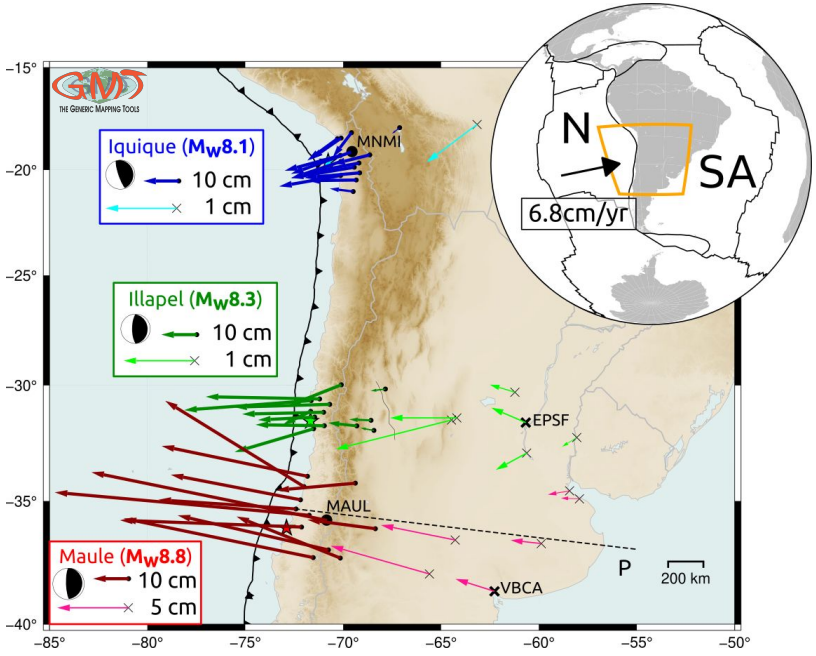
Comparison of horizontal post-seismic deformations induced by Maule, Iquique, and Illapel megathrust earthquakes:

A clue to a linear asthenospheric viscosity?



EGU General Assembly 2022

Session G3.4

EGU22-6216ECS

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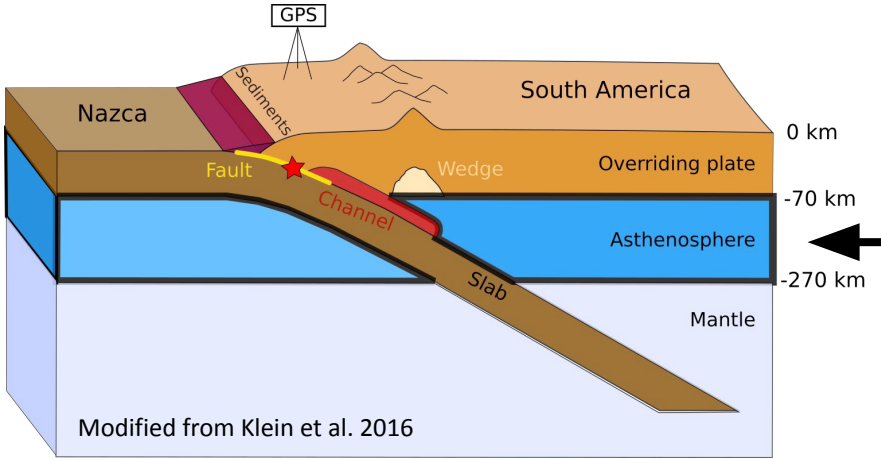
Context

The post-seismic phase of the seismic cycle induces very **large-scale** and **long-lasting** deformations of the lithosphere generally attributed to **viscous creep** in the **asthenosphere**.



Asthenosphere:

⇒ low-viscosity layer (10^{18} Pa.s)

⇒ extending from 70-270 km depth

A long term debate concerning asthenospheric viscous law

NEWTONIAN vs POWER-LAW

$\dot{\varepsilon}$: strain rate
σ: stress
C: constant

$\dot{\varepsilon} = C.\sigma$

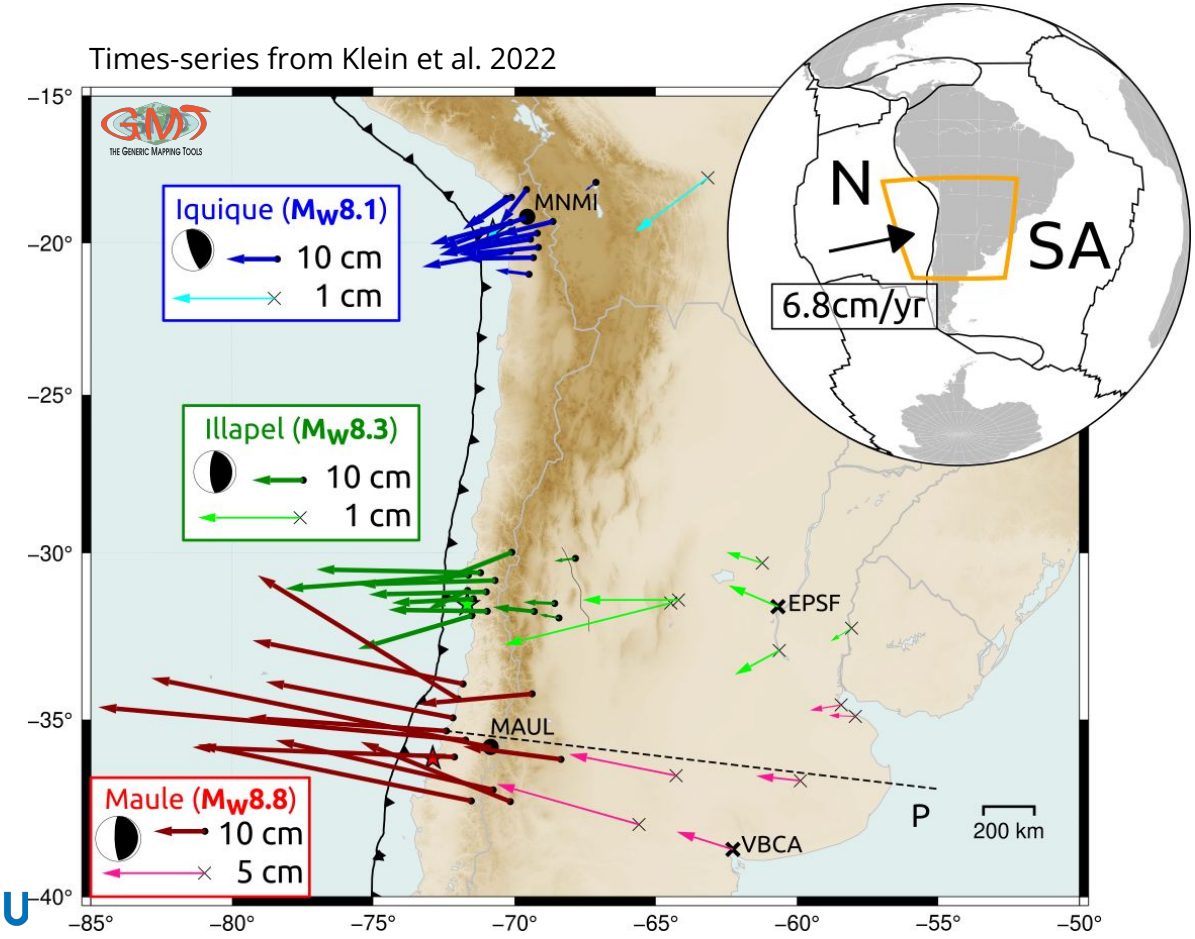
⇒ linear relationship

$\dot{\varepsilon} = C.\sigma^3$

⇒ non-linear relationship

Cumulative post-seismic displacements over 5 yrs **(POST)**

Times-series from Klein et al. 2022



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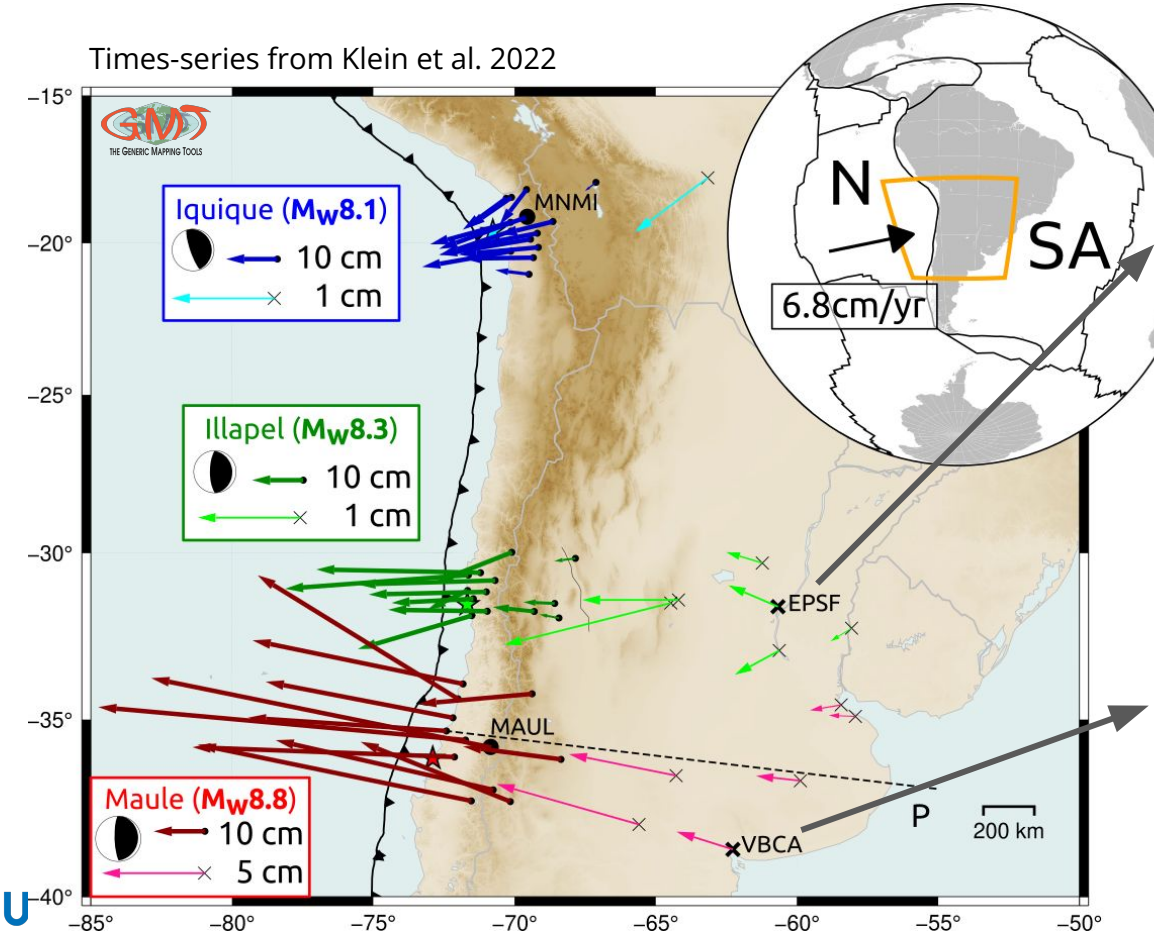

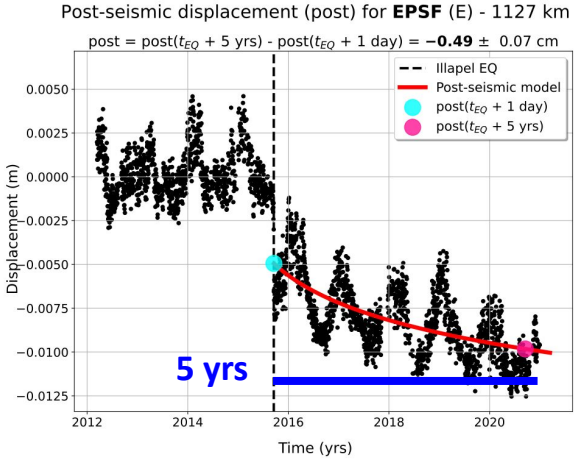

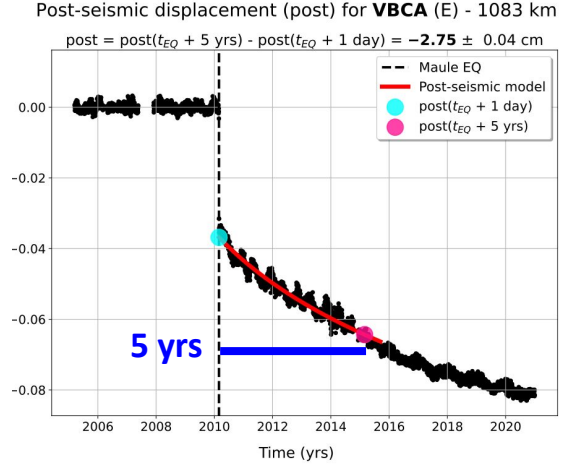

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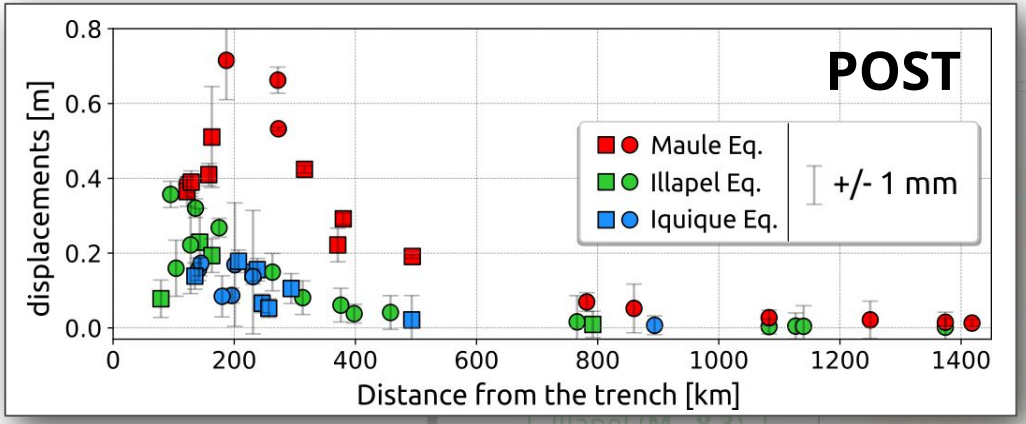
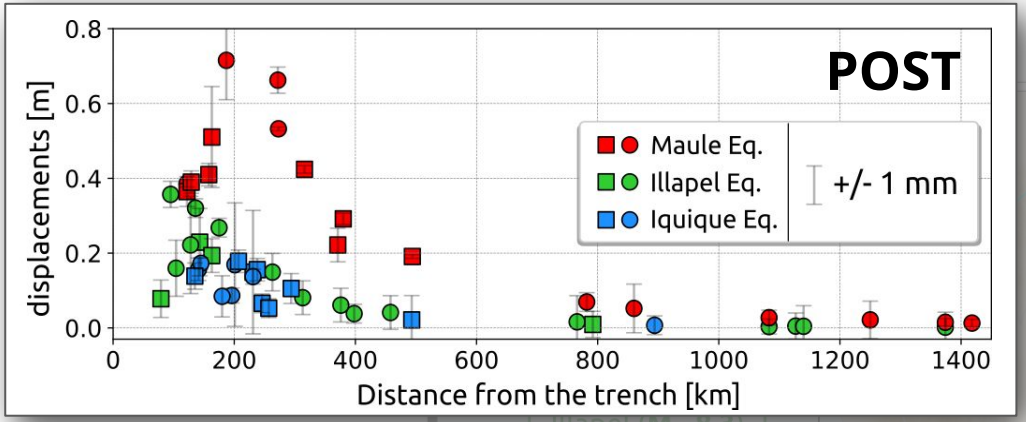
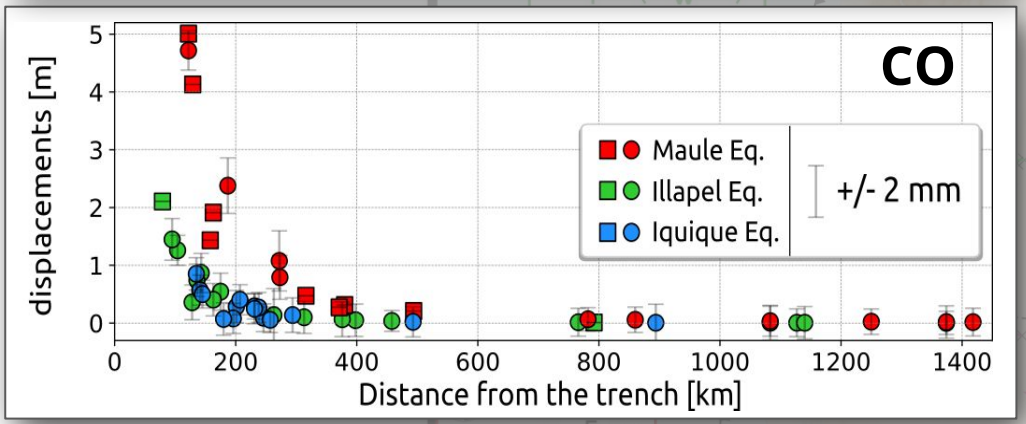


Cumulative post-seismic displacements **decrease** with distance from the trench

Post-seismic displacements **(POST)** and co-seismic offsets **(CO)**

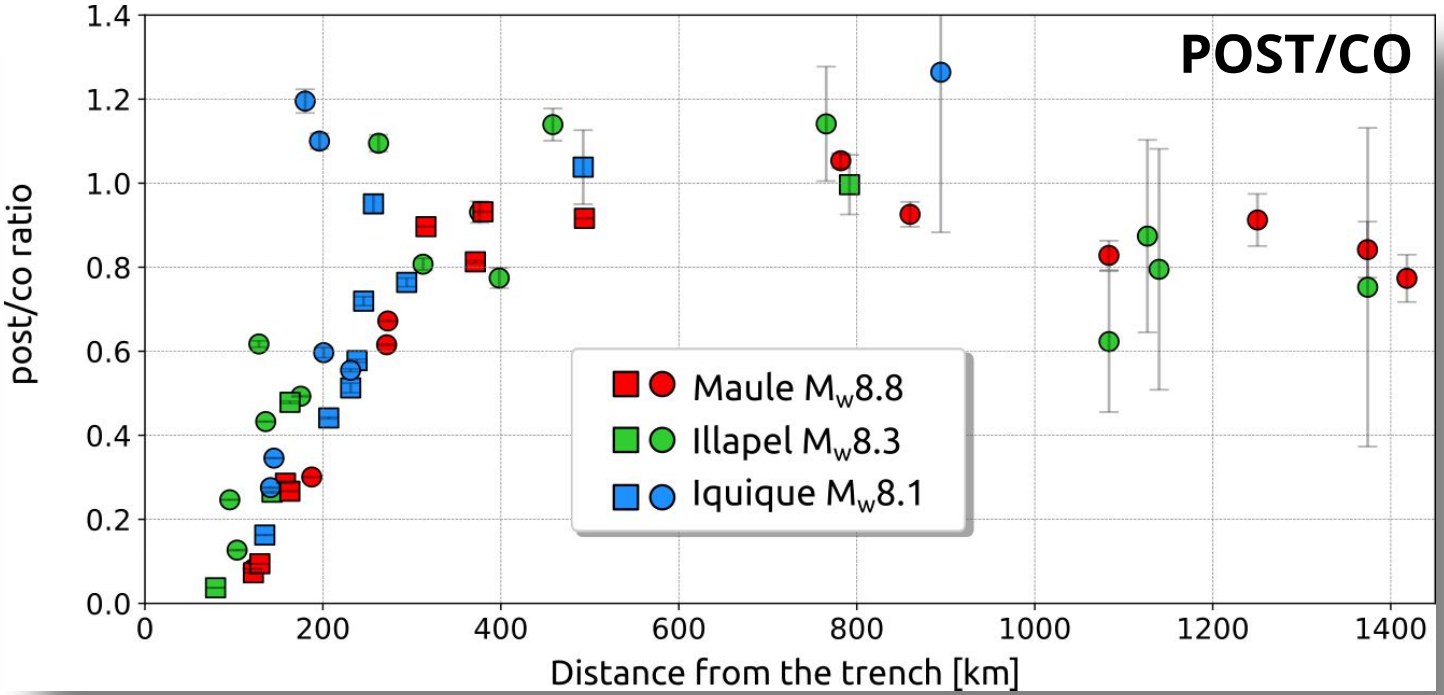




Cumulative post-seismic displacements **decrease** with distance from the trench

Co-seismic offsets **decrease** with distance from the trench too

A surprising observation



⇒ **POST/CO** ratios **increase** with distance from the trench and are **equivalent** for the three earthquakes (at a given distance)

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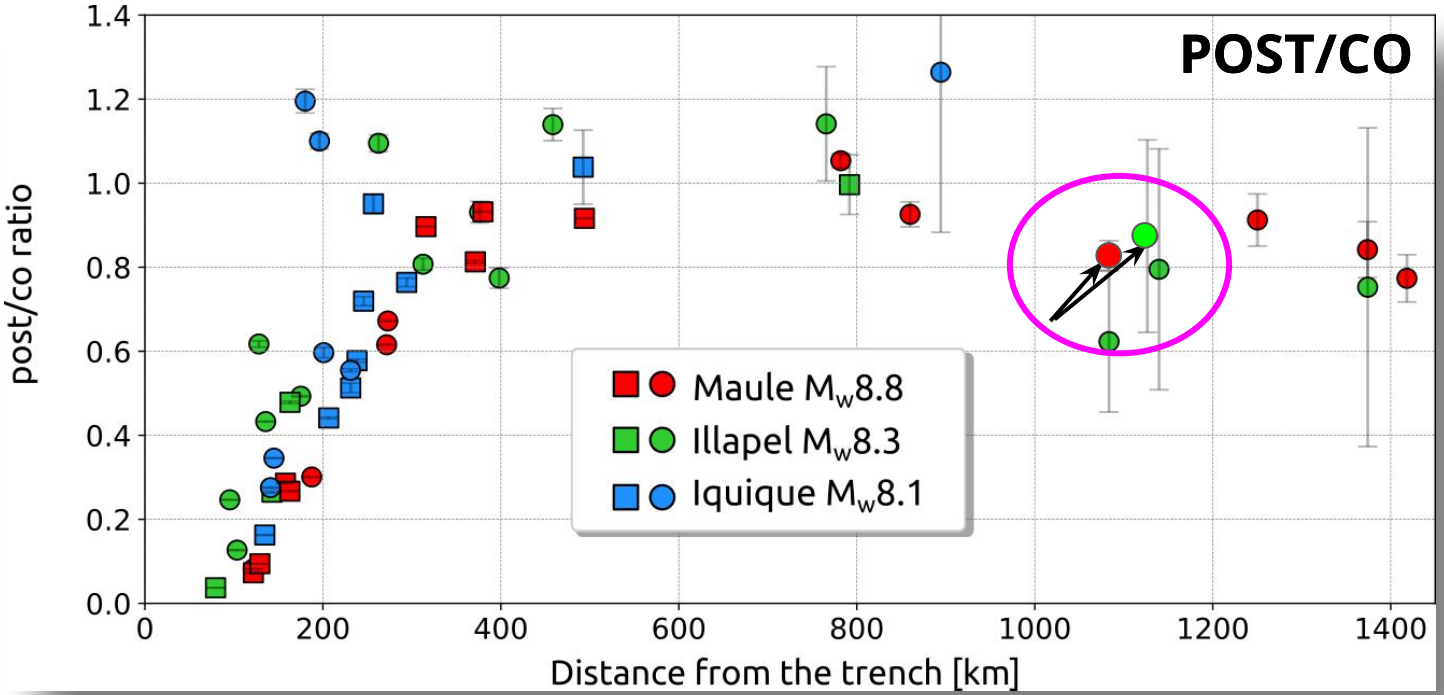

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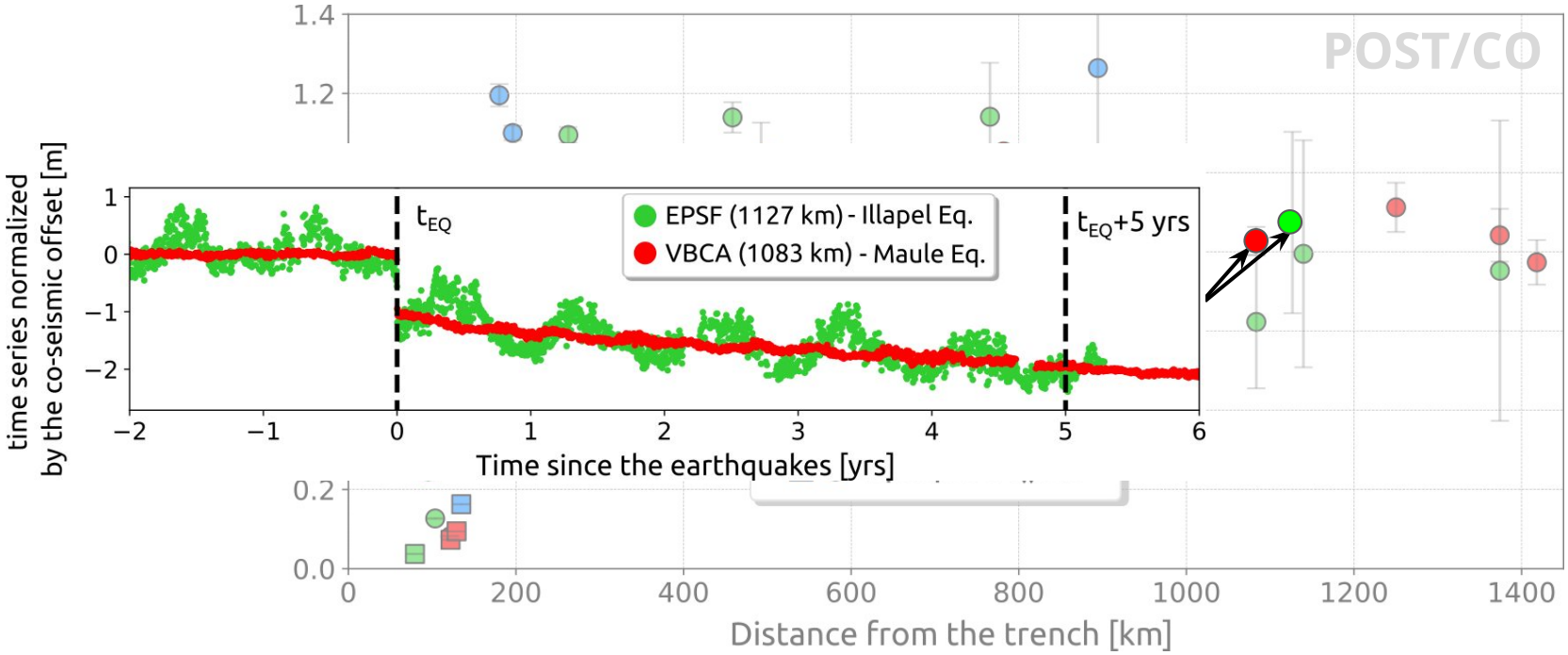


⇒ **Post-seismic time-series** normalised by the co-seismic offset superimposed very well

What are the implications for viscosity?

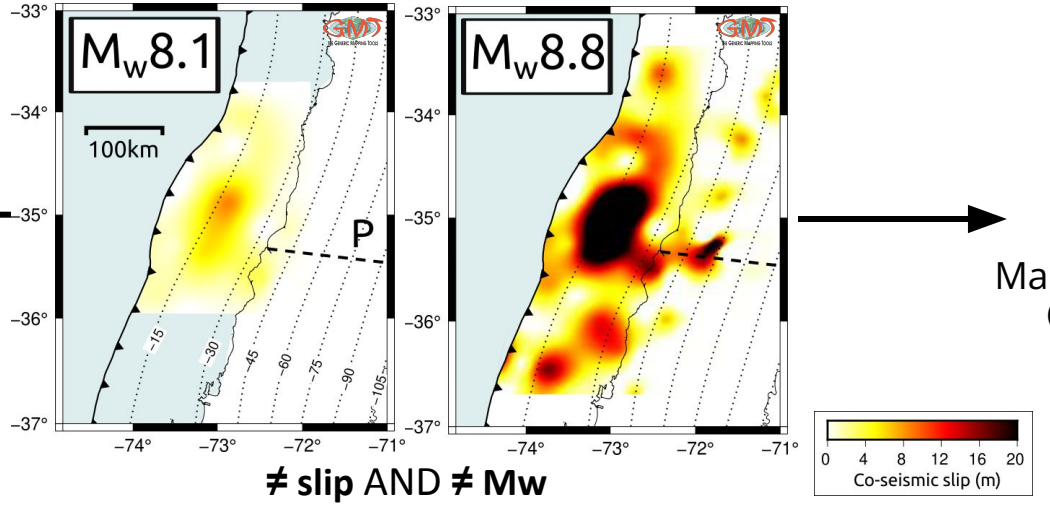
Post-seismic and co-seismic displacements depend mainly on 3 parameters:

magnitude

slip distribution

viscosity law of asthenosphere (Newtonian vs Power-law)

Fictive earthquake

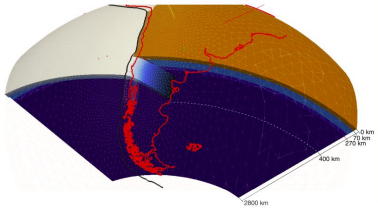


Maule earthquake
(Klein et al. 2016)

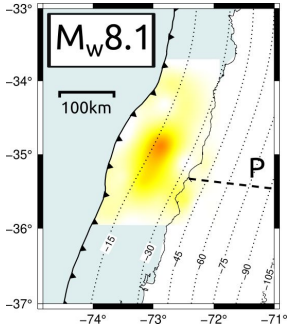
≠ slip AND **≠ Mw**

Compare **post/co** ratios predicted for both **Newtonian** and **Power-law** viscosities

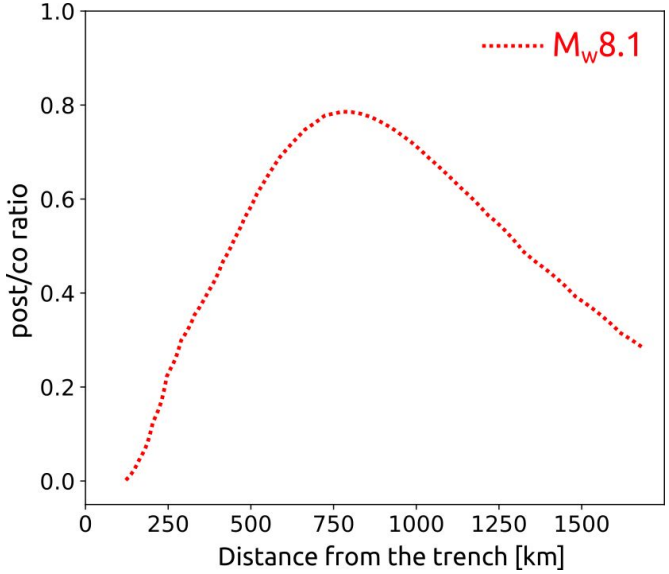
Numerical tests with Finite Element models



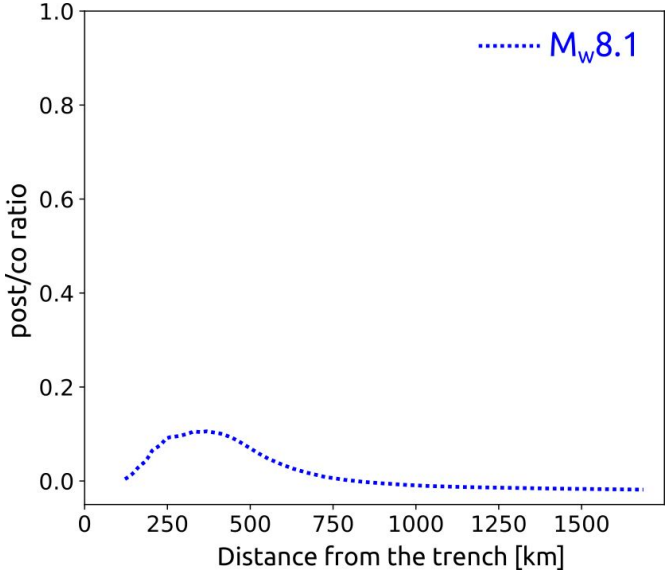
3D models from Klein et al. 2016



NEWTONIAN



POWER-LAW



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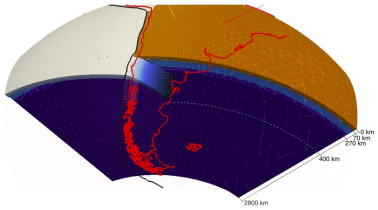

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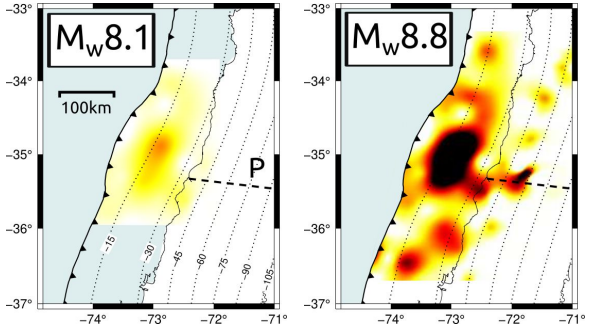
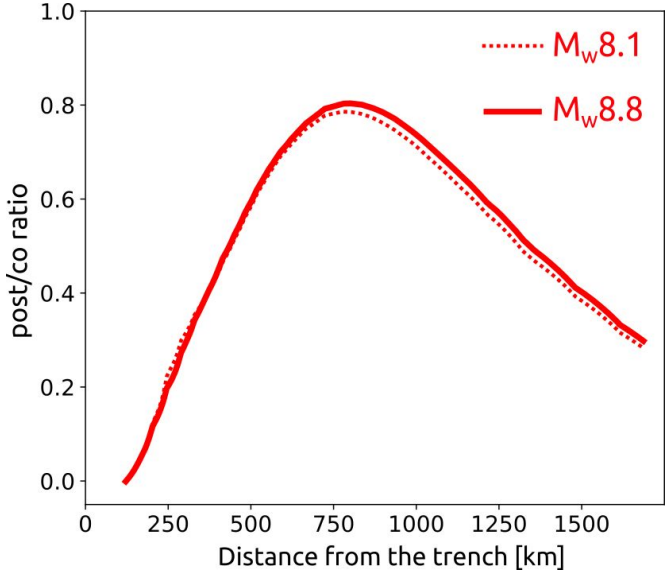
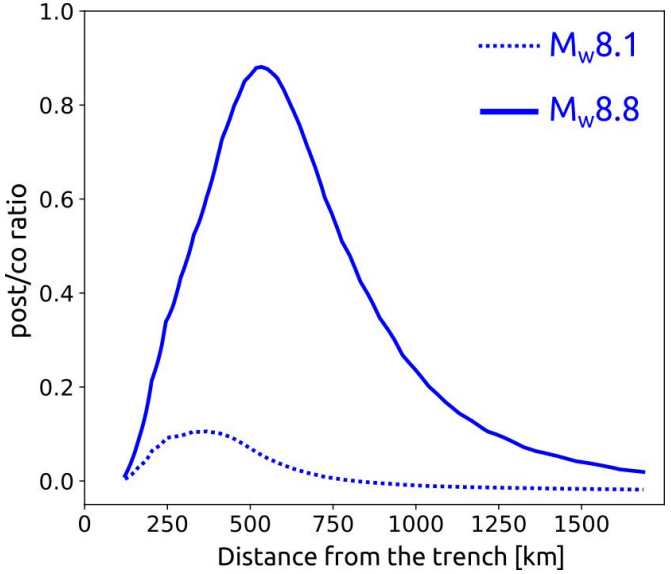


NEWTONIAN

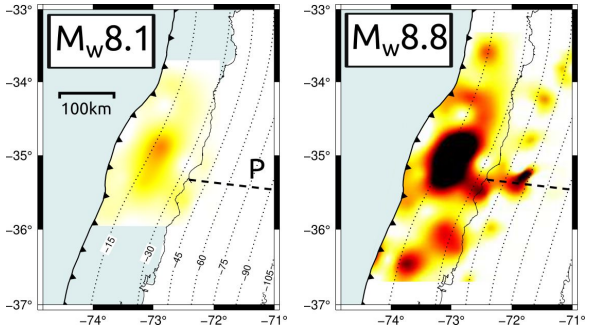


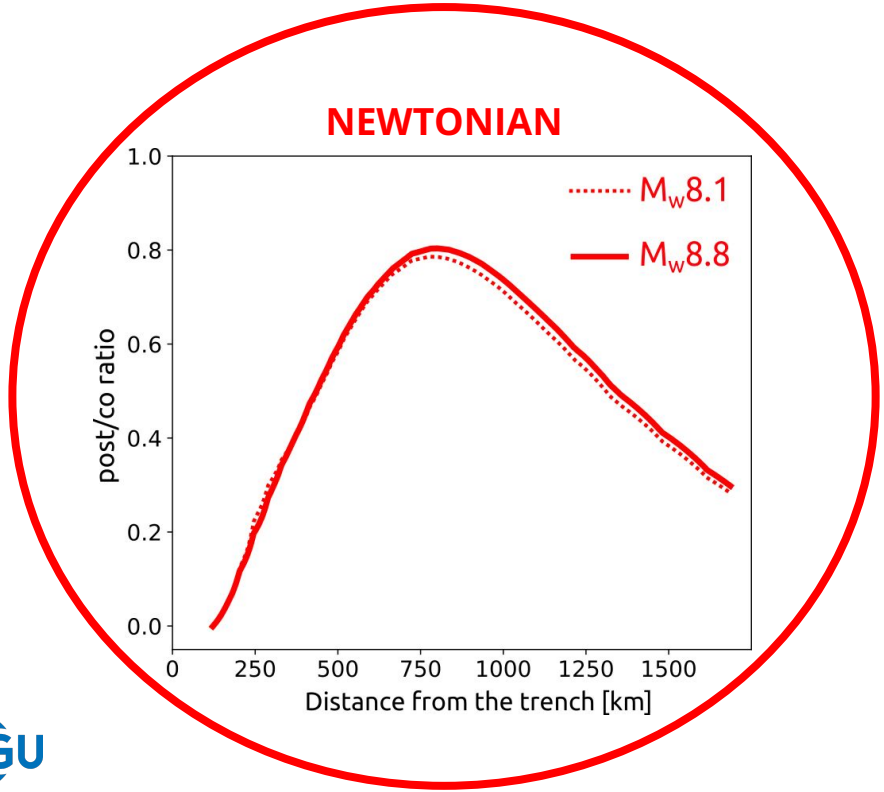
POWER-LAW

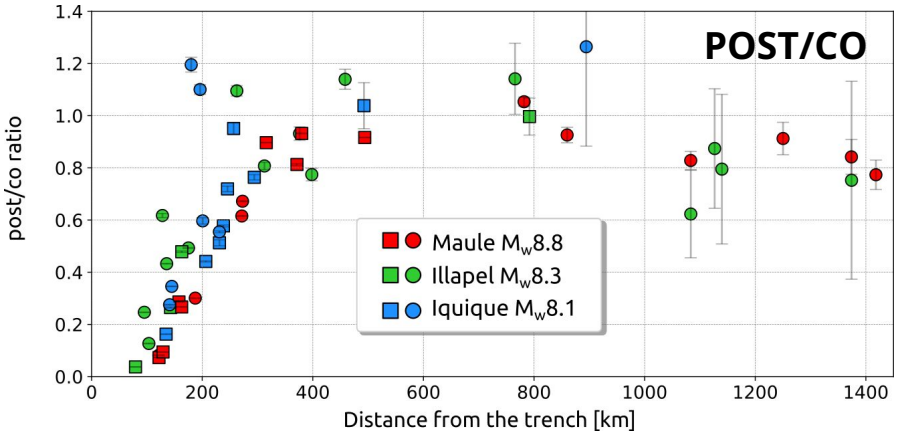


Numerical tests with Finite Element models

⇒ independence of the slip distribution
(tests made with homothetic earthquakes)







Take Home Messages

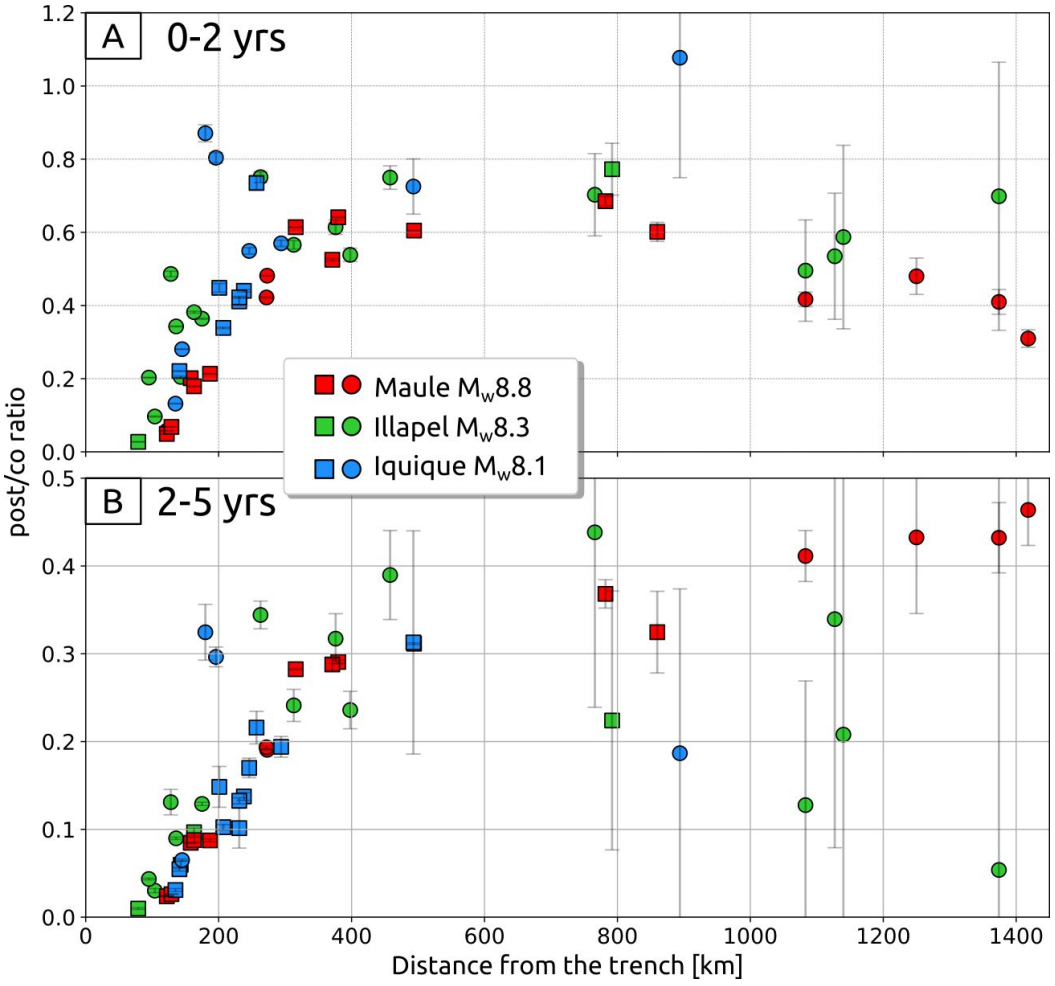
POST/CO ratios from Maule, Iquique and Illapel earthquakes are **equivalent** at a given distance from the trench

⇒ Post-seismic deformations can be modeled with a **Newtonian asthenospheric viscosity**

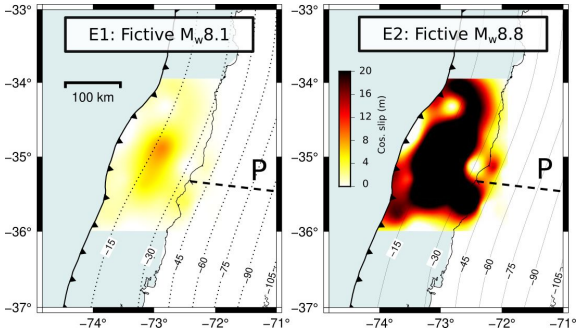
A campaign GPS site in the Region of Coquimbo, Chile, April 2022. © H. Boulze

Supporting information

Afterslip


A
0-2 yrs
B
2-5 yrs
Maule M_w8.8
Illapel M_w8.3
Iquique M_w8.1
post/co ratio
Distance from the trench [km]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.8
1.0
1.2
0
200
400
600
800
1000
1200
1400

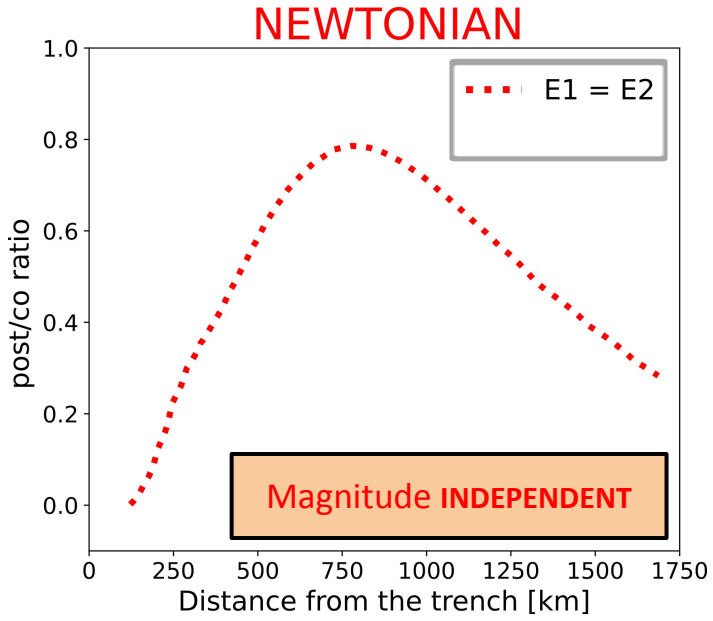
Homothetic earthquakes (E1 & E2)

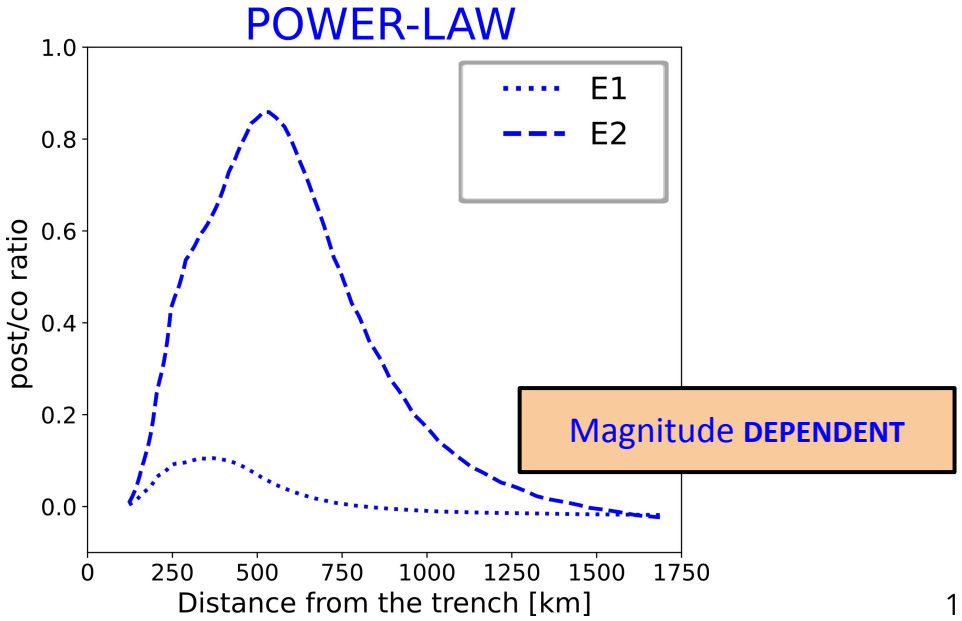


= co-seismic distribution slip

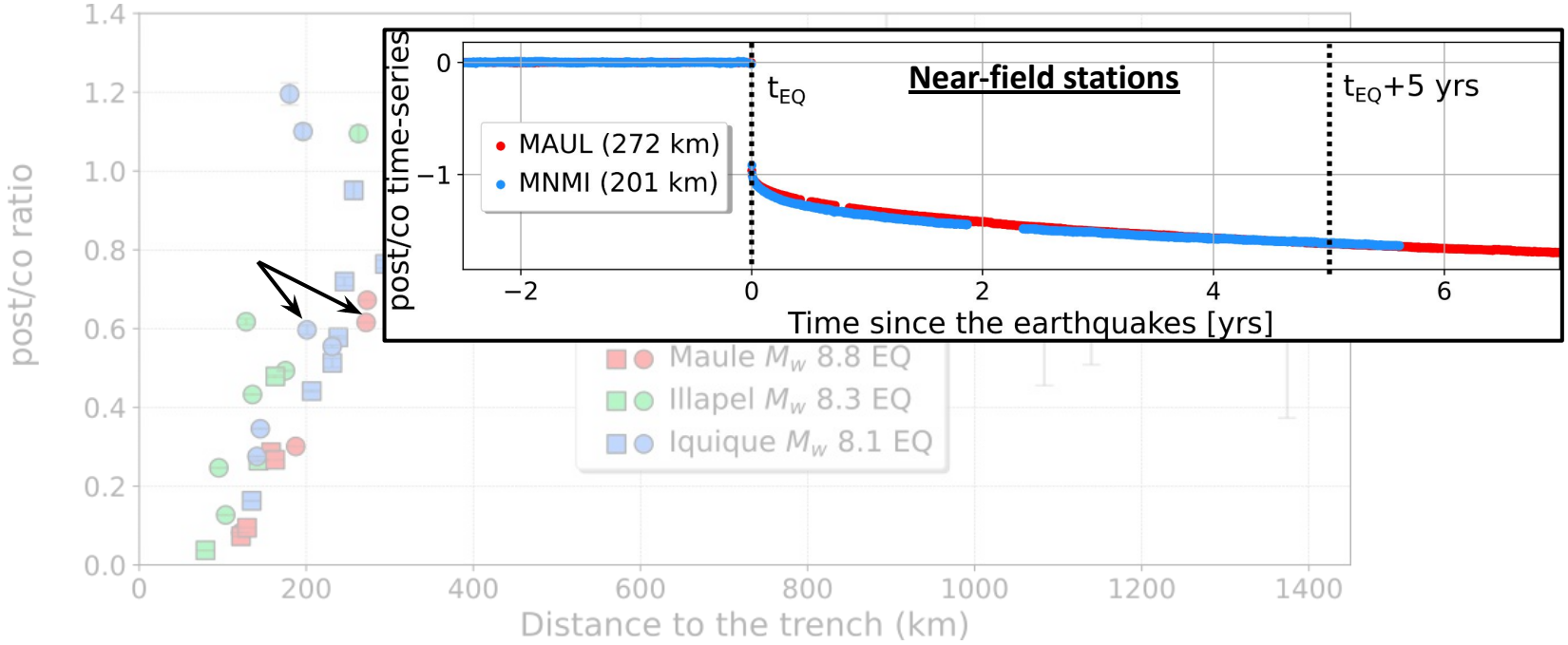
BUT

≠ Mw





A surprising observation - POST/CO ratio



Finite Element model