THE ECOLGITE CONDUNDRUM AND

THE THERMAL EVOLUTION OF MOUNTAIN BELTS

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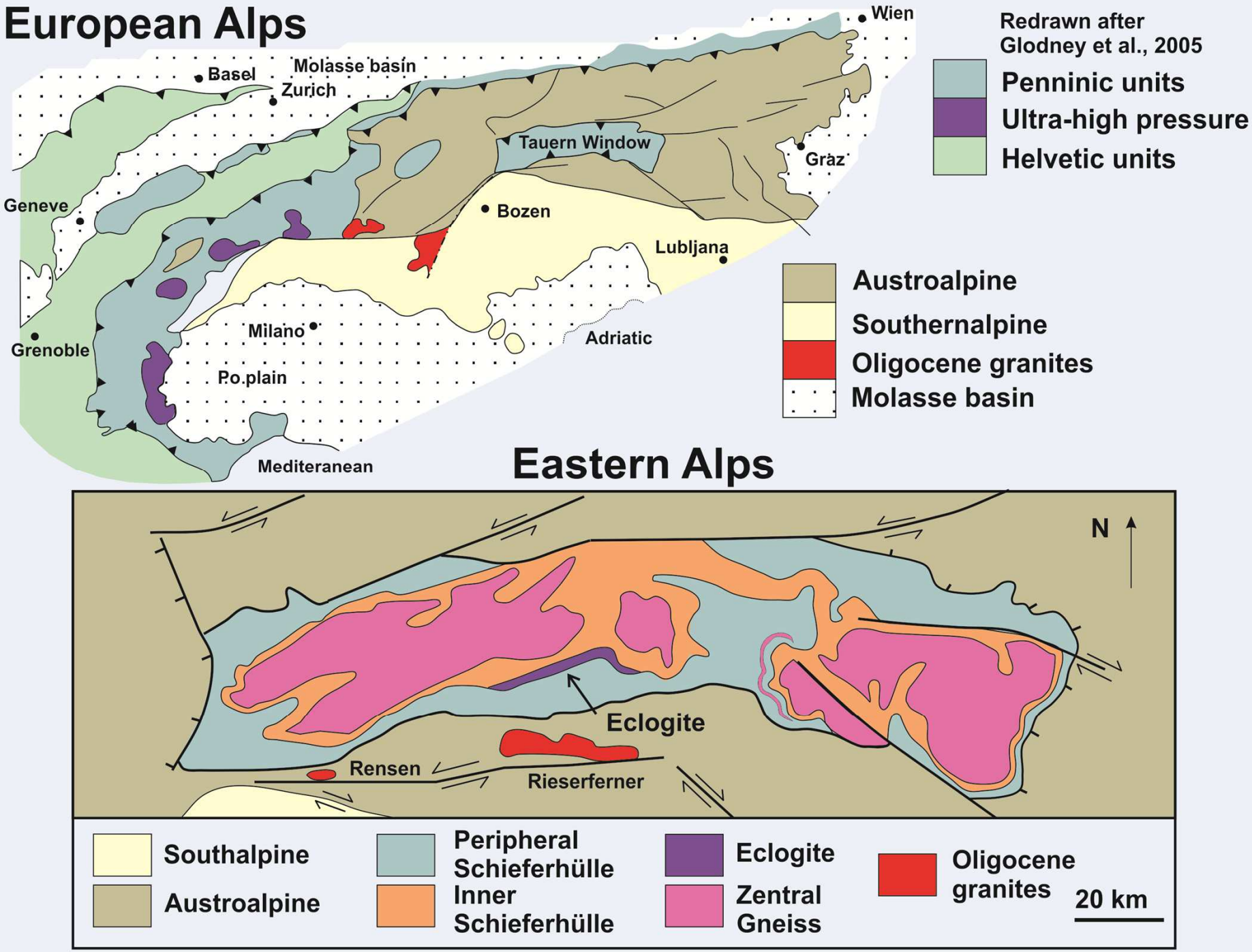
1) Thermal modelling used to be simple - there was plenty of time.

"A preliminary thermal model for regional metamorphism in the Eastern Alps, 1975, EPSL"

2) Metamorphic pressures of crustal rocks have increased!

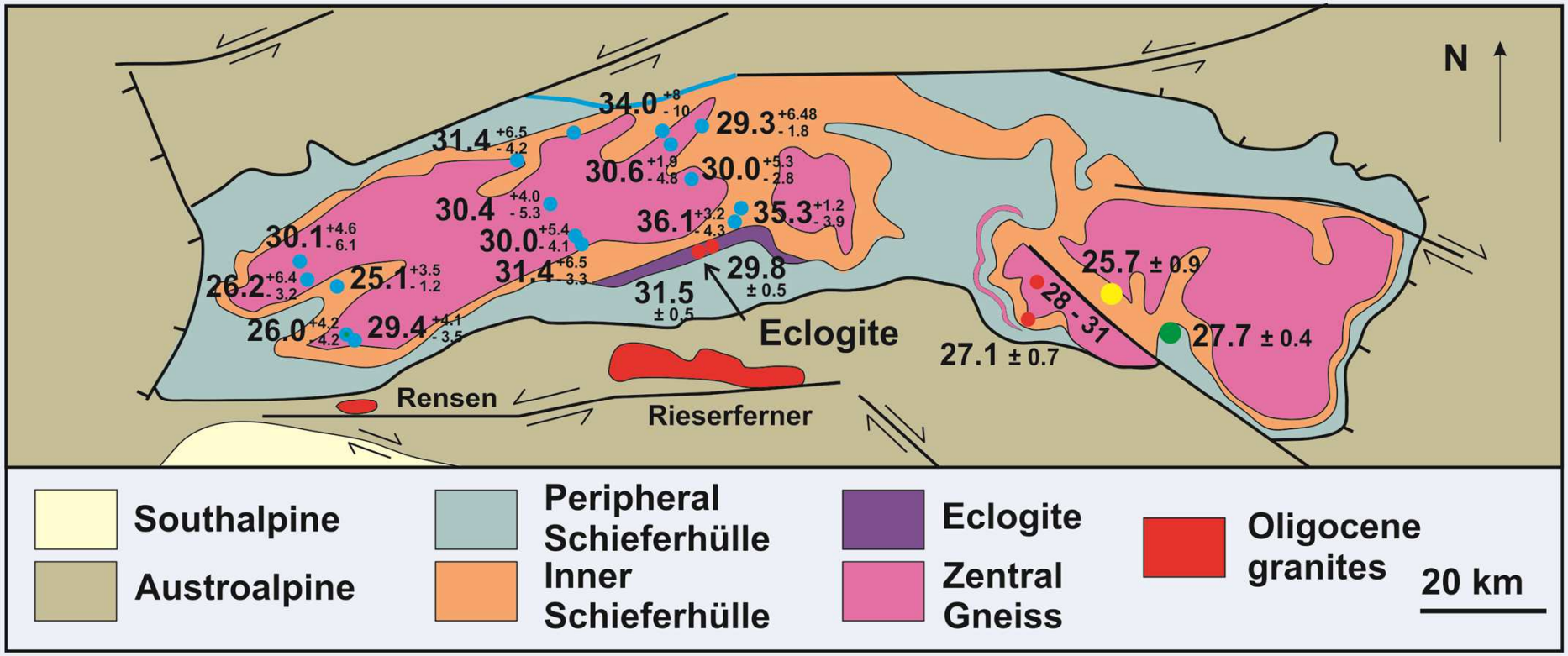
How are they exhumed?

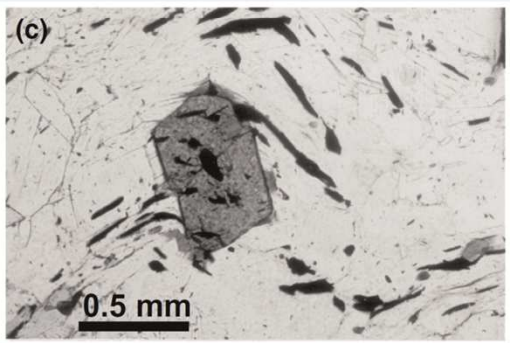
3) Synchronous emplacement of high/ultra-high pressure rocks questions models for thermal evolution of mountain belts.

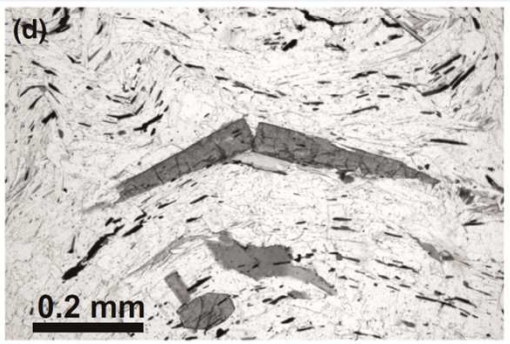

European Alps
Wien
Basel
Molasse basin
Zurich
Tauern Window
Graz
Geneve
Bozen
Lubljana
Milano
Adriatic
Grenoble
Po plain
Mediteranean
Redrawn after
Glodney et al., 2005
Penninic units
Ultra-high pressure
Helvetic units
Austroalpine
Southernalpine
Oligocene granites
Molasse basin
Eastern Alps
N
Eclogite
Rensen
Rieserferner
Southalpine
Austroalpine
Peripheral
Schieferhülle
Inner
Schieferhülle
Eclogite
Zentral
Gneiss
Oligocene
granites
20 km

Ages Greenschist-Amphibolite facies Barrovian metamorphism

- U-Pb apatite (450 °C) Sneider et al. 2015
- Rb-Sr white mica (550 °C) Reddy et al. 1993, Glodny et al., 2005, Gleisner et al., (2007) 27-31, 29.8 ± 0.5, 31.5 ± 0.5.
- Th-Pb allanite 27.7 ± 0.7 Cliff et al. 2015: D_A^2
- Sm-Nd garnet 25.7 ± 0.9 isochron. Favaro et al., 2015 post-dating D_A^2

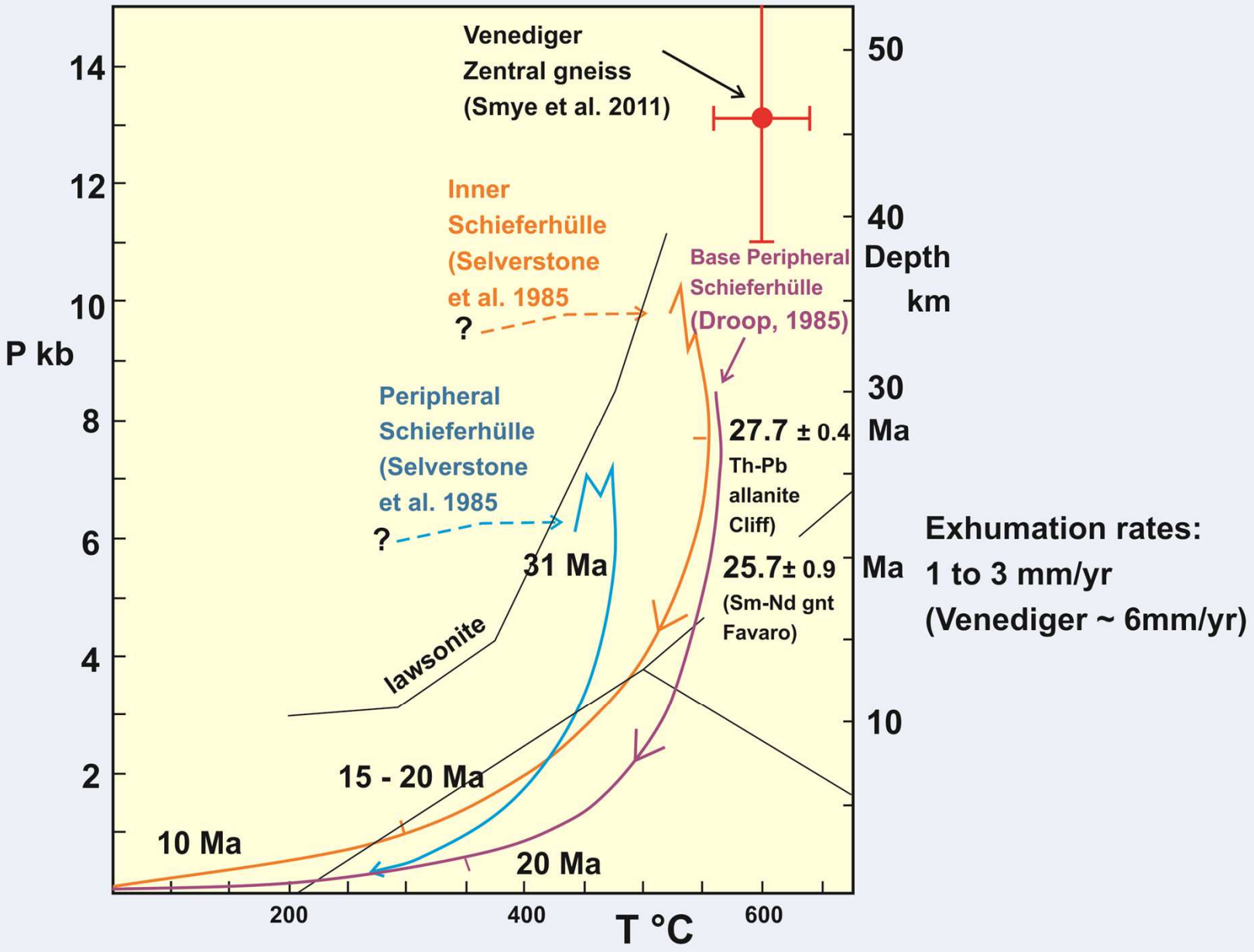






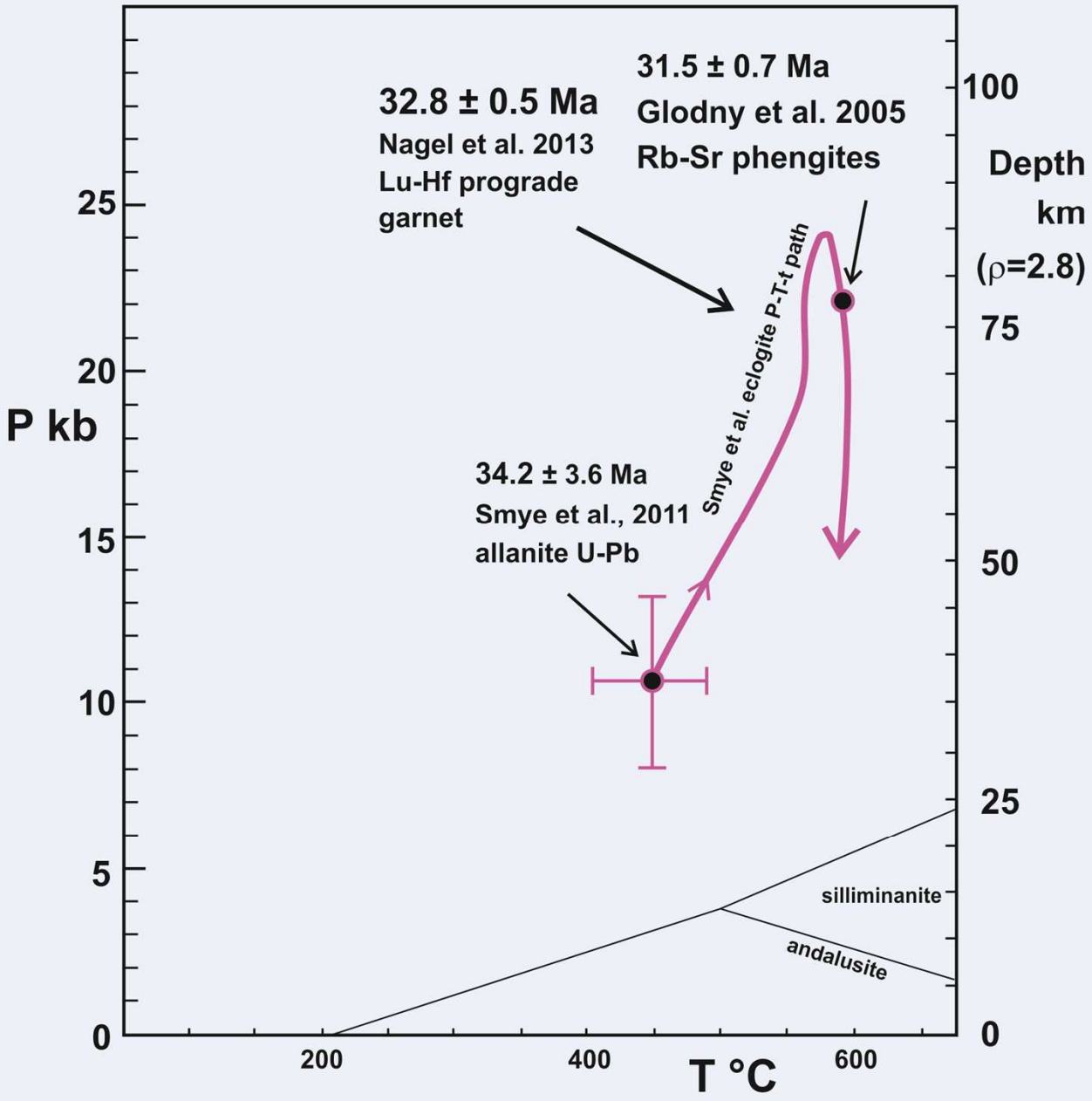
Allanites dated by Cliff et al., 2015 showing post and syn-D_A^2 growth 27.7 ± 0.4 Ma

P-T-t paths Tauern Barrovian metamorphism

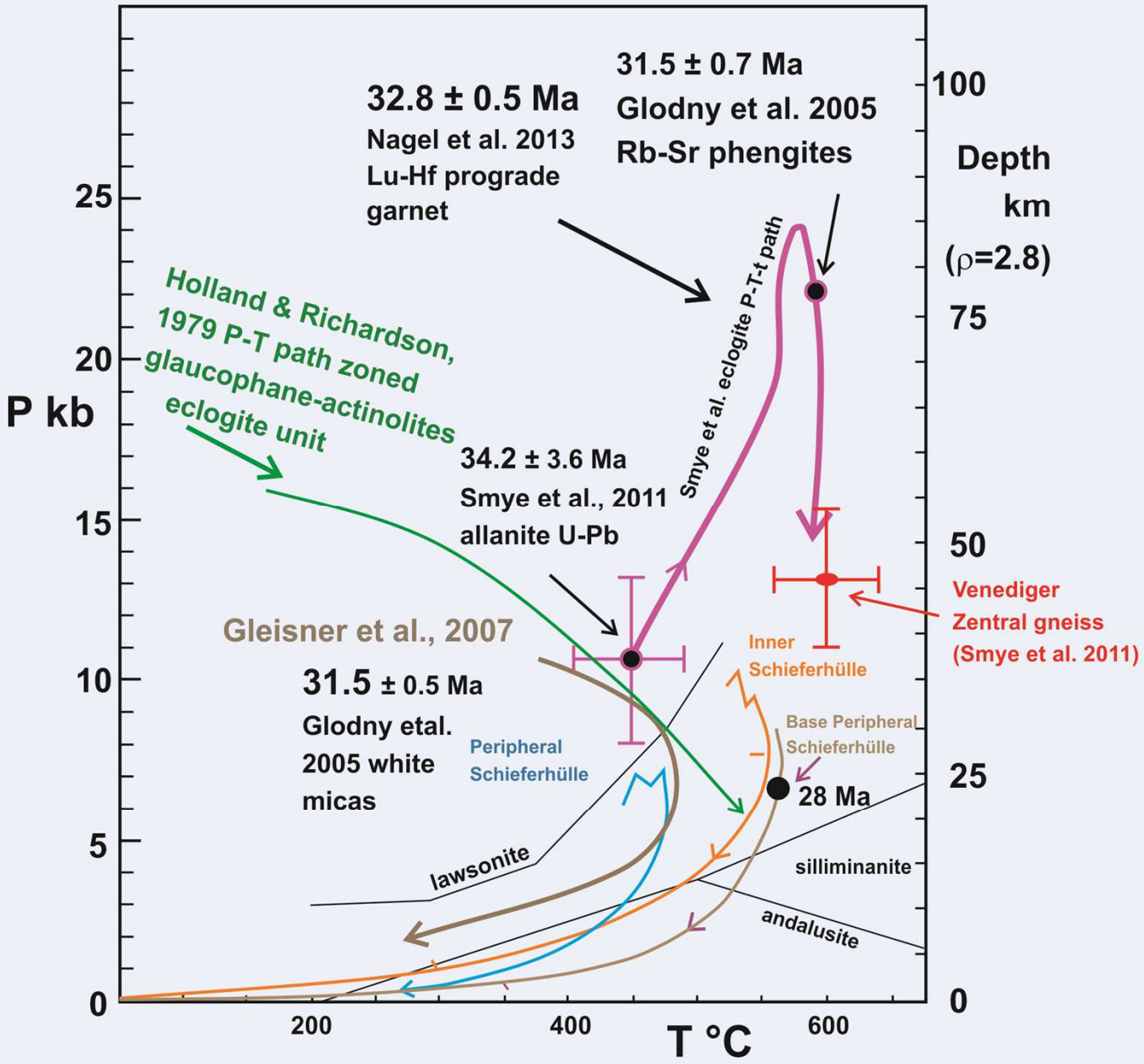


Exhumation rates:
1 to 3 mm/yr
(Venediger ~ 6mm/yr)

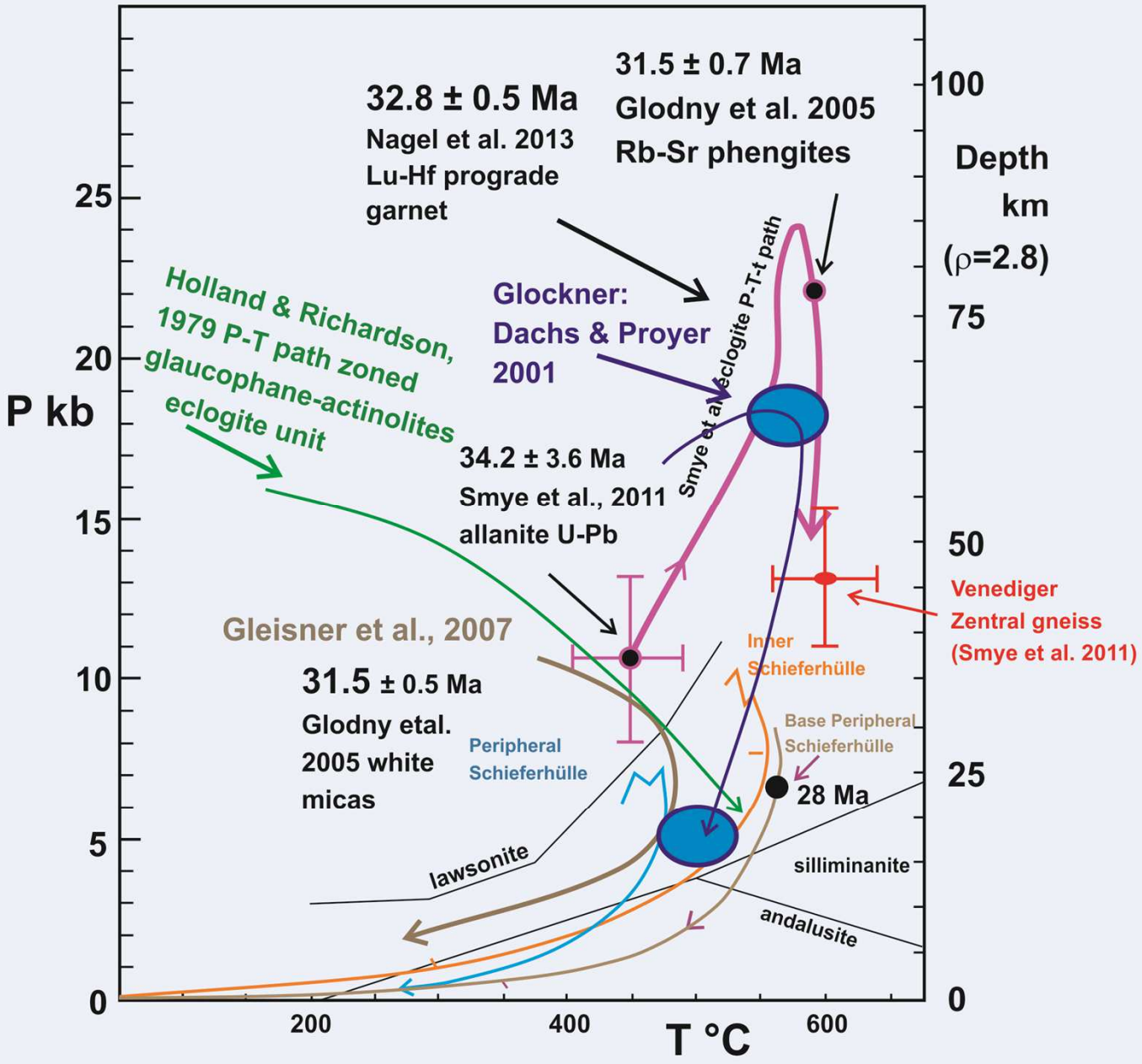
P-T-t paths Ecligite to Barrovian



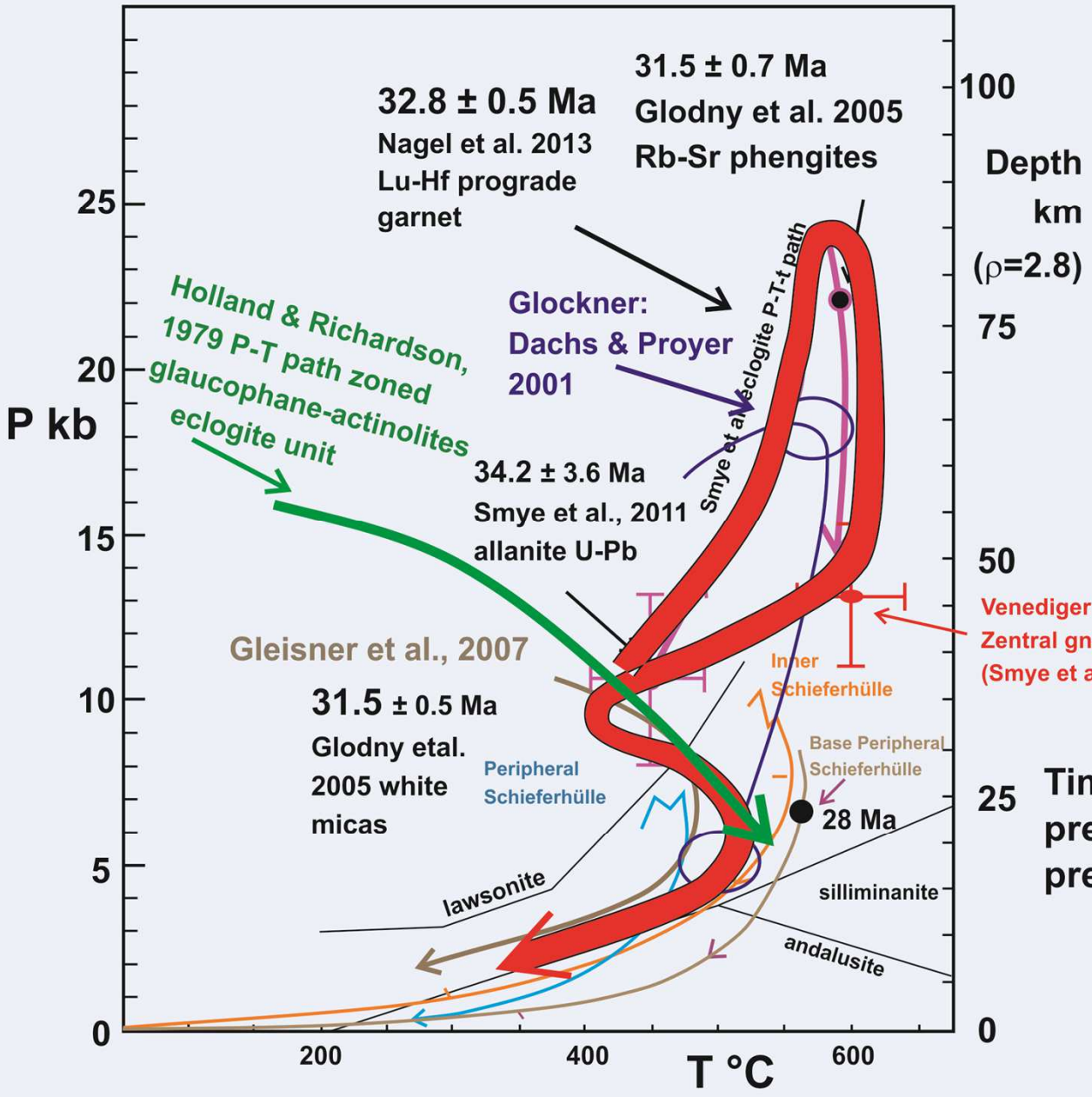
P-T-t paths Ecligite to Barrovian



P-T-t paths Ecligite to Barrovian



P-T-t paths Ecligite to Barrovian



Eclogite exhumation rates

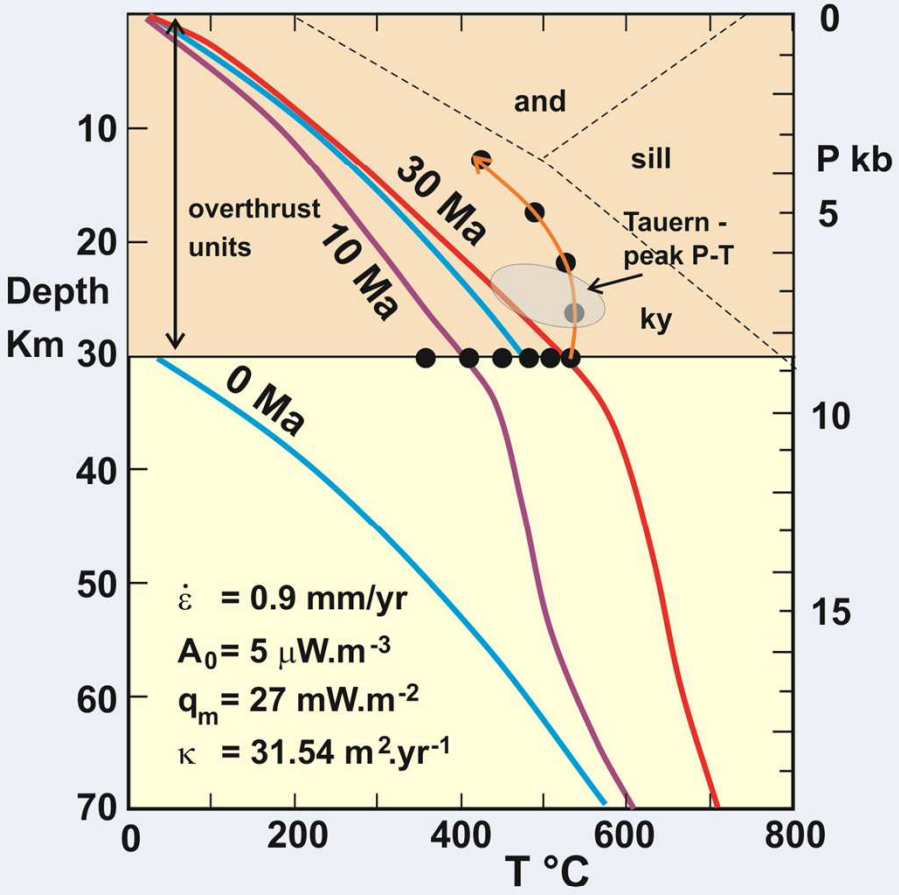
~ 38 mm/yr

Barrovian exhumation rates:

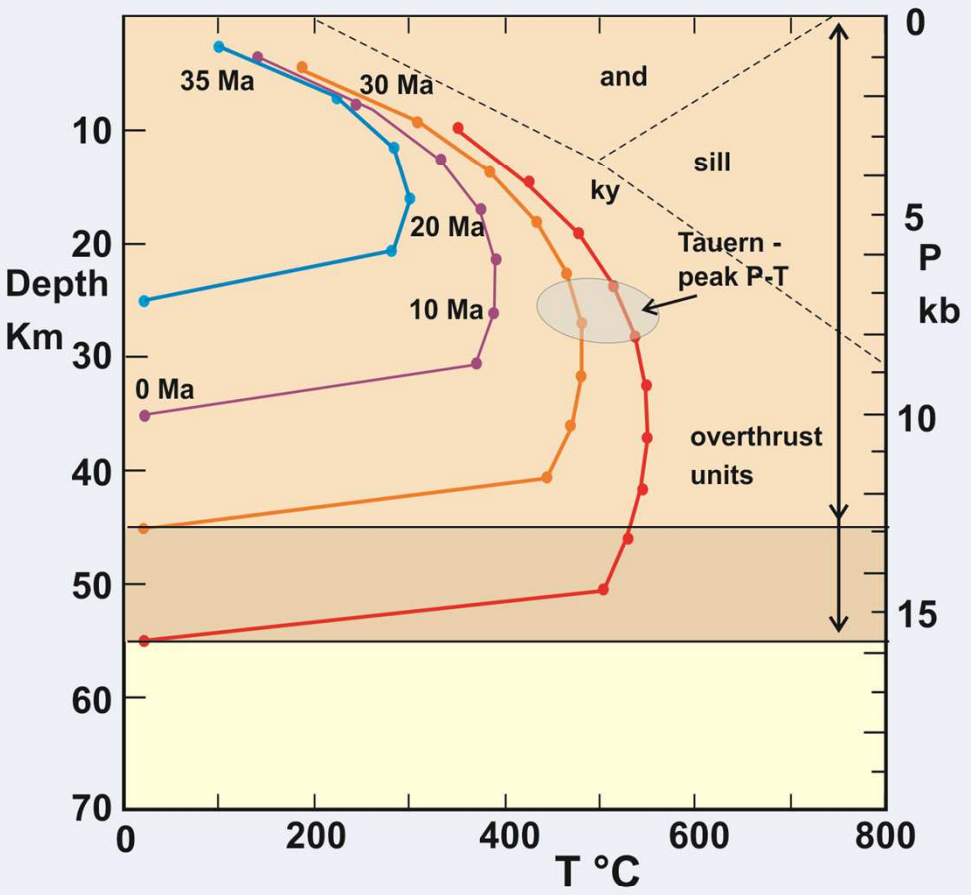
1 to 3 mm/yr

Time between peak Eclogite pressures and peak Barrovian pressures less than ~ 2 Ma

Thermal model - 30 Ma before exhumation
e.g. Bickle et al. 1975



Thermal model - 5 Ma before exhumation
at 0.9 mm/yr (Smye et al., 2011)



Thicker overburden - faster heating - to a point - needs faster and earlier exhumation

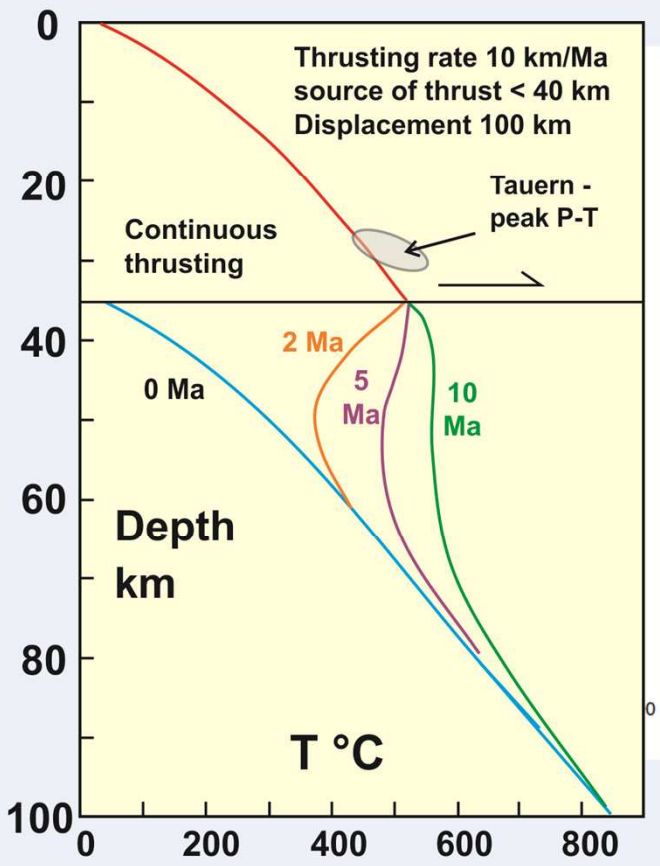
Note: Thick overburden implies crustal thickening ~ 10 Ma before peak 28 Ma conditions and much exhumation faster than 1 mm/yr

Solutions:

1) Additional heat sources - cools too slowly

2) Overthrust sheet with basal temperature ~ 600 °C

3) Insert eclogites into thickened crust.



Continuous thrusting -

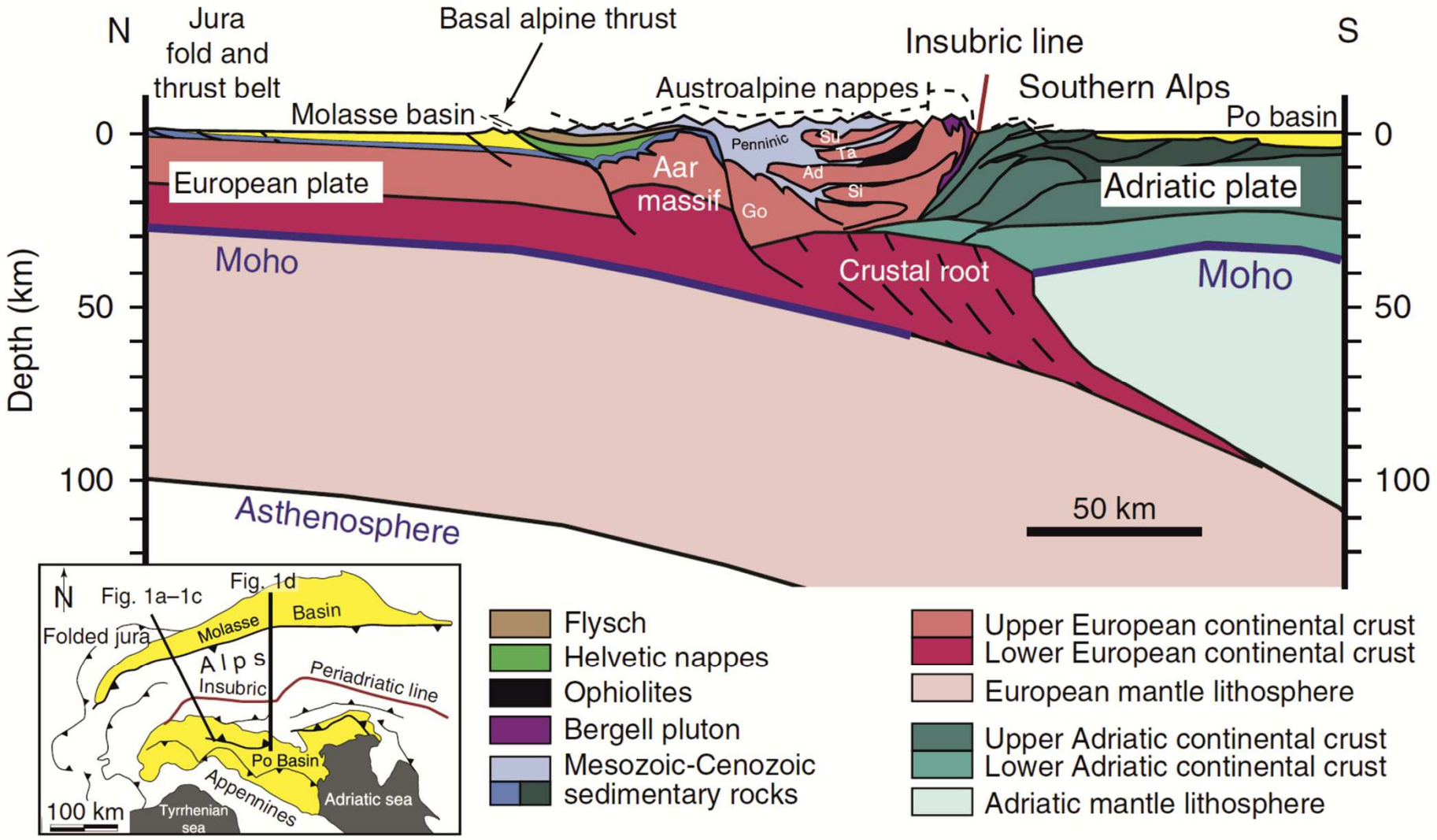
1) Requires base of thrust not far from hot source.

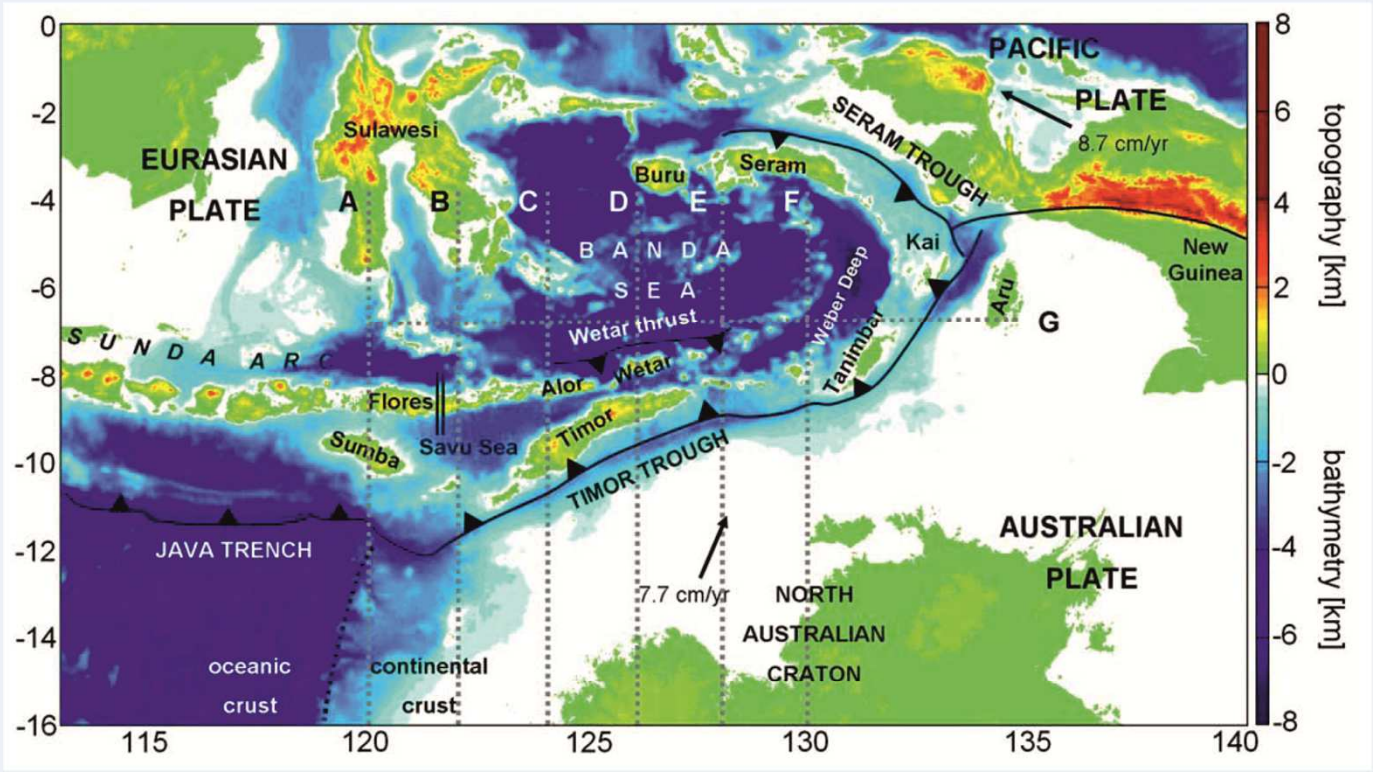
2) Needs thrust sheet rapidly exhumed - huge amount of sediment produced.

3) Evidence that base of Altkristallin sheet cooled below 350 °C (biotite Rb-Sr ages at 65 Ma, Brewer, 1969).

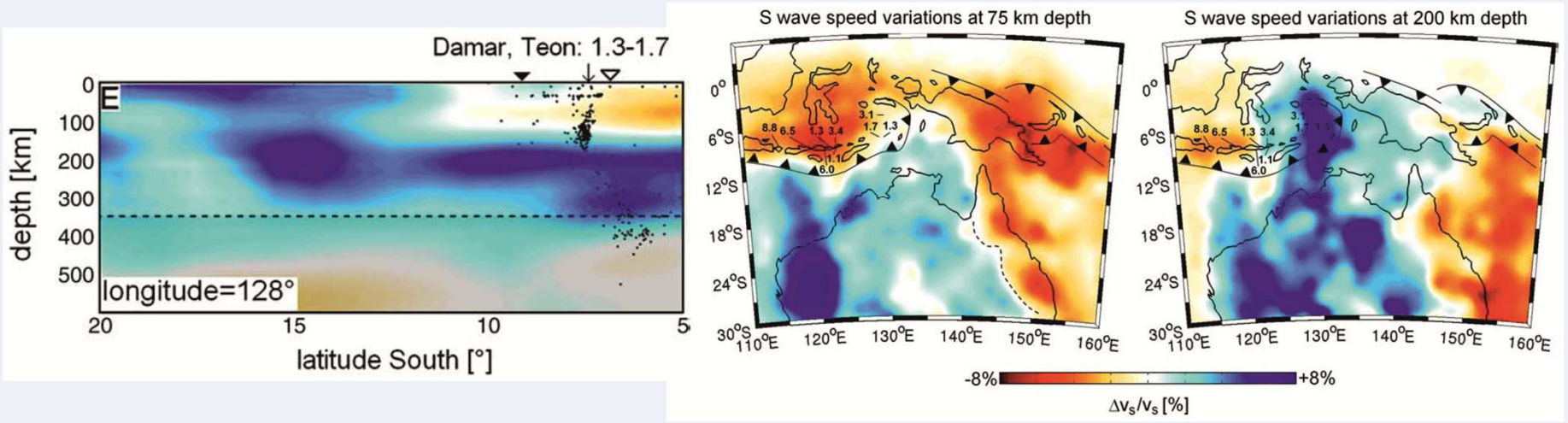
4) Peak temperatures at base of Altkristallin ~ 420 C (Bickle et al., 1975).

From Schlunegger & Kissling (2015) Nature Communications - modified from Fry et al, (2010) EPSL





Subduction of continental lithosphere to ~ 200 km in Banda Arc.
(Fichtner etal. 2010, EPSL).



Tomography (velocities) from full waveform tomography