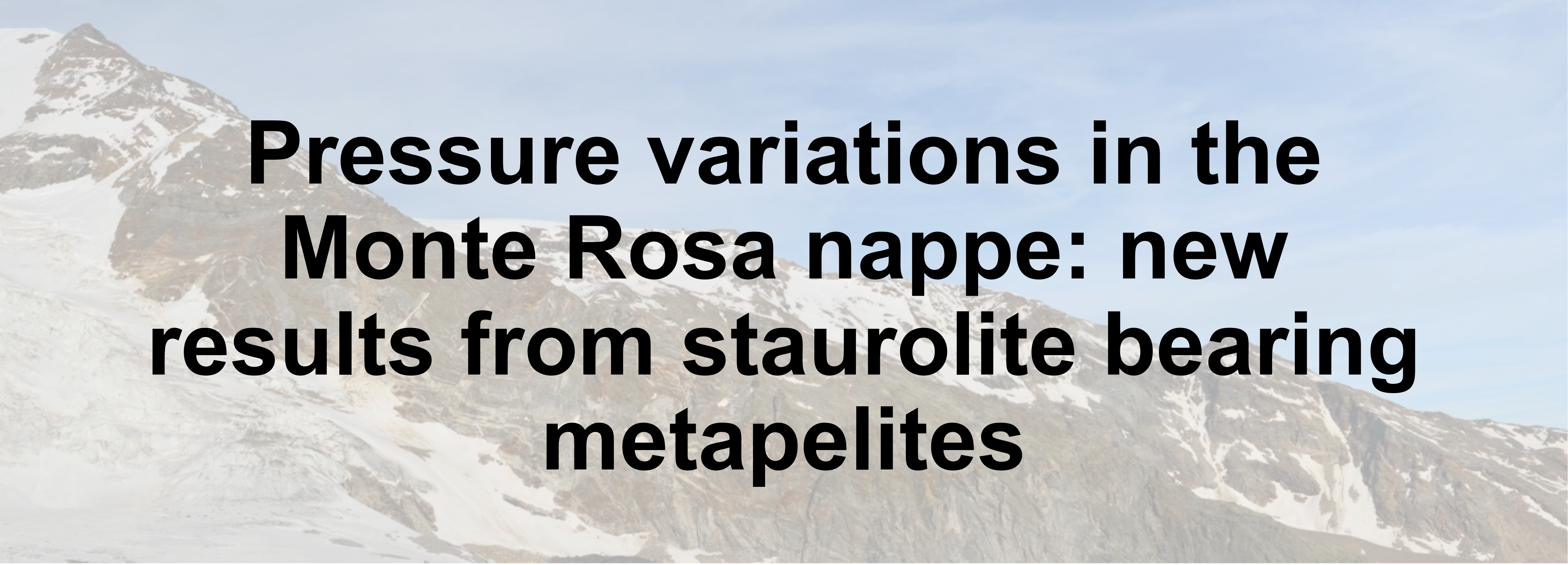

Pressure variations in the Monte Rosa nappe: new results from staurolite bearing metapelites

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Metamorphic pressure variation in a coherent Alpine nappe challenges lithostatic pressure paradigm

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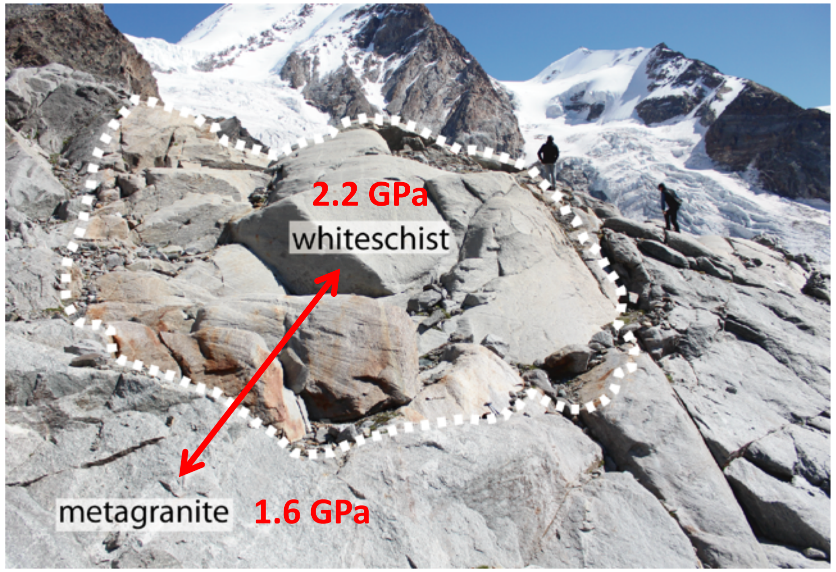


Alpine peak pressure:

Whiteschist: ca <u>2.2 GPa</u>

Metagranite: ca <u>1.6 GPa</u>

Why pressure difference? Possible explanations:

1) Tectonic mélange

2) Granite did not record peak-P
   (a) sluggish kinetics
   (b) retrogression

3) Thermodynamic database

4) <u>Mechanical P variations</u>

Aims of this study:

(*manuscript under review)

- **Continue to investigate P-variations in the Monte Rosa nappe**

- **Analyse basement metapelite samples:**

  Newly discovered peak Alpine assemblages

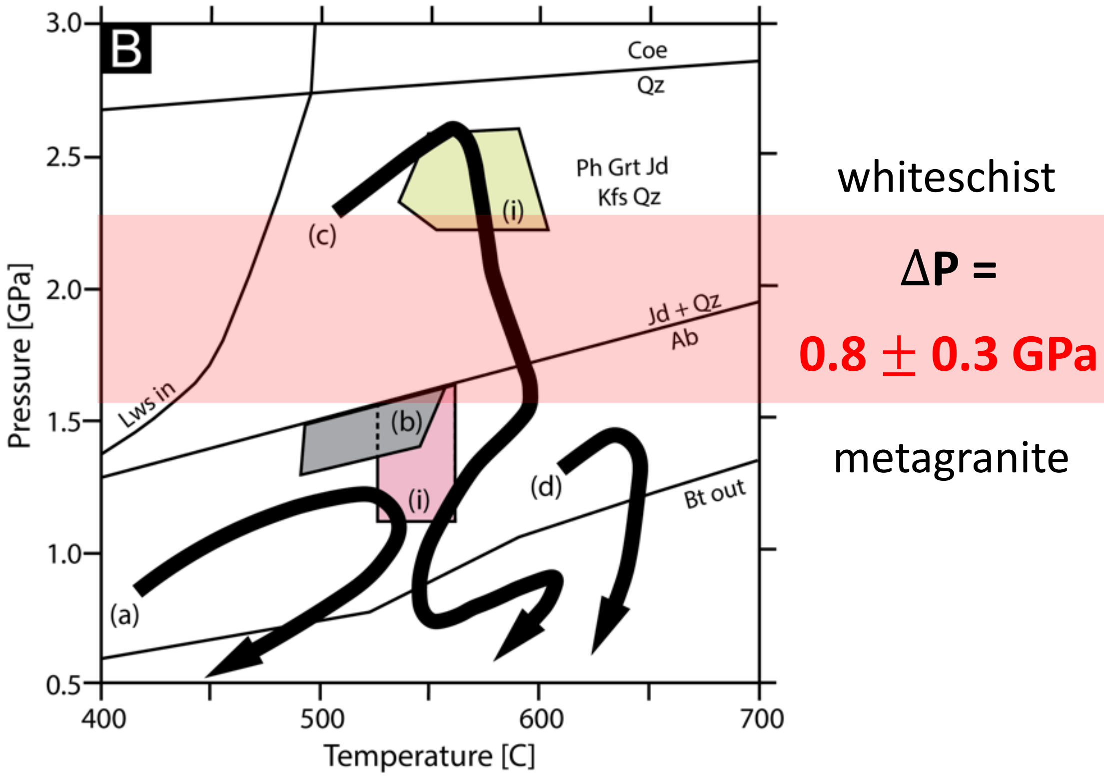
  Calculate P and T

- **Pressure variations:**

  Mechanically induced

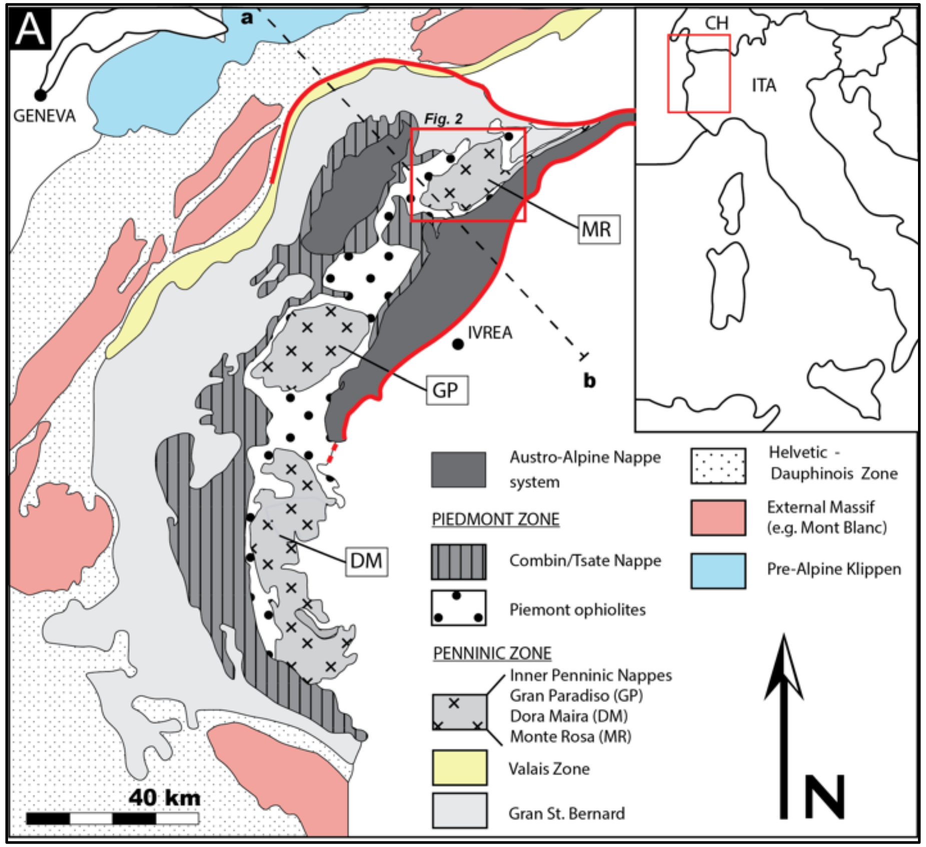
  Chemically induced

- **Geodynamic implications**

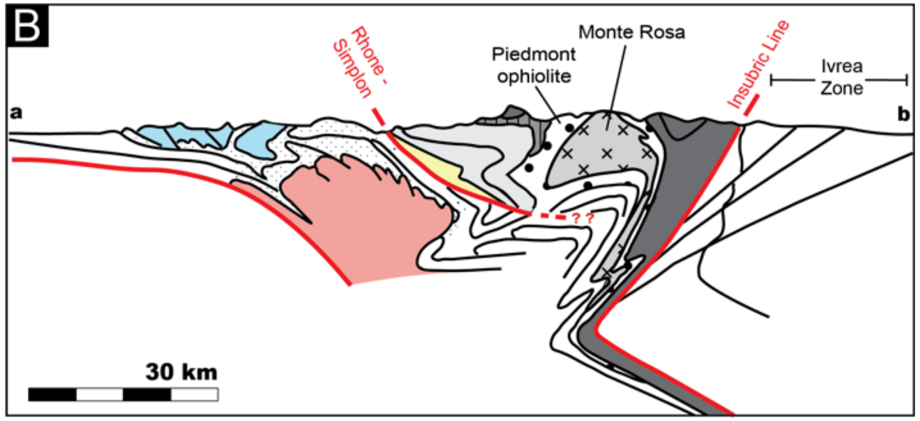


(a) Borghi et al., 2004
(b) Dal Piaz and Lombardo 1986
(c) Gasco et al., 2011
(d) Keller et al., 2004
(e) Le Bayon et al., 2006
(f) Lapen et al., 2007
(g) Le Bayon et al., 2006
(h) Chopin and Monie 1984
(i) Luisier et al., 2019

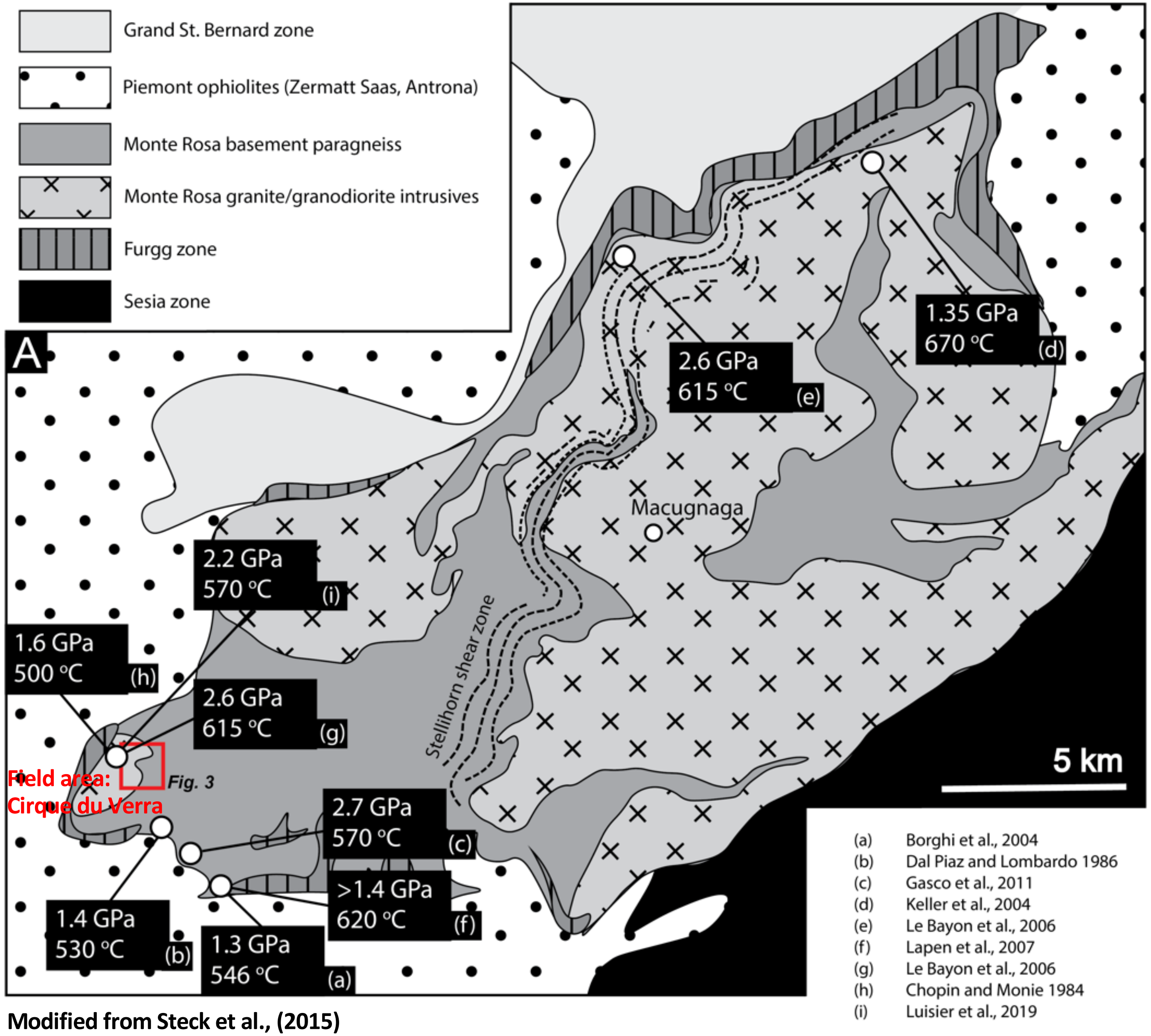
Tectonic location of the Monte Rosa:



Modified from Beltrando et al., (2010)



Modified from Steck et al., (2015)



Modified from Steck et al., (2015)

Field area: "Cirque du Verra"

- Far western extent of Monte Rosa nappe
- Recent glacial retreat has uncovered fresh exposure for mapping

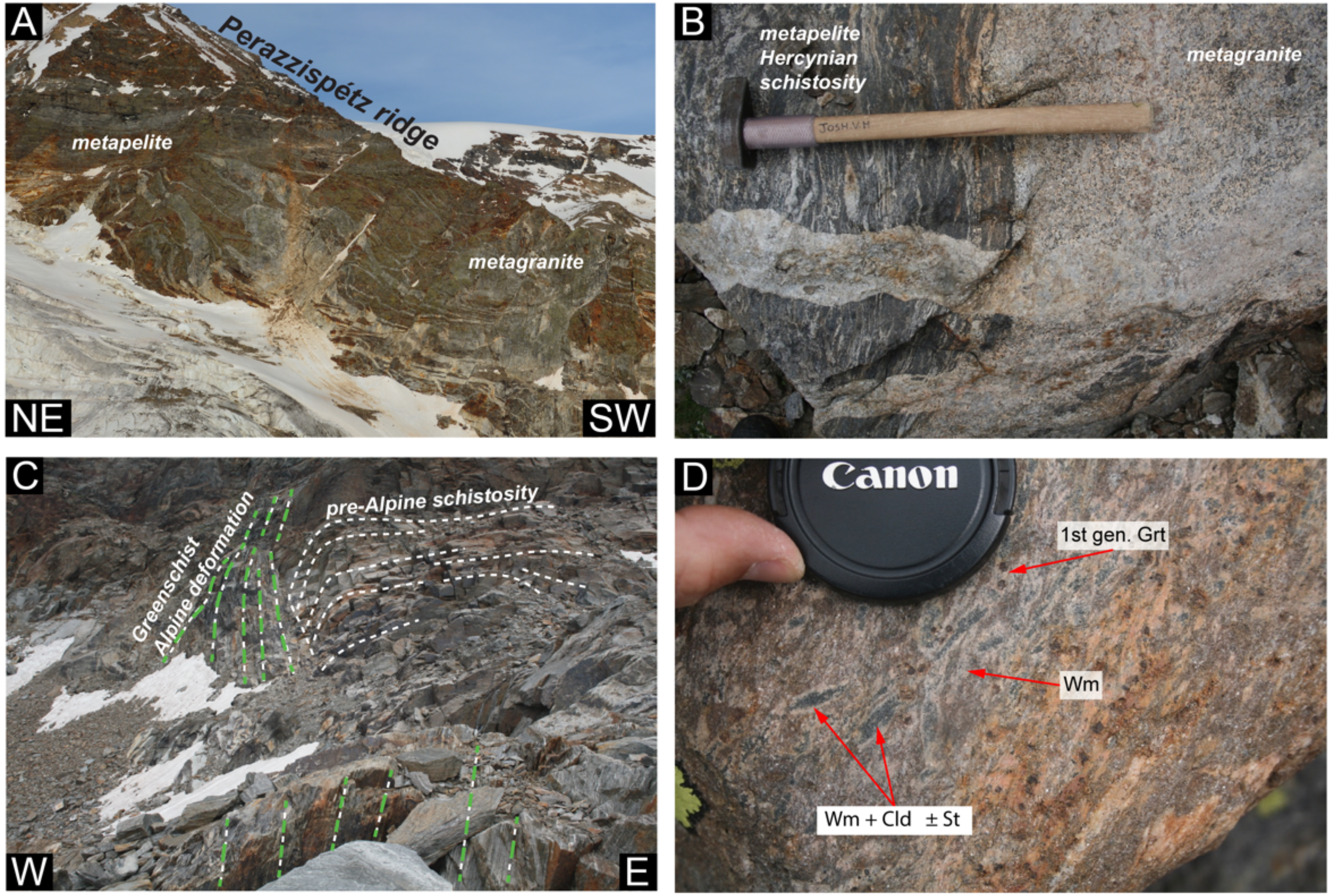
Metapelite sample: outcrop observations

A - Large scale igneous textures.

B - Igneous contact => coherent unit and therefore **not a tectonic mélange**.

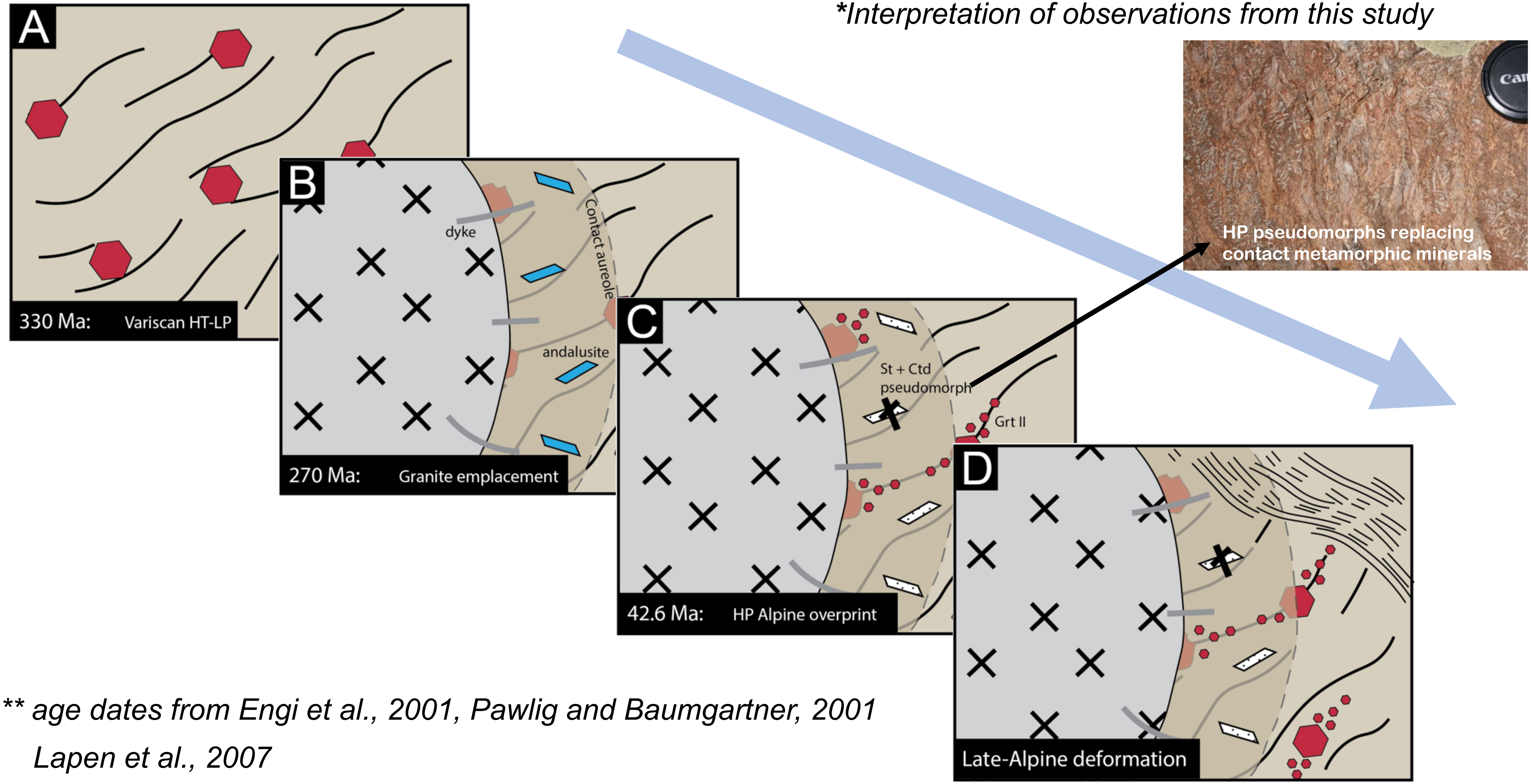
C - High pressure Alpine imprint is preserved within a pre-Alpine schistosity unaffected by late-Alpine greenschist over-printing.

D - High pressure assemblages within pseudomorphs replacing former contact metamorphic andelusite….



Schematic geological history of metapelite:

**Interpretation of observations from this study*



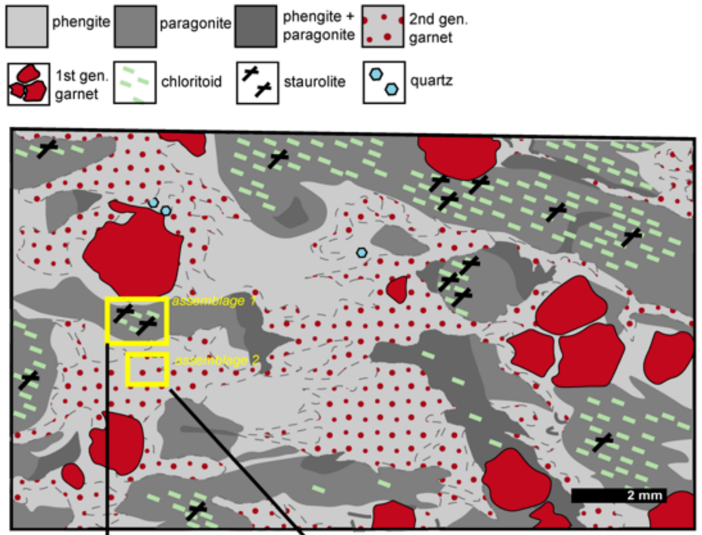
*** age dates from Engi et al., 2001, Pawlig and Baumgartner, 2001*
Lapen et al., 2007

Metapelite petrology: 3x equilibrium assemblages

Sample 16MR-17 & 19MR-04: unique staurolite + chloritoid bearing assemblages:

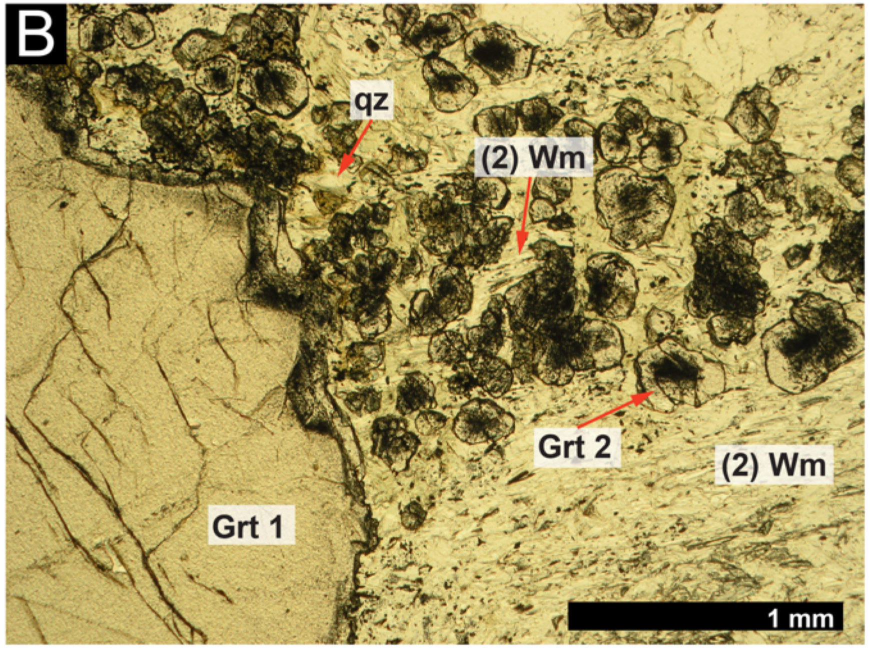
Grt + Ms + Pg + Cld + St + Chl + Bt + Qtz + Als (+ accessory mineral Ap, Rt and Mz)

- Representing peak Alpine metamorphism
- Water saturated conditions (no sluggish kinetics)

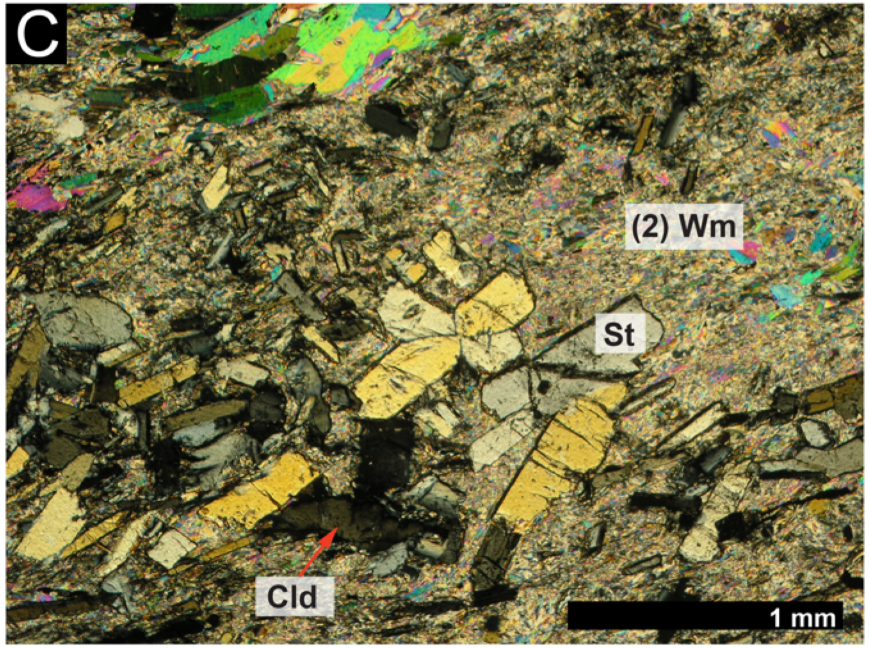


Assemblage 1:
St + Cld + Ms + Pg

Assemblage 2:
Grt + Chl + Ms + Pg



Assemblage 2:
Grt + Chl + Ms + Pg



Assemblage 1:
St + Cld + Ms + Pg

Assemblage 3:
Cld + Ms + Pg

Similar to Assemblage 1 (without St)

Chemistry of peak metamorphic minerals:

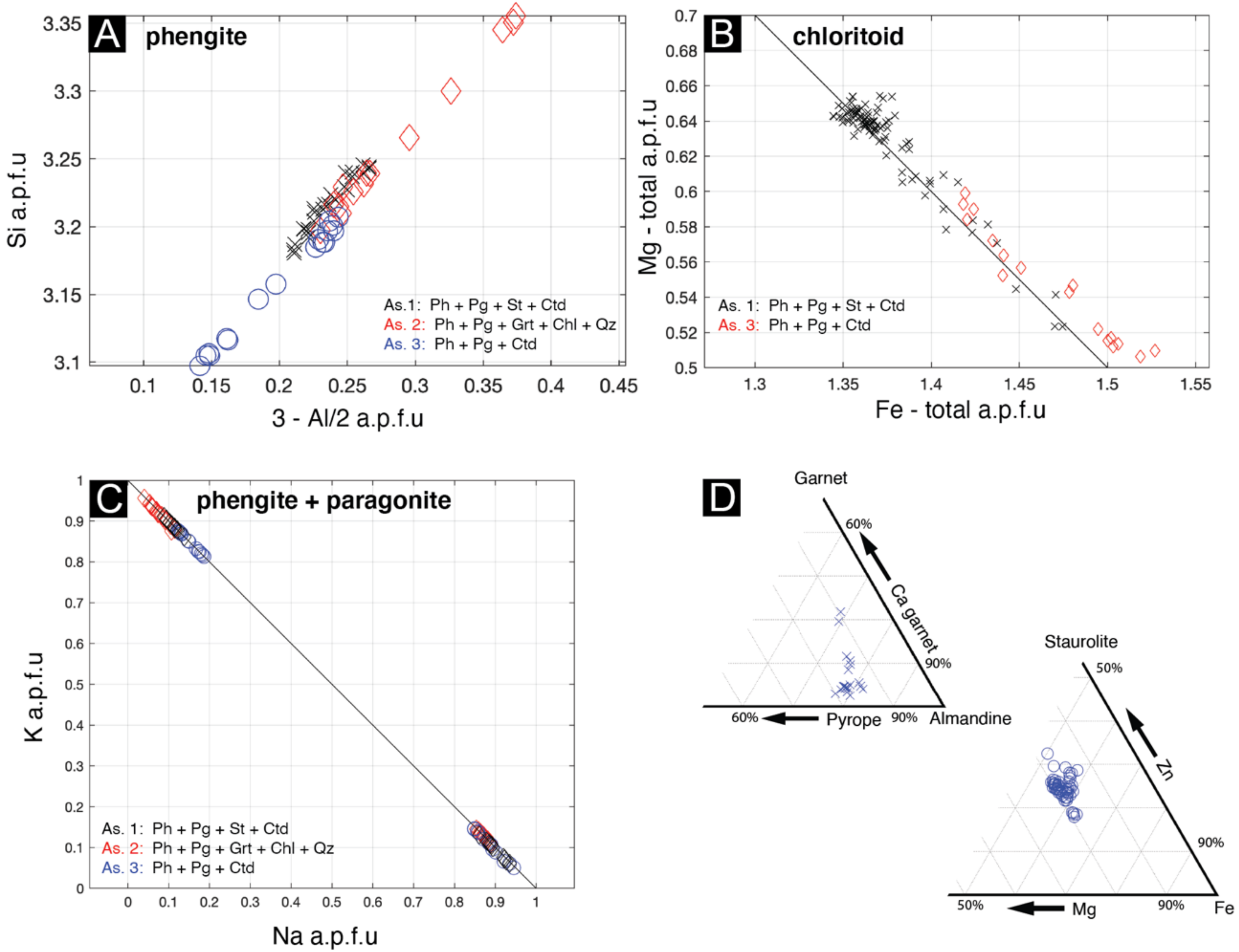
A - Si in phengite.

B - Mg and Fe-total in chloritoid.

C - Na in paragonite and K in phengite mixing gap.

D - Ternary plot for garnet compositions in assemblage 2, and ternary plot for staurolite compositions in assemblage 1.

*__note non-negligible Zn__



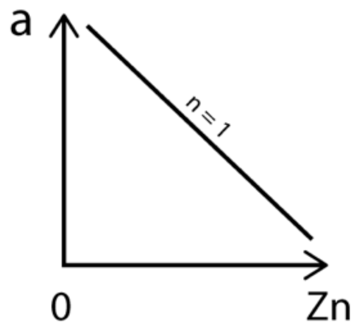
Zn in staurolite activity reduction:

- In order to account for the lack of solution models for Zn in staurolite we have employed a method to adjust the activity of available solid solution end-member data.
- Only Mg and Fe end-member data is available, therefore an entropy adjustment is needed:

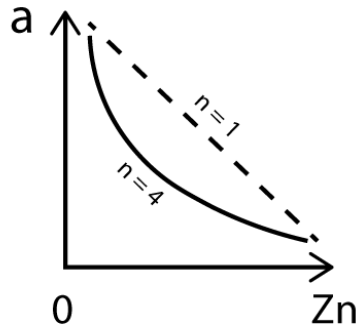
$$S^{corr} = S^{o} - R \ln a$$

- a = 1 for a pure phase.
- Site multiplicity of staurolite being 4 (Fe2+ = Mg = Zn = Mn).

Molecular mixing model: $a = XMg = \left(1 - \left(\frac{Zn}{4}\right)\right)$

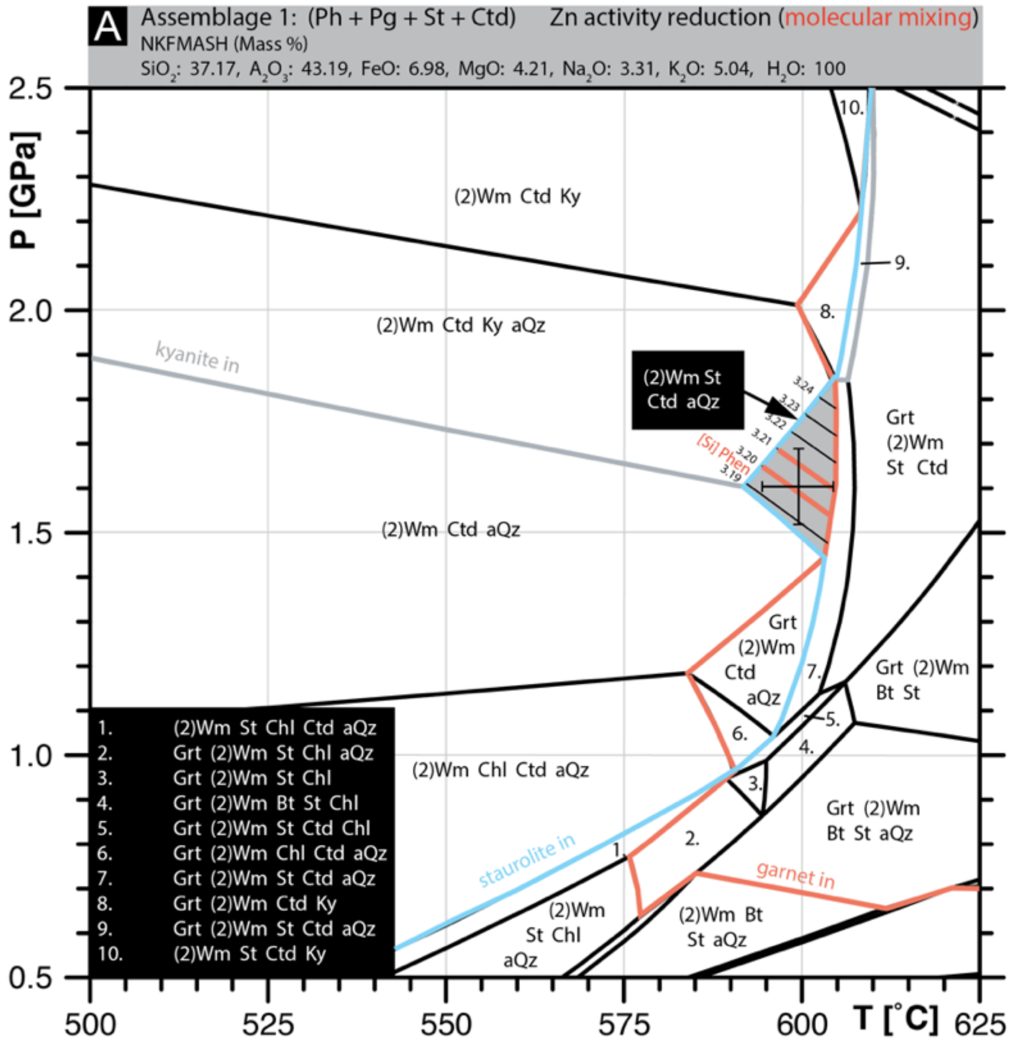


Site mixing model: $a = XMg = \left(1 - \left(\frac{Zn}{4}\right)\right)^{4}$



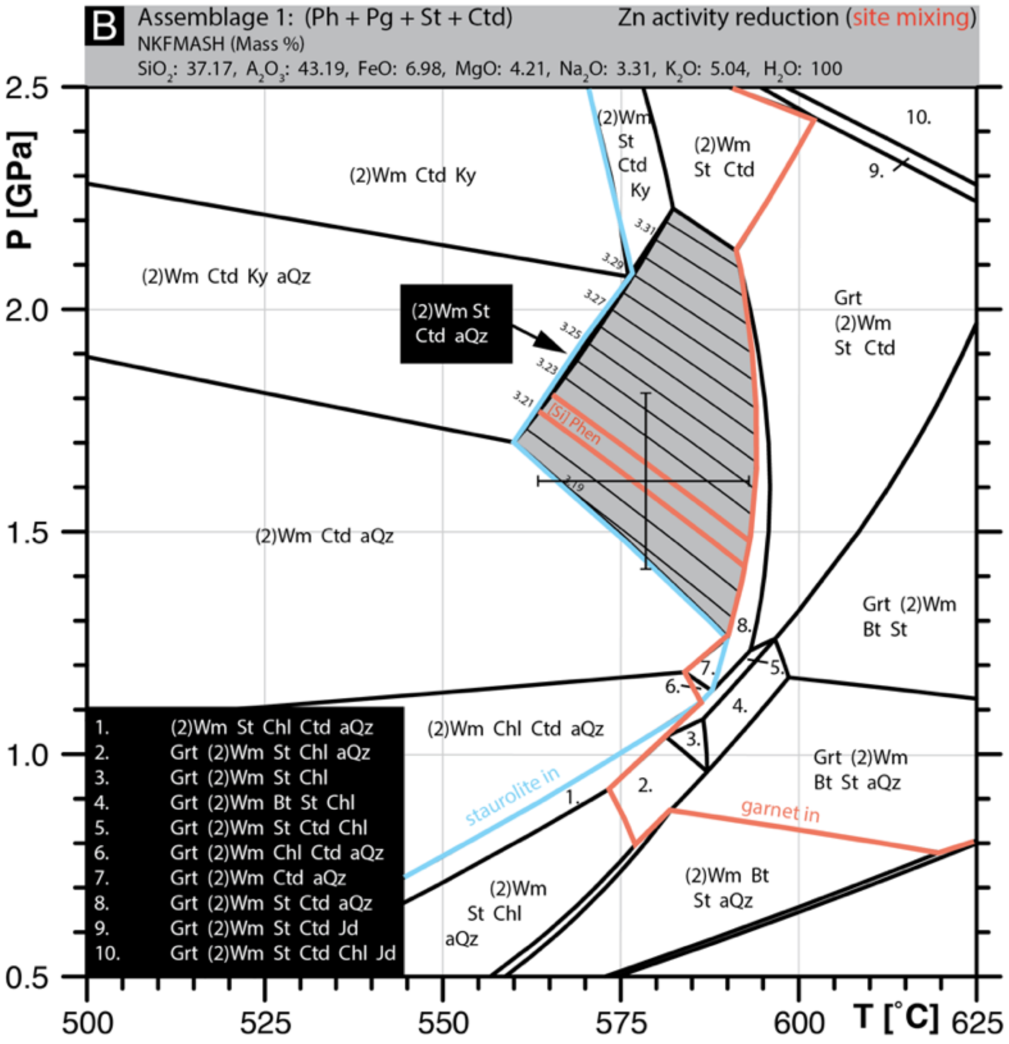
Pseudosection results: assemblage 1

Molecular mixing:



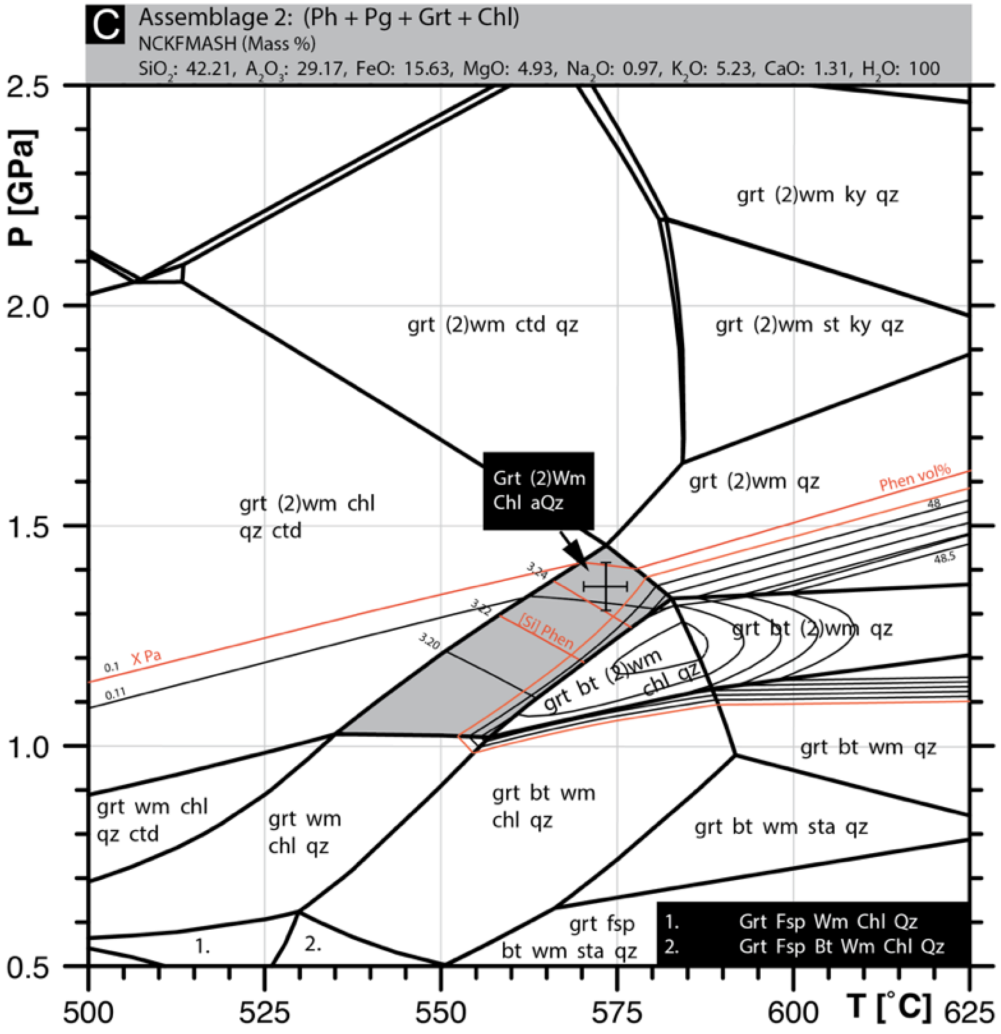
1.6 ± 0.1 GPa,
600 ± 5 ºC

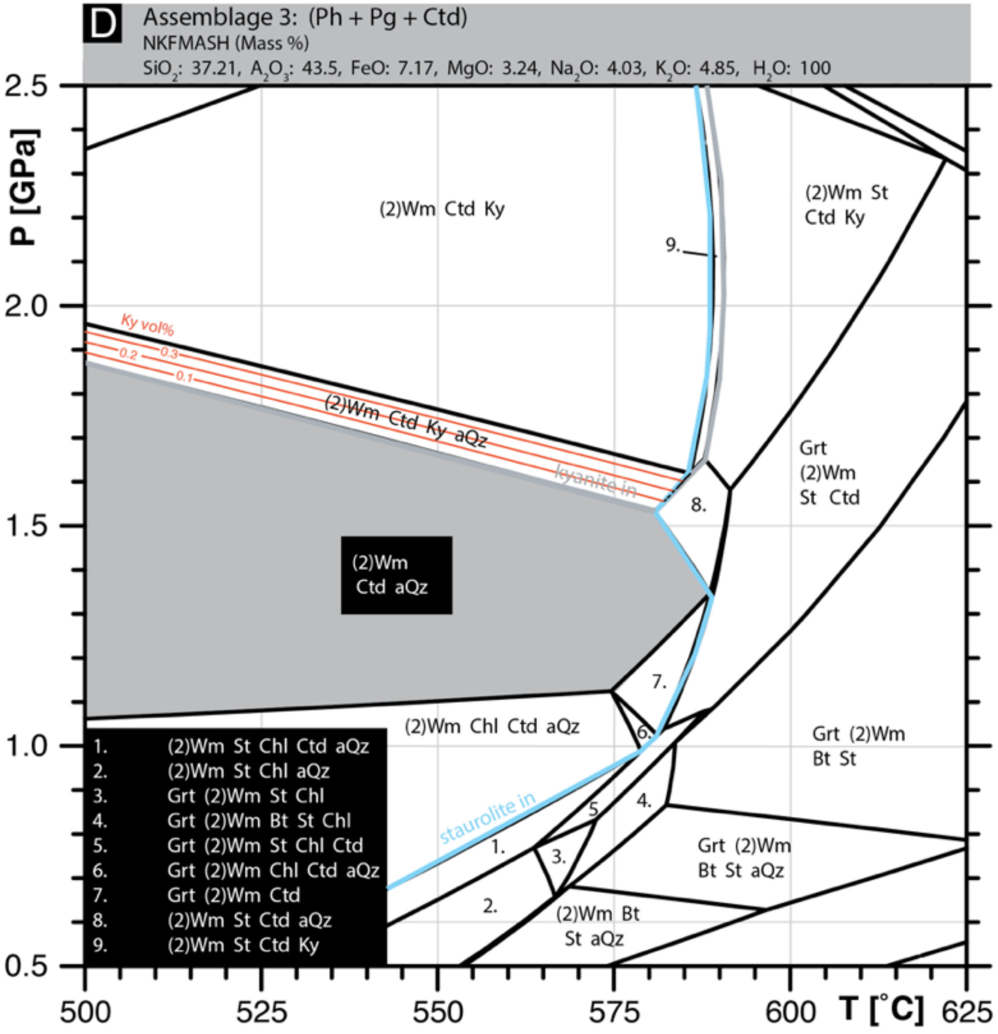
Site mixing:



1.6 ± 0.2 GPa,
580 ± 15 ºC

Pseudosection results: assemblages 2 and 3

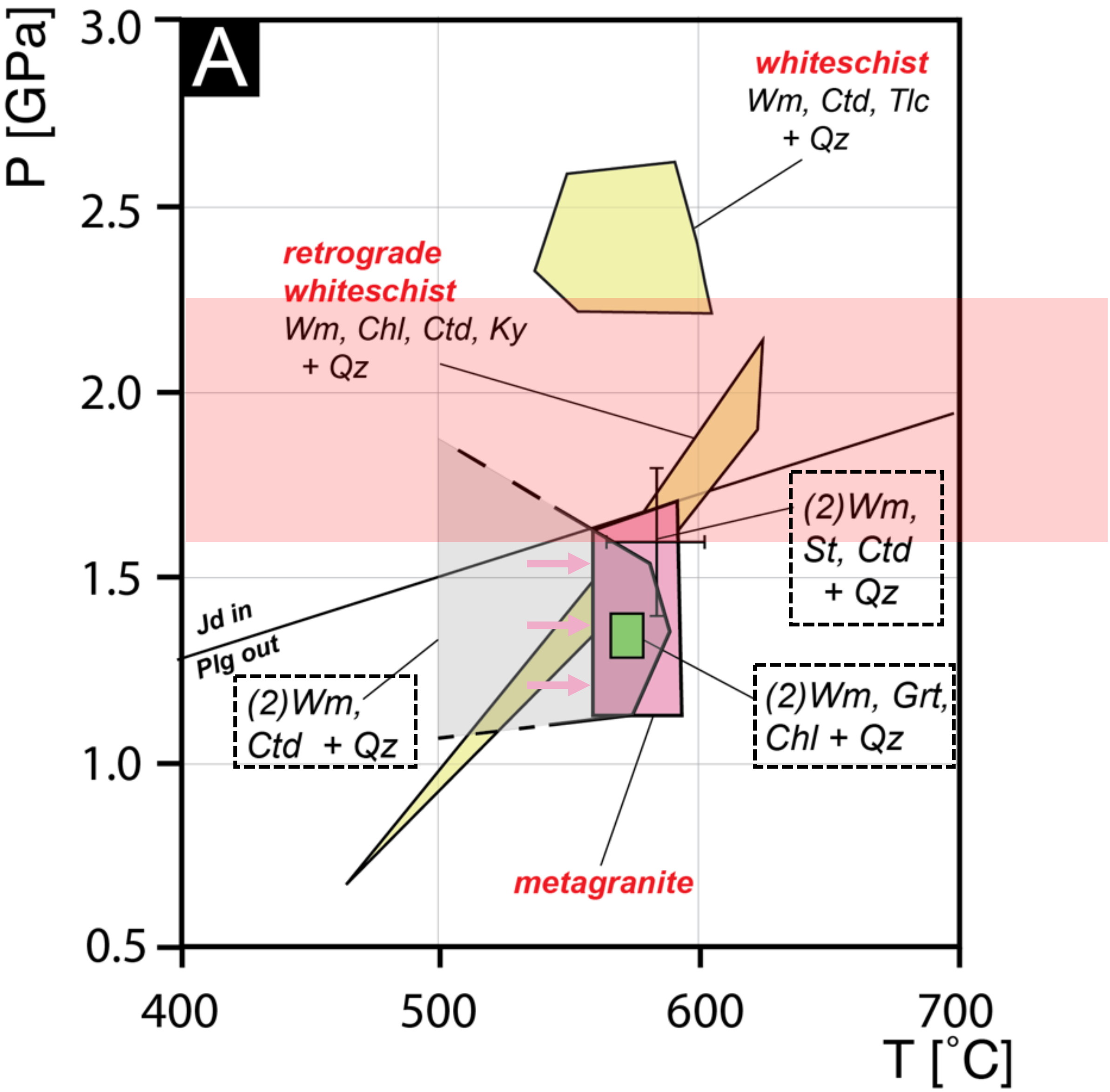




1.3 – 1.4 GPa, ca. 575 °C

ca. 1.6 GPa at 575 °C

Comparison with whiteschist:



ΔP =

0.6 $\pm$ 0.2

GPa

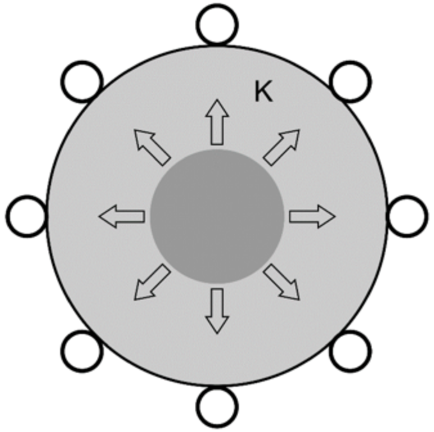
- Peak Metamorphic conditions from metapelitic samples <u>re-affirm pressure variations</u>
- Whiteschist is consistently at a higher pressures compared to all metagranite and metapelite lithologies examined
- Varying P but consistently similar T conditions => <u>isothermal decompression</u>?
- Rapid isothermal exhumation, or mechanical P variations?

Mechanical P variation: ….the options

Reaction-induced stress

Dehydration under isochoric conditions

0.4 – 0.5 GPa



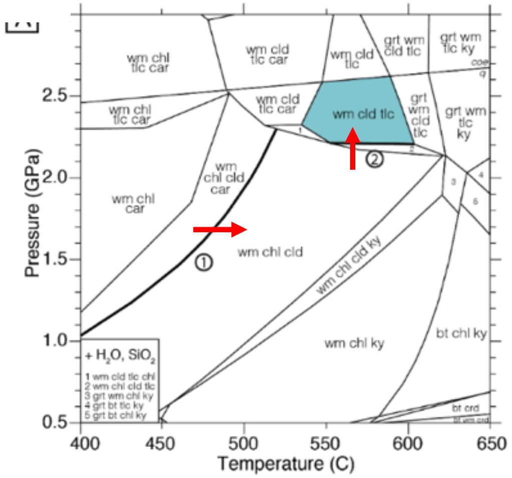
$$\Delta V_{tot} = \Delta V_{ela} + \Delta V_{rea} = 0$$

$$\Delta p = K \frac{\Delta V_{ela}}{\Delta V_0} = -K \frac{\Delta V_{rea}}{\Delta V_0}$$

$$\Delta p = -\frac{1}{\beta} \frac{\Delta V_{rea}}{\Delta V_0} = -\rho \frac{dp}{d\rho} \frac{\Delta V_{rea}}{\Delta V_0}$$

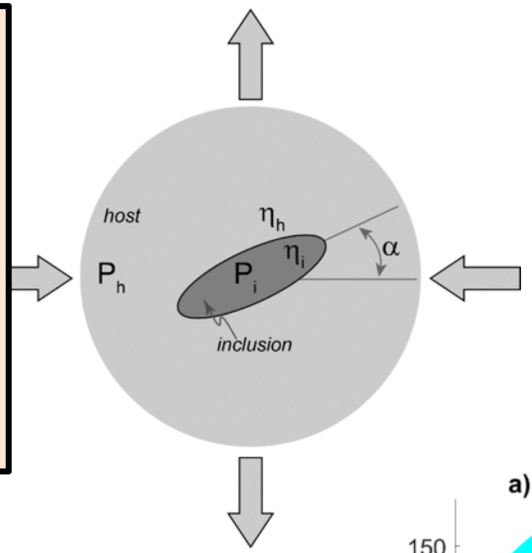
In reality it can be a mixture of both processes…

What is needed are <u>rheological heterogeneities</u>

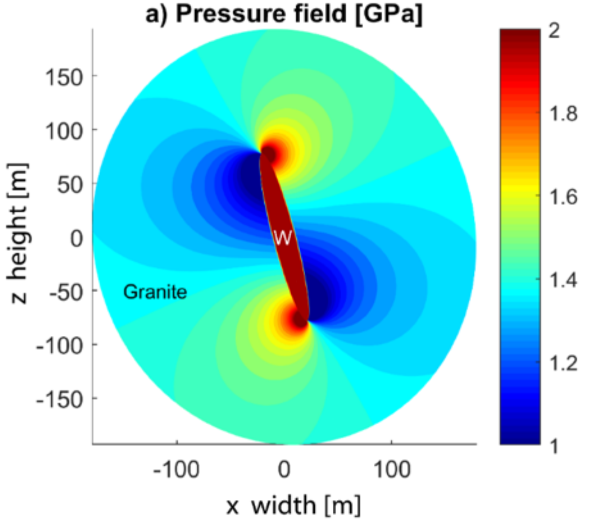


Compression-induced stress

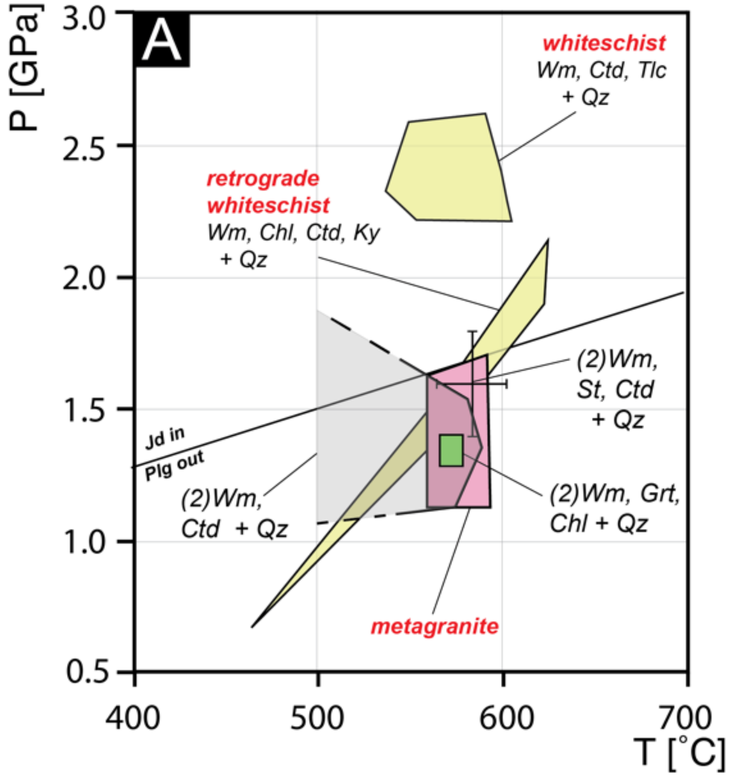
Weak inclusion in strong host

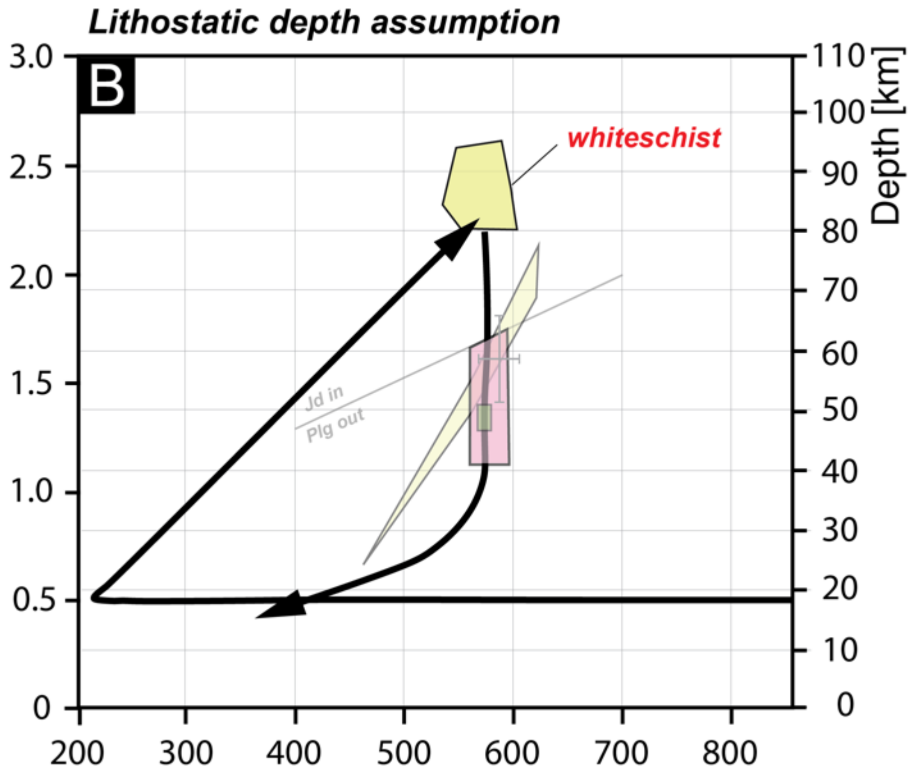


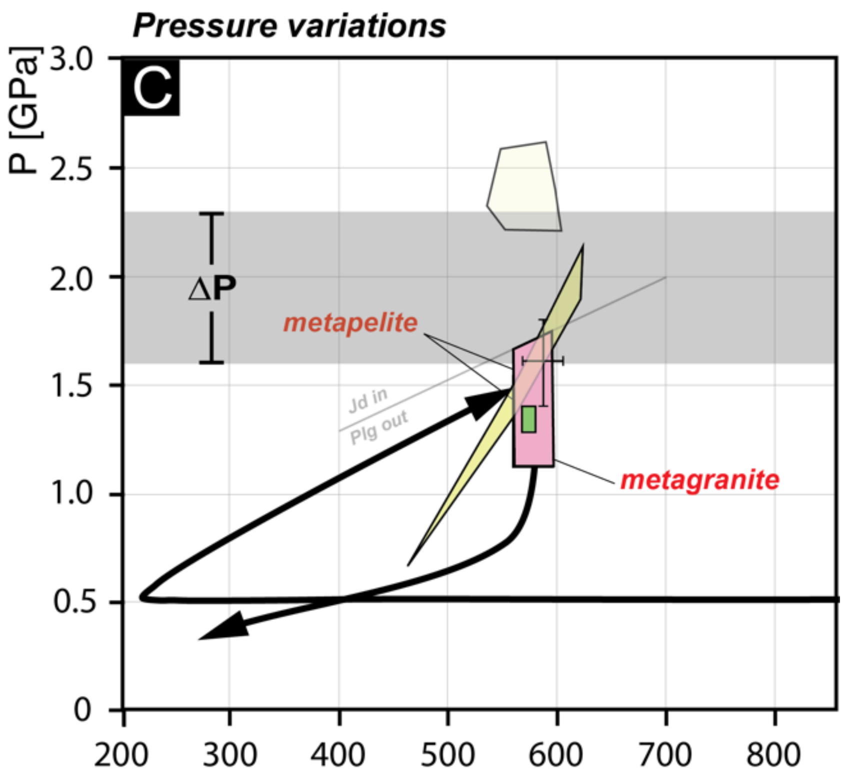
ΔP ~ Txx



Geodynamic implications:







- ***Deep subduction***
- ***Mechanically weak and homogeneous rock unit***

- Lithostatic pressure
- Pressure directly related to Depth
- Peak P = deepest burial of the Monte Rosa nappe

- P variations
- Whiteschist represents local pressure variations
- Metapelite and Metagranite lithologies represent regional peak pressure of the Monte Rosa nappe

- ***Moderate subduction***
- ***Mechanically heterogeneous rock unit***

Thank you