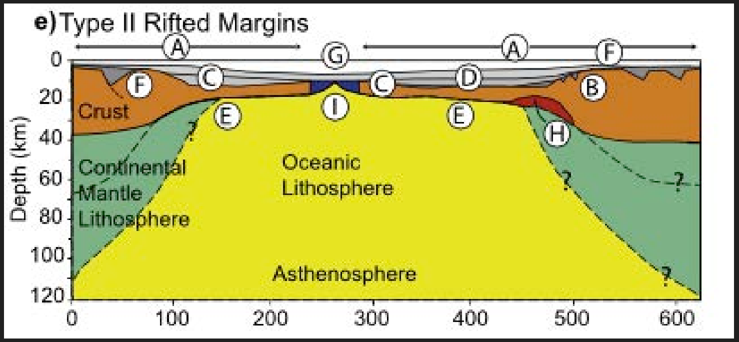
PENNSTATE 1855

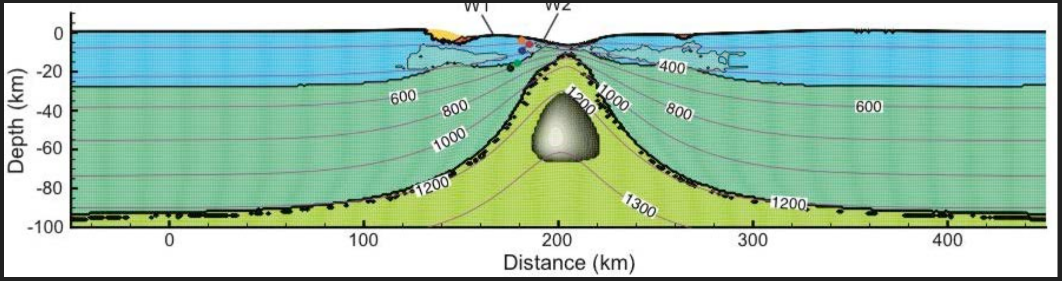
Motivation & Outline

1. How is strain vertically distributed during rifting?



Huismans & Beaumont 2014

2. What are typical rates of mantle cooling/upwelling during extension?

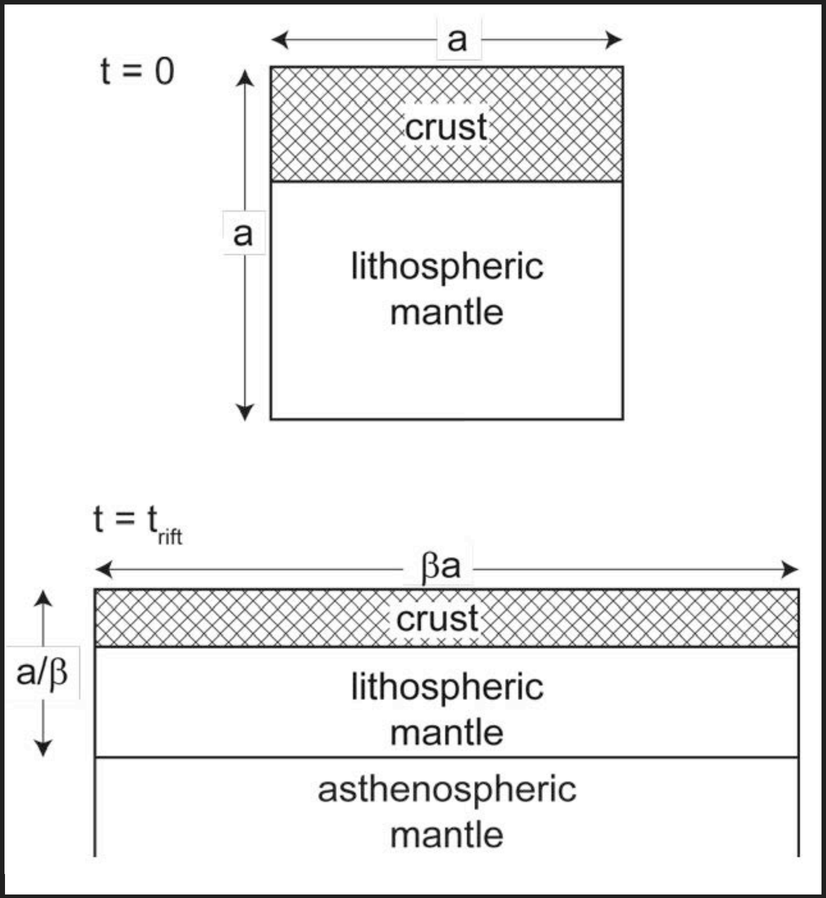


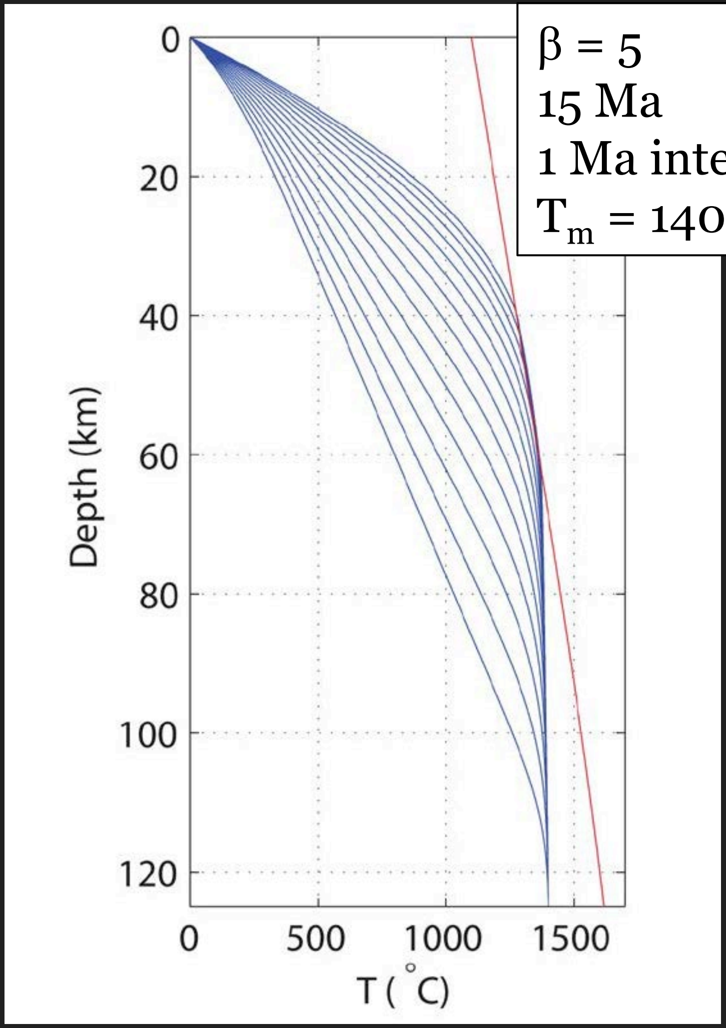
Lavier, *unpub.*

Approach: use high-T thermochronology and diffusion speedometry to harness thermal signature of geodynamics

1. Strain distribution and thermal history

→ *Uniform thinning (pure shear)*



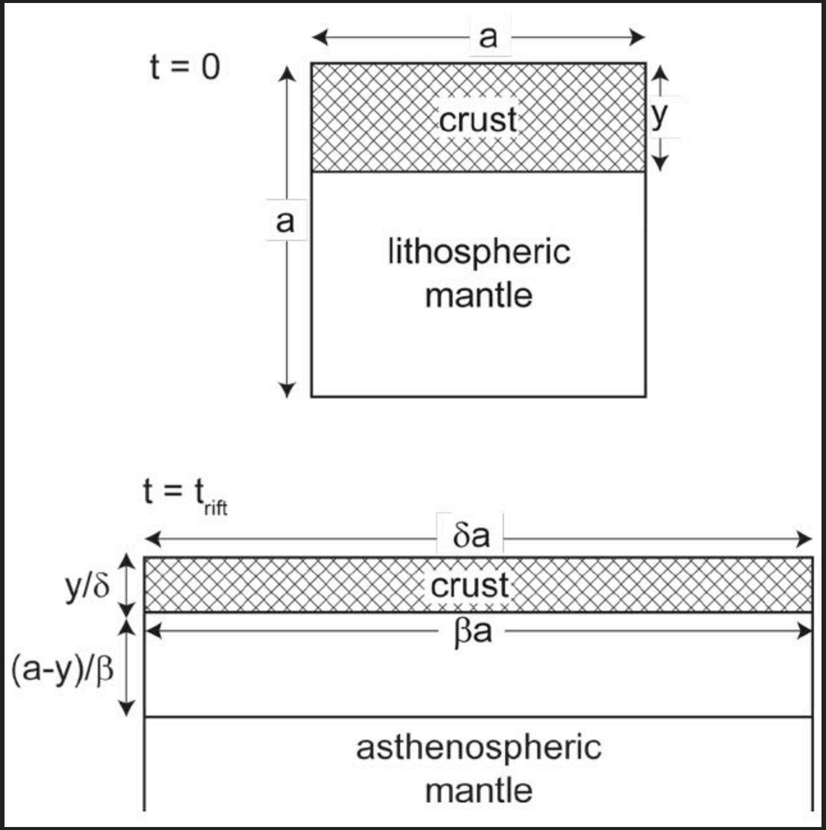


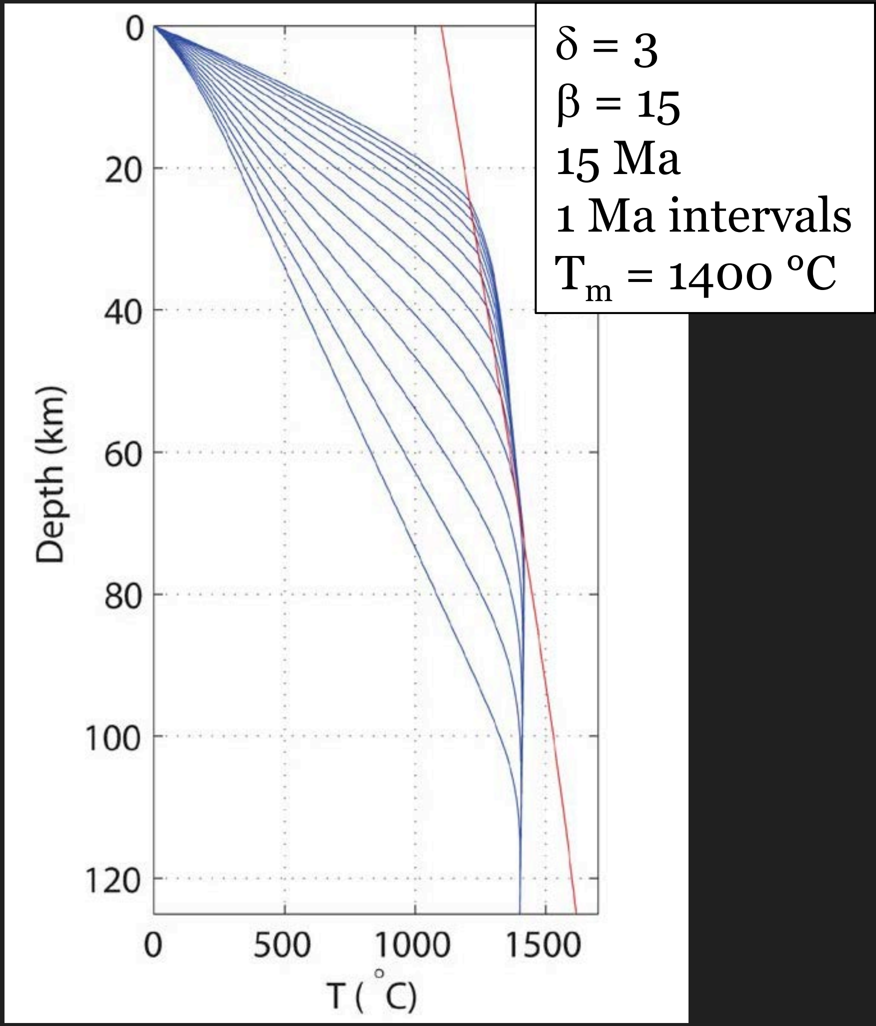
$\beta = 5$
15 Ma
1 Ma intervals
$T_m = 1400$ °C

McKenzie 1978

1. Strain distribution and thermal history

→ *Depth-dependent thinning*

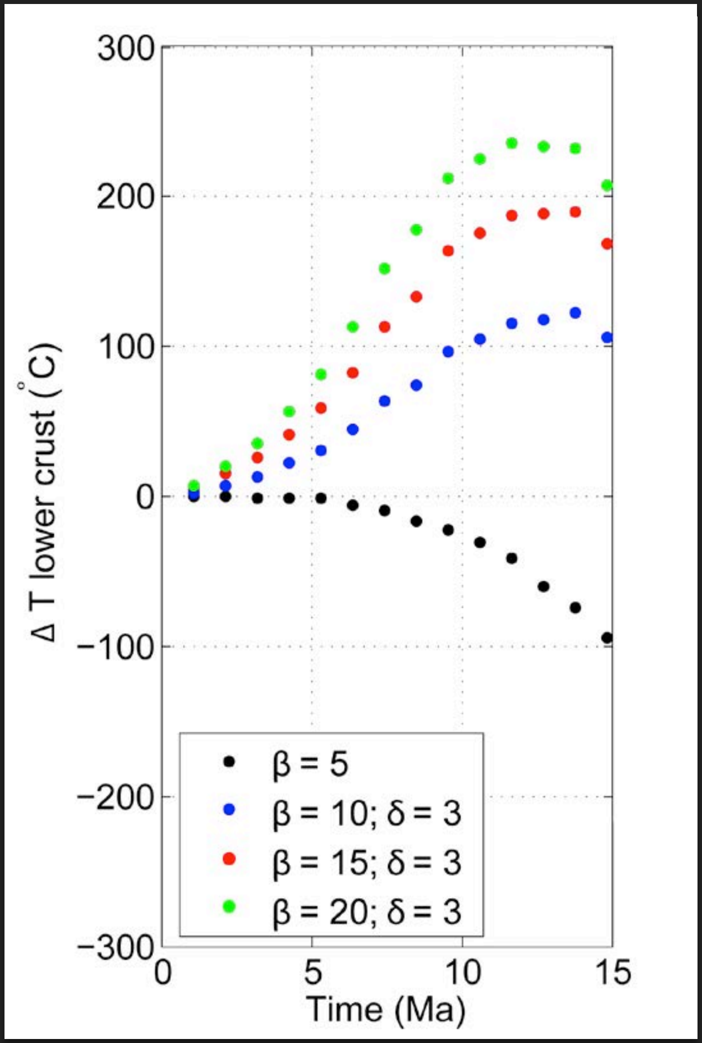




Royden & Keen 1980

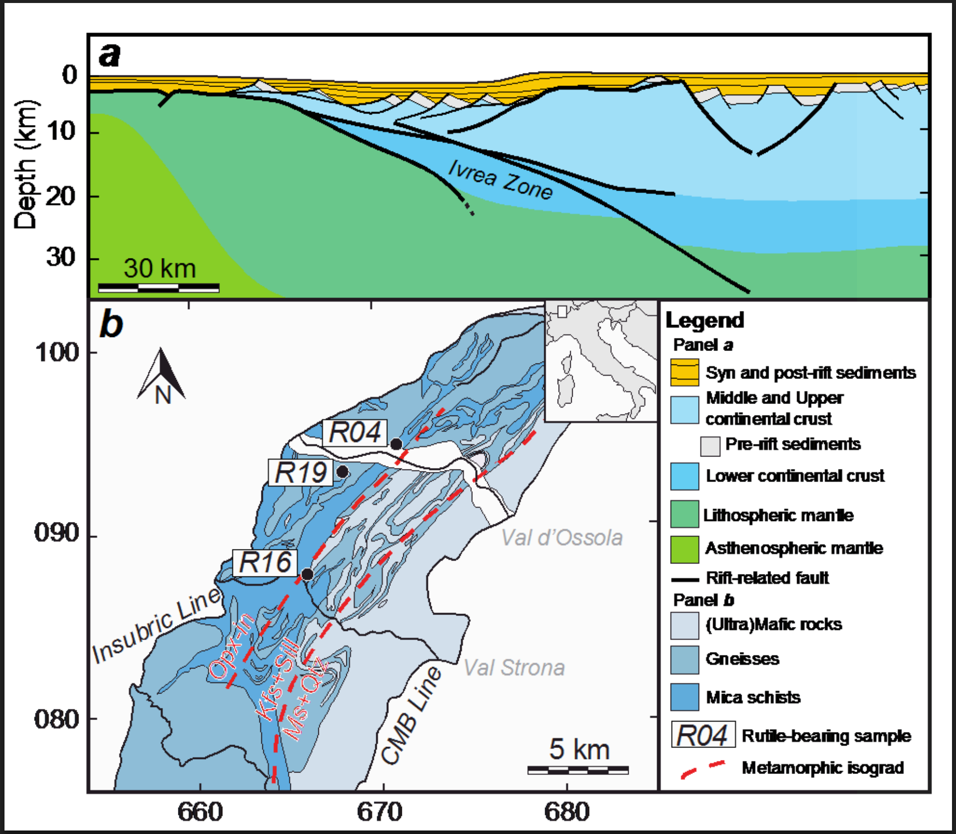
1. Strain distribution and thermal history

- Uniform thinning drives cooling at all structural levels
- Partitioning of strain into mantle lithosphere drives conductive heating of lower/middle crust
- *Is this signal recorded in attenuated lower crust?*



1. Strain distribution and thermal history

→ *Application: attenuated lower crust; Ivrea Zone, Italy*

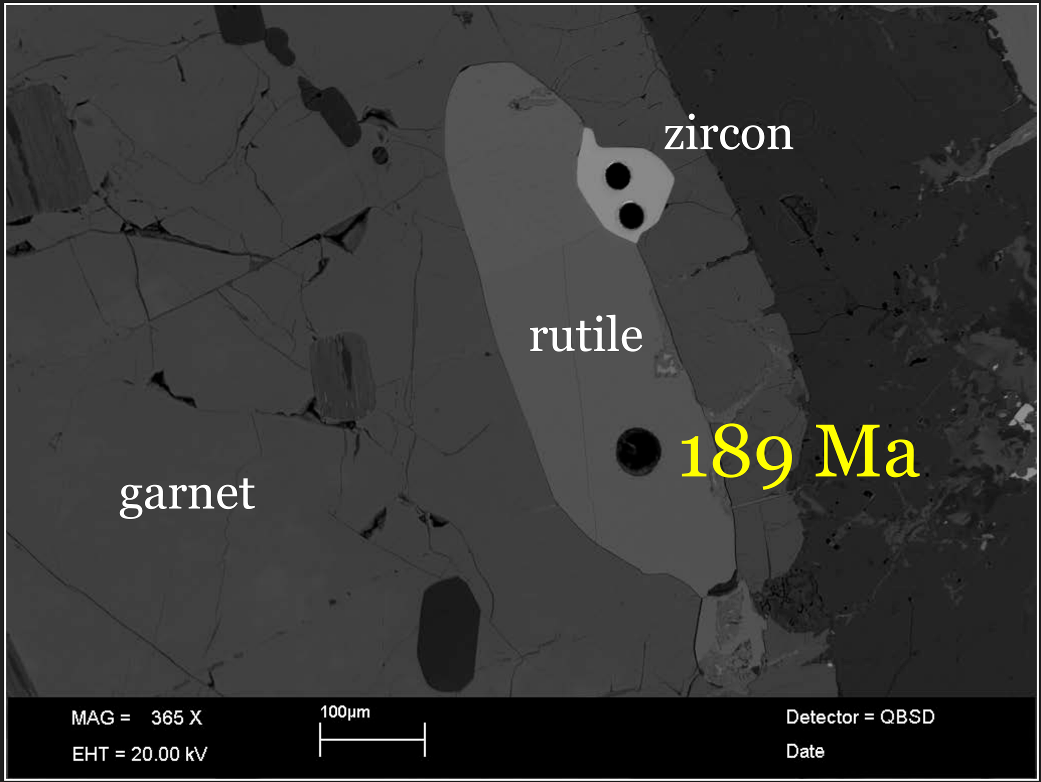


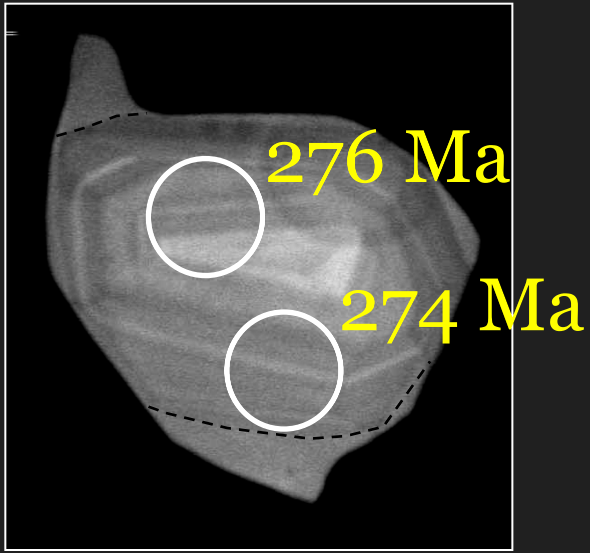
~ 6 kbar, Mu+Qtz

~ 8 kbar, Gt+Kfs+Sill+melt

1. Strain distribution and thermal history

→ *Rutile U-Pb thermochronology, Ivrea Zone*

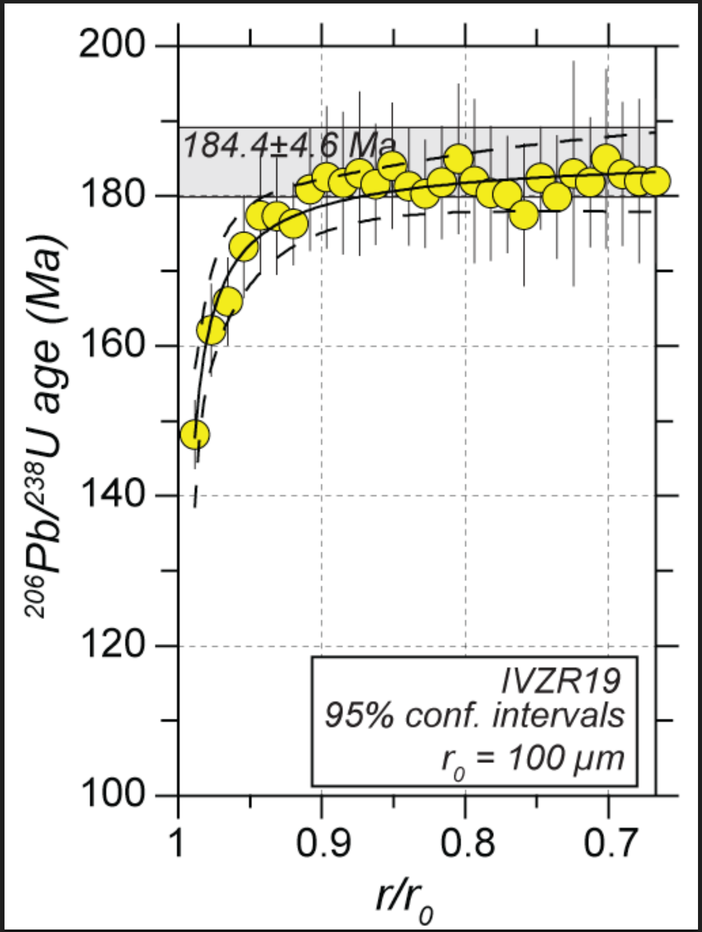


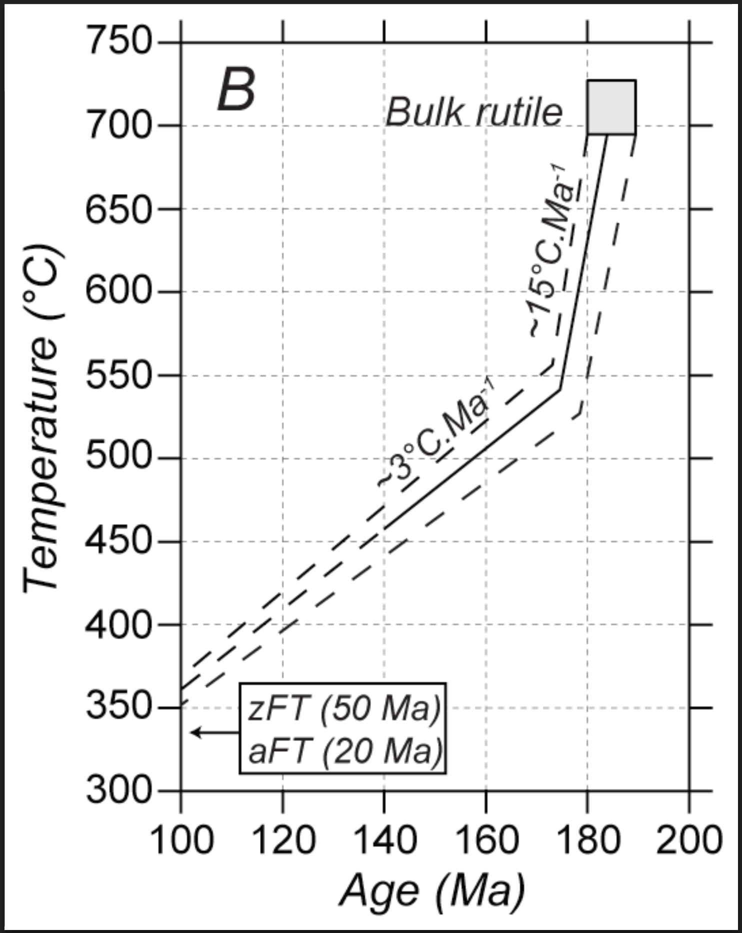


- Zircon texturally younger than rutile, yet >90 Ma older
- U-Pb rutile system reset ~180-190 Ma

1. Strain distribution and thermal history

→ *Rutile U-Pb thermochronology, Ivrea Zone*

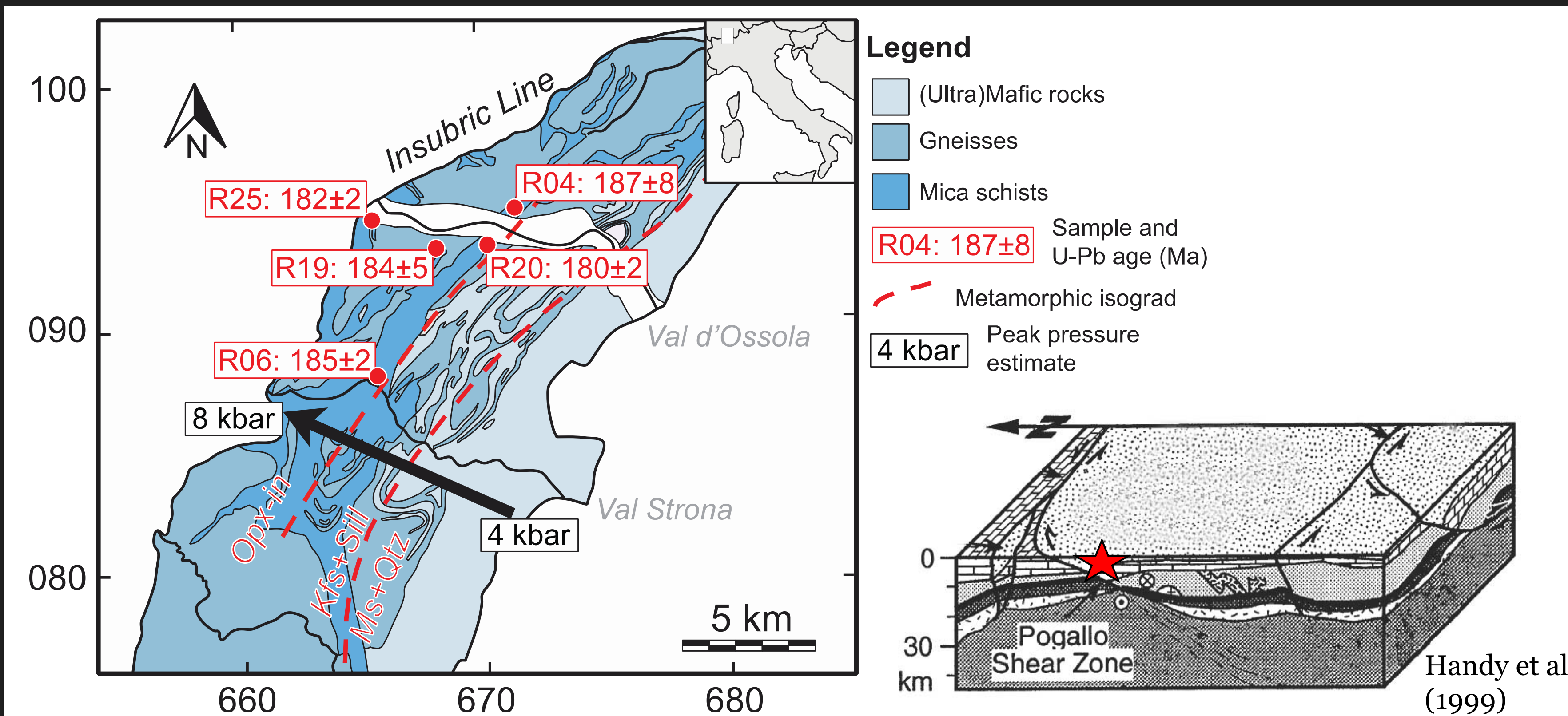




Smye & Stockli 2014, *EPSL*

1. Strain distribution and thermal history

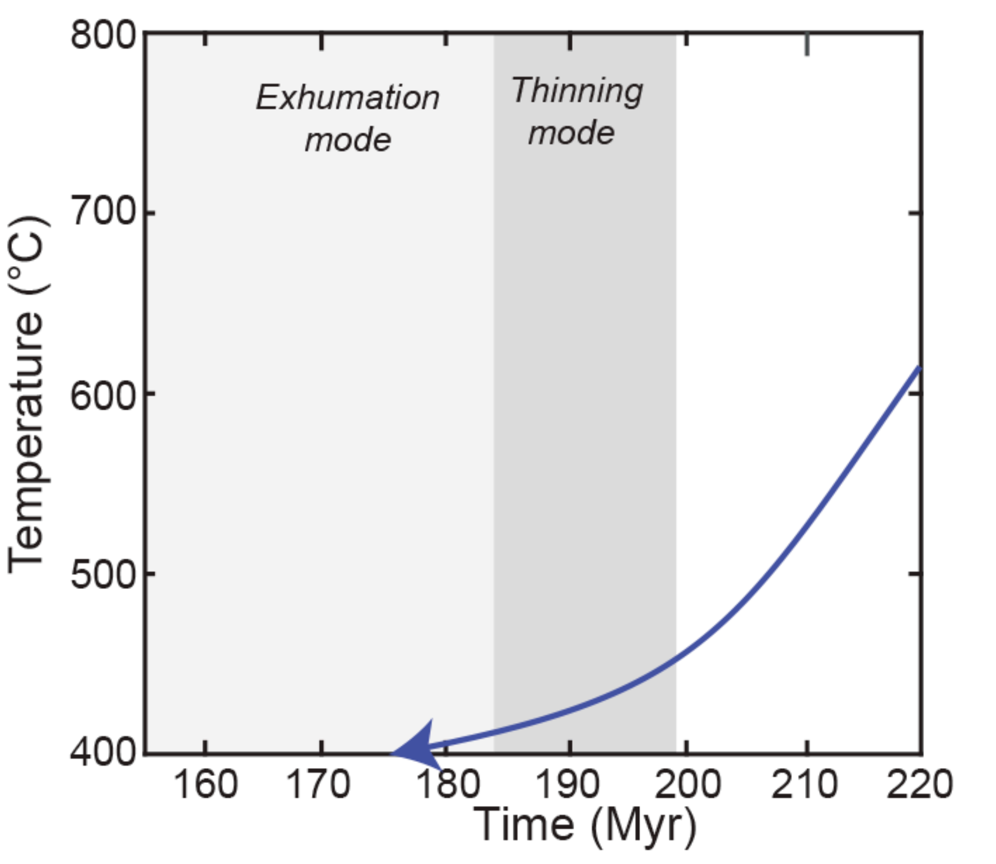
→ *Rutile U-Pb thermochronology, Ivrea Zone*



- 4 km depth interval of granulites (at 20° C/km ΔT is 80° C)
- 5° C/Ma cooling, 40 Ma age spread is expected
- Elevated dT/dz at onset of rift-related exhumation, ~180 Ma

1. Strain distribution and thermal history

→ *Revised thermal history, Ivrea Zone*



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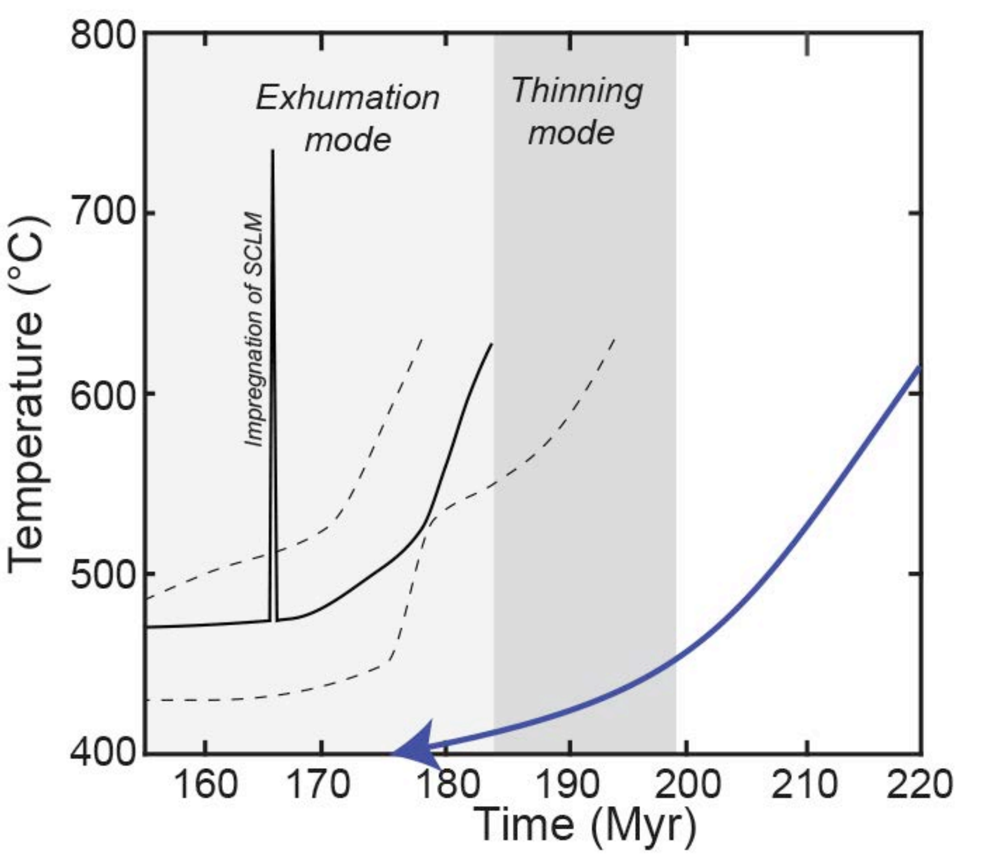
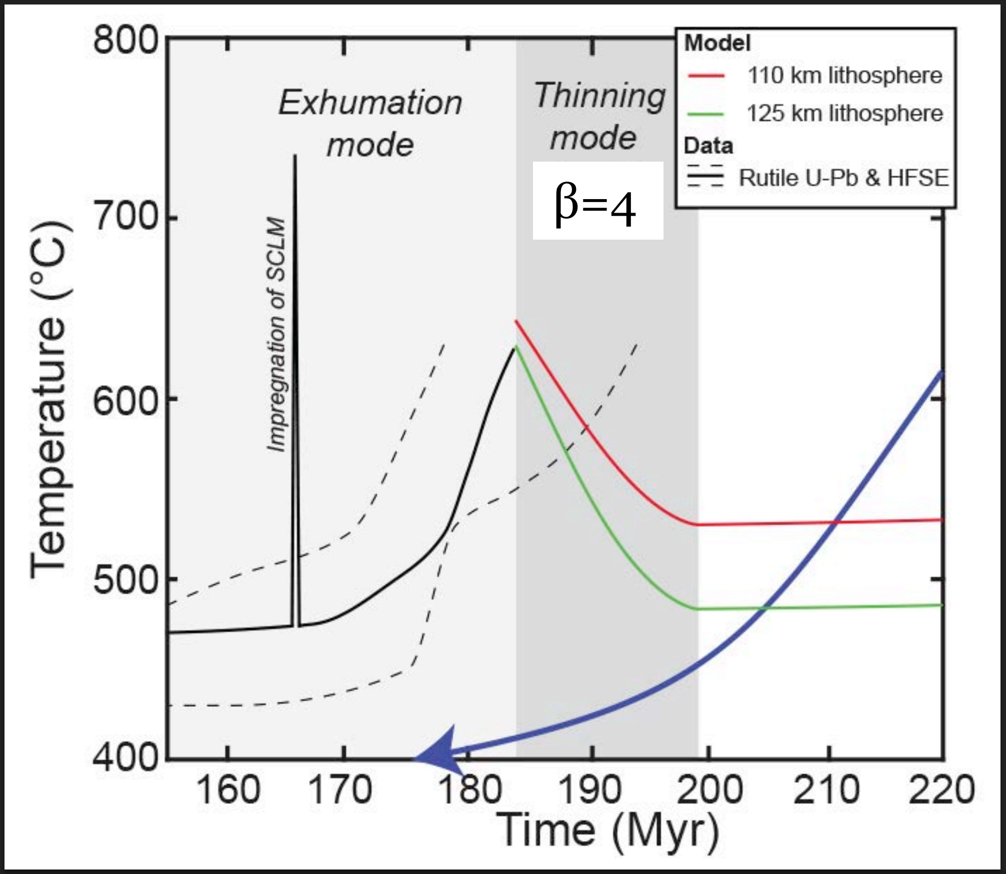


1. Strain distribution and thermal history

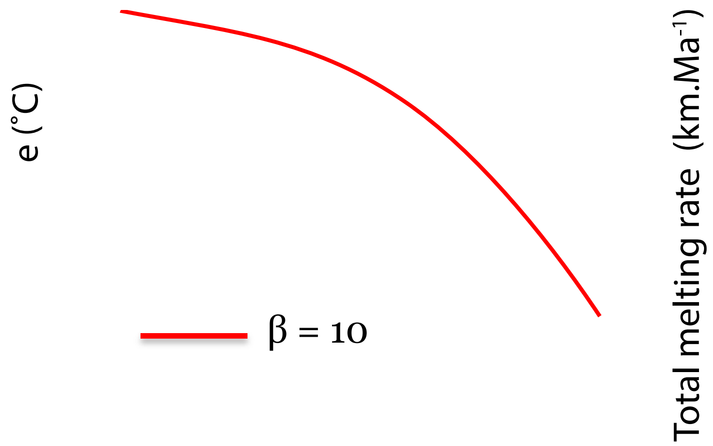
→ *High-magnitude thinning of the lithospheric mantle*



Thermal history consistent with preferential thinning of lithospheric mantle (δ:β > 1:4)

2. Rates of mantle cooling/upwelling

→ *Duration of rifting critical for melt generation (Bown & White 1995)*



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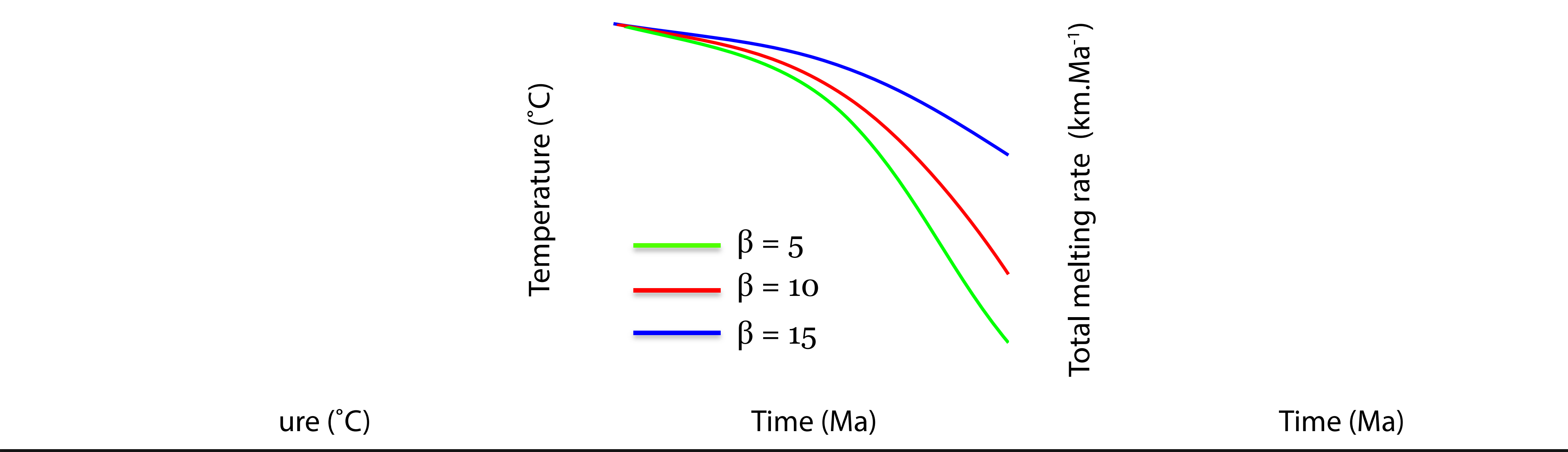
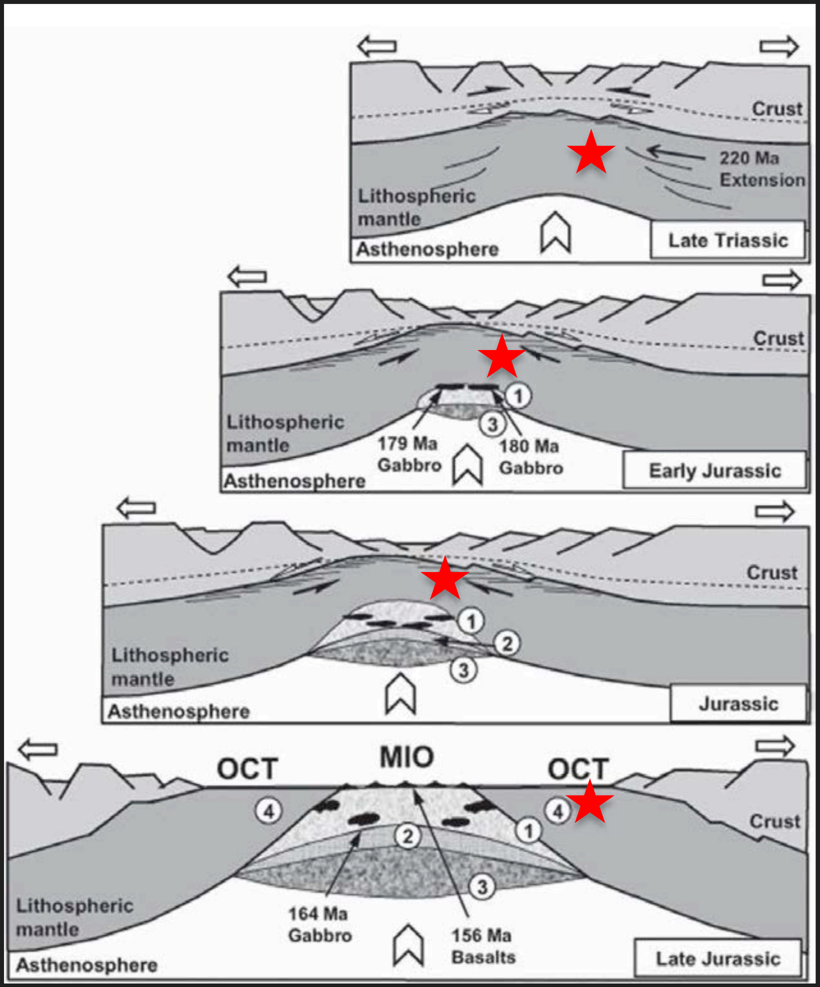
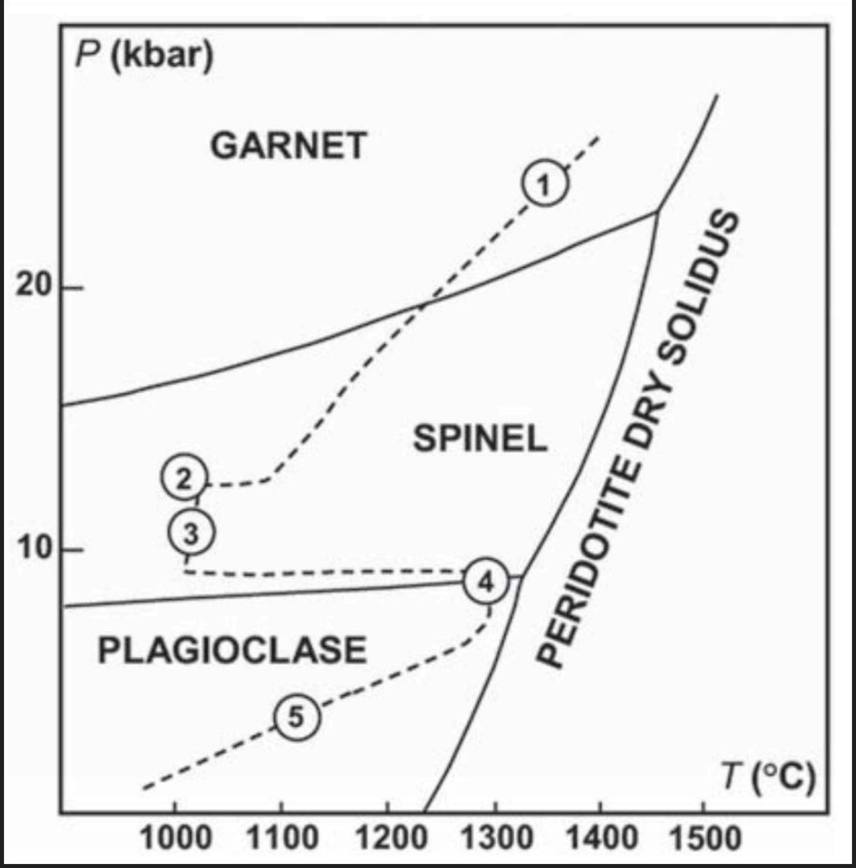


→ *Cooling rate of lithospheric mantle is a good indicator of melt generation during extension*

2. Rates of mantle cooling/upwelling

→ *Lanzo peridotite massif, Italy*

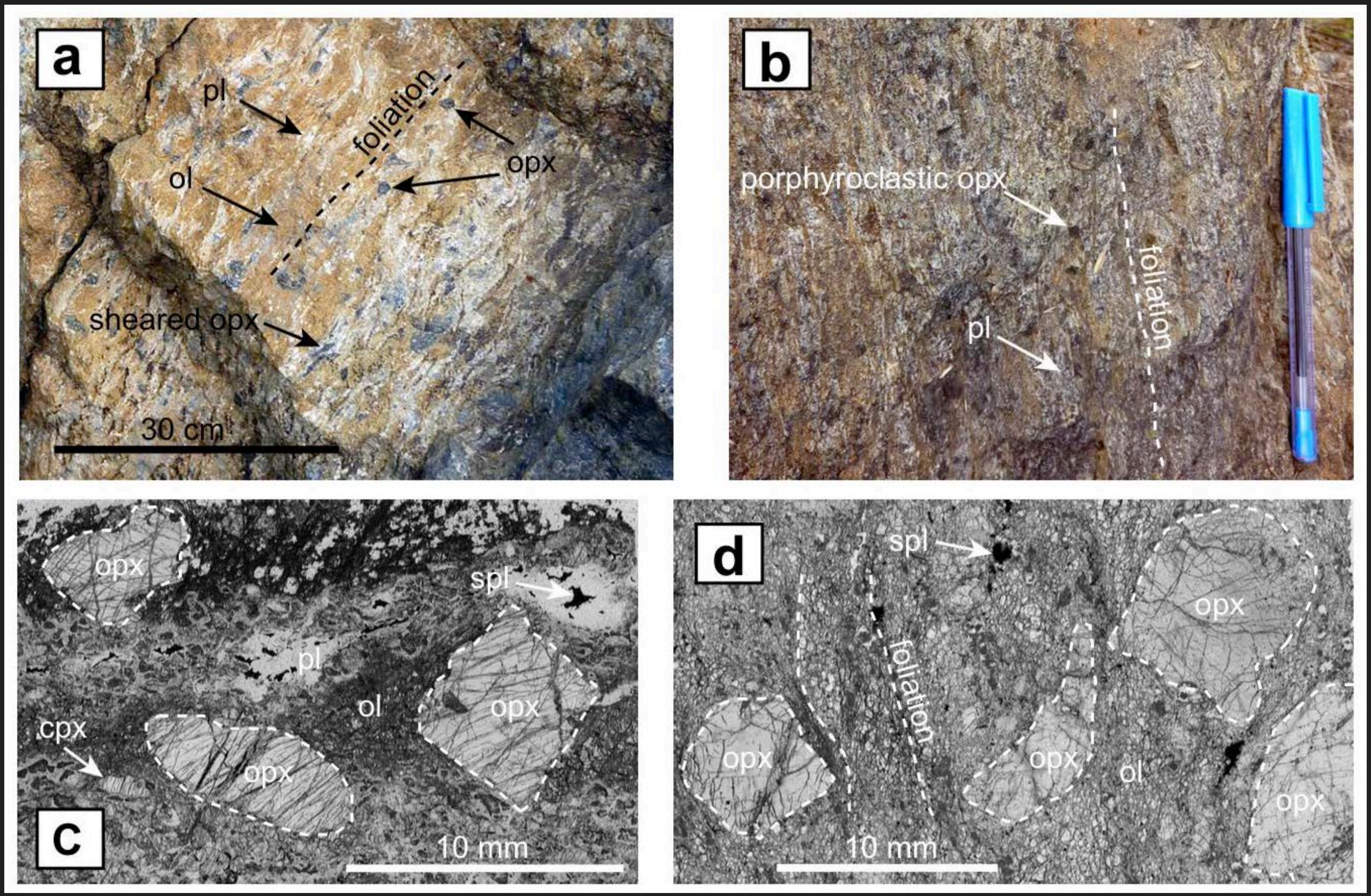




Piccardo et al 2009

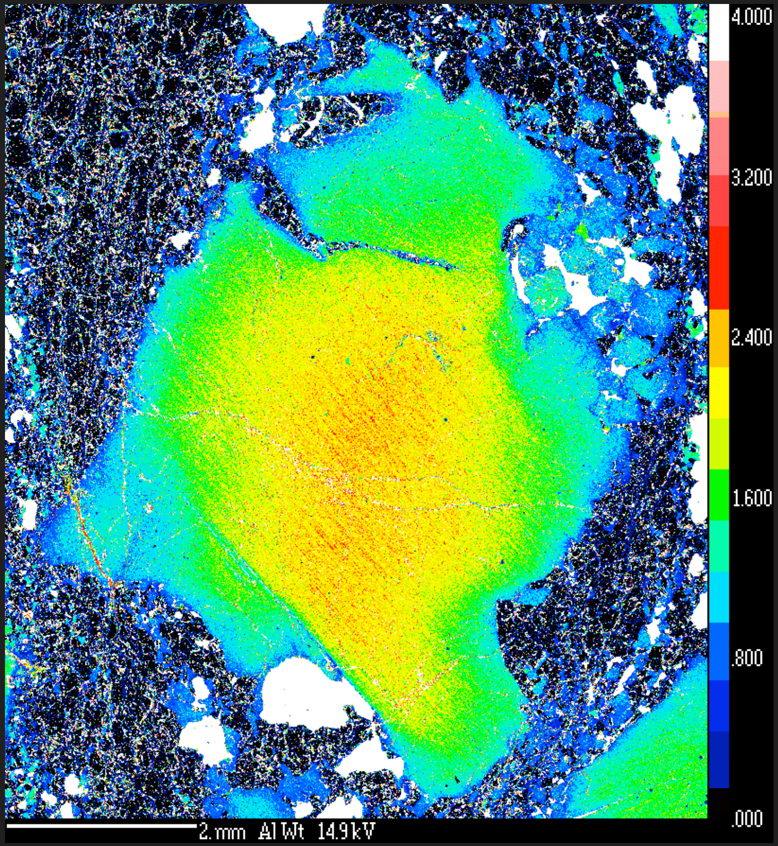
2. Rates of mantle cooling/upwelling

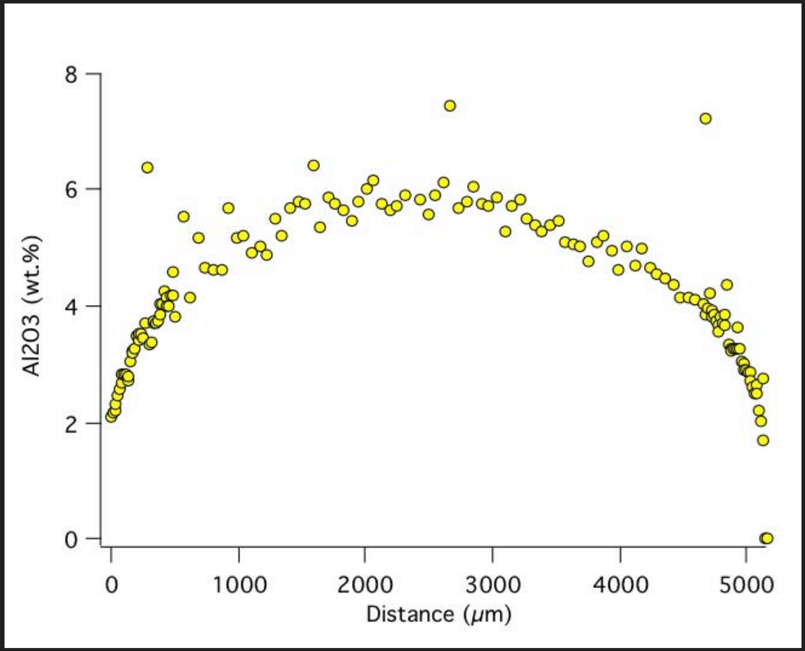
→ *Porphyroclastic peridotites of exhumed lithospheric mantle*



2. Rates of mantle cooling/upwelling

→ *Diffusional equilibration of opx during mantle upwelling*





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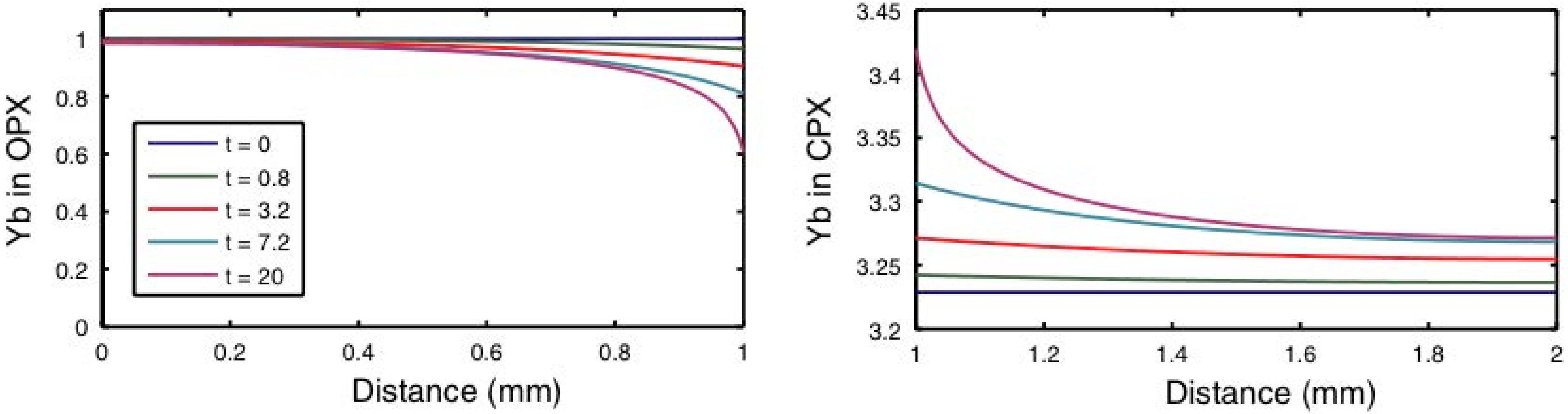

Cherniak & Liang 2007

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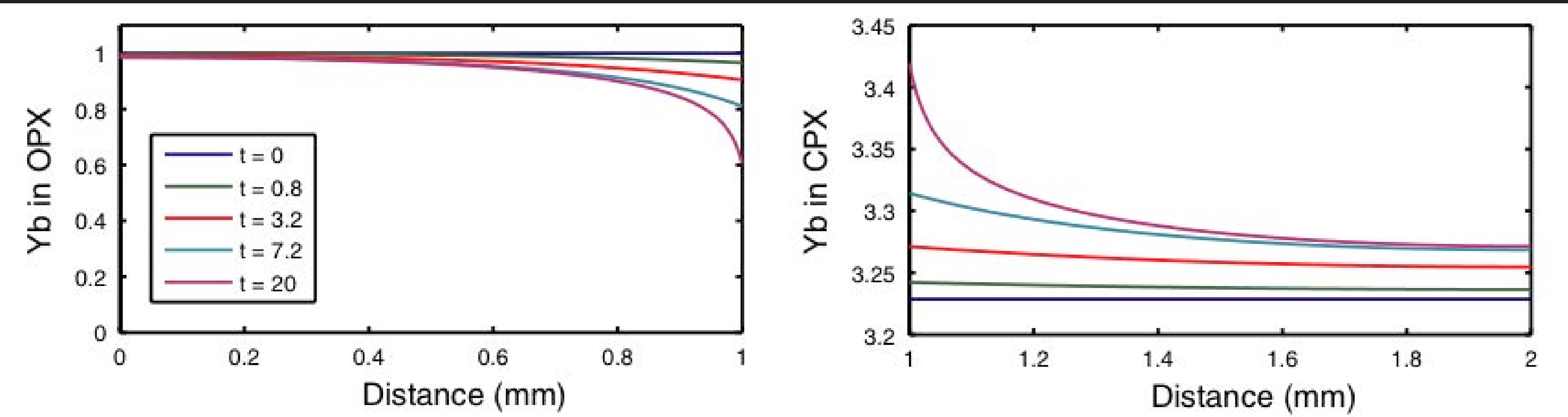
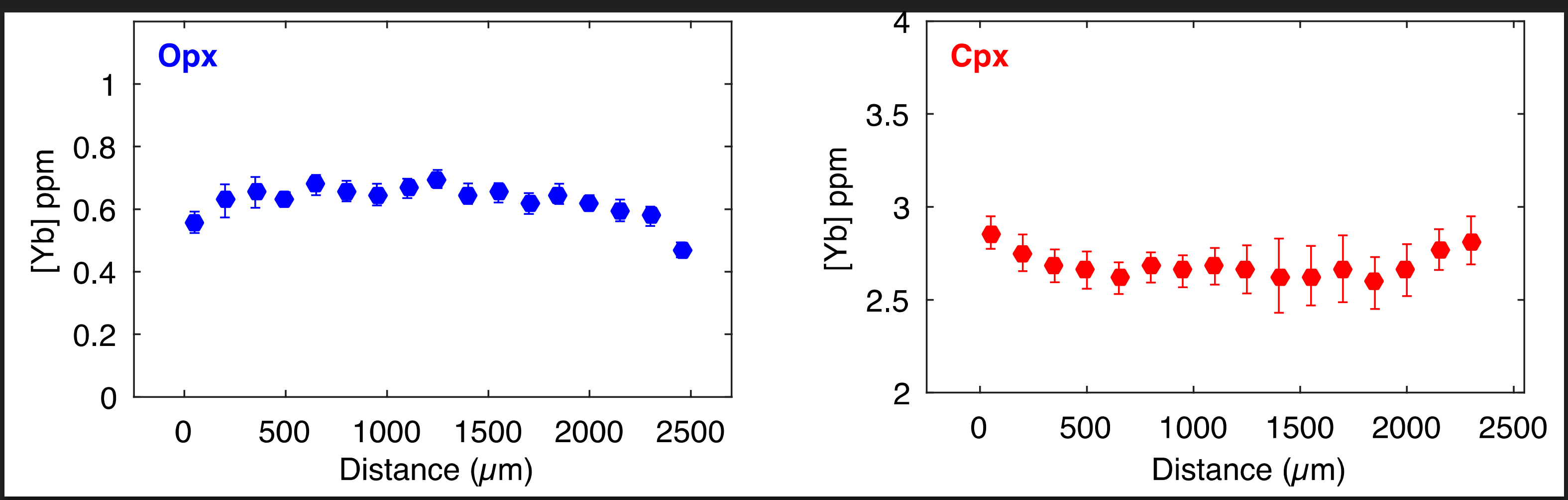
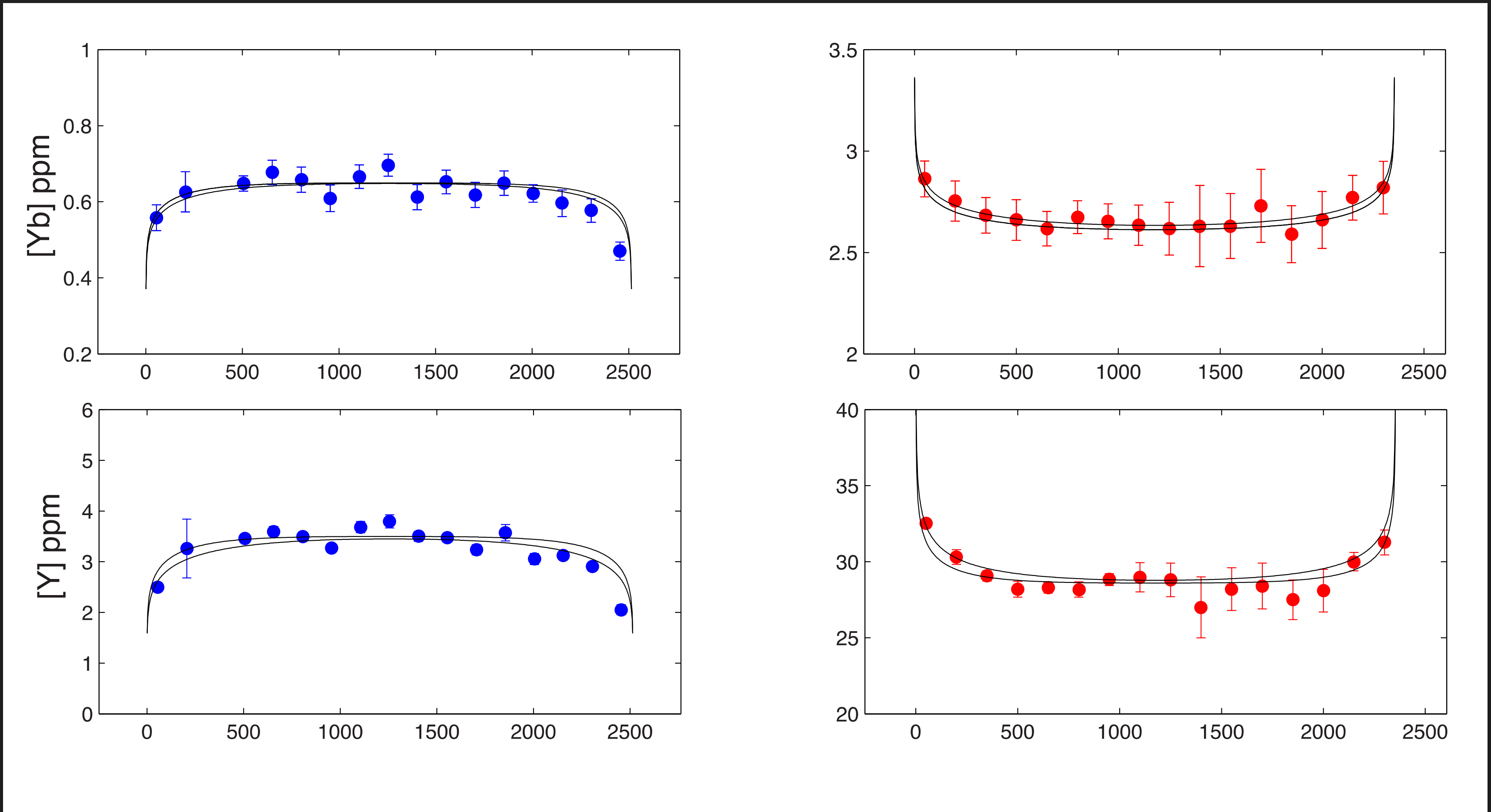


Cherniak & Liang 2007



2. Rates of mantle cooling/upwelling

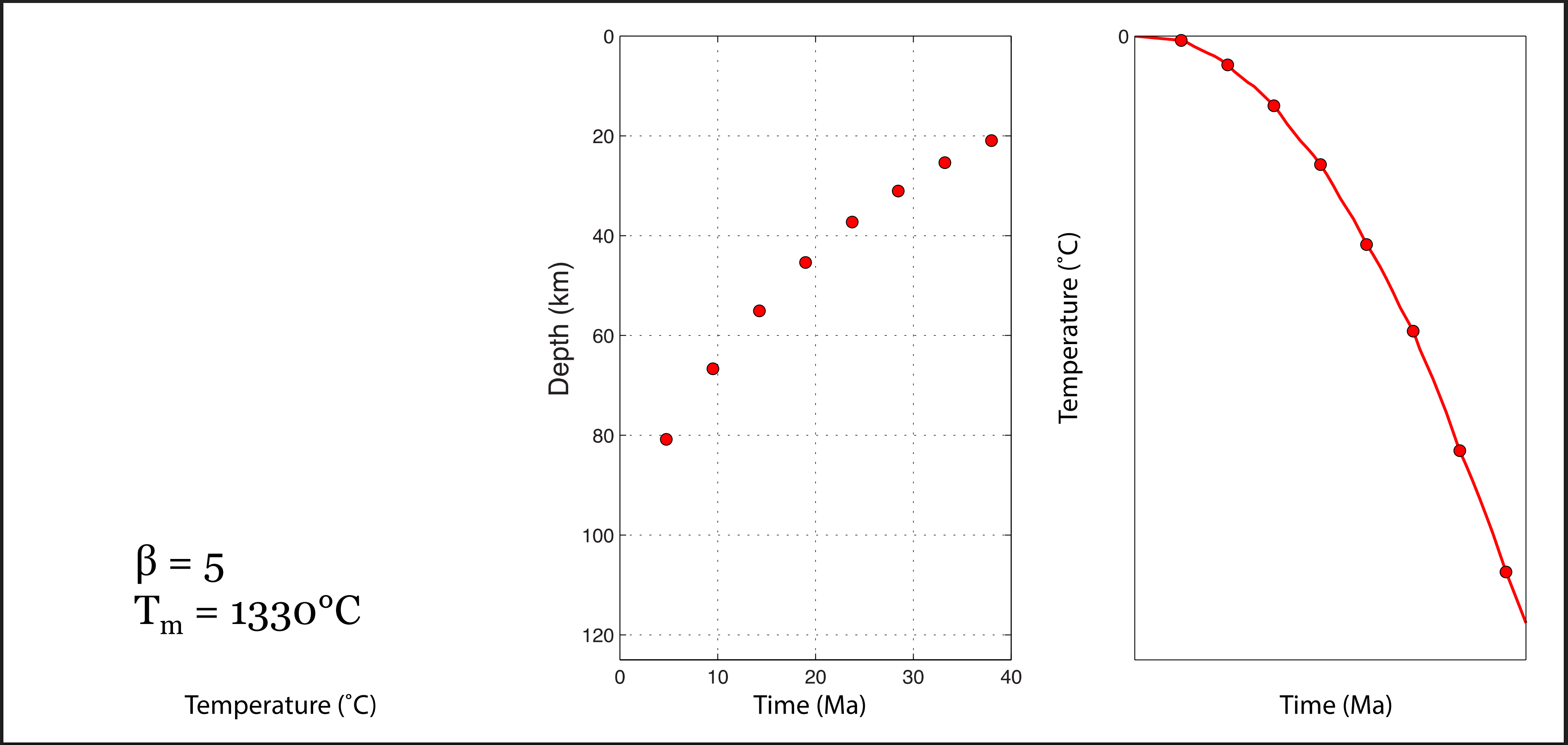
→ *Cooling rate determination by opx speedometry*



2. Rates of mantle cooling/upwelling

→ *Implications of slow cooling, Lanzo peridotite body*

→ *10 °C/Ma cooling of lithospheric mantle achieved when β=5; slow enough to suppress melt generation*



Conclusions

1. U-Pb thermochronology and diffusion speedometry afford opportunity to recover thermal history information relevant to extension.
2. Lower crust of Adriatic margin underwent reheating ~180 Ma, contemporaneous with the onset of mantle exhumation.
3. Adriatic lithospheric mantle cooled at ~10 °C/Myr, slow enough to suppress significant melt generation.