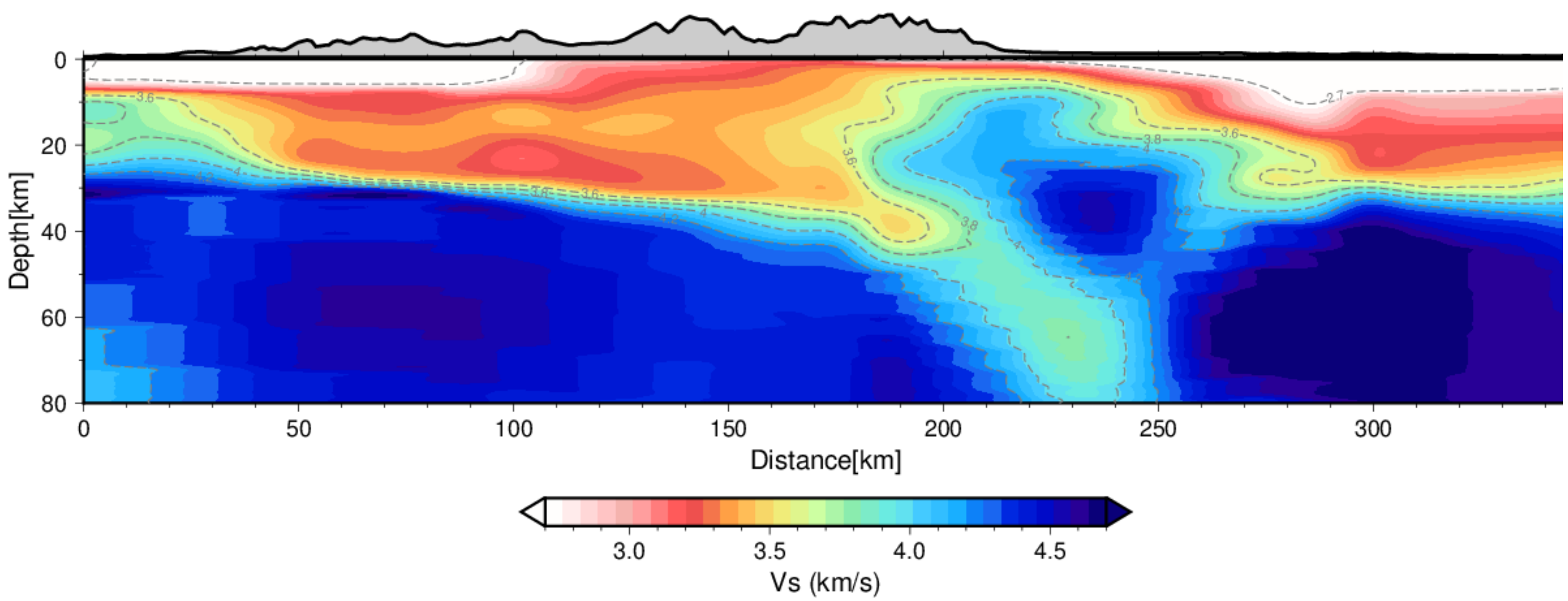
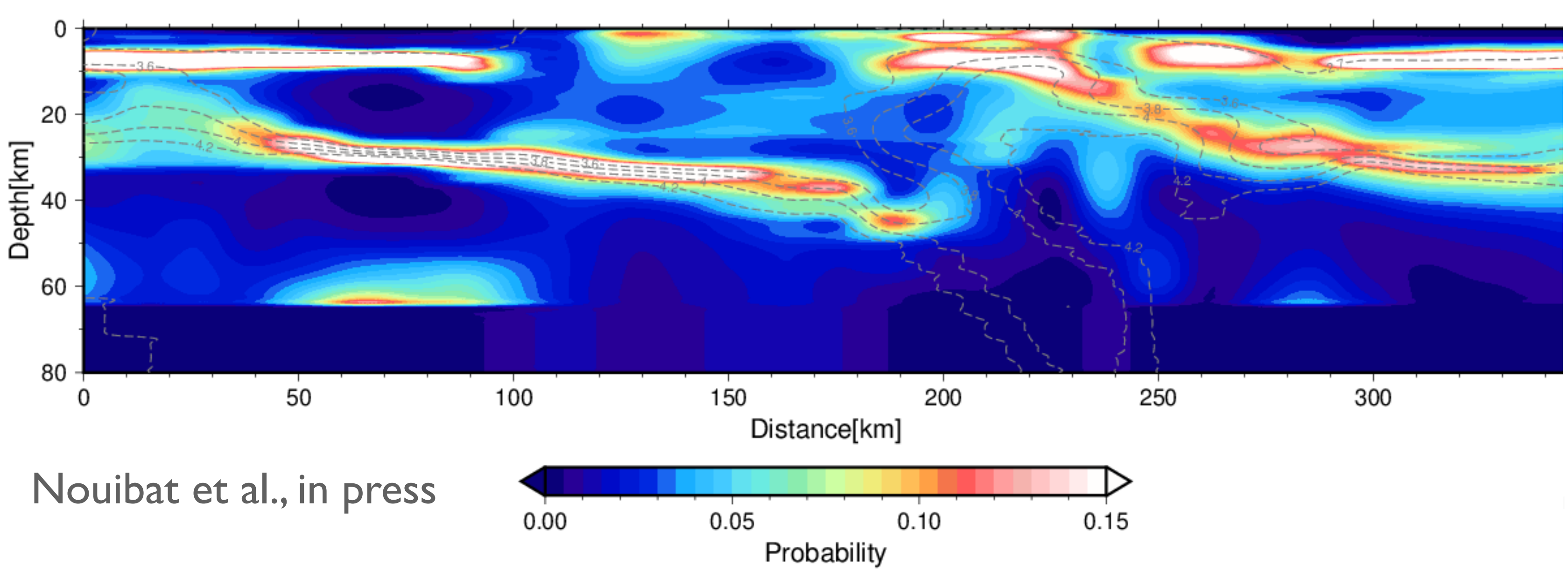
1. ISTeP, Sorbonne University, Paris.
2. LG TPE, Jean Monnet University, St Etienne
3. BRGM, Orléans.
4. ISTerre, Grenoble-Alpes University.

Seismic properties profiles of the alpine slab predicted by petrophysics versus ambient noise tomography lithospheric model

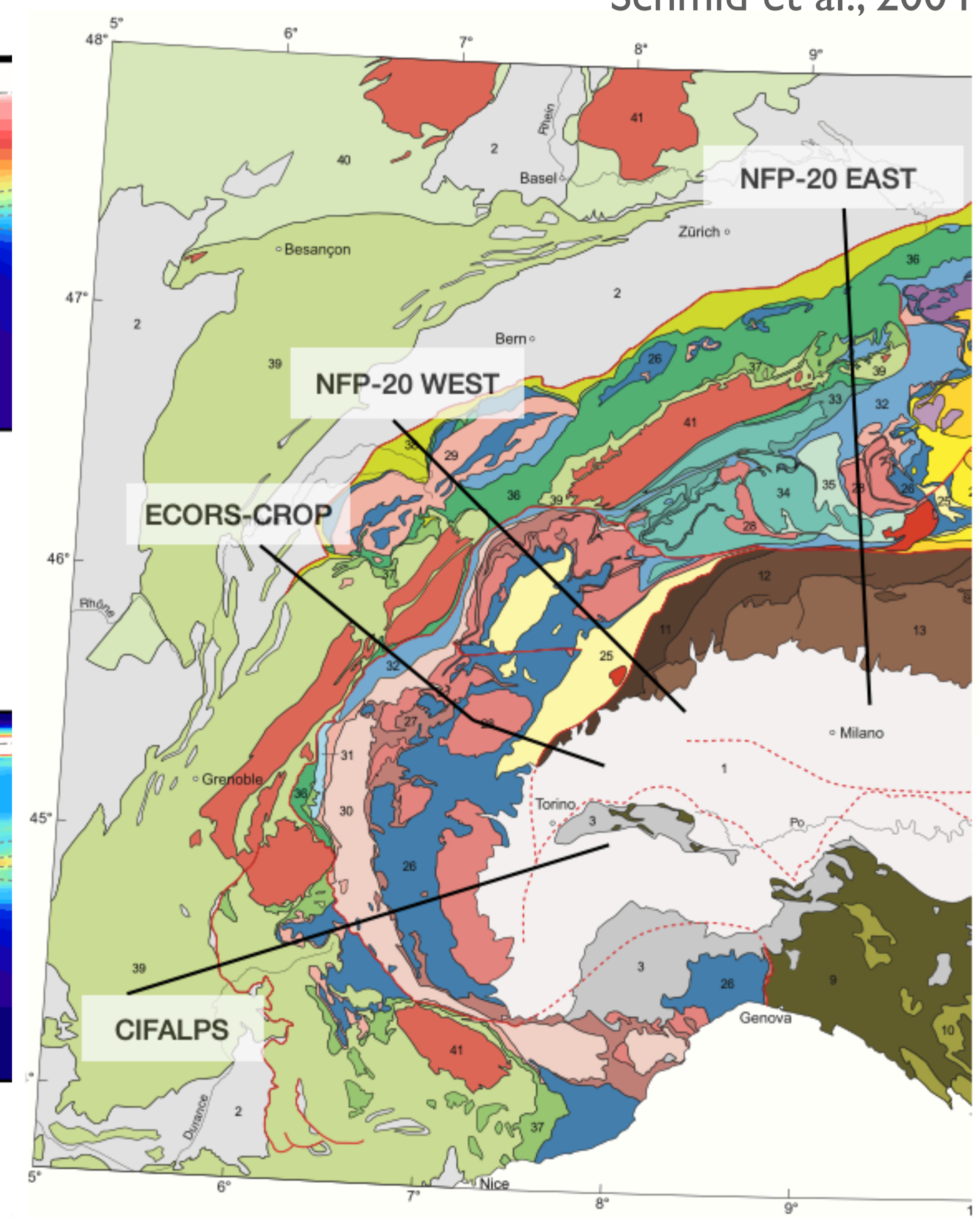
Sonnet M[1]., Labrousse L[1]. ,Bascou J[2]., Plunder A[3]., Nouibat A[4]., Paul A[4]., Stehly L[4].





Nouibat et al., in press

Schmid et al., 2004

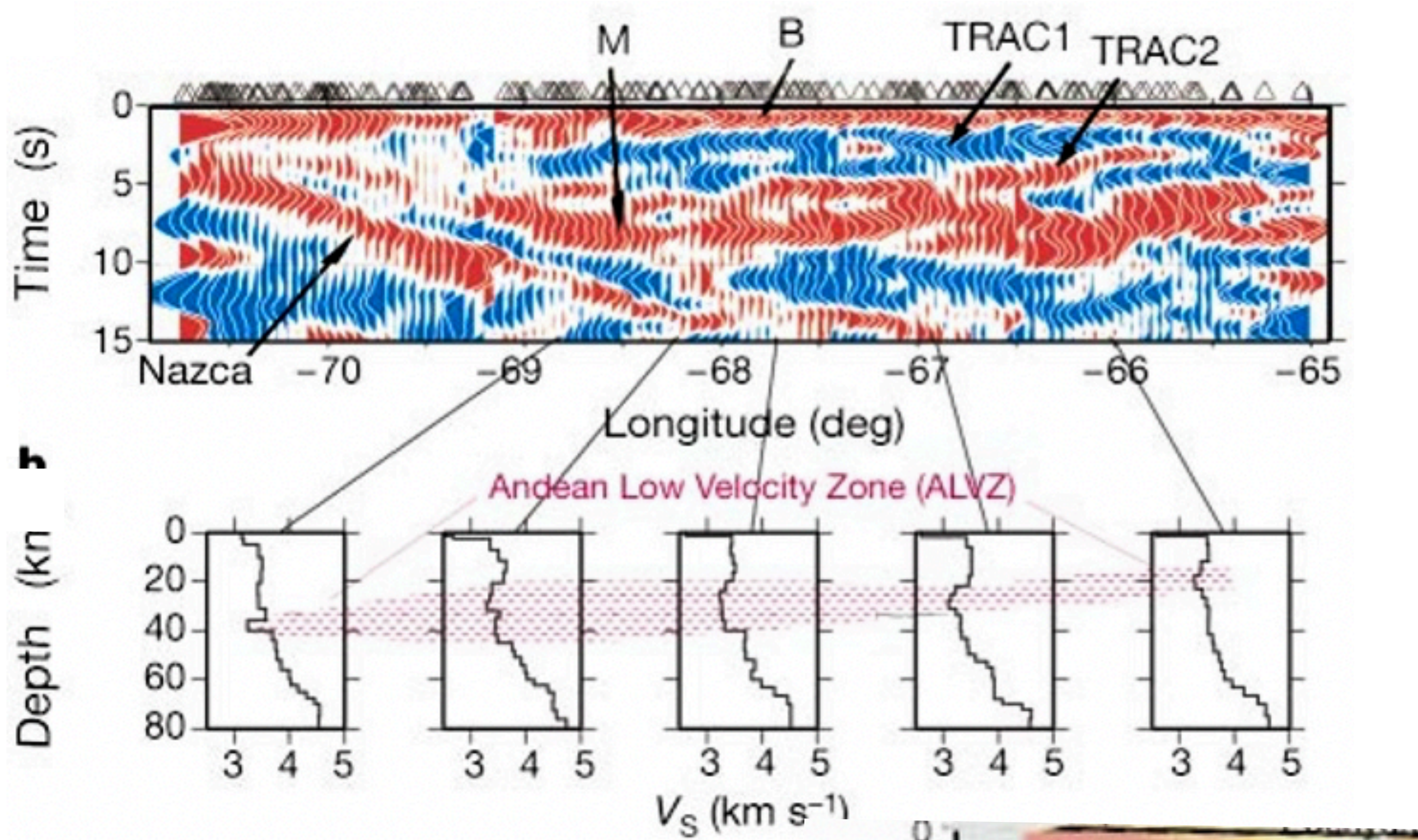


May 23th 2022

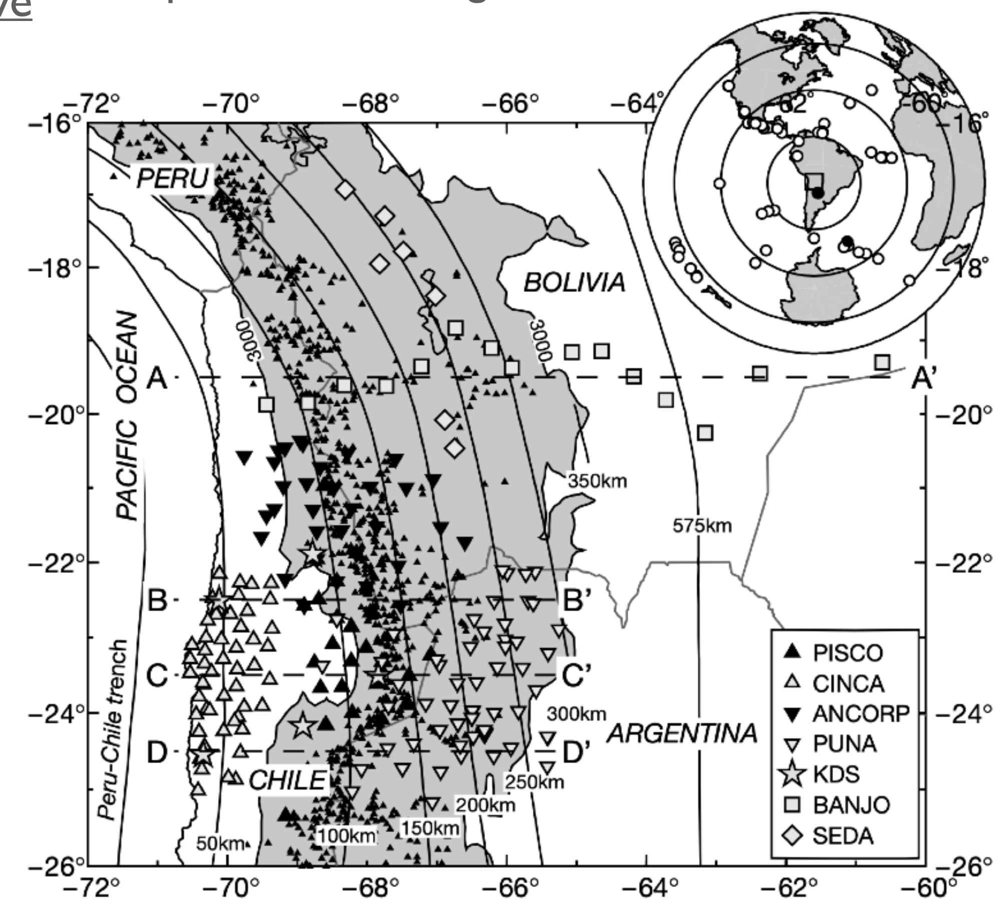
What petrological details are recognizable in geophysics?

- Reaction fronts can be identified

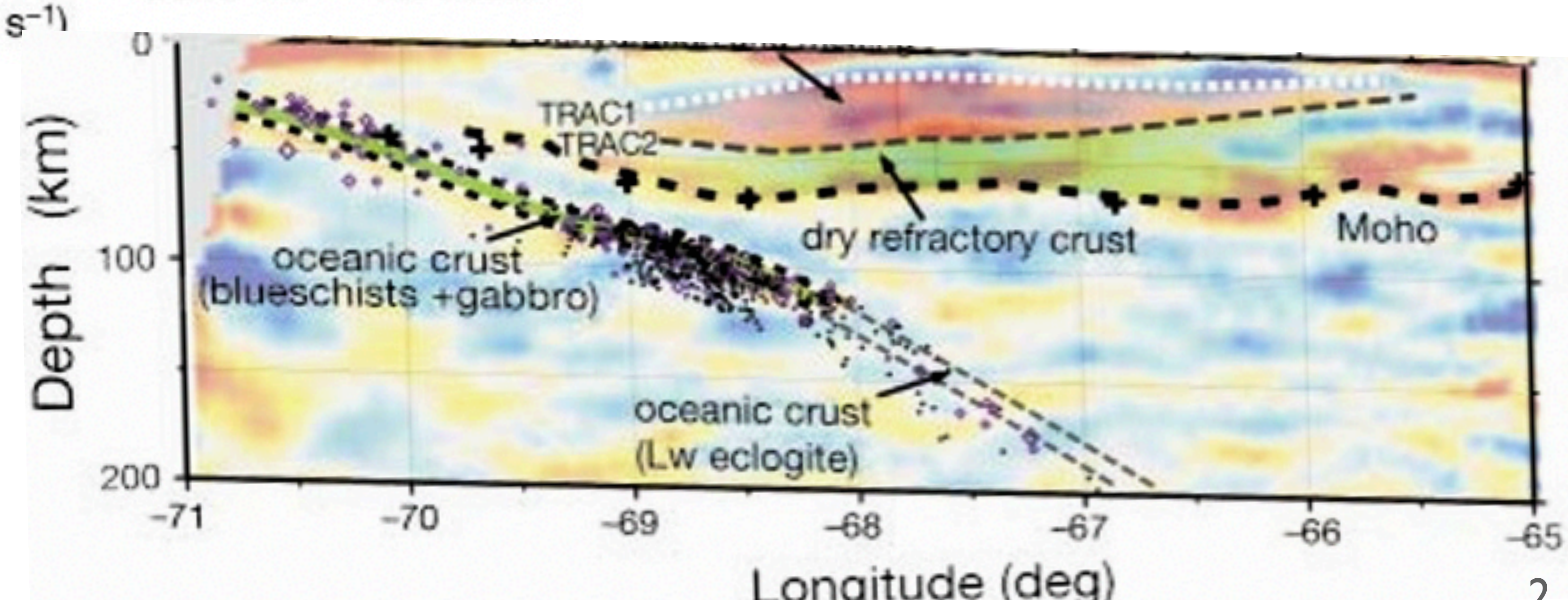
Time domains RFs averaged over a 30 km wide moving window and crustal S-wave velocity models along an E-W profile.



Map of the Central Andes, showing networks of passive seismological stations used.



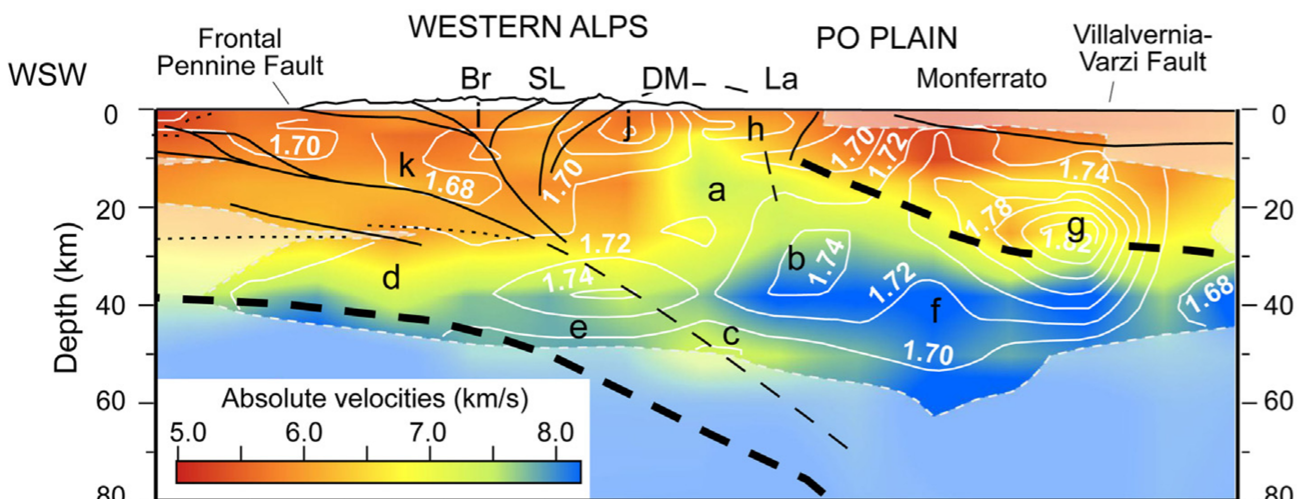
Interpretation with depth-migrated RF image as background averaged.



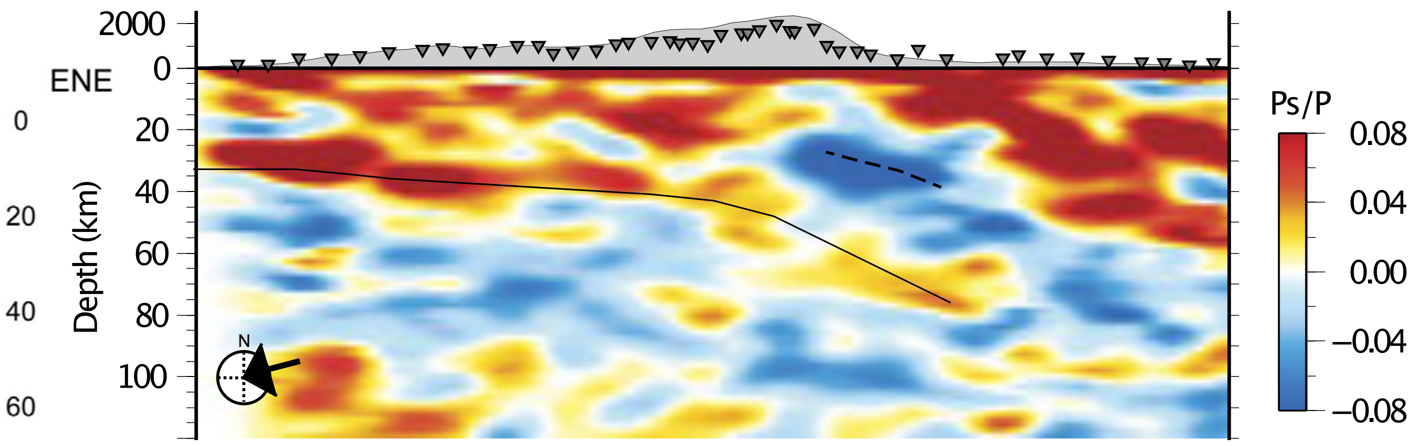
Yuan et al. 2000

Images available along the CIFALPS profile: receiver function and P-wave tomography

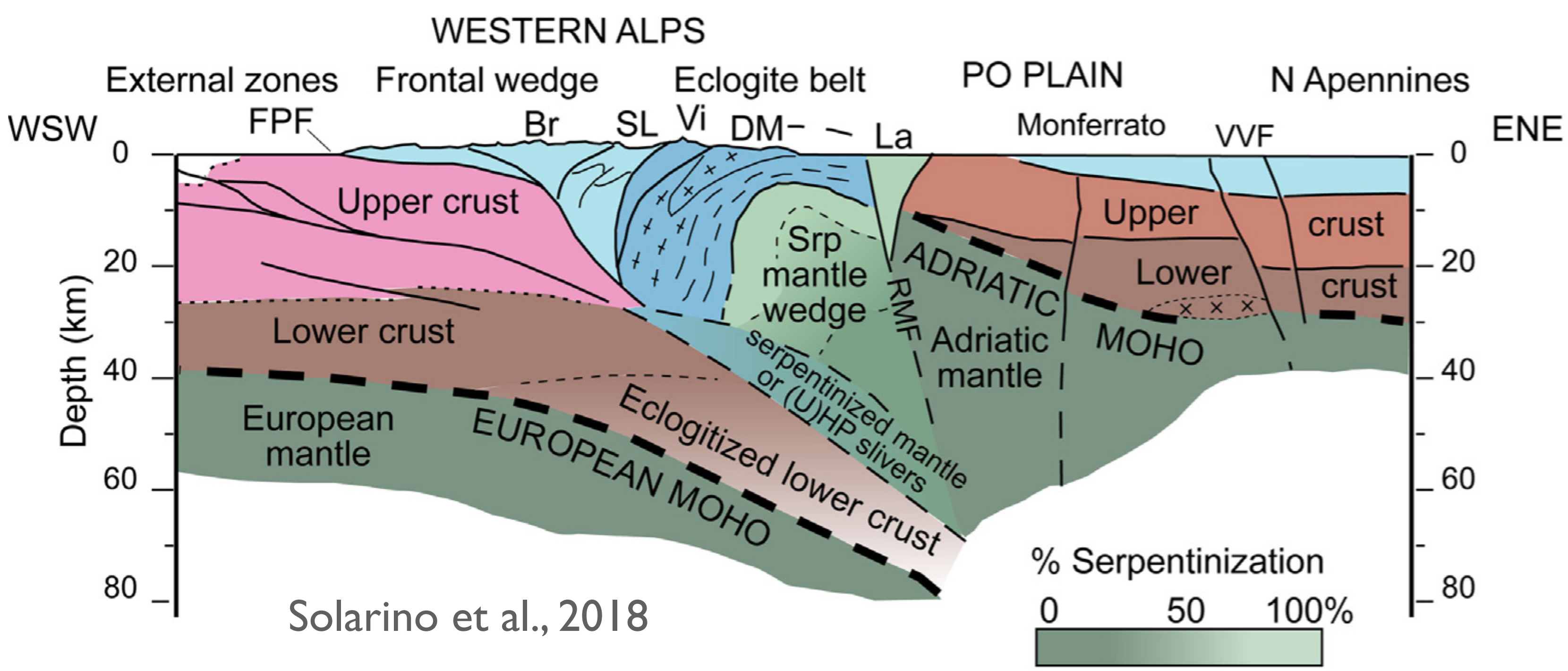
Geophysical data and inferred mantle wedge structure.



CCP depth section computed from teleseismic along CIFALPS transect.

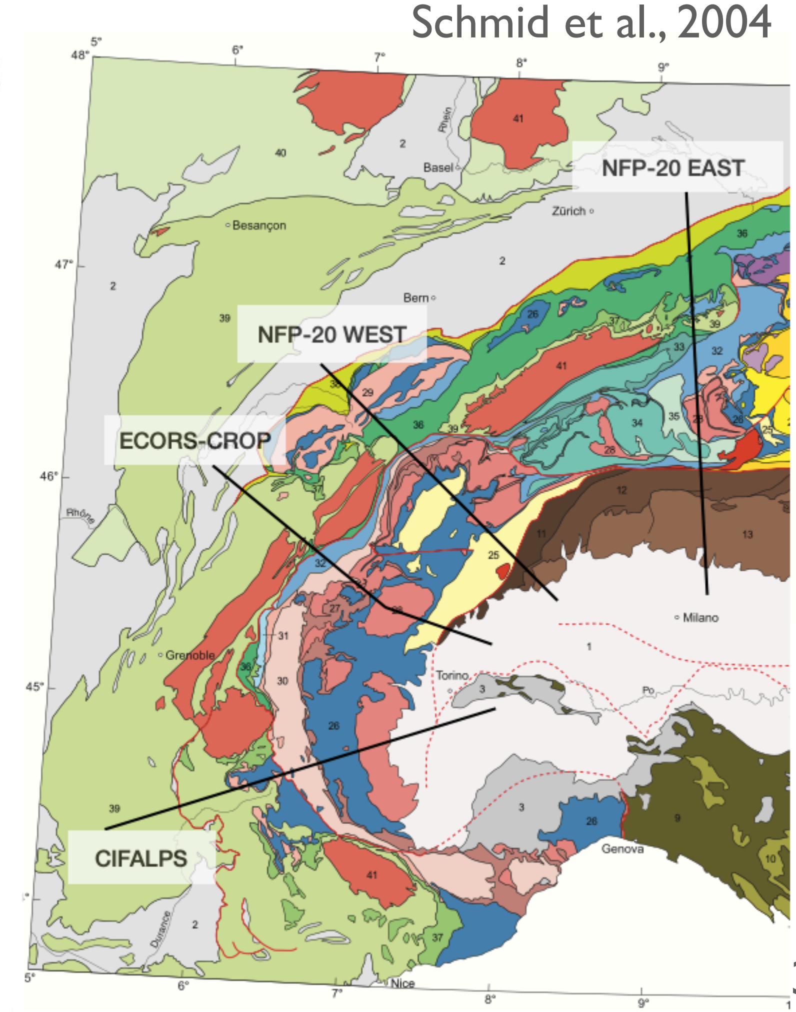


Zhao et al. 2015



Solarino et al., 2018

Schmid et al., 2004



- Continuity of the European lower crust with the Alpine dipping panel.
- Variations of the velocities according to the back azimuths.
- Unexplained local increase of the Vp/Vs ratio at the limit of the transformation zone.

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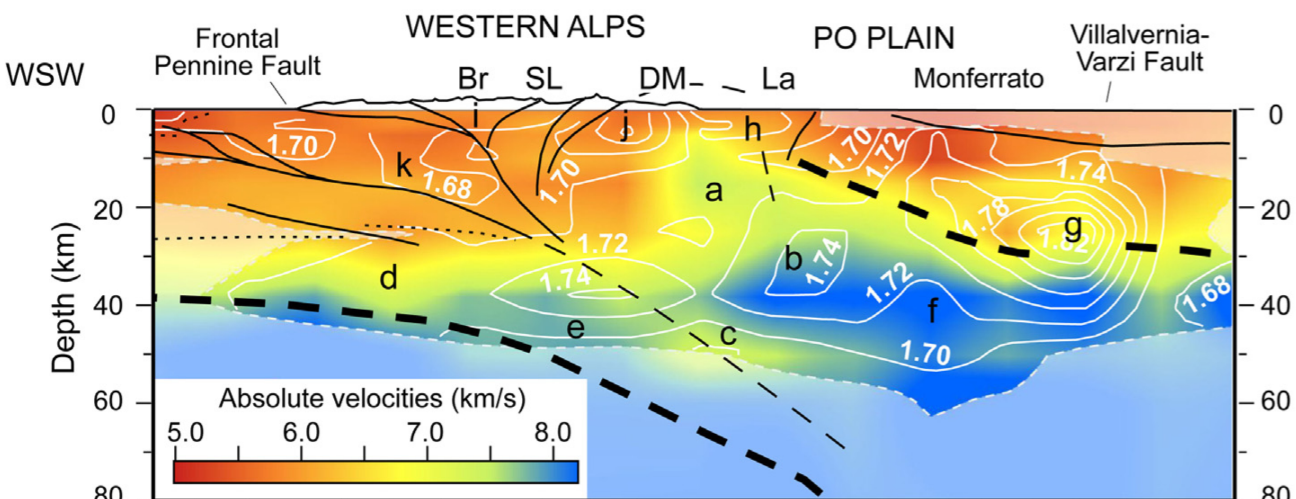

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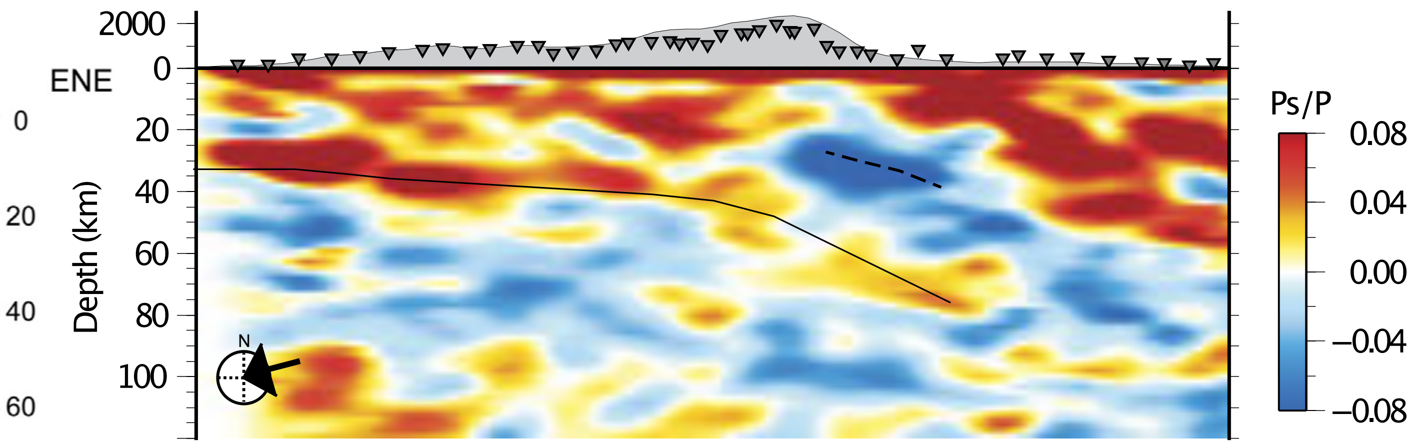
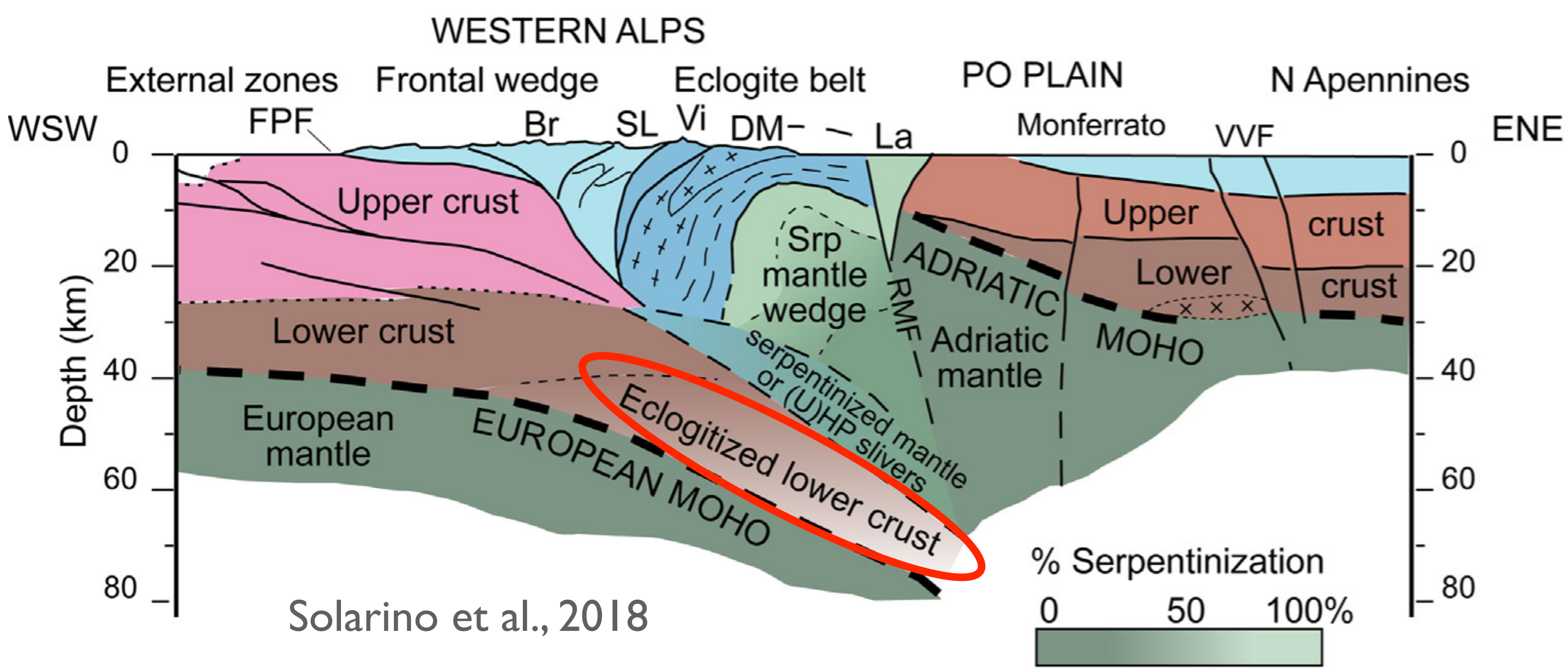
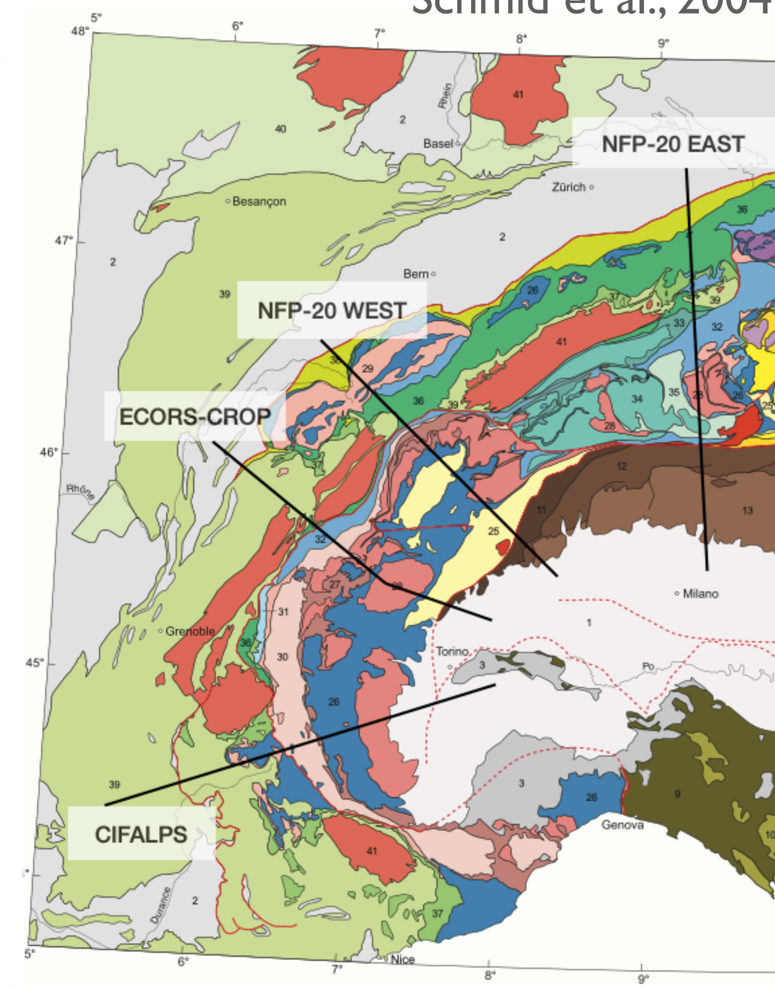


Zhao et al. 2015



Solarino et al., 2018

Schmid et al., 2004



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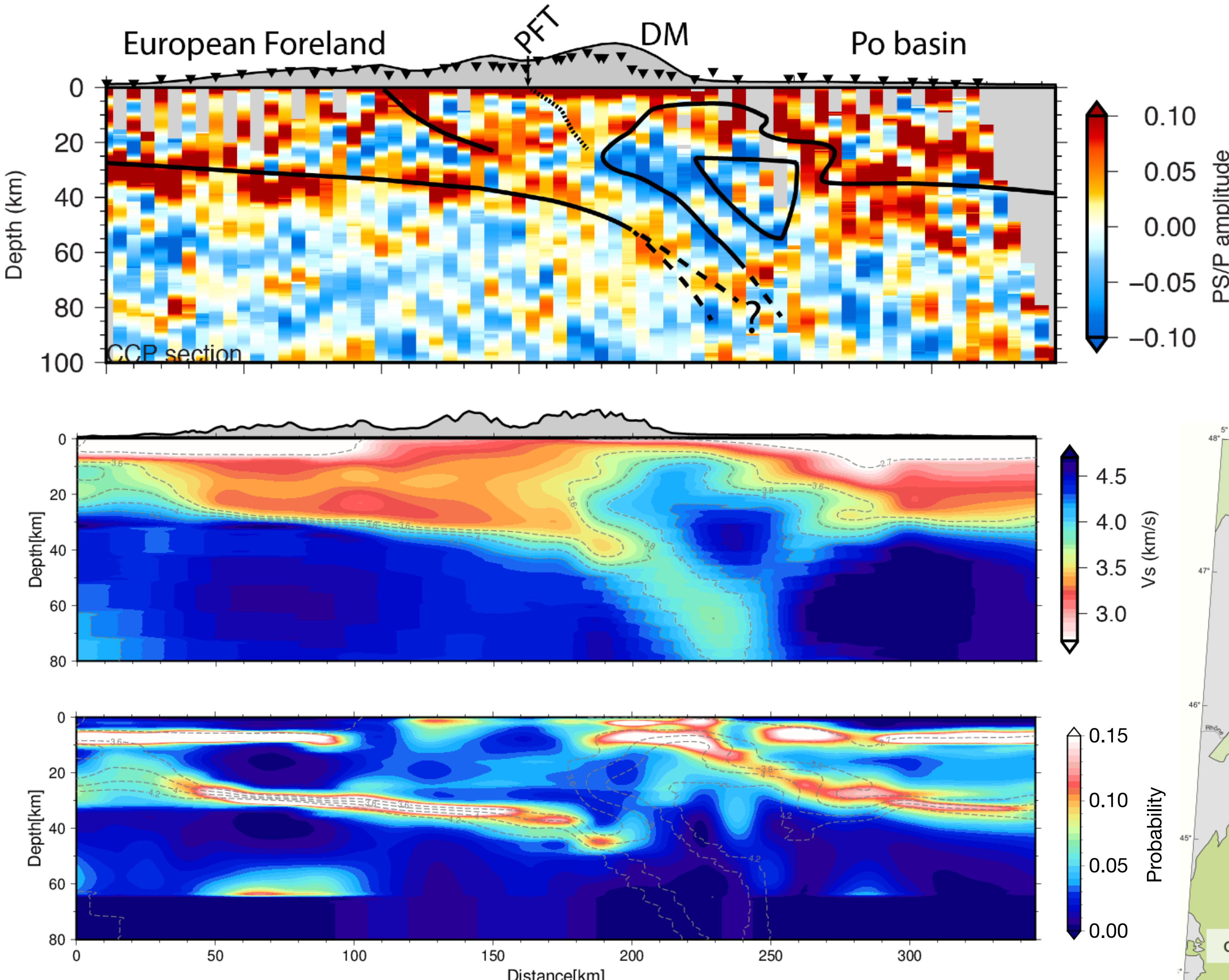
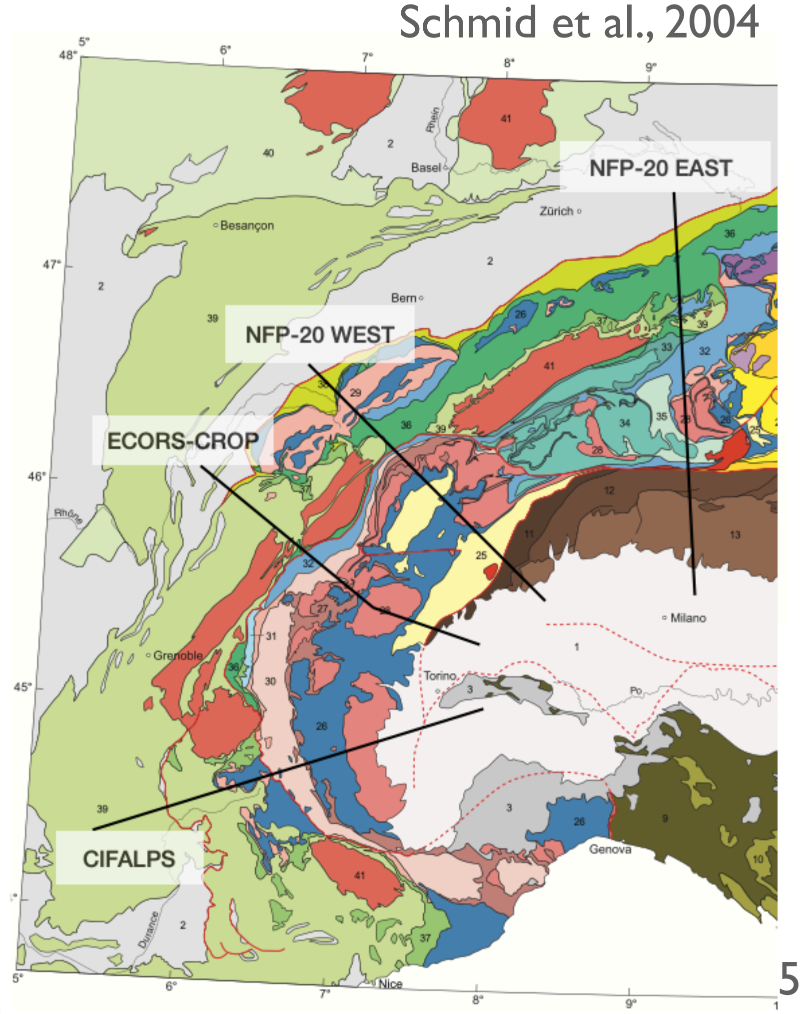
Images available along the CIFALPS profile: receiver function and P-wave tomography

Depth sections of observations and inversion results along the Cifalps WSW-ENE profile



- Independent of previous data.
- Resolved in depth.
- Vs model with associated uncertainties.

Schmid et al., 2004



Nouibat et al., in press

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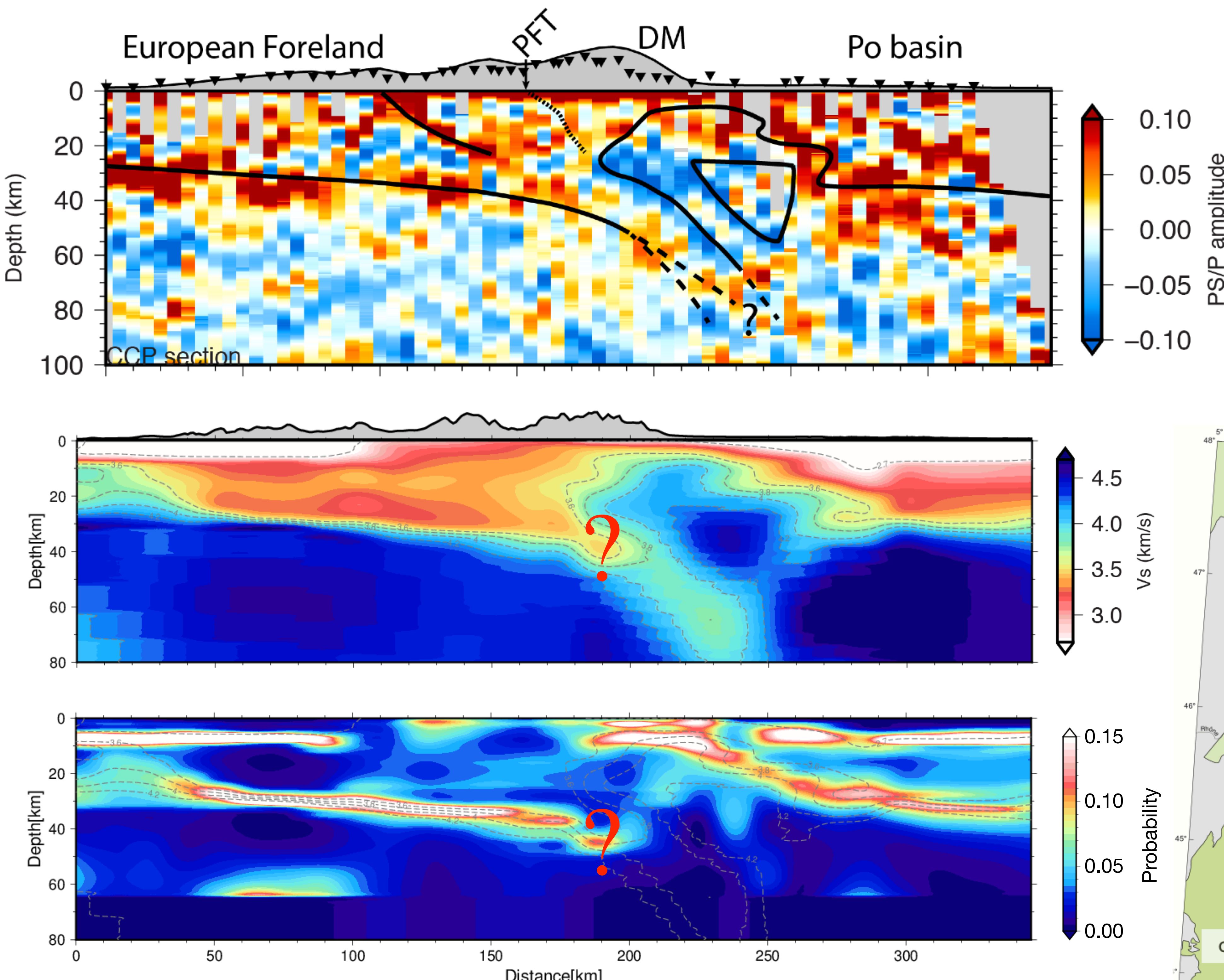

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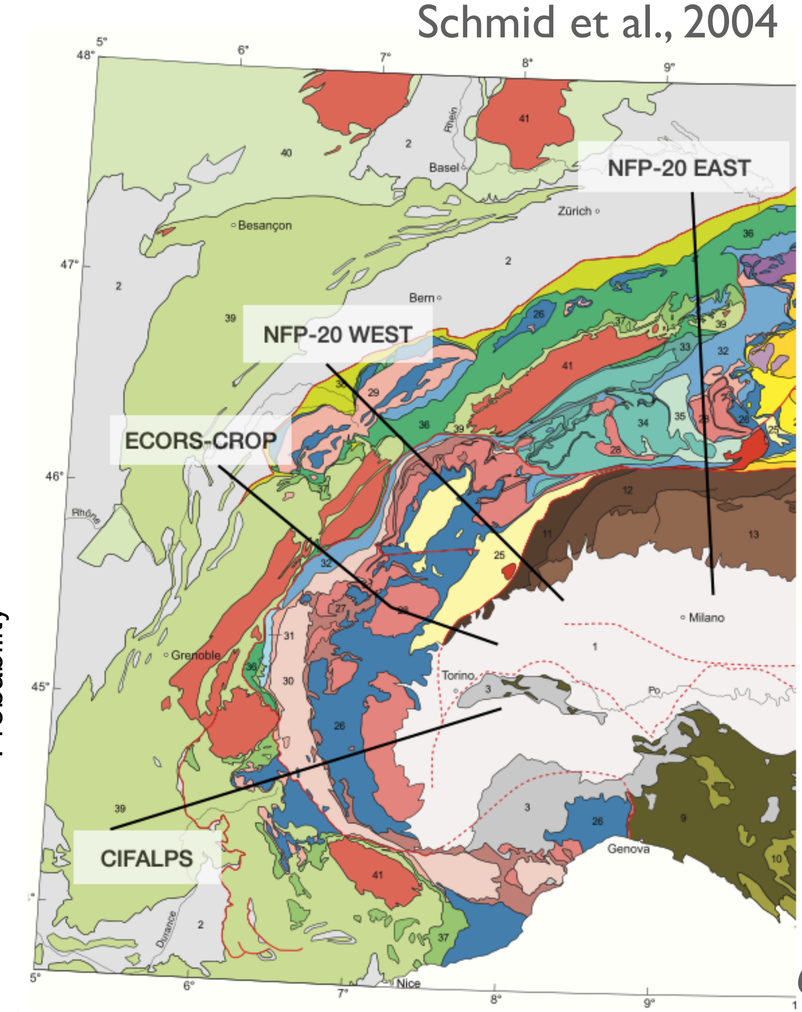
Schmid et al., 2004

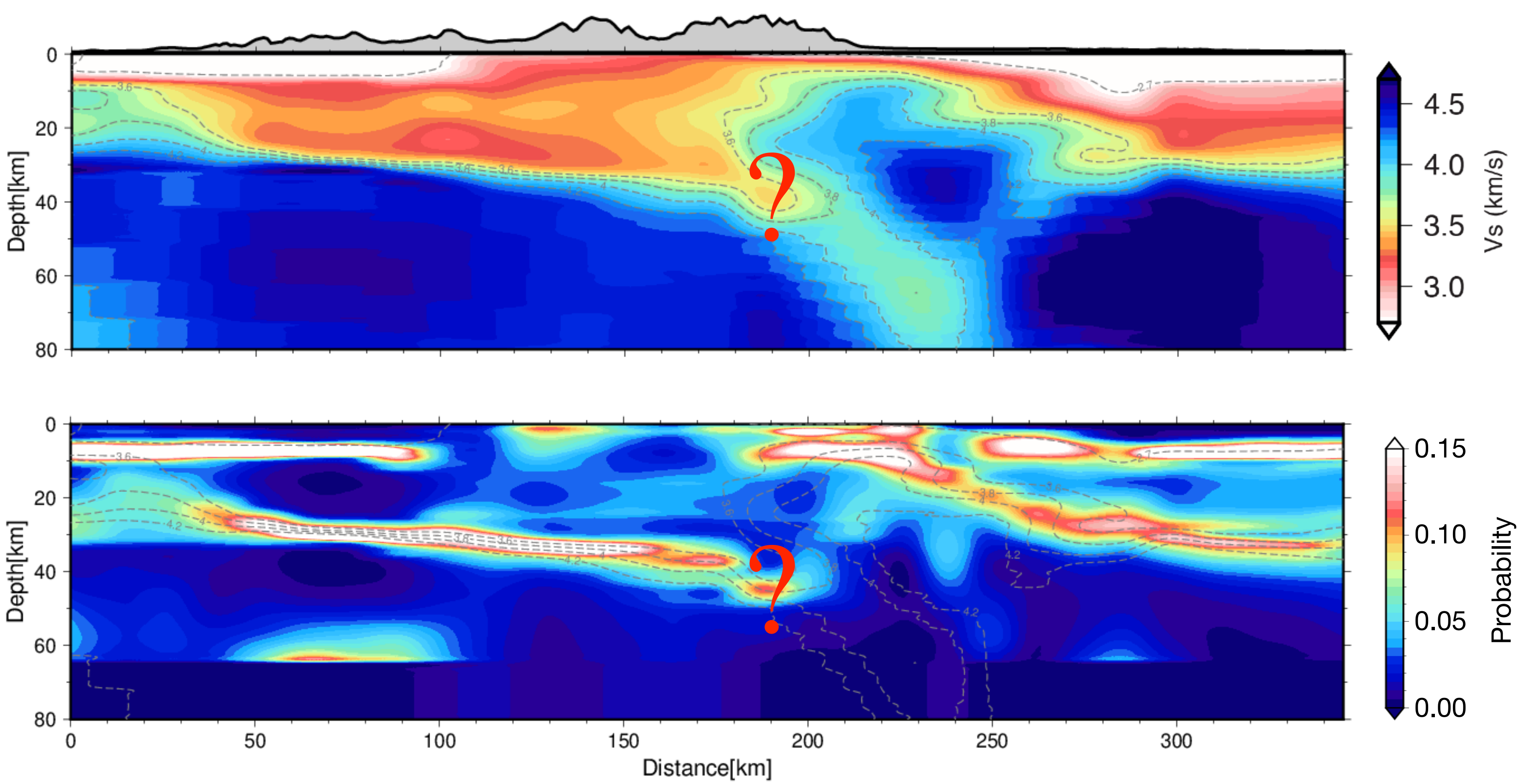


Nouibat et al., in press

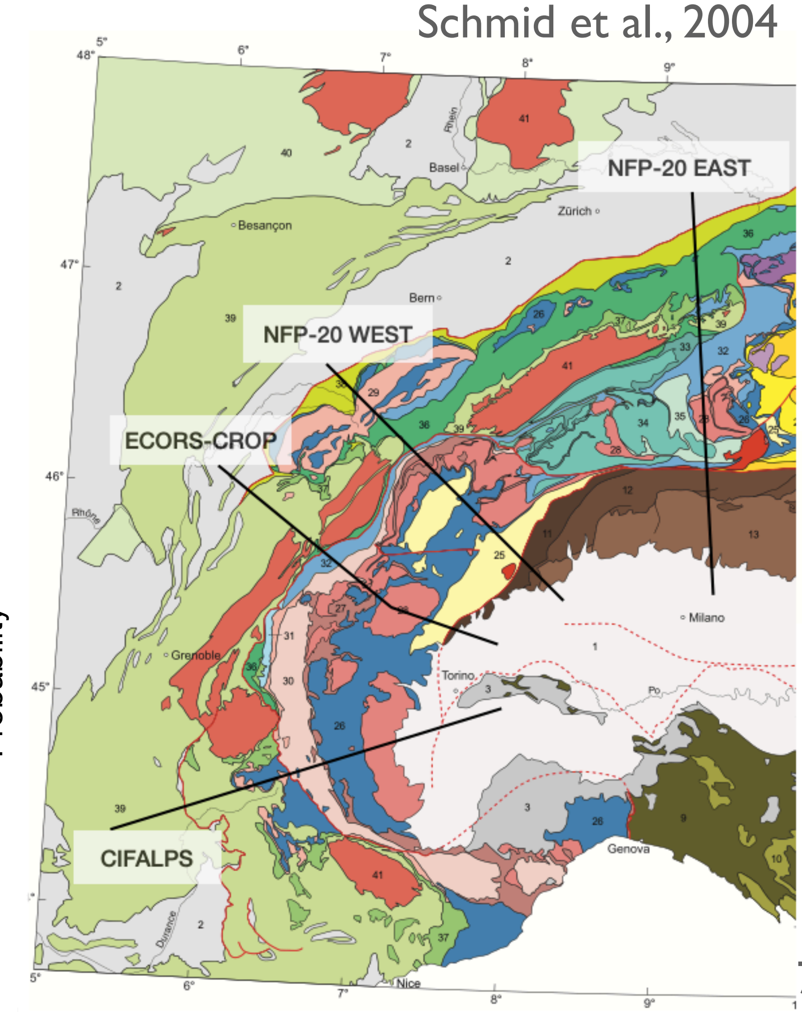
How to explain the seismic velocities observed within the Alpine dipping panel?

Assumptions:

- European lower crust forms the top of the subducting lithospheric panel.
- Rocks sampled at the surface are either analogous to the subducting lower crust or to its yet unmodified protolith.



Nouibat et al., in press



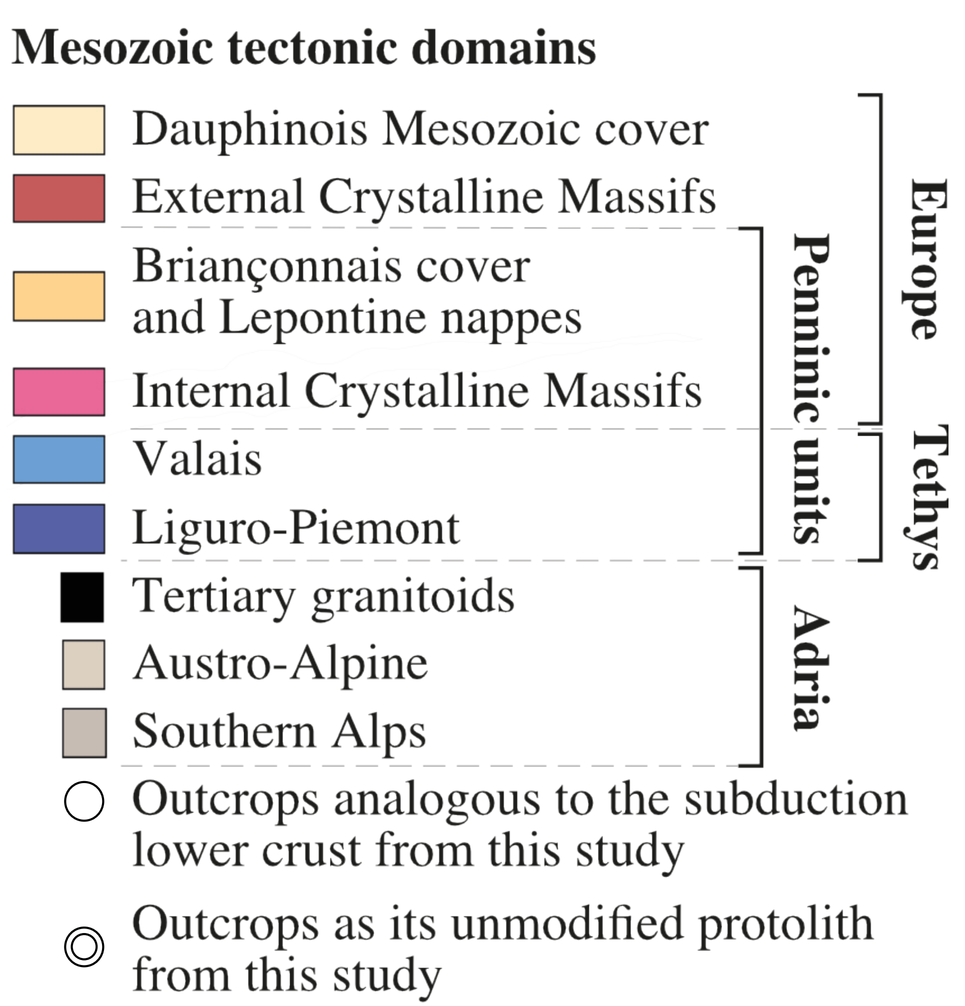
Schmid et al., 2004

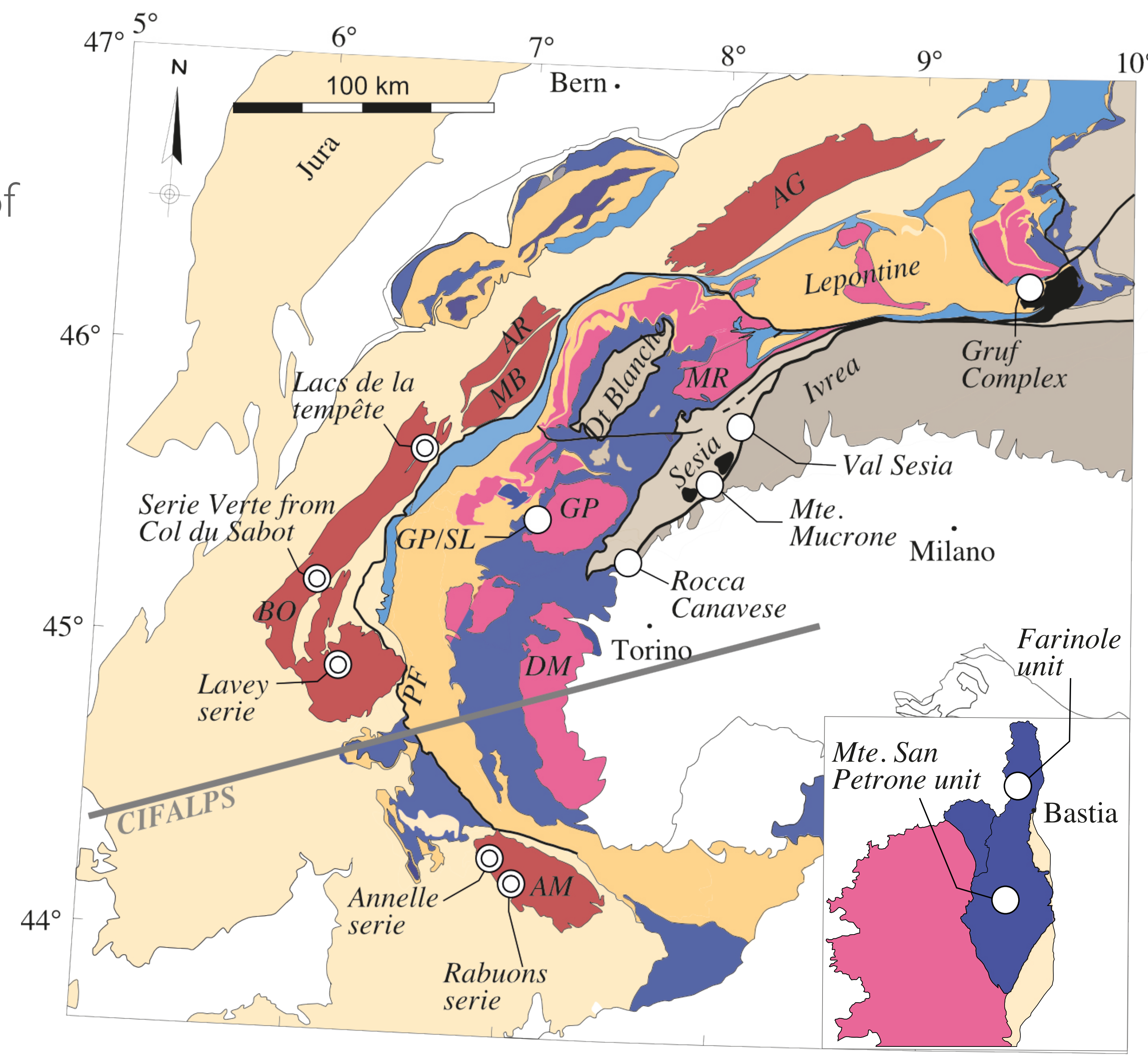
How to explain the seismic velocities observed within the Alpine dipping panel?

Where are these local analogues located?

Requires local analogues as chemical composition governs the exact position of metamorphic reactions and thus velocity contrasts.

Location map of the samples used in this study

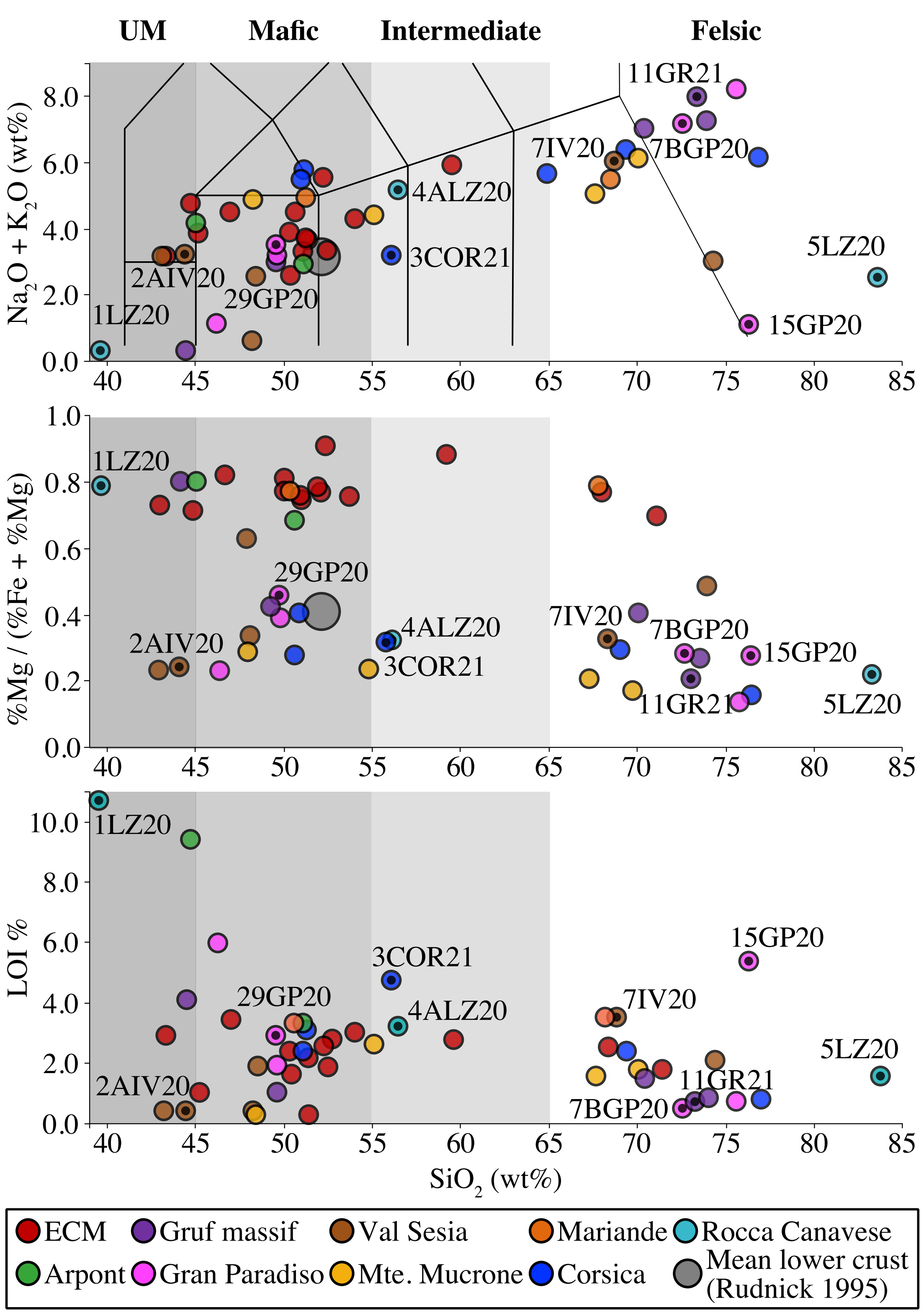




Modified from Agard 2021

How to explain the seismic velocities observed within the Alpine dipping panel?

Chemical diagrams from ICP-OES analyses



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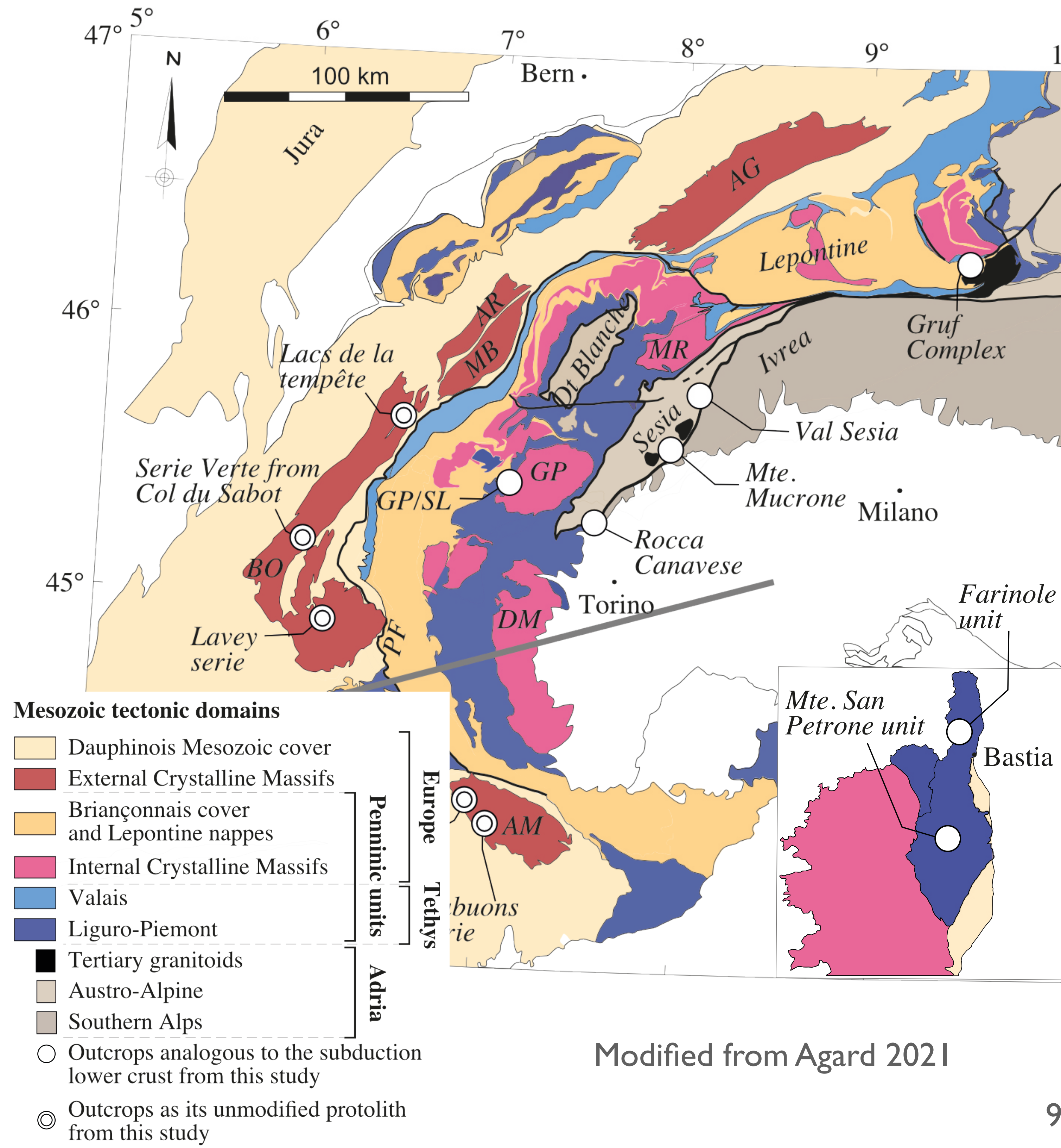
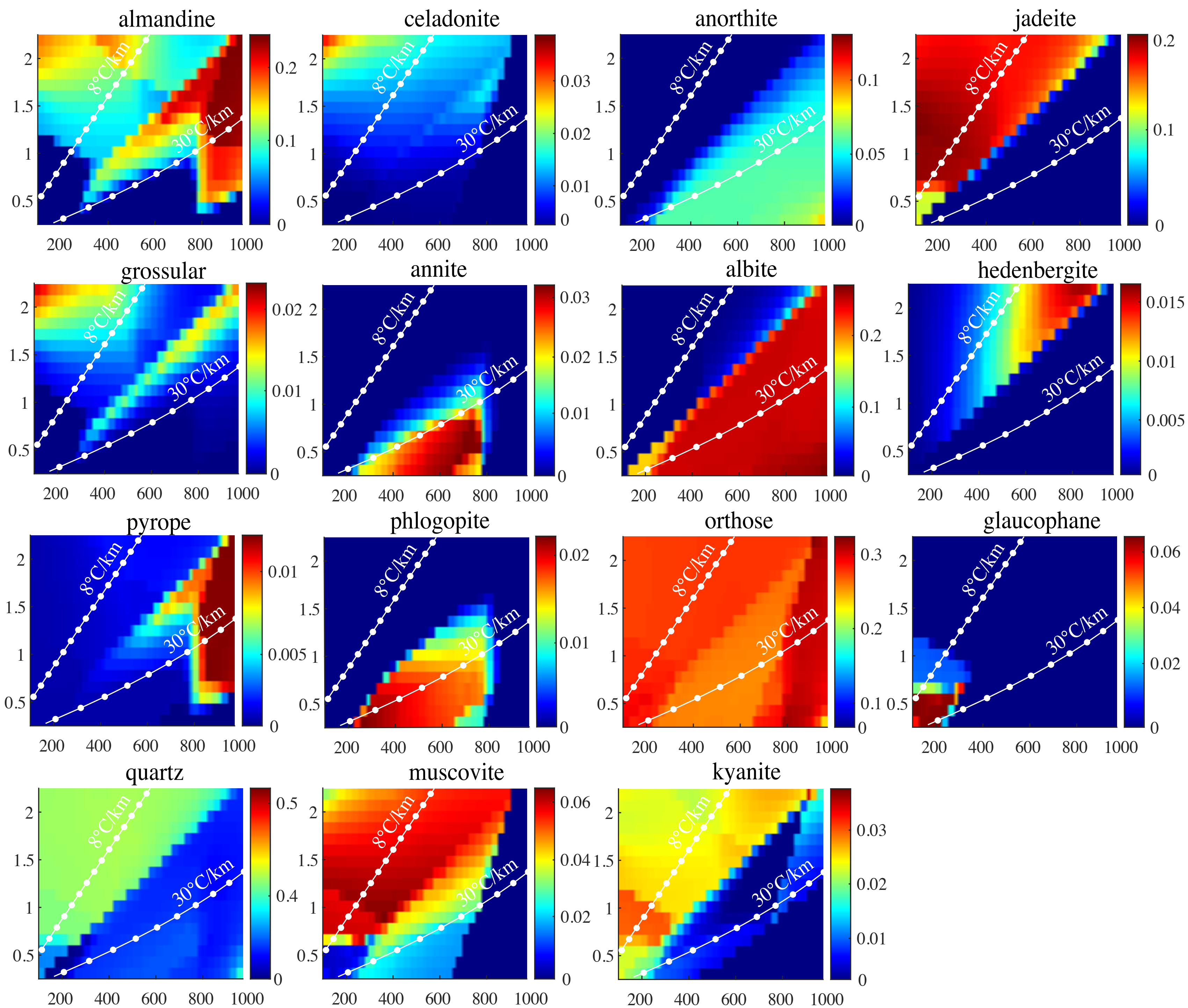


Modified from Agard 2021

Modeling the evolution of seismic properties of rocks during burial

Map of mineral phases at equilibrium as a function of PT for a given chemistry, derived from thermodynamic models. (7BGP20 sample)



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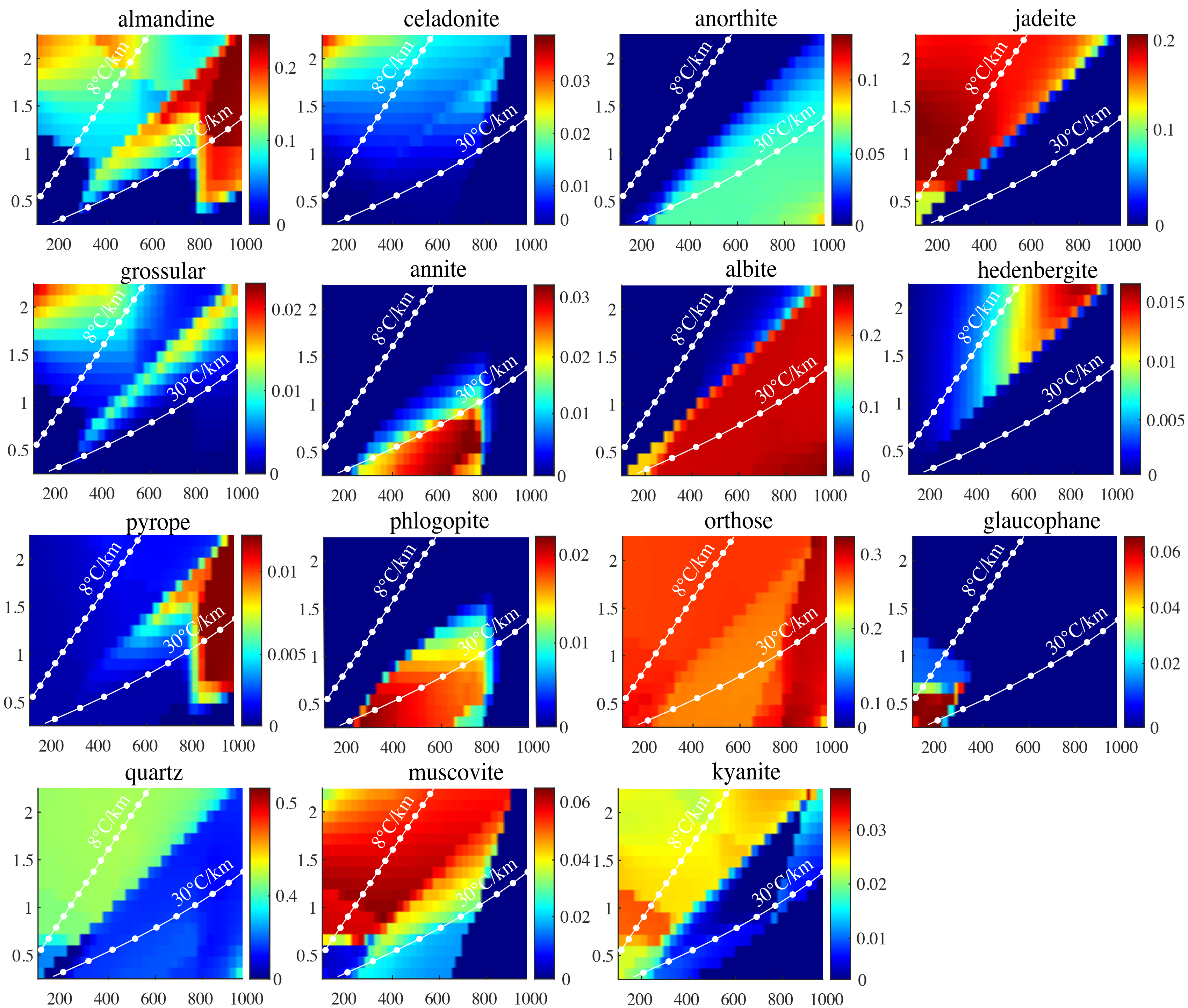
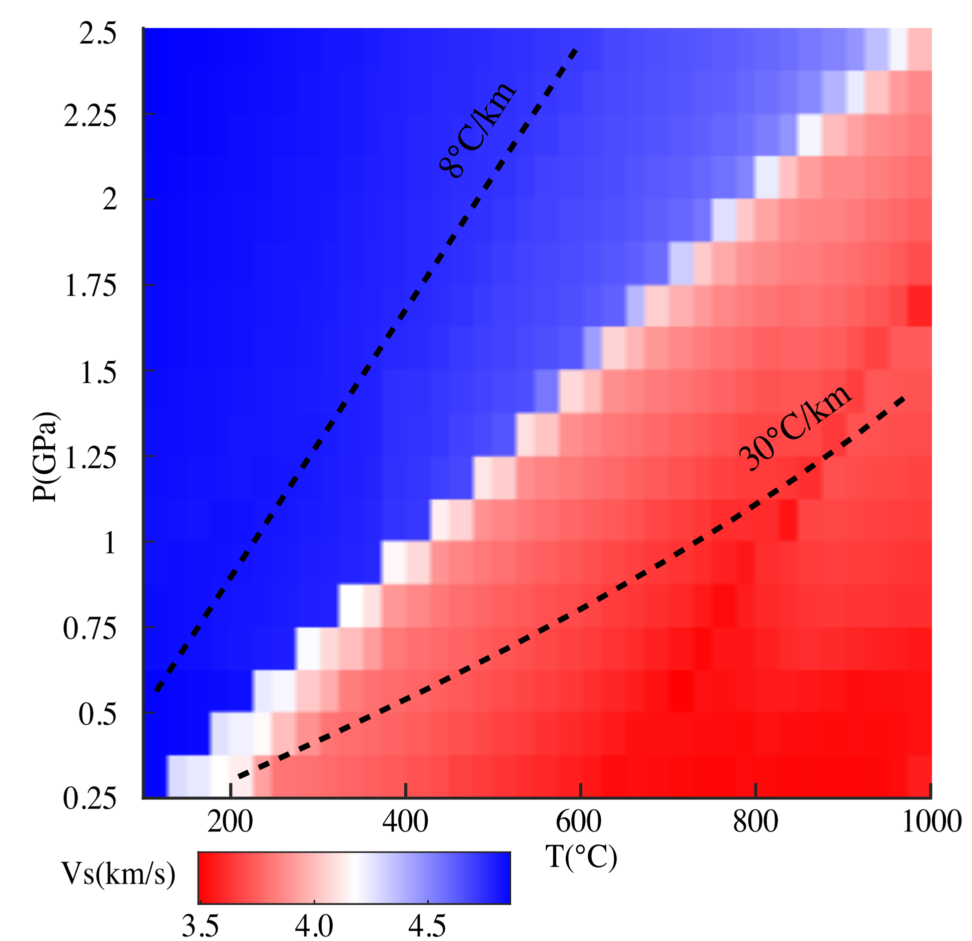


Resulting velocity map, calculated from single crystal elastic tensors.



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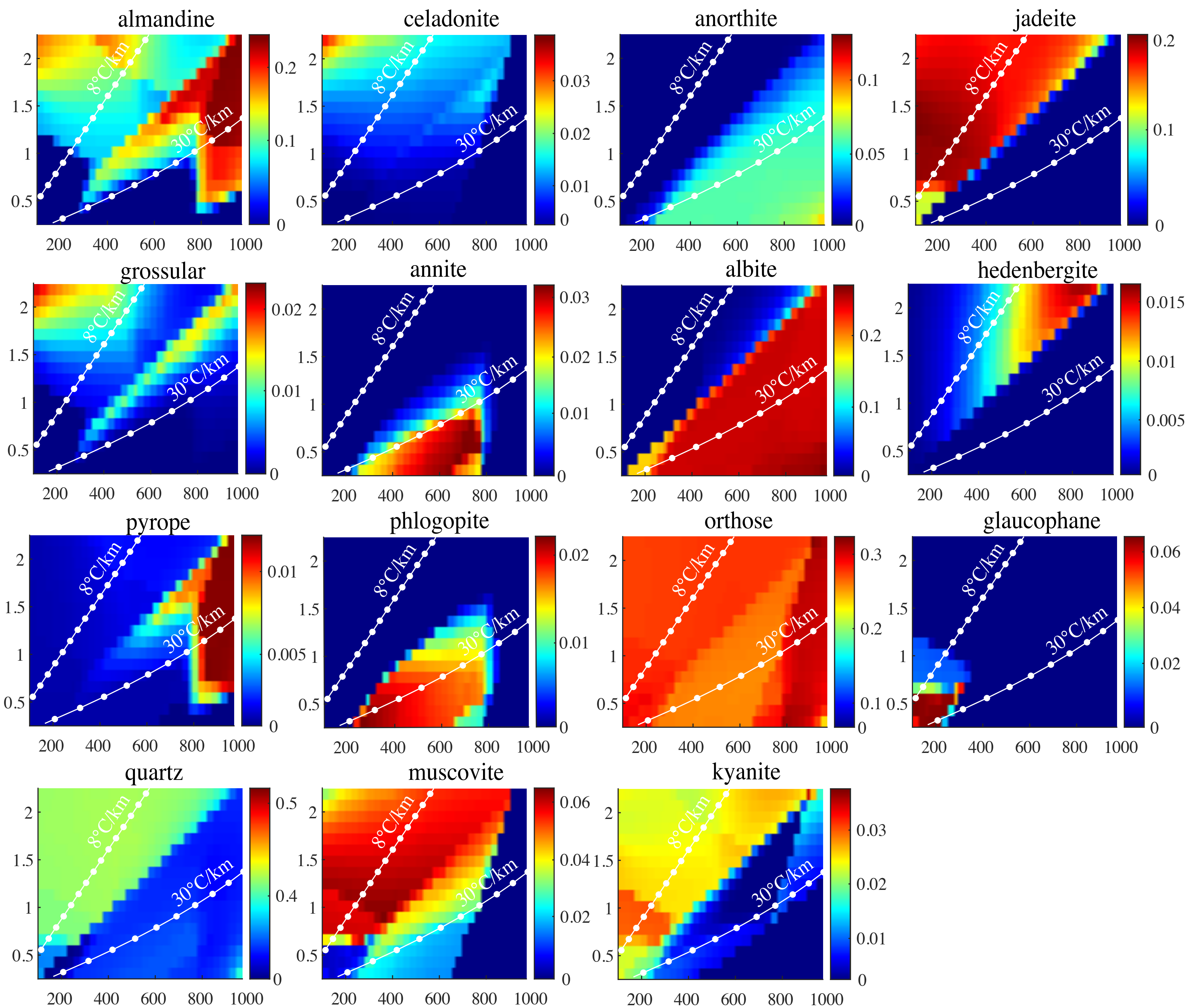

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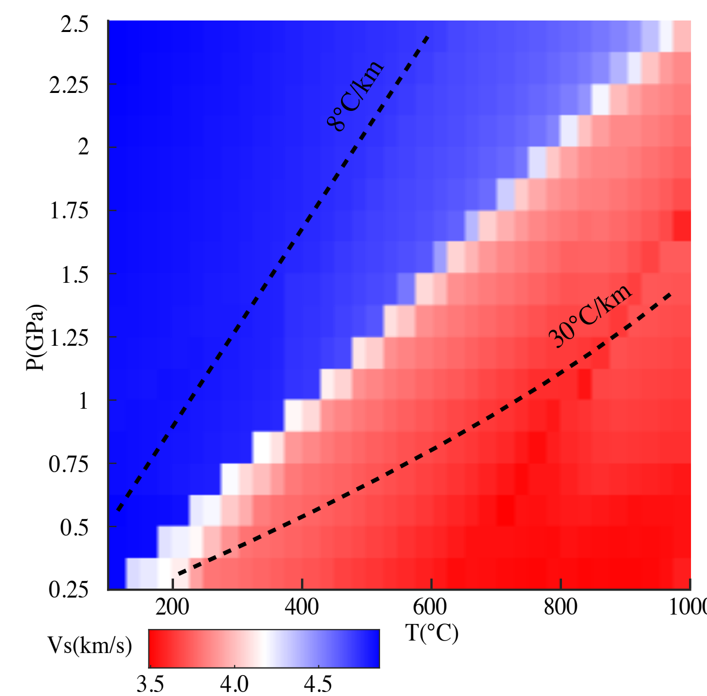
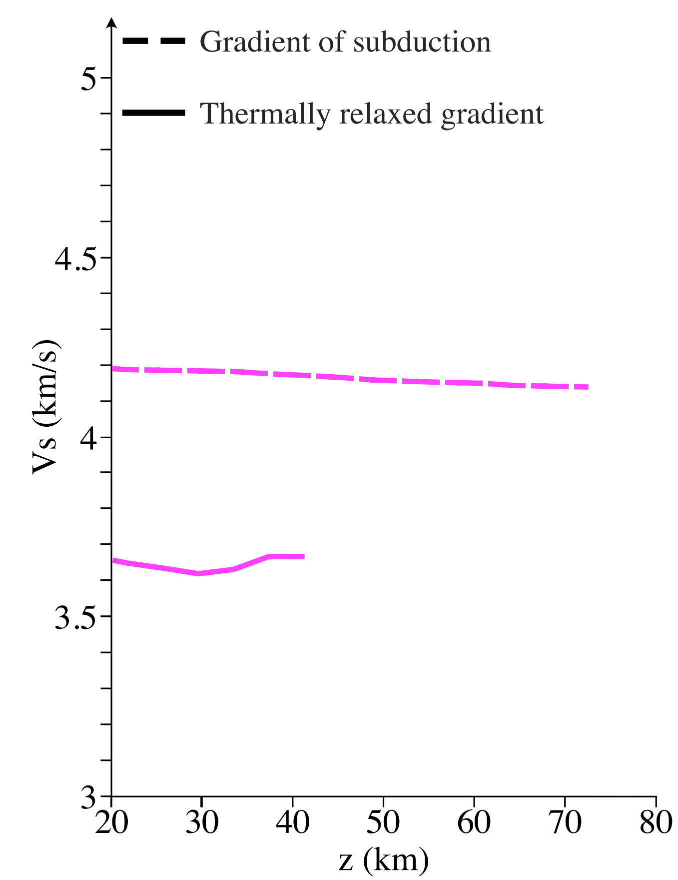
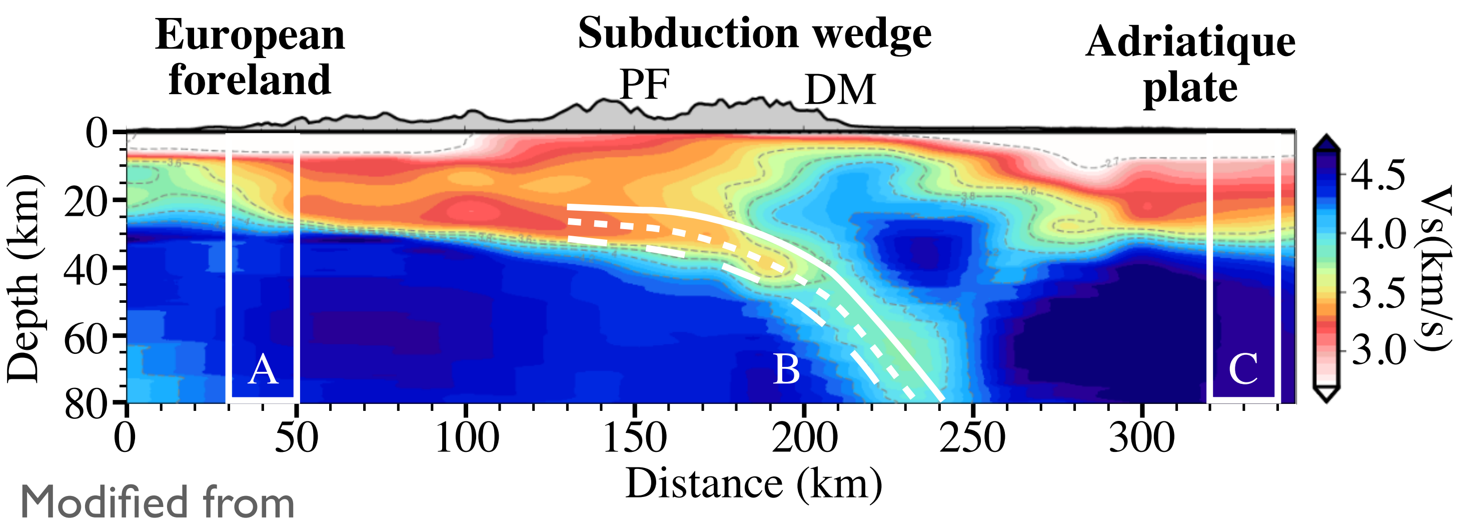




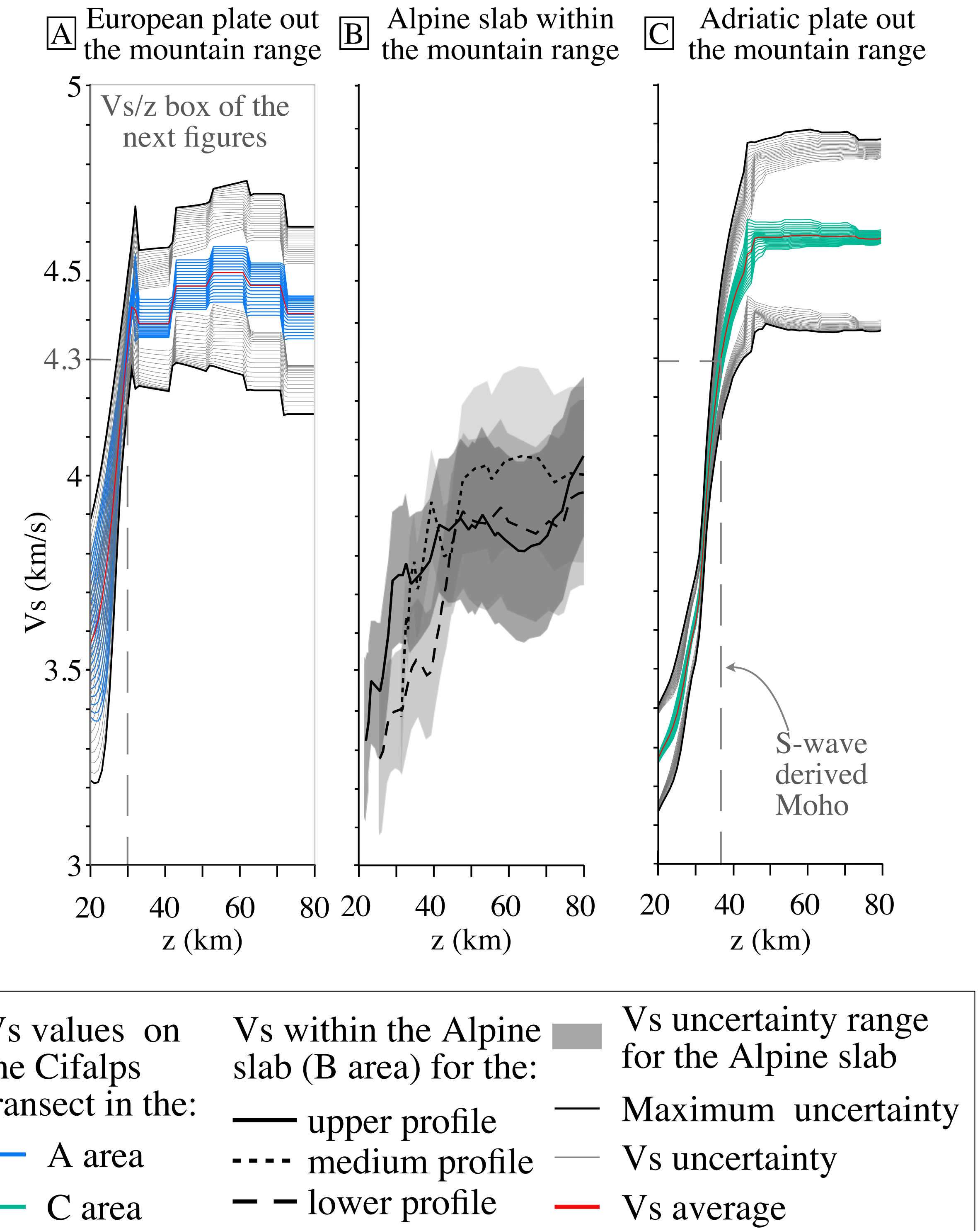
Compare modeled seismic properties with those from ambiant noise tomography model

Location of the areas and profiles from which are extracted the velocities Vs and the associated uncertainties.

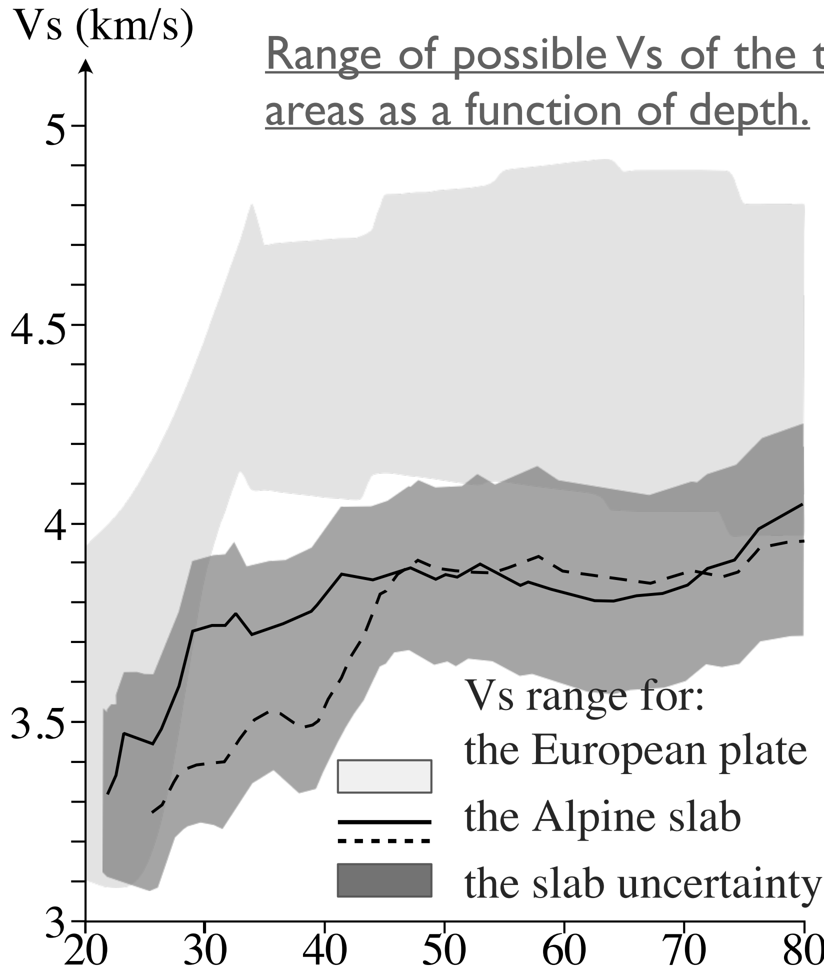


Modified from Nouibat et al., in press

S-wave velocity profiles as function of depth extracted from the tomographic Cifalps transect.



Range of possible Vs of the targeted areas as a function of depth.



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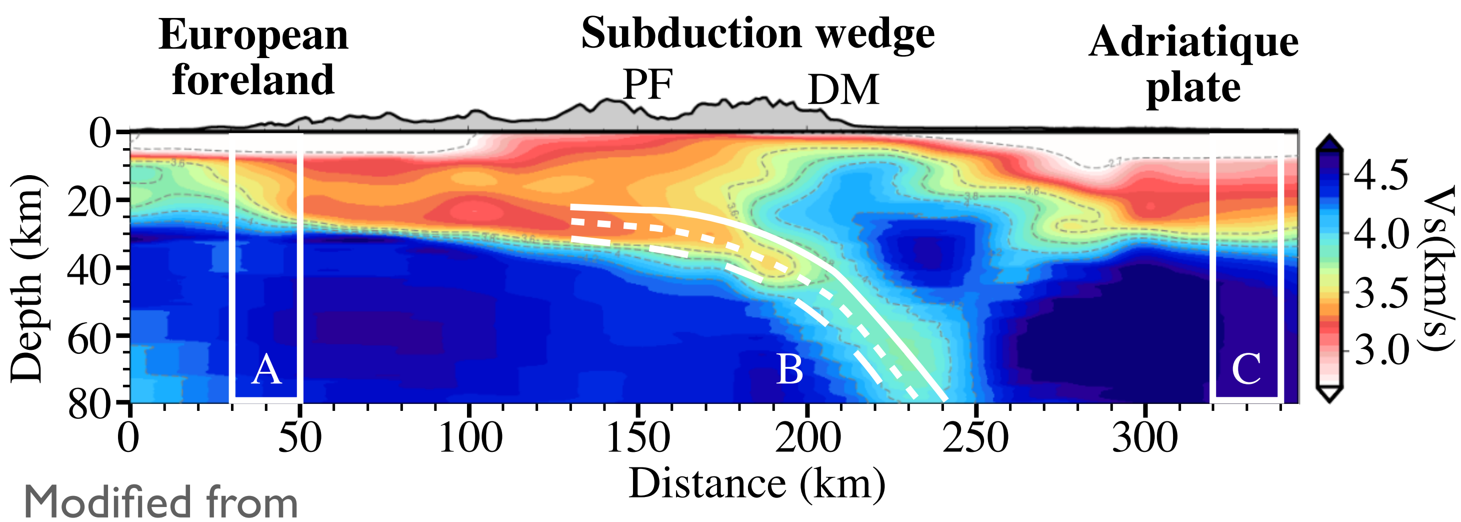

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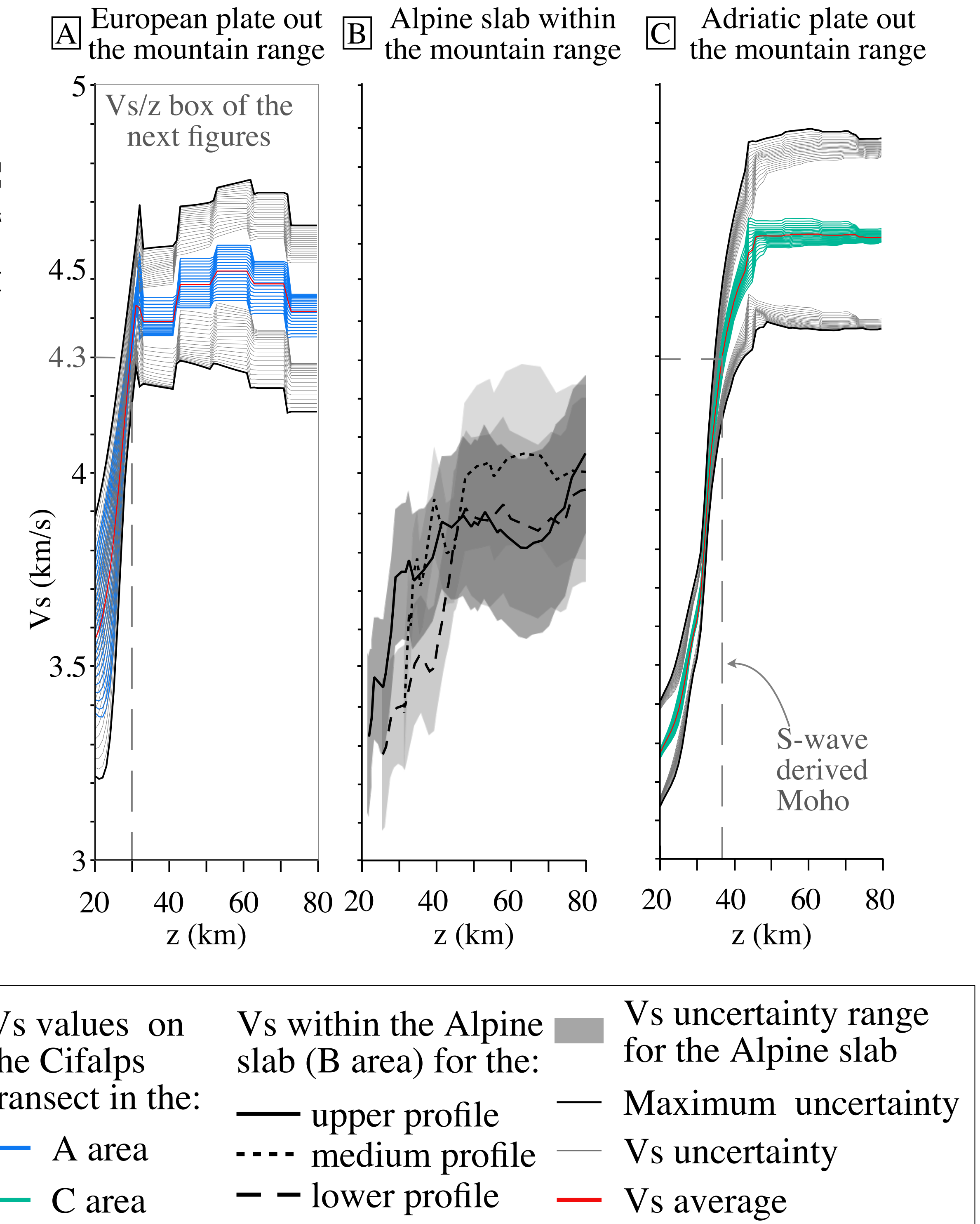

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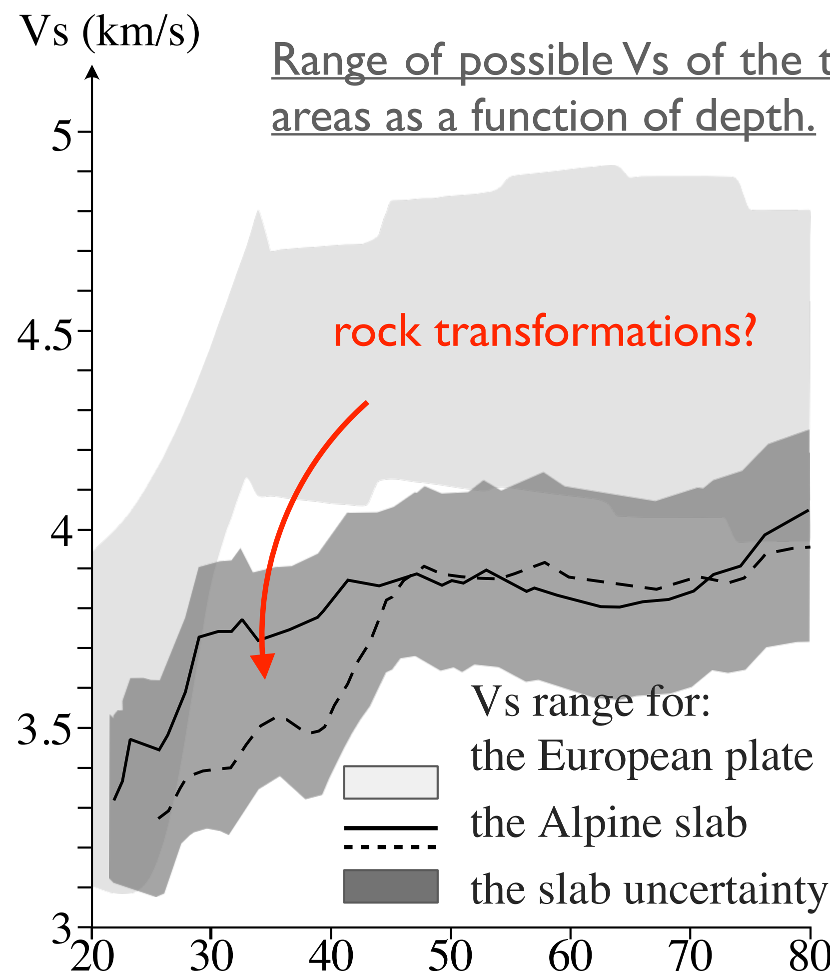
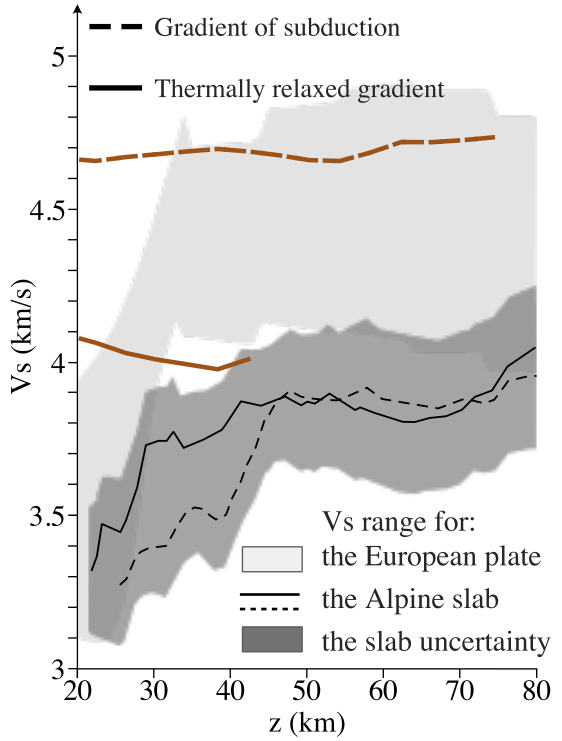
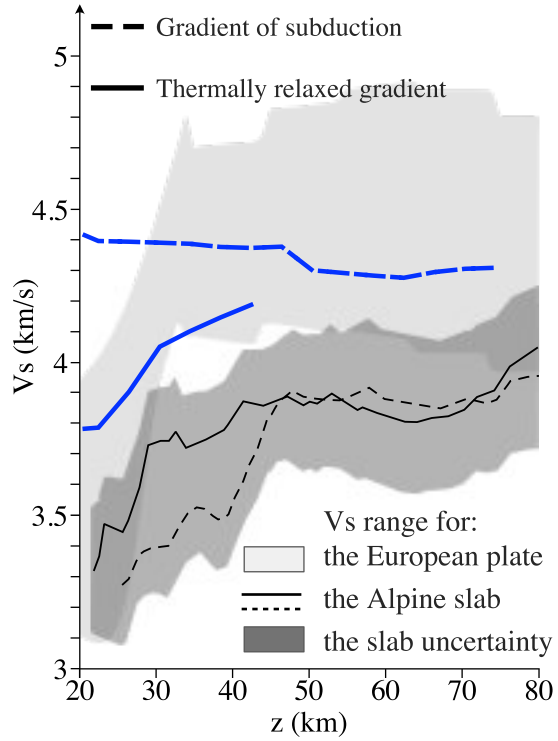


Compare modeled seismic properties with those from ambiant noise tomography model

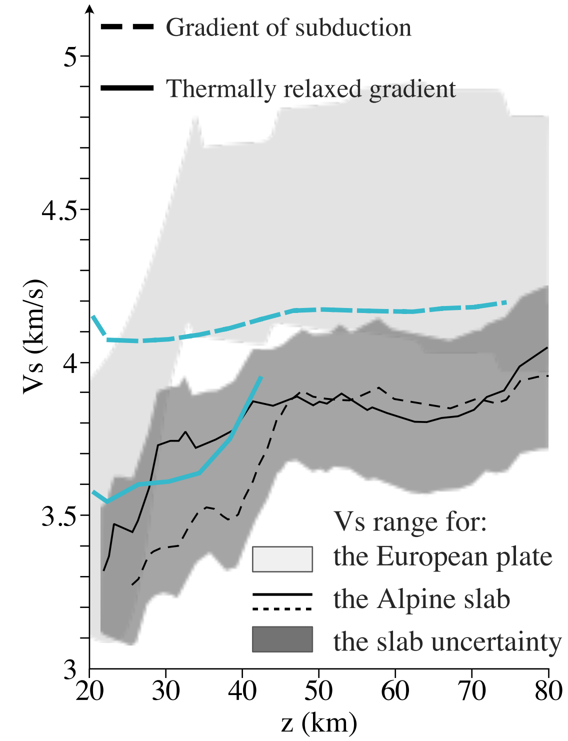
2AIV20 composition:
44.5%SiO2 22%Al2O3 14.5%FeO 5.1%MgO
6%CaO 3.1%Na2O 0.2%K2O LOI = 0.4%



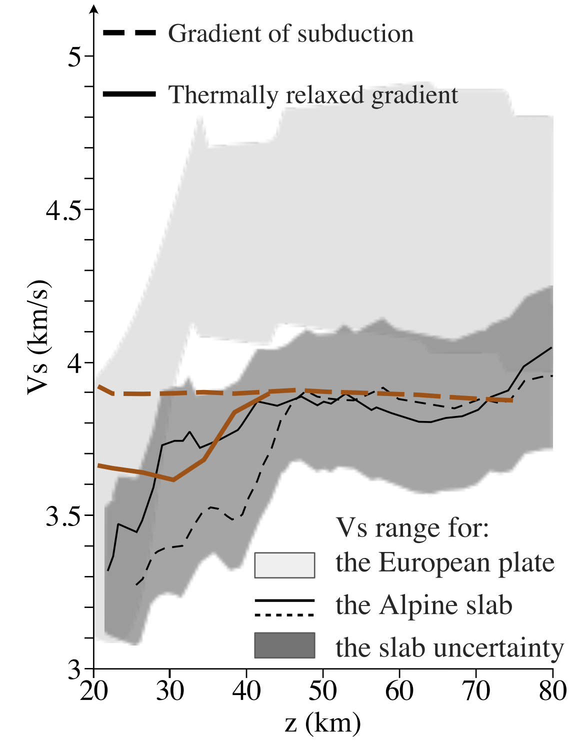
3COR21 composition:
56.25%Si2O 15.9%Al2O3 7.6%FeO 3.8%MgO
4.6%CaO 1.7%Na2O 1.5%K2O LOI = 4.7%



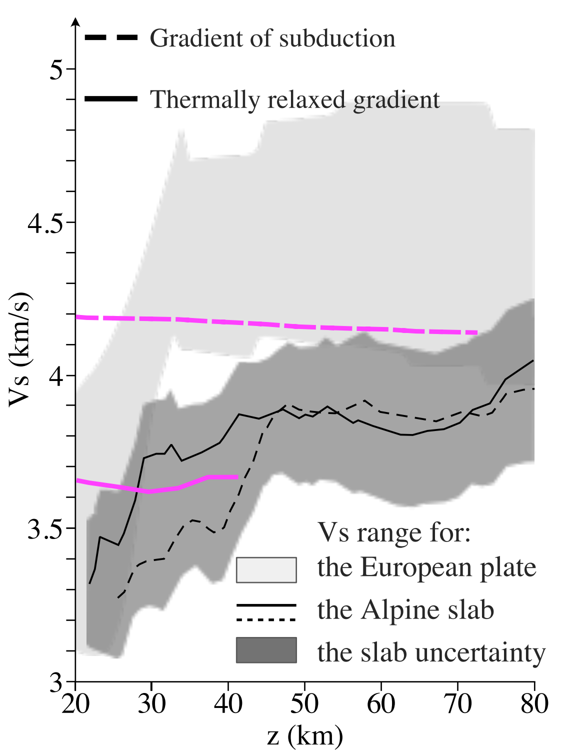
4ALZ20 composition:
56.6%SiO2 16.5%Al2O3 8.4%FeO 4.3%MgO
3%CaO 3%Na2O 2.3%K2O LOI = 3.2%



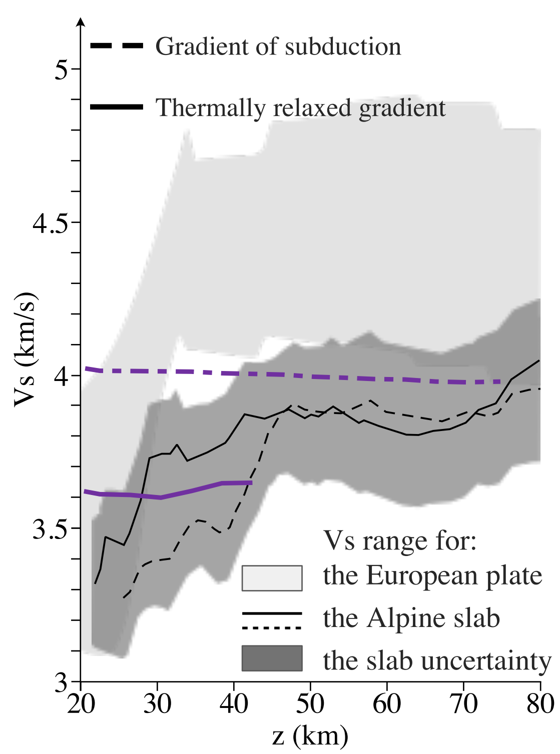
7IV20 composition:
68.8%Si2O 15.5%Al2O3 2.4%FeO 1.3%MgO
1.2%CaO 0.8%Na2O 5.3%K2O LOI = 3.5%



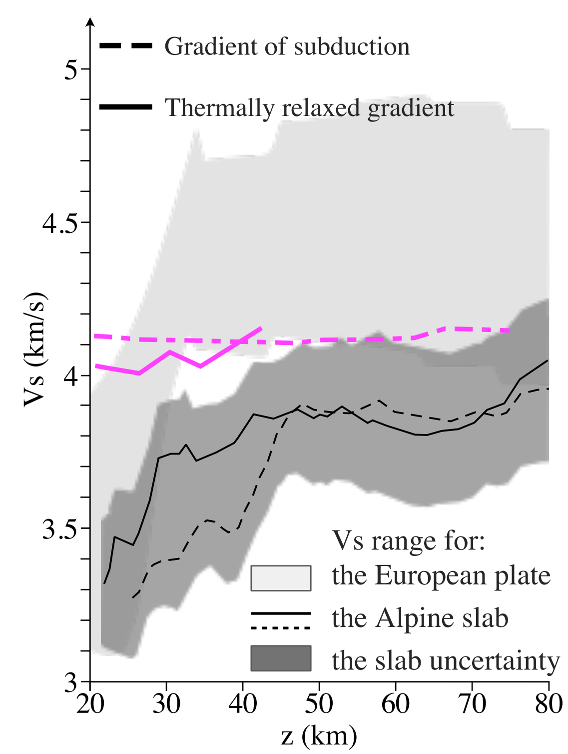
7BGP20 composition:
72.7%Si2O 14.4%Al2O3 1.25%FeO 0.5%MgO
1.8%CaO 4.1%Na2O 3.1%K2O LOI = 0.4%



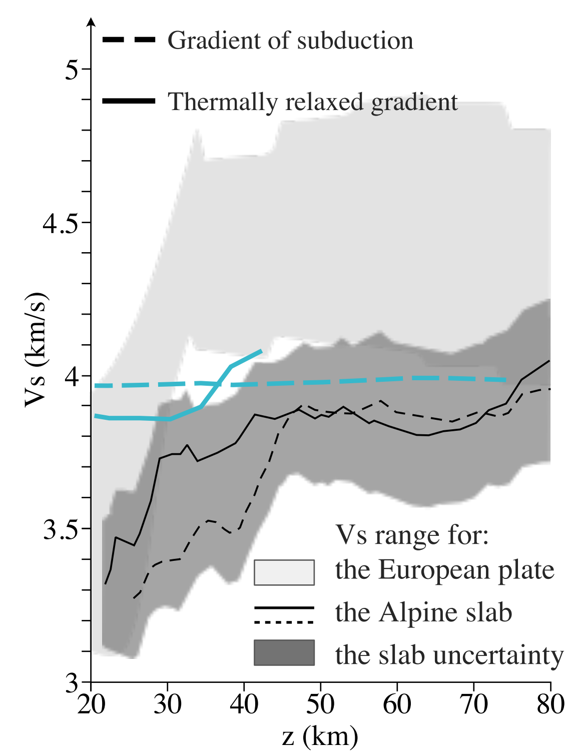
11GR21 composition:
73.5%Si2O 14.1%Al2O3 1.6%FeO 0.5%MgO
1.3%CaO 3%Na2O 5%K2O LOI = 0.7%



15GP20 composition:
76.45%Si2O 5.4%Al2O3 3.15%FeO 1.2%MgO
6.6%CaO 0.04%Na2O 1.13%K2O LOI = 5.4%



5LZ20 composition:
83.75%SiO2 7.1%Al2O3 3.2%FeO 1%MgO
0.2%CaO 0.2%Na2O 2.4%K2O LOI= 1.5%



Compare modeled seismic properties with those from ambiant noise tomography model

Mafic lithologies are too fast to reproduce the observed seismic velocities !

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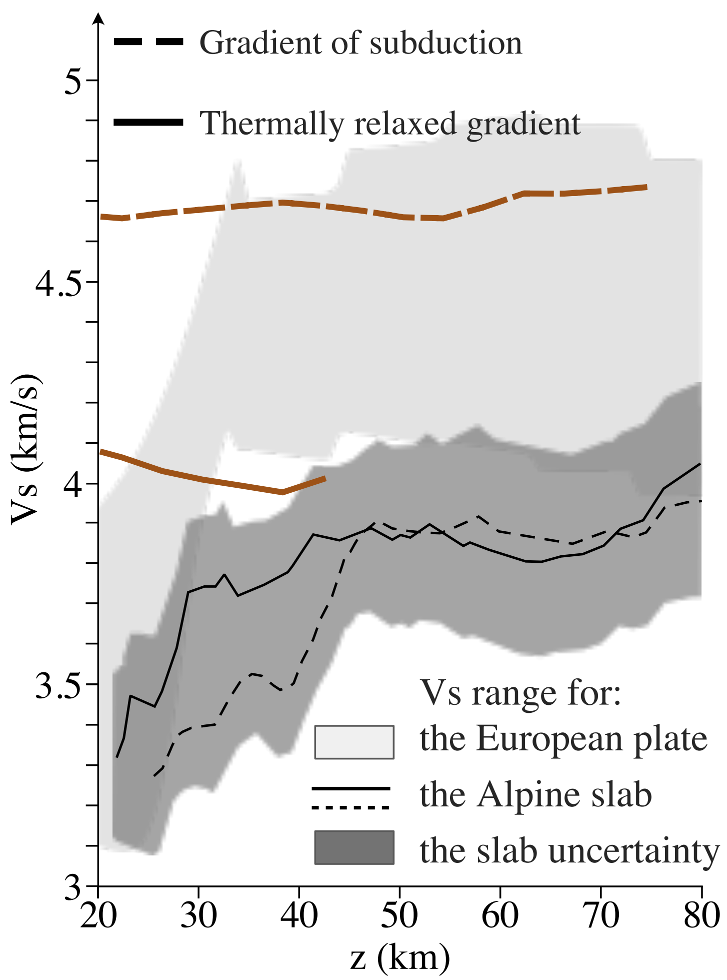
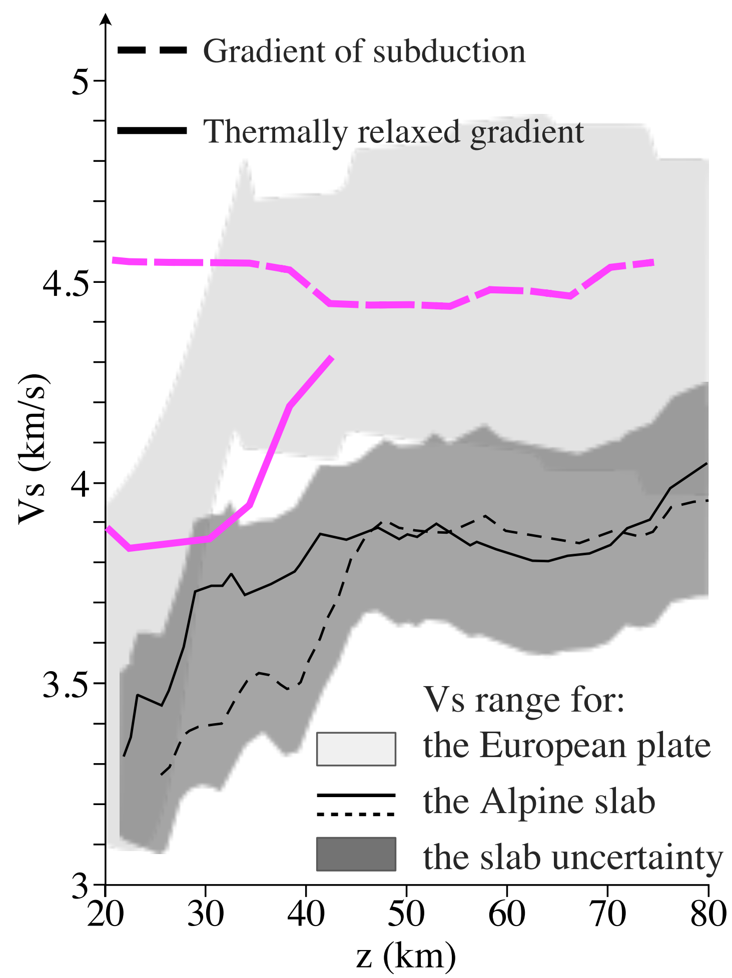
44.5%SiO2 22%Al2O3 14.5%FeO 5.1%MgO
6%CaO 3.1%Na2O 0.2%K2O LOI = 0.4%



29GP20 composition:
49.7%Si2O 15.6%Al2O3 10.6%FeO 9%MgO
7%CaO 3.4%Na2O 0.2%K2O LOI = 2.9%



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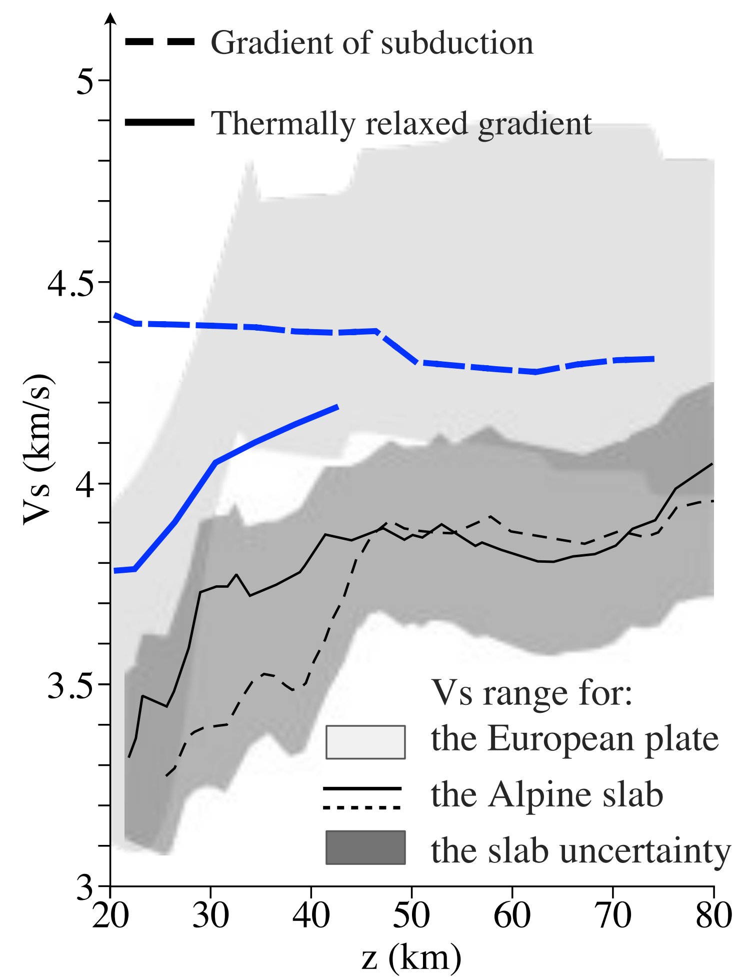
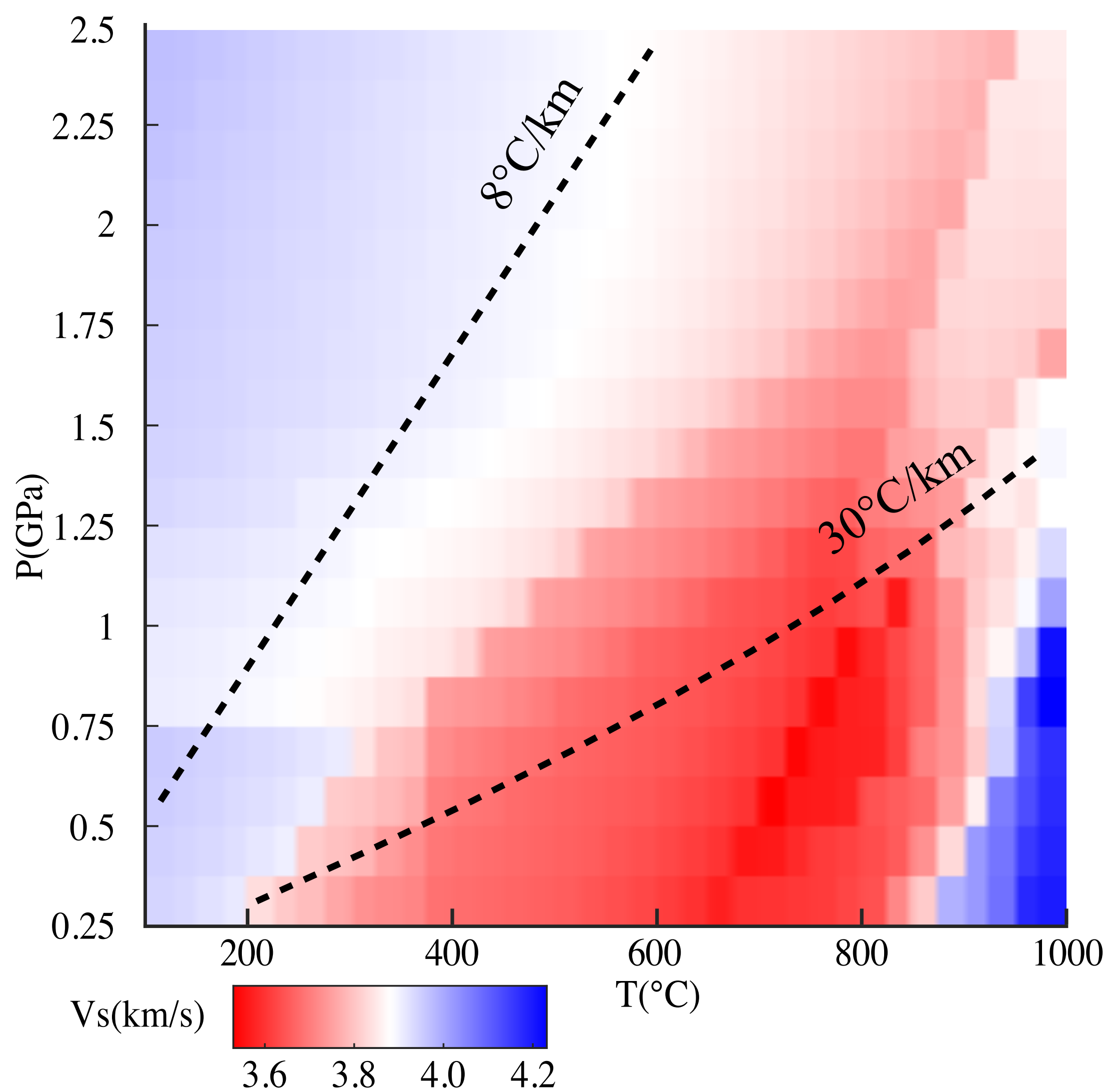


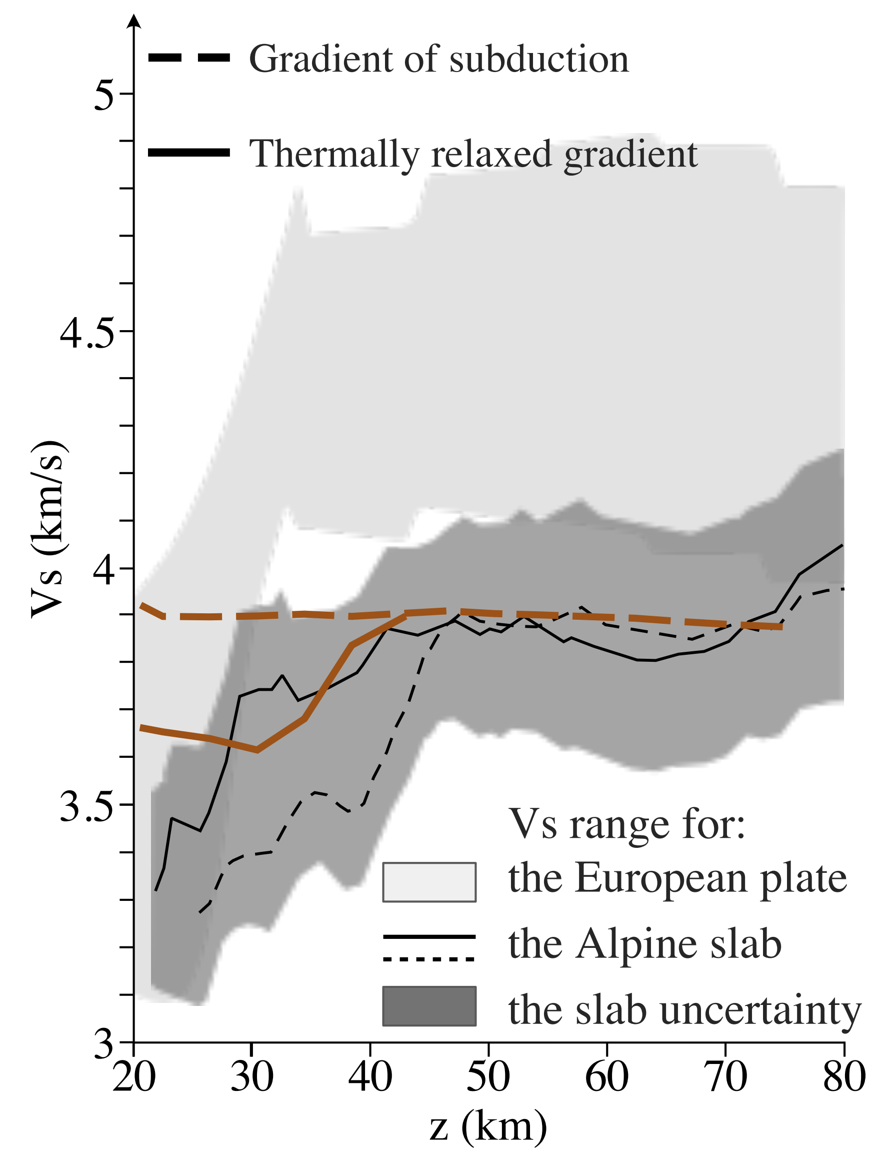
Compare modeled seismic properties with those from ambiant noise tomography model

The seismic contrast may be due to **the entrance of rocks into HP the granulites facies along the collision gradient.**

7IV20 composition:

68.8%Si2O 15.5%Al2O3 2.4%FeO 1.3%MgO 1.2%CaO 0.8%Na2O 5.3%K2O LOI = 3.5%





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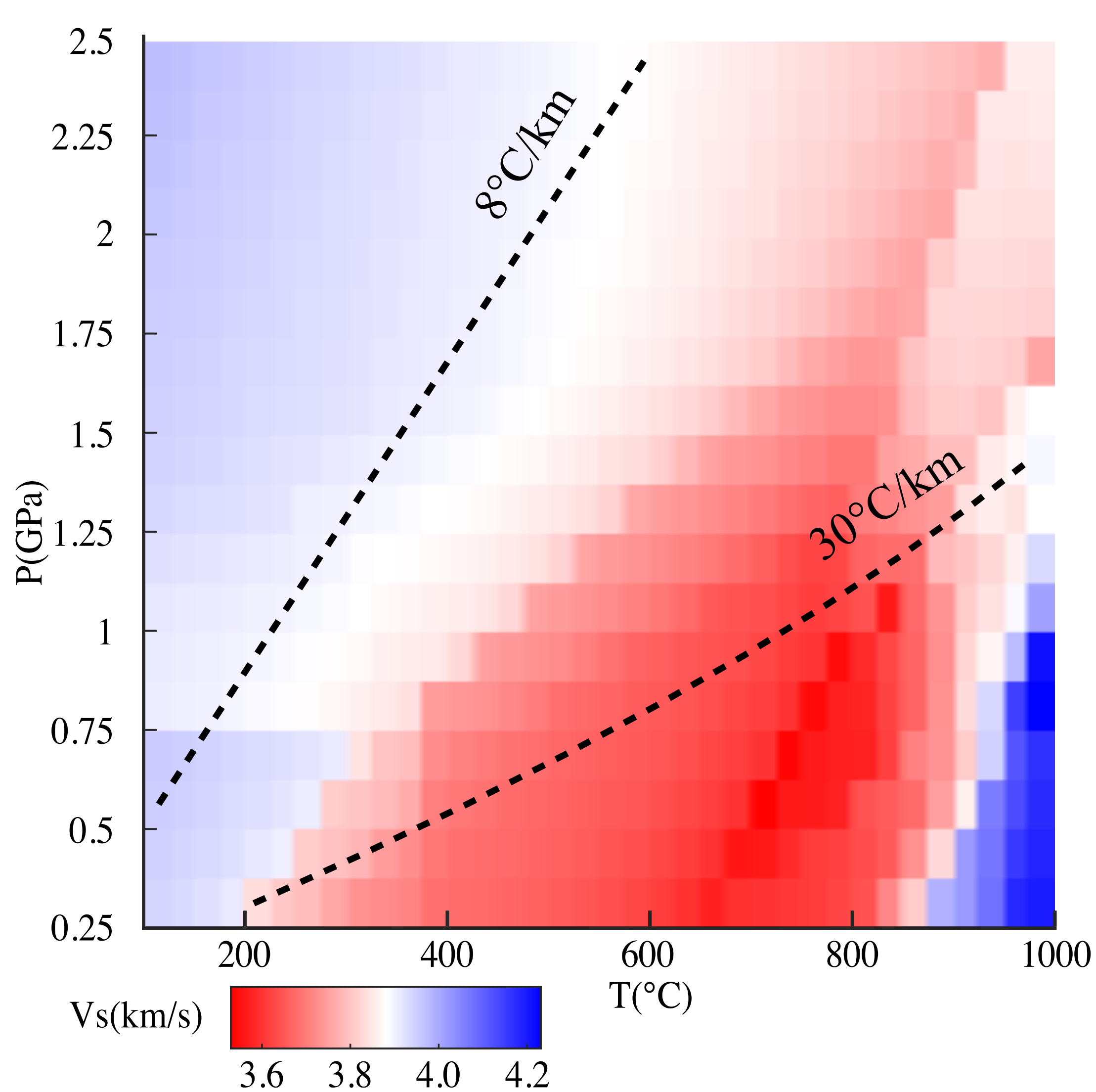

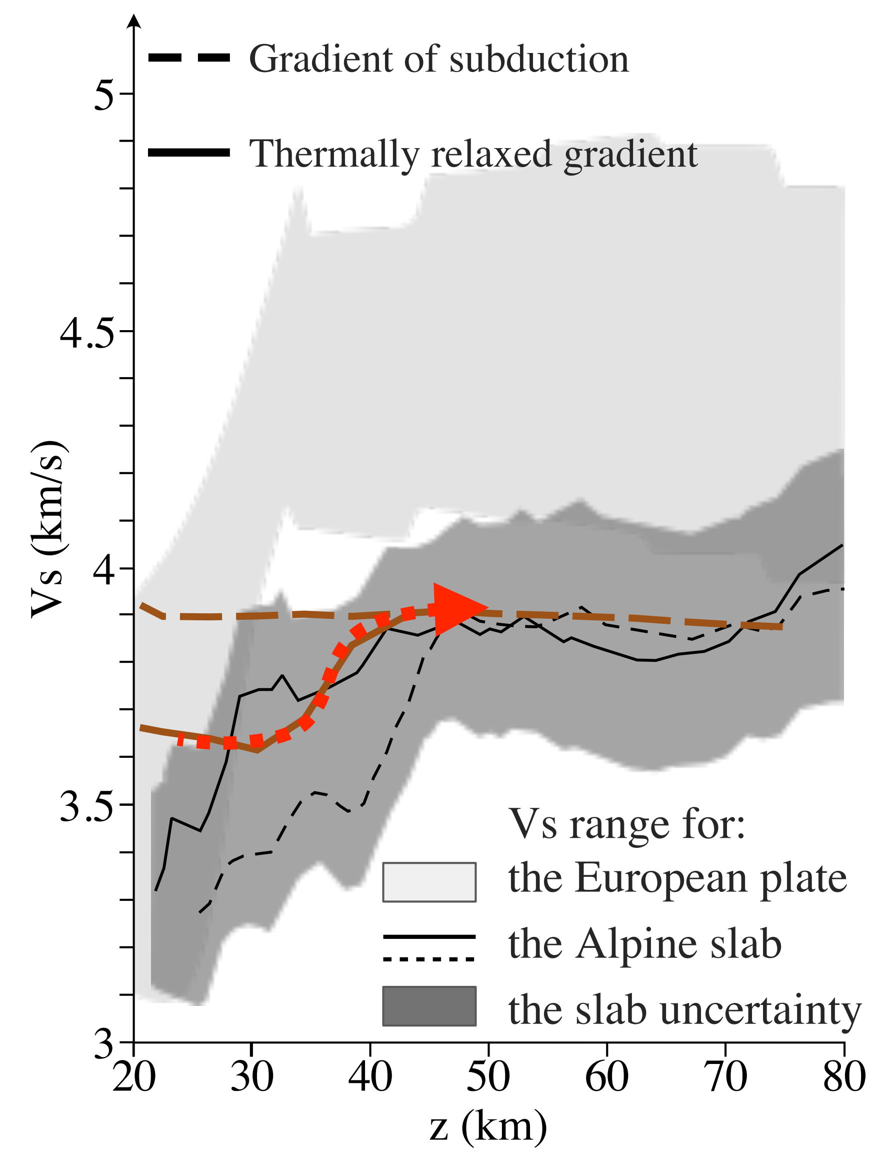

Compare modeled seismic properties with those from ambiant noise tomography model

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What's about kinetic effects ?

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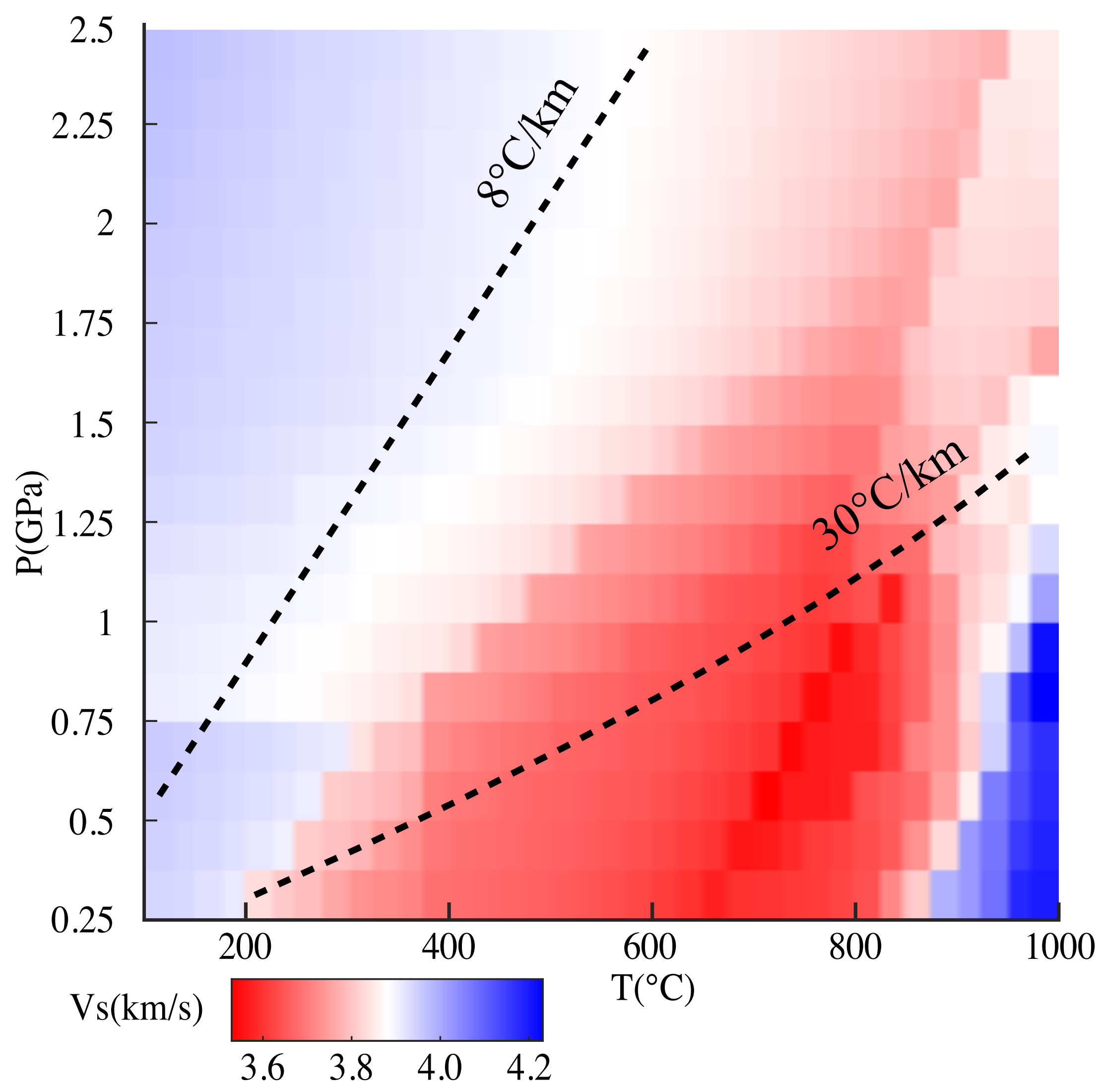

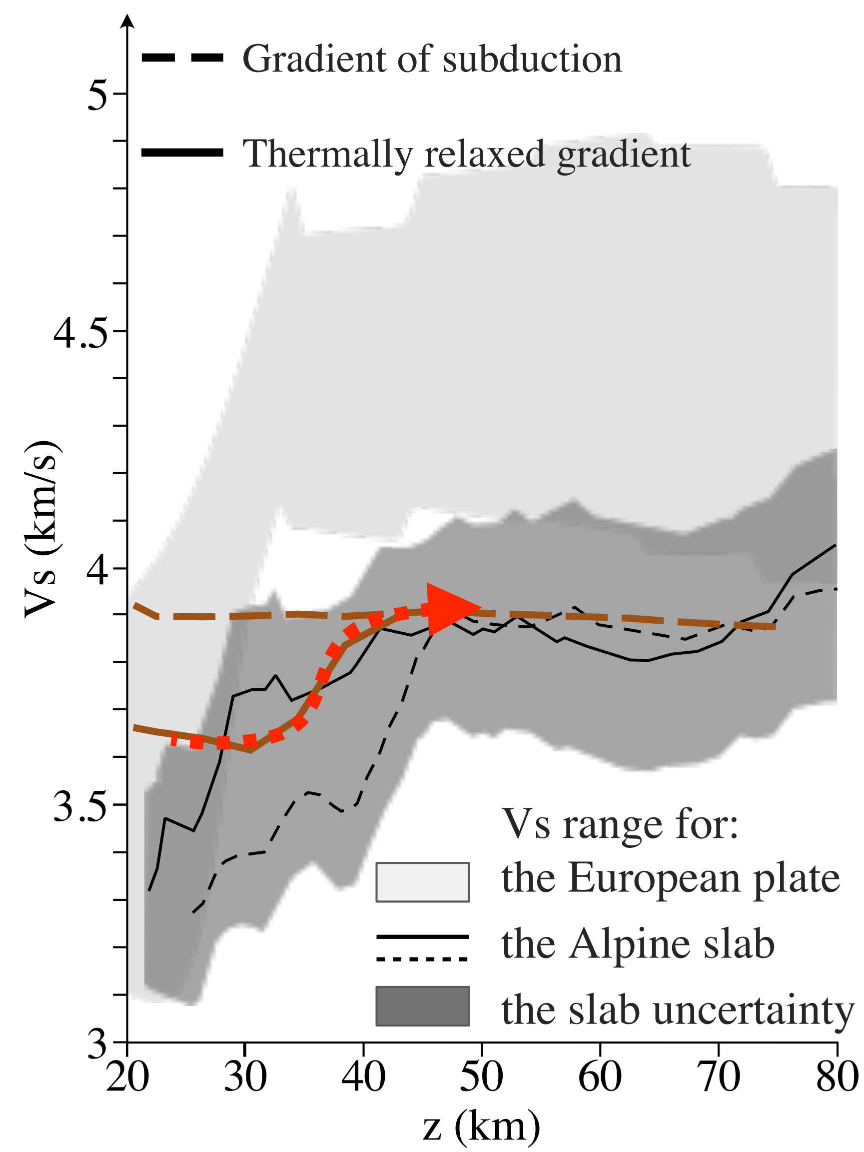

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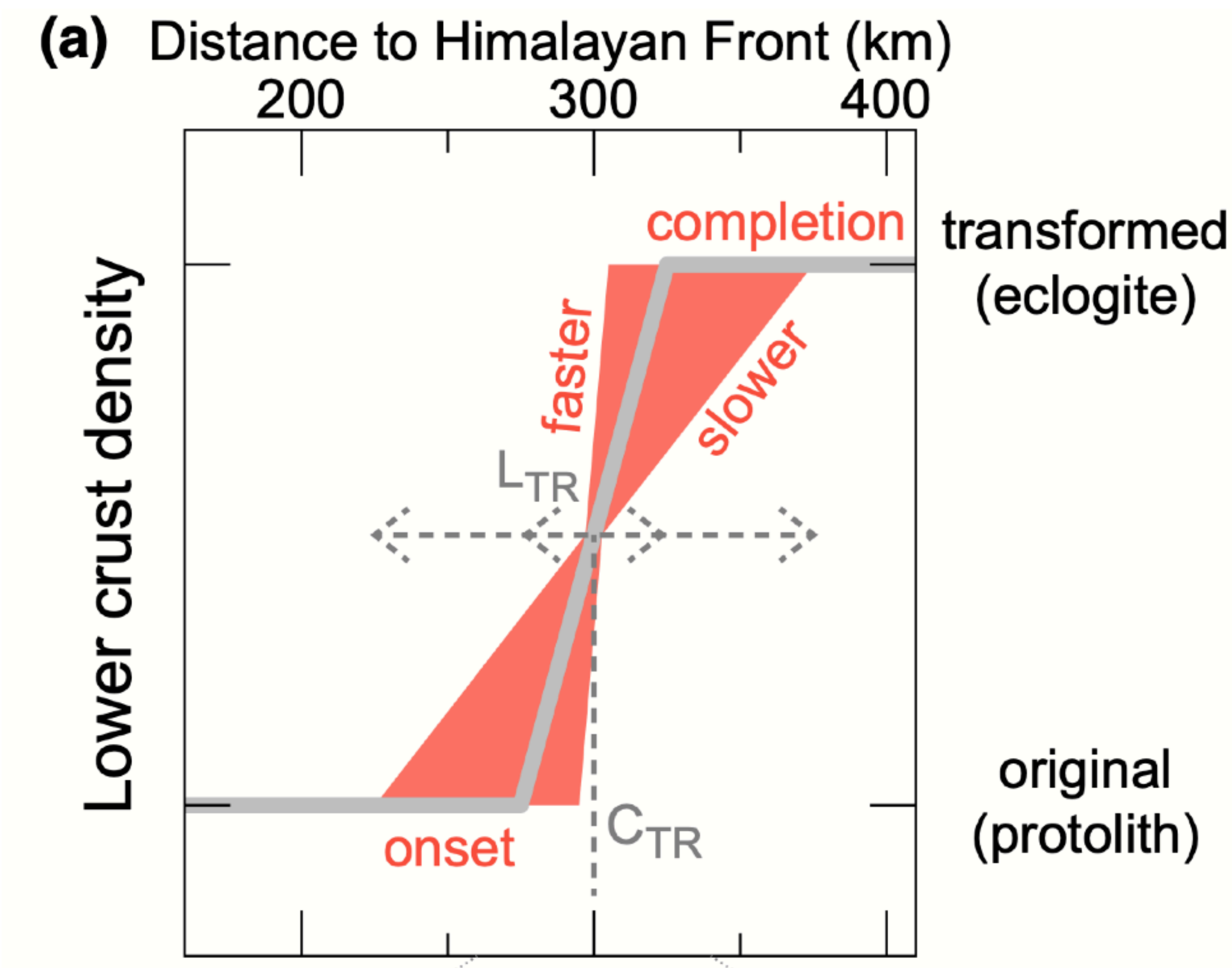
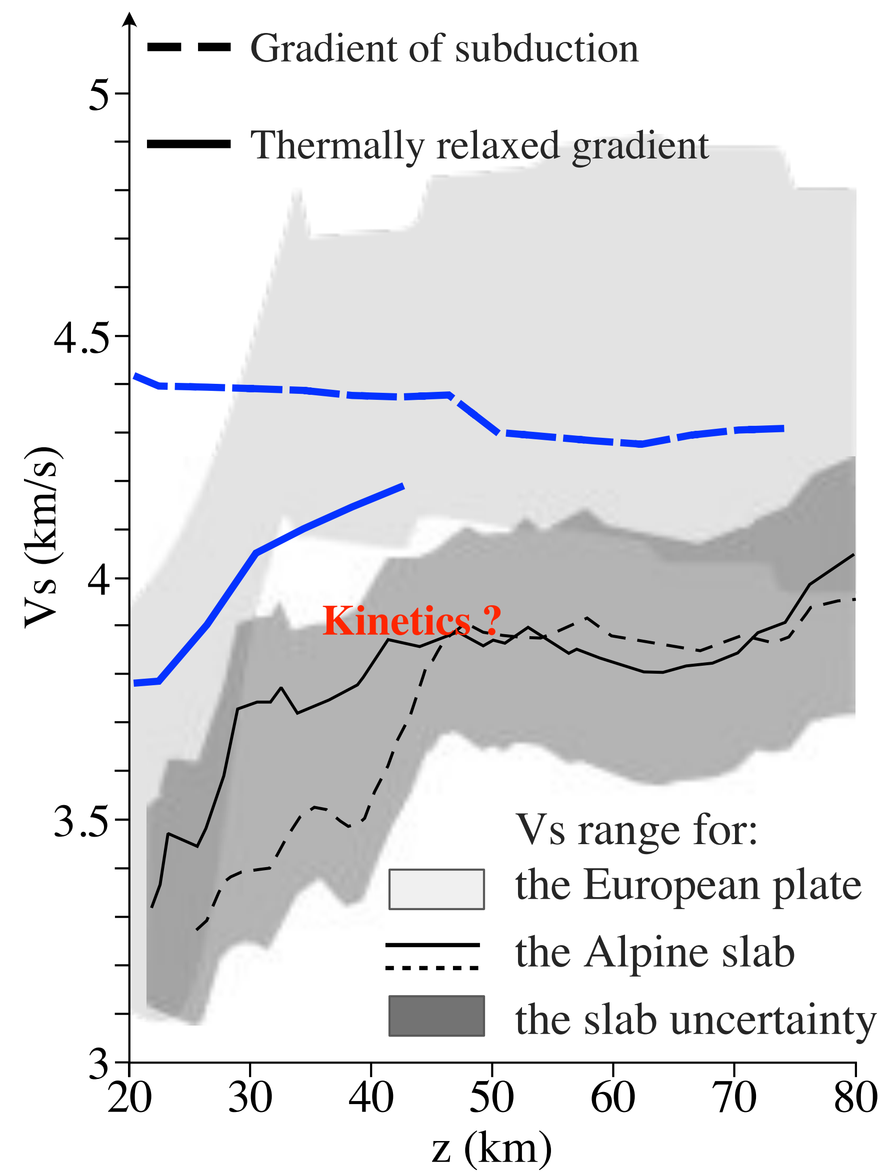


Hetényi et al., 2021



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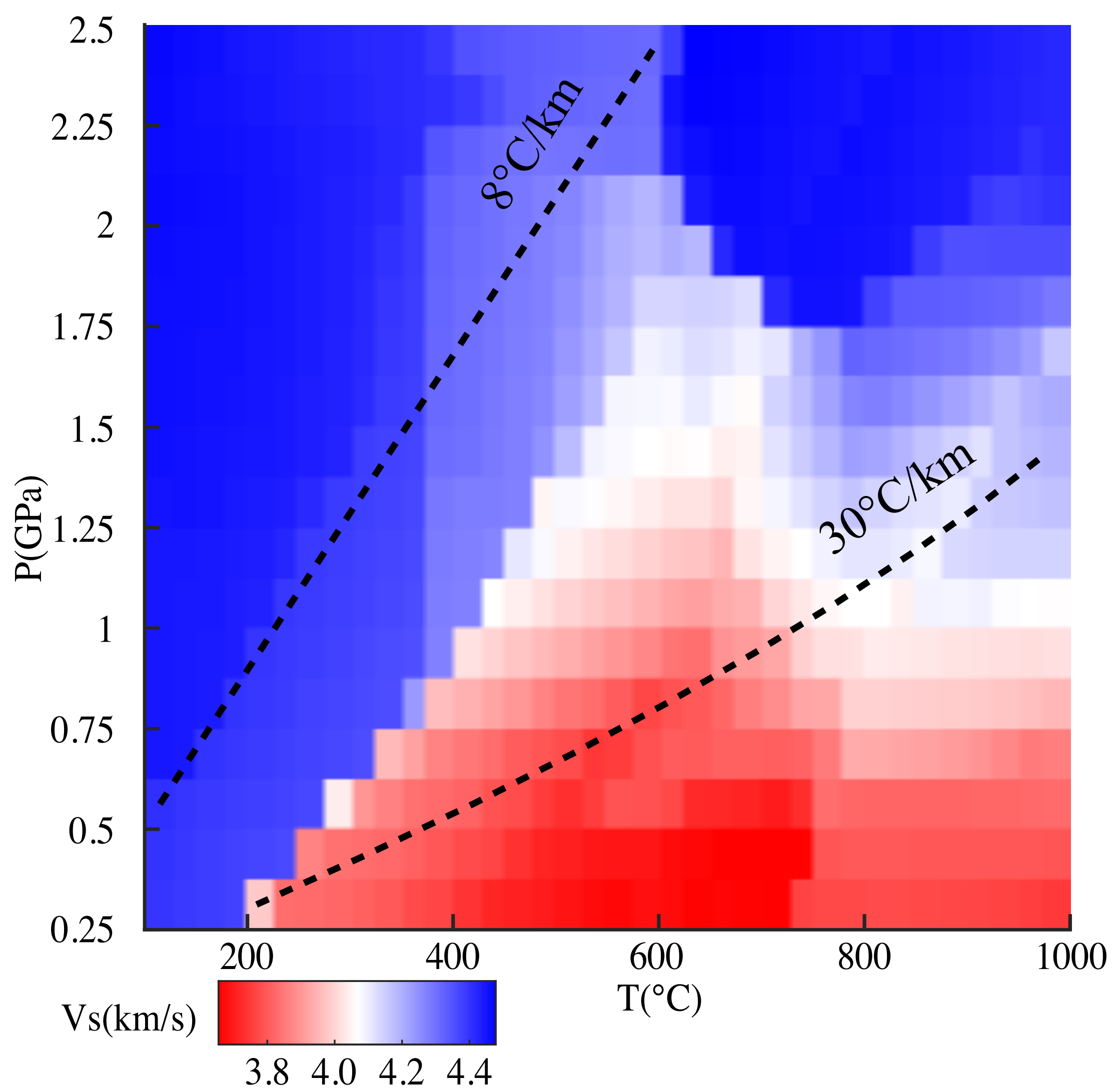
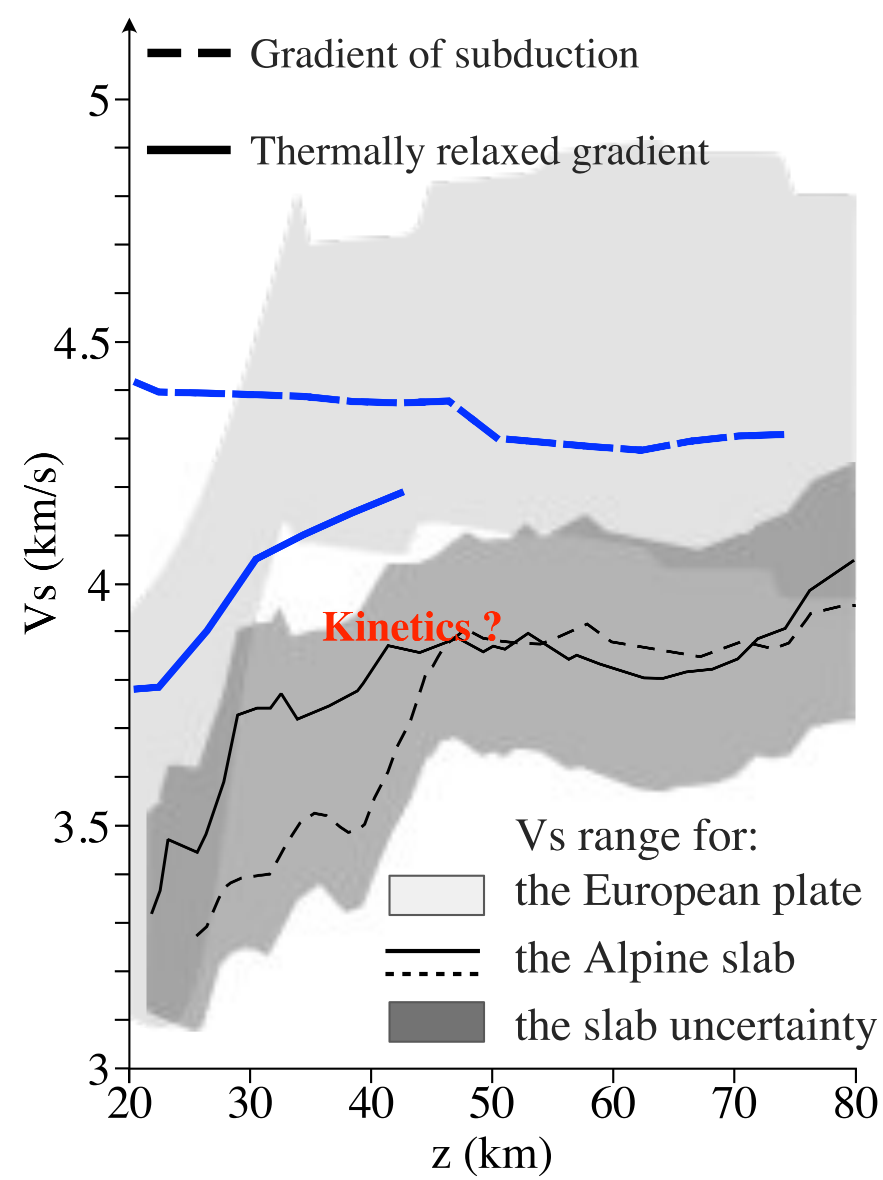
56.3%SiO_2 16%Al_2O_3 7.6%FeO 4.6%CaO 3.8%MgO 1.7%Na_2O 1.5%K_2O LOI = 4.7%



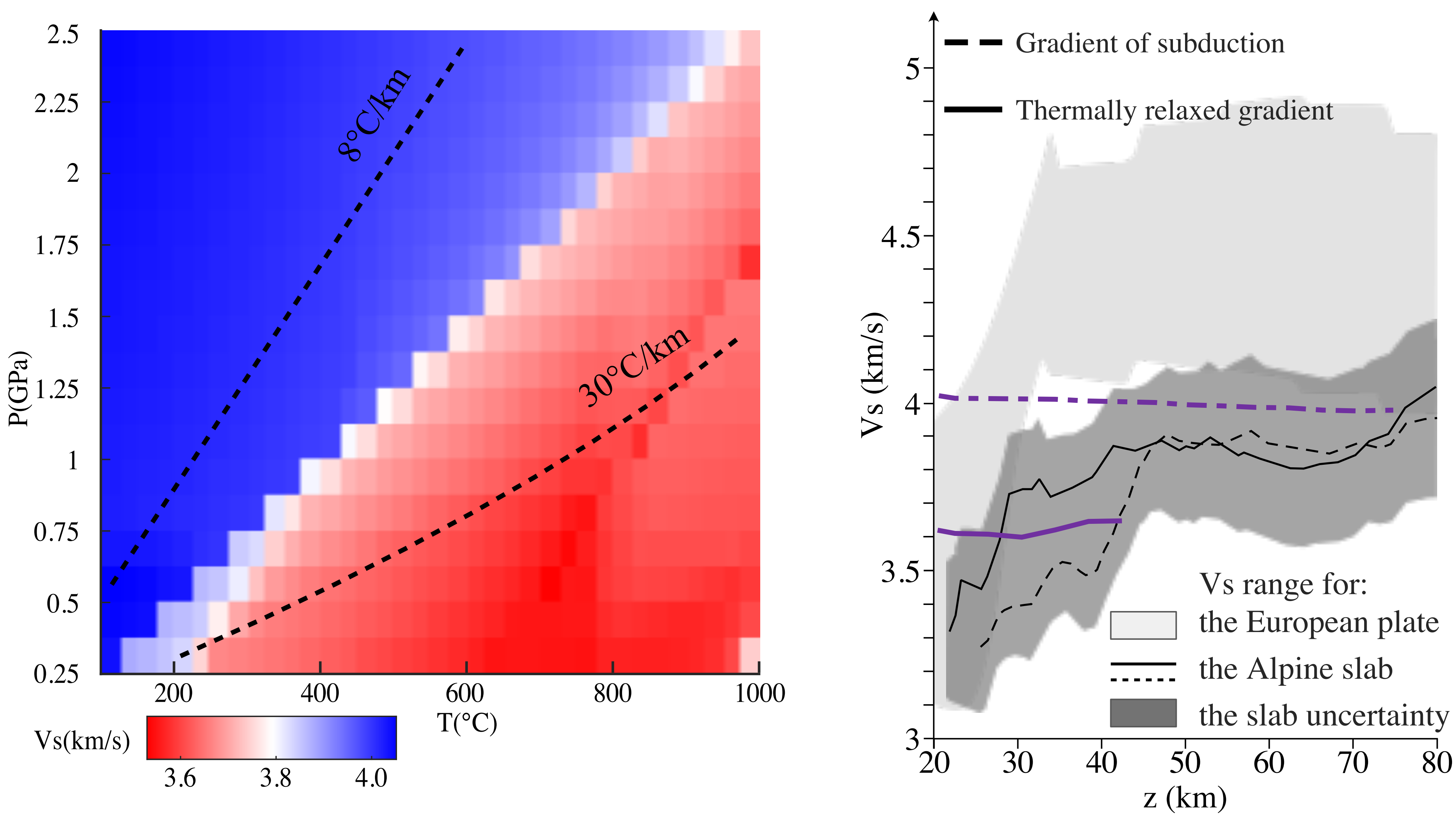


Compare modeled seismic properties with those from ambiant noise tomography model

The seismic contrast may be due to **the fossil record of the transition from subduction to collision gradient.**

11GR21 composition:

73.5%Si2O 14.1%Al2O3 1.6%FeO 0.5%MgO 1.3%CaO 3%Na2O 5%K2O LOI = 0.7%



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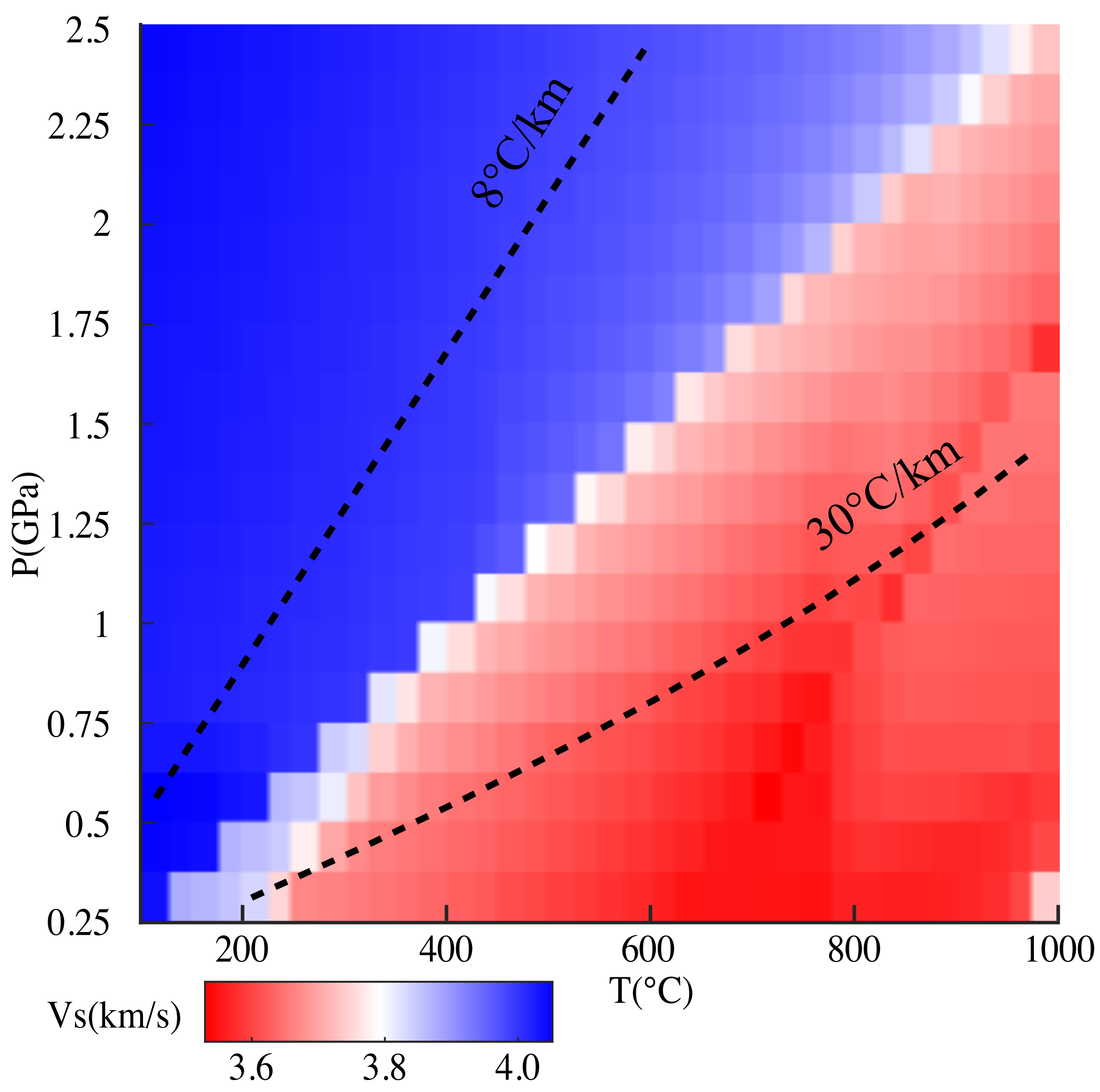

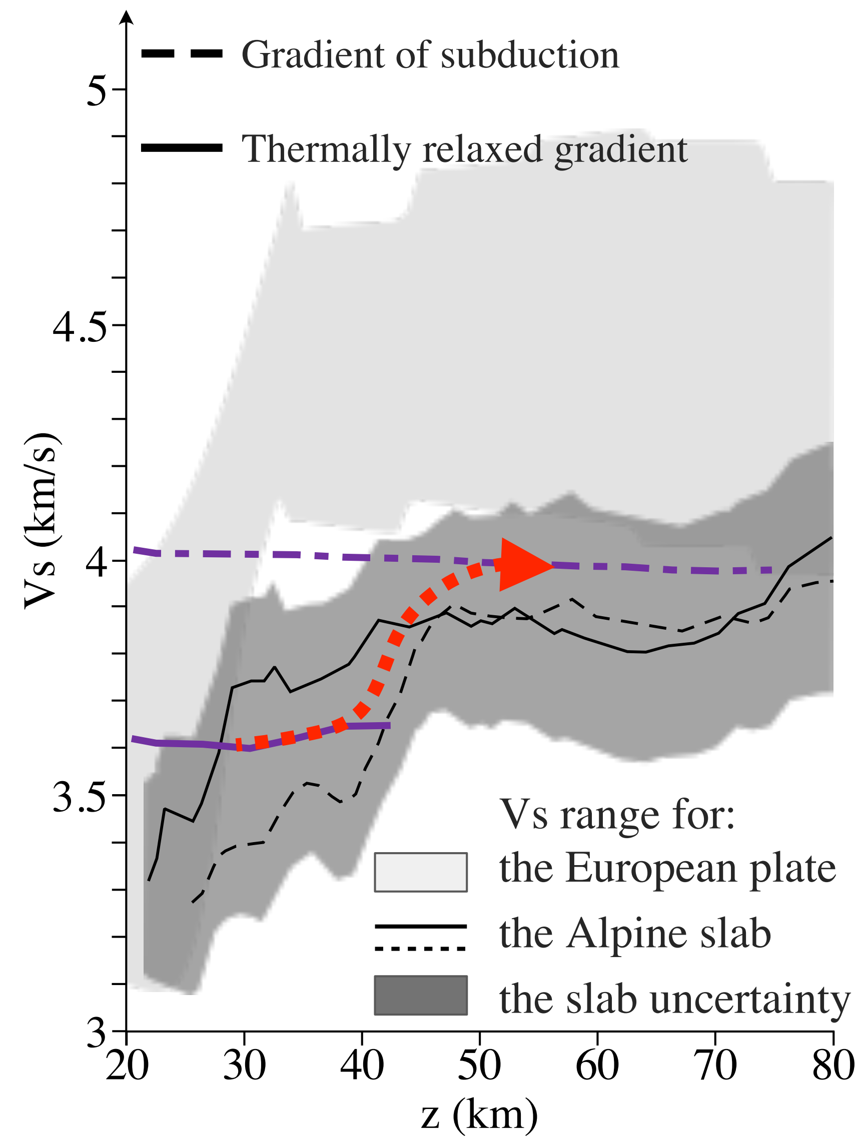

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What is the signature of an eclogite facies slab later thermally re-equilibrated?

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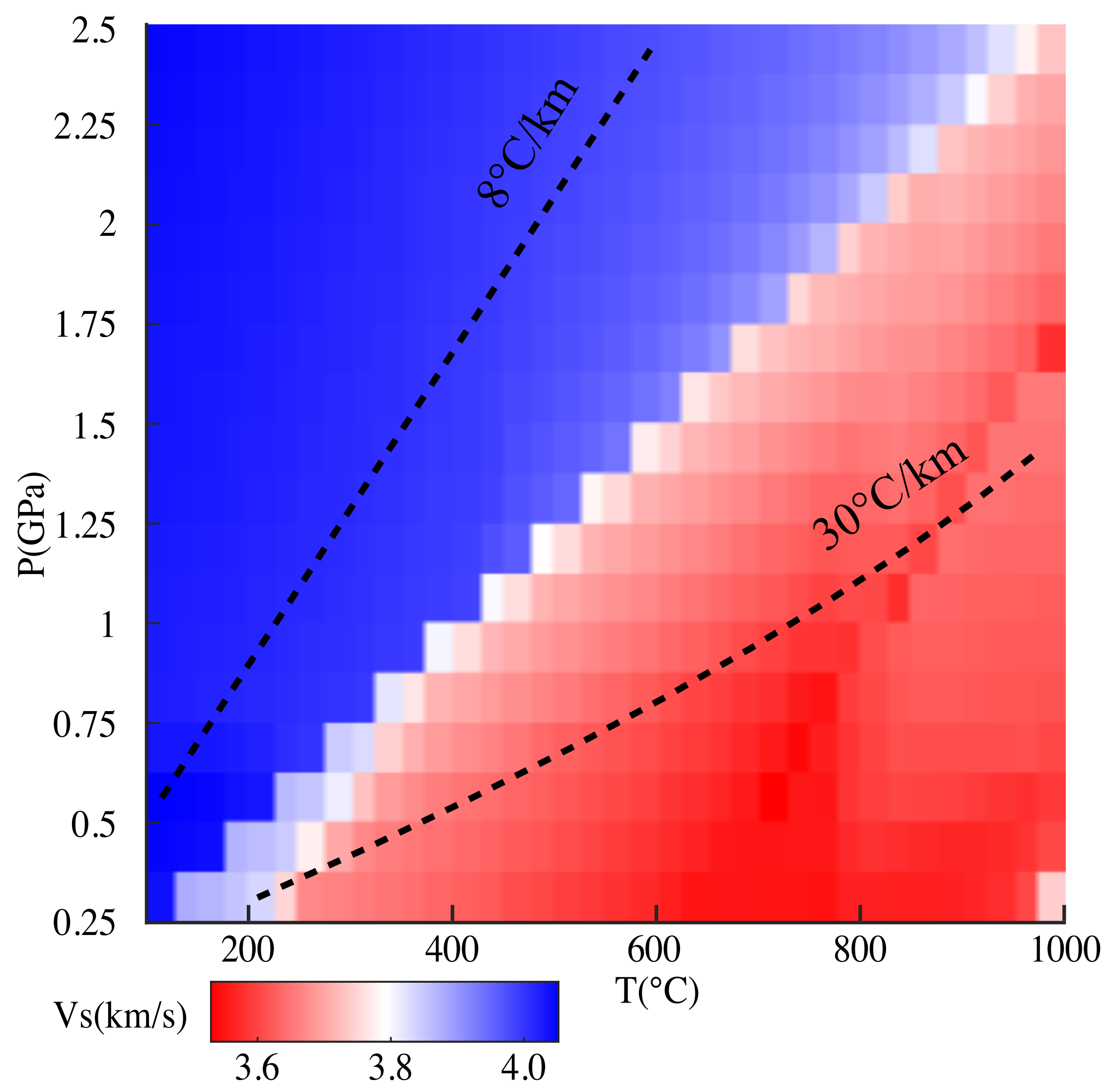

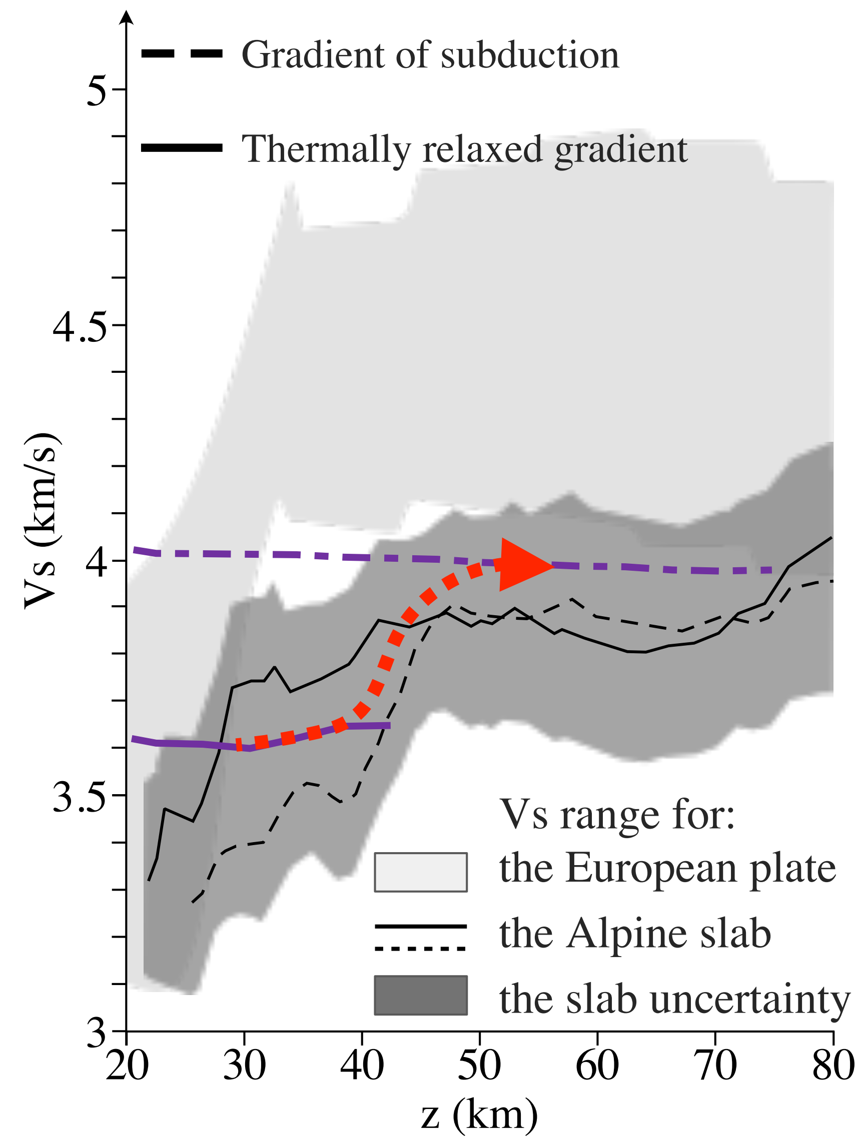

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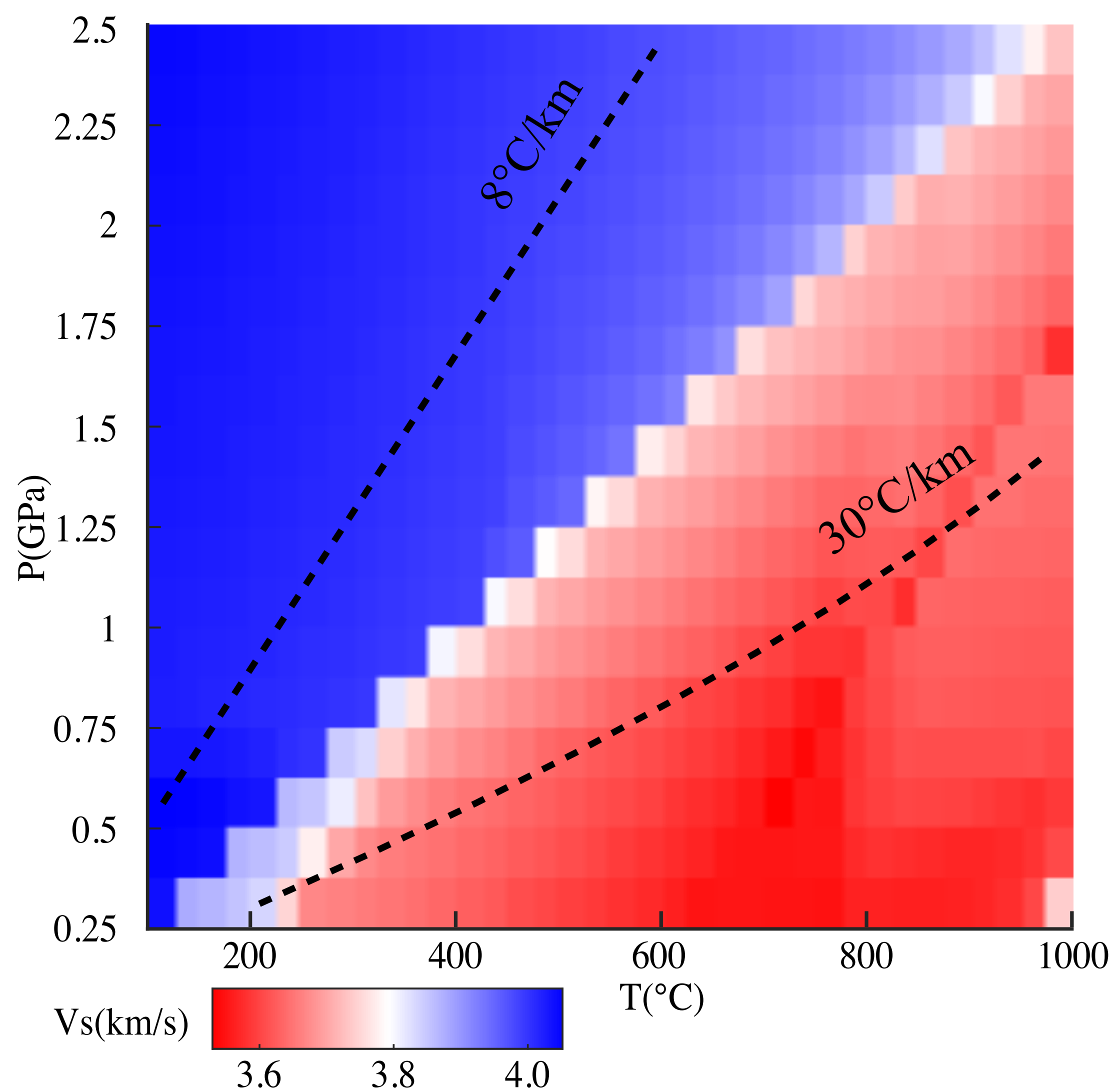
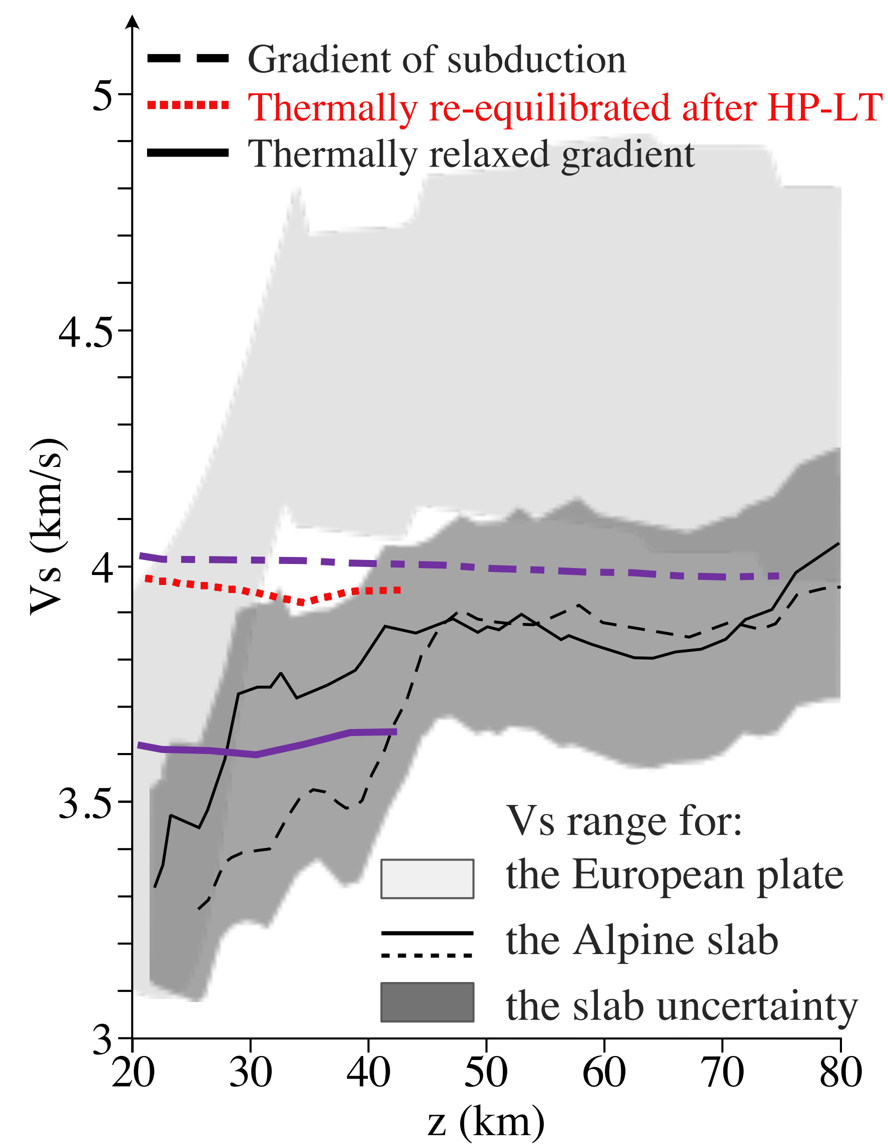
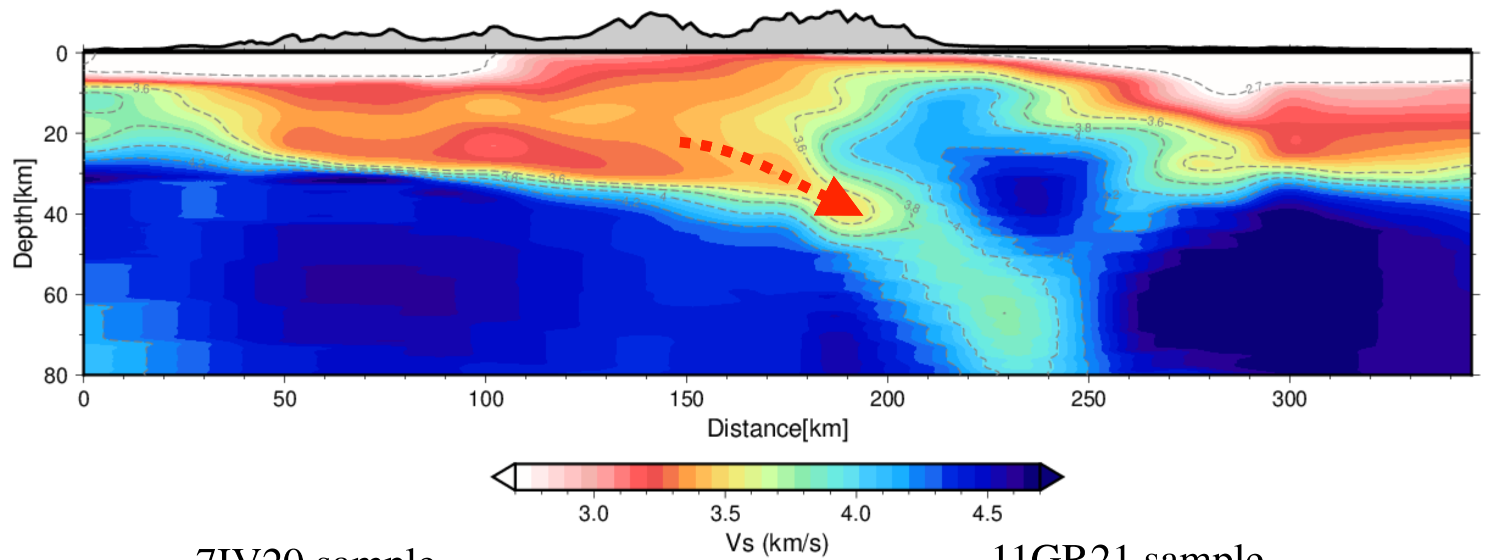




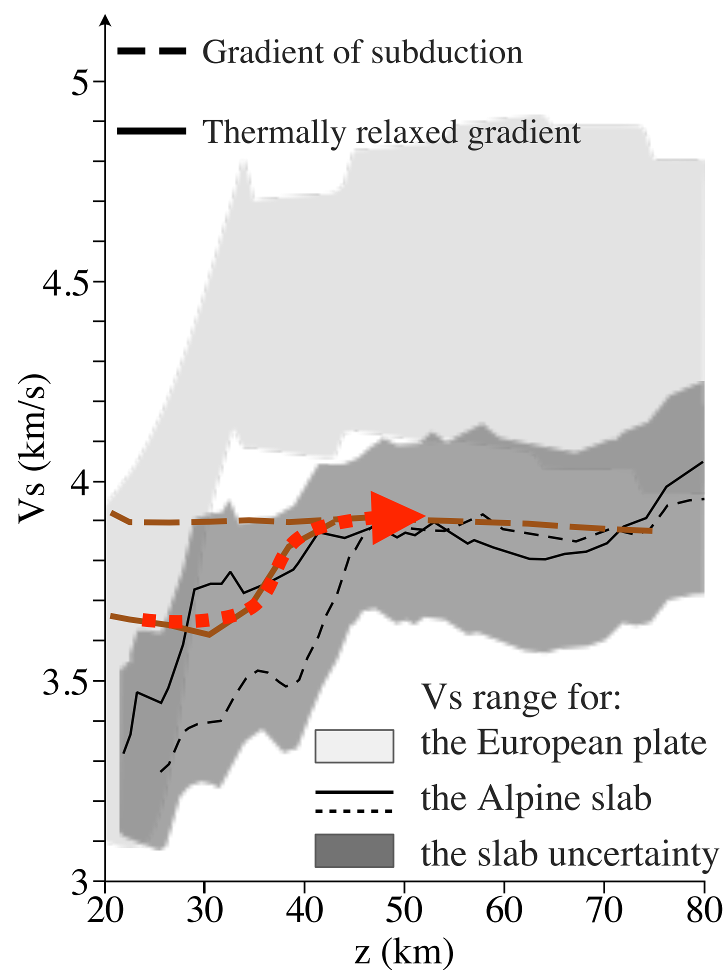
Compare modeled seismic properties with those from ambiant noise tomography model

The seismic contrast within the Alpine dipping panel most probably reflects the signature of the collision !

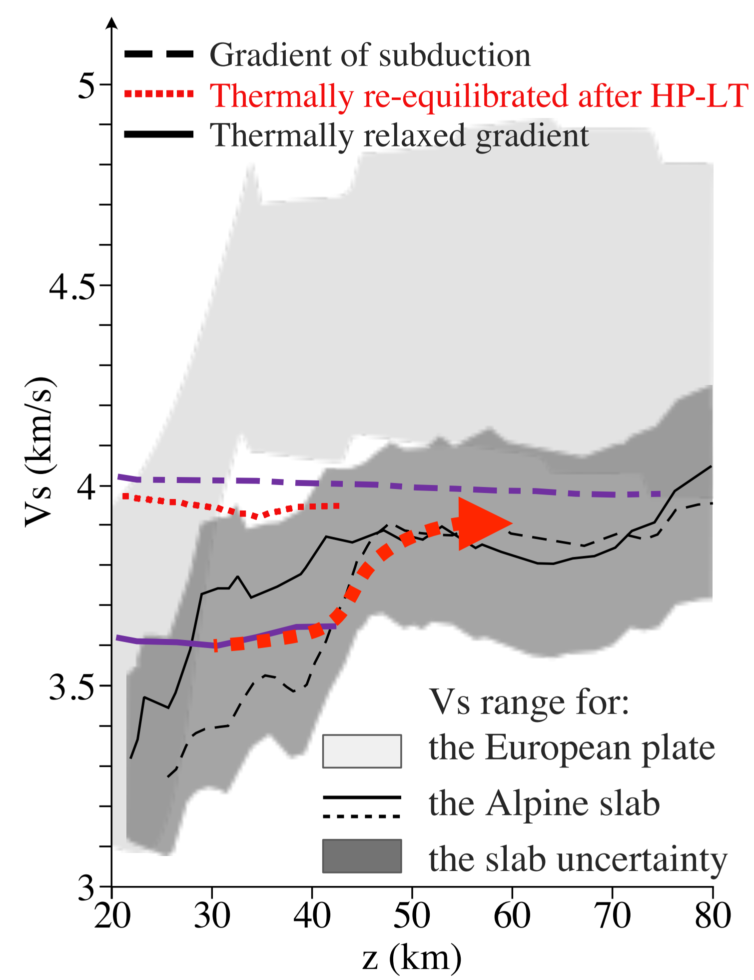
Modified from Nouibat et al., in press



7IV20 sample



11GR21 sample



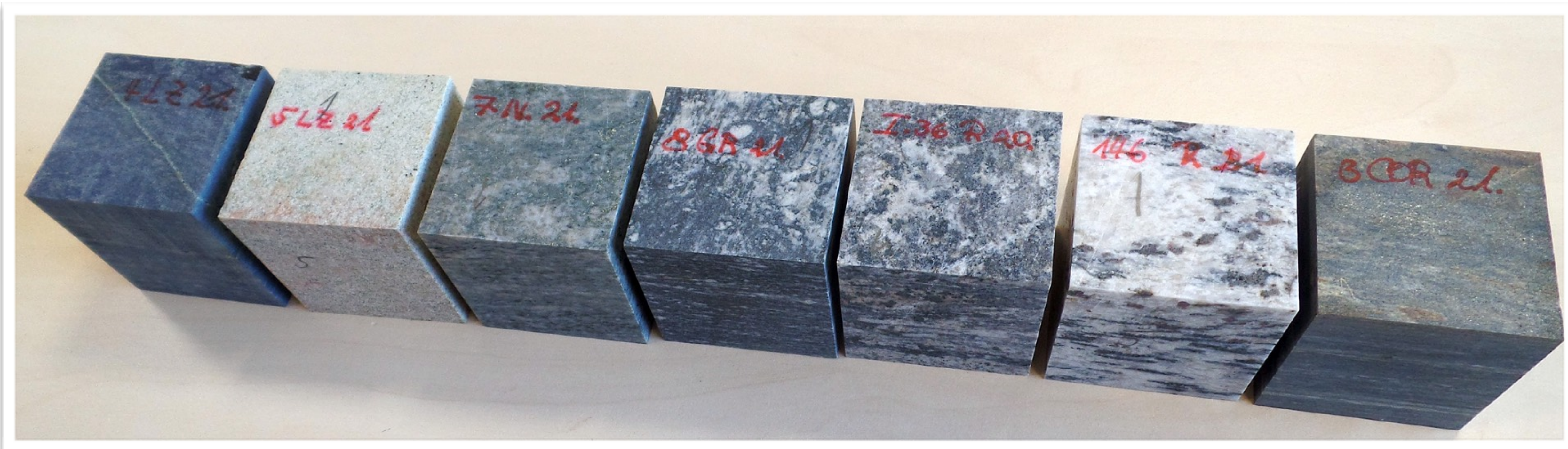
1

HP granulite metamorphic facies along a collisional gradient

2

Fossil transition from subduction to collision

Compare modeled seismic properties with those from ambiant noise tomography model



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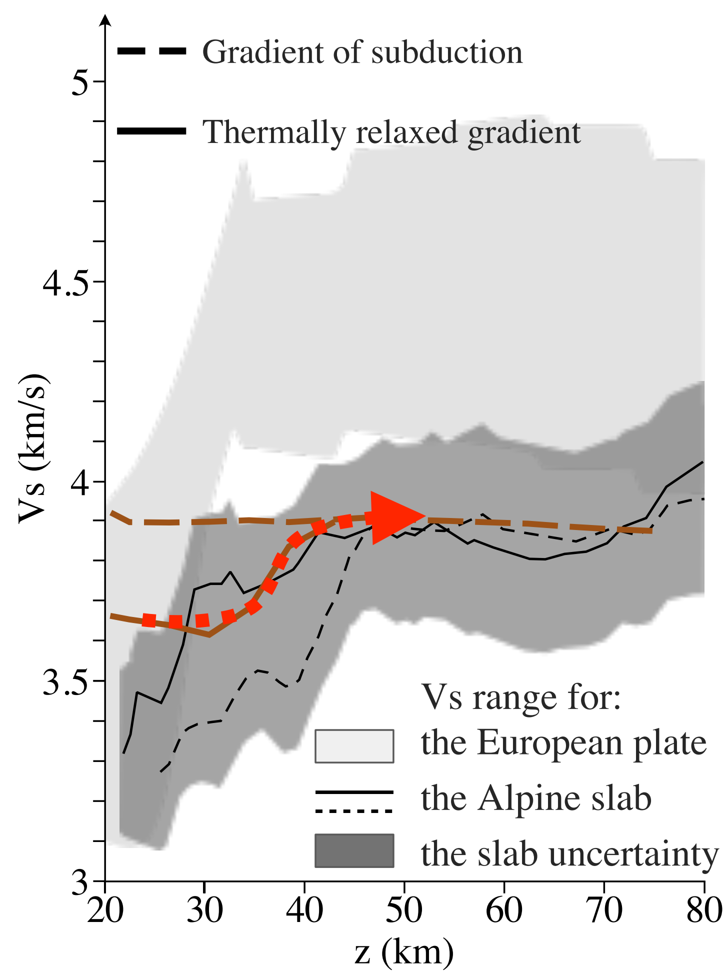

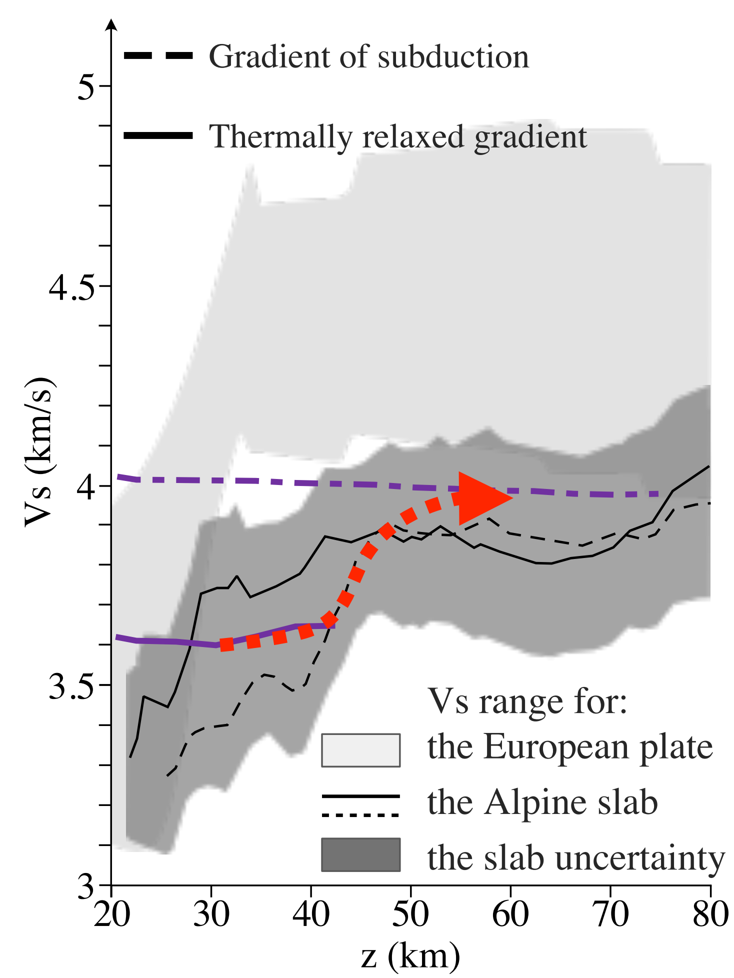

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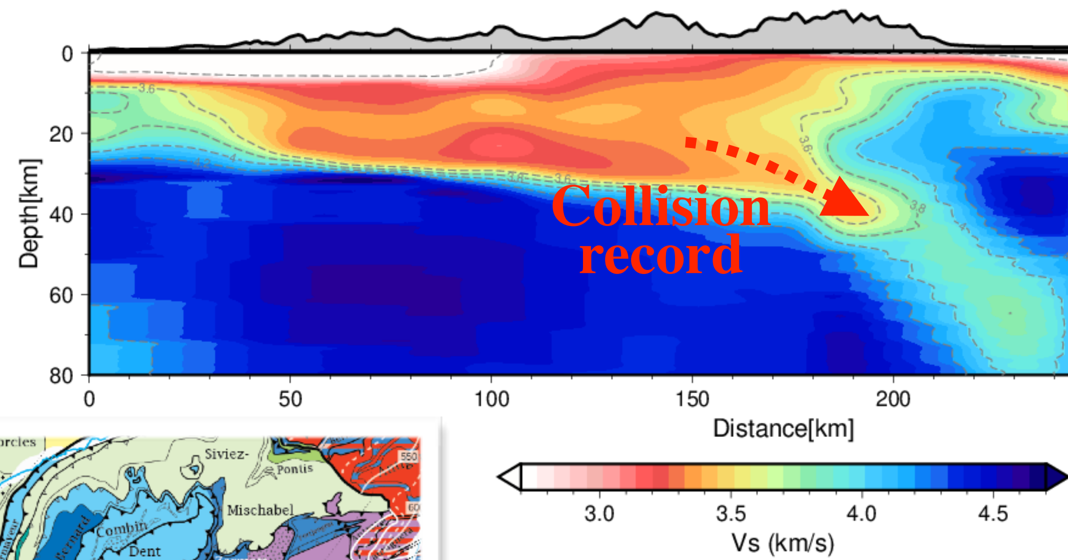

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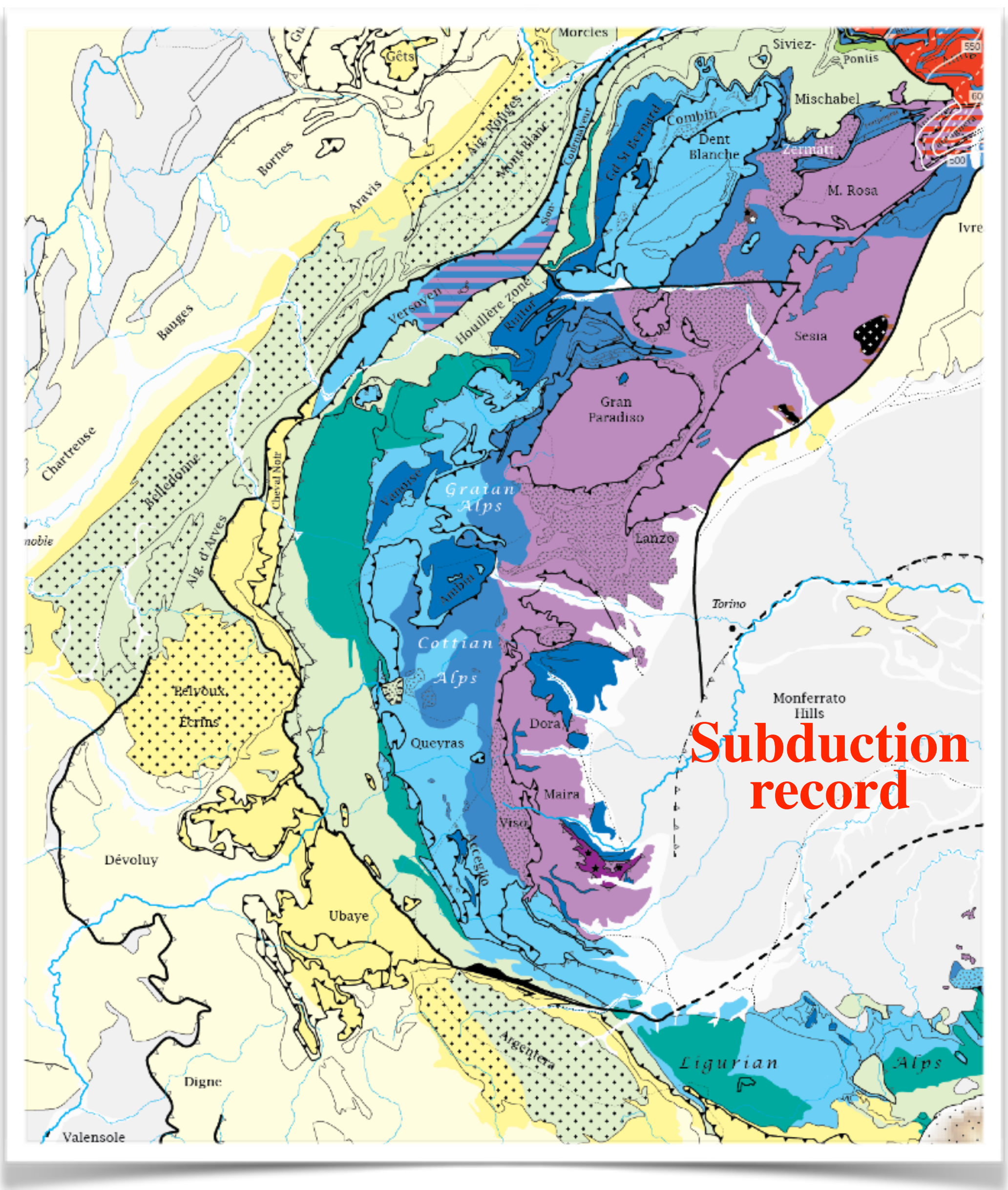
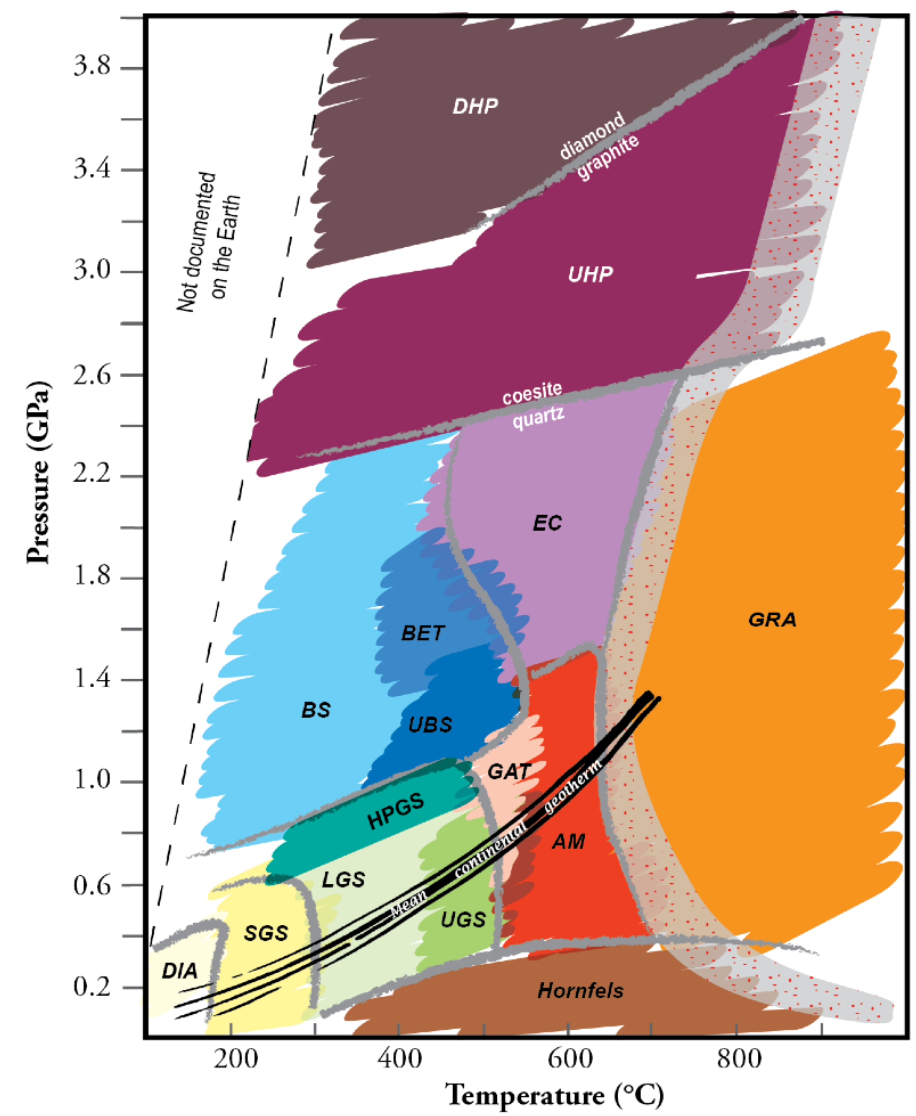


Metamorphic framework of the Alps. Bousquet et al. 2012



Thanks for your attention!