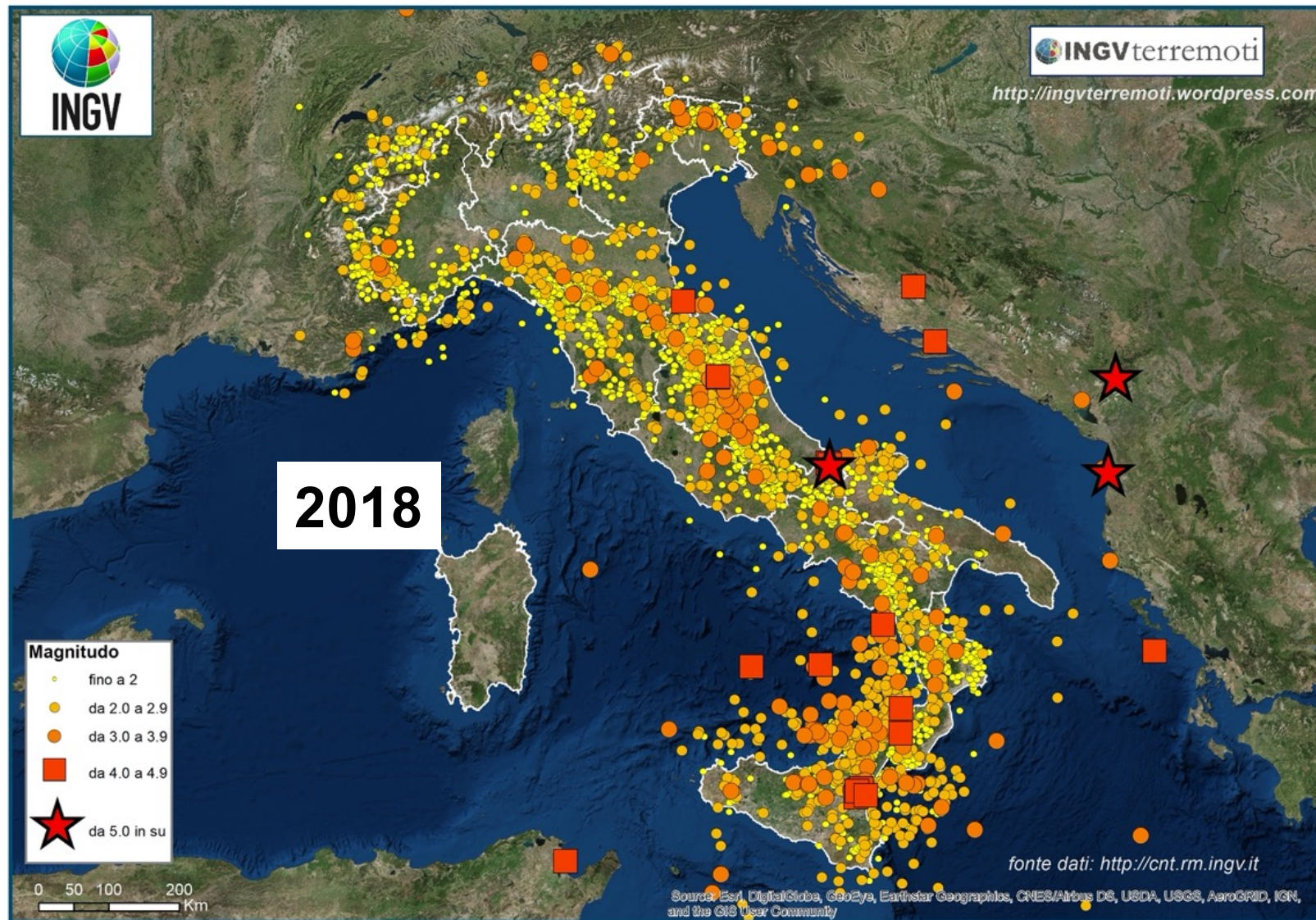
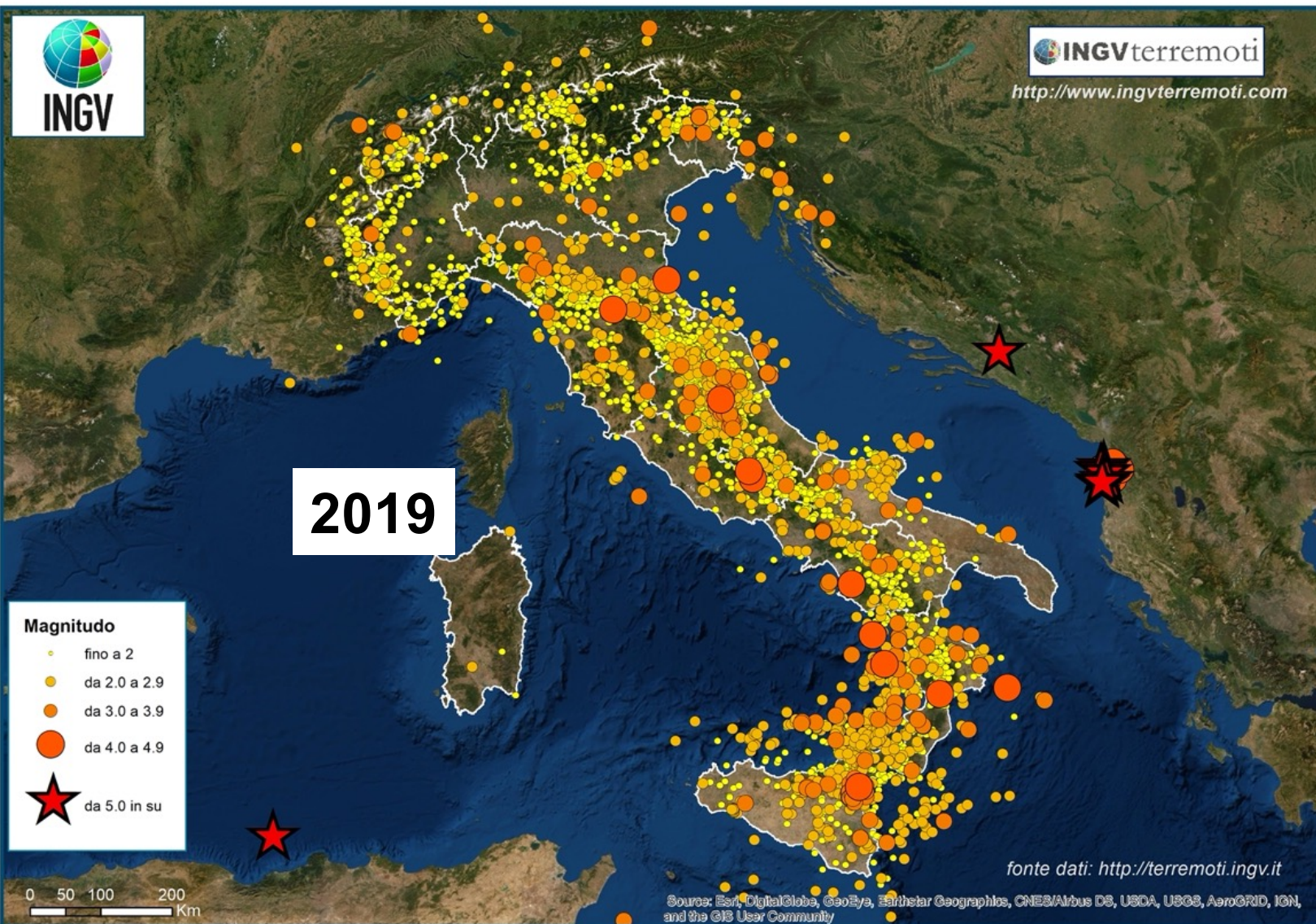
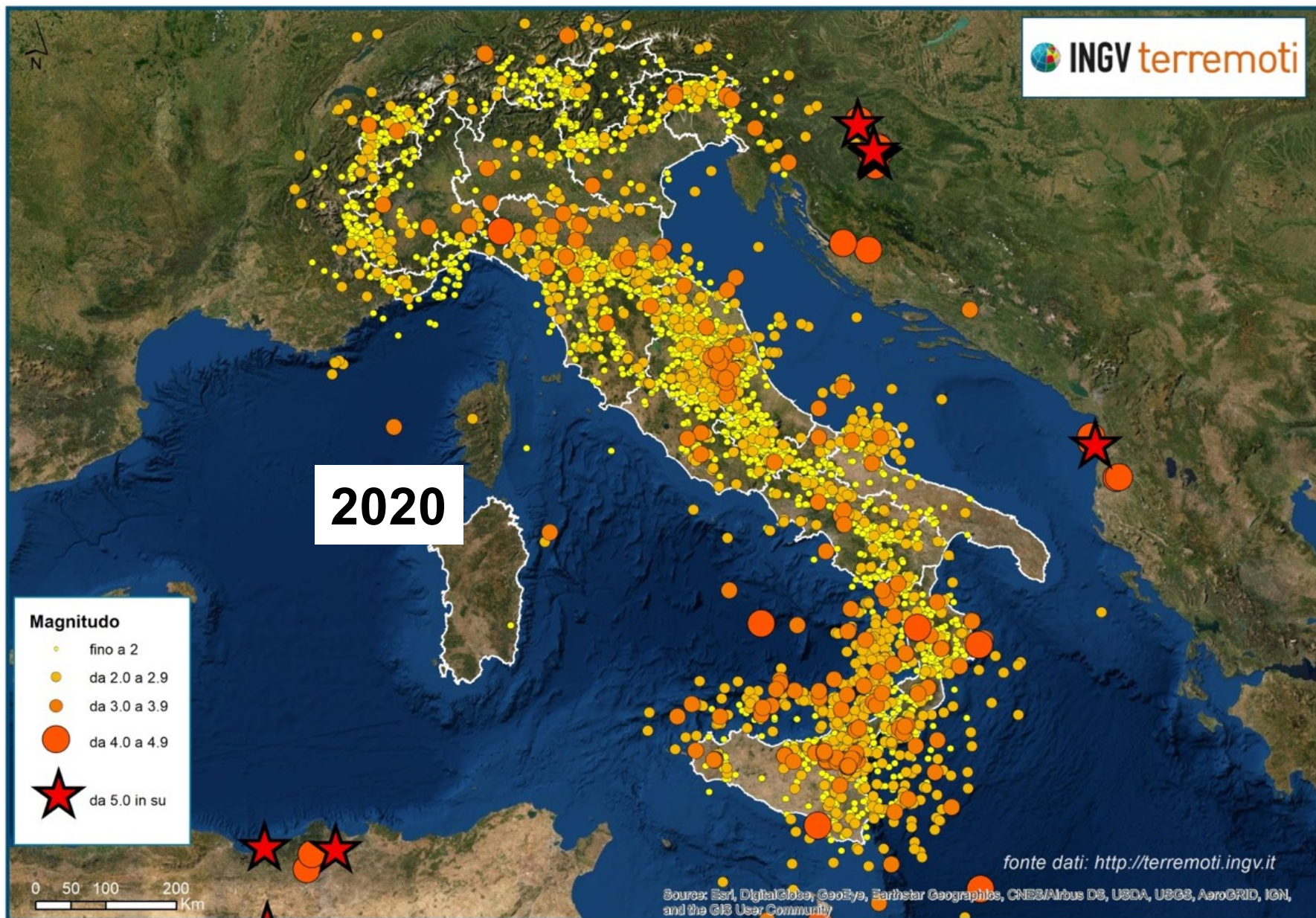


Tettonica e pericolosità sismica in Italia



Carlo Doglioni

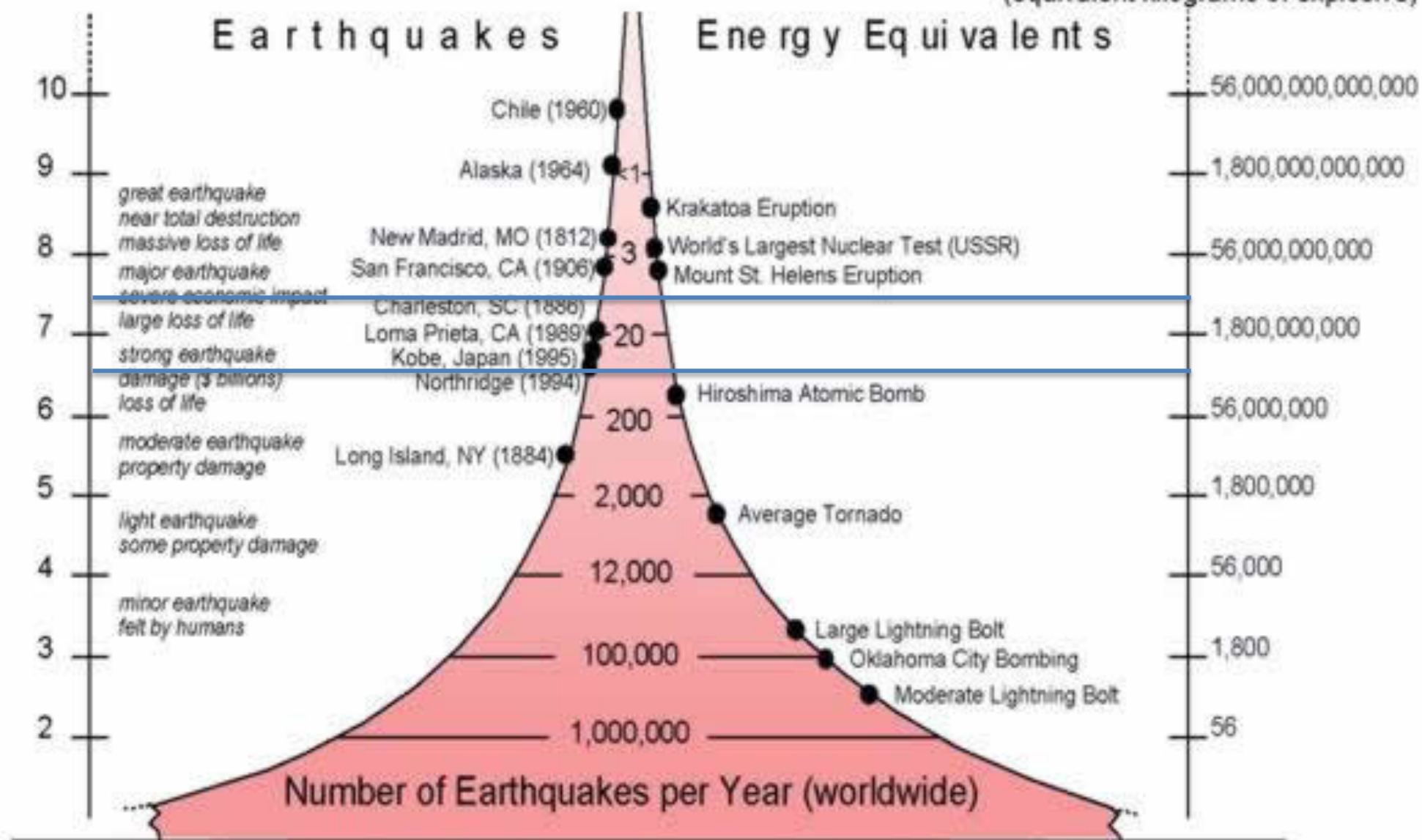




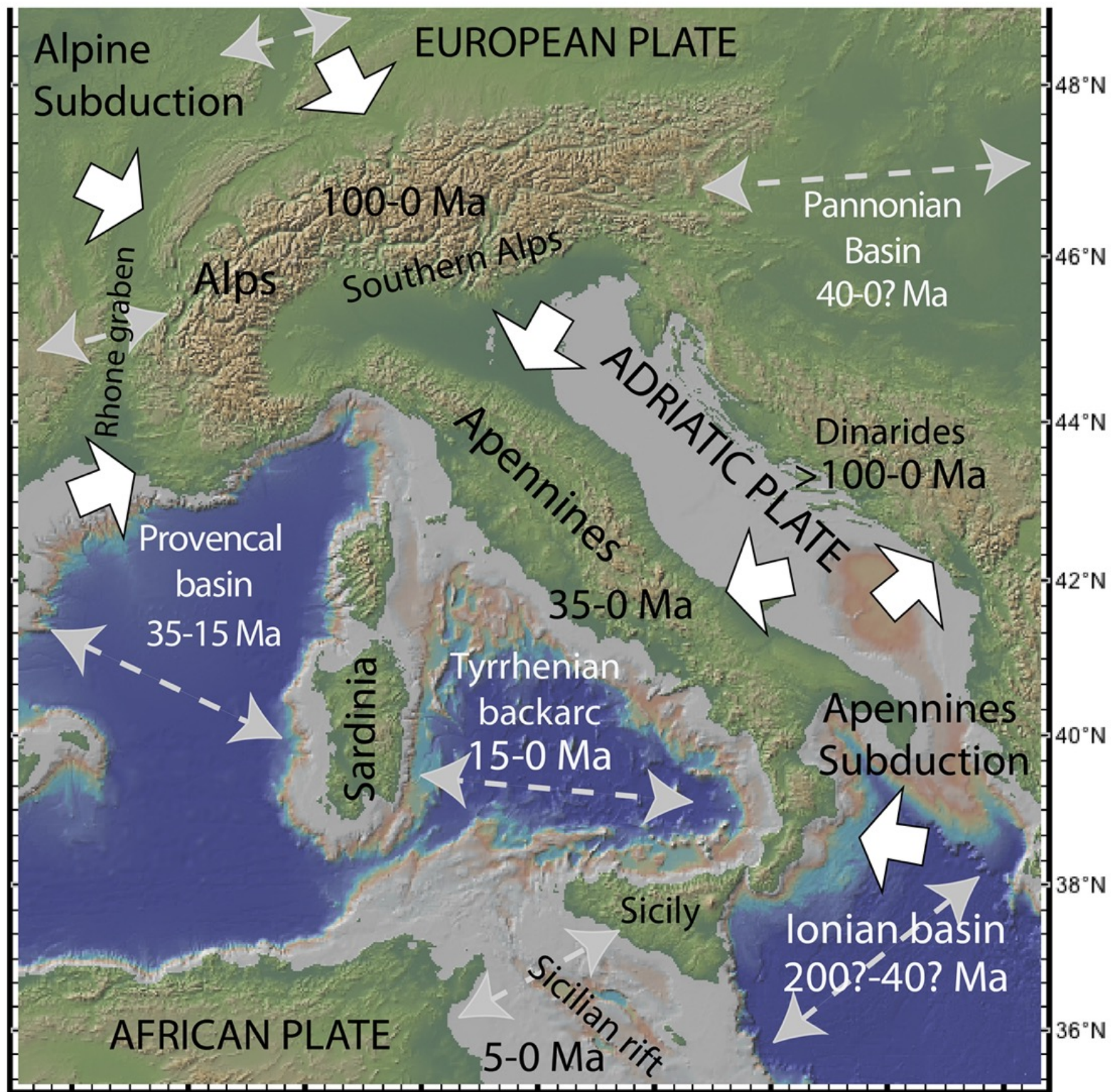
Magnitude

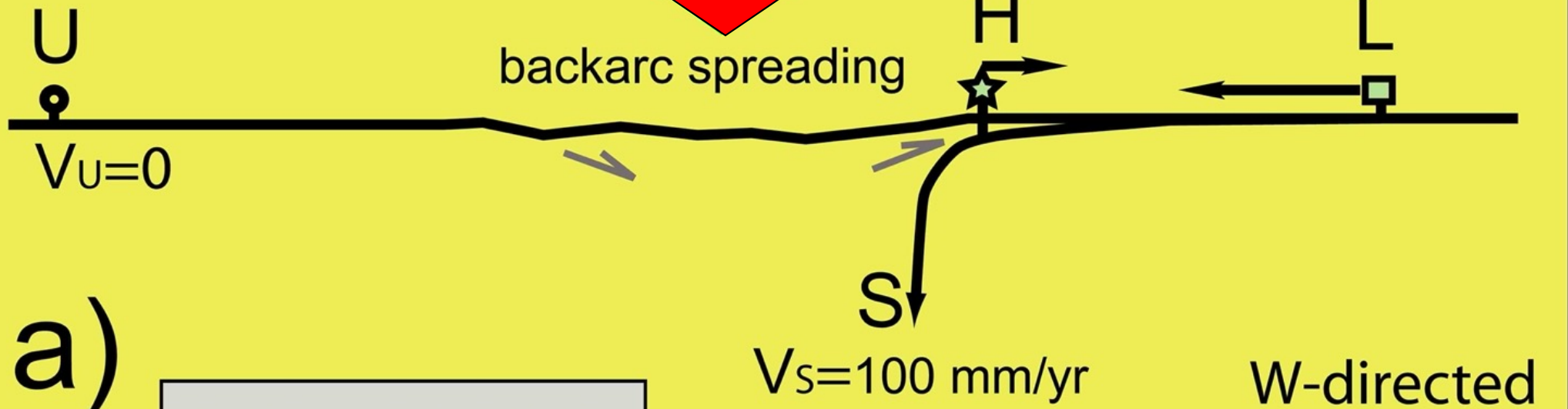
Energy Release

(equivalent kilograms of explosive)



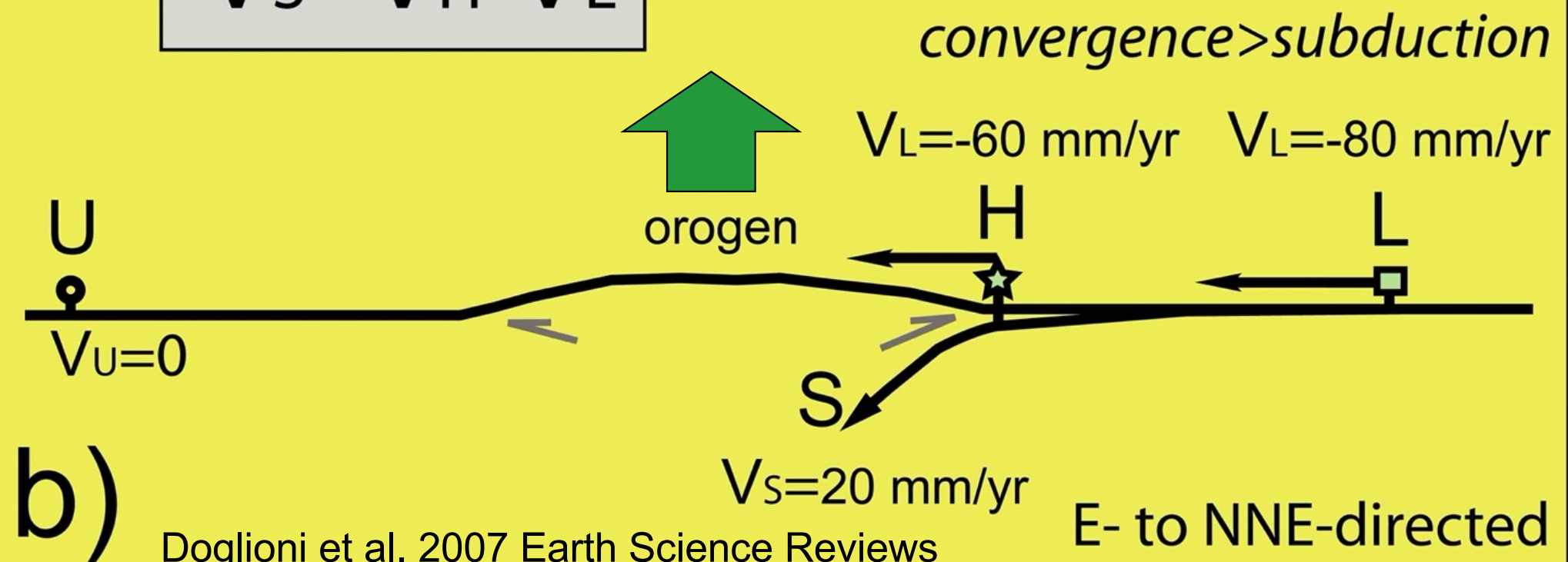
Sulla pericolosità sismica in Italia



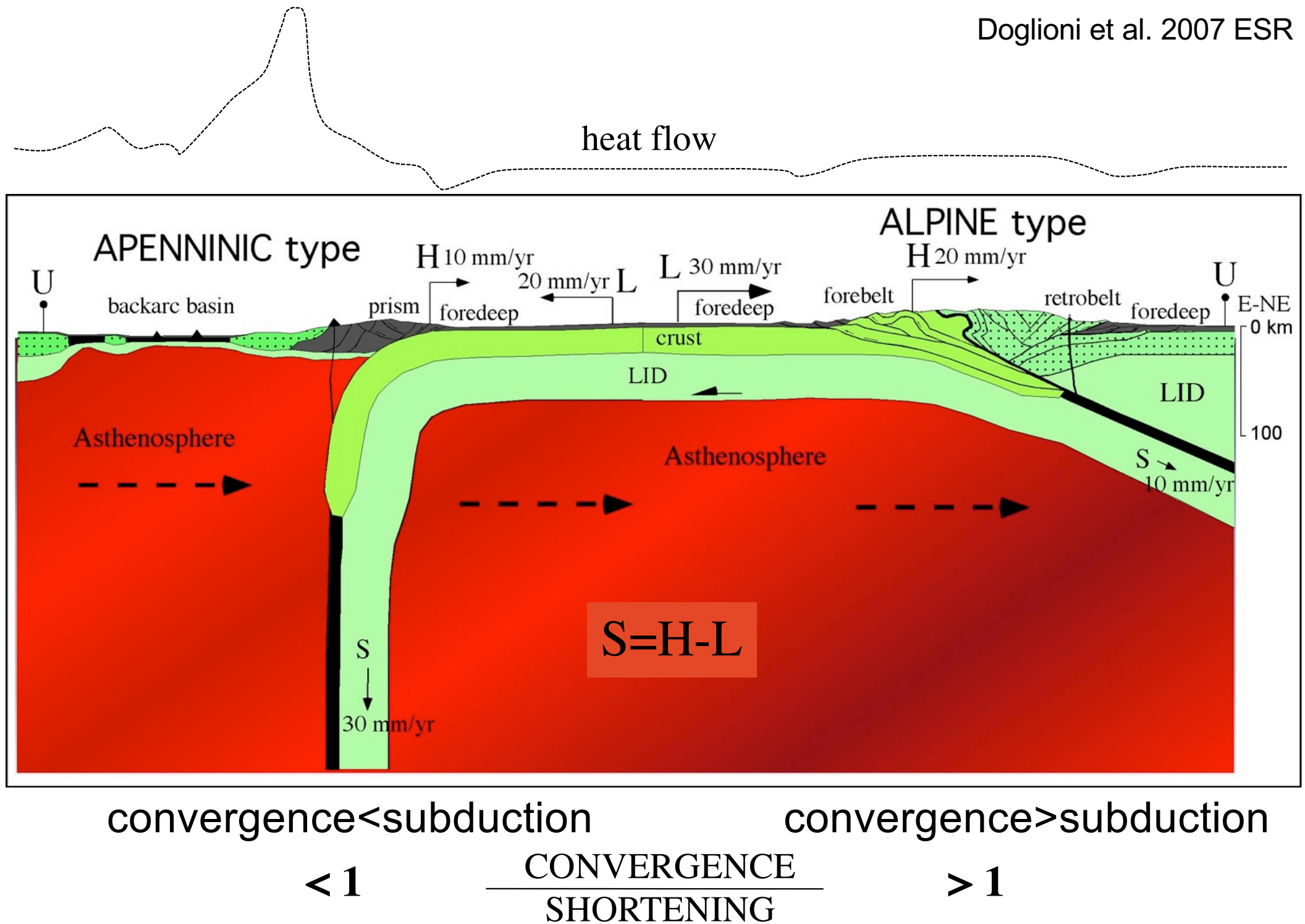


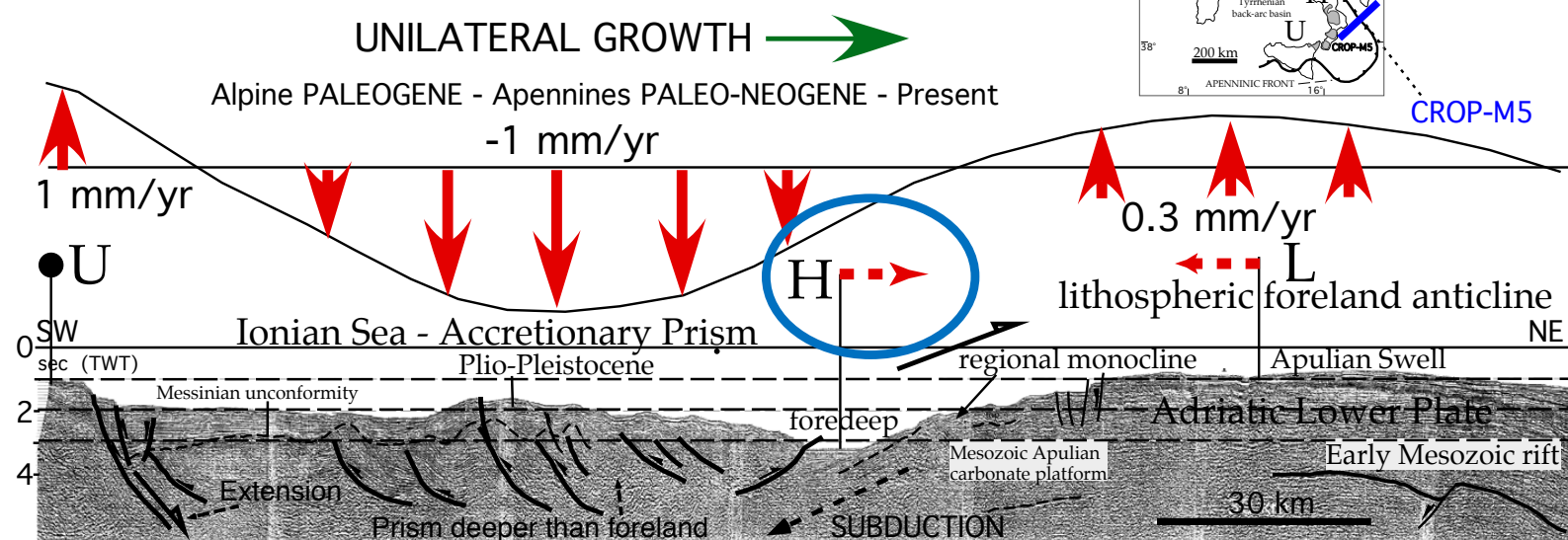
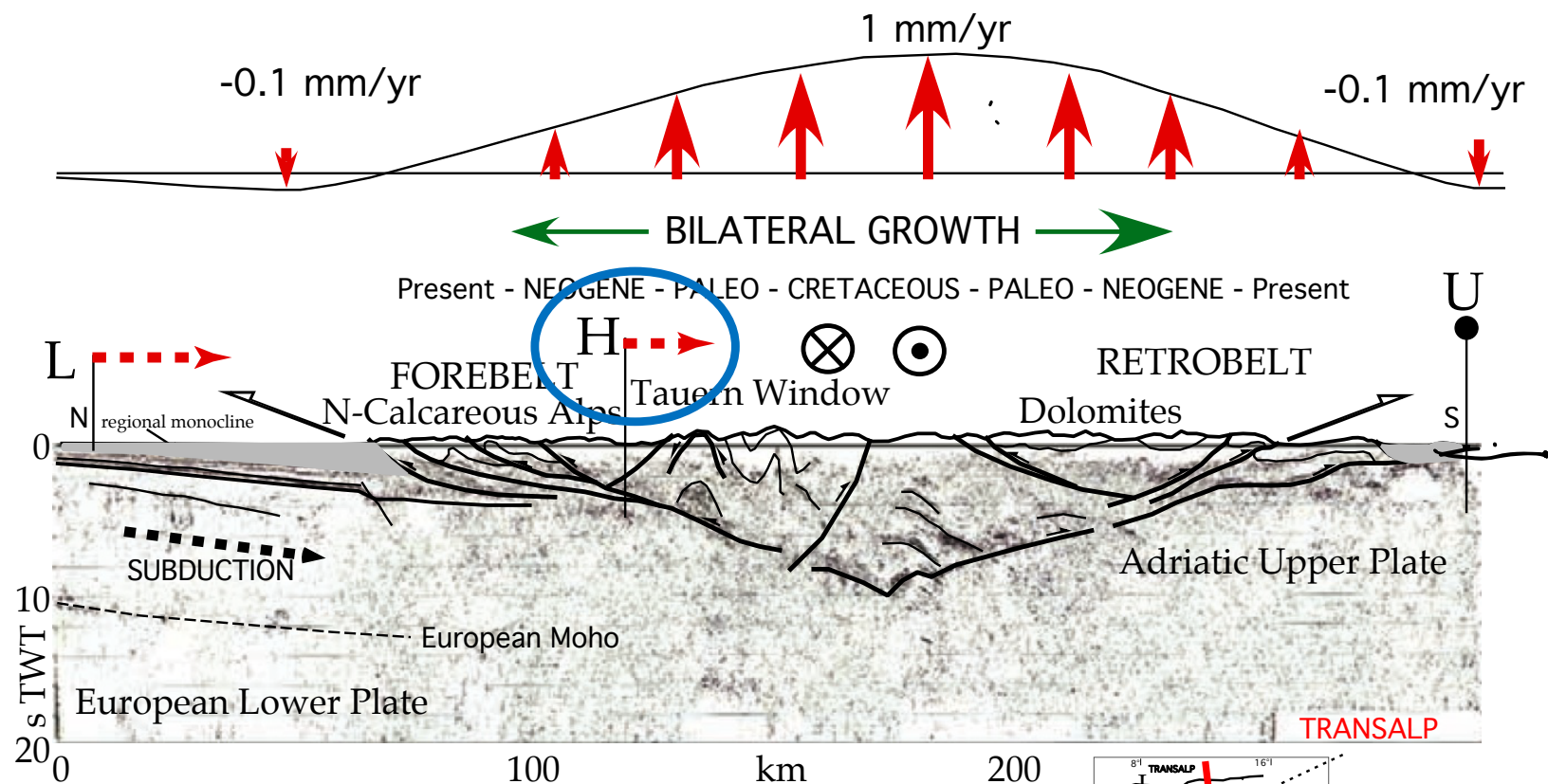
a)

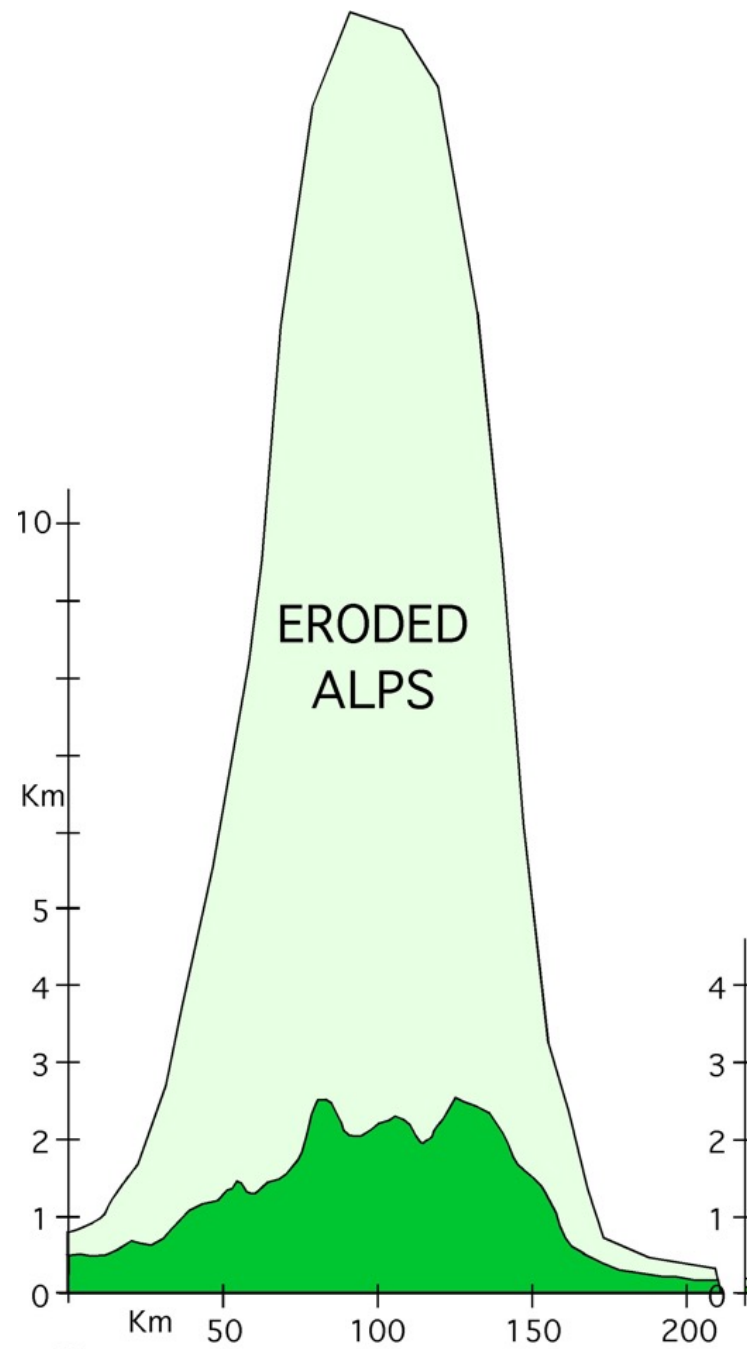
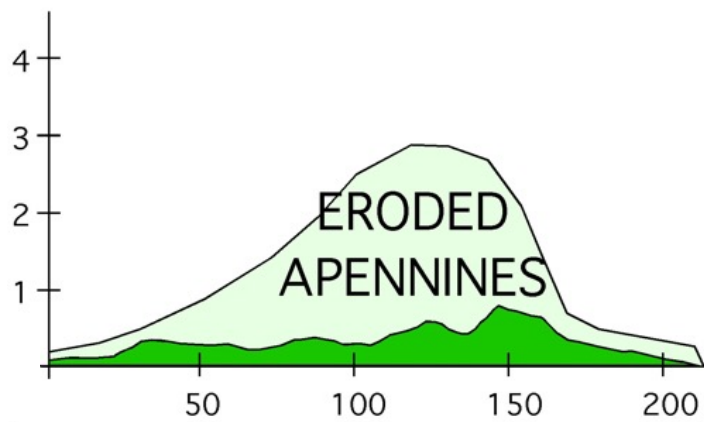
$$V_S = V_H - V_L$$

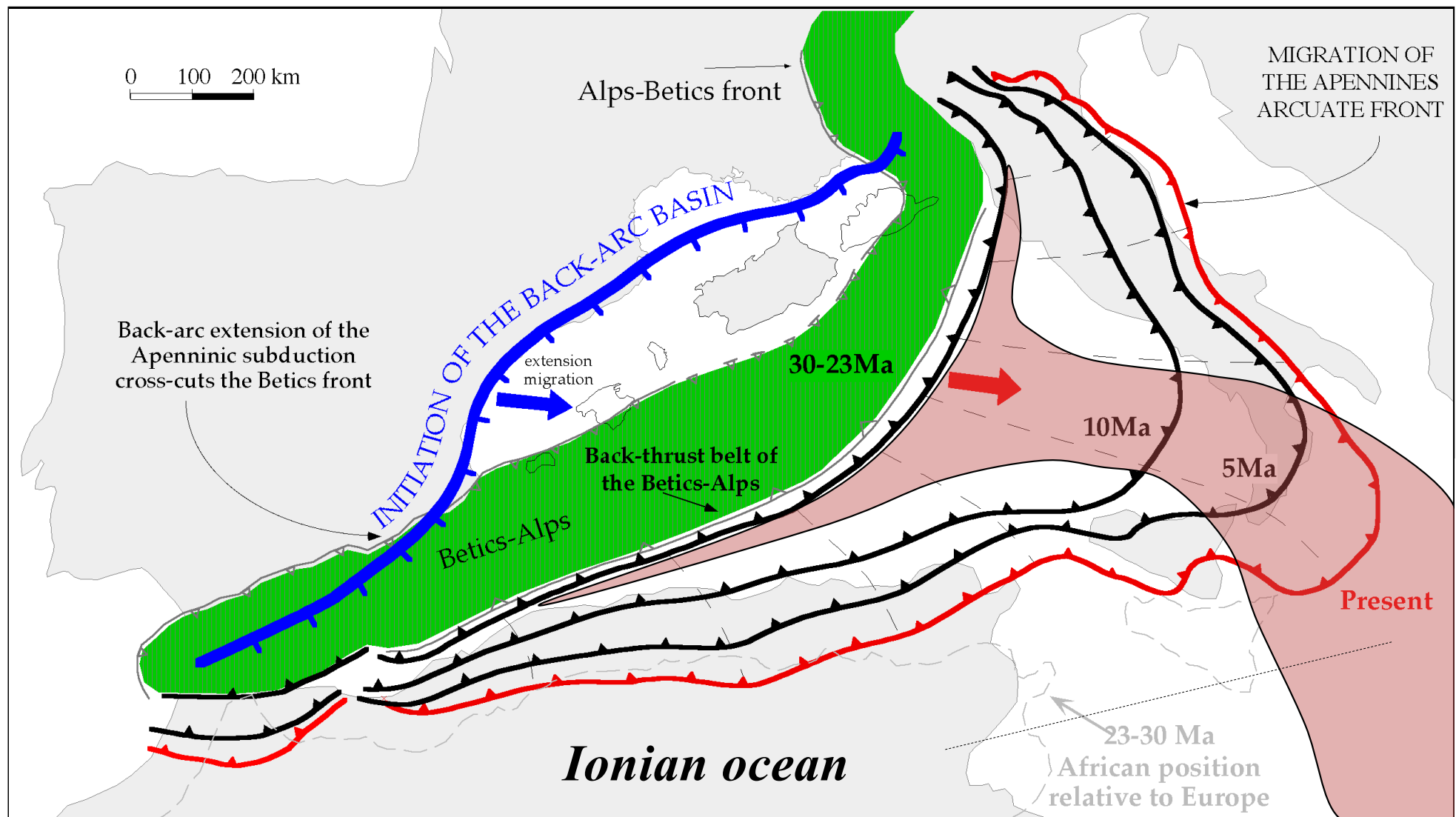


b)

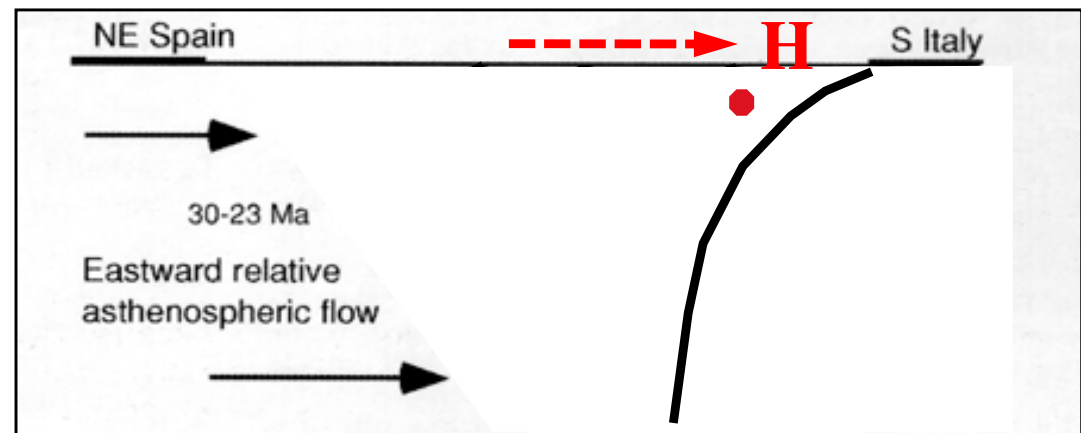








*E-ward slab retreat
5 times faster than N-S
convergence*



extension

contraction

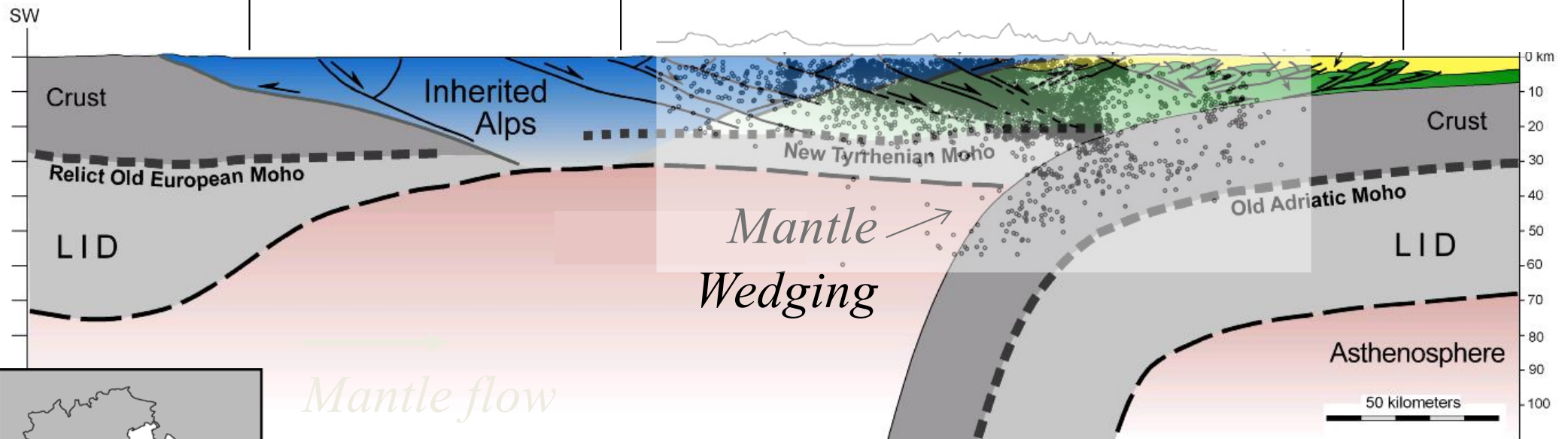
coast

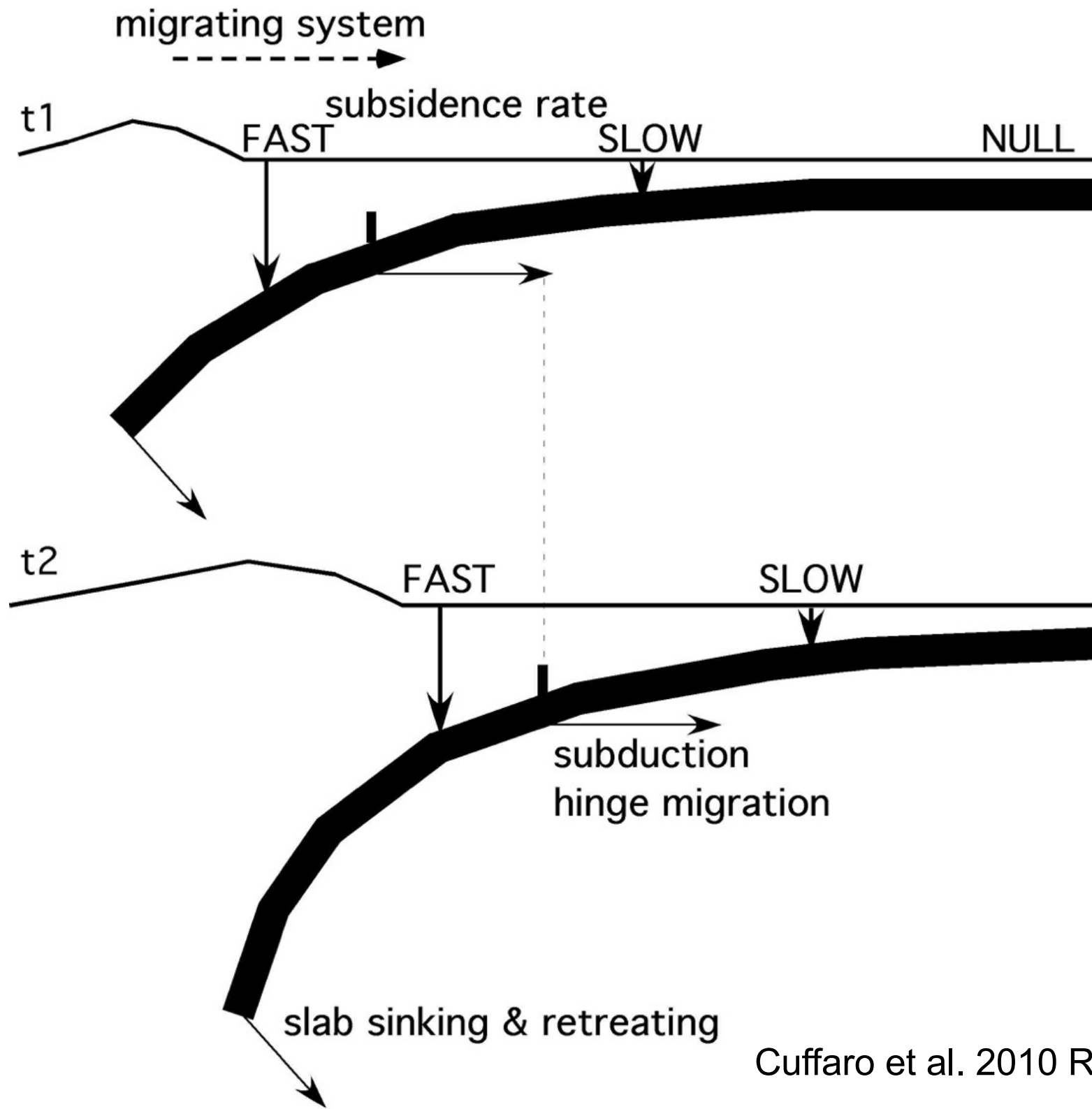
Tirreno

coast

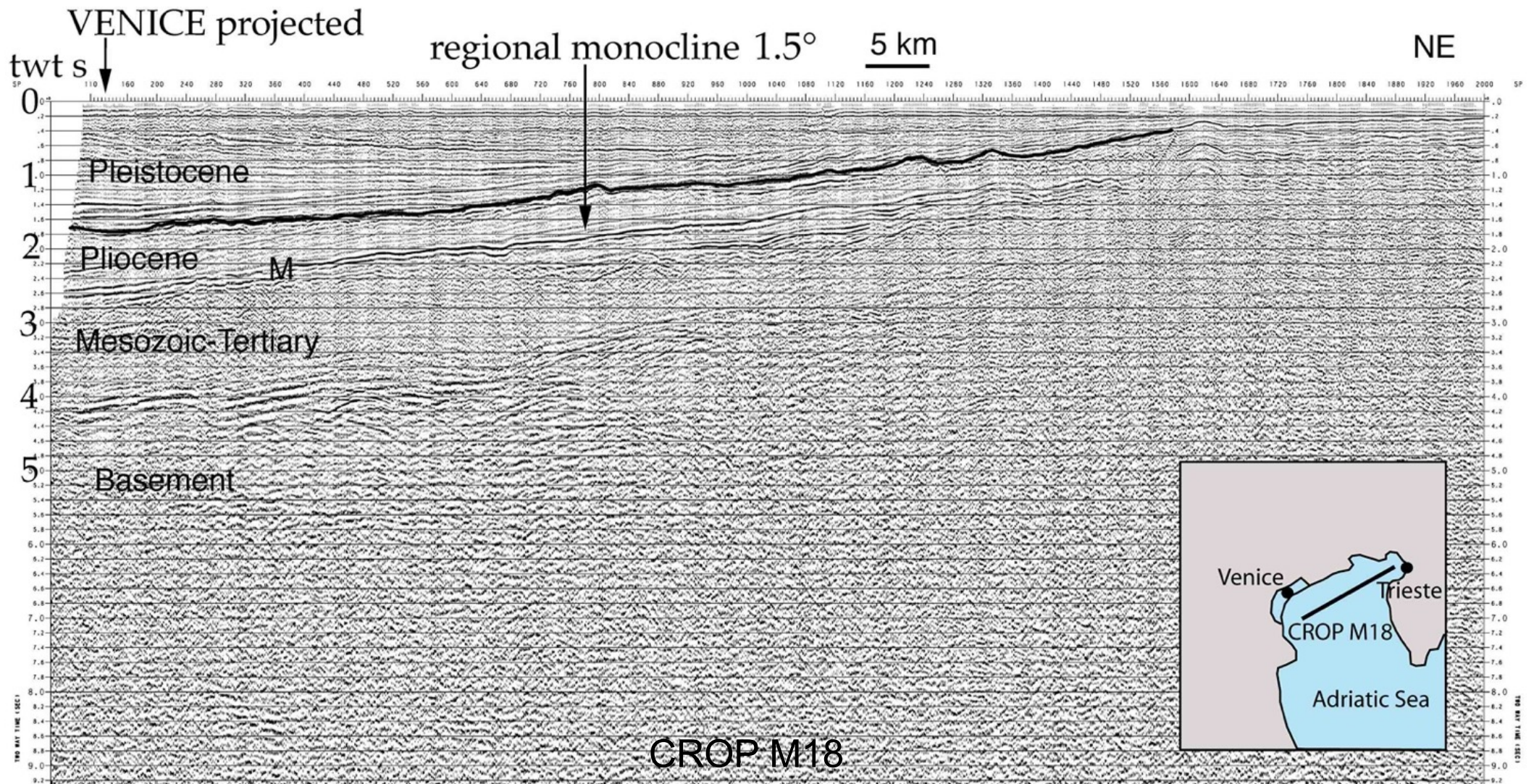
Appennini

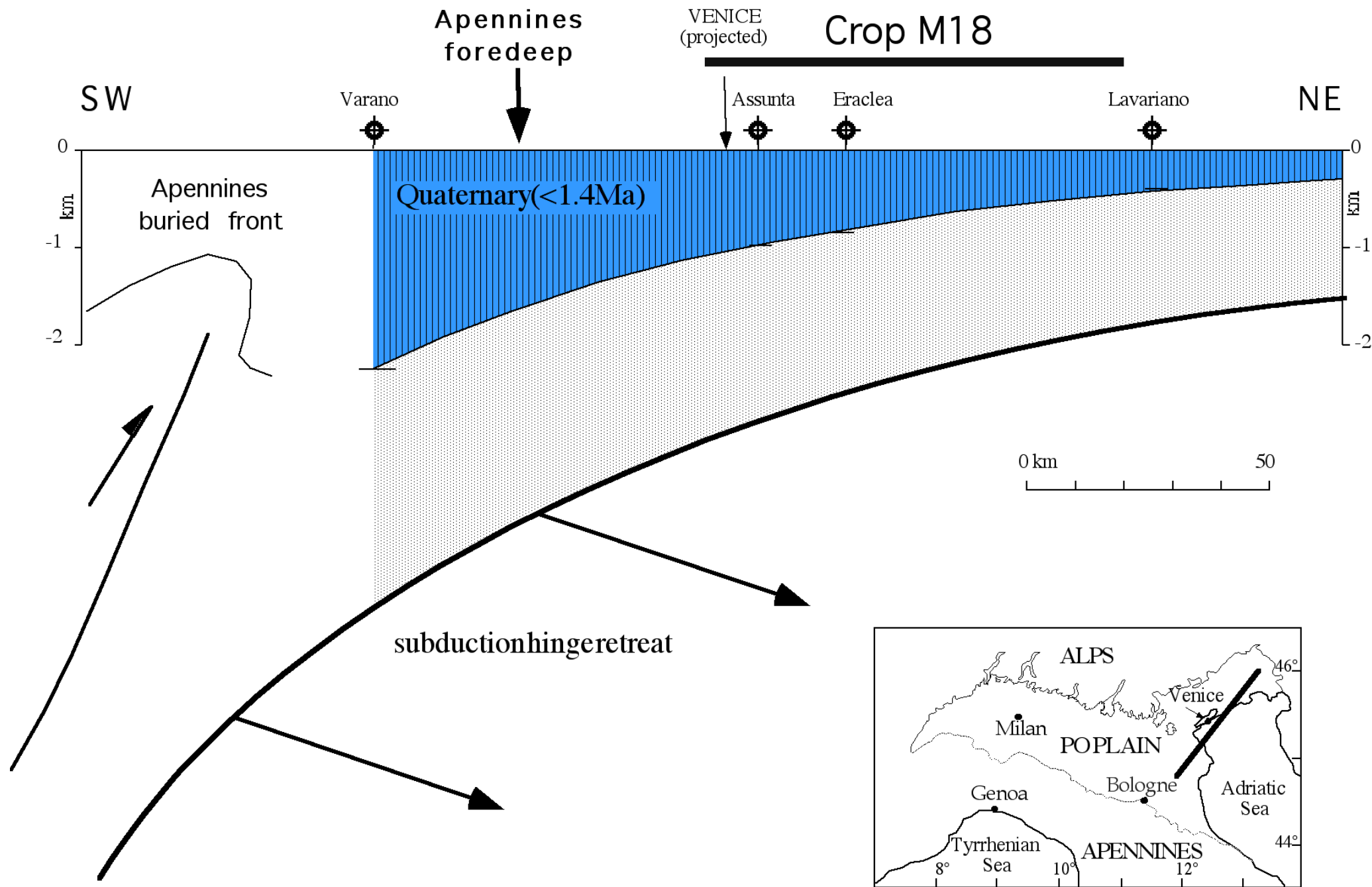
coast

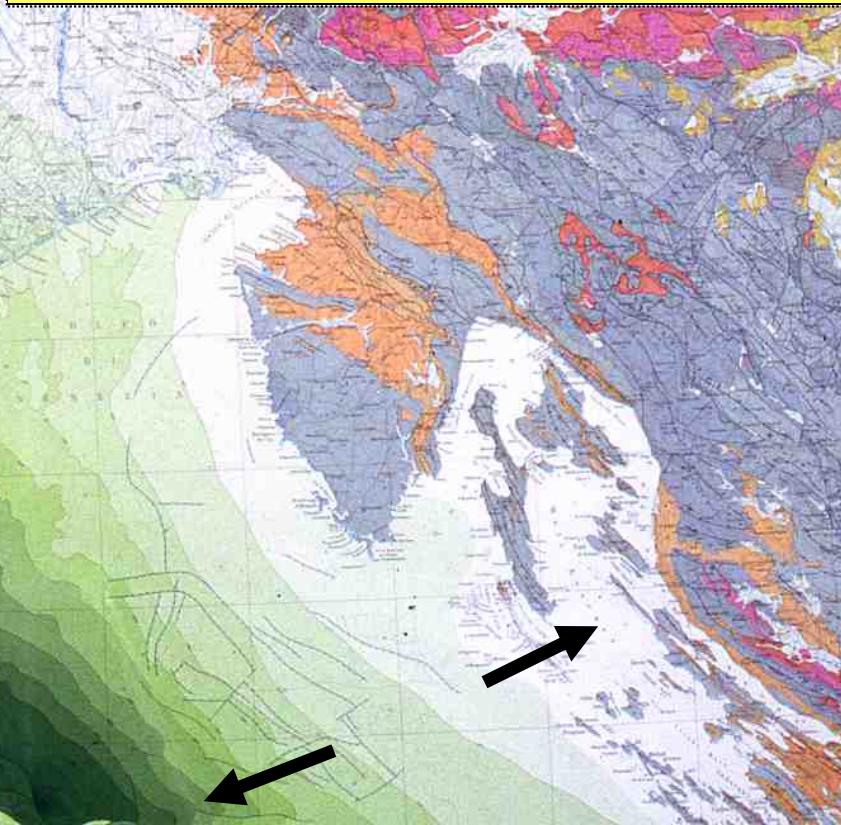
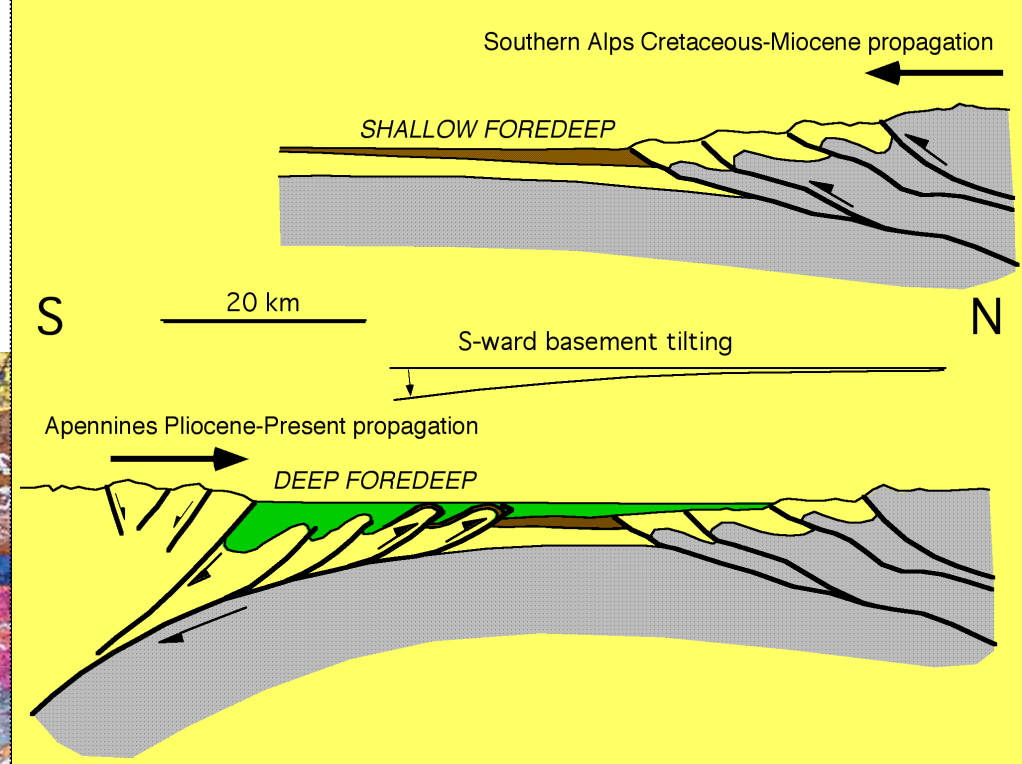
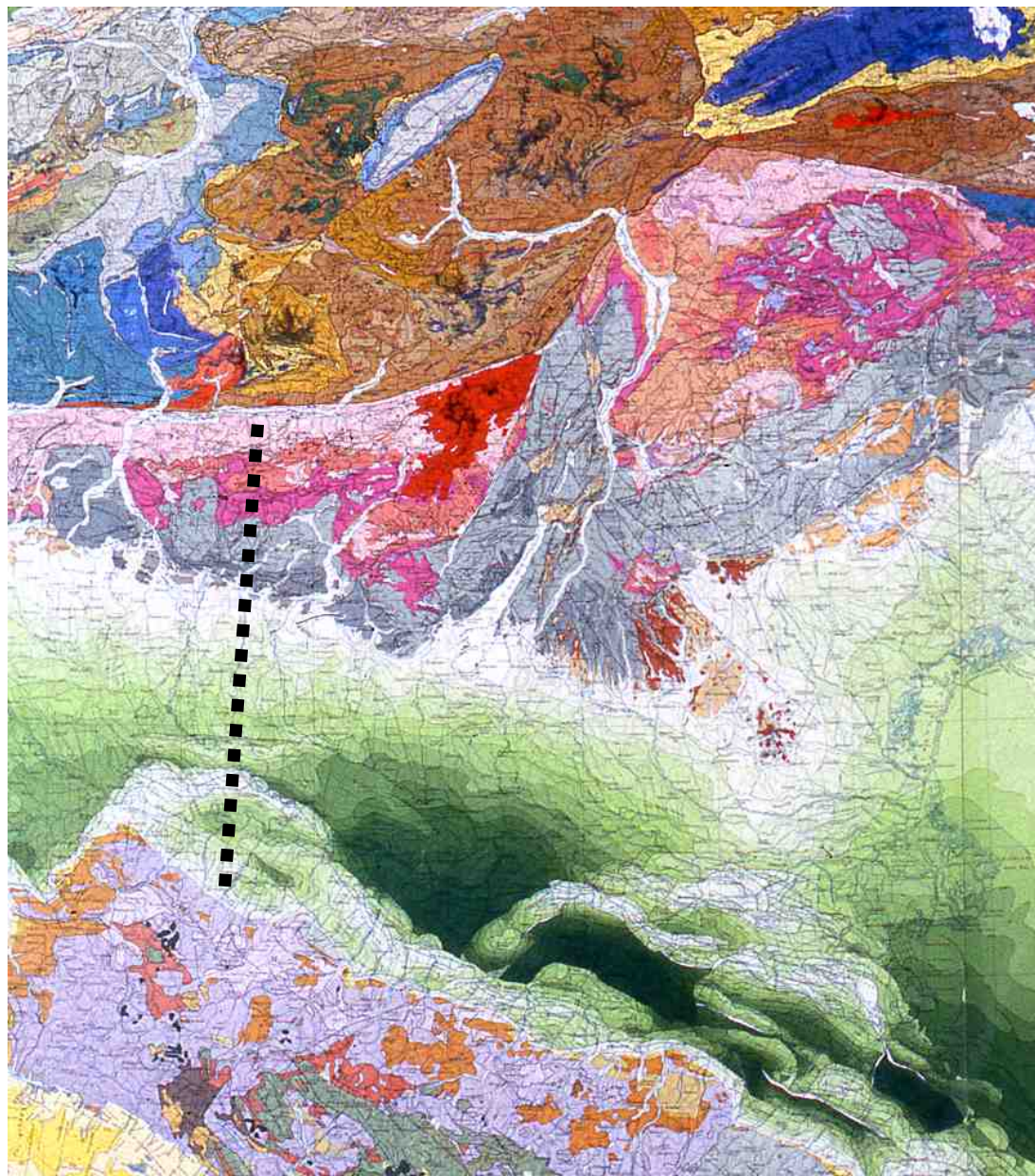


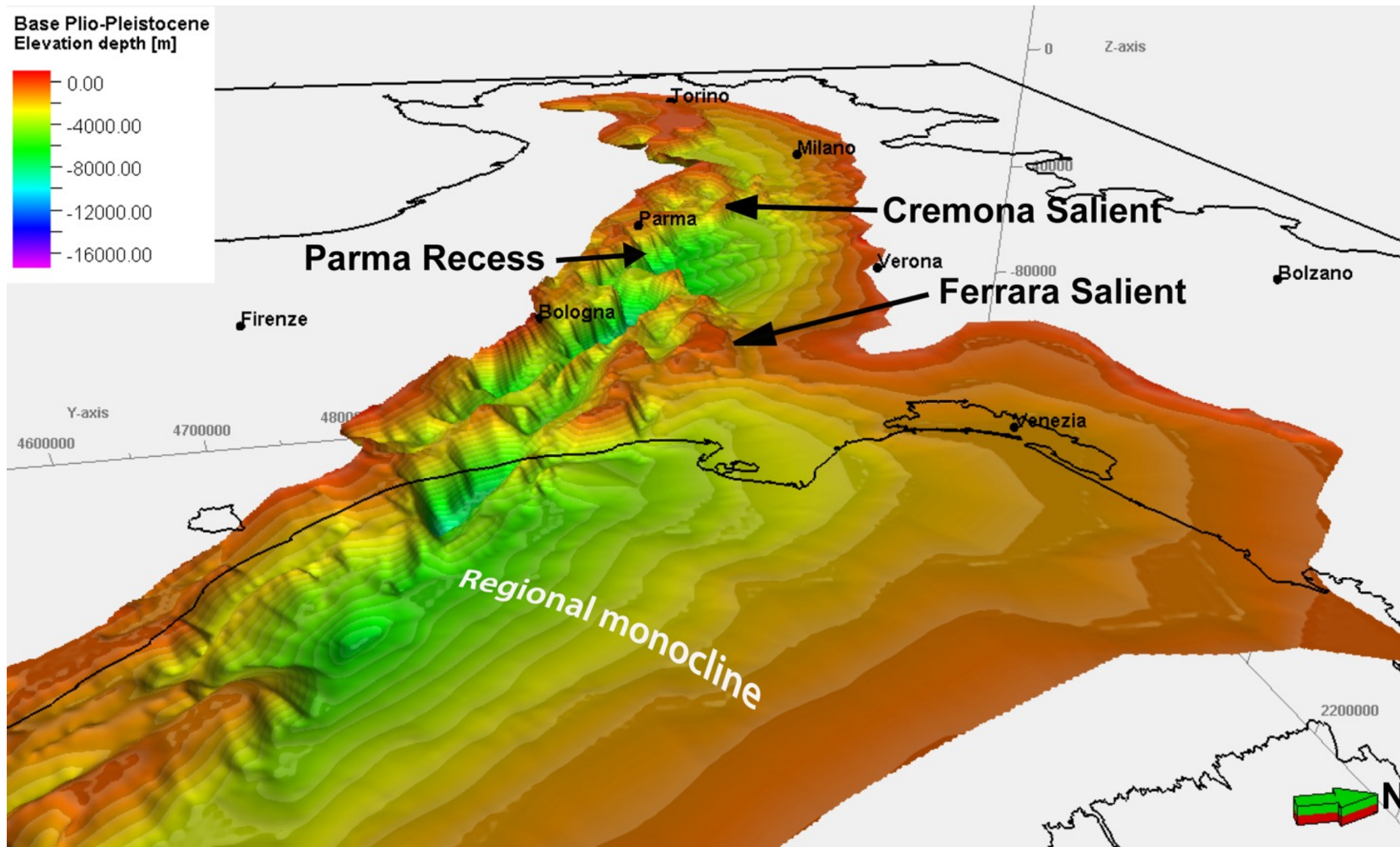


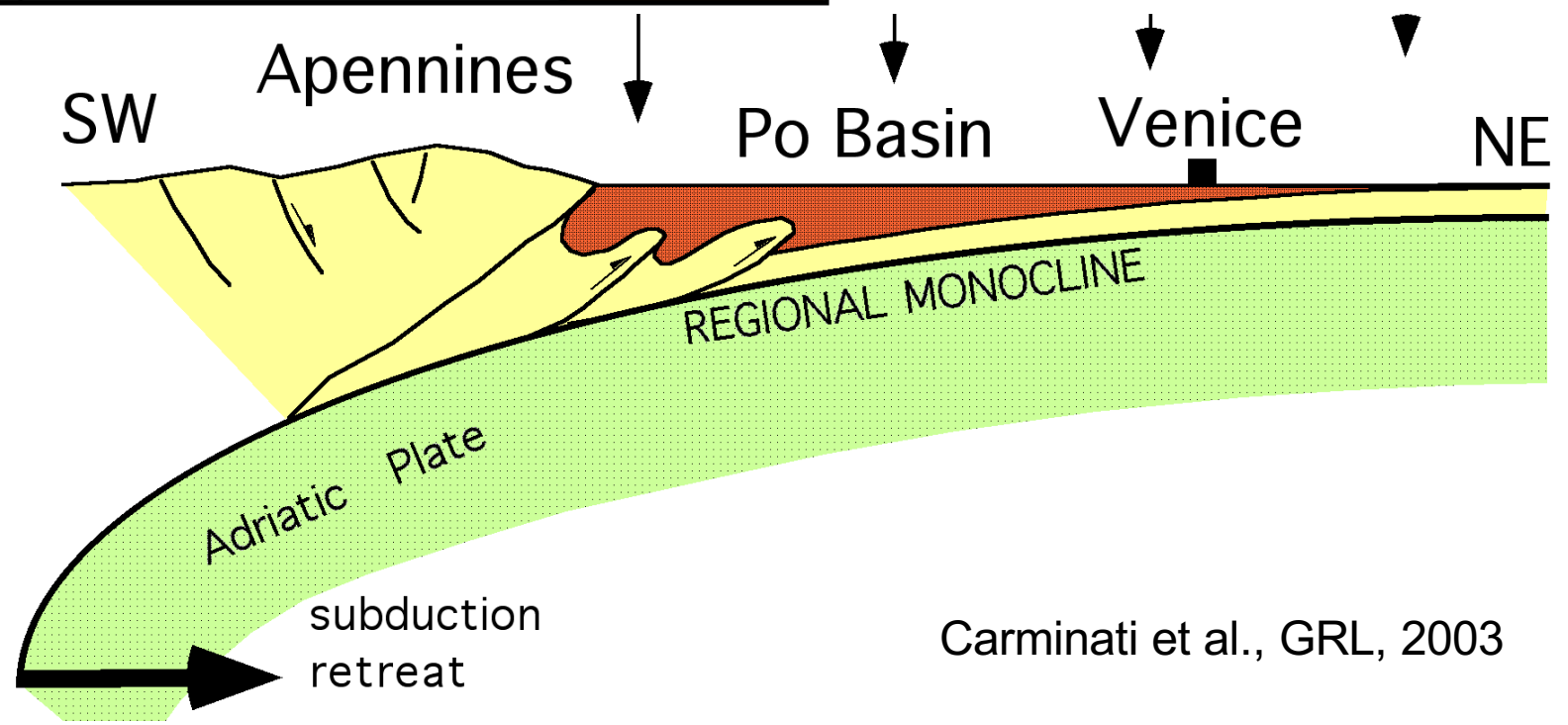
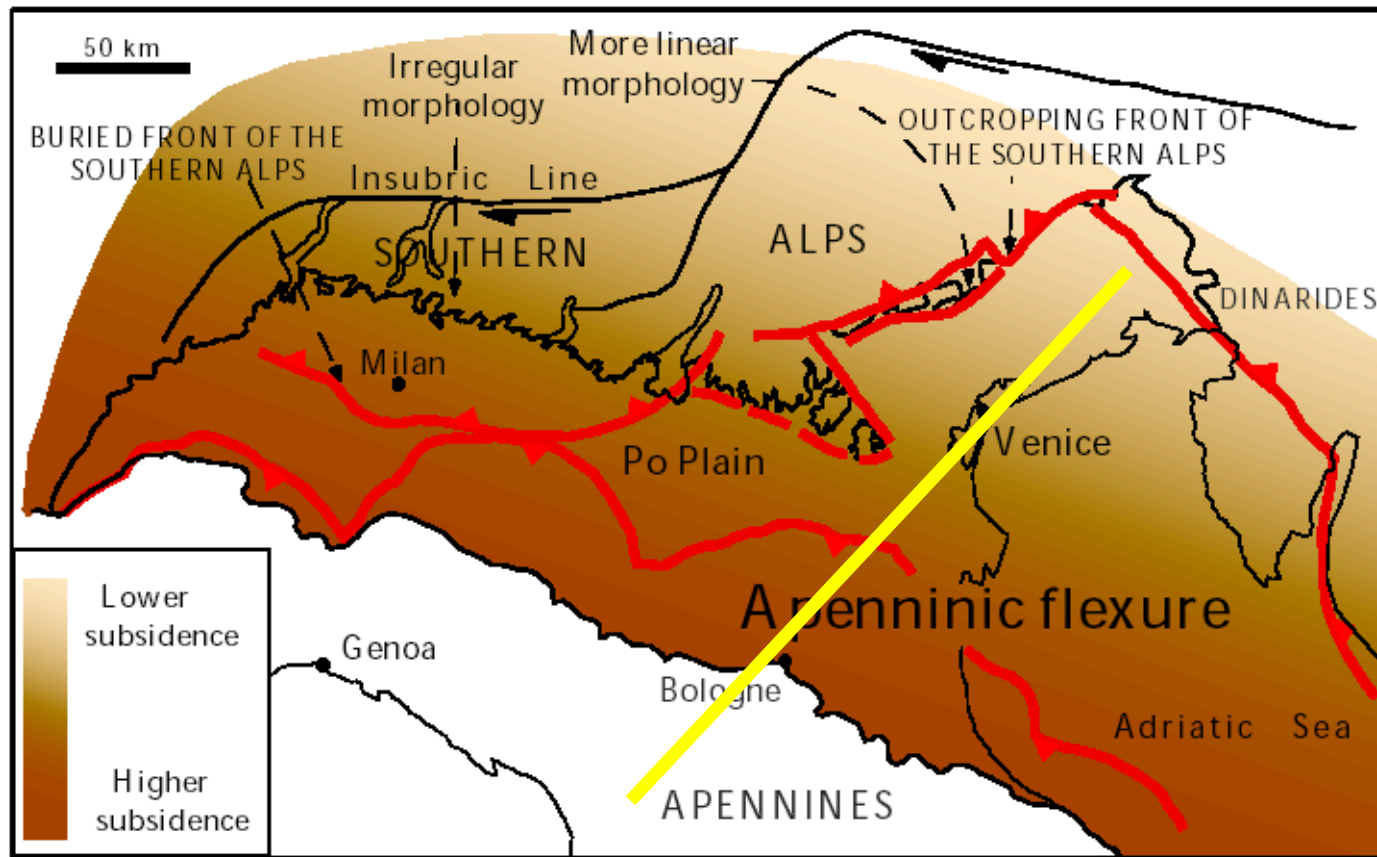
Pleistocene subsidence ≈ 1 mm/yr











Carminati et al., GRL, 2003

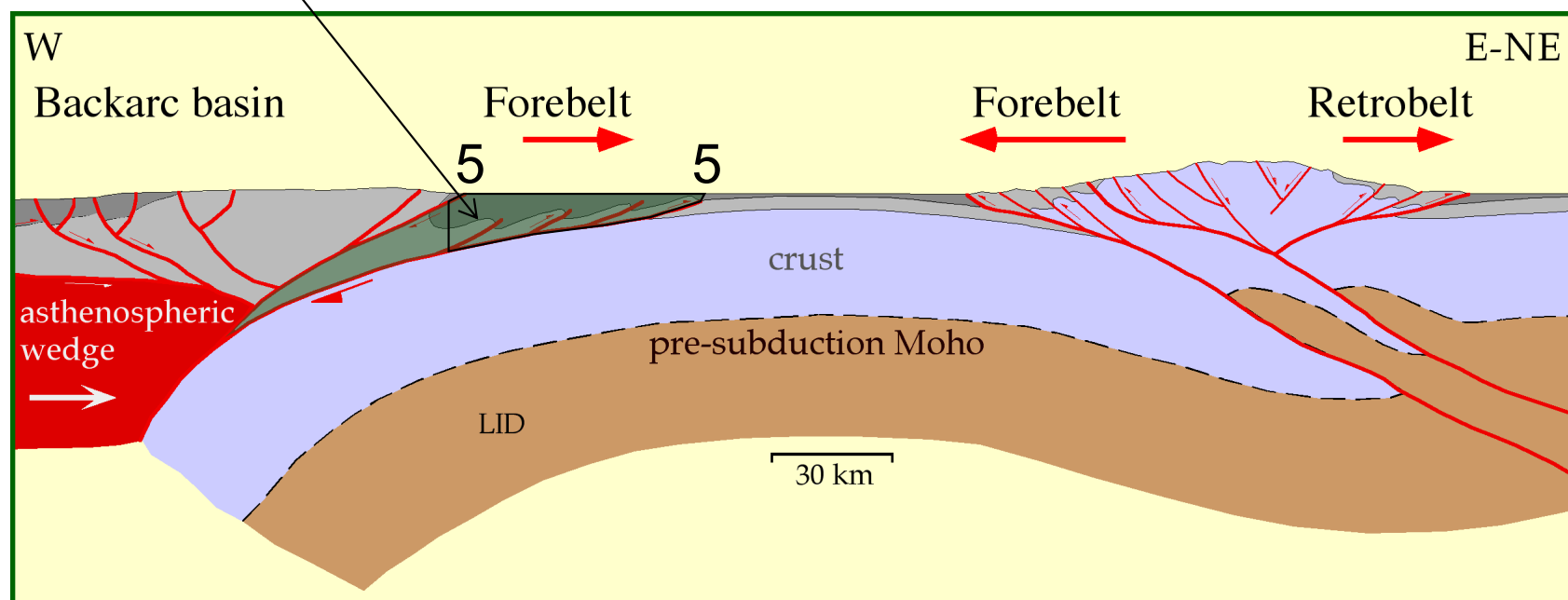
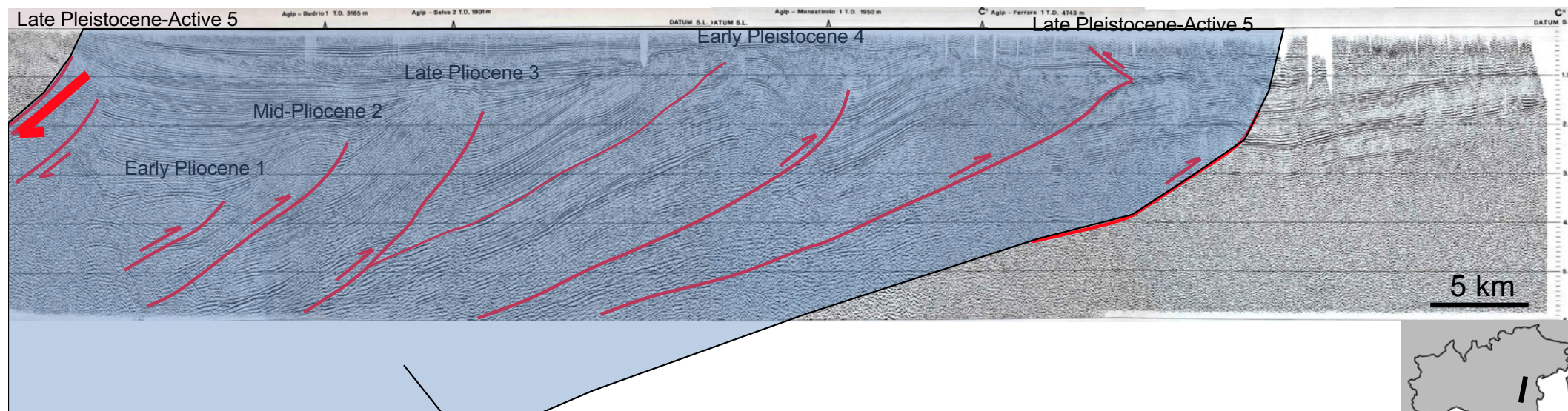
Out-of-sequence thrust

5

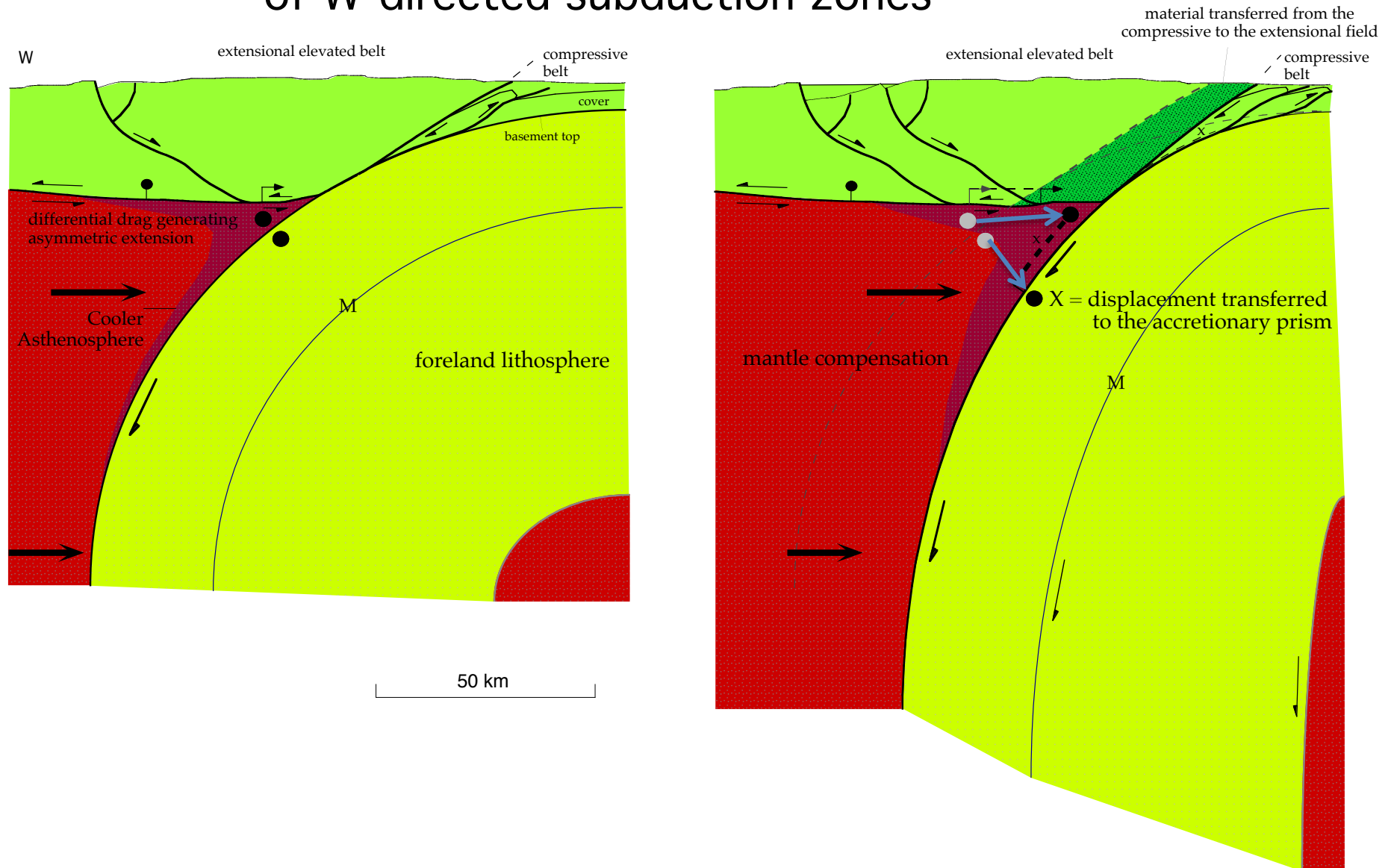
Present N-Apennines accretionary prism

Frontal thrust

5

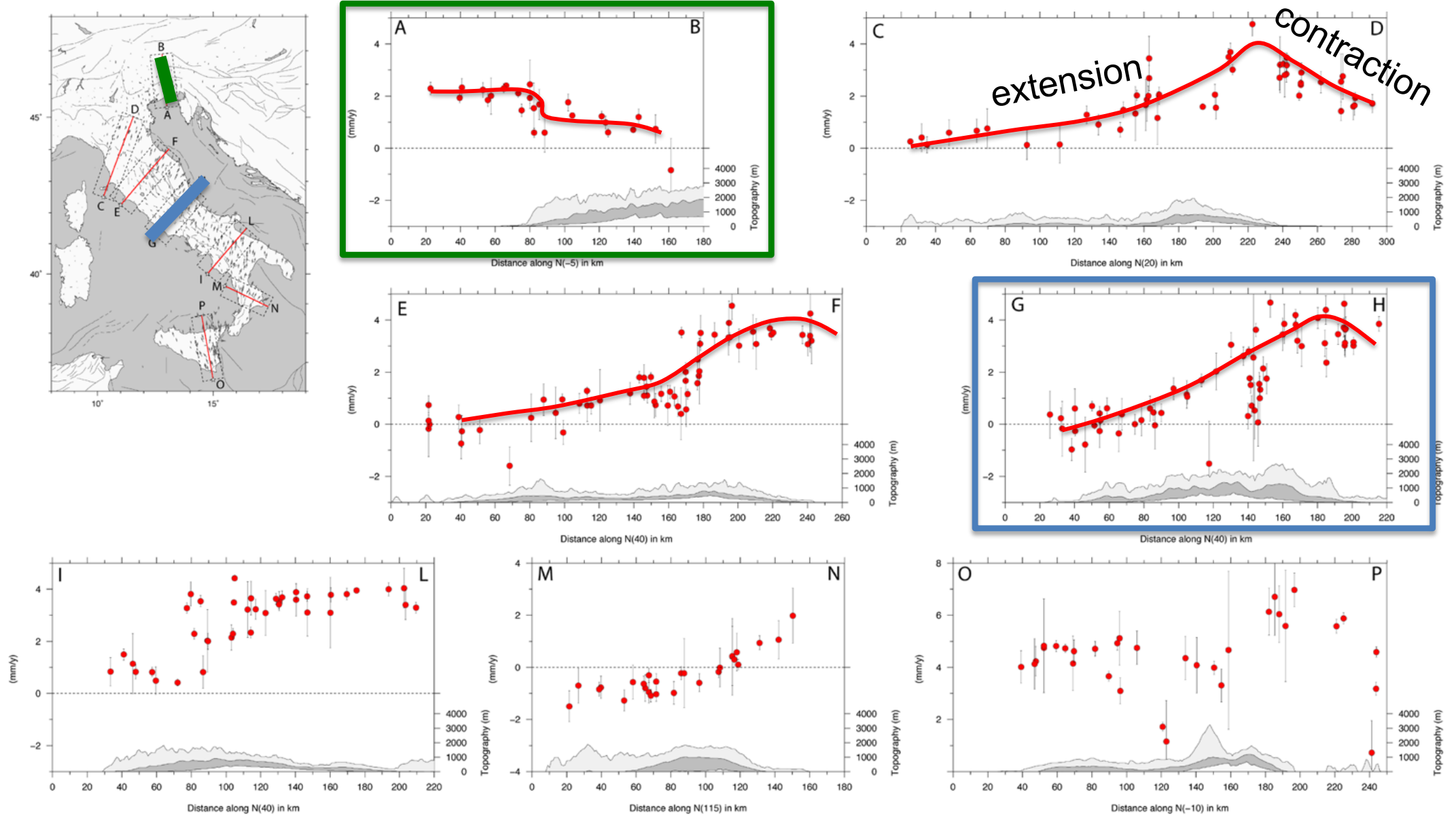


kinematics of the extensional and compressional belts of W-directed subduction zones





INGV



Devoti et al. 2017 Ann. Geophys.

Gran Sasso Range

Pizzo Intermesoli

N

ACTIVE NORMAL FAULT
Quaternary

3

K

onlap

T

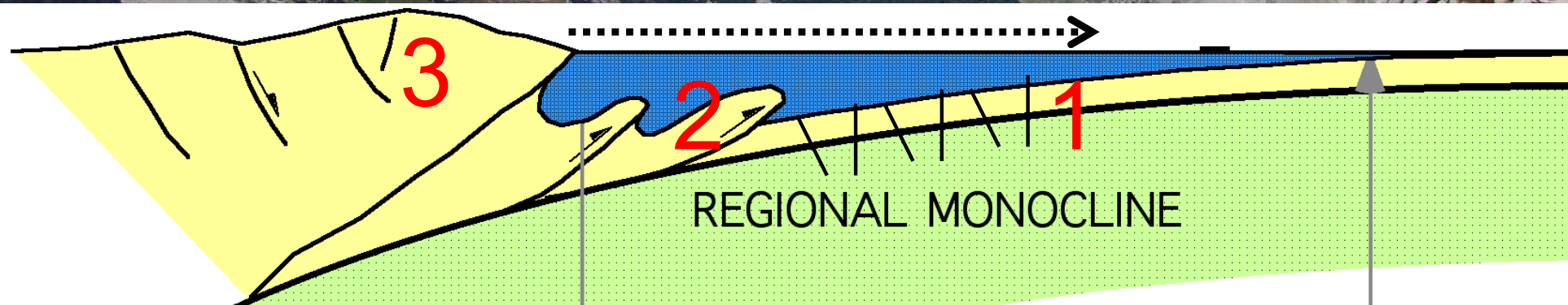
FAULT-PROPAGATION FOLD
Messinian-PI

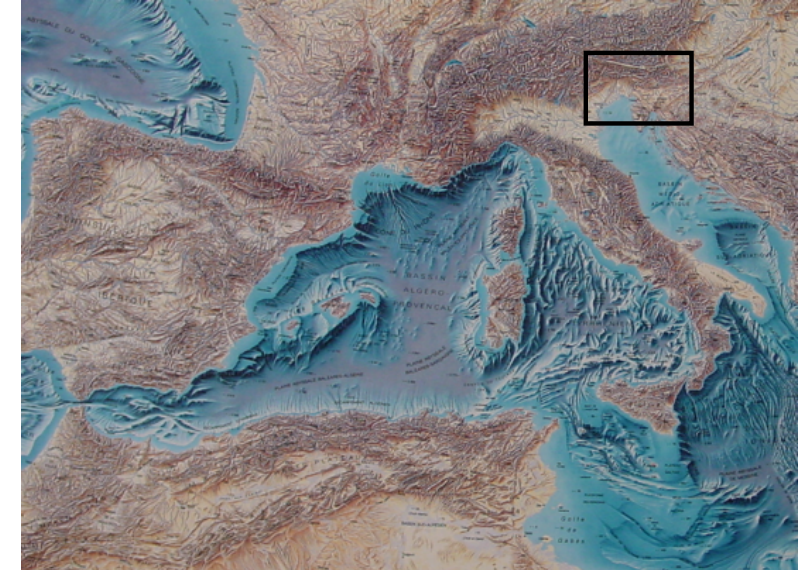
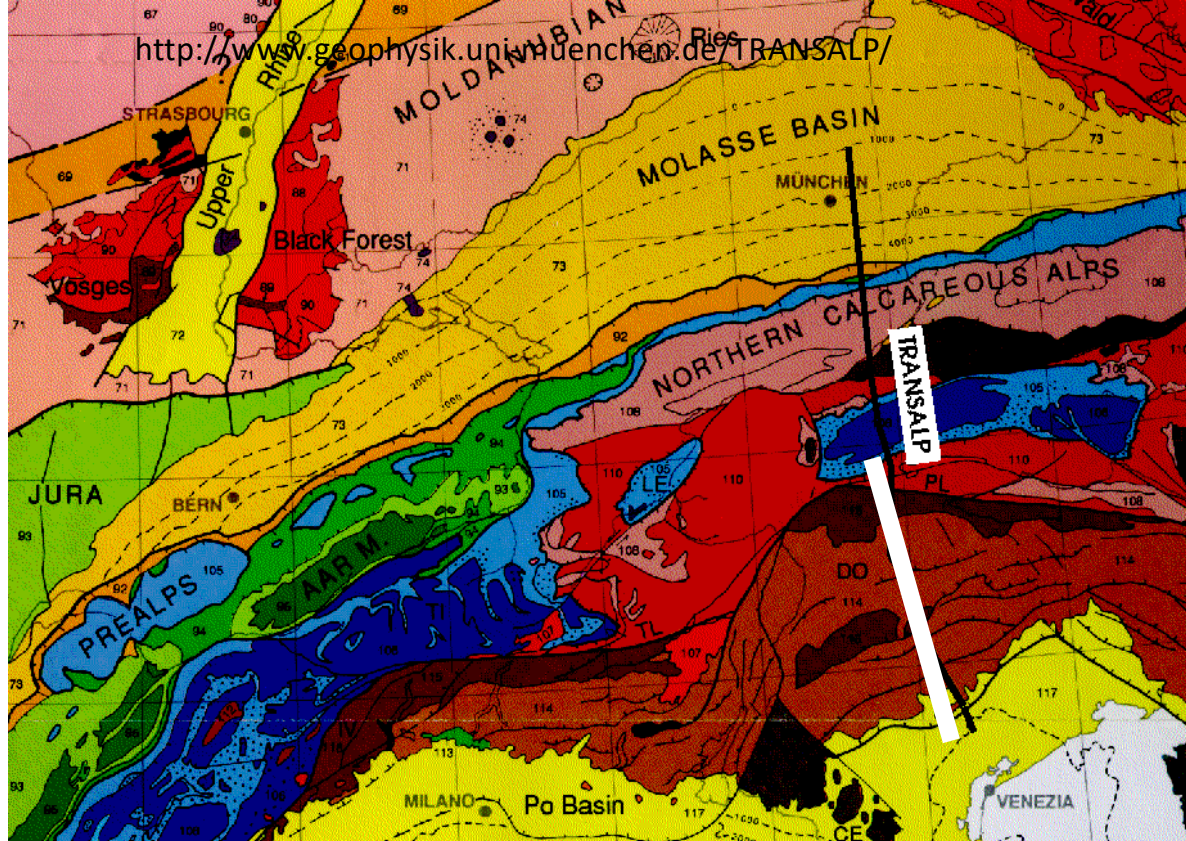
2

J

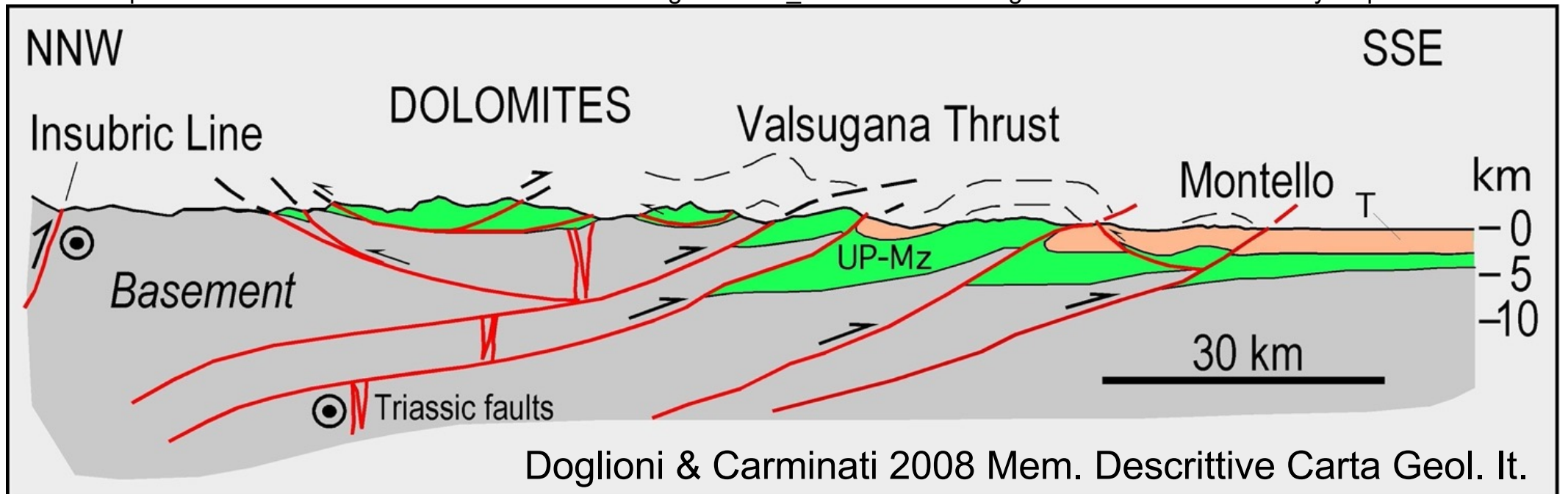
1

LATE JURASSIC TRANSTENSIONAL TECTONICS
Jurassic



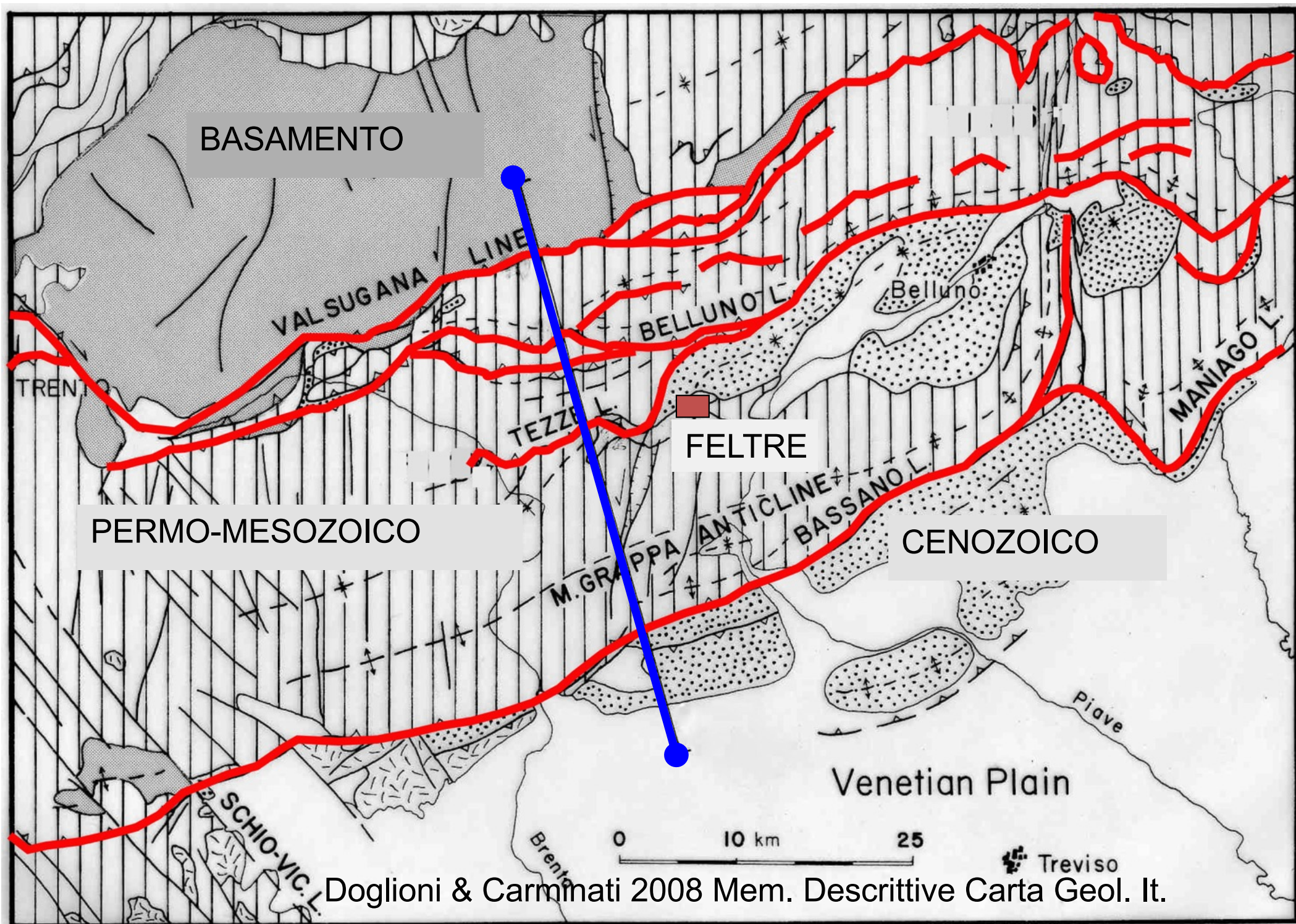


http://www.dst.uniroma1.it/dst1/sciterra/sezioni/doglionii/Publ_download/2008DoglioniCarminatiStructuralStyles.pdf

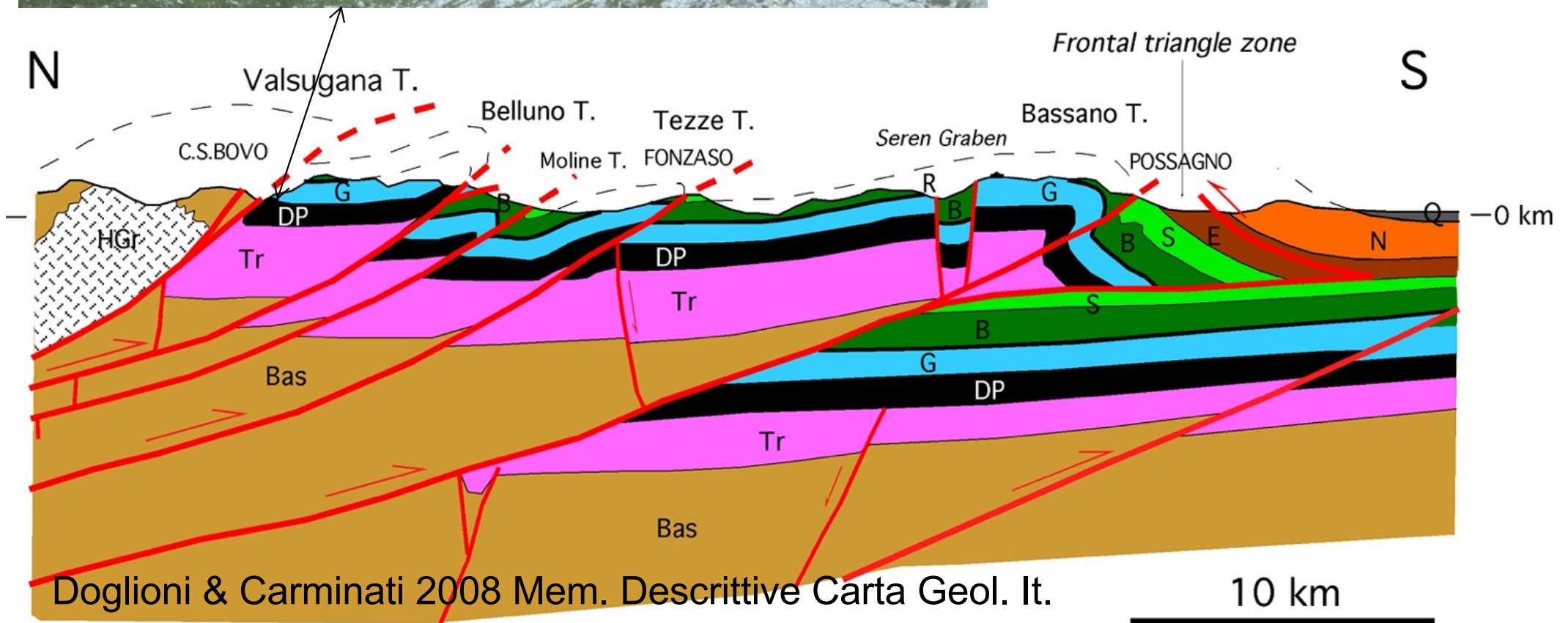
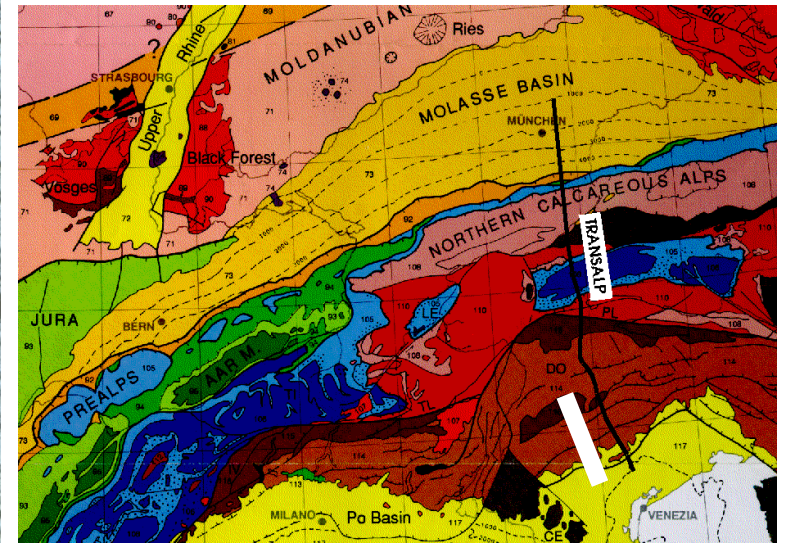


Principali sovrascorrimenti e pieghe delle Alpi Venete





Dogliani & Carminati 2008 Mem. Descrittive Carta Geol. It.



S

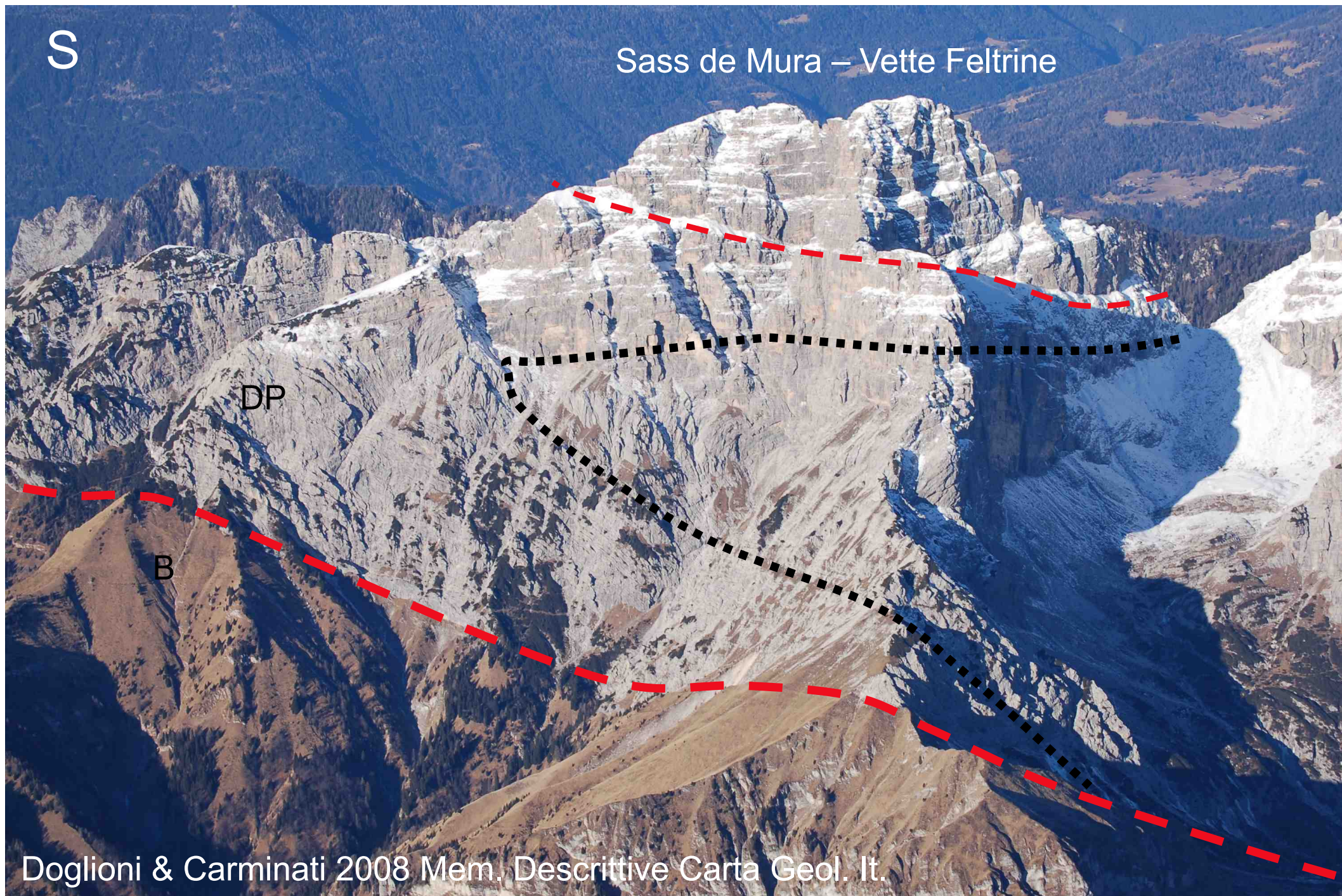
Sass de Mura – Vette Feltrine

DP

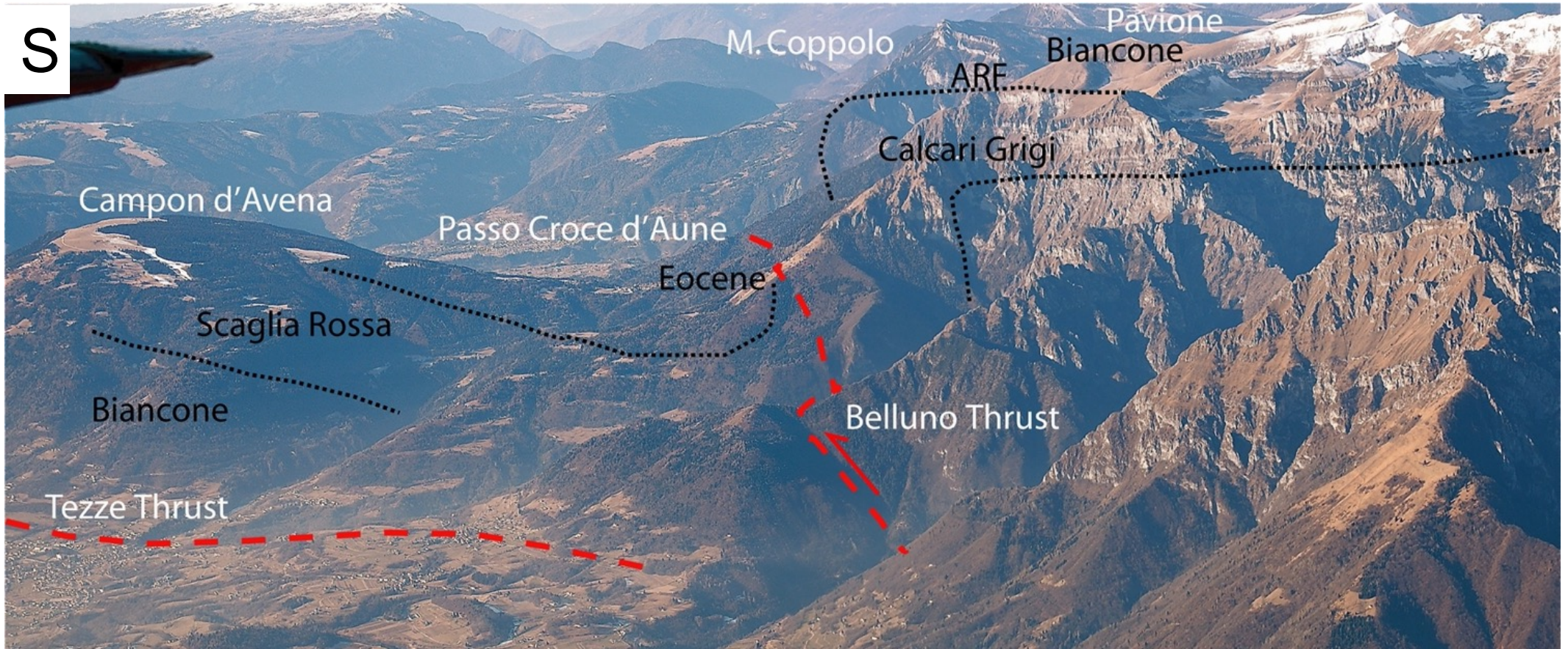
B

Doglioni & Carminati 2008 Mem. Descrittive Carta Geol. It.

http://www.dst.uniroma1.it/dst1/sciterra/sezioni/doglioni/Publ_download/2008DoglioniCarminatiStructuralStyles.pdf

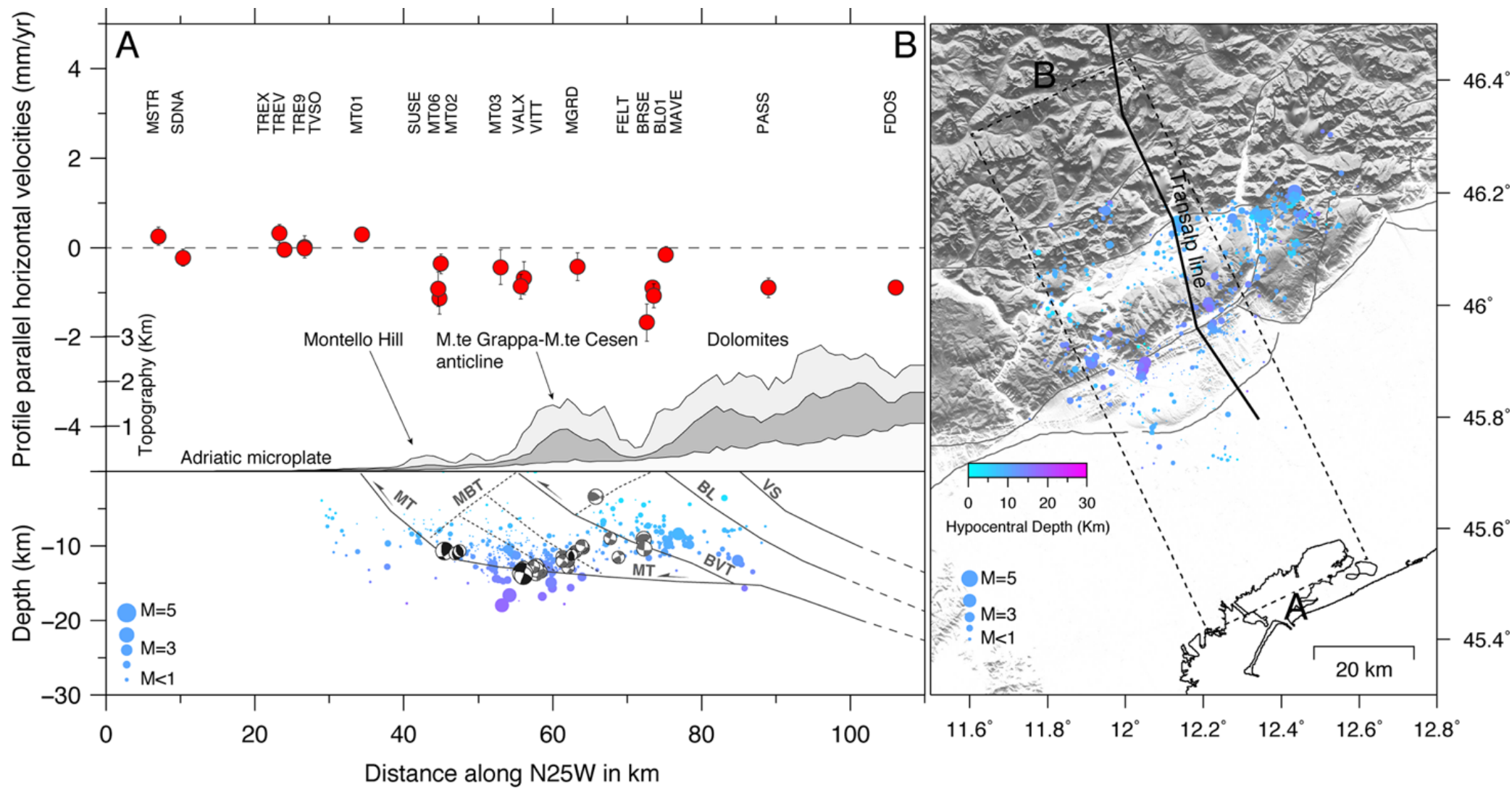


Campon d'Avena e Vette Feltrine

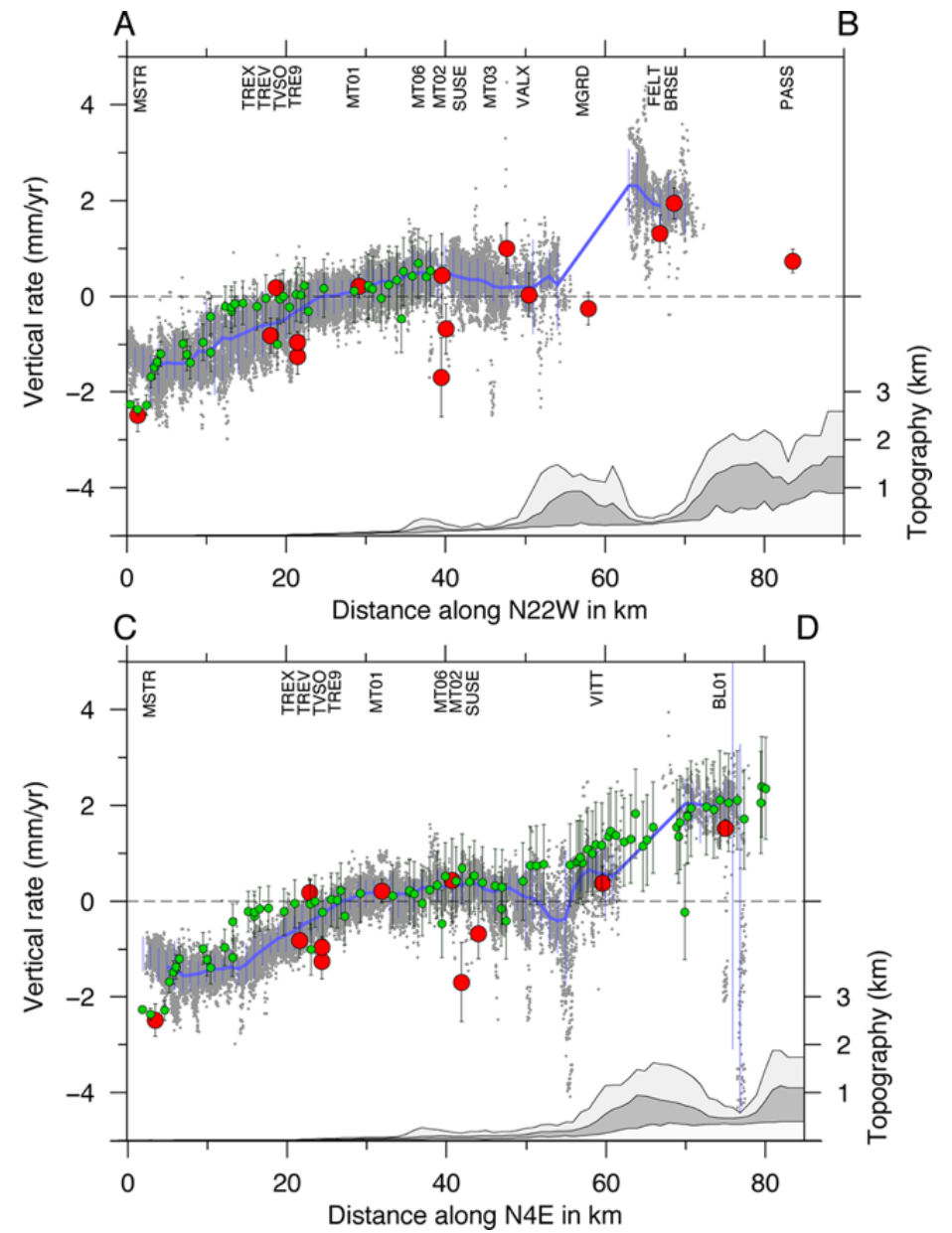
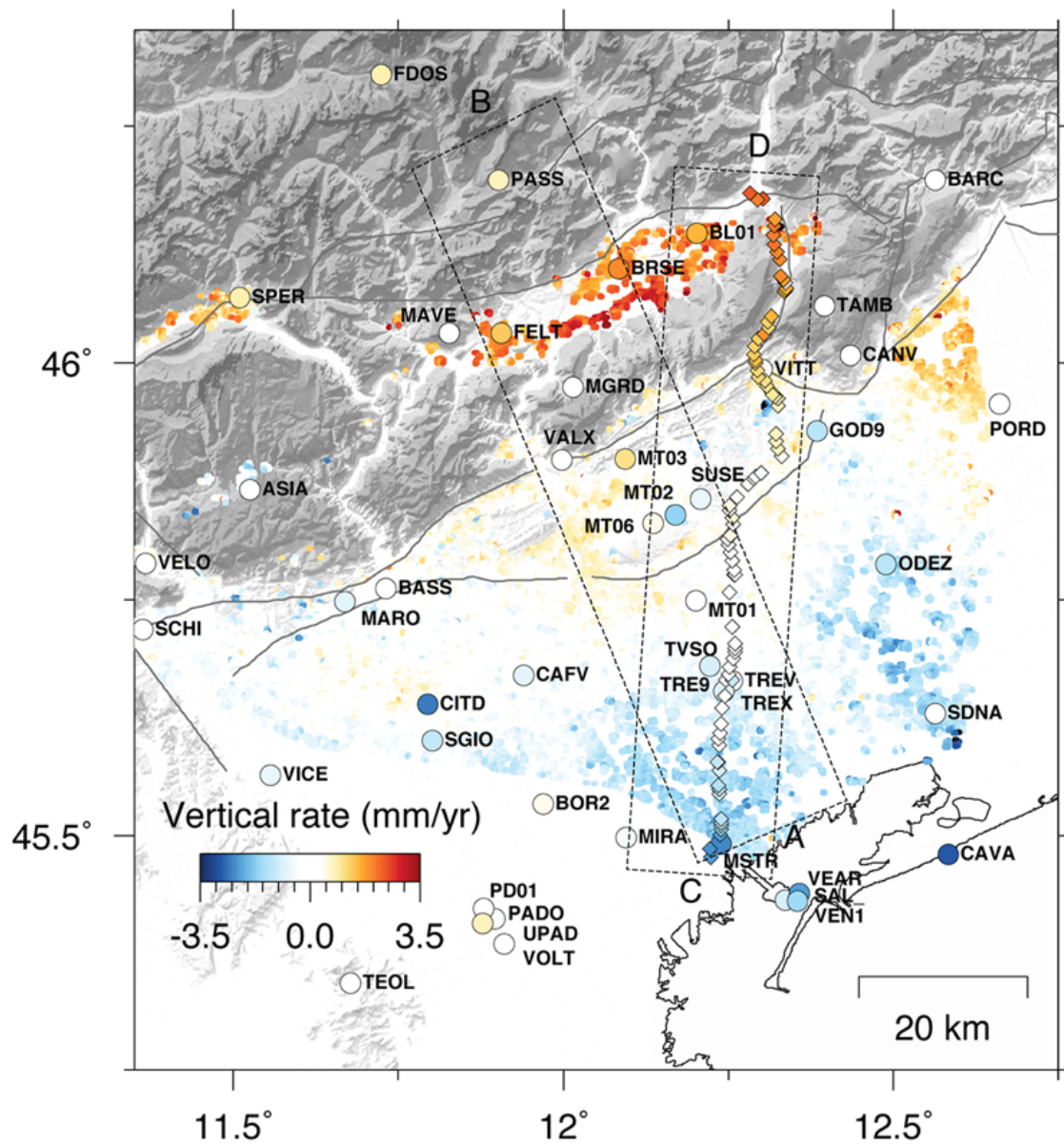


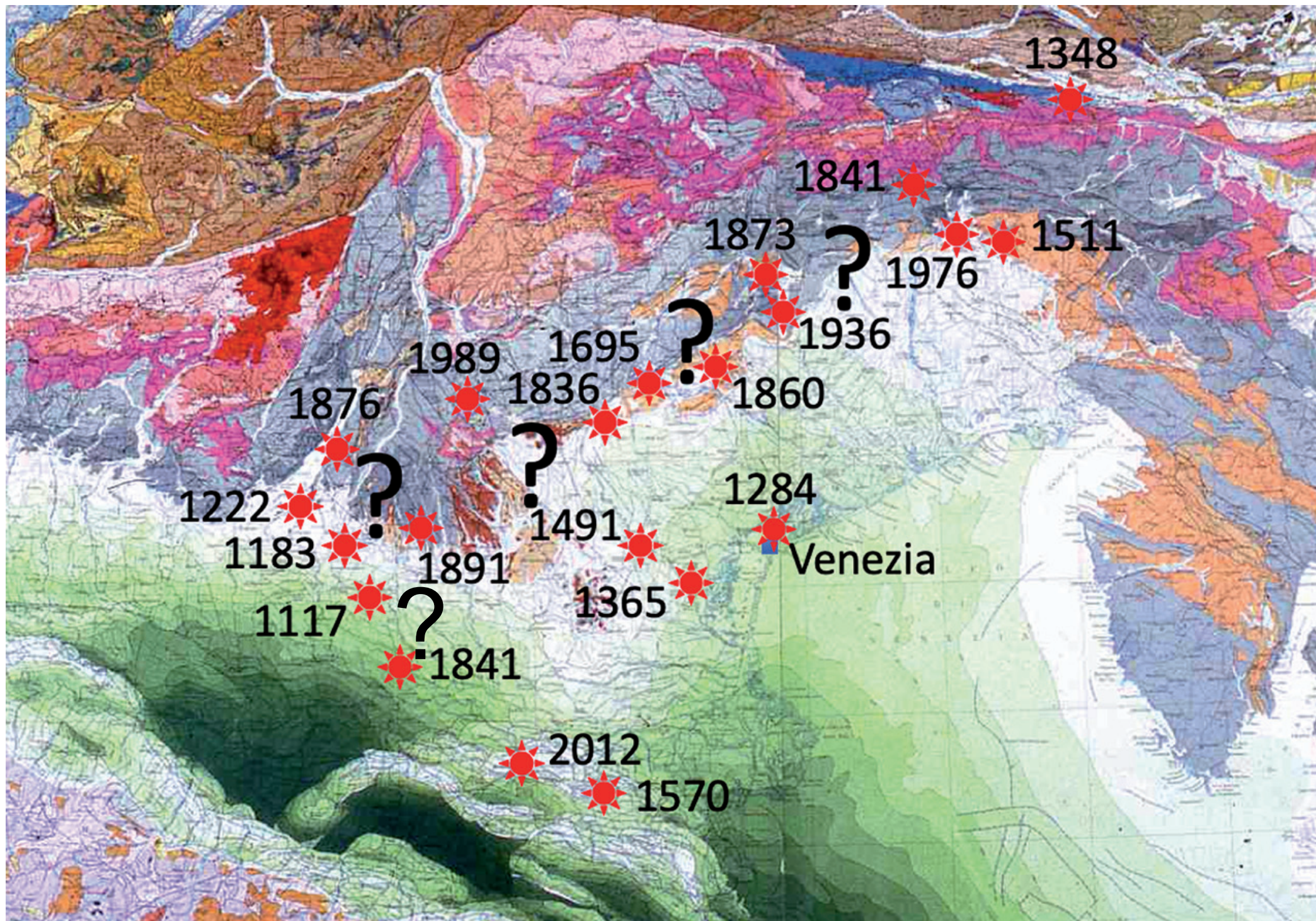
Doglioni & Carminati 2008 Mem. Descrittive Carta Geol. It.

http://www.dst.uniroma1.it/dst1/sciterra/sezioni/doglioni/Publ_download/2008DoglioniCarminatiStructuralStyles.pdf

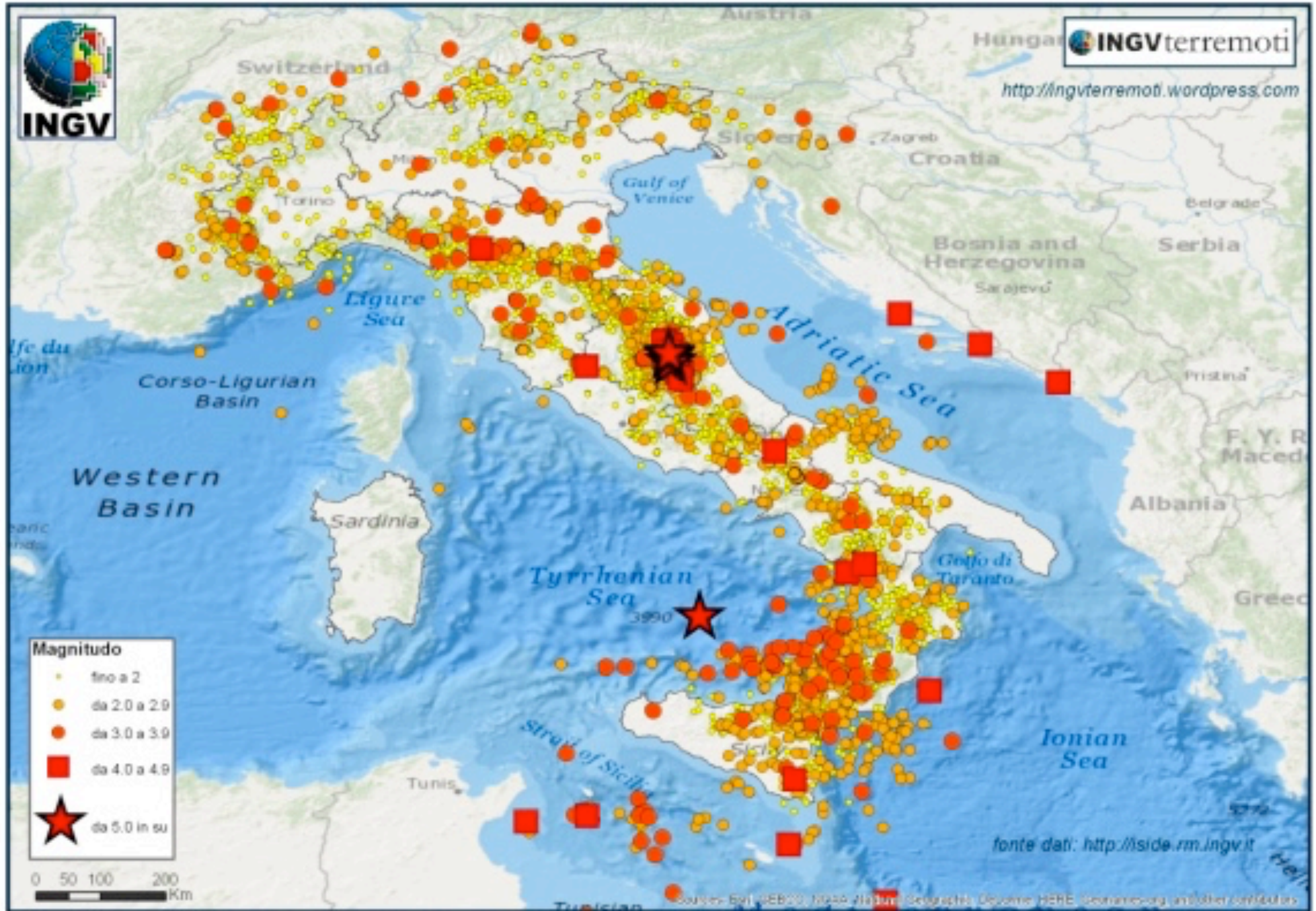


Anderlini et al. 2020

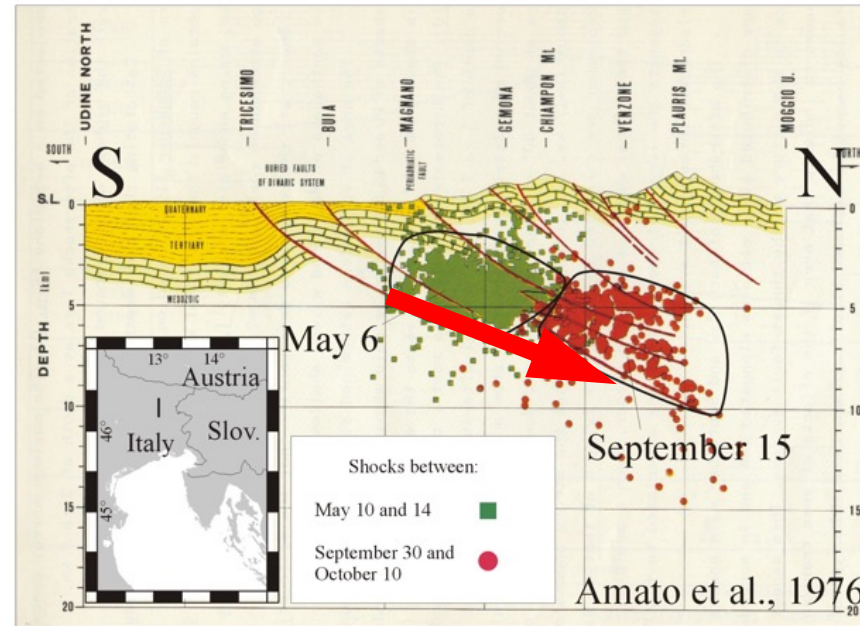




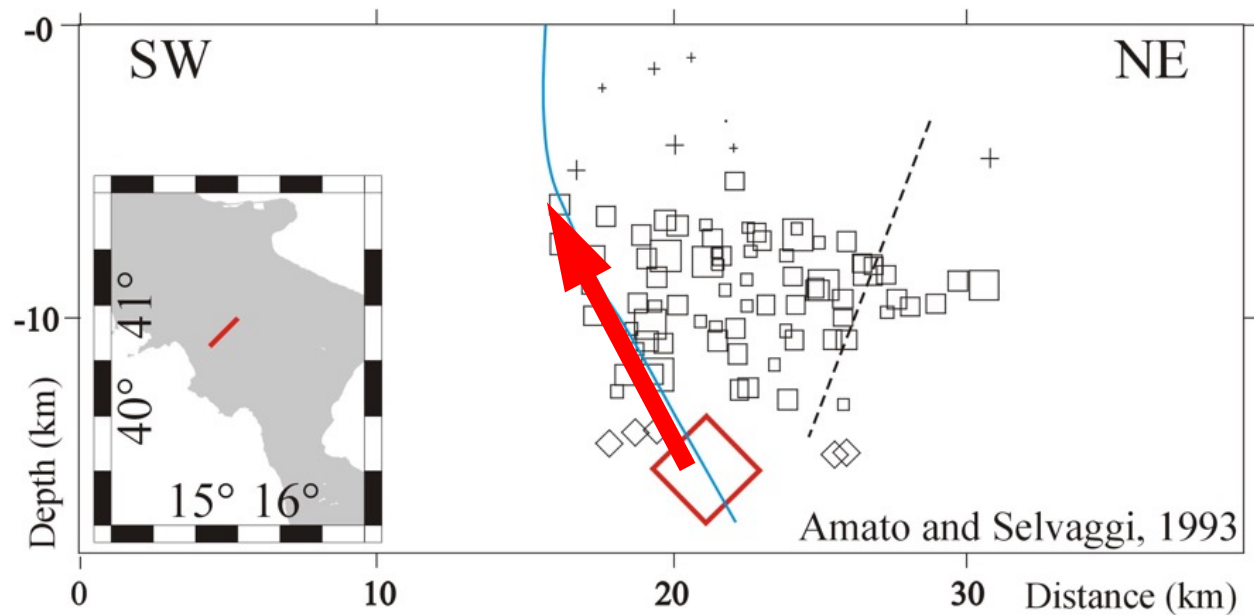
2016



The 1976 Friuli earthquake

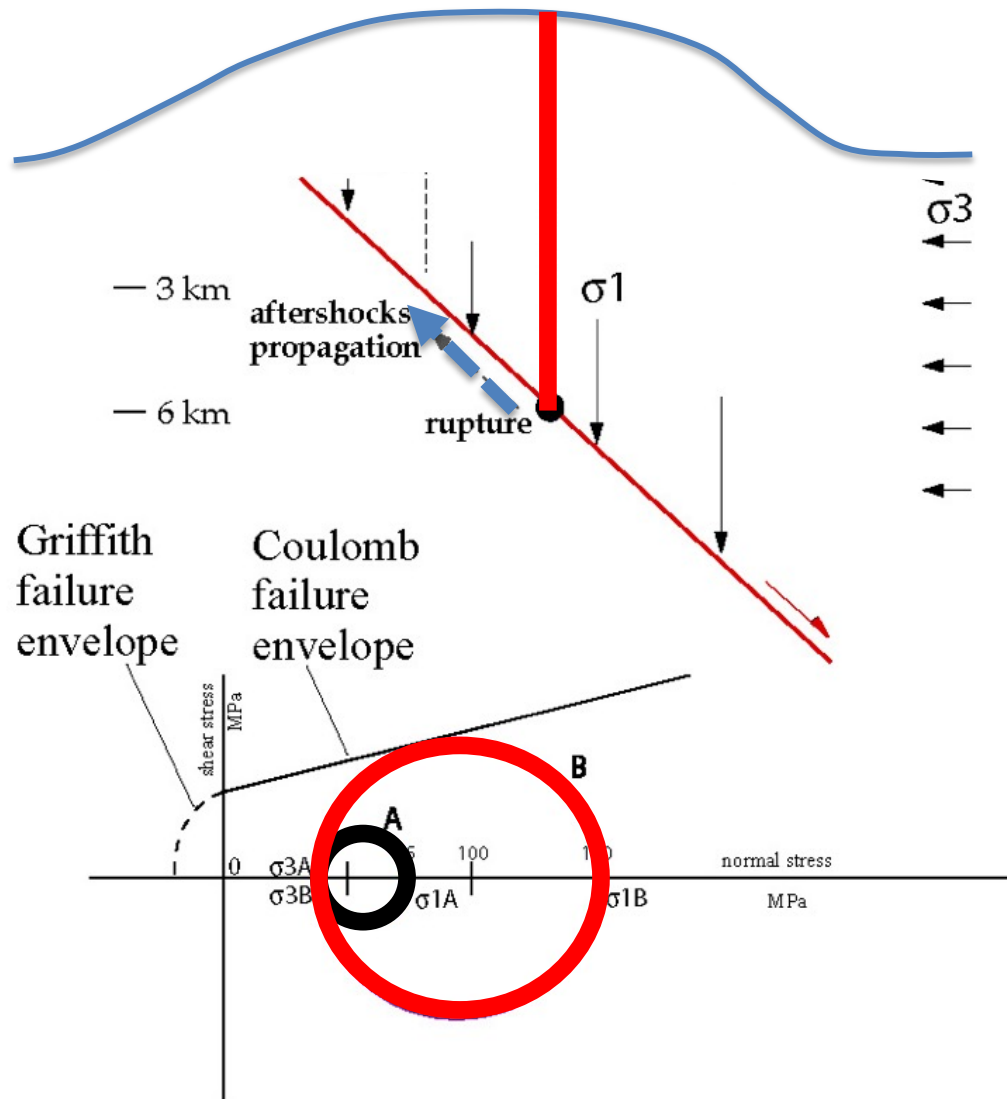


The 1980 Irpinia earthquake



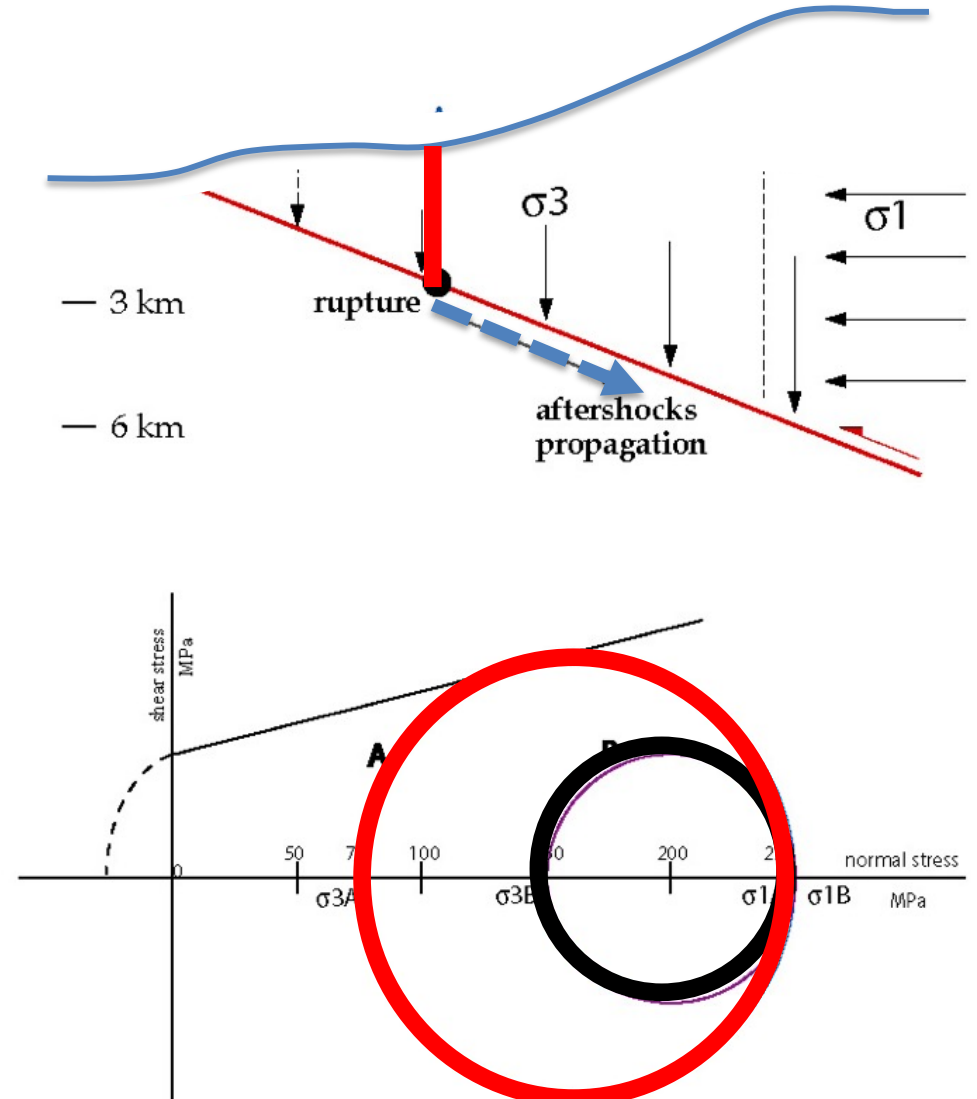
NORMAL FAULT

lithostatic load= σ_1



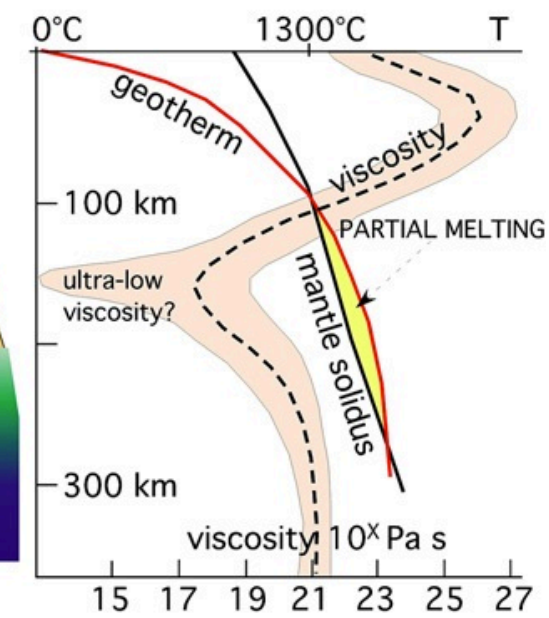
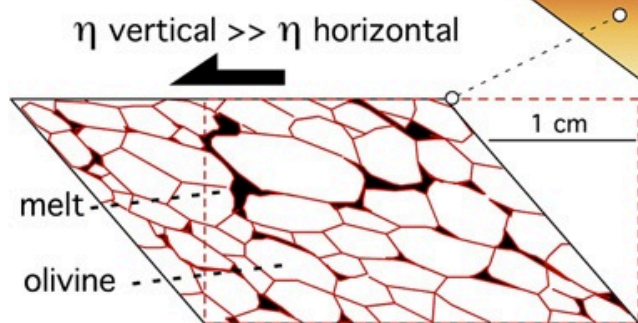
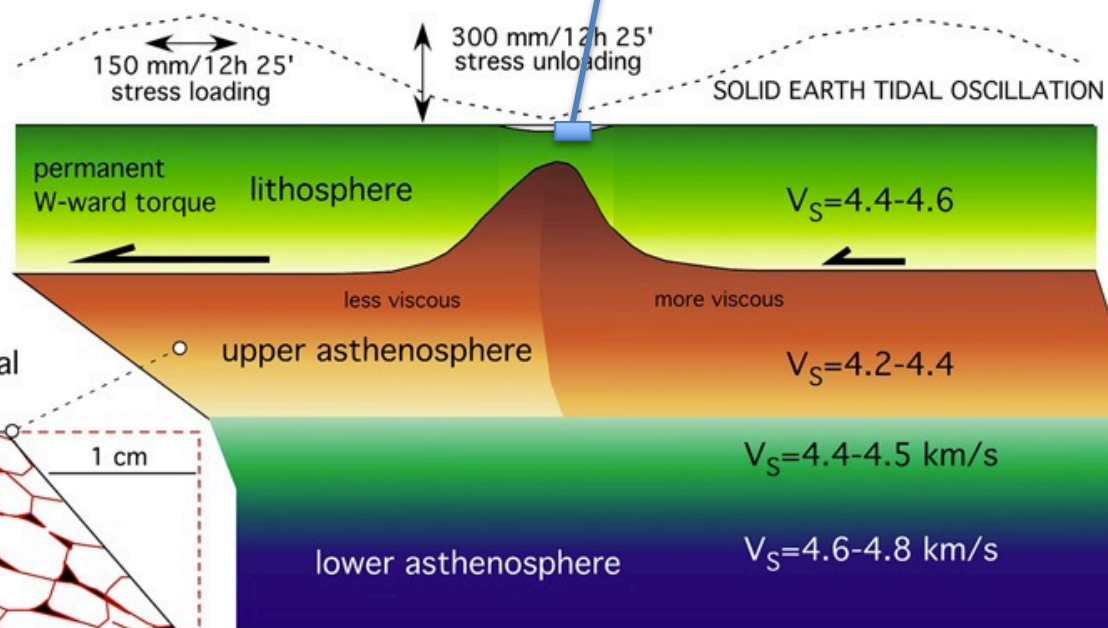
THRUST

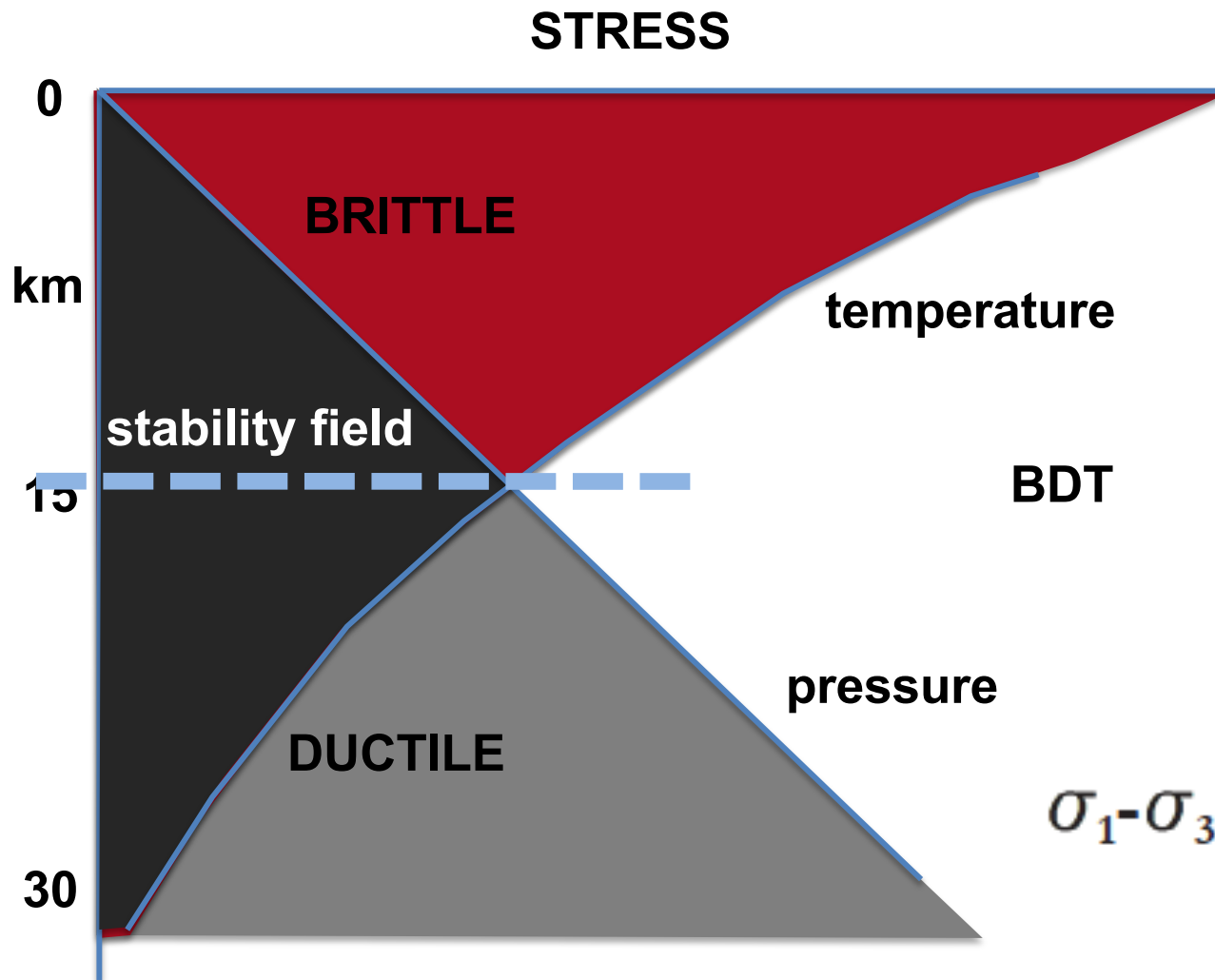
lithostatic load= σ_3



Carminati et al. 2004 Earth Science Reviews

Loading favours normal faulting – Unloading favours thrust faulting





$$\sigma_1 - \sigma_3 = \beta \rho g z (1 - \lambda)$$

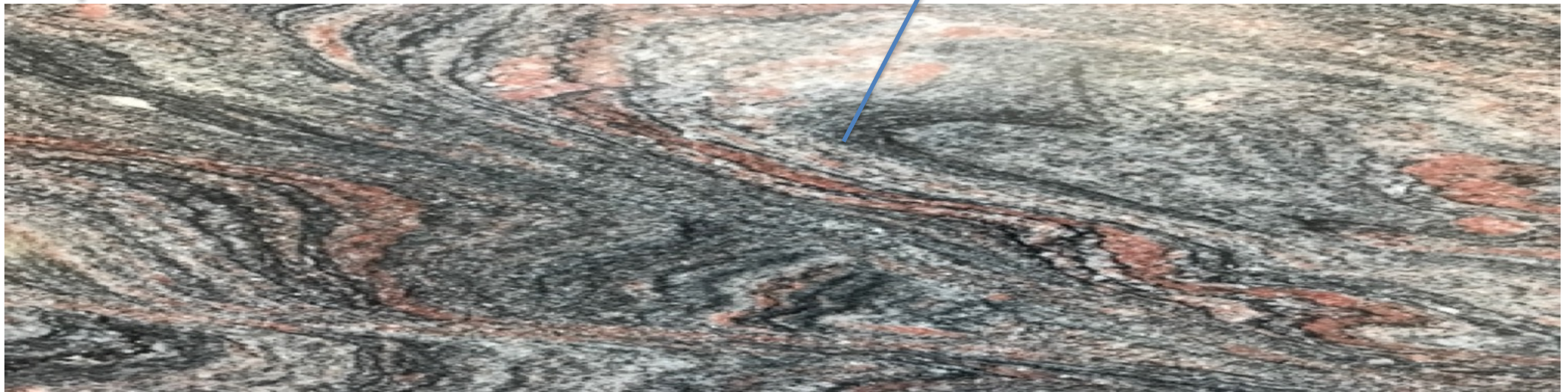
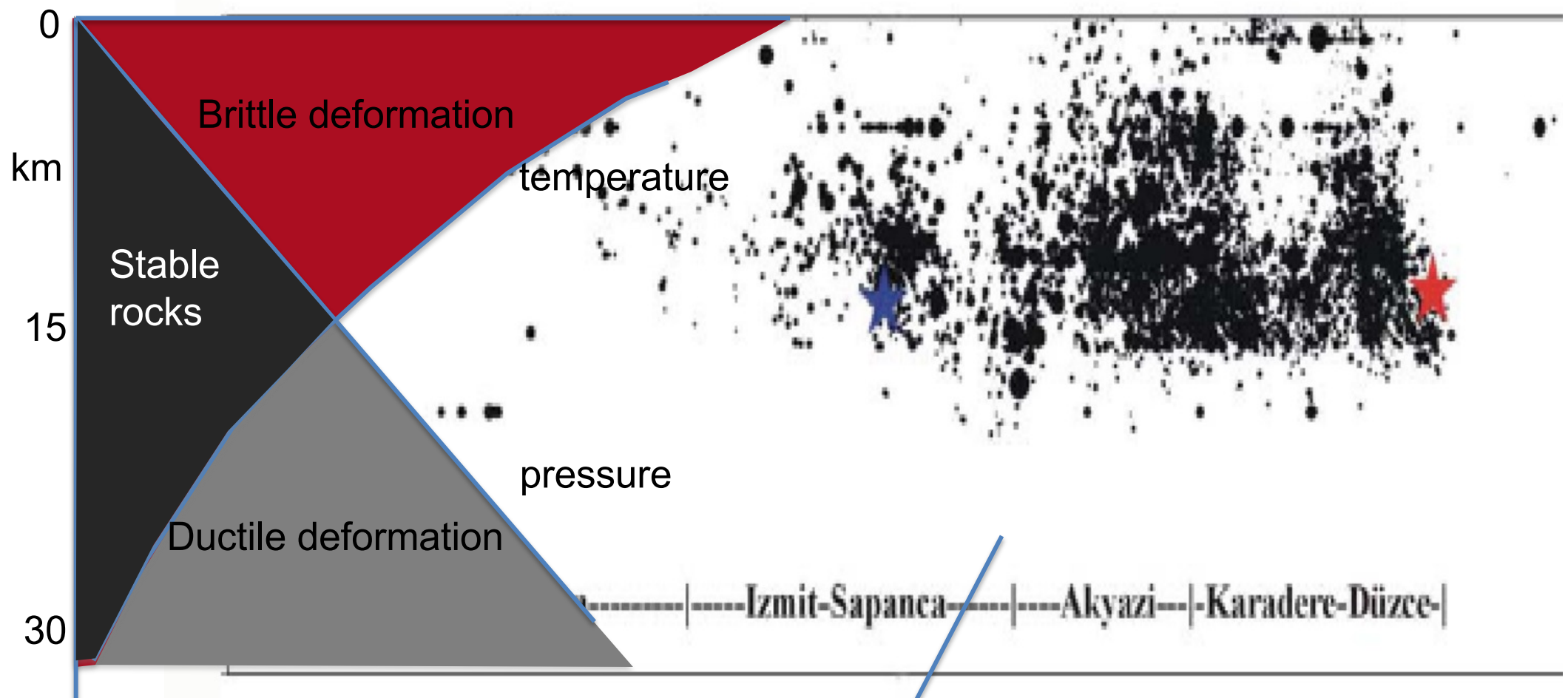
λ , pore fluids
 β , type of fault

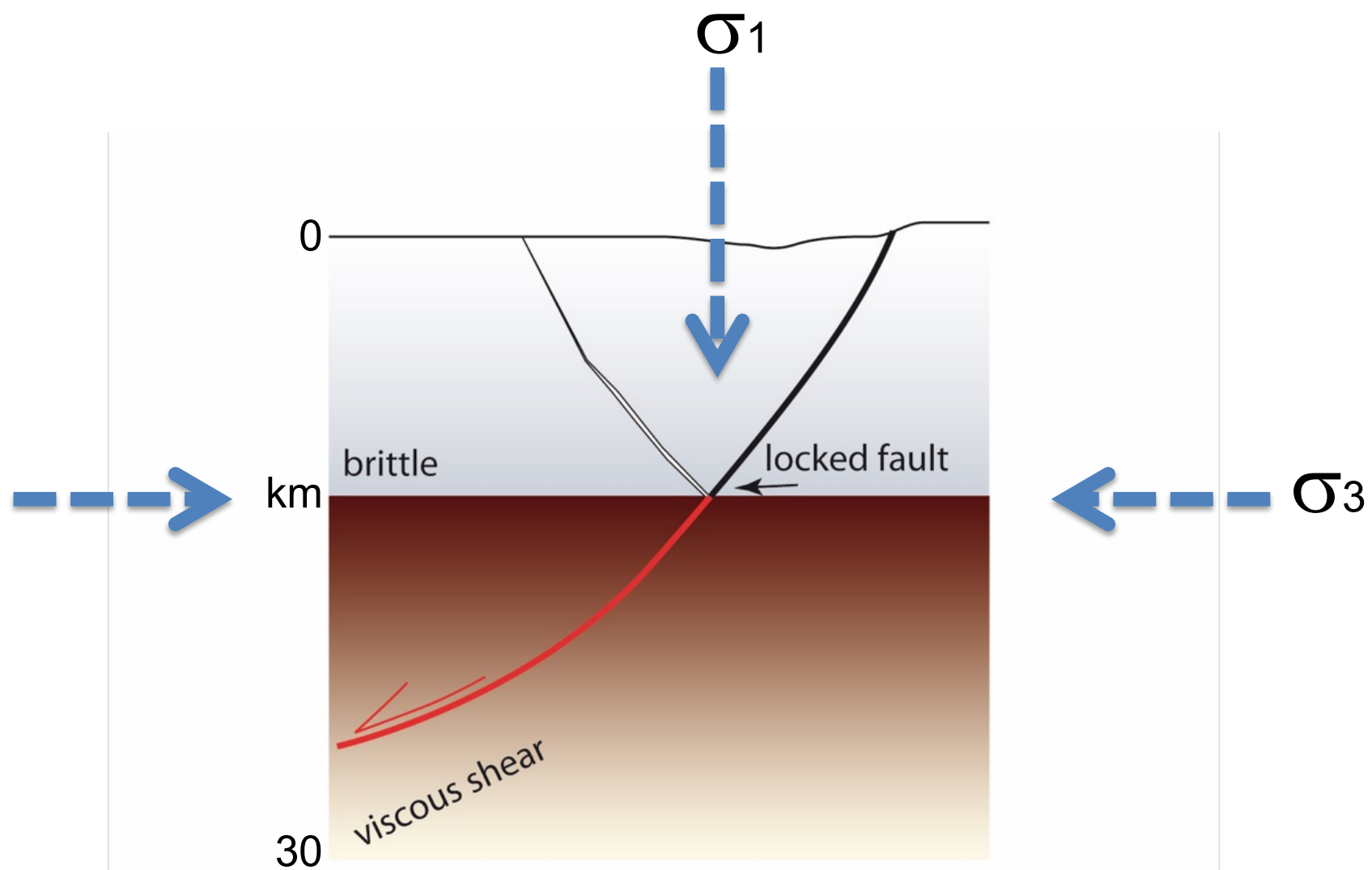
$$\sigma_1 - \sigma_3 = \left(\frac{\dot{\epsilon}}{A} \right)^{1/n} \exp \left(\frac{Q}{nRT} \right)$$

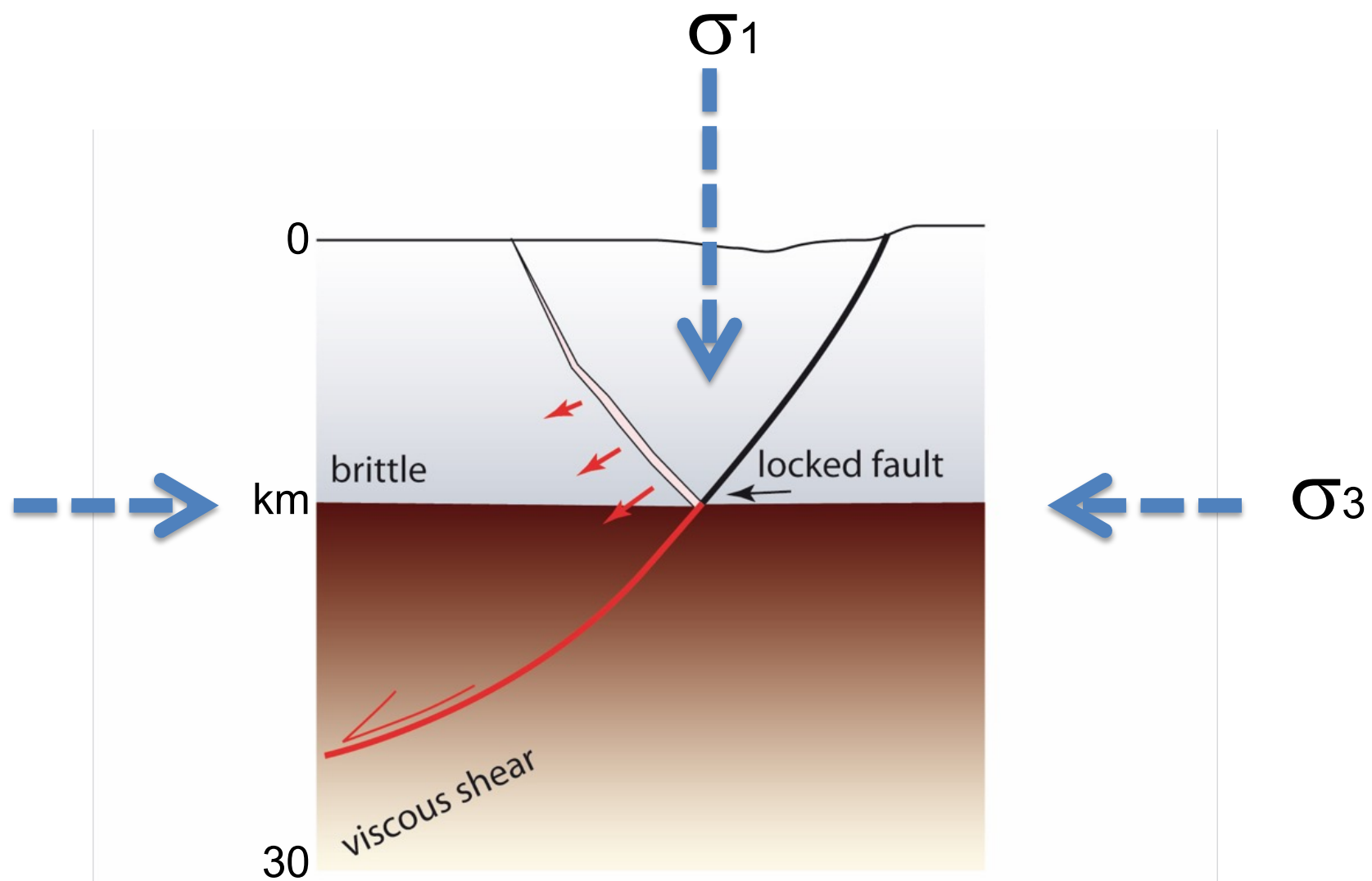
Q , activation energy
 A , viscosity coefficient
 $\dot{\epsilon}$, effective strain
 n , stress power law

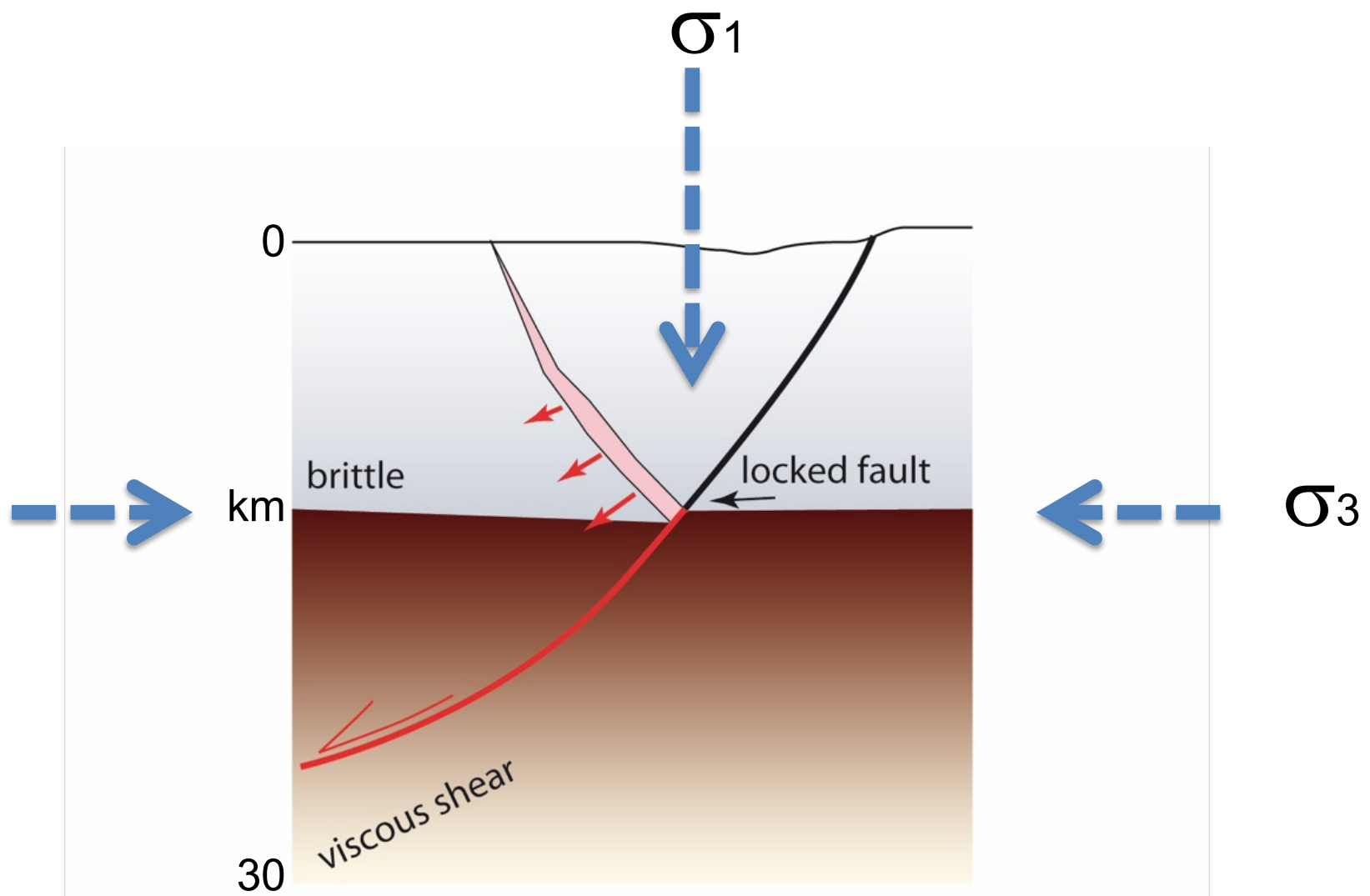
$\beta=3$ thrust, 1.2 strike-slip, 0.75 normal fault

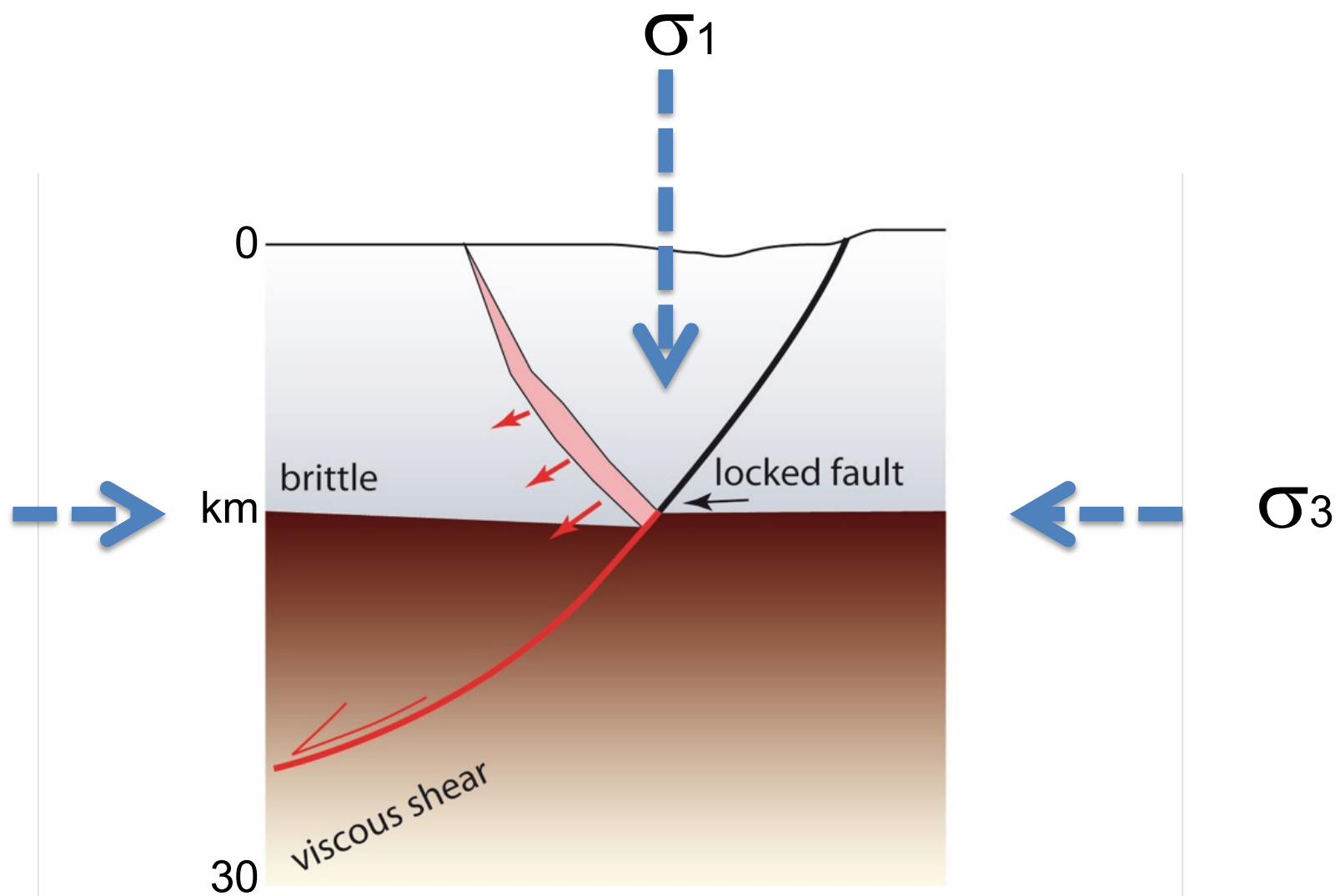
STRESS

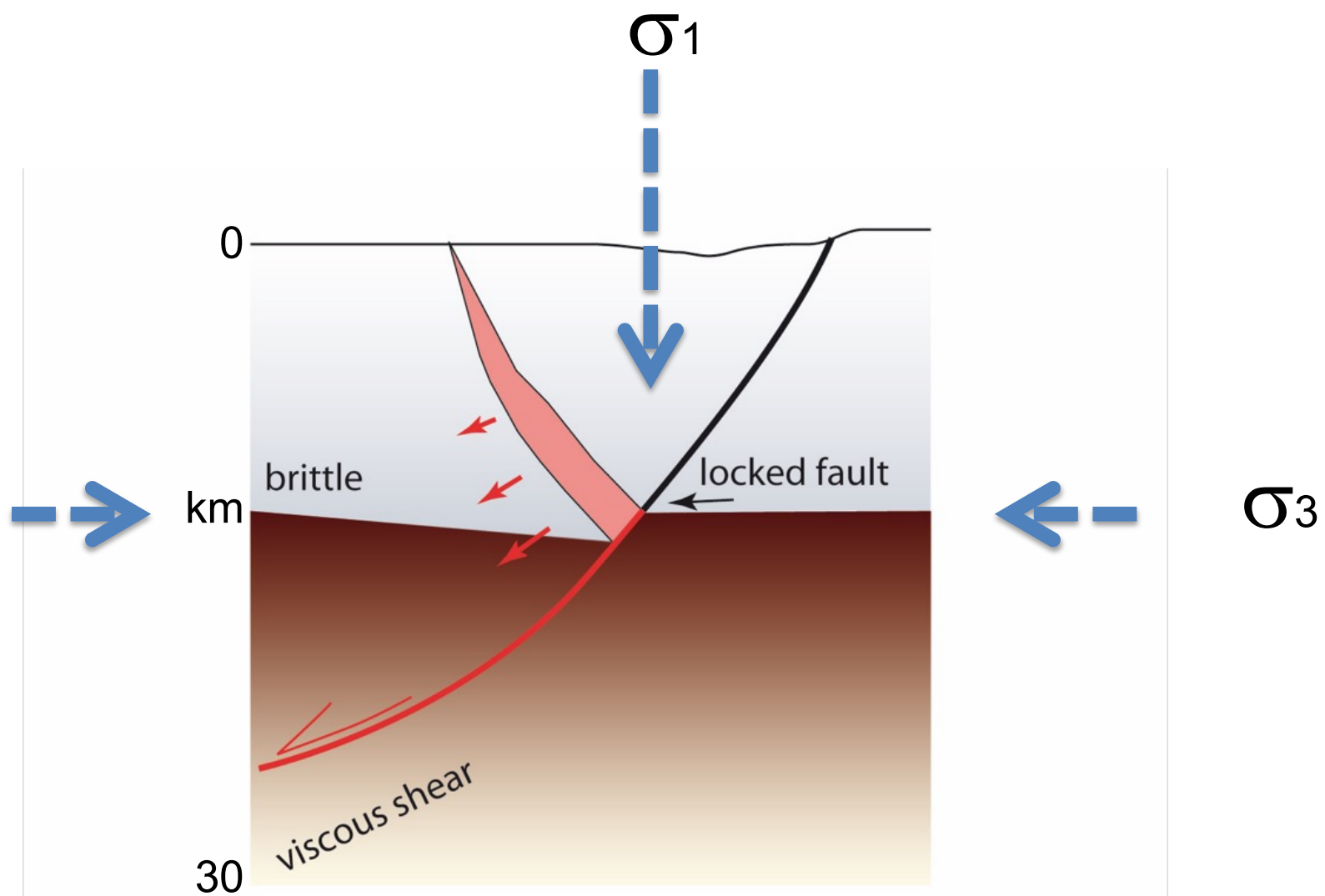


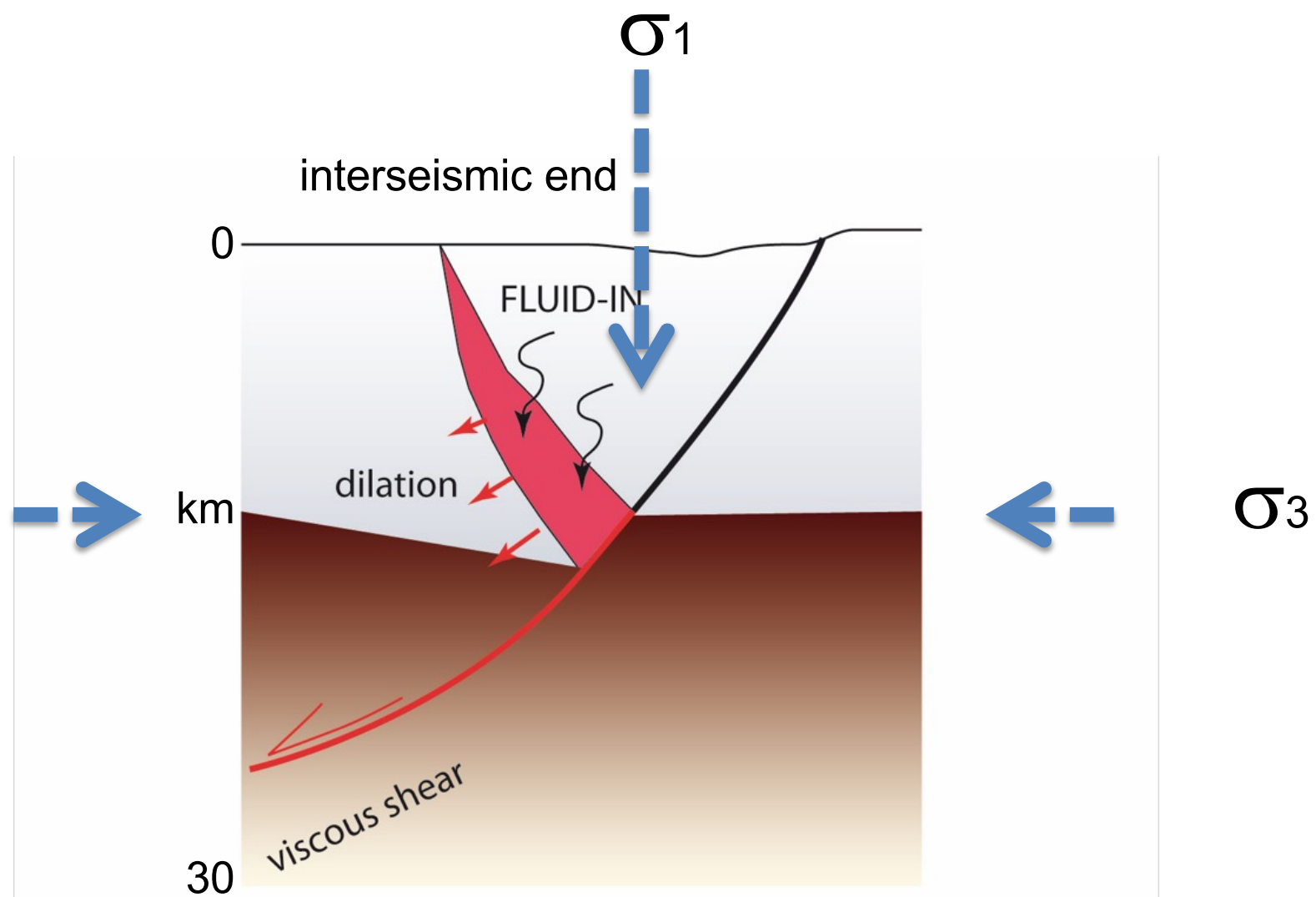


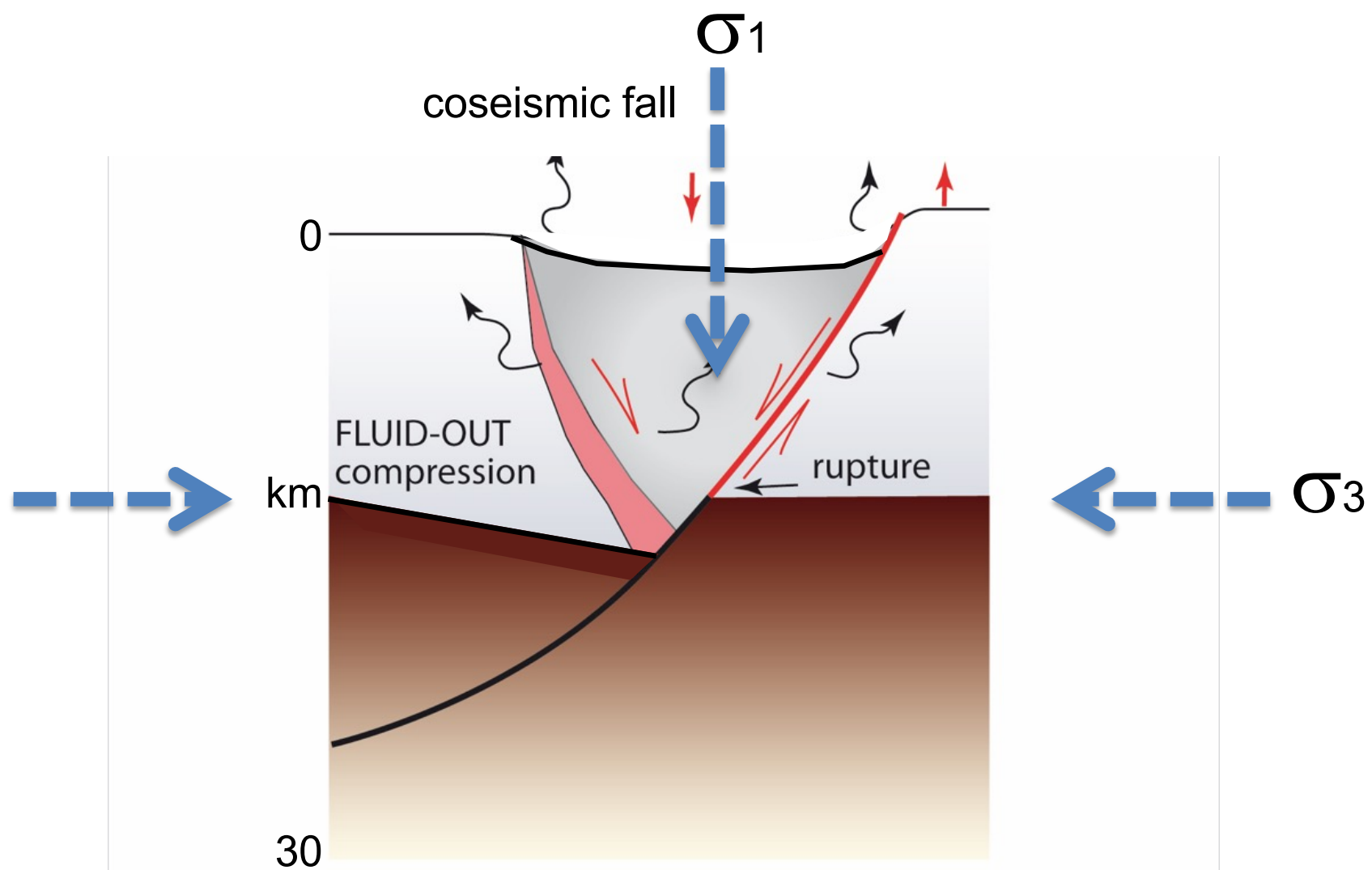




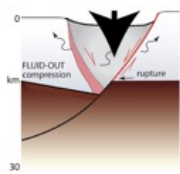




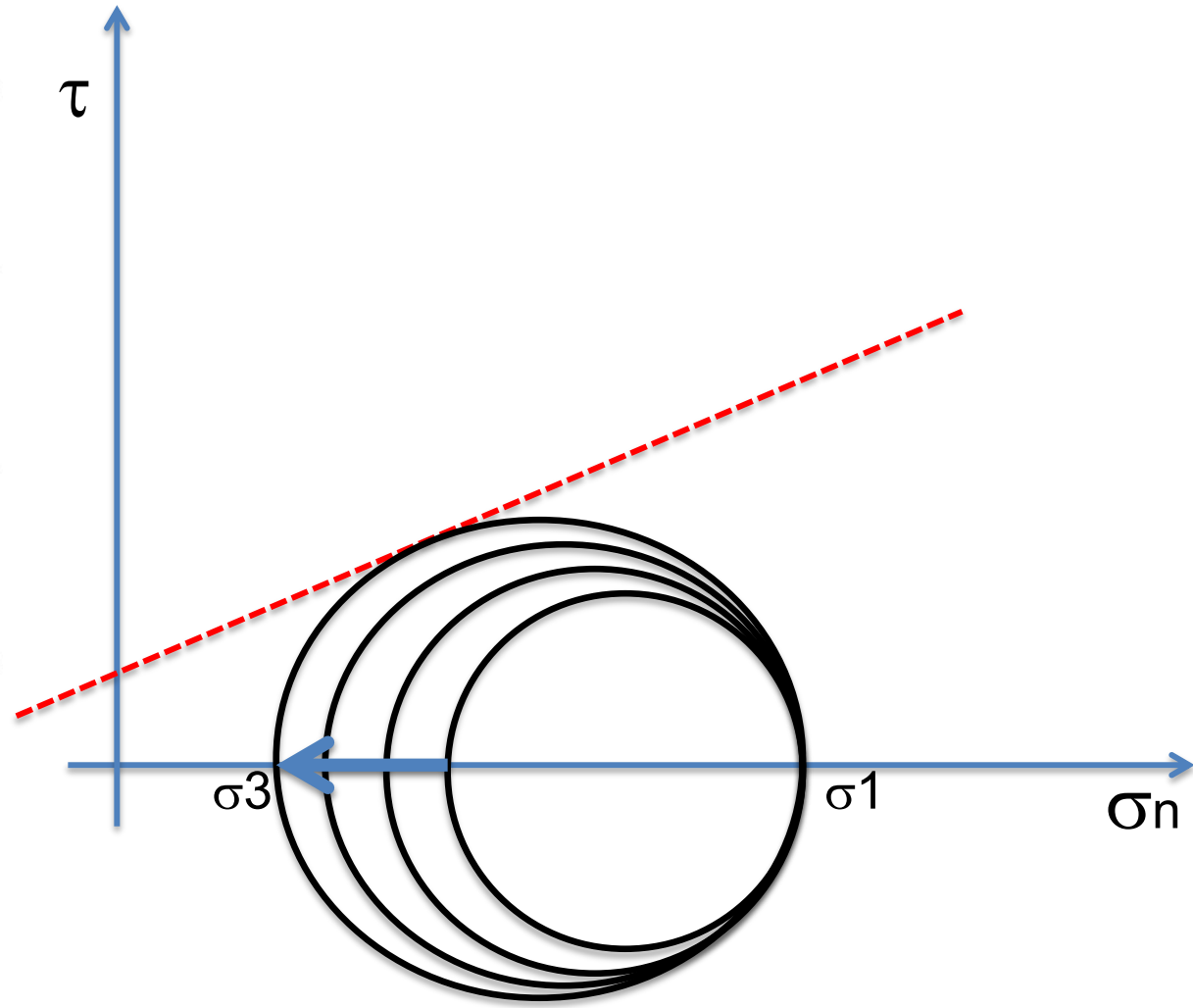
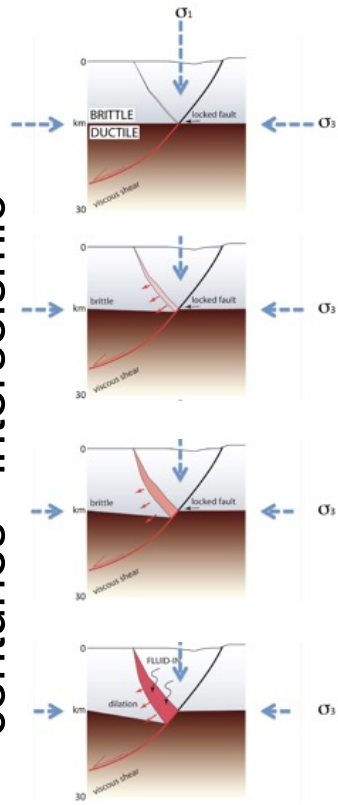




seconds
coseismic

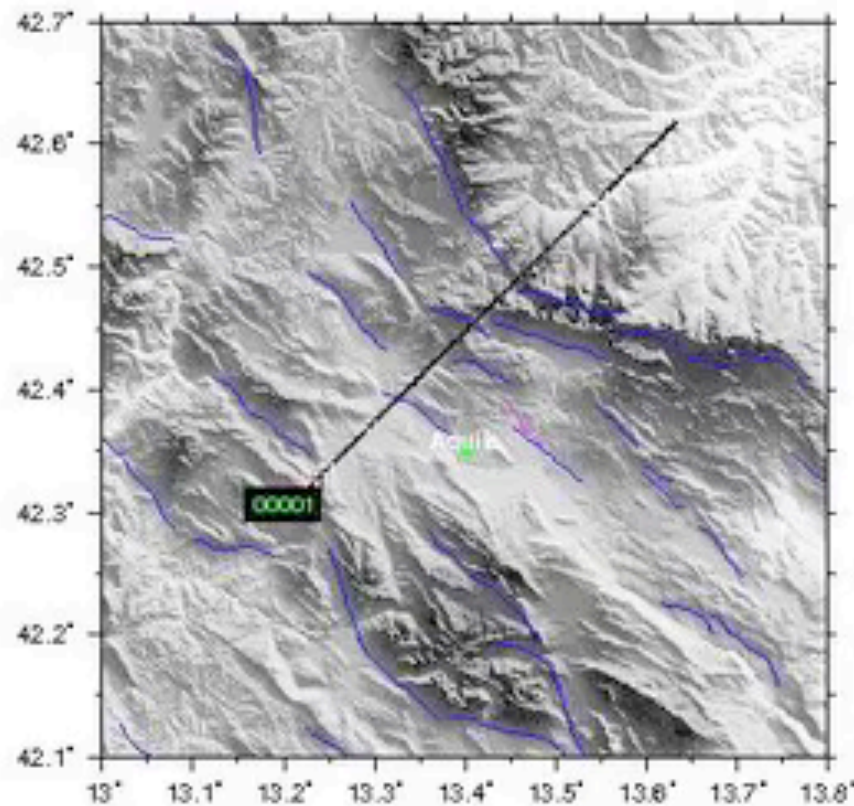
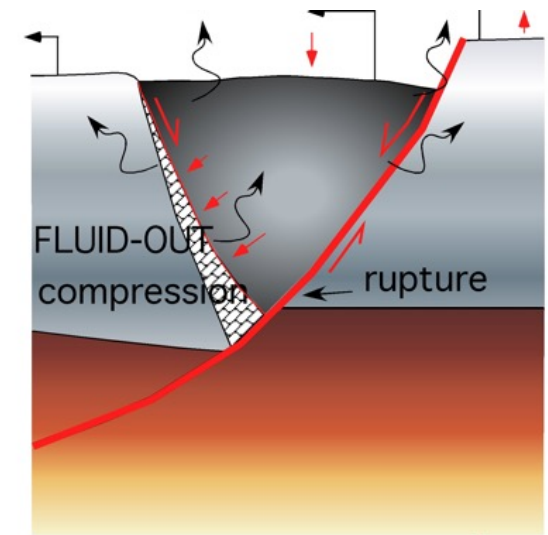
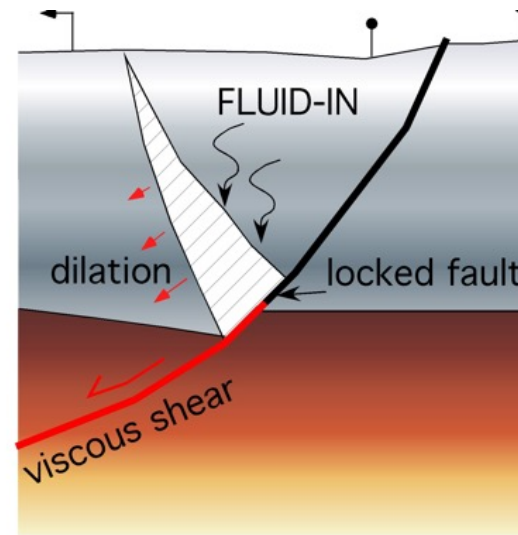


centuries - interseismic

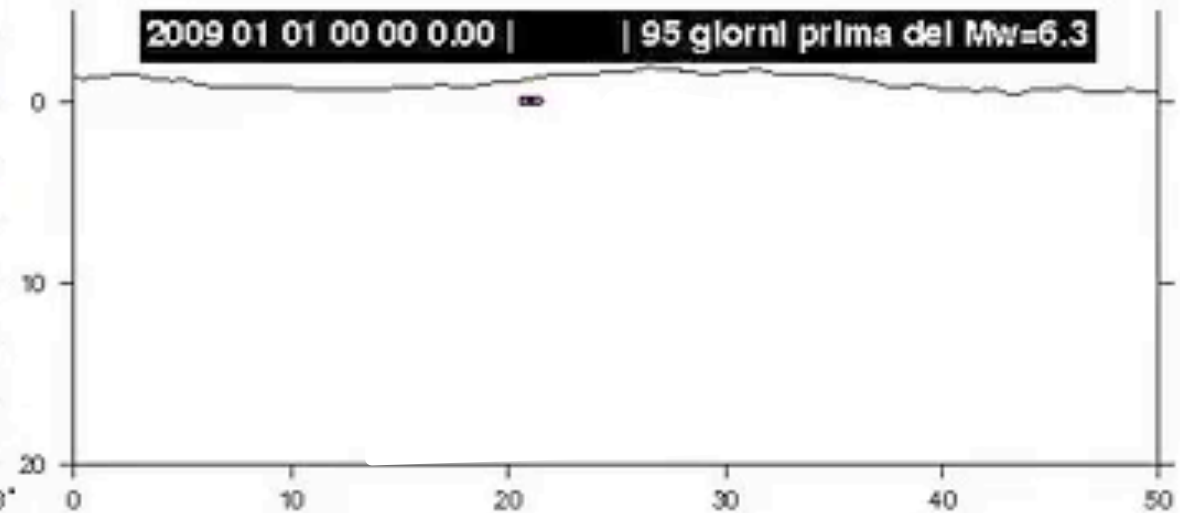


interseismic

coseismic

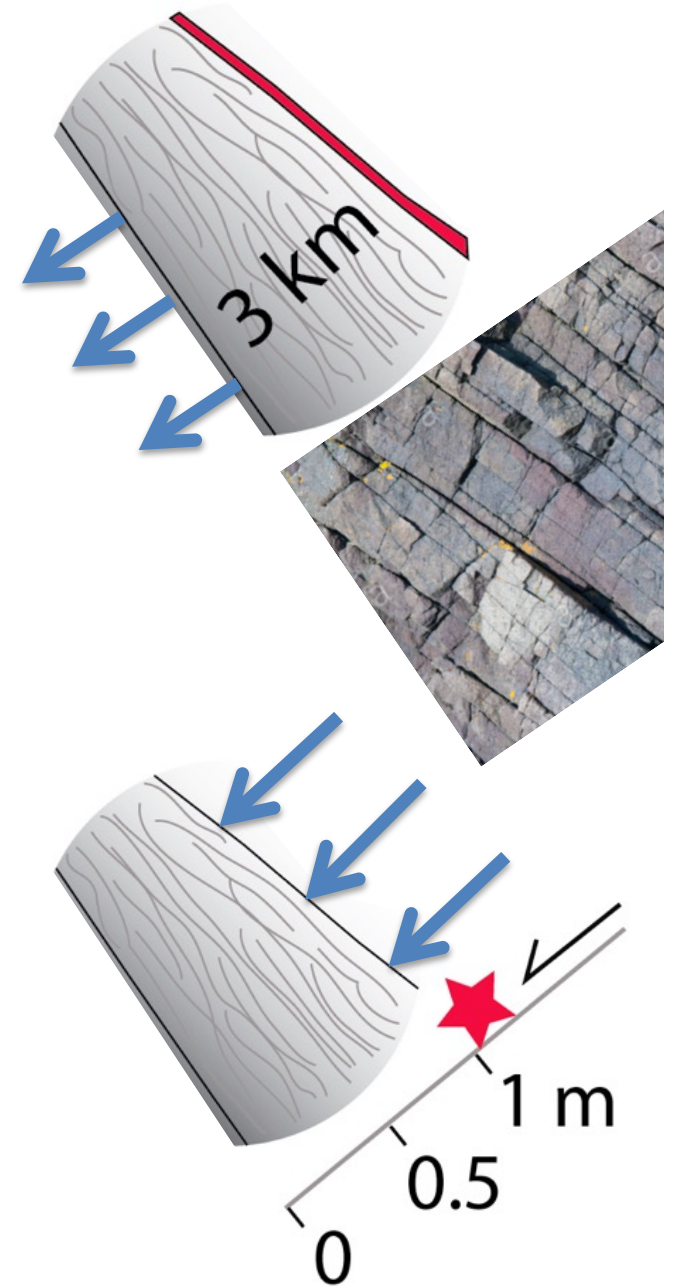
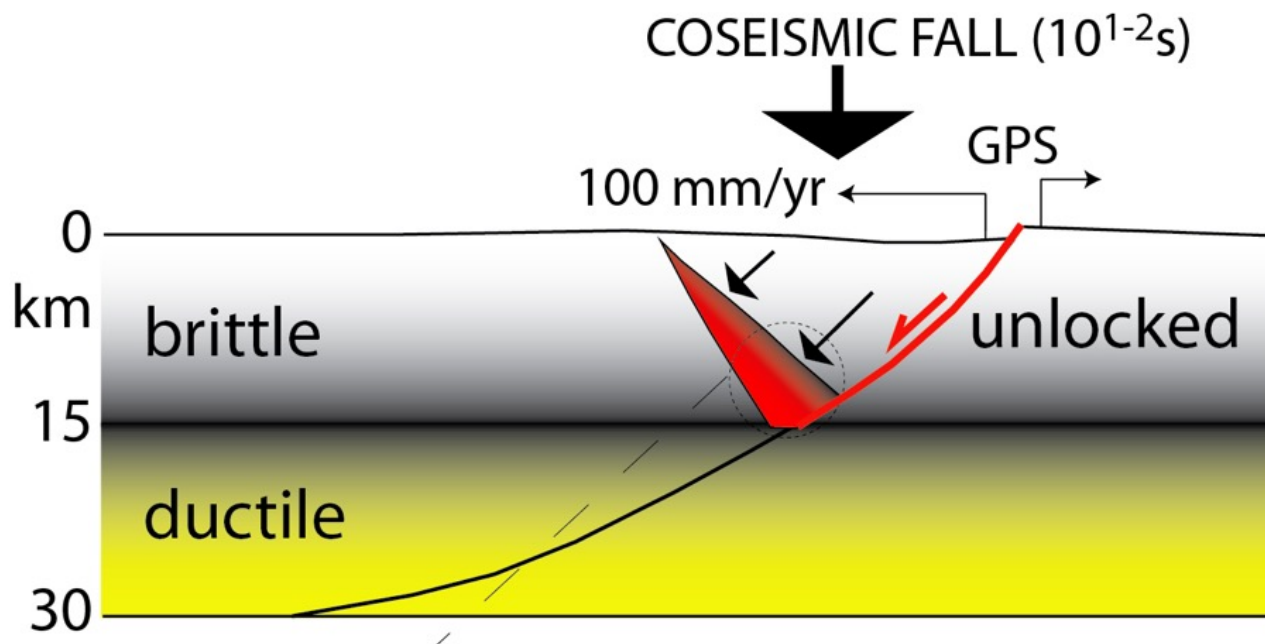
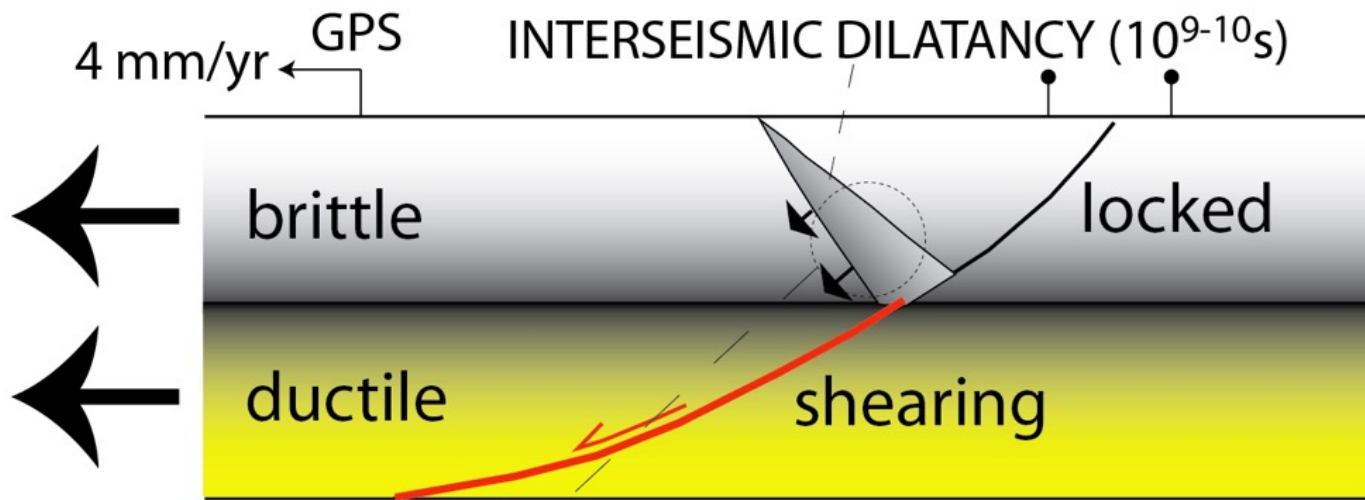


GMT 2010 Apr 14 1E2000



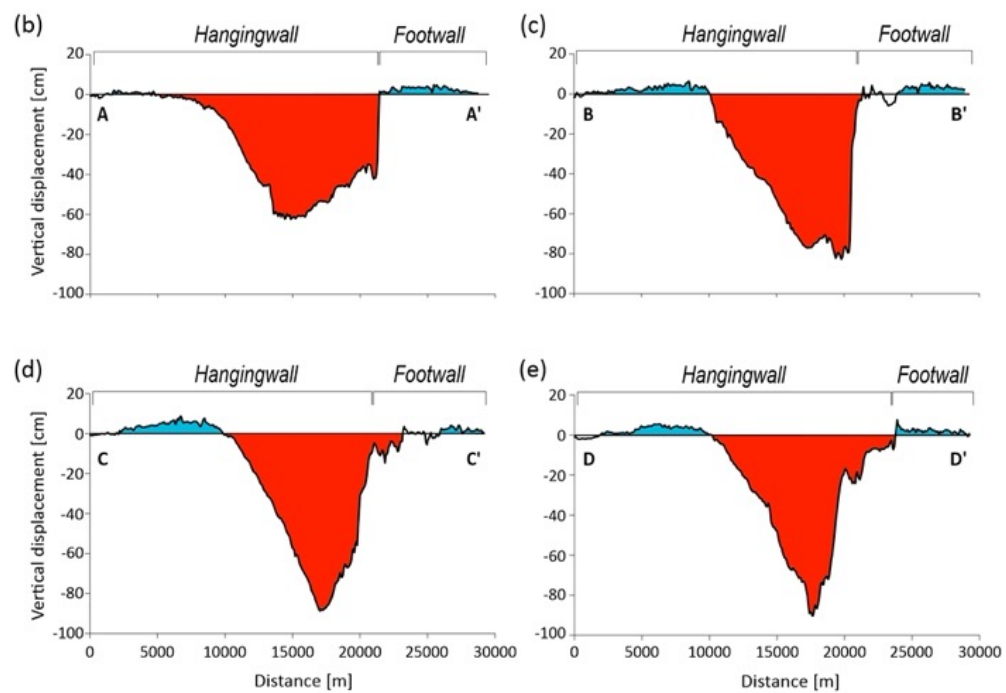
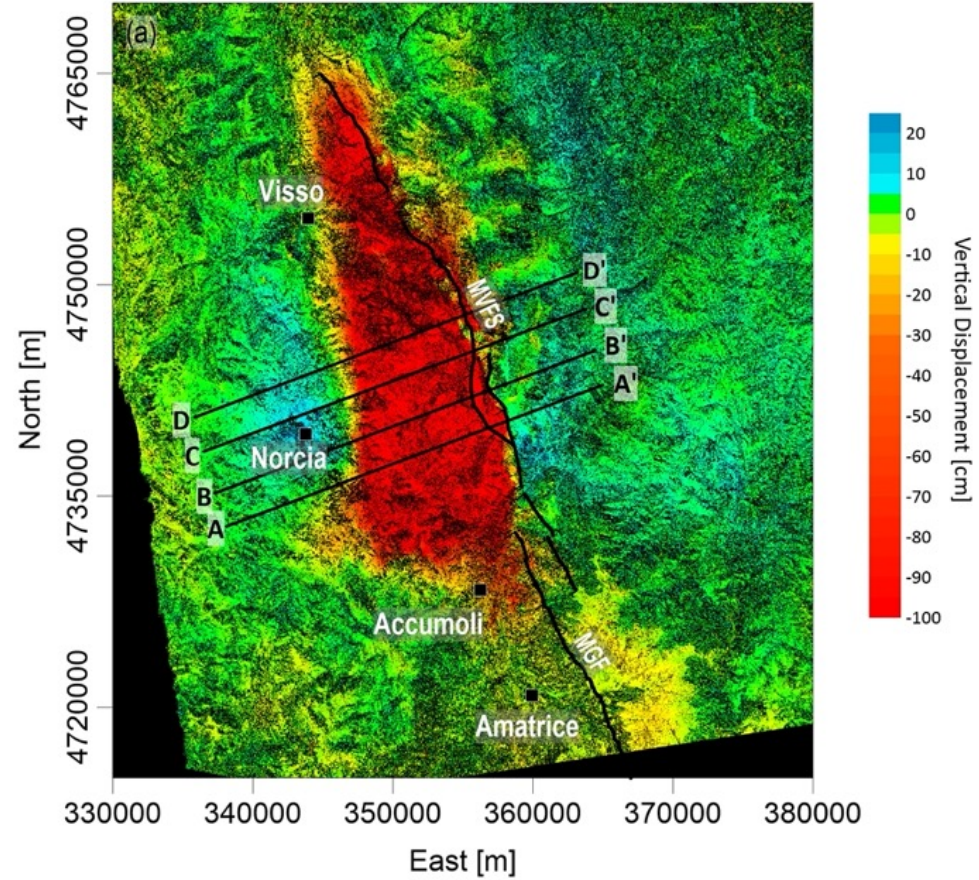
Courtesy R. Di Stefano

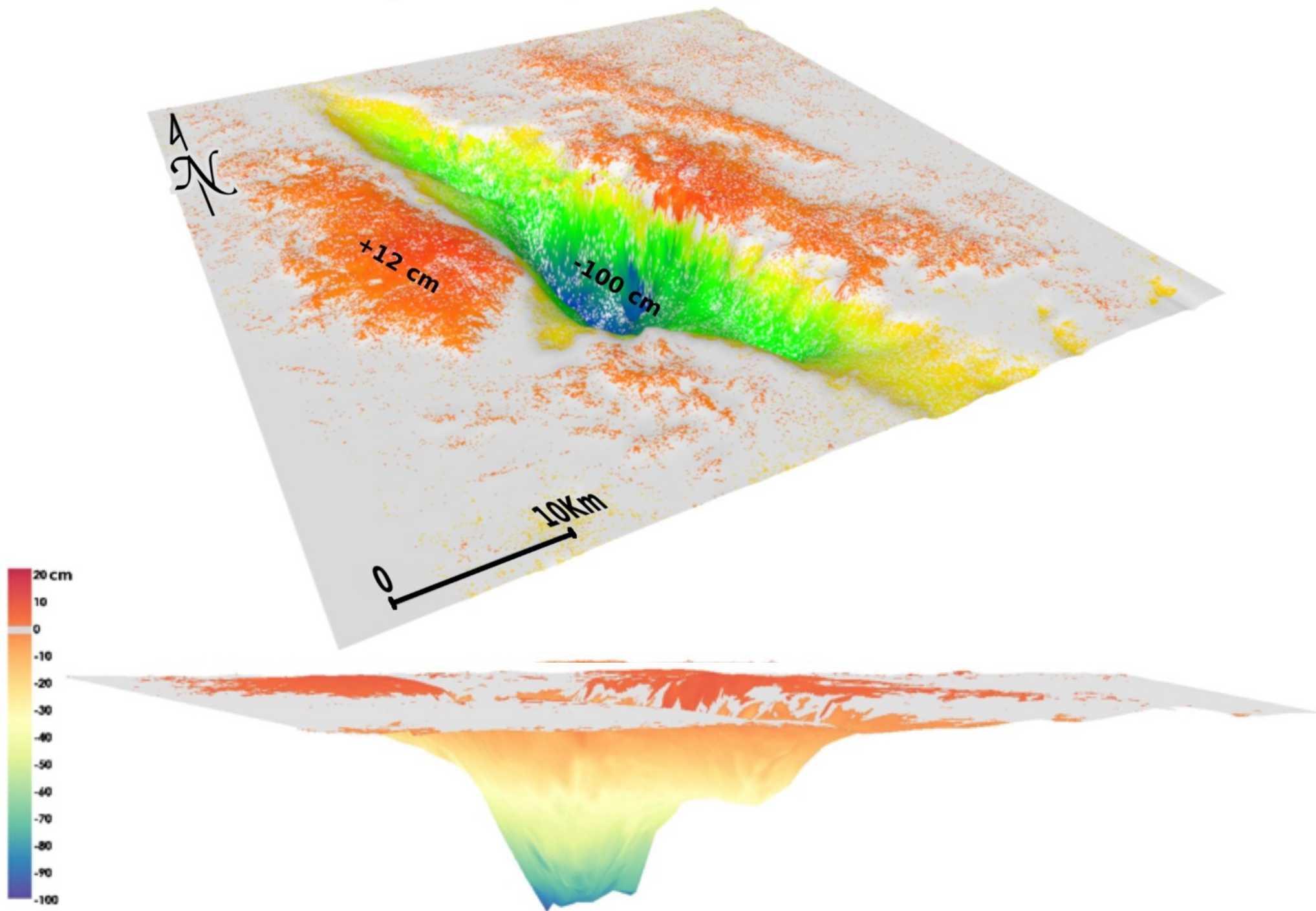
normal fault seismic cycle

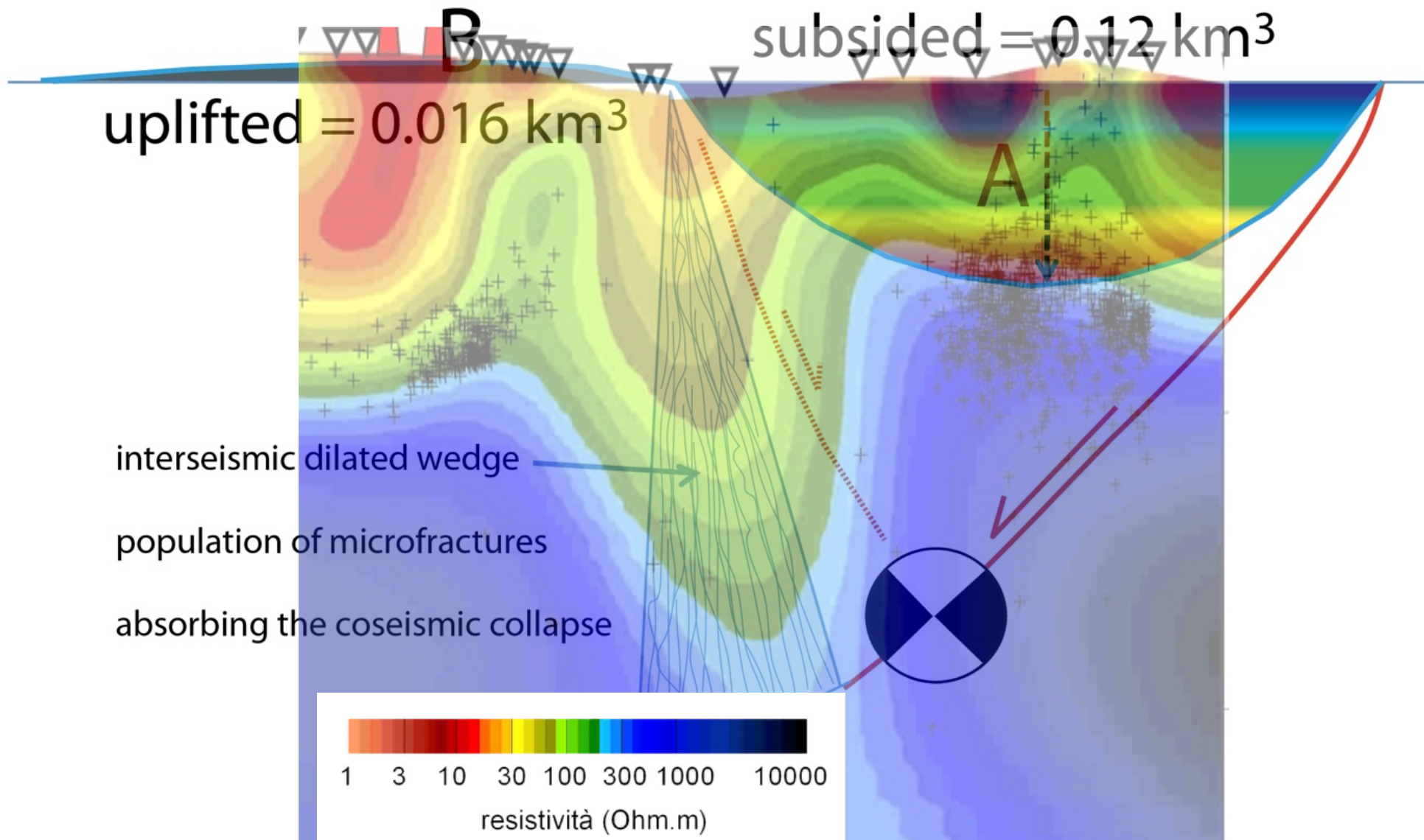




USGS

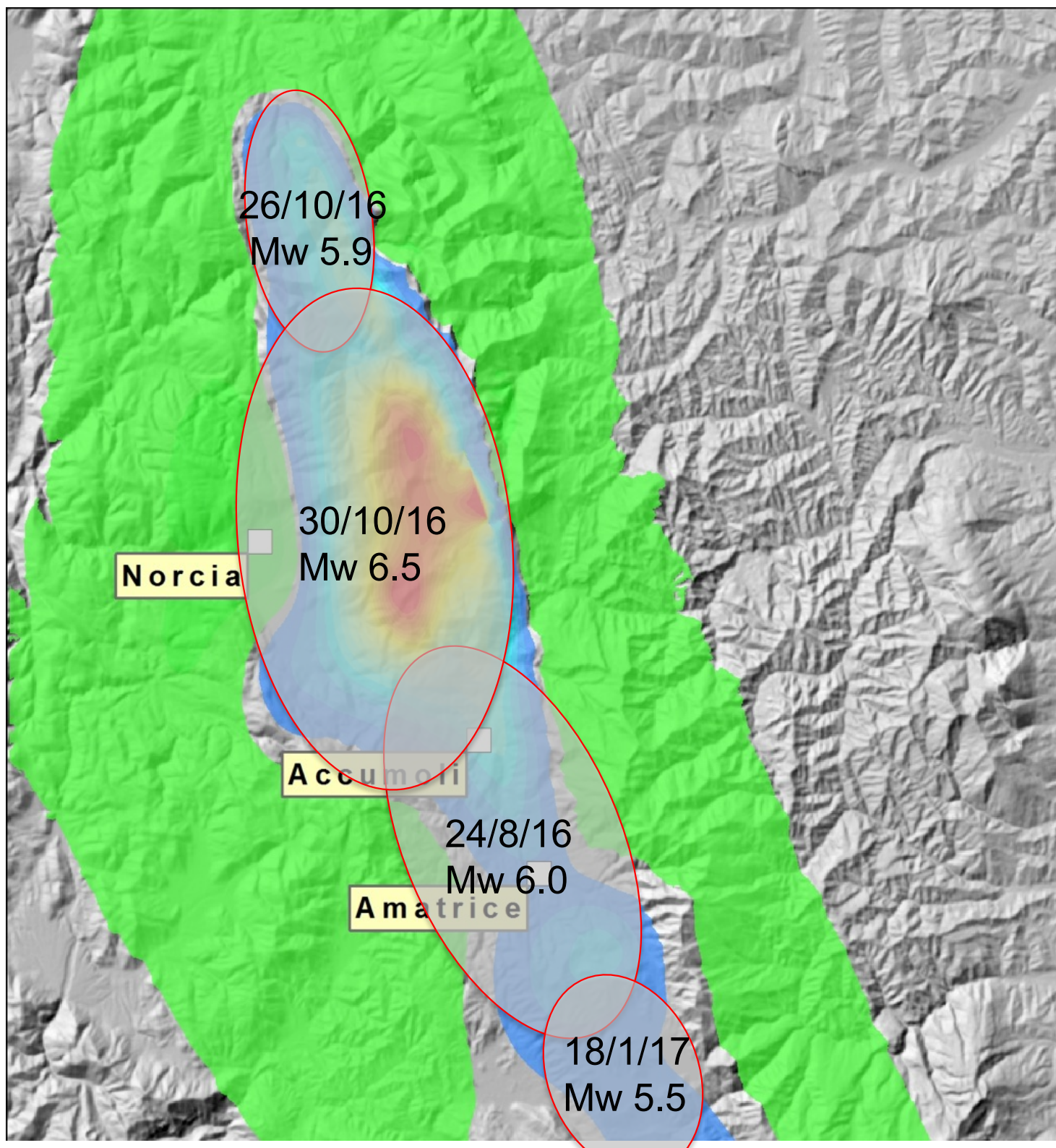




$$A \approx 7.5B$$


2016-2017
6000 km³

Vertical displacement m

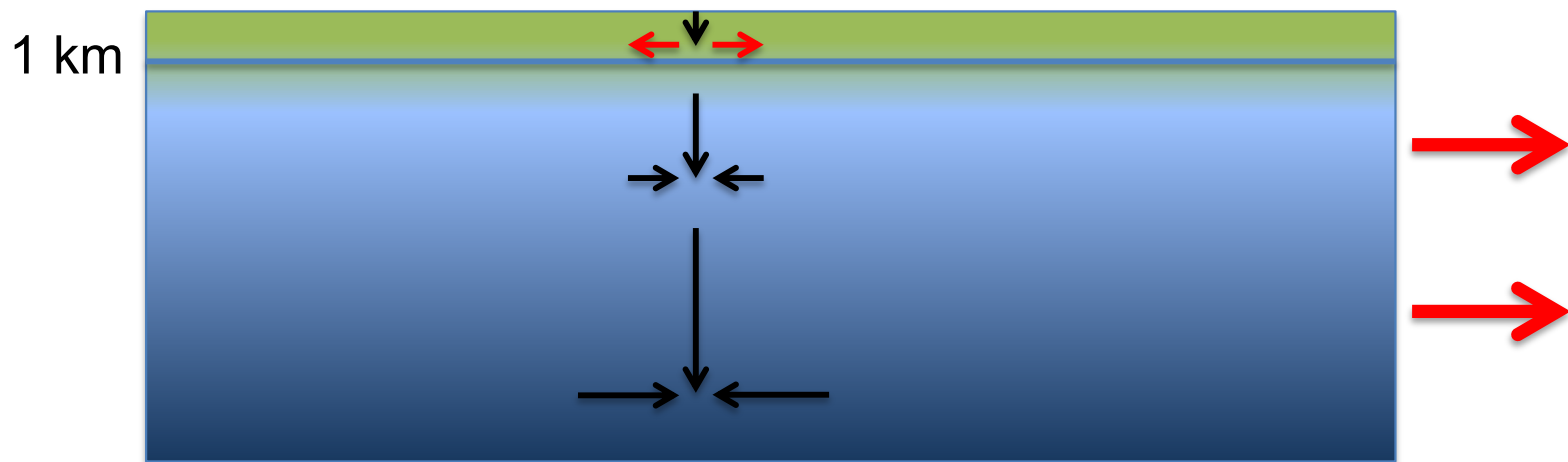
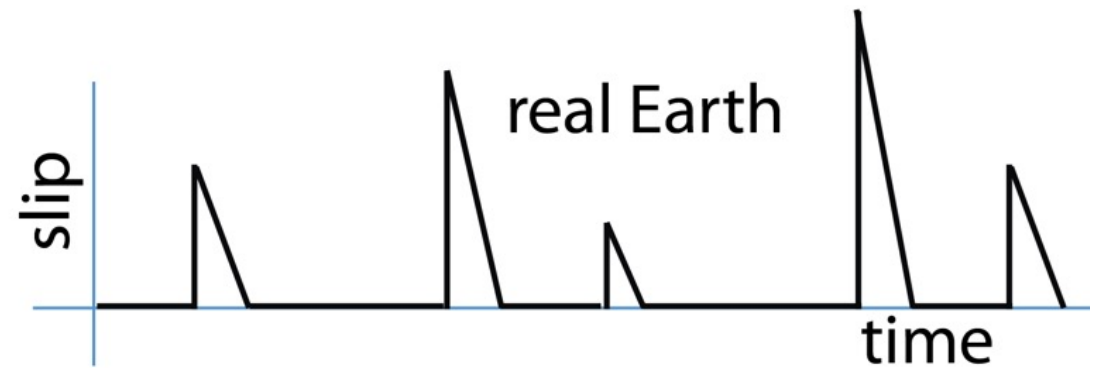
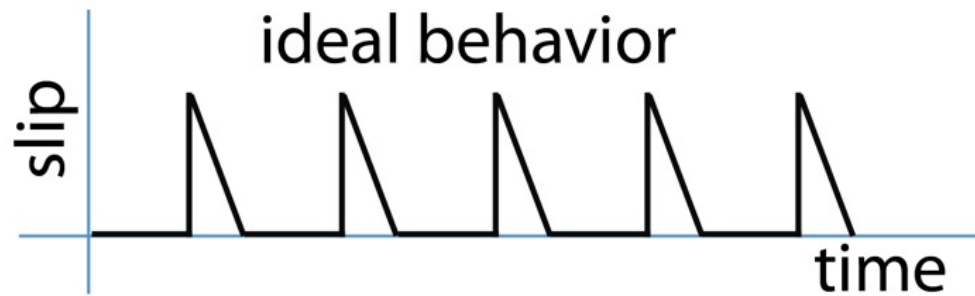


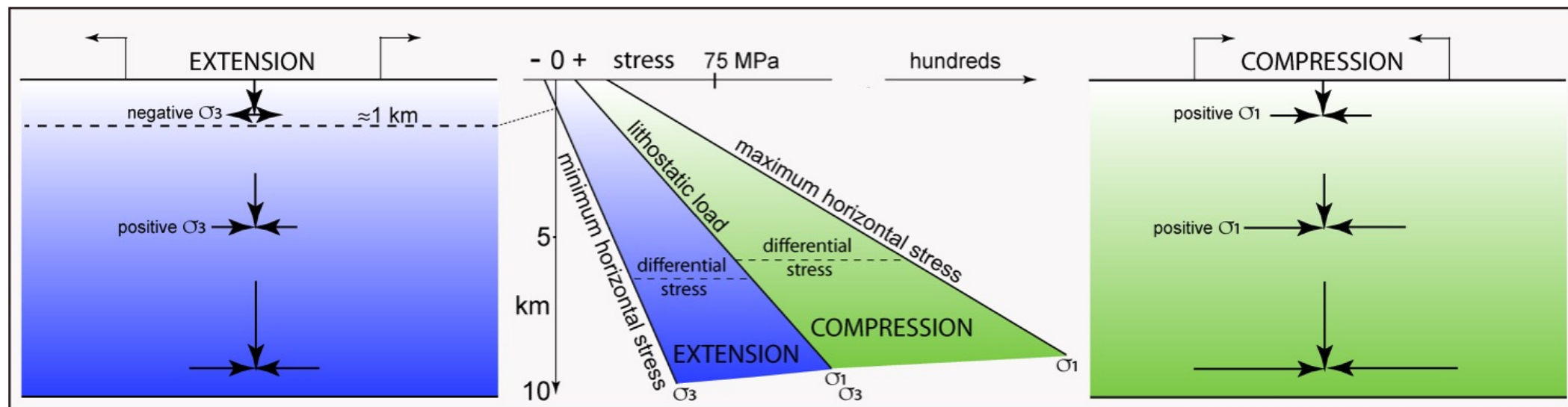
<VALUE>



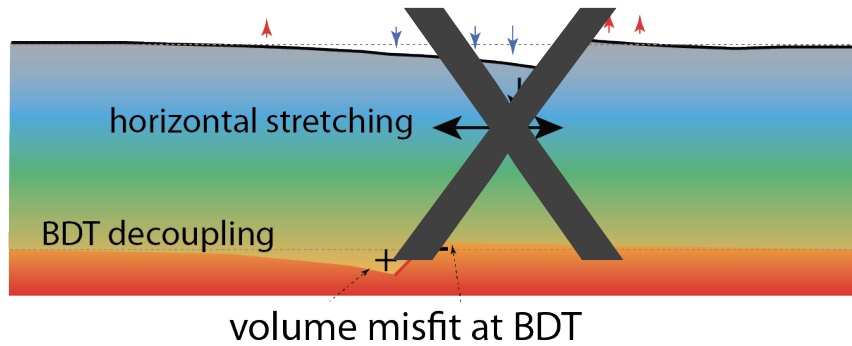


standard model

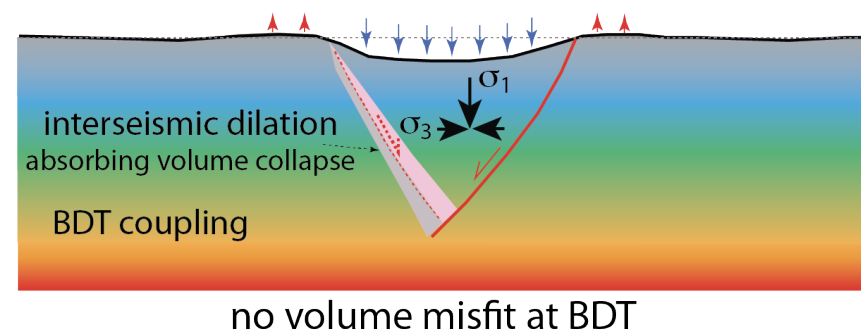


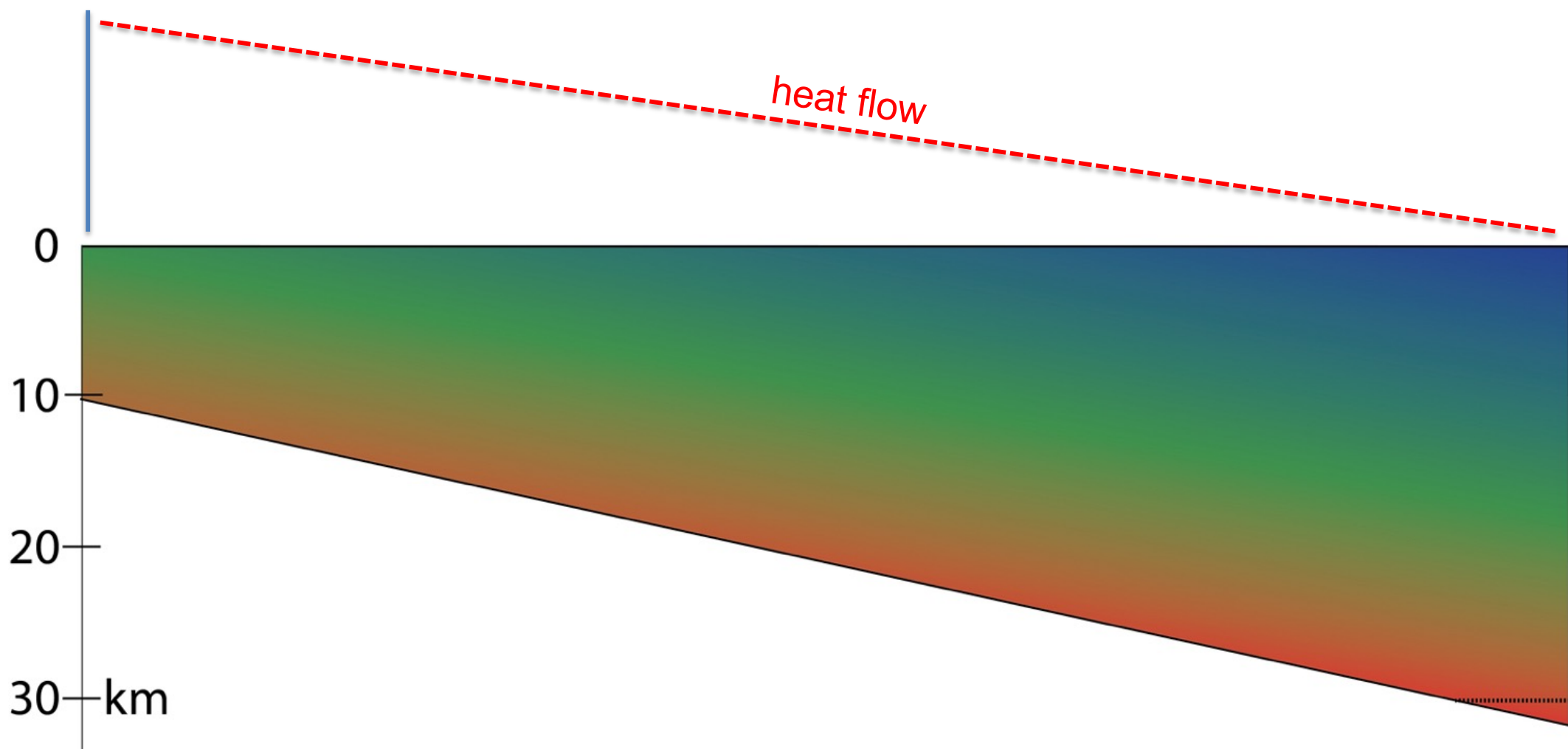


ELASTIC REBOUND

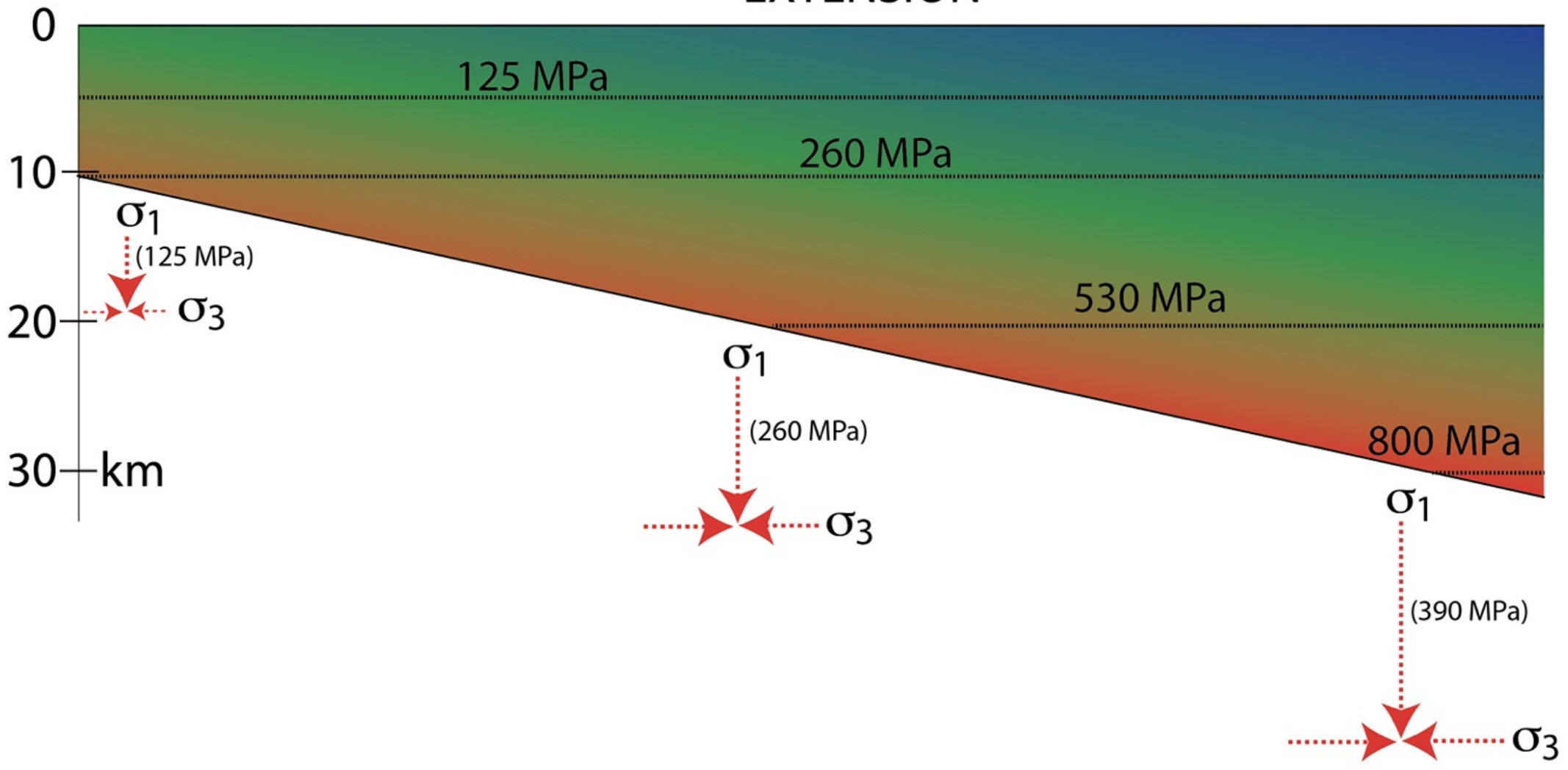


GRAVIQUAKE

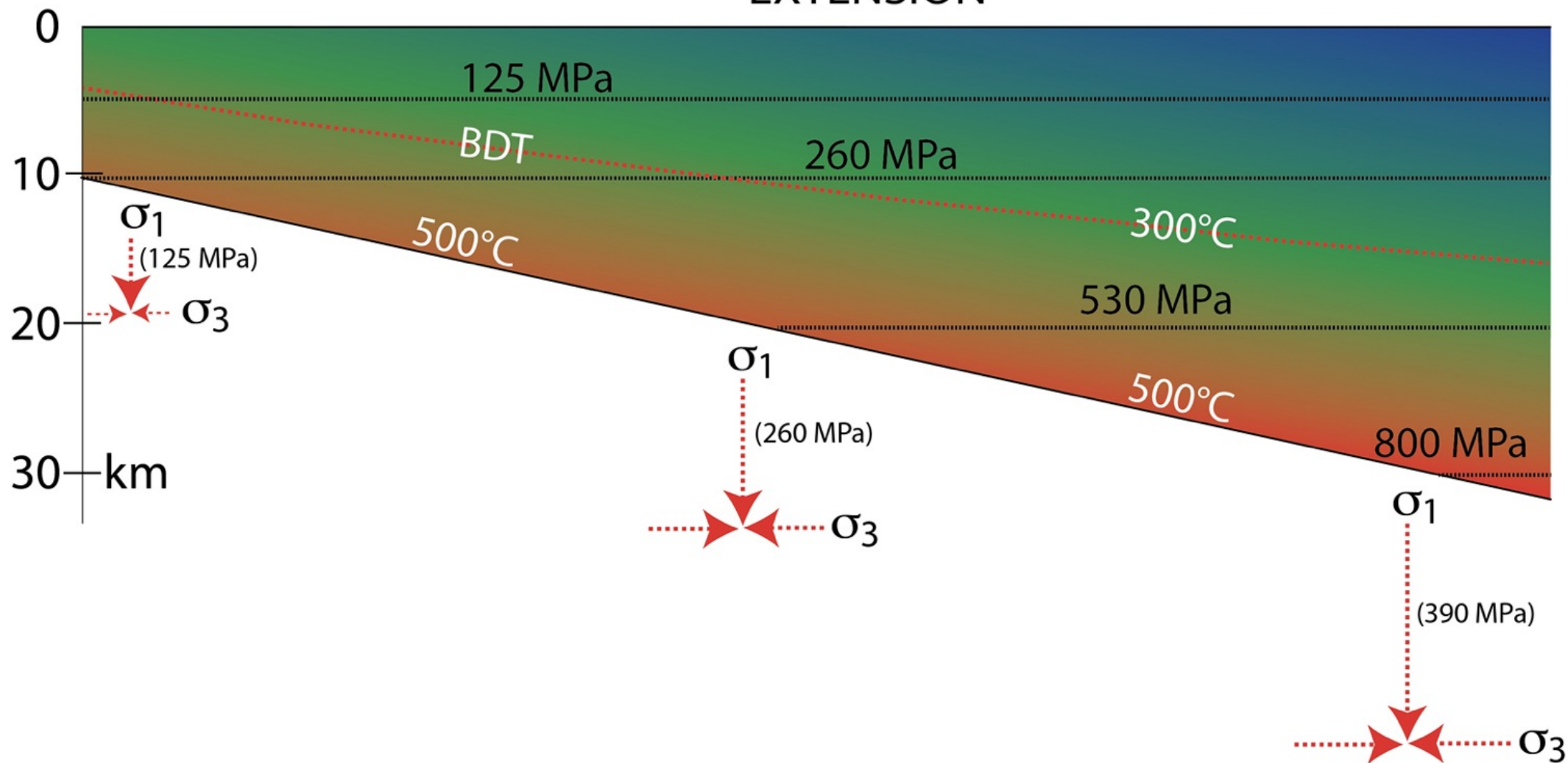


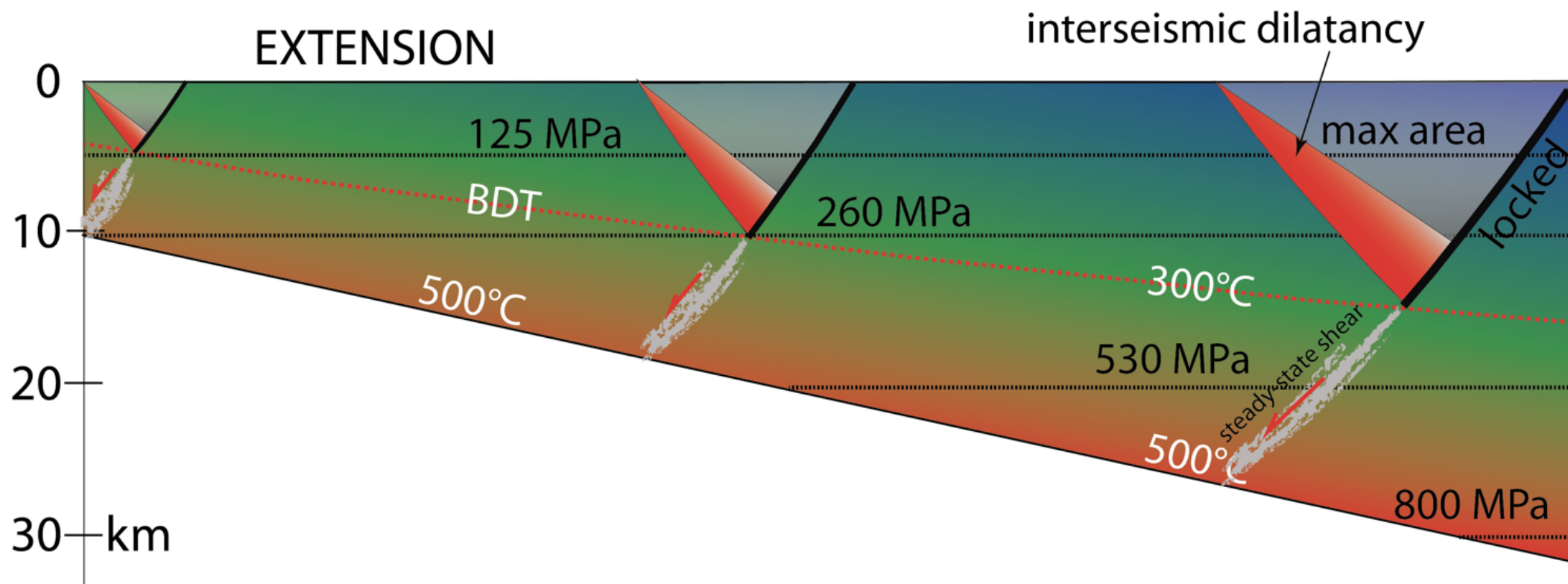


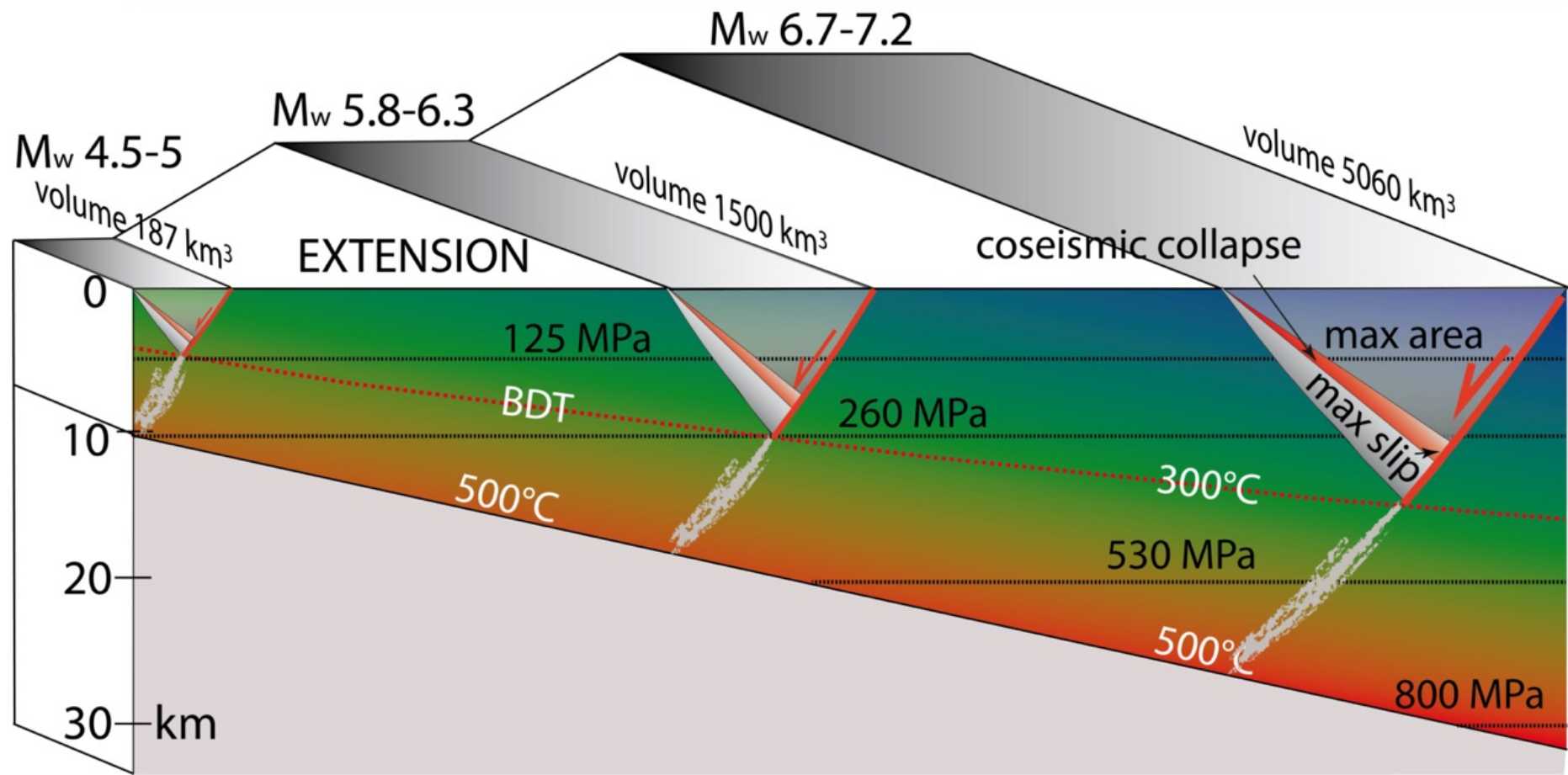
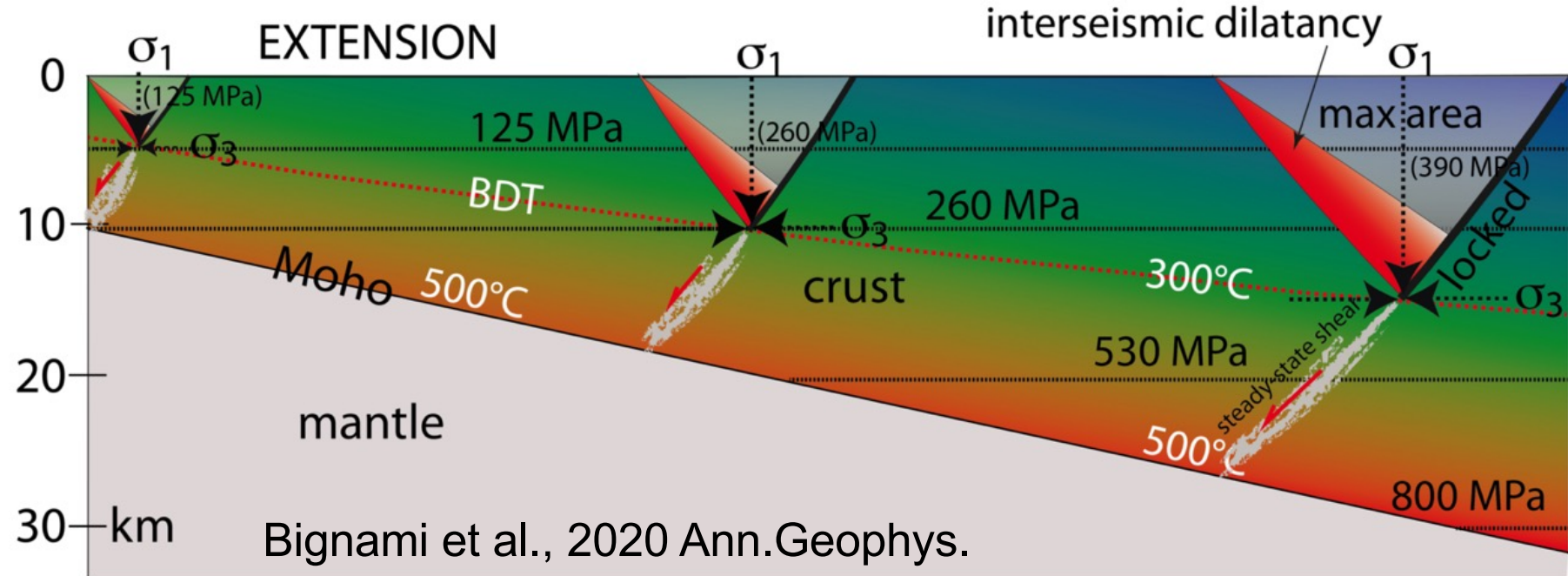
EXTENSION



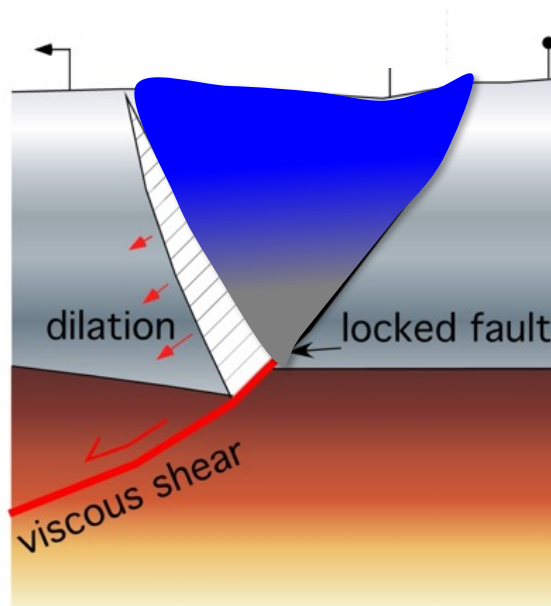
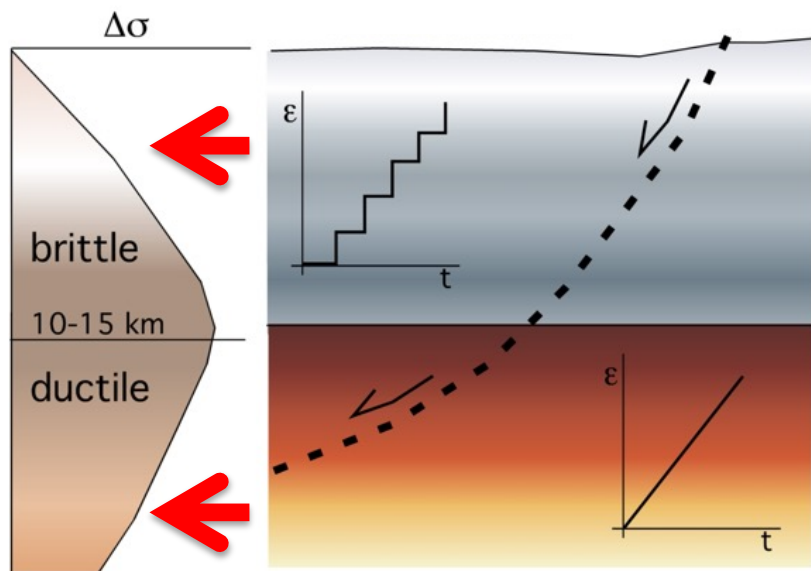
EXTENSION



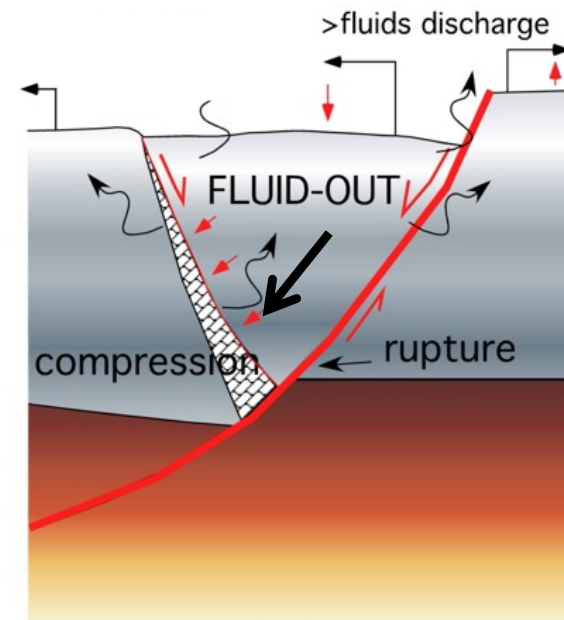




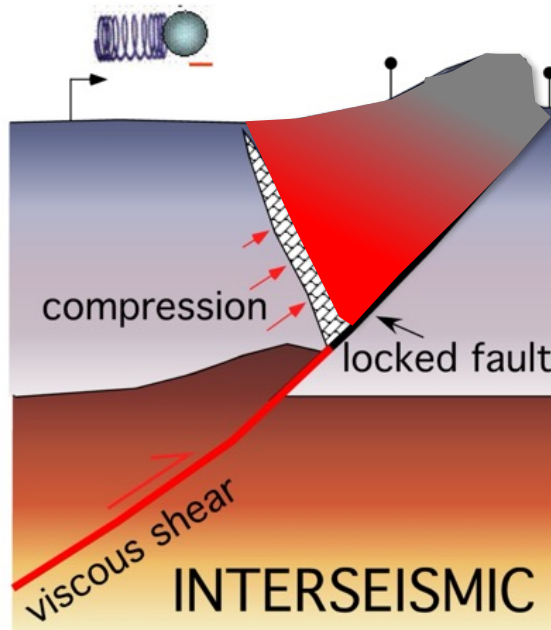
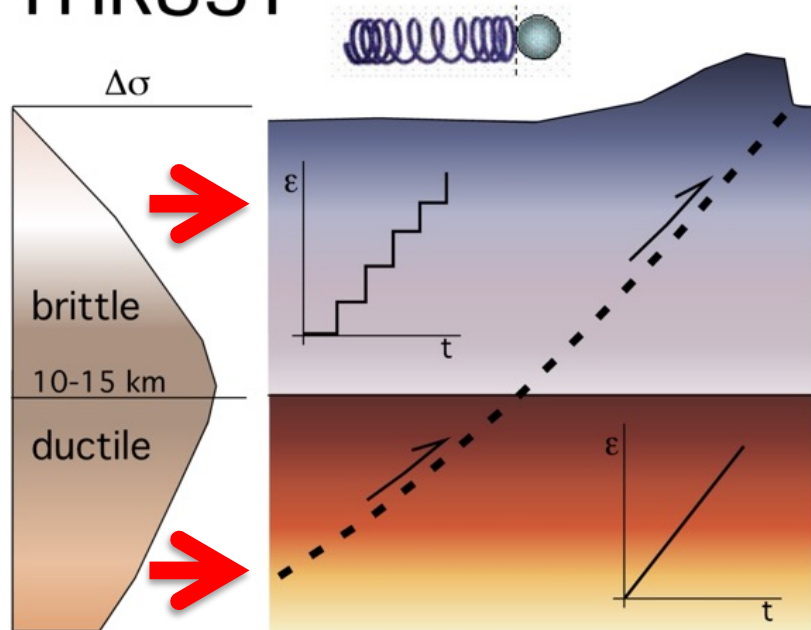
NORMAL FAULT



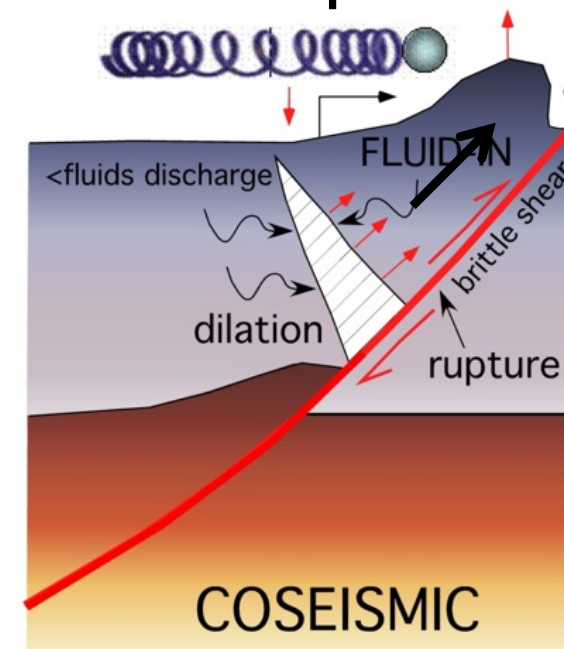
graviquake



THRUST

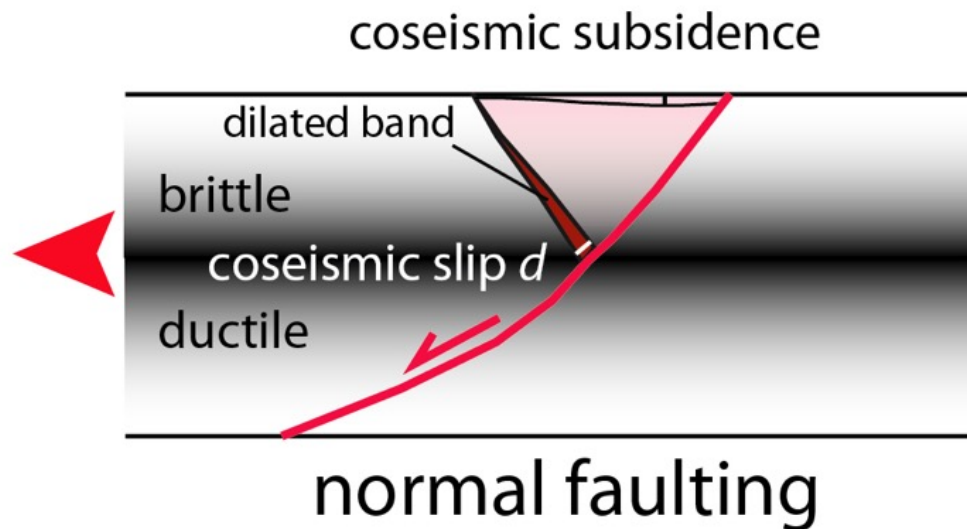


elastoquake



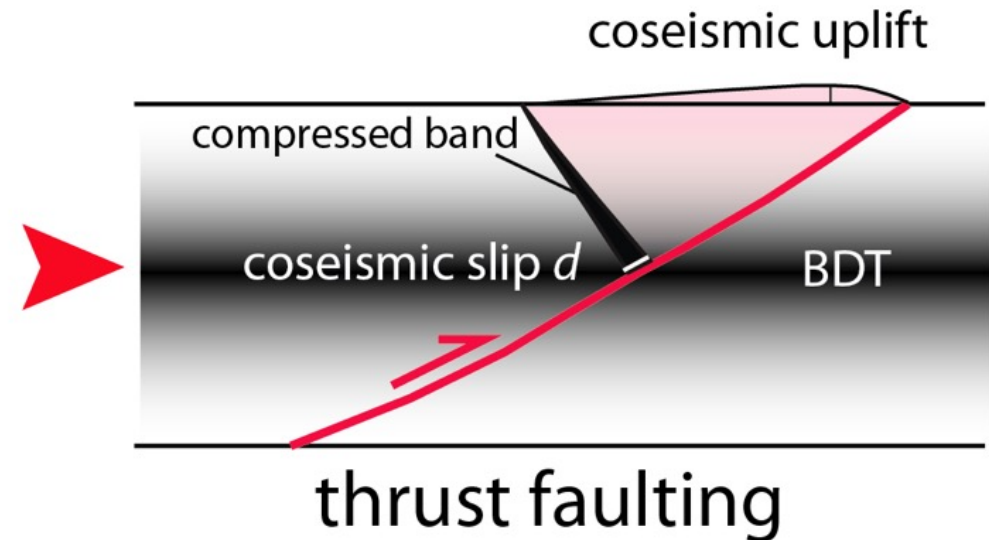
EARTHQUAKE ENERGY

GRAVIQUAKE



$$E = mgh(\mu_s, \Theta)$$

ELASTOQUAKE

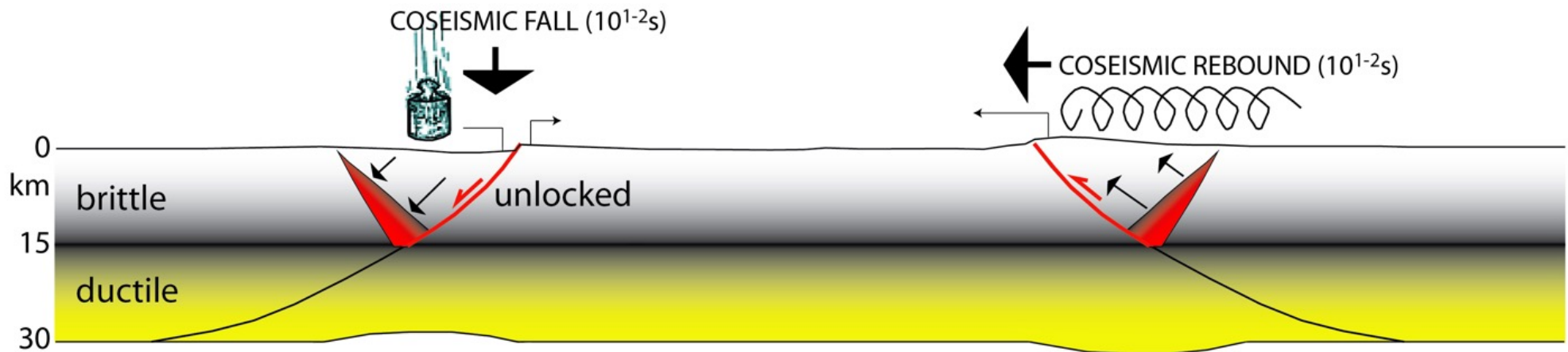


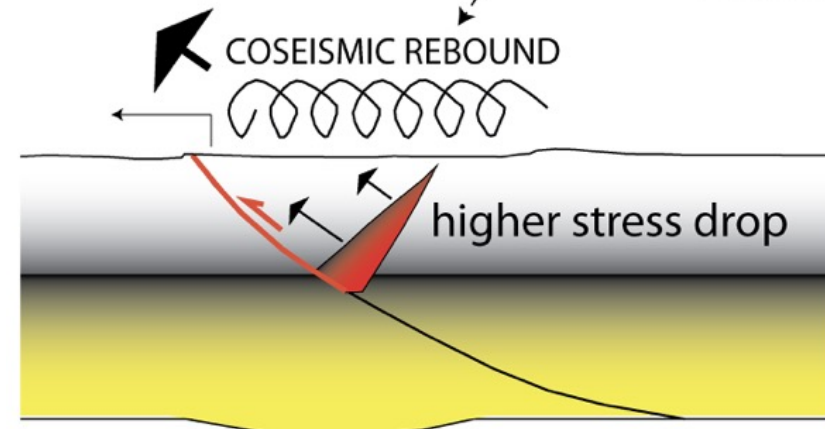
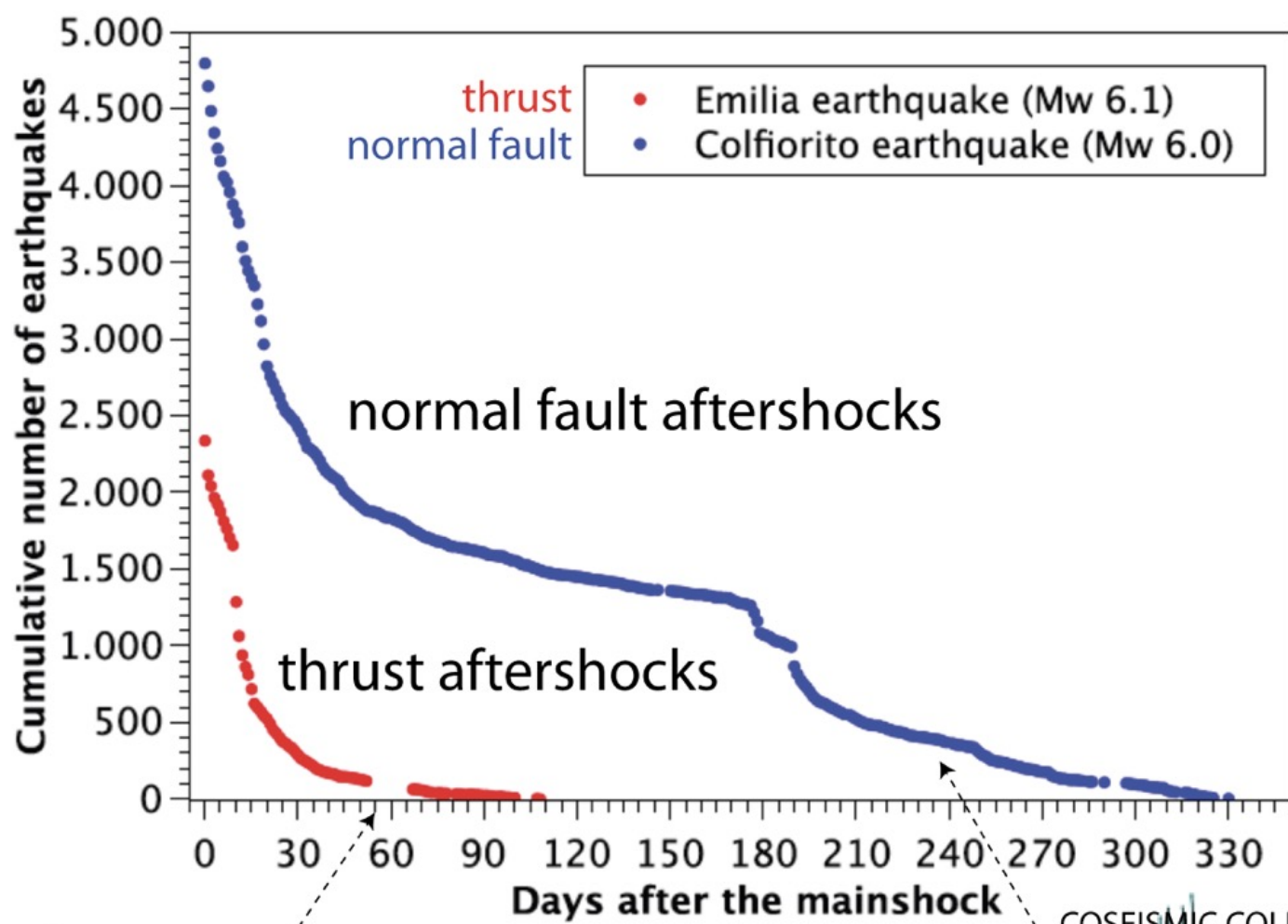
$$E = \frac{1}{2} K \left(\frac{\Delta V (\mu_s, \Theta)}{V} \right)^2 \frac{m}{\rho}$$

pro gravity

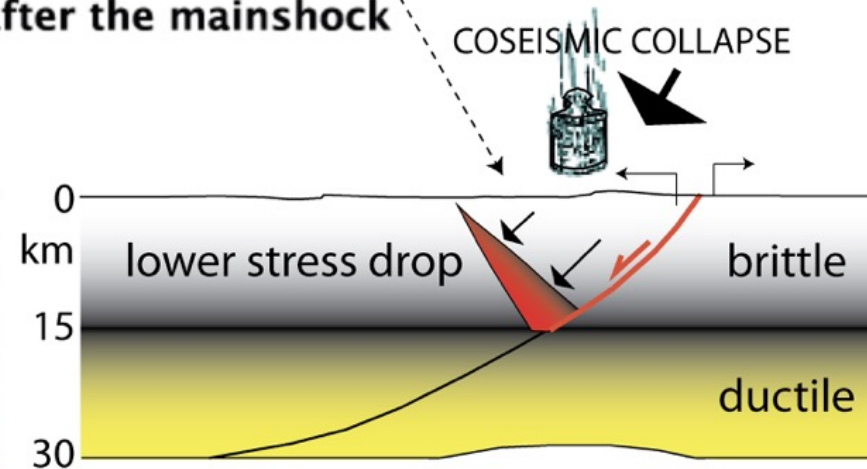


against gravity

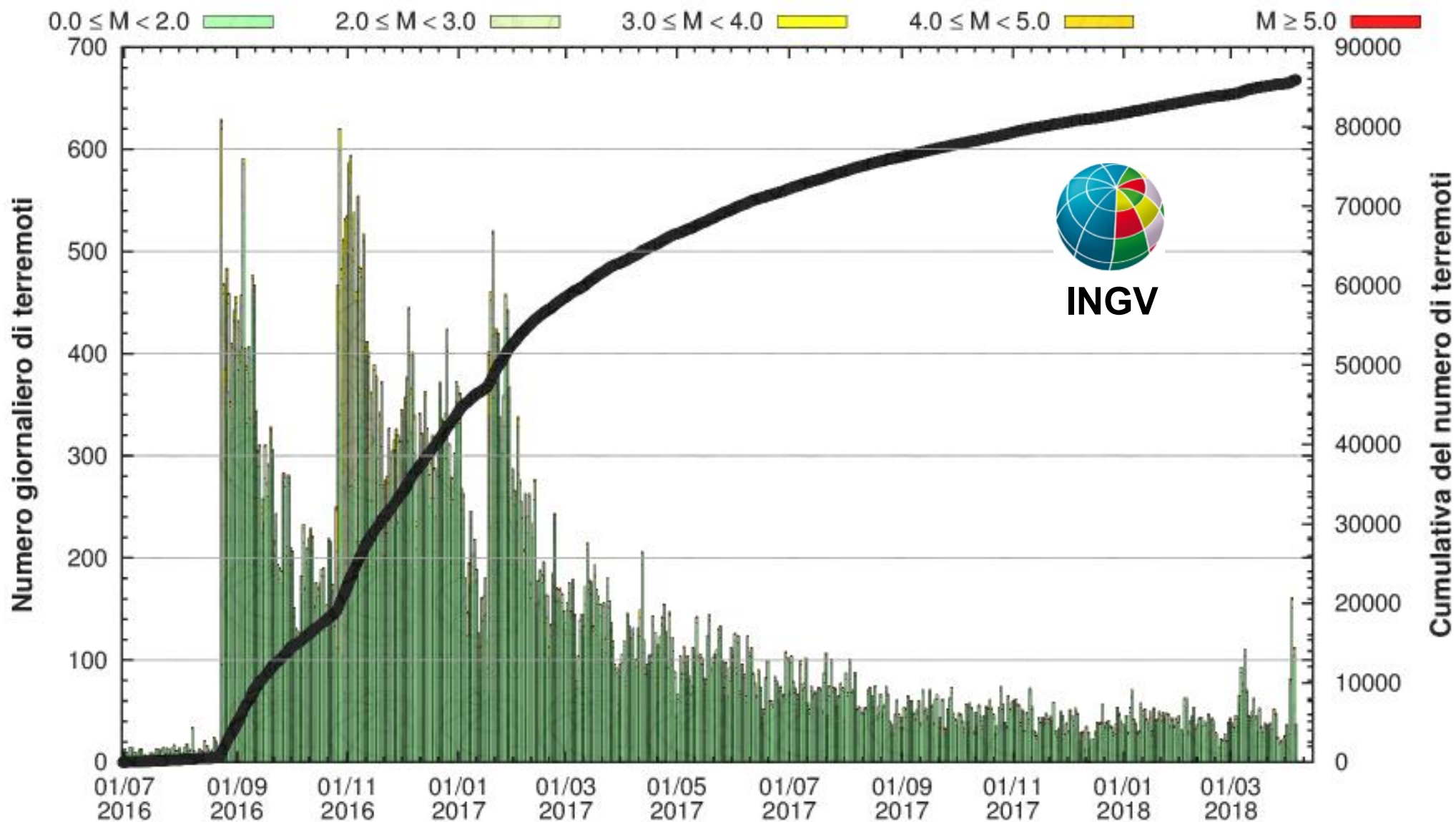




ELASTICITY DRIVEN SEISMICITY
(elastoquakes)

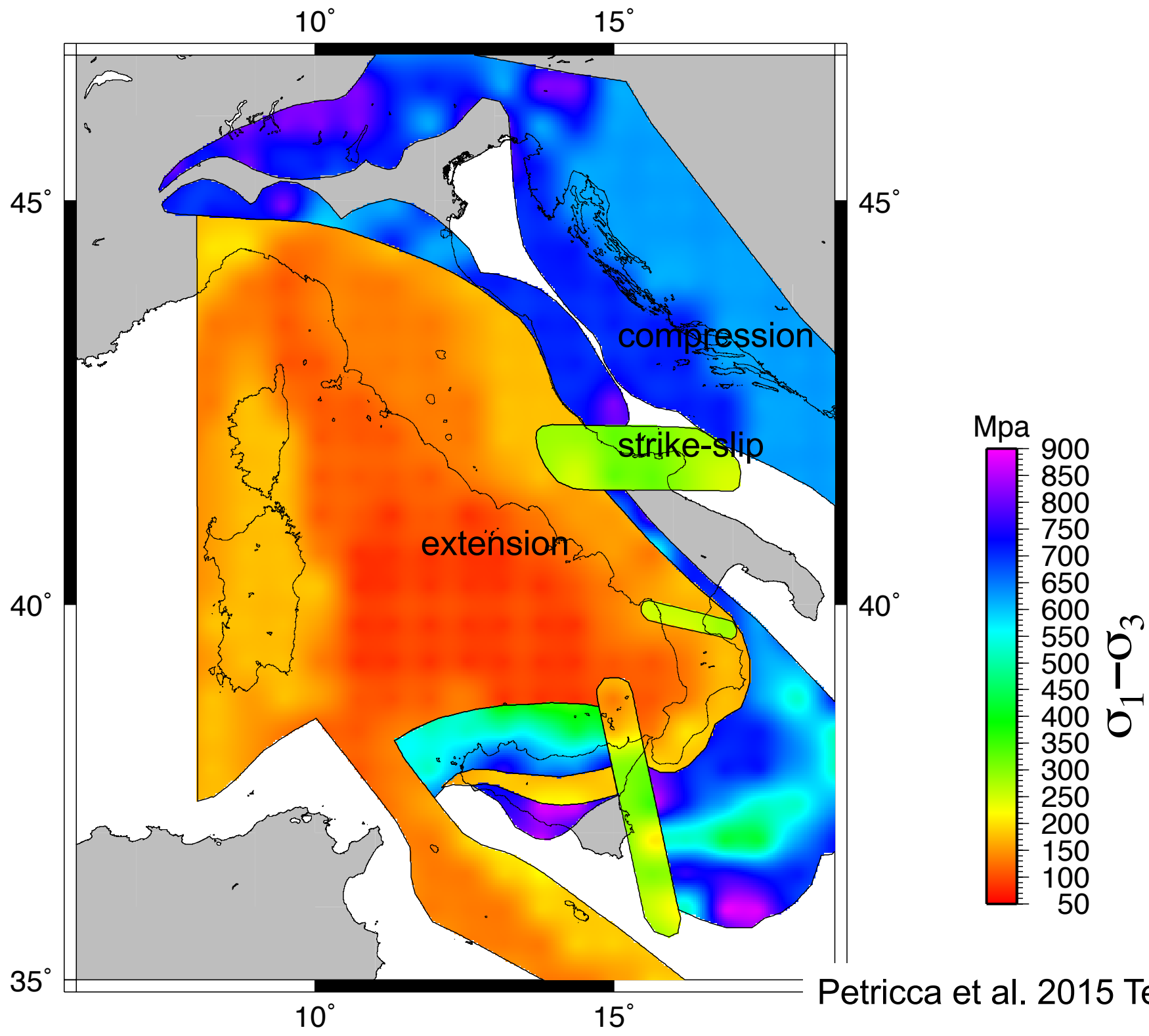


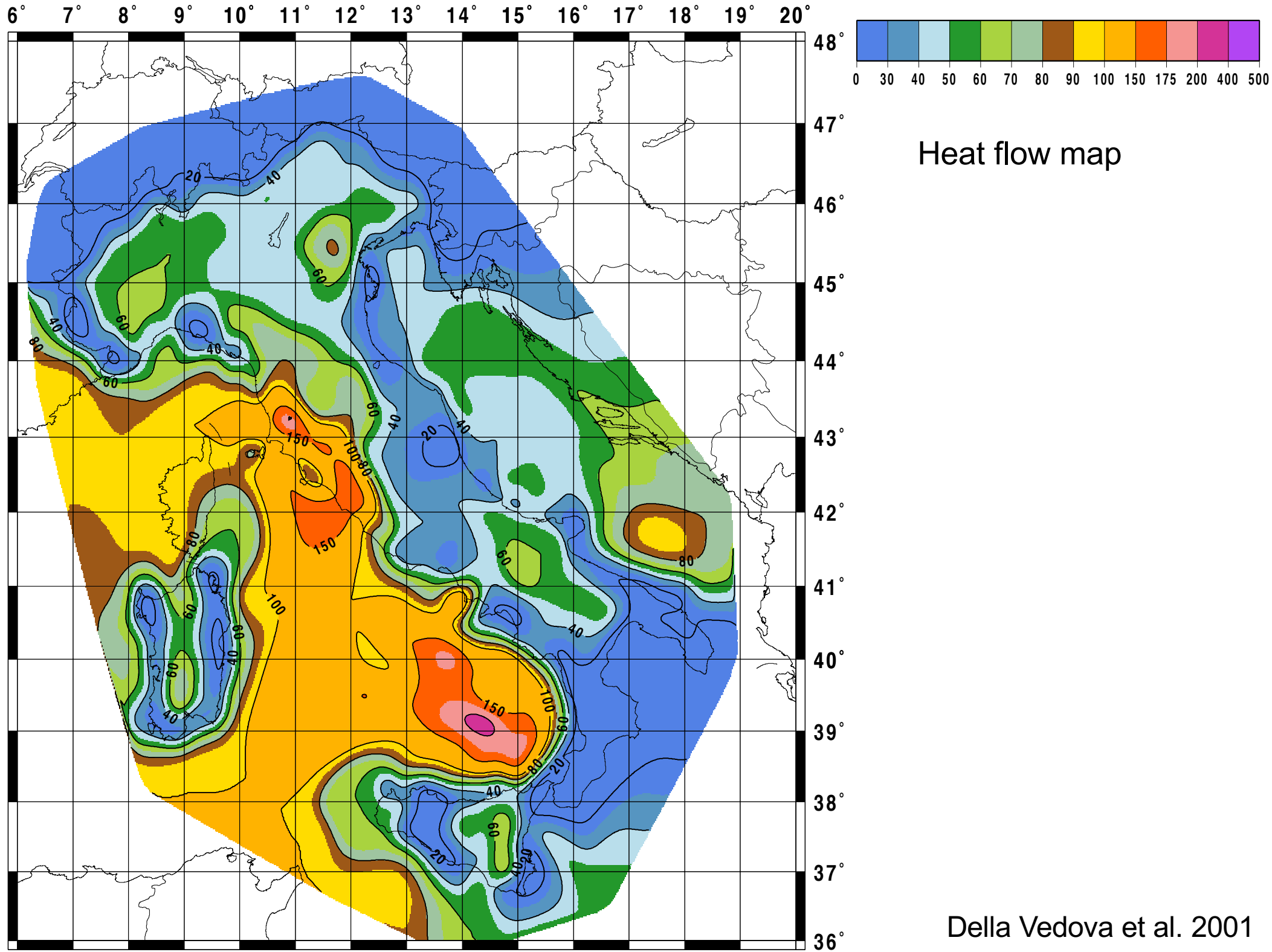
GRAVITY DRIVEN SEISMICITY
(graviquakes)



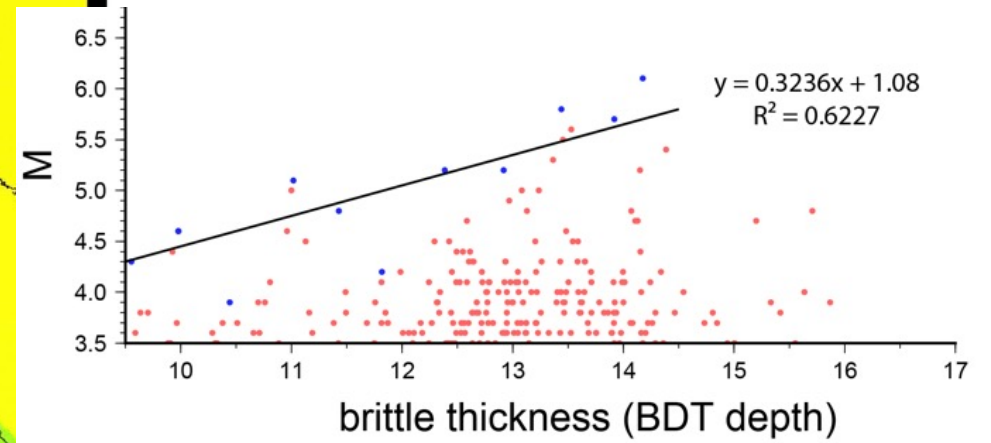
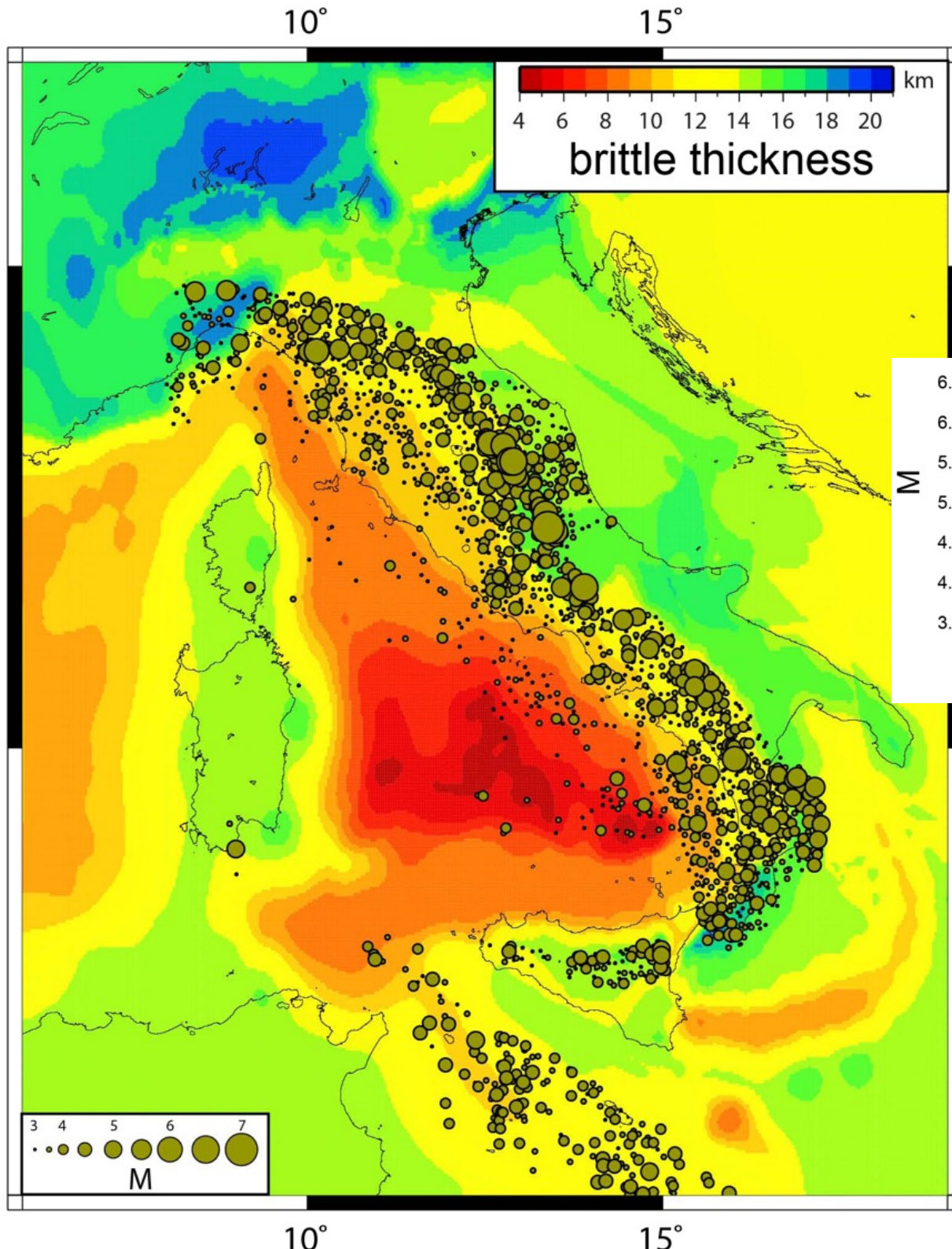
Aggiornamento: 04/06/18 10:25:52 (ora locale)

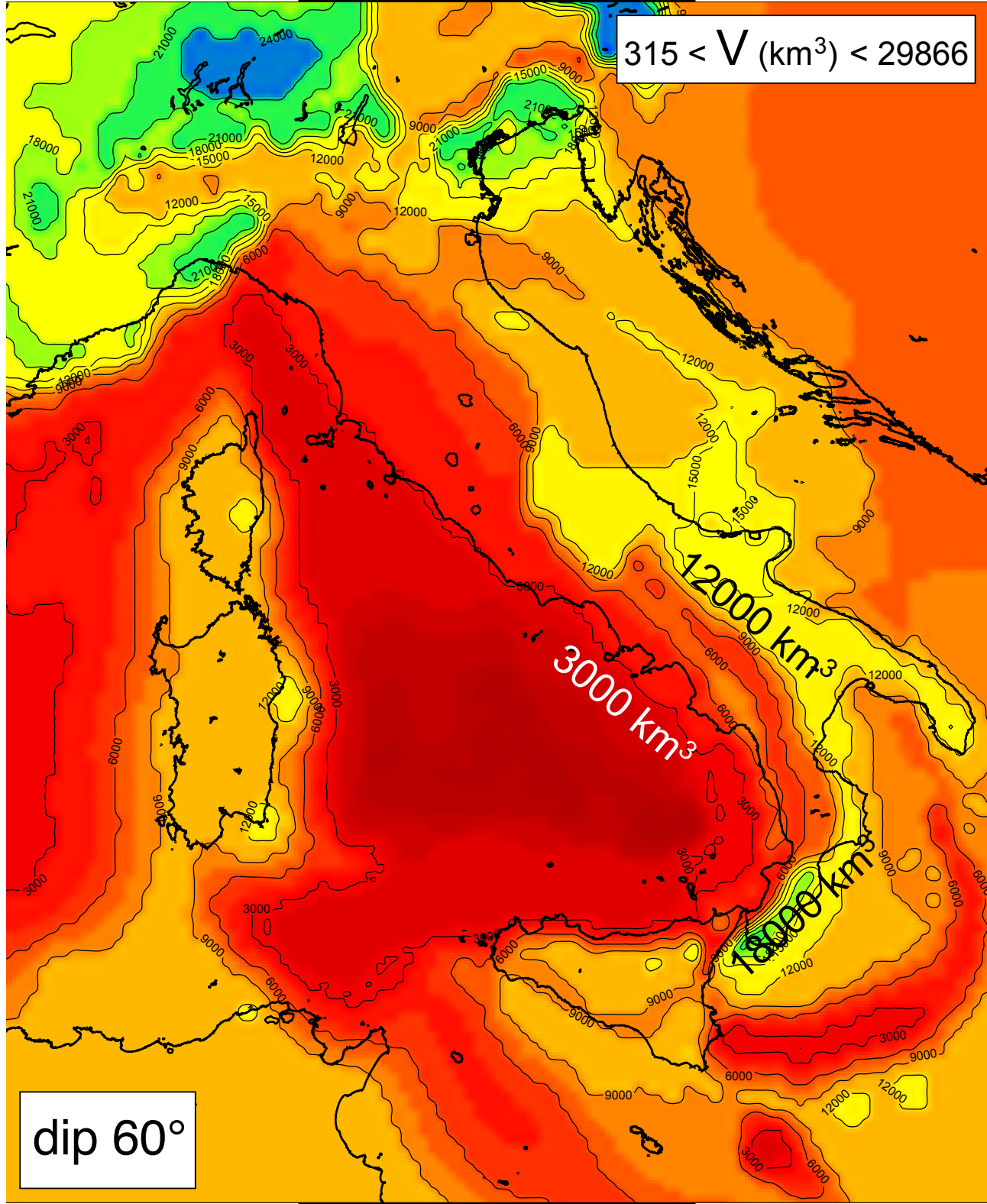
da <http://iside.rm.ingv.it/>





Della Vedova et al. 2001





45°

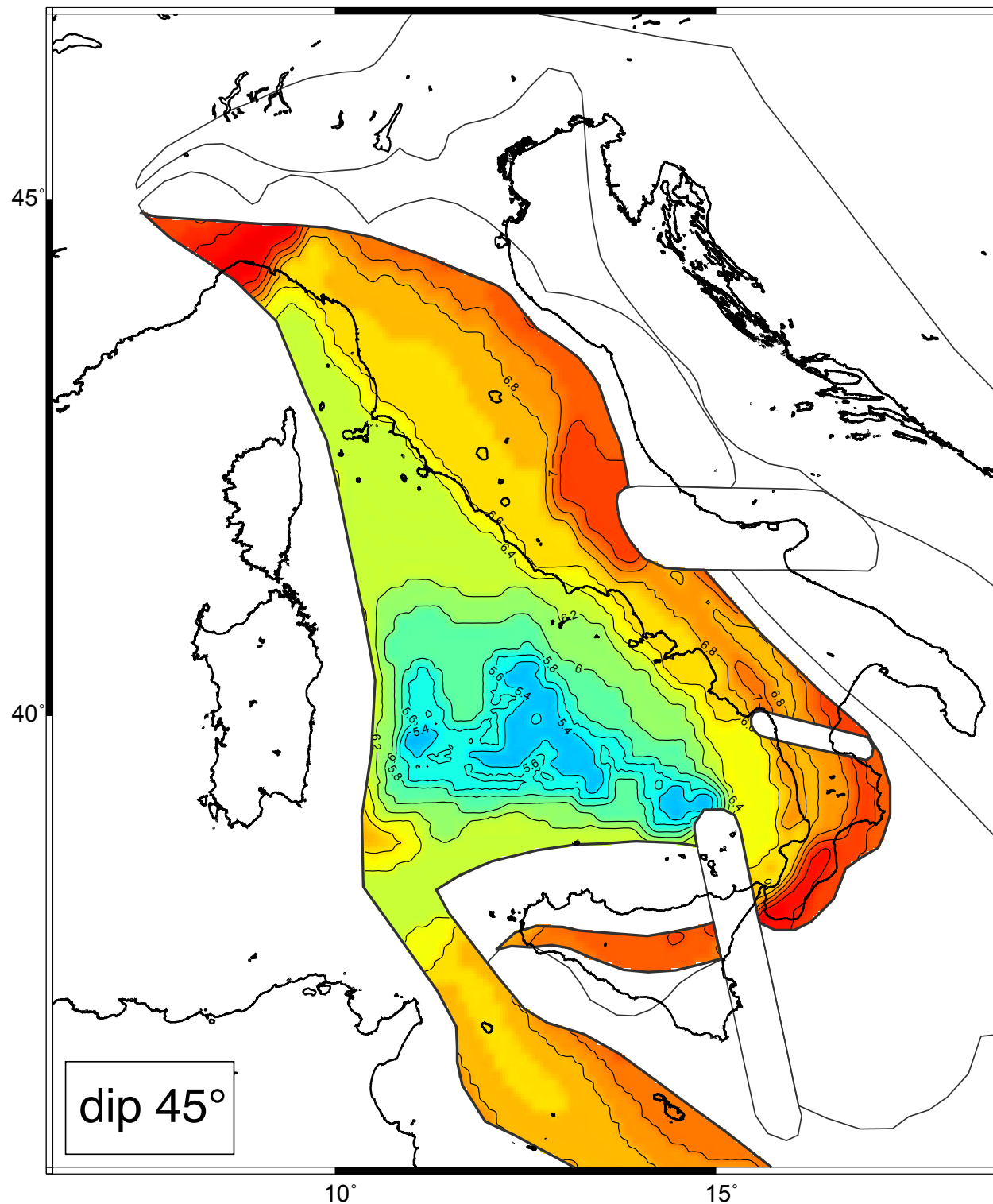
Brittle Volume (km³)

0 5000 10000 15000 20000 25000

40°

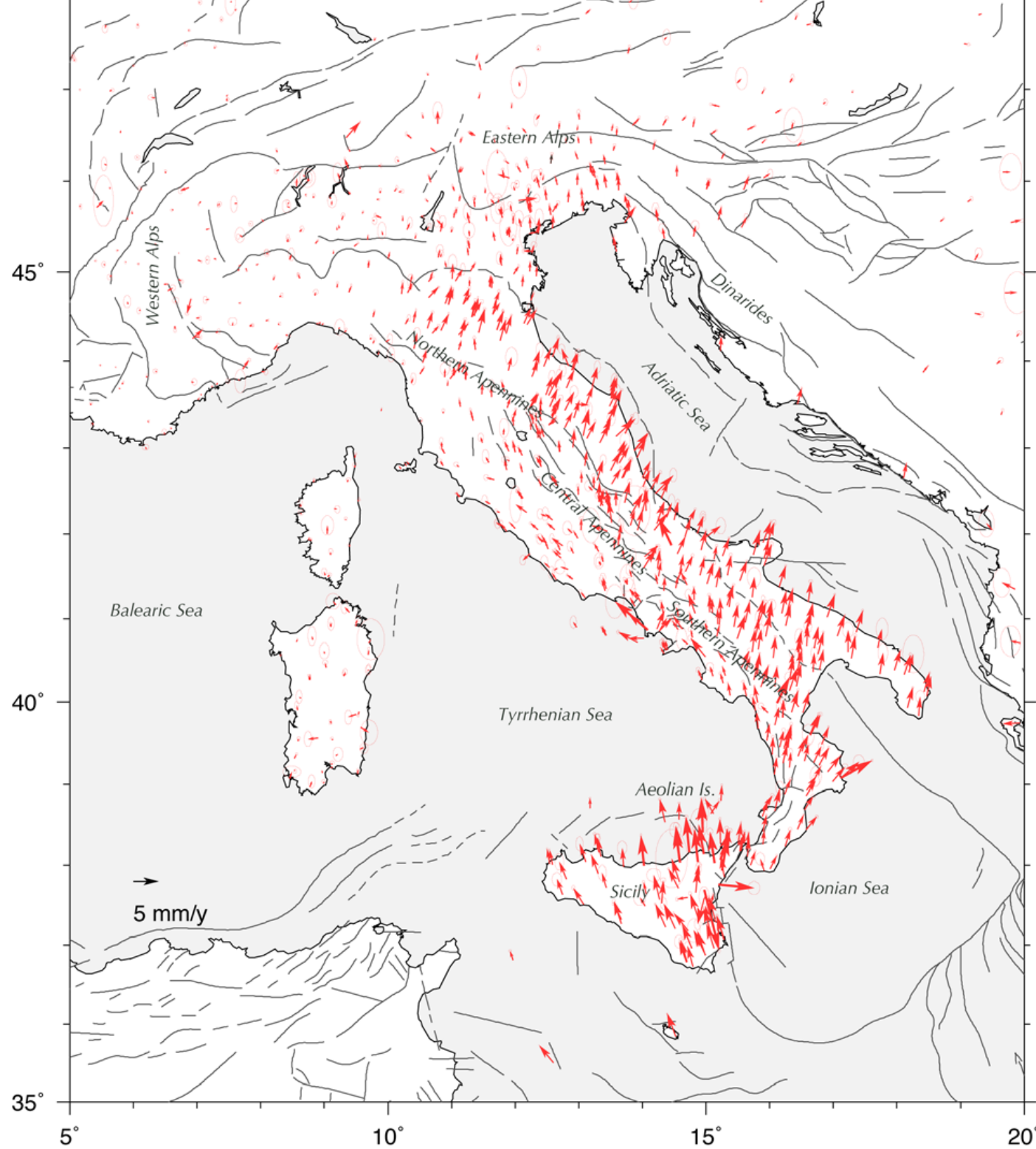


INGV

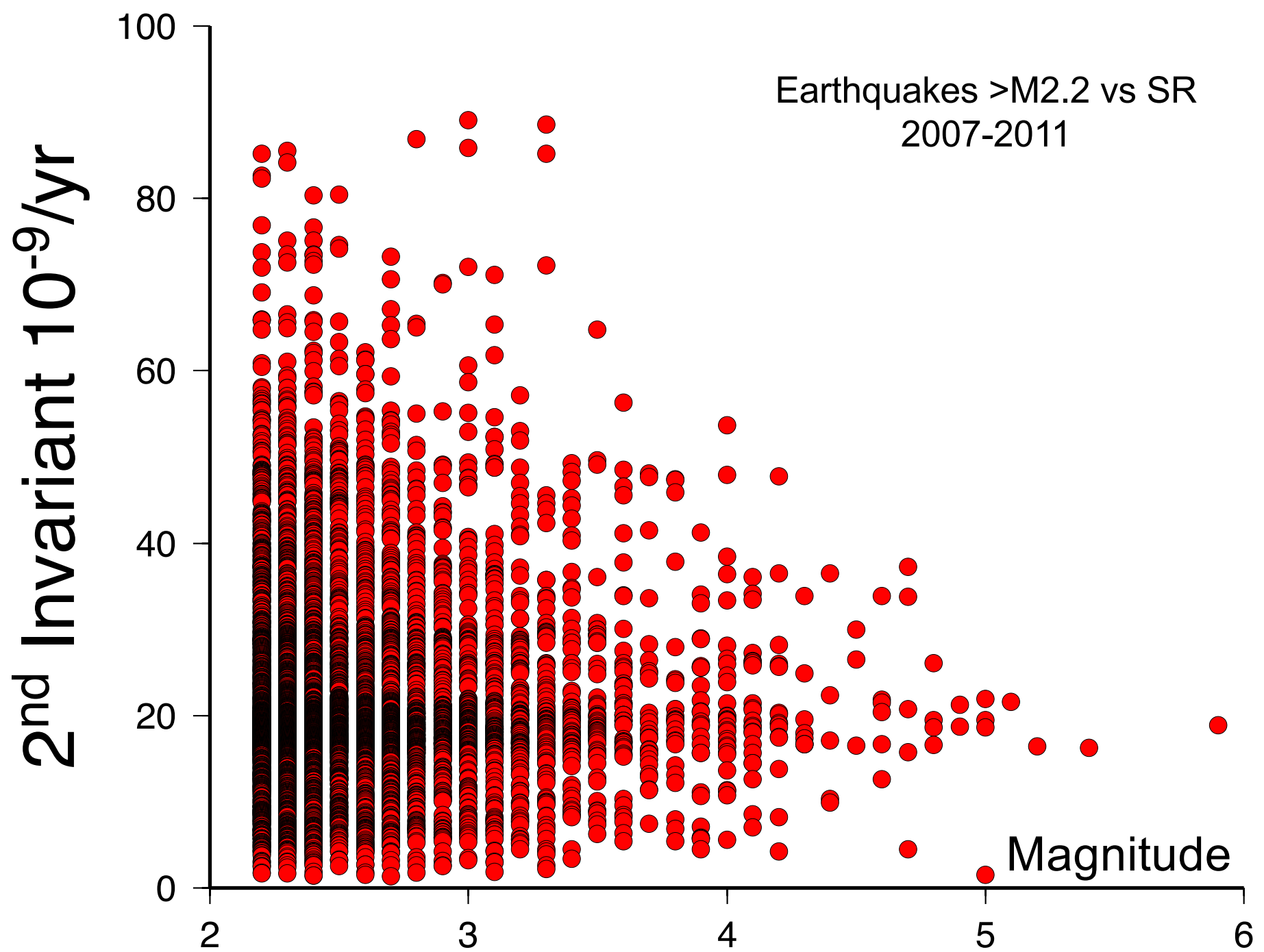




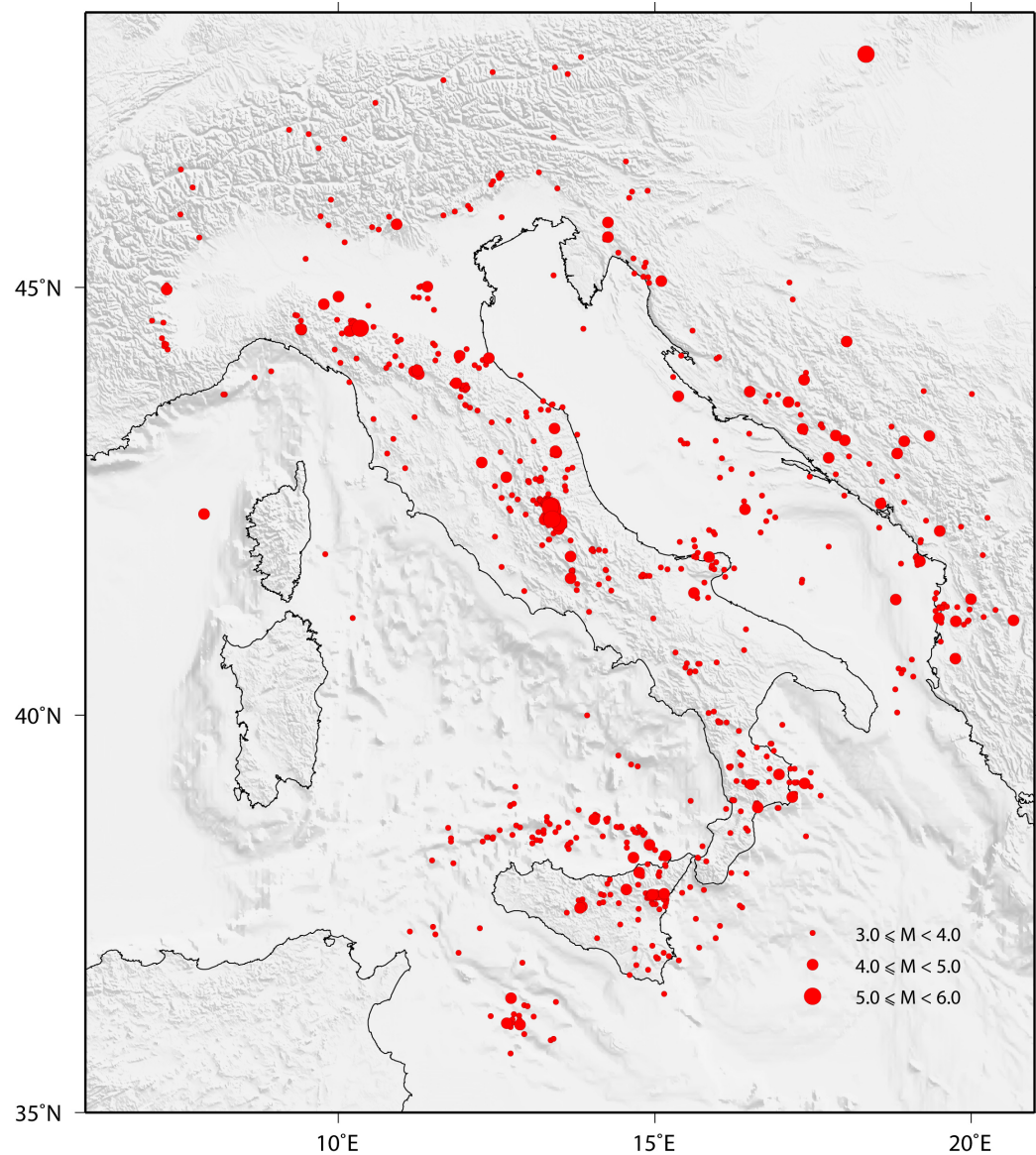
INGV



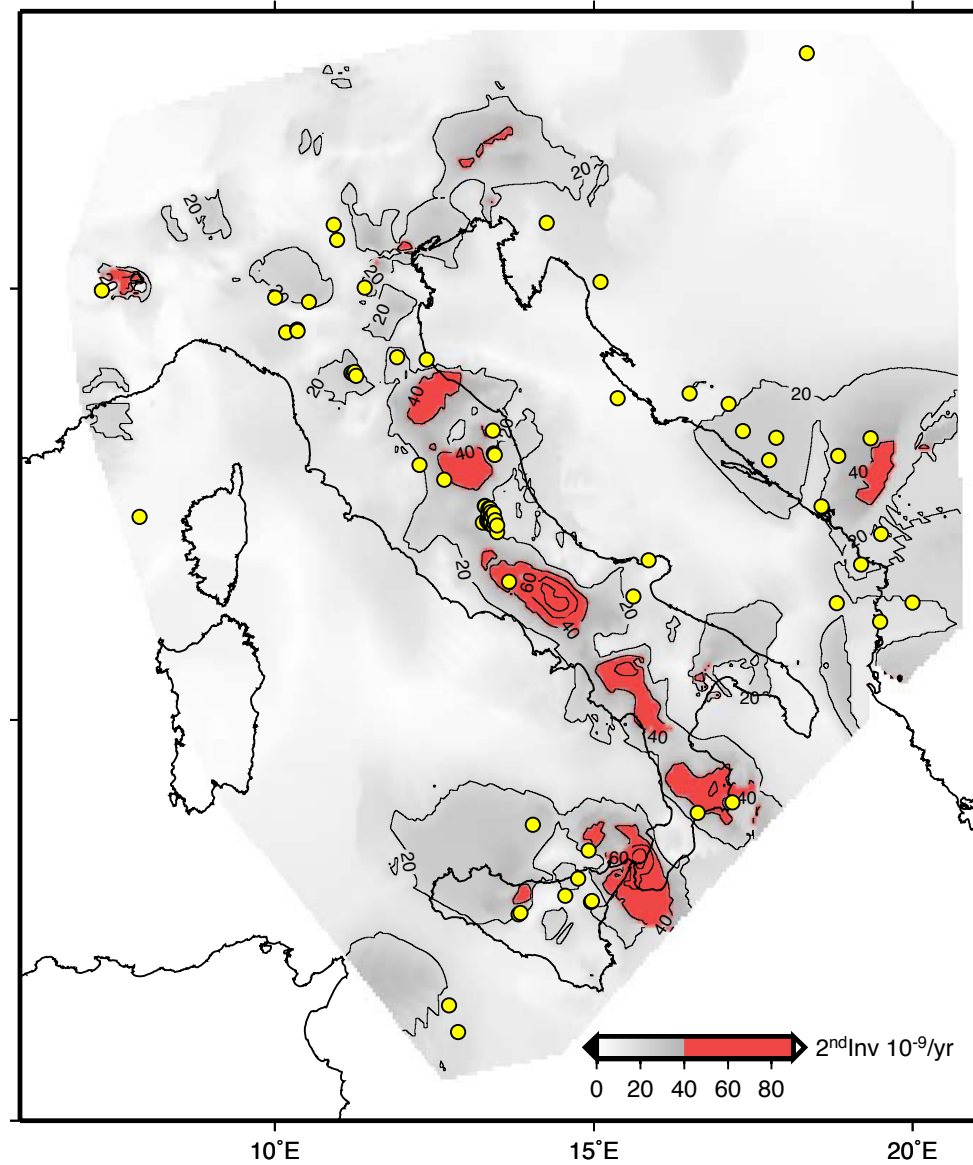
Devoti et al. 2017

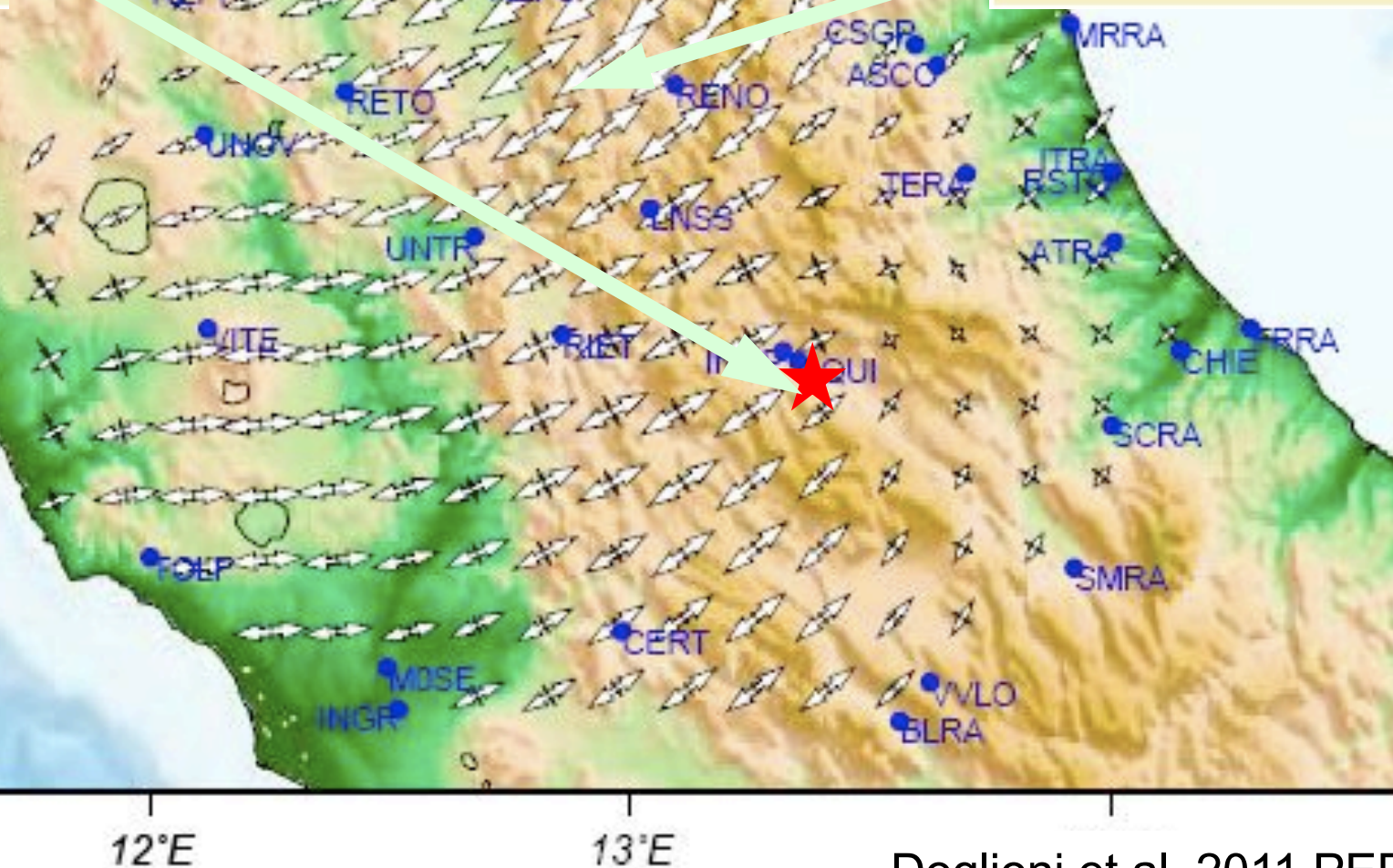
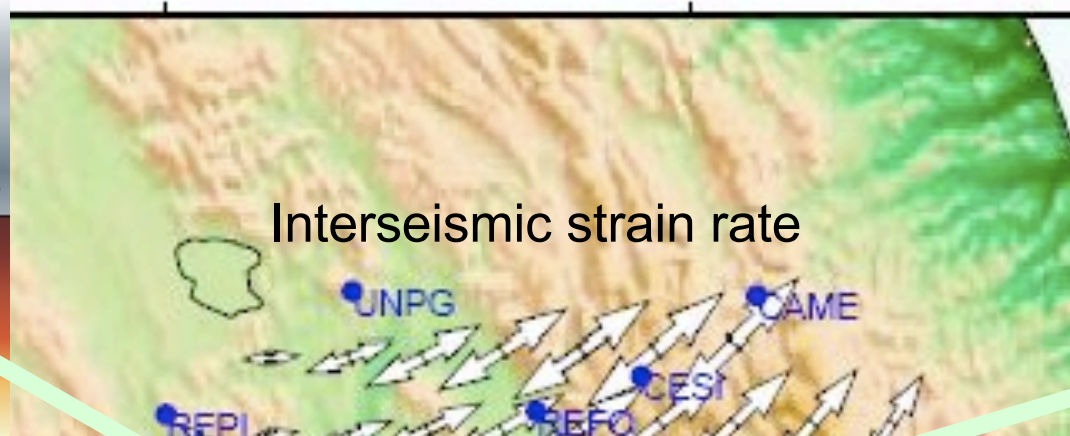


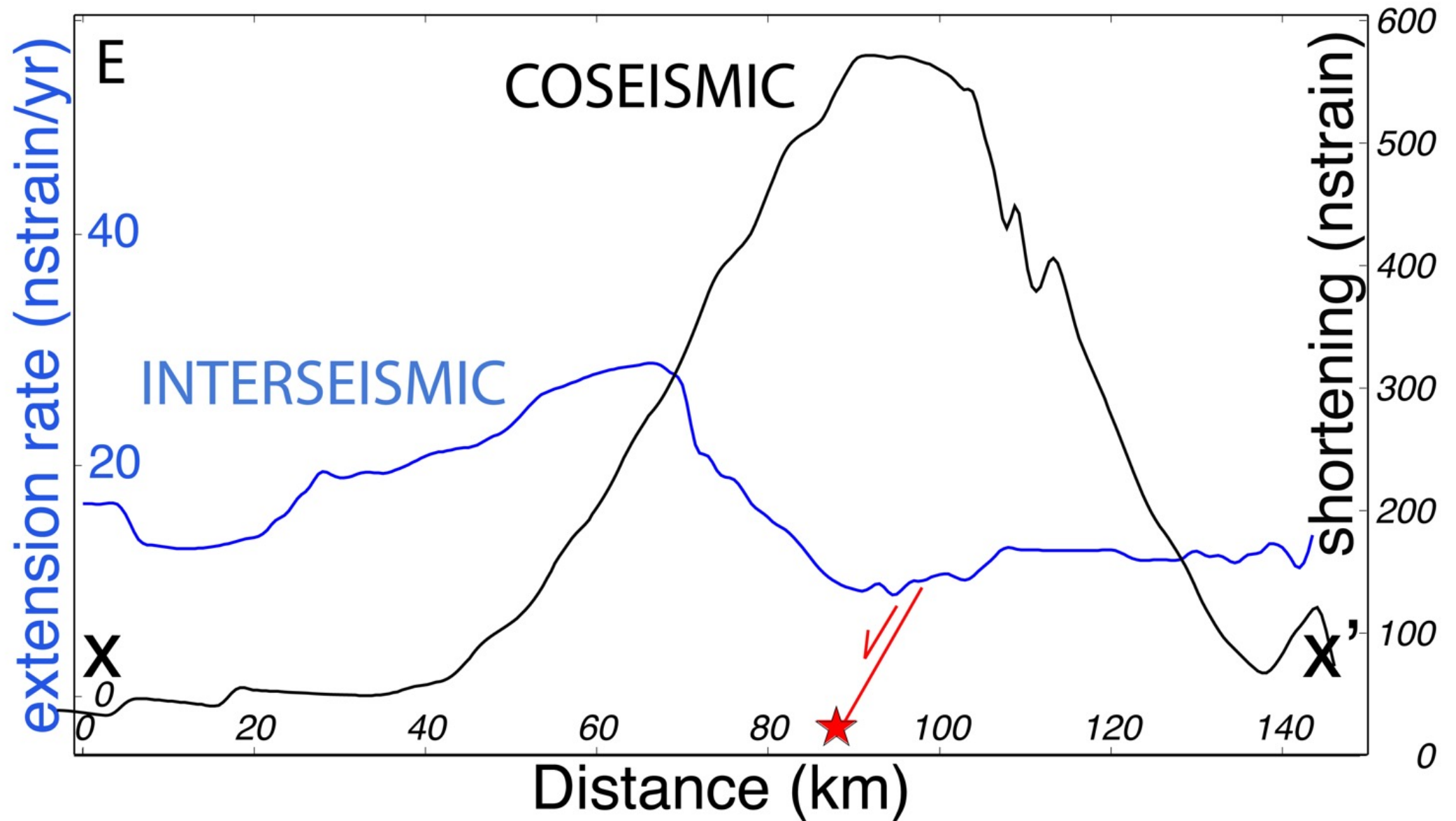
Seismicity (>M3) 2007-2011

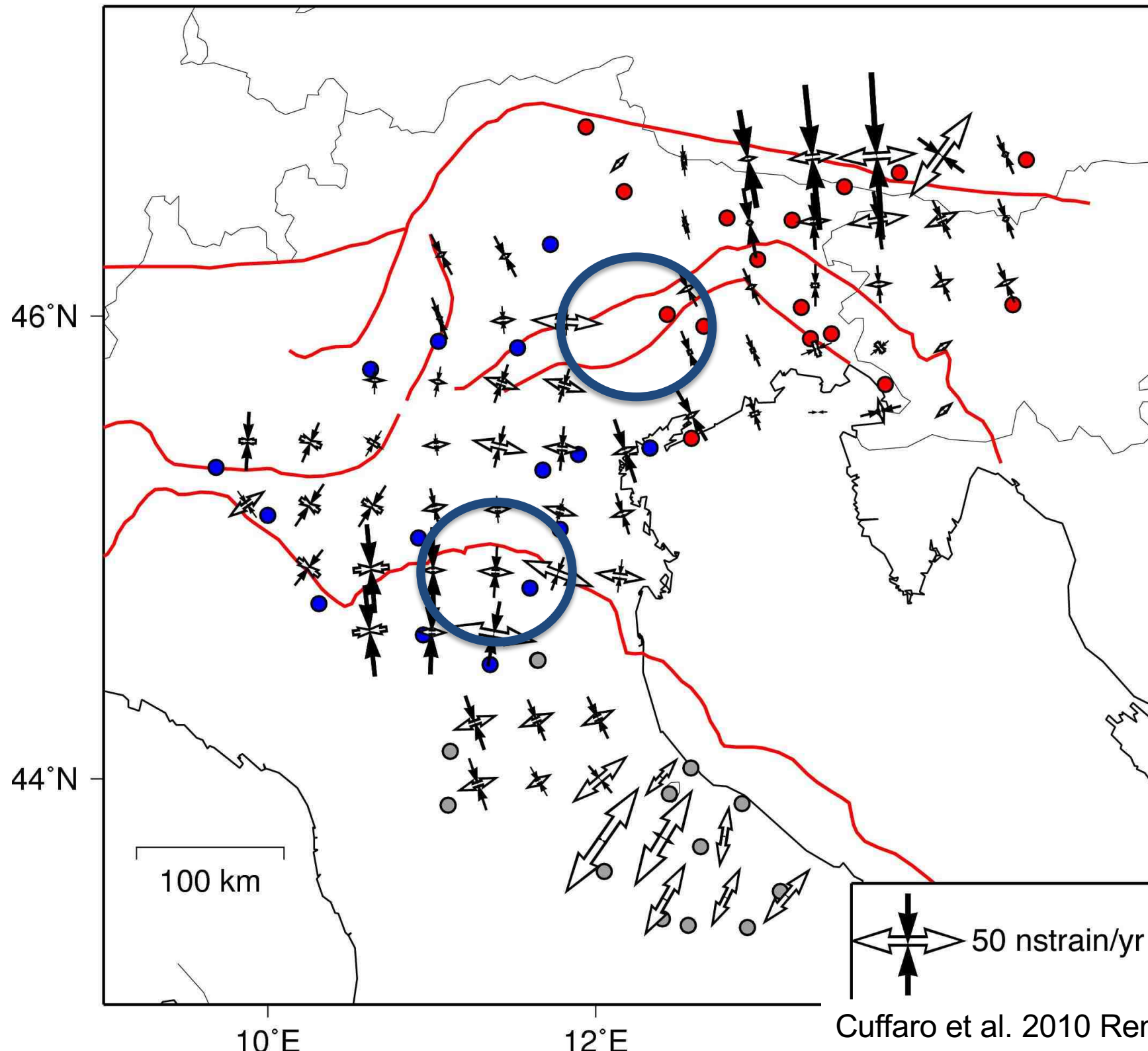


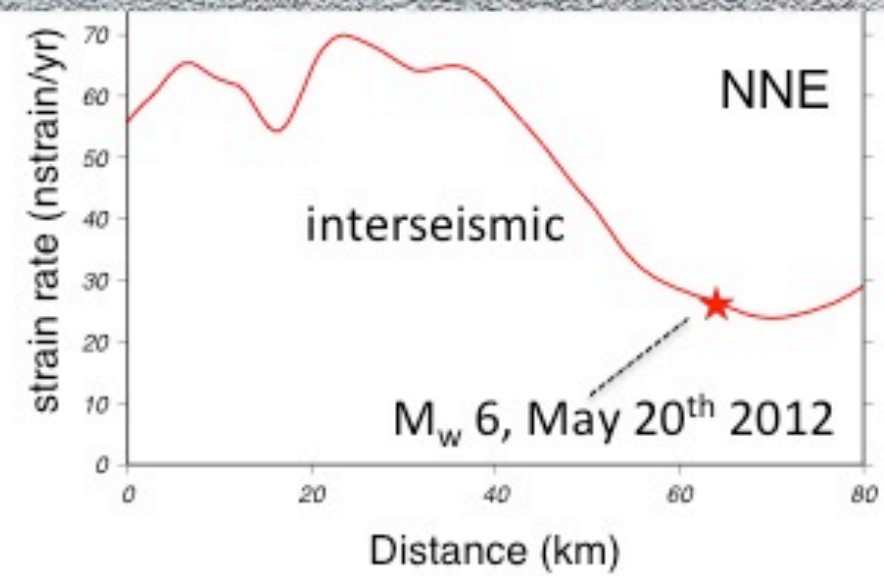
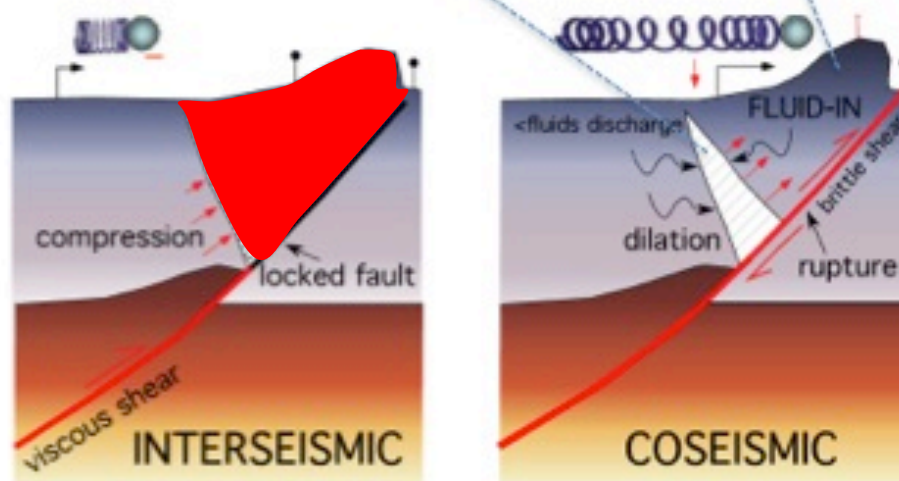
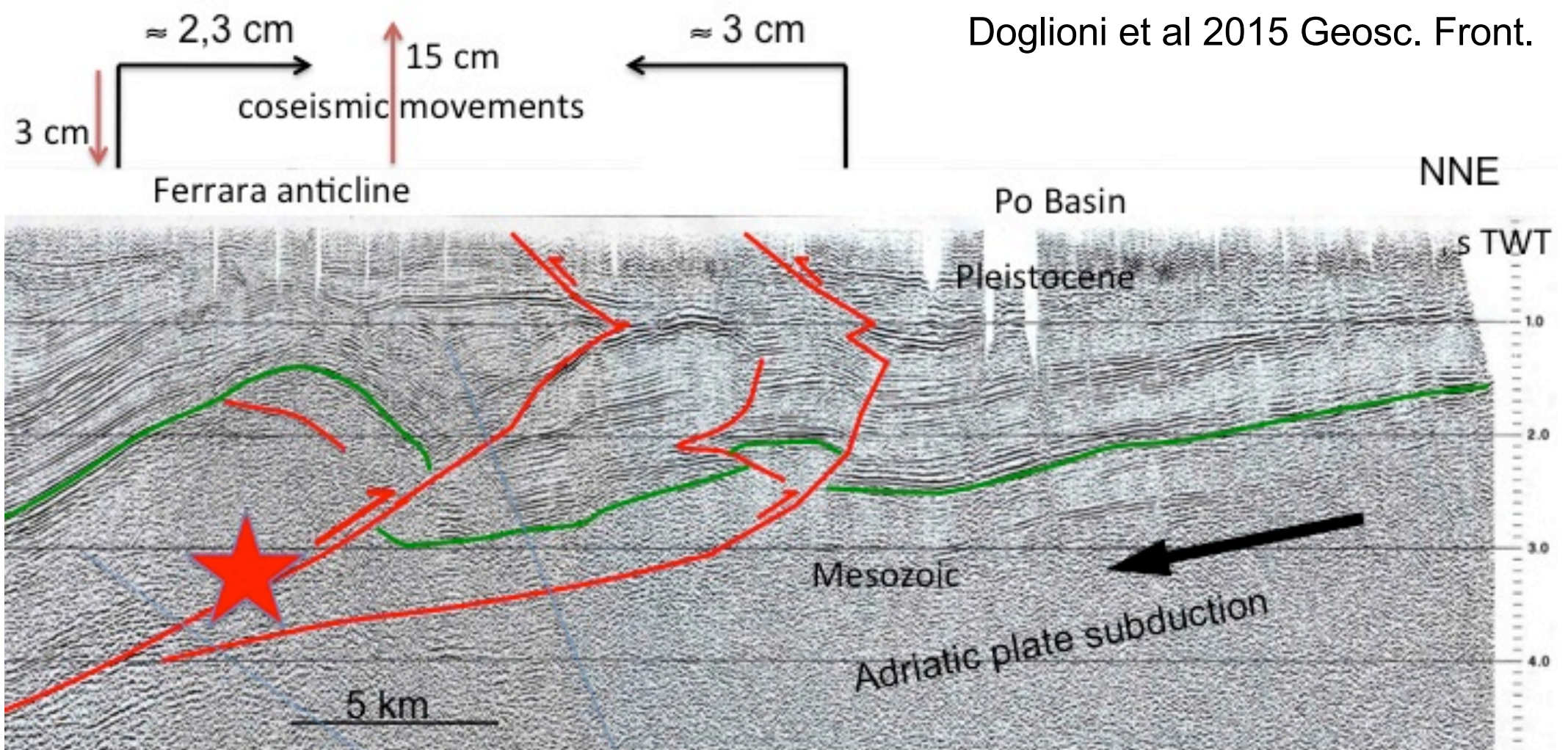
same time frame >M4 vs SR>40 ns



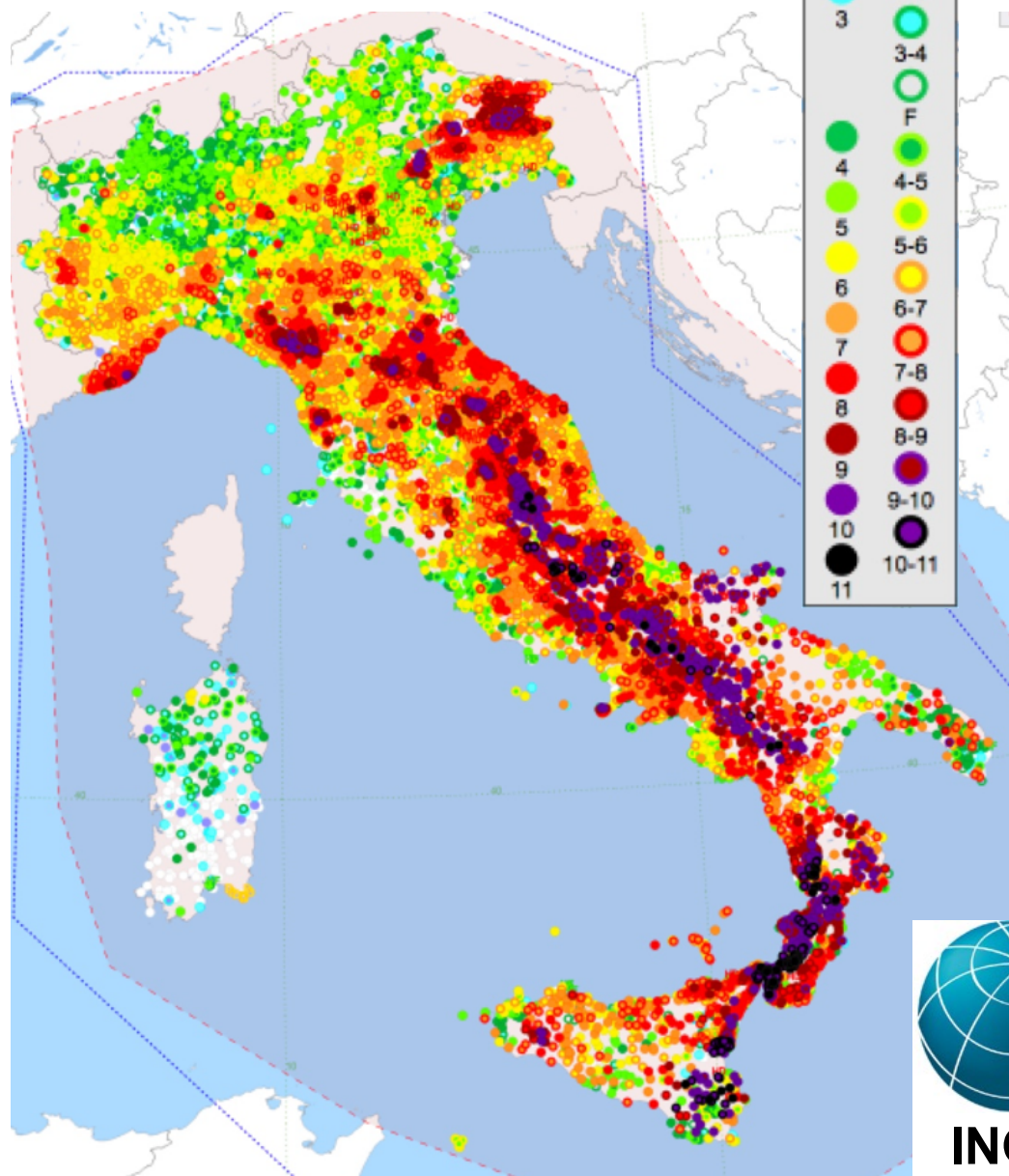






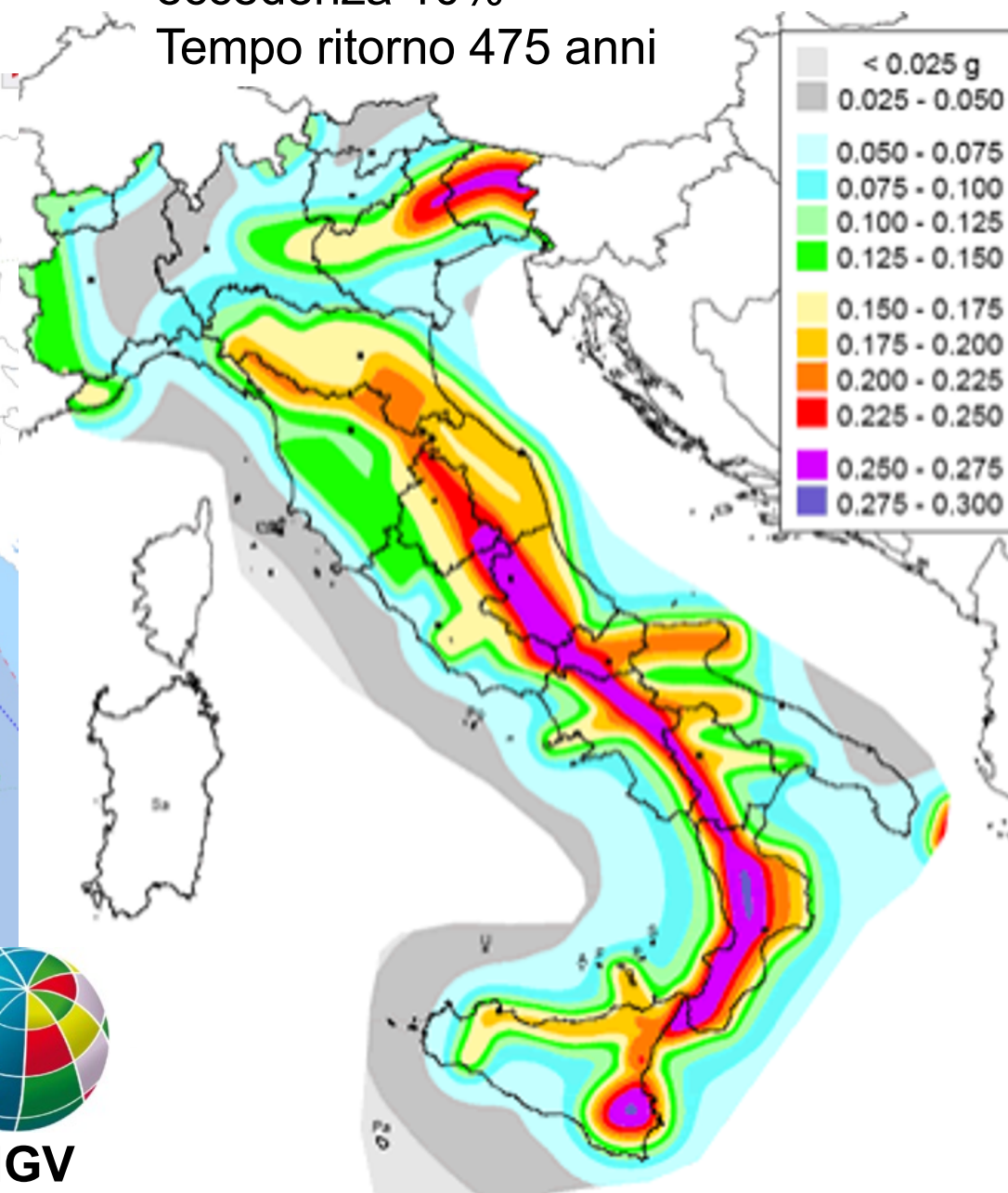


Earthquakes after 1000 AD

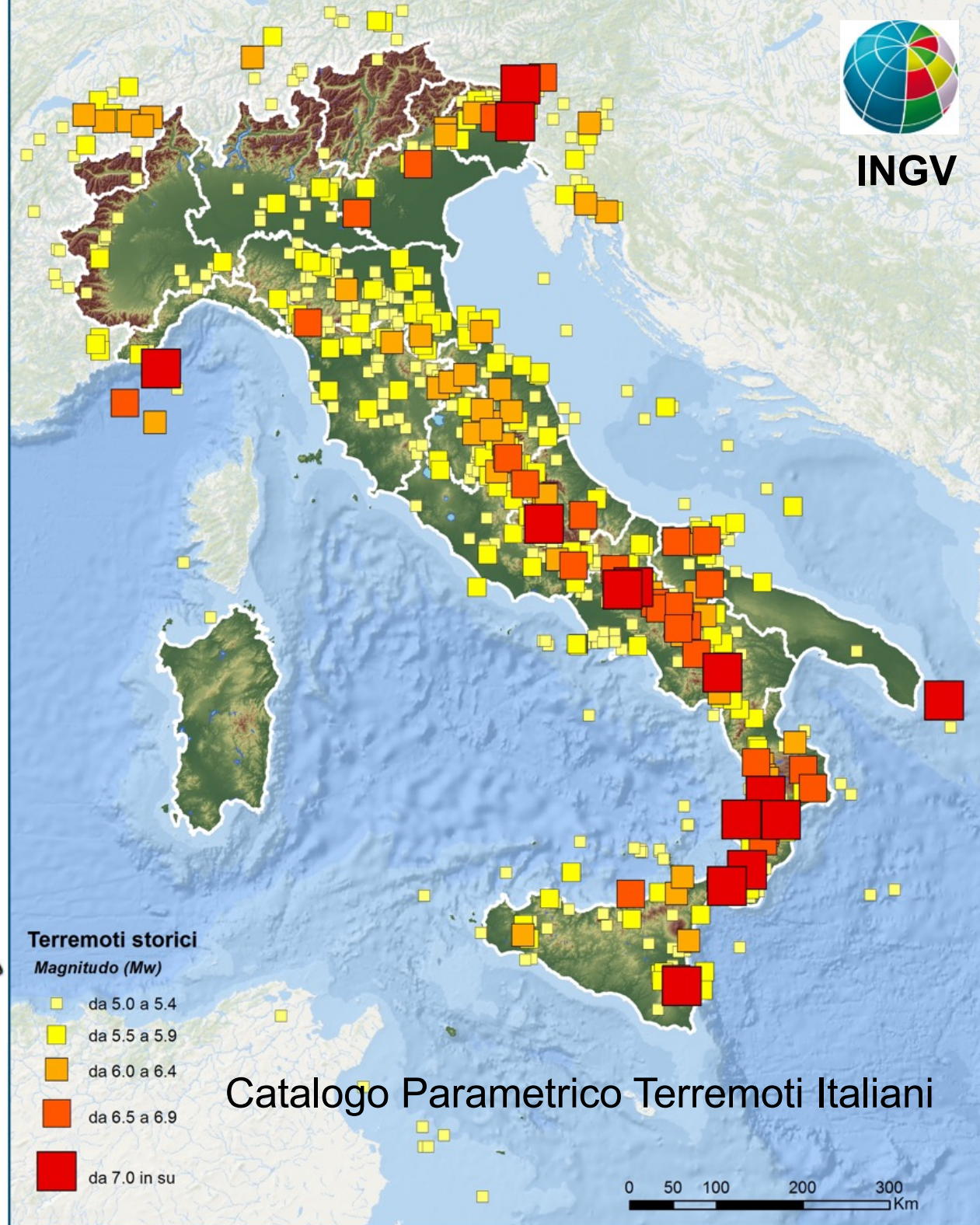
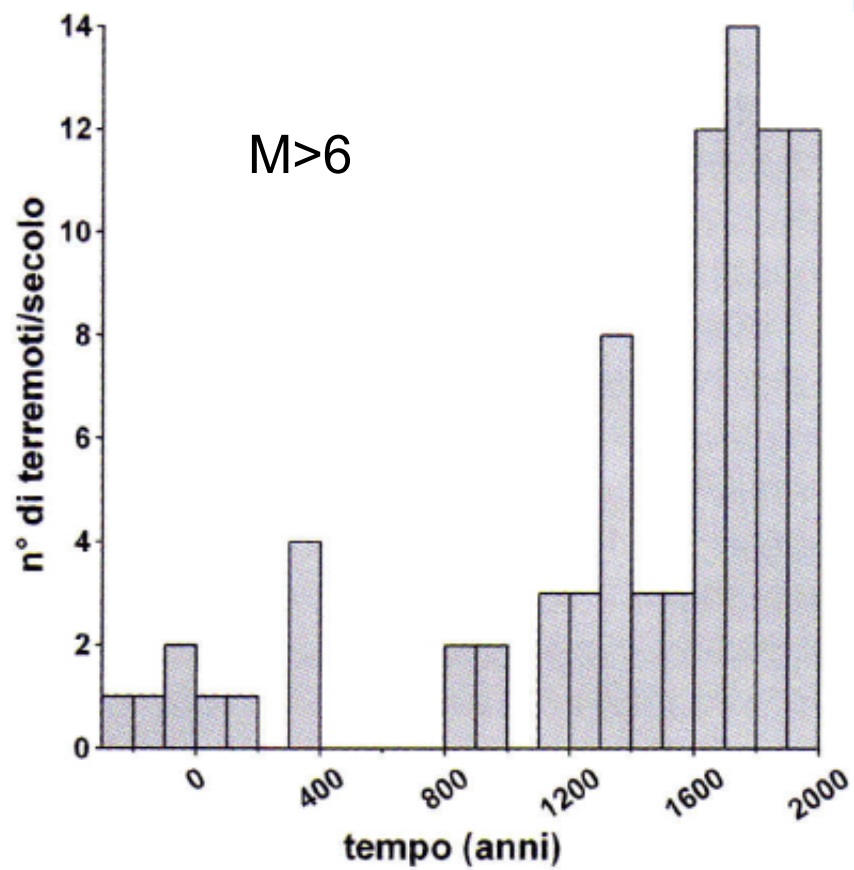


Catalogo Parametrico Terremoti Italiani

50 anni
eccedenza 10%
Tempo ritorno 475 anni



Carta della Pericolosità Sismica



Terremoti dal 1600 al 2017

$\geq M 6 = 68 = 170$ su 10 secoli

$\geq M 6.5 = 30 = 75$ su 10 secoli

Terremoti dal 1900 al 2000

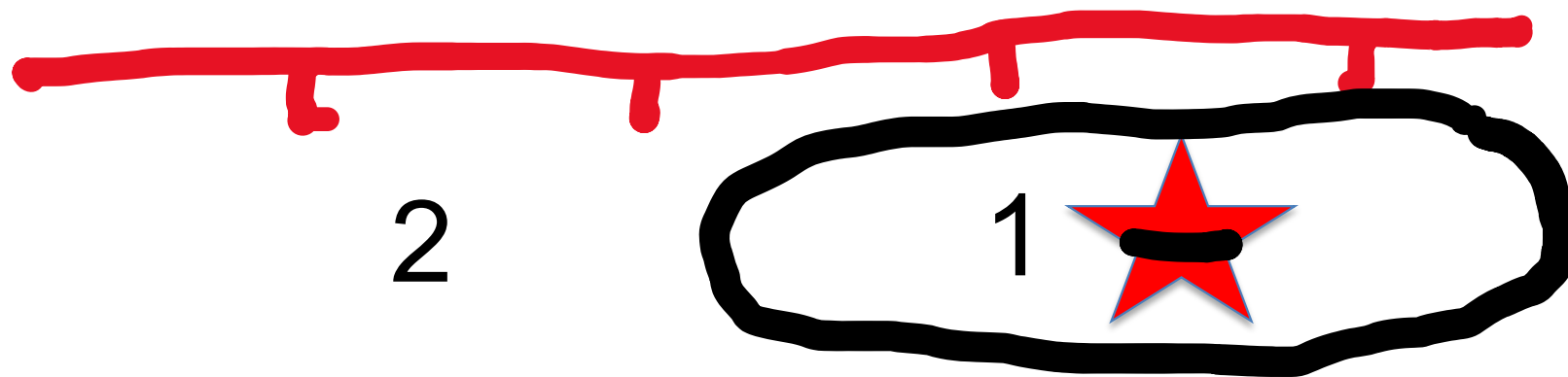
$\geq M 5 \leq M 6 = 235 = 2350$ su 10 secoli

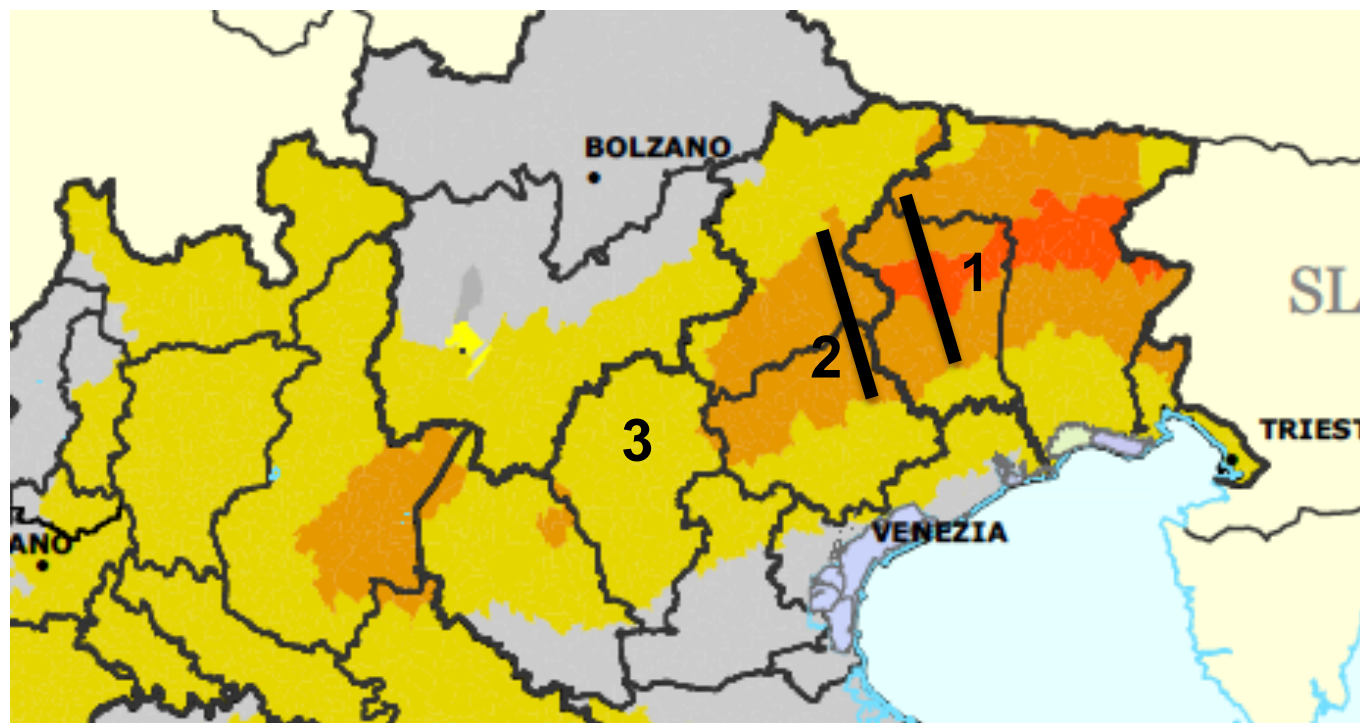
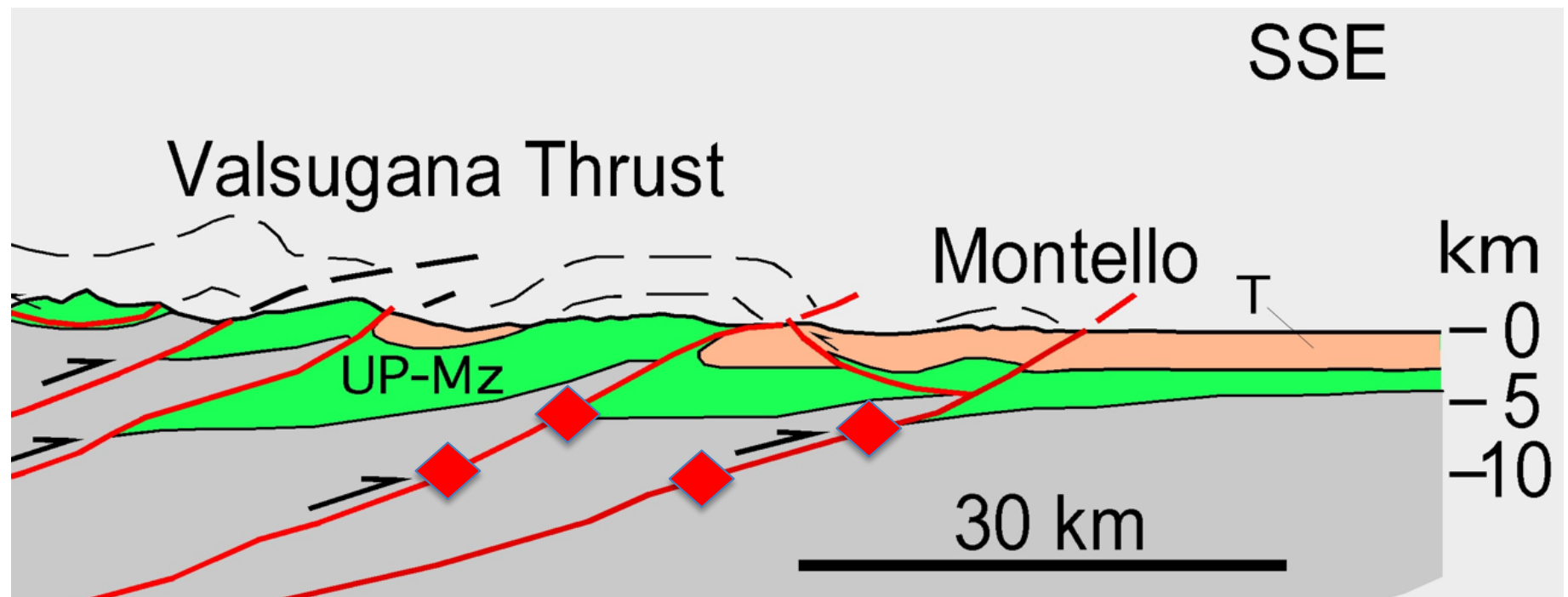
Terremoti dal 1000 al 2017

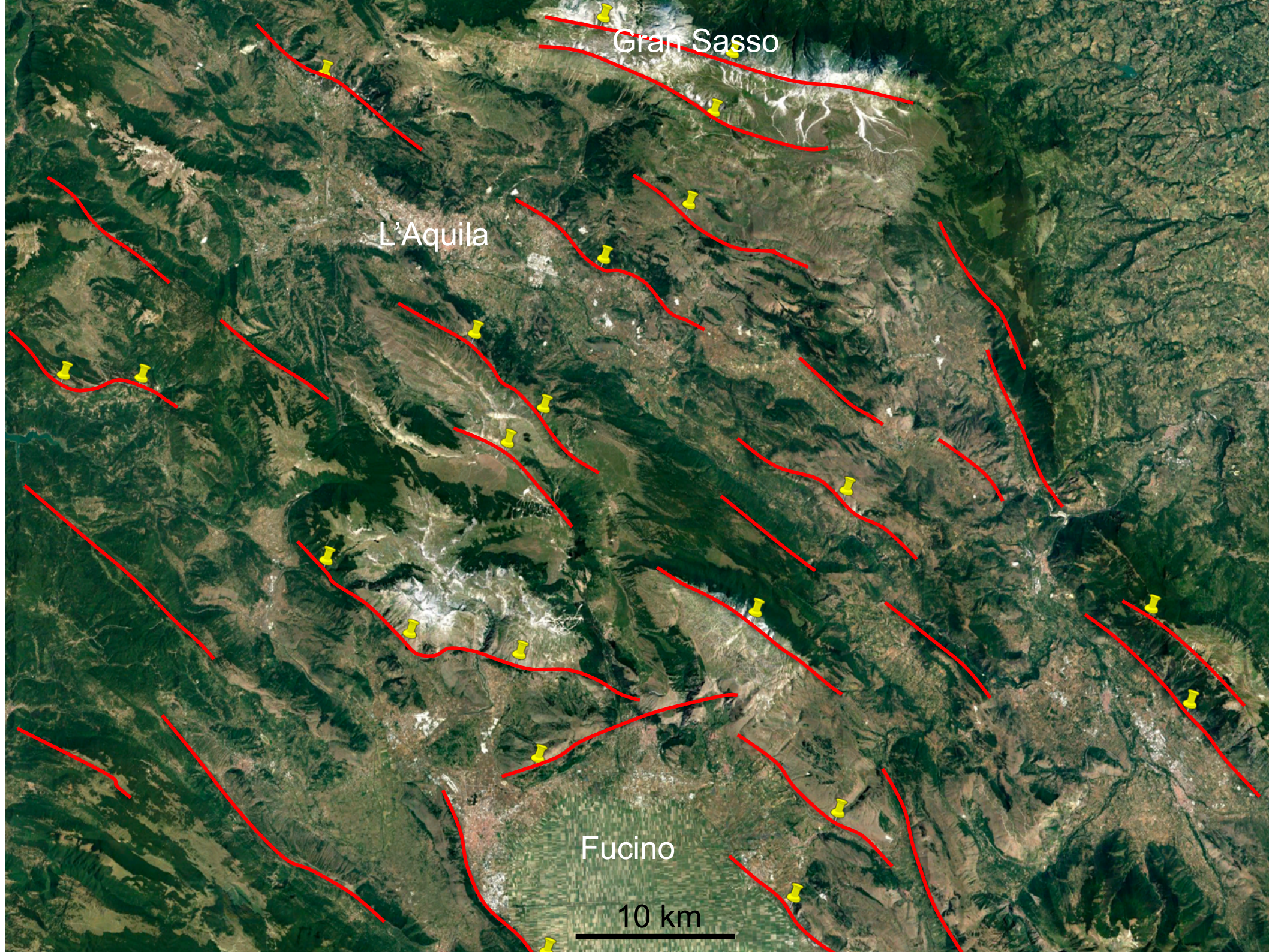
$\geq M 5-6 = 651$ (-1699)

$\geq M 6 = 91$ (-79)

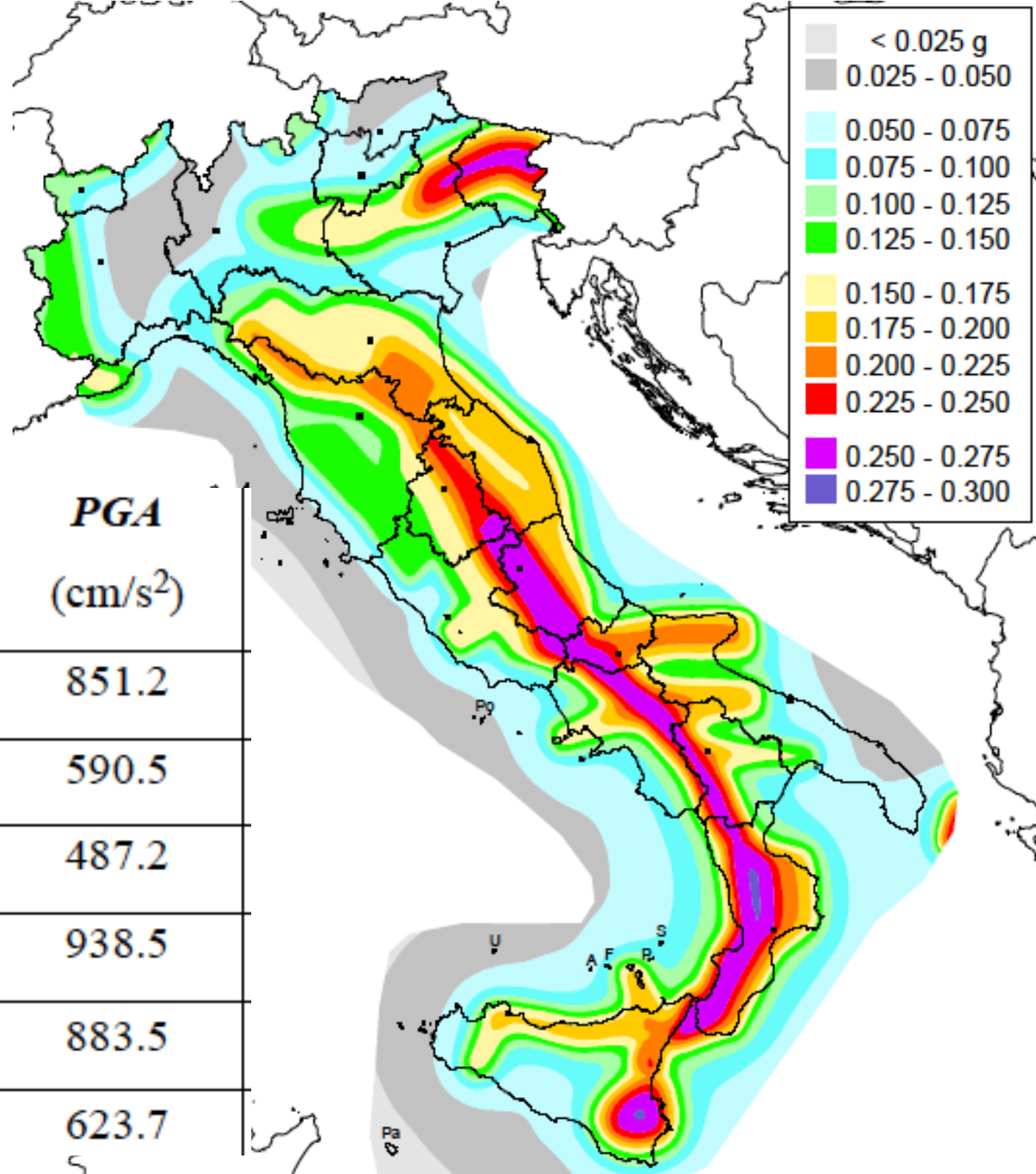
$\geq M 6.5 = 39$ (-36)

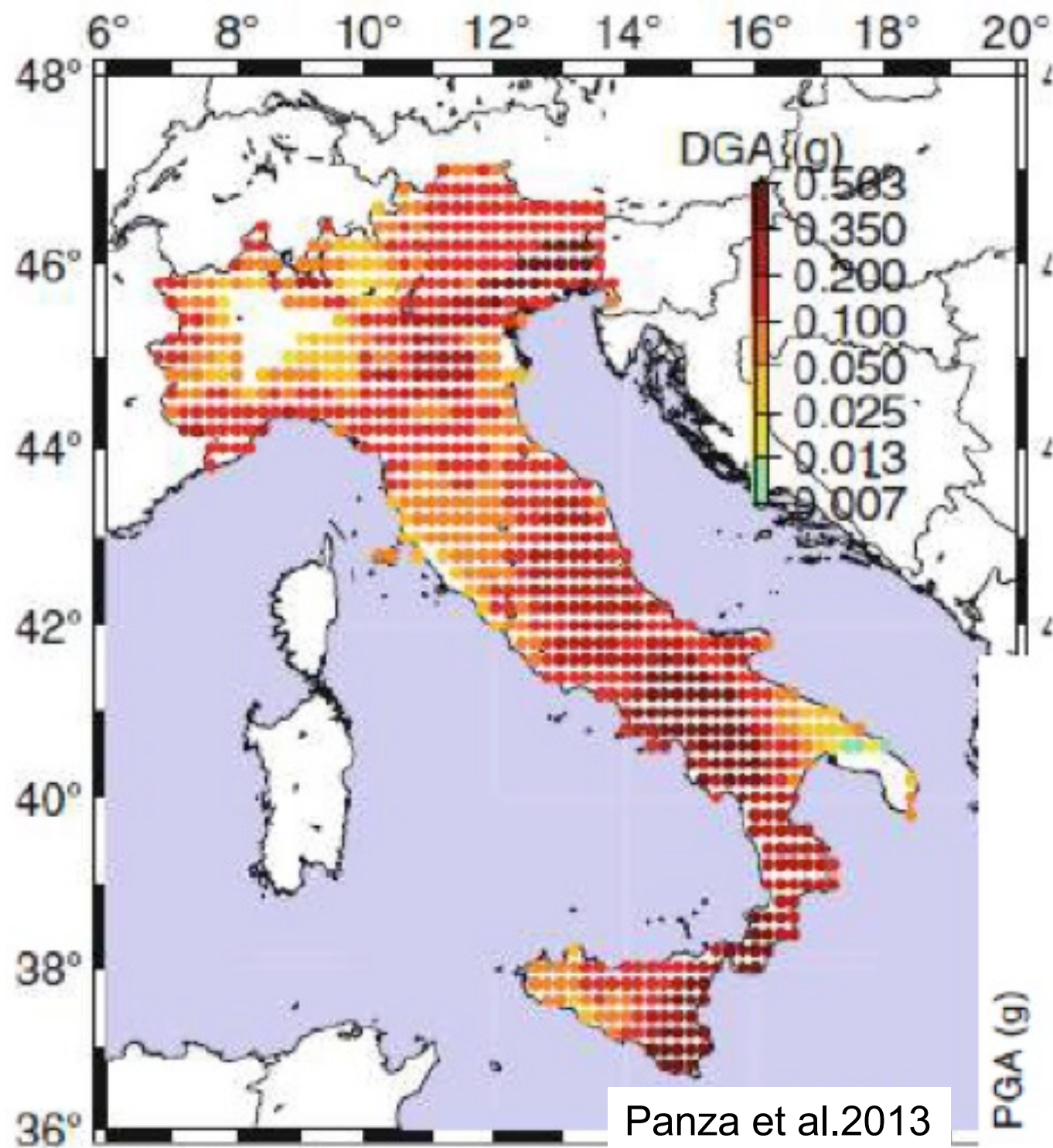


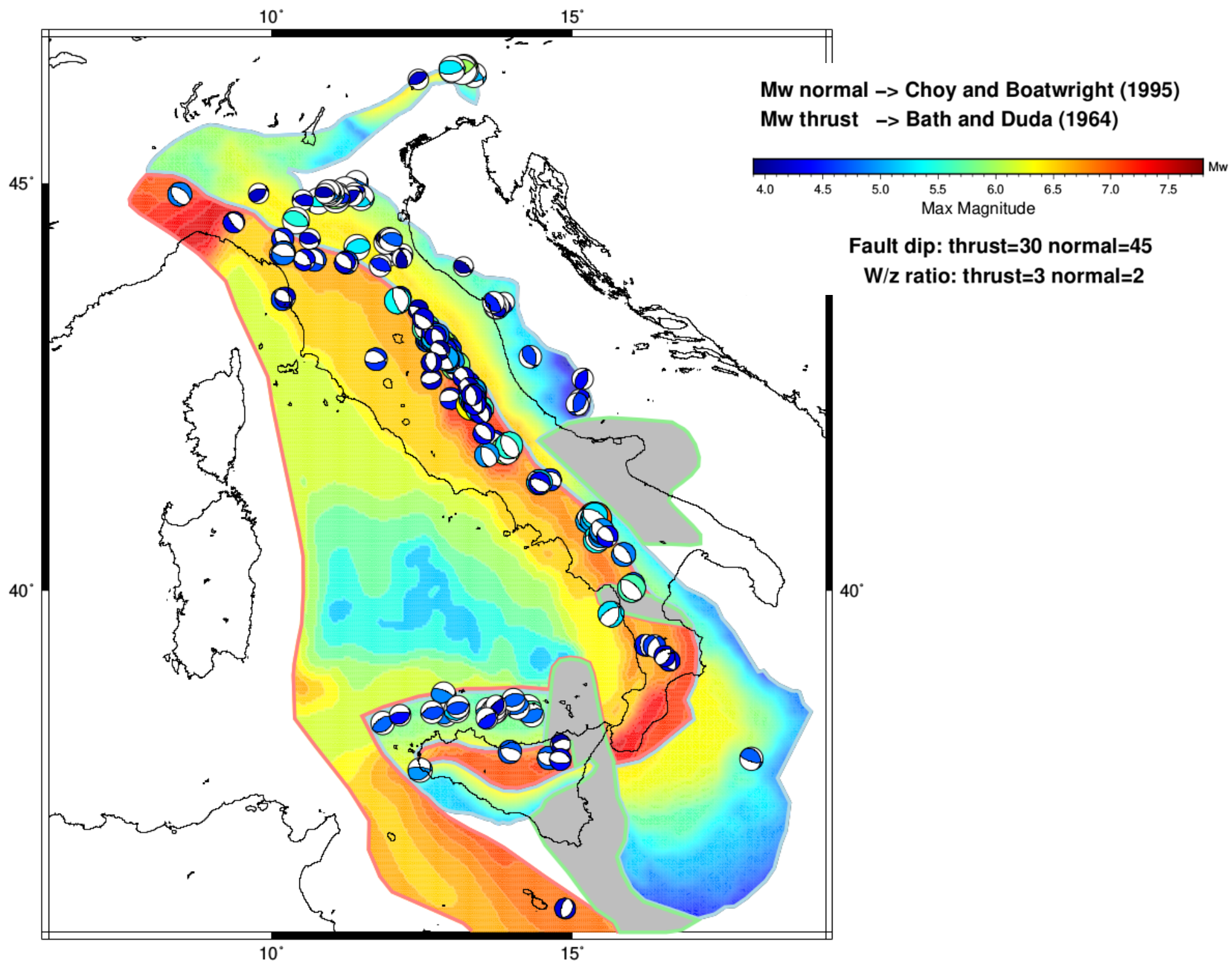




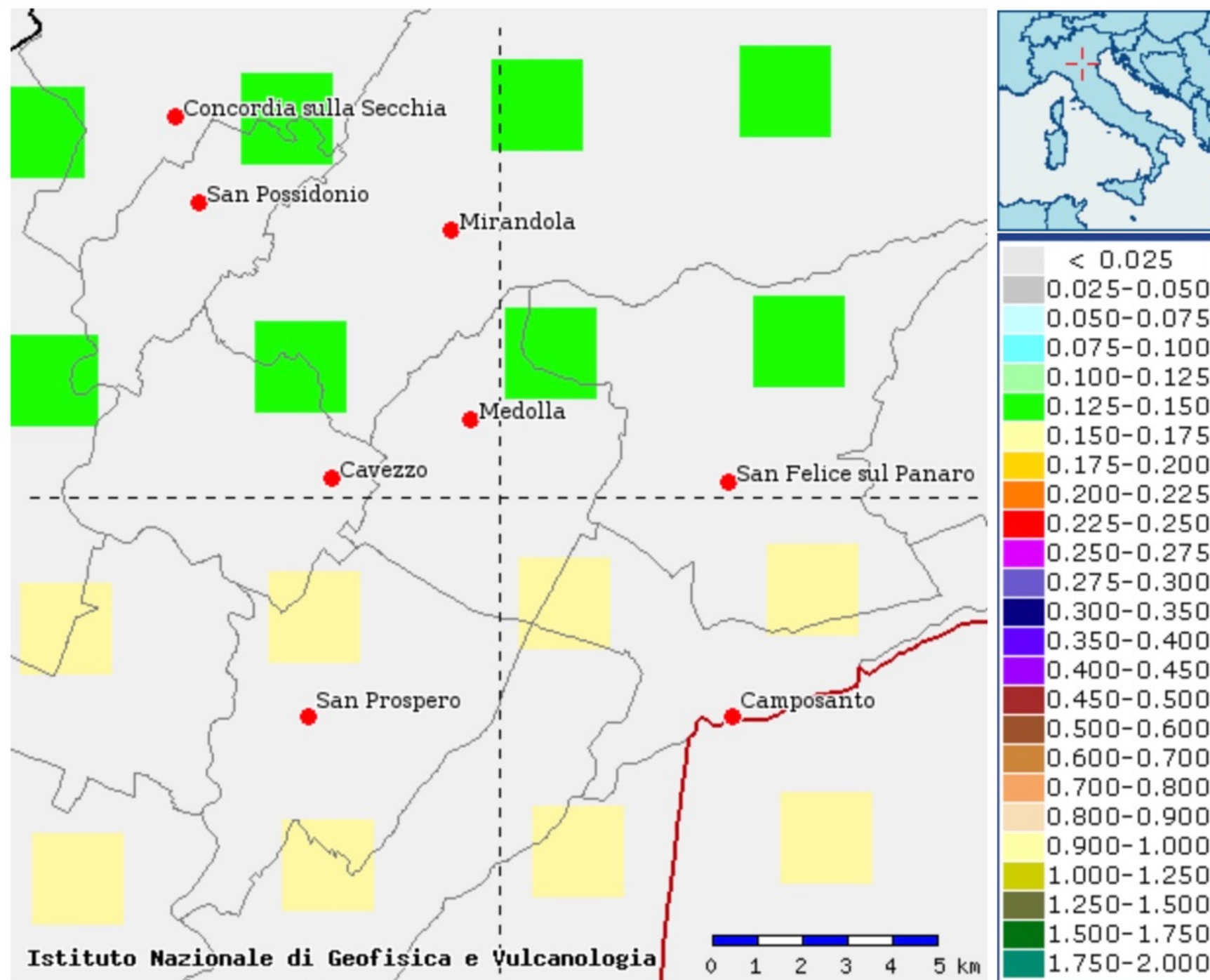
Station	Date	<i>PGA</i> (cm/s ²)
AMT	2016/08/24	851.2
CLO	2016/10/30	590.5
CNE	2016/10/30	487.2
FCC	2016/10/30	938.5
IV.T1213	2016/10/30	883.5
IV.T1214	2016/10/30	623.7







Mappe interattive di pericolosità



Event

Event id IT-2012-0011 
Date 2012-05-29 07:00:02
Event name EMILIA_2ND_SHOCK
 M_L 5.8
 M_W 6.0

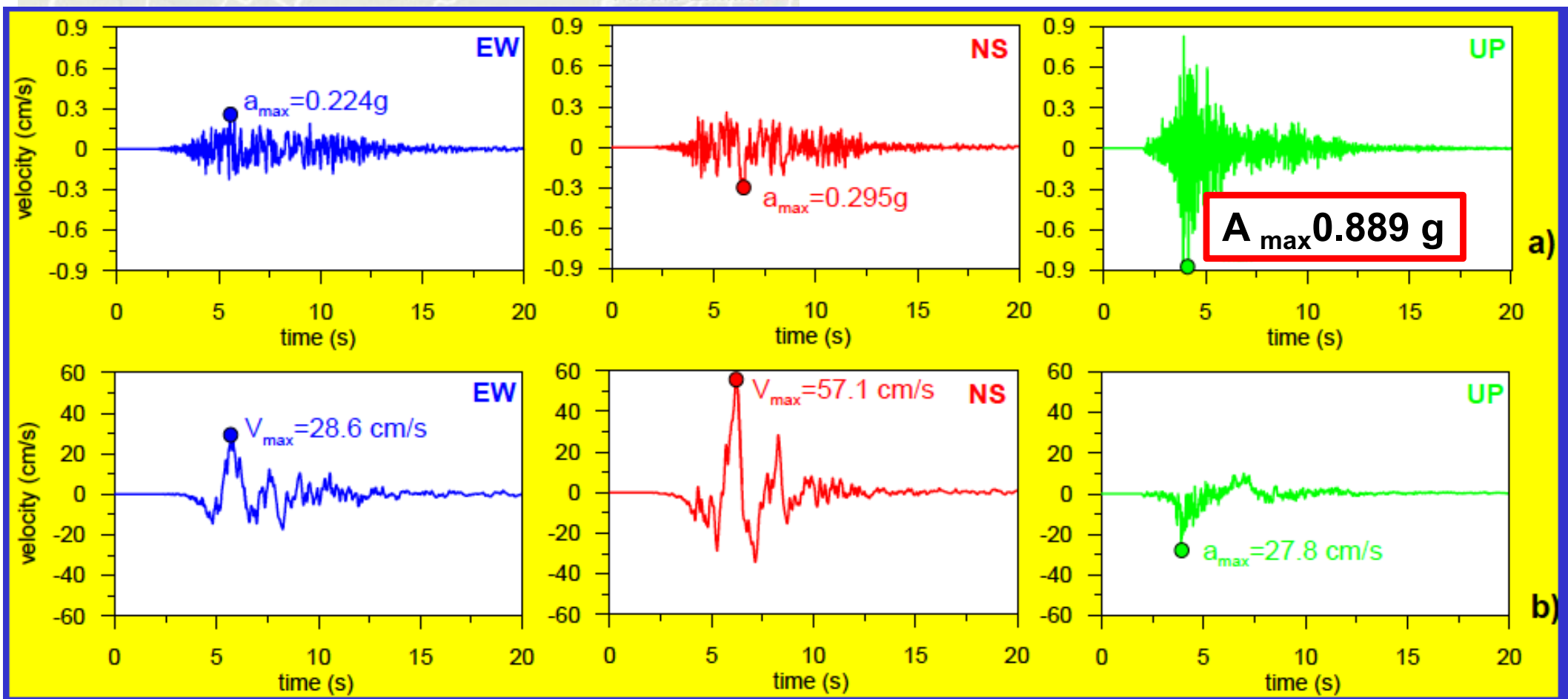


Mirandola station 29 May 2012

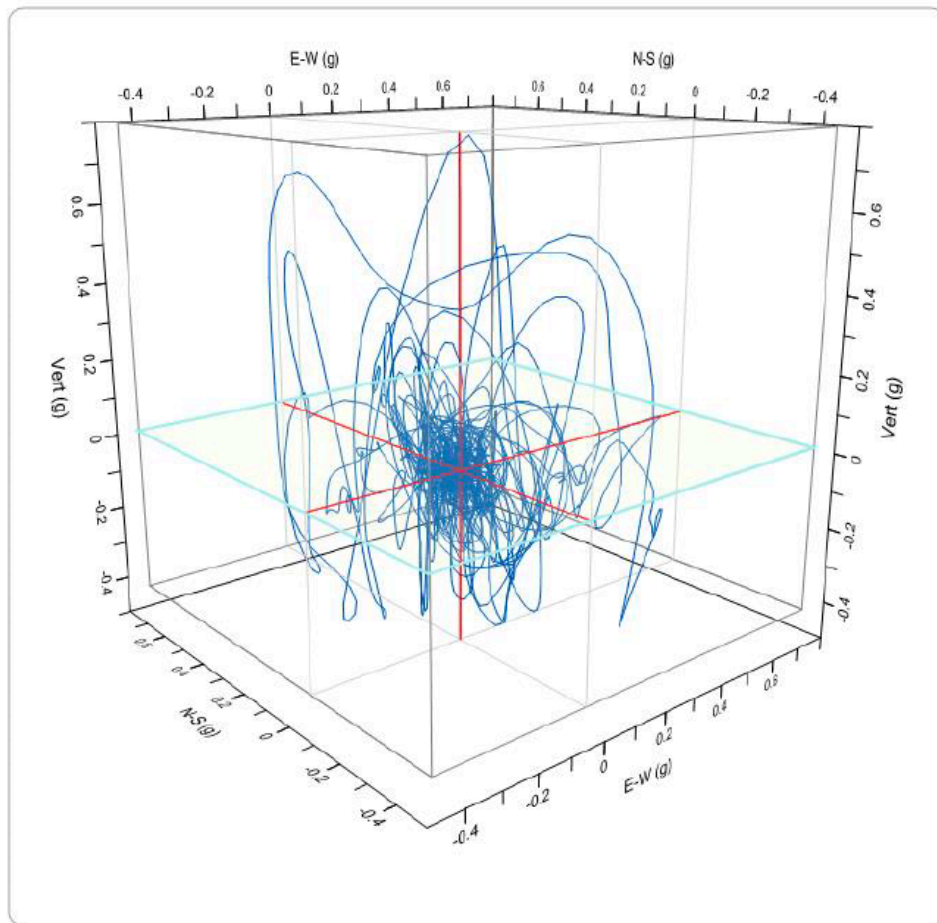
Stazione RAN su suolo C

Amplificazione $1.125 \times 1.5 = (0.18-0.20)$

Maugeri et al.

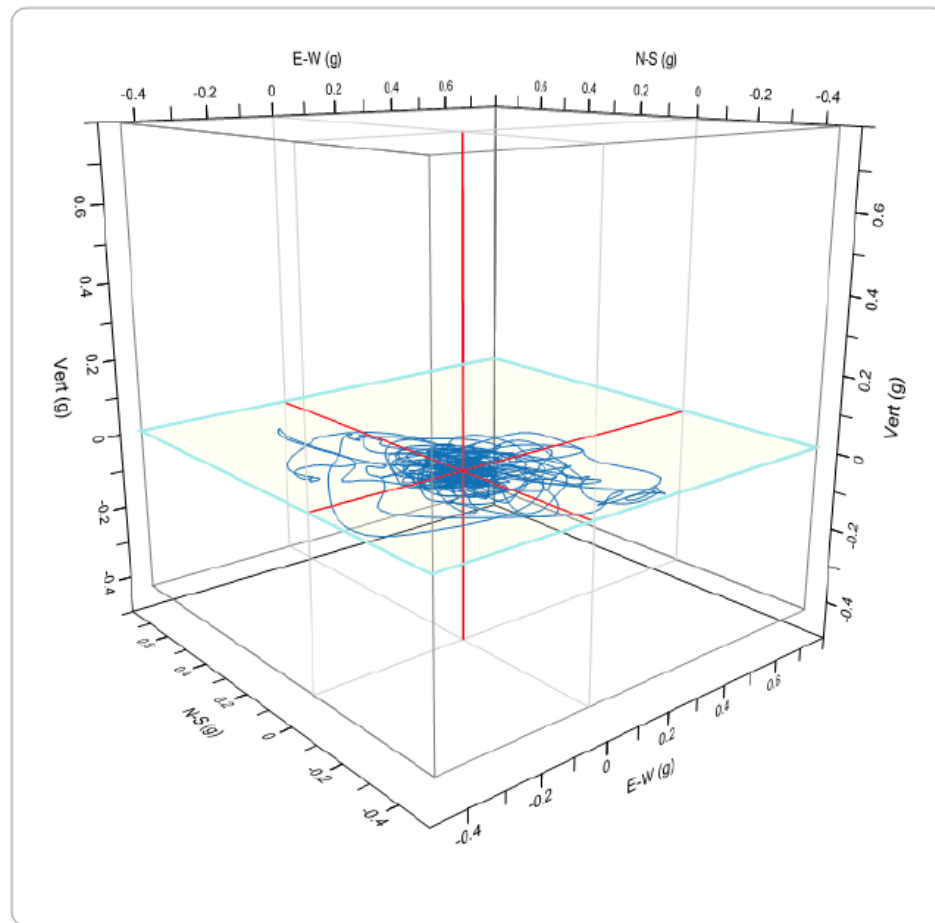


ITALIA CENTRALE 30-10-2016 - CLO (CASTELLUCCIO DI NORCIA) - 7,8km DALL'EPICENTRO:
accelerazione



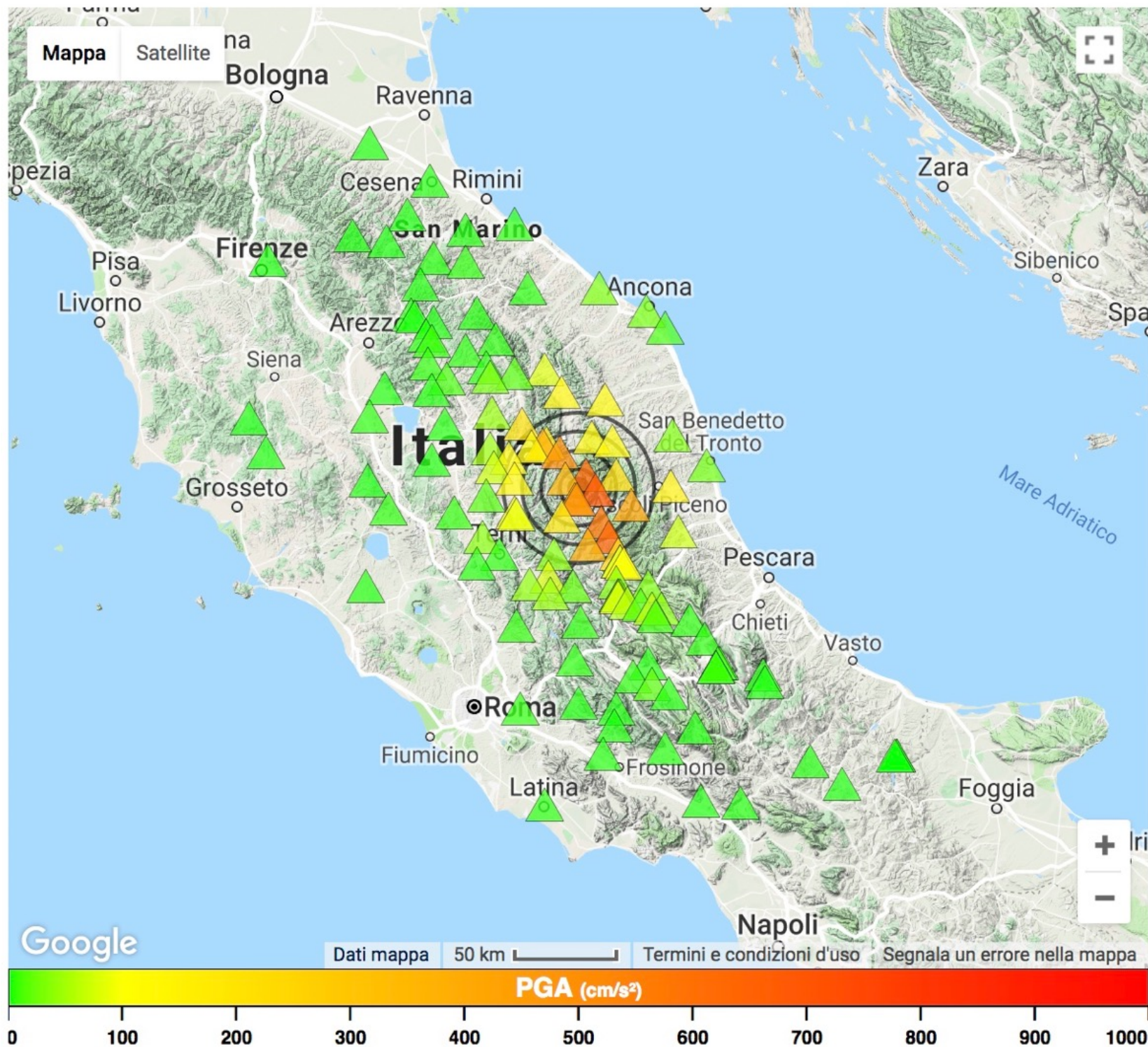
Con presenza di accelerazione verticale

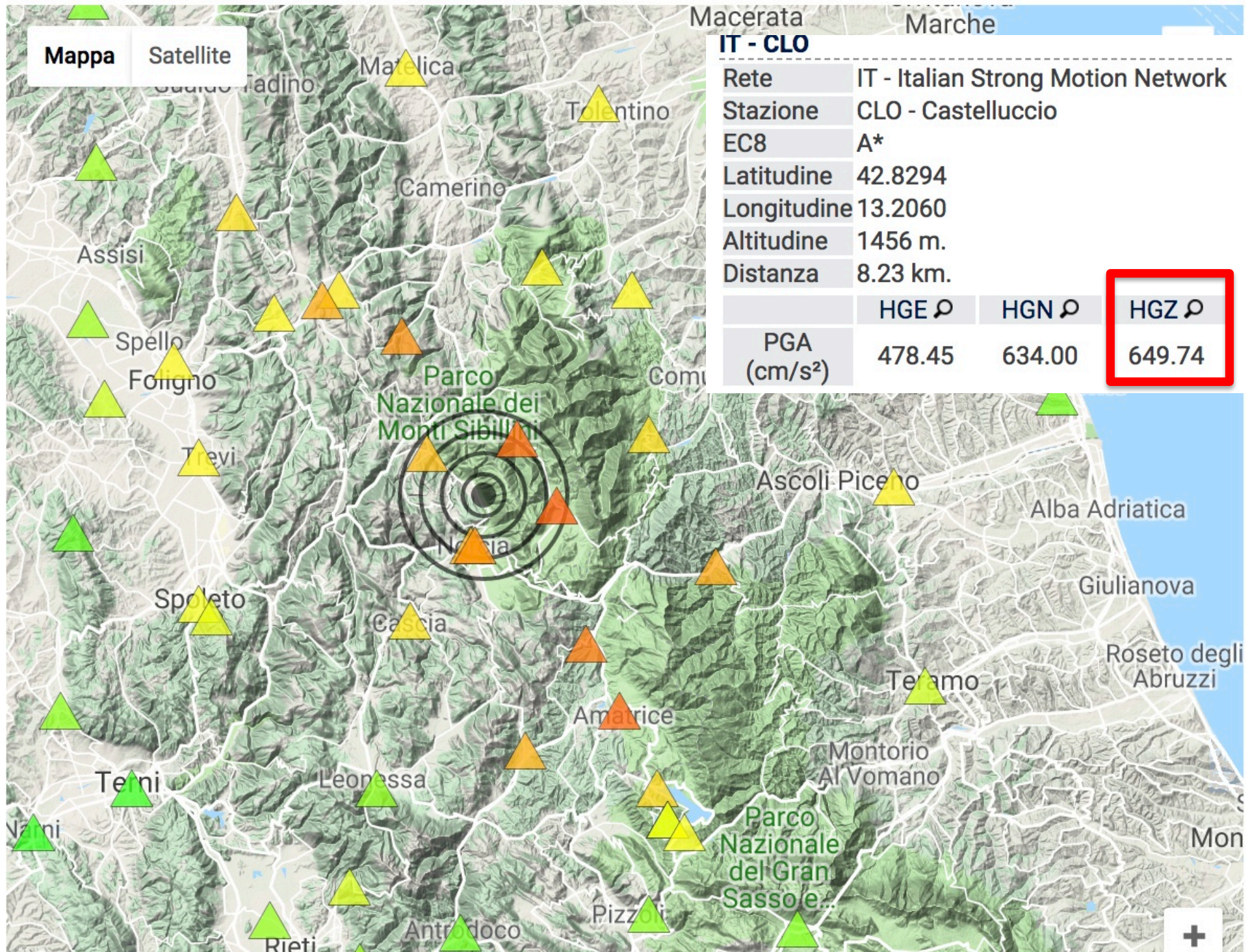
ITALIA CENTRALE 30-10-2016 - CLO (CASTELLUCCIO DI NORCIA) - 7,8km DALL'EPICENTRO:
accelerazione

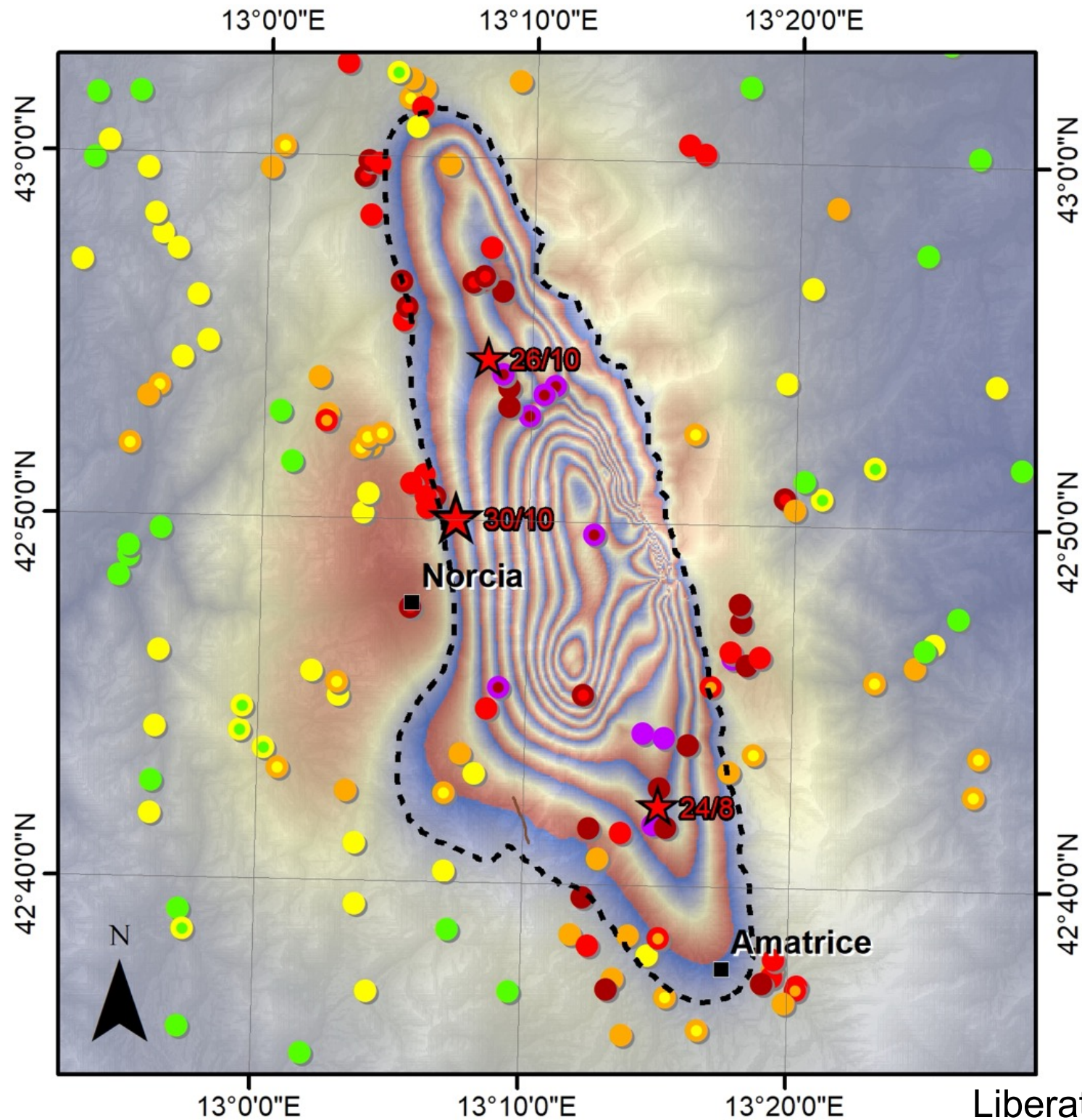


Senza presenza di accelerazione verticale

RETE ACCELEROMETRICA NAZIONALE- RAN DOWNLOAD

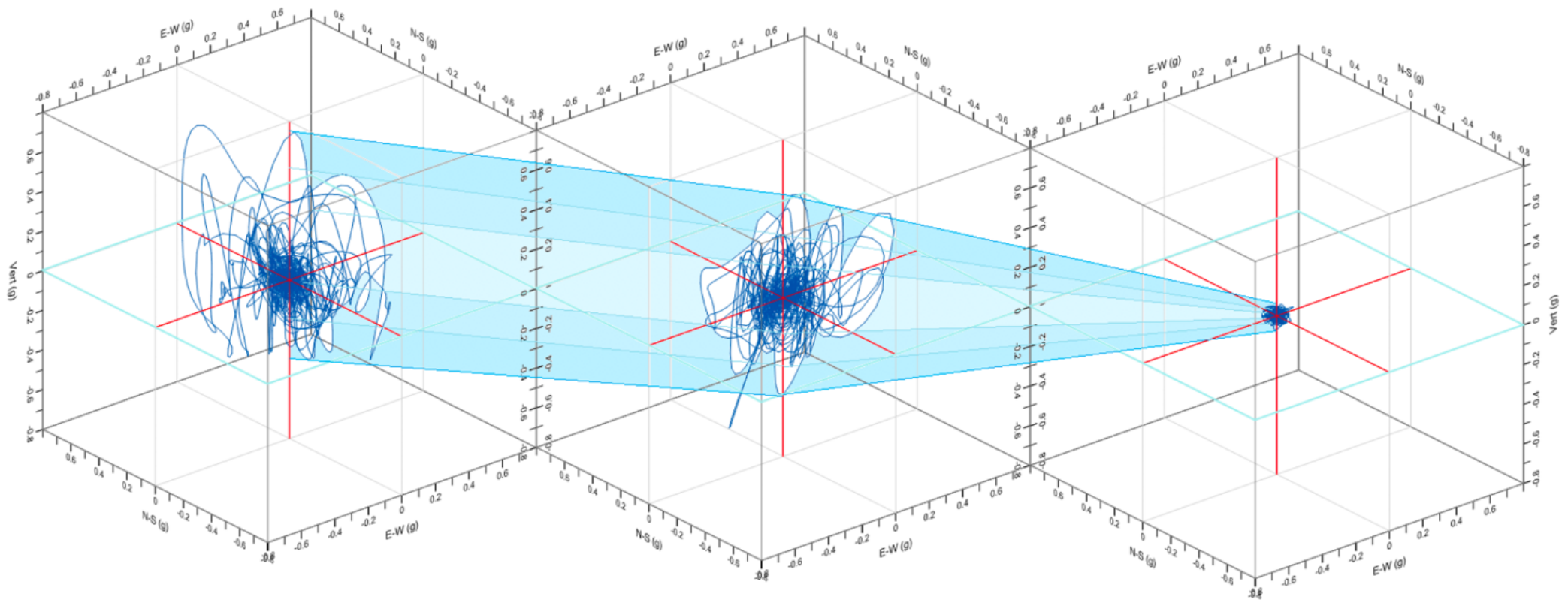






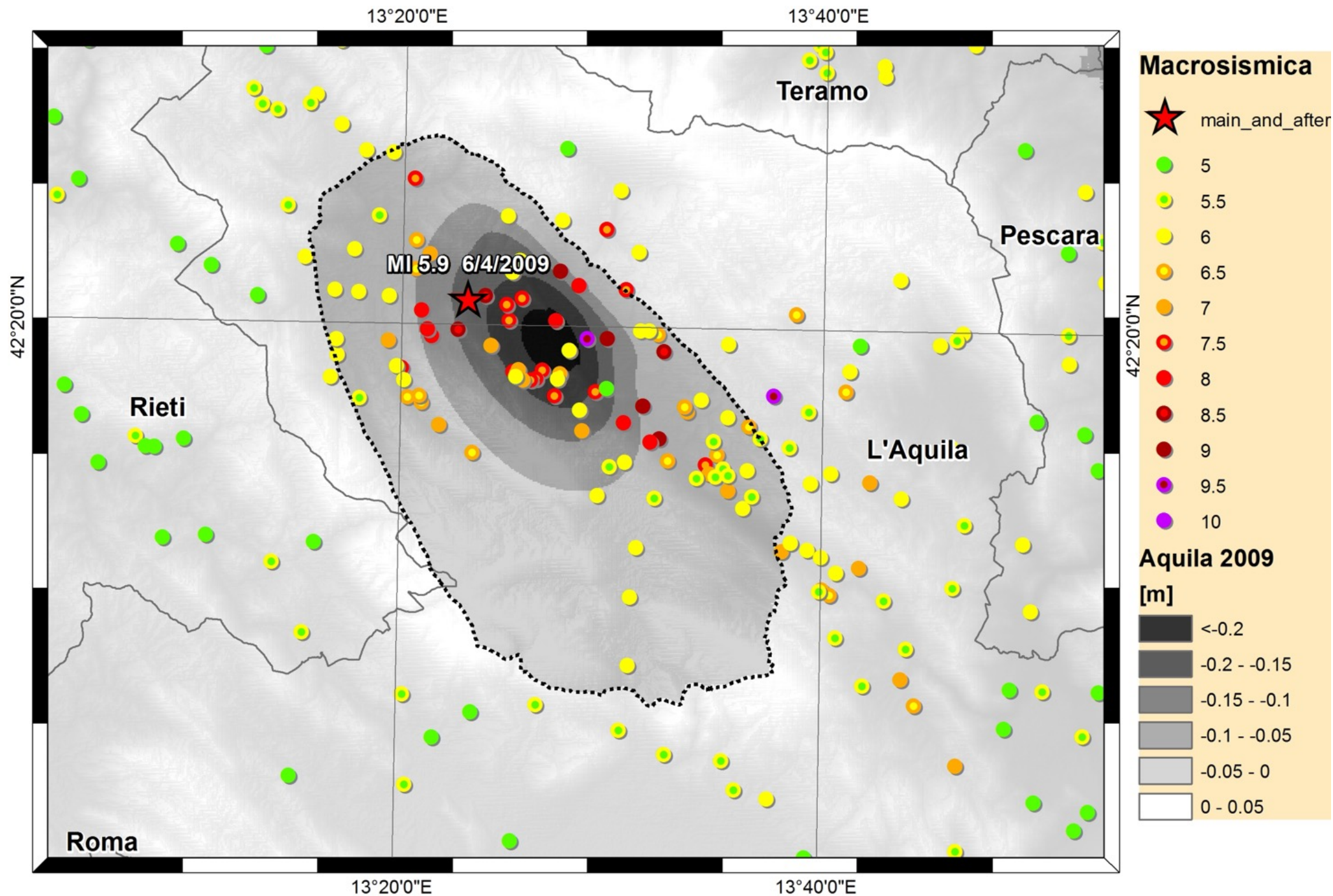
Intensity (EMS)

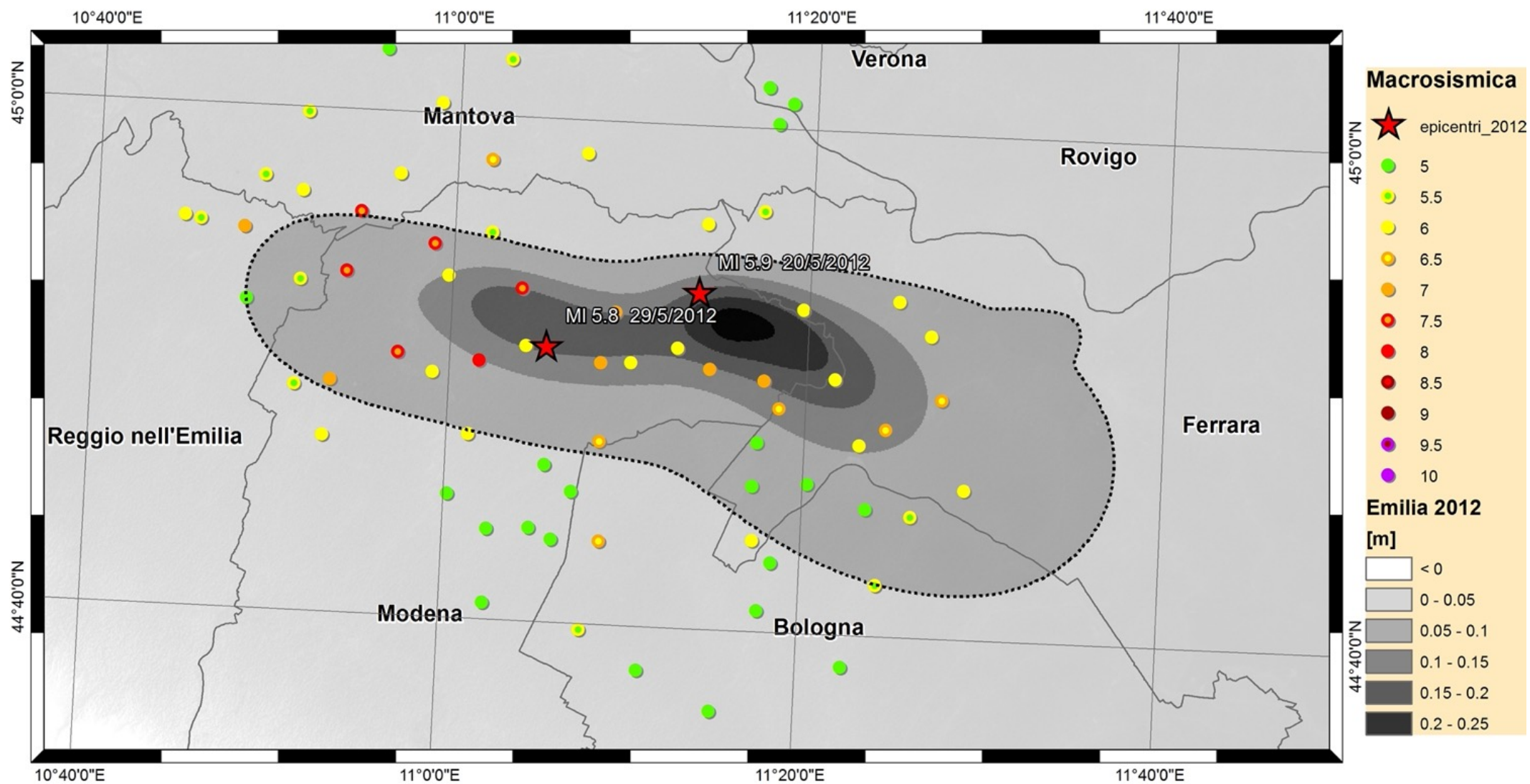


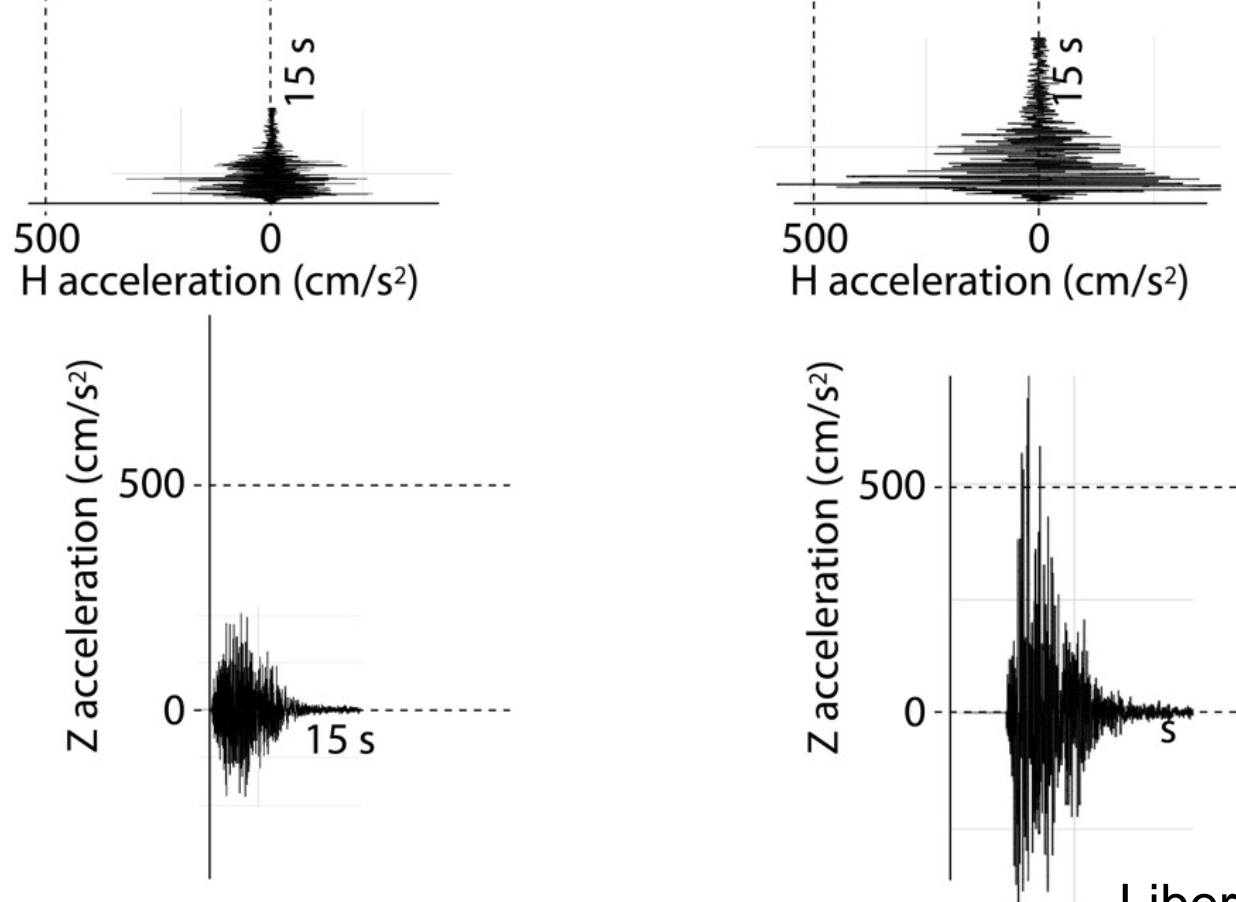


ITALIA CENTRALE, 30.10.2016

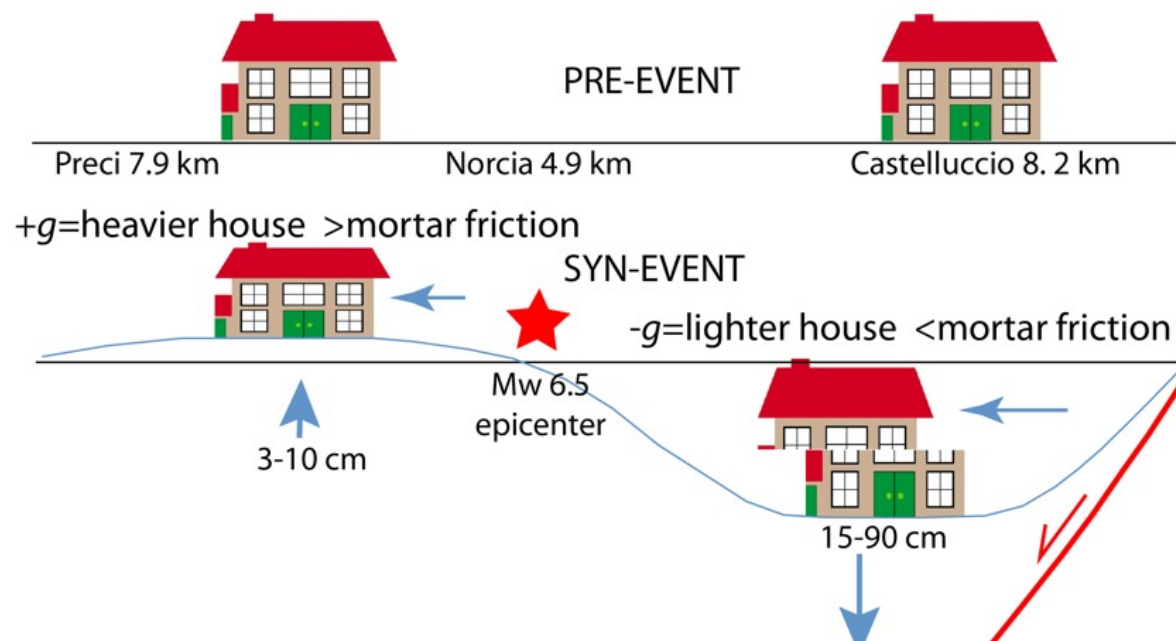
CASTELLUCCIO DI NORCIA CLO: 7.8 km → ACCUMULI ACC: 18.6 km → FABRIANO FBR: 59.1 km

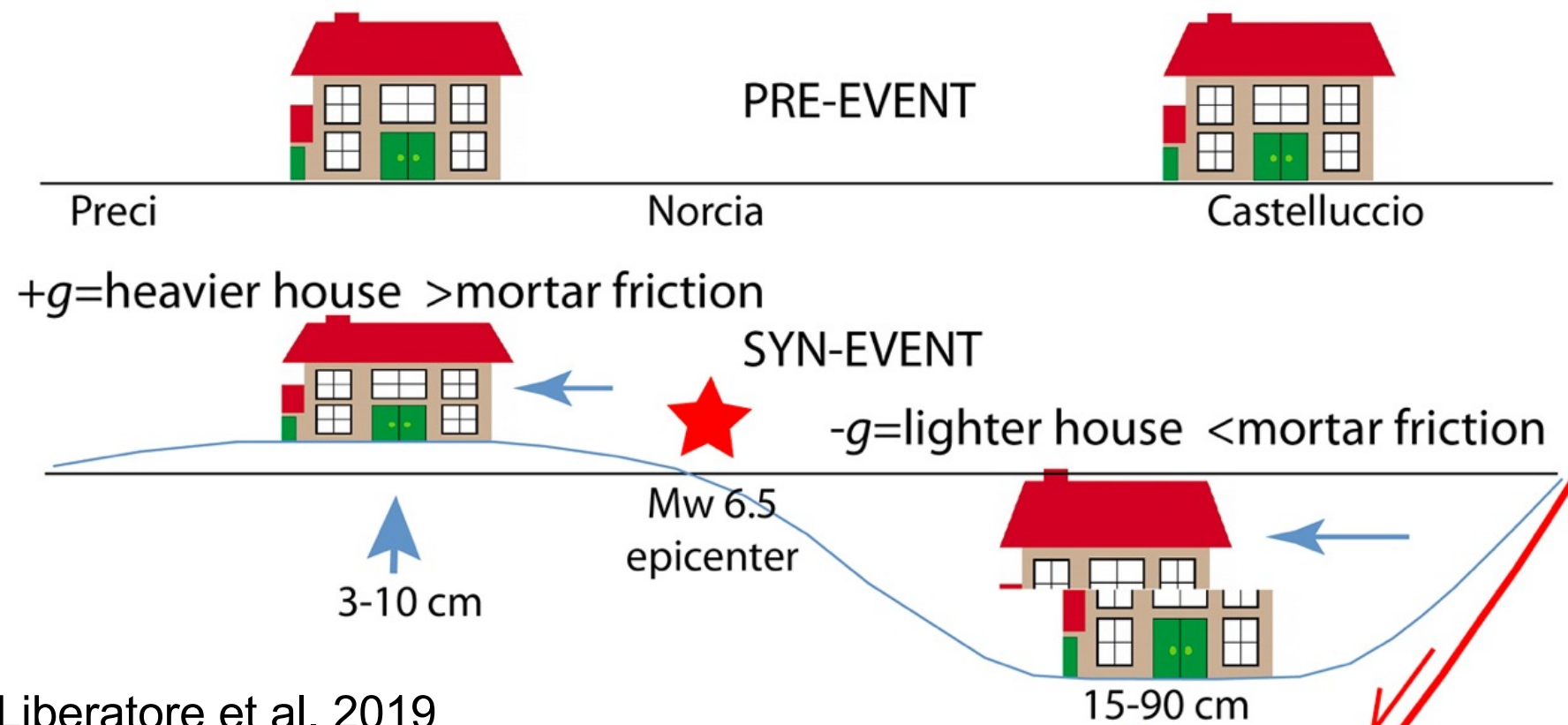




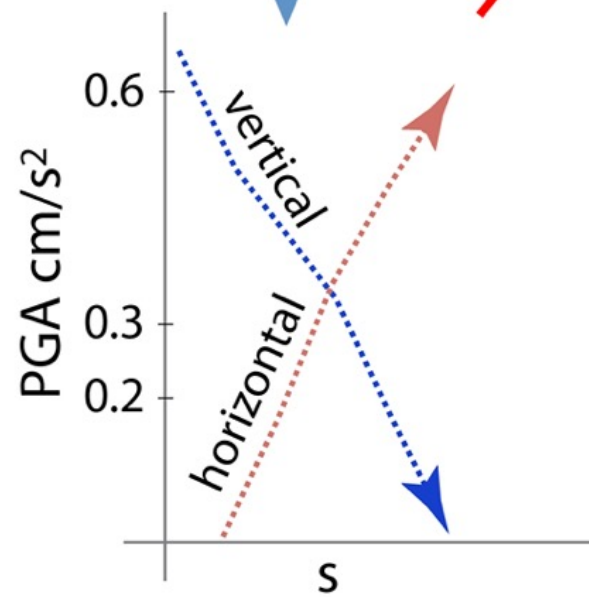
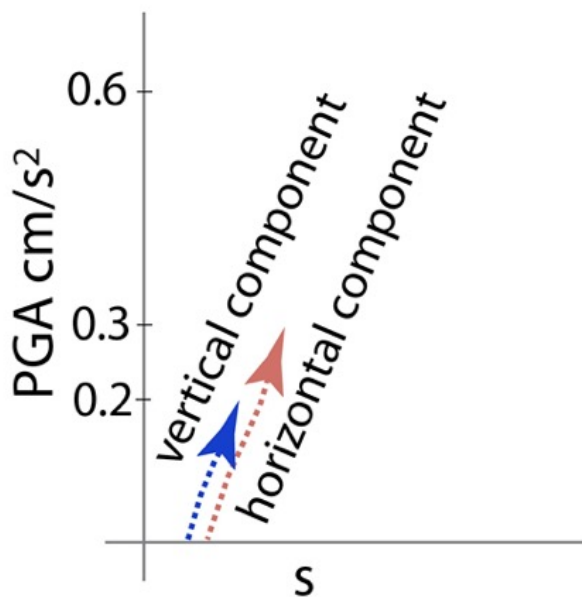


Liberatore et al. 2019

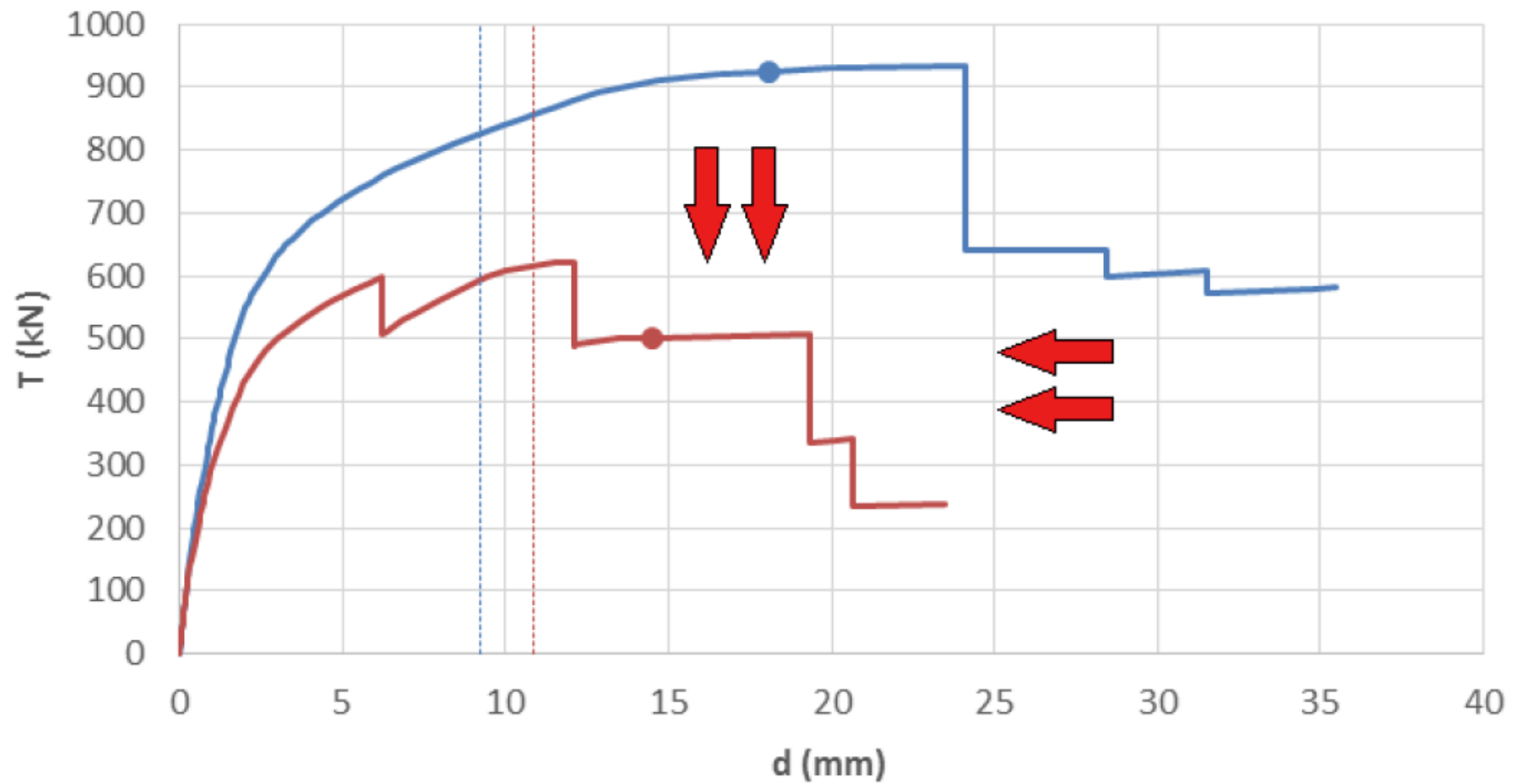




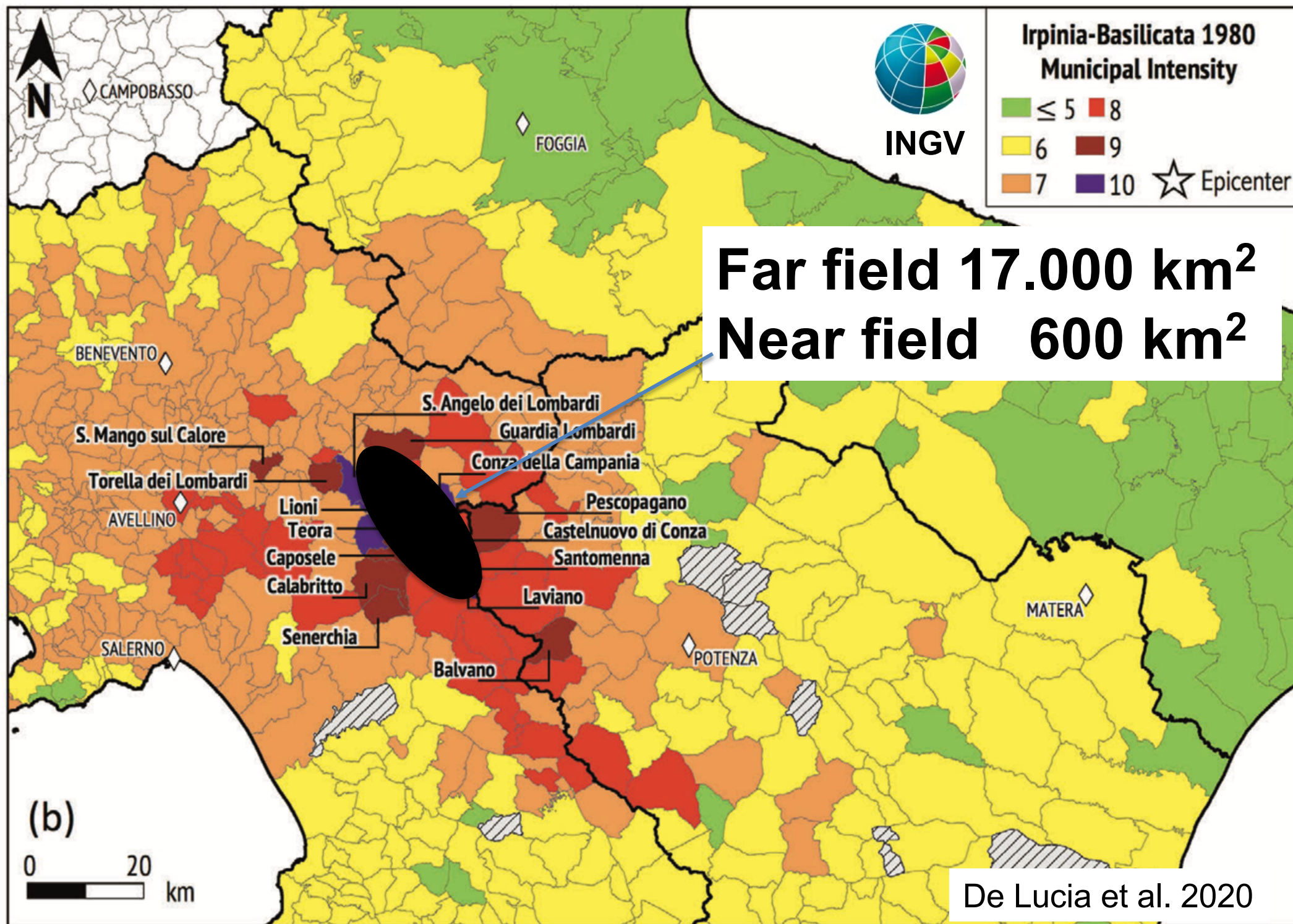
Liberatore et al. 2019

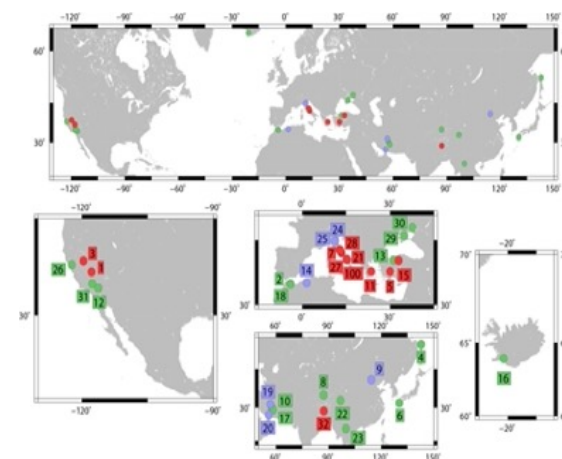
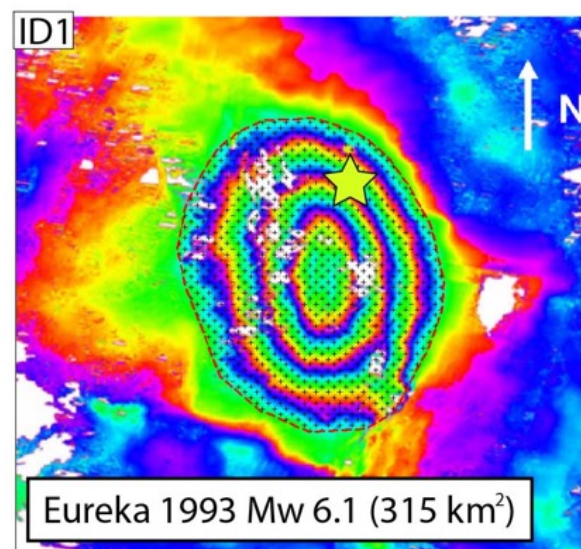
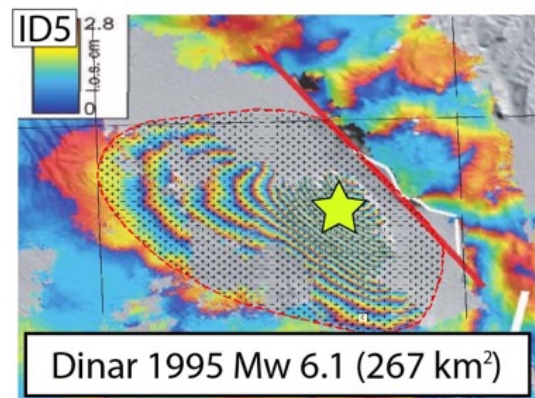
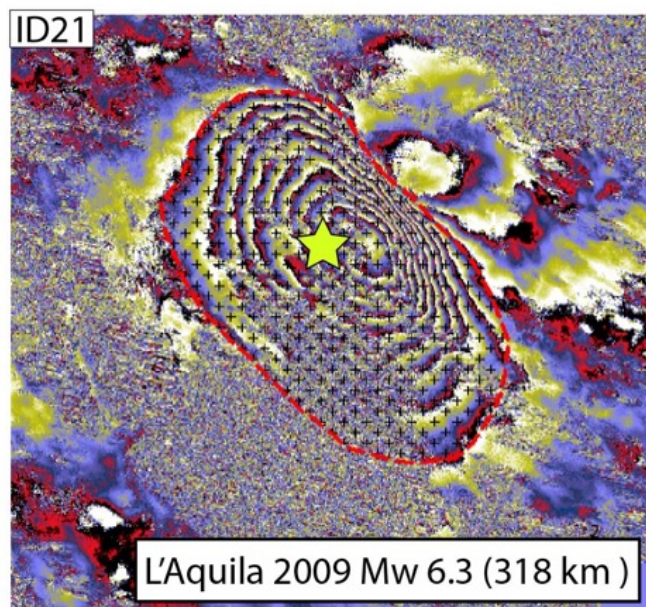
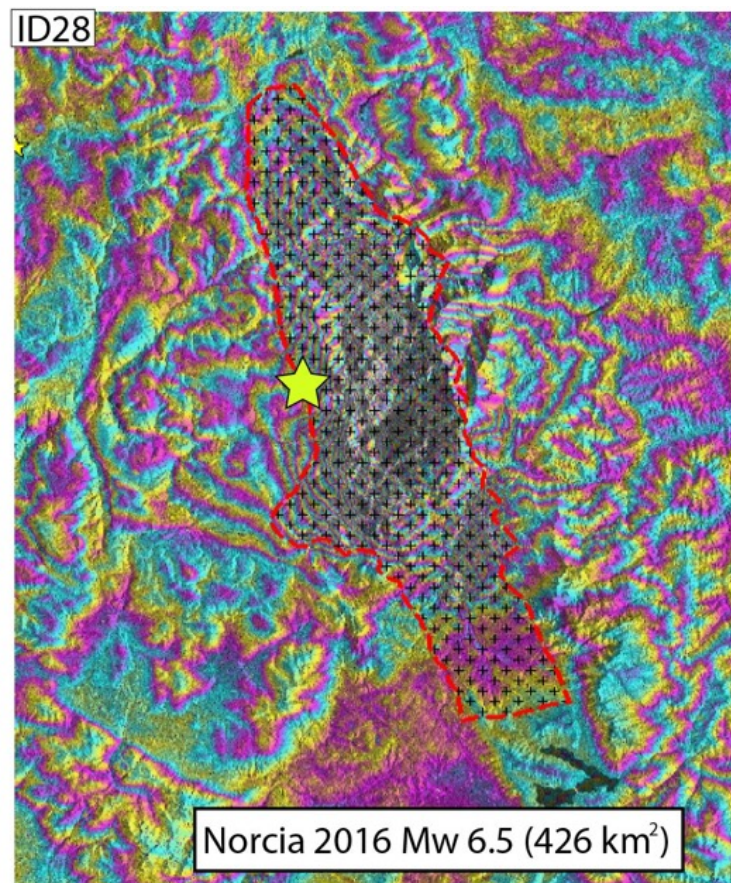
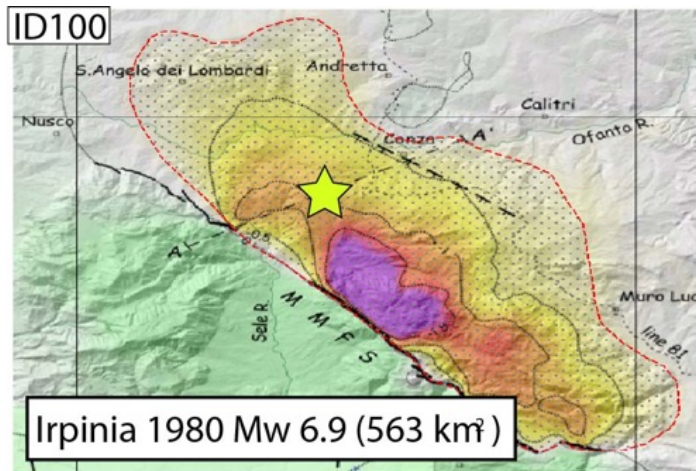


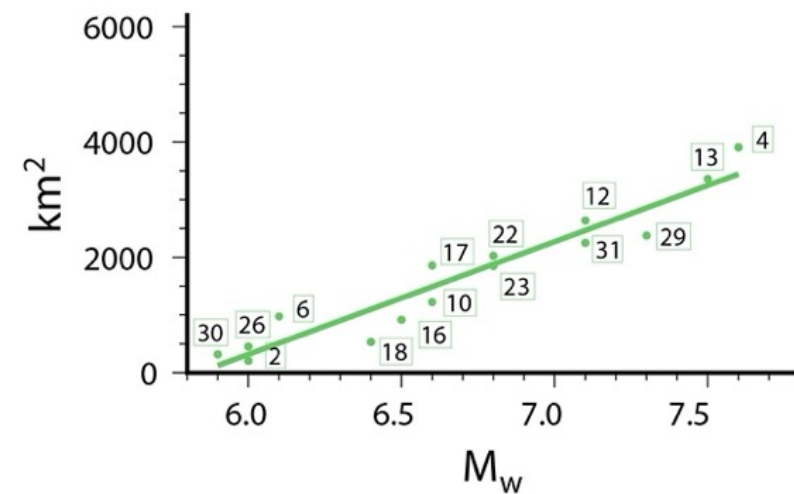
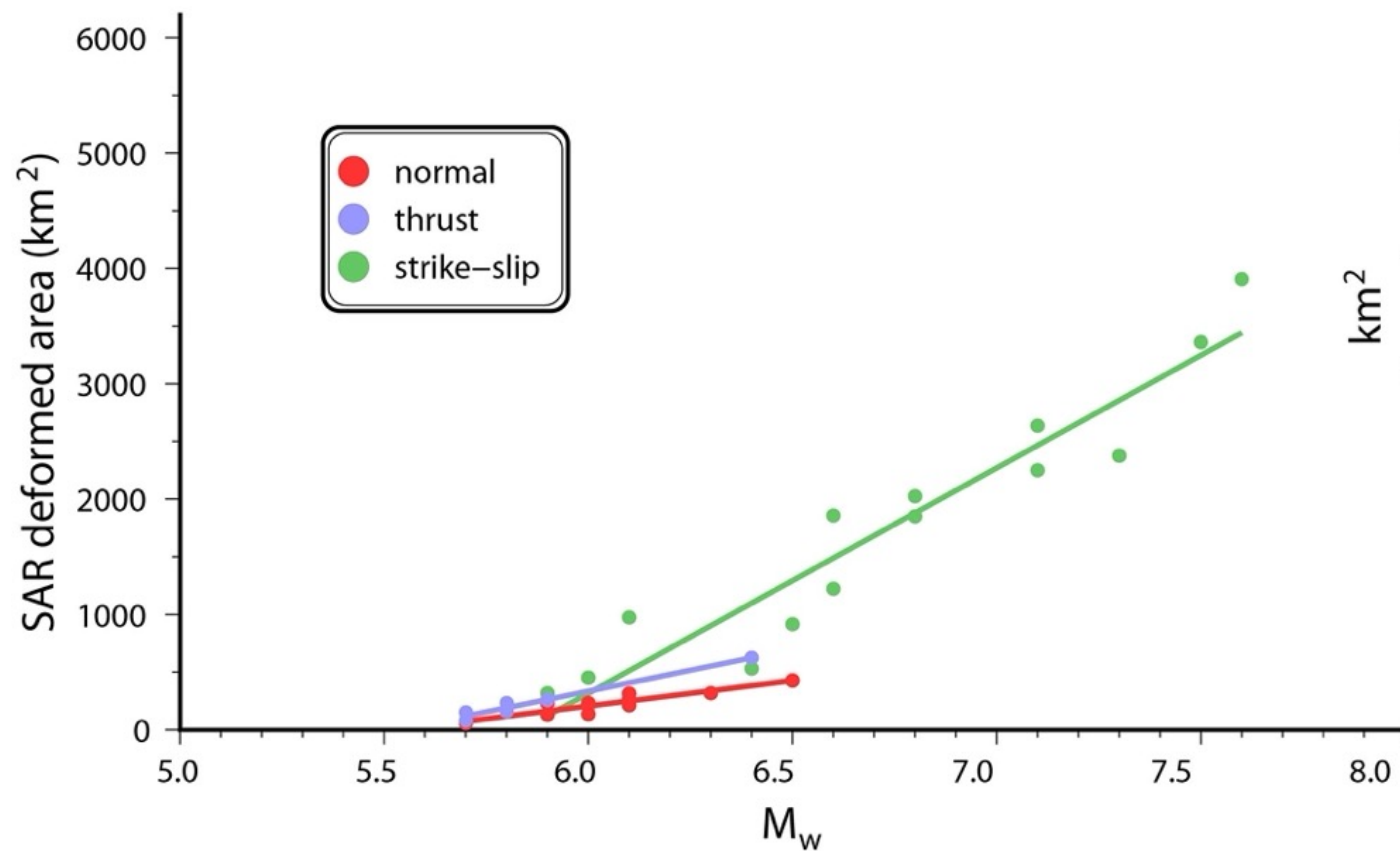
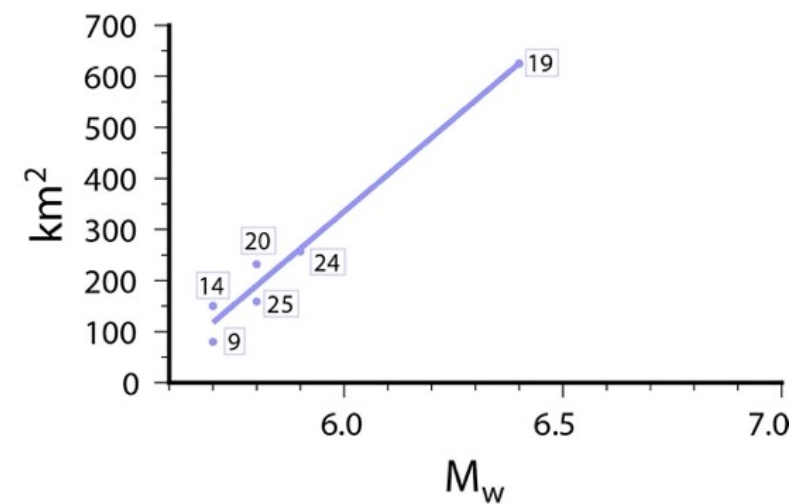
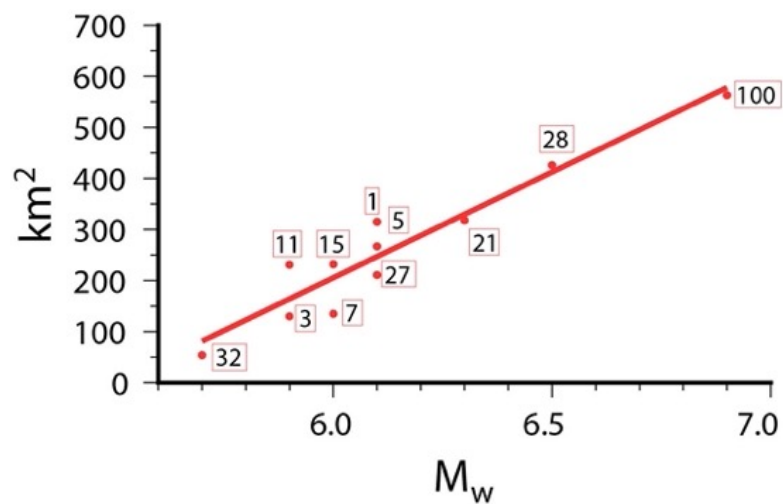
Muratura A6

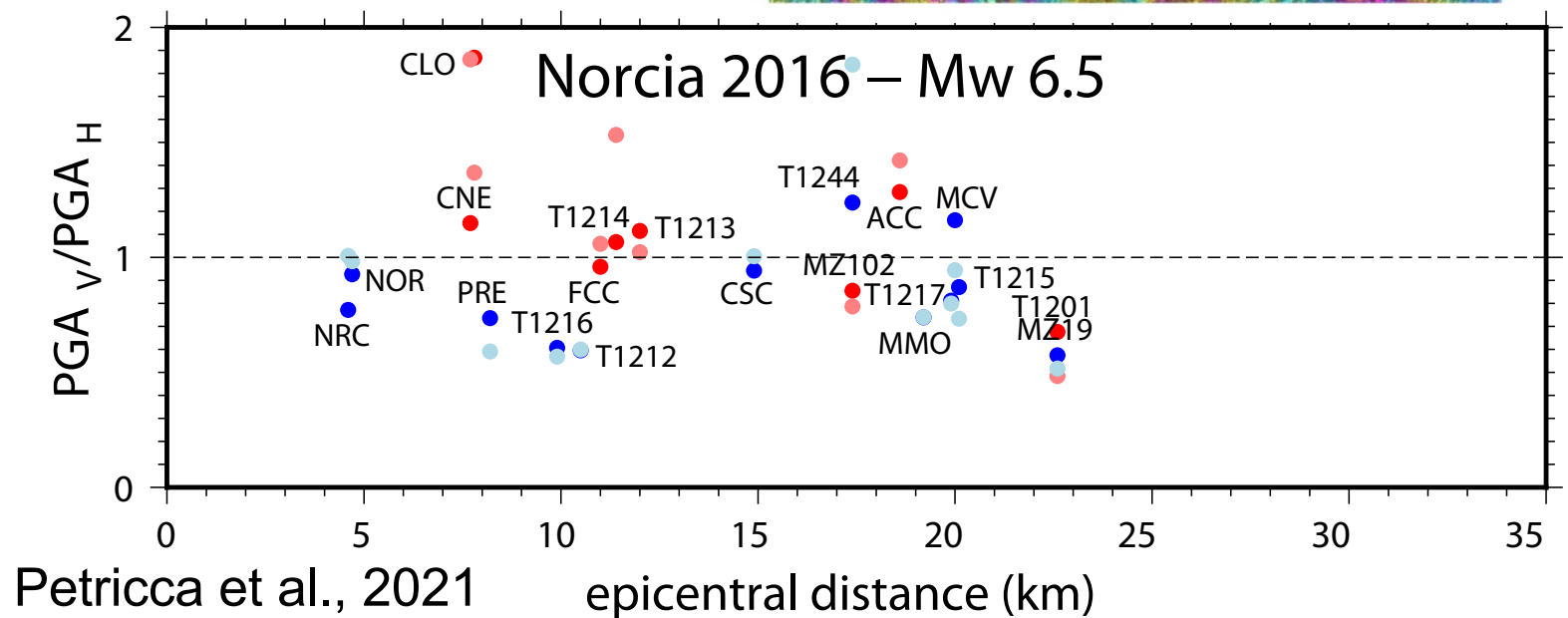
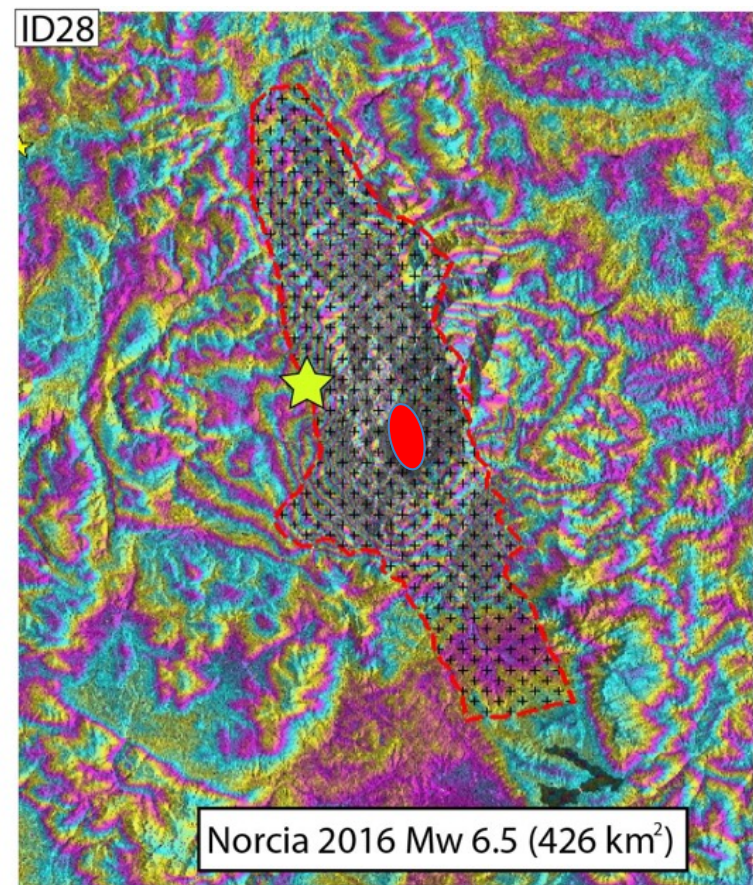
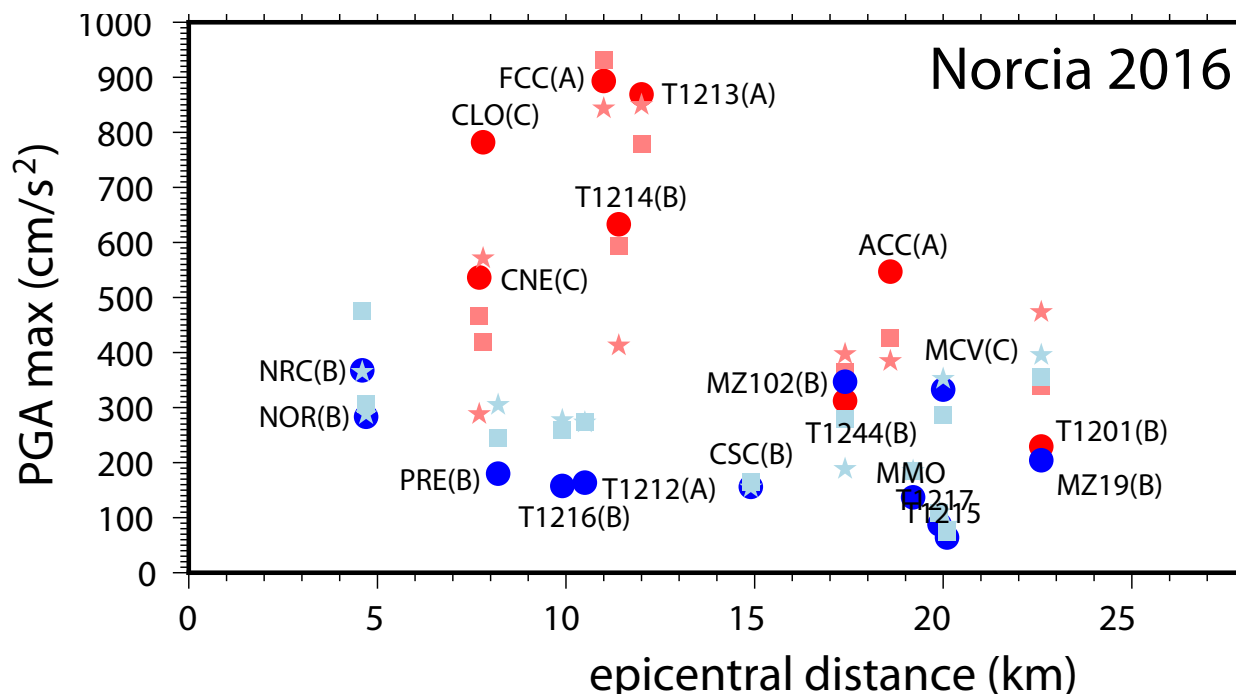




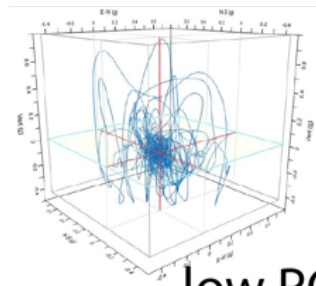






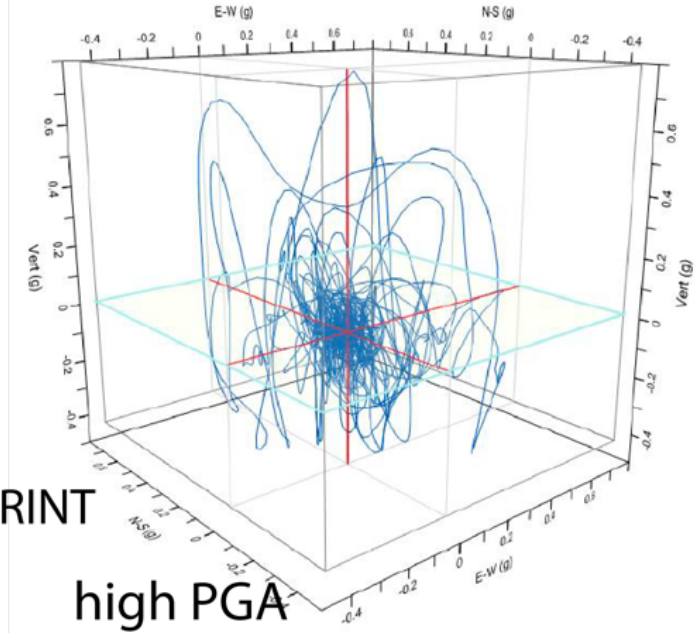


Petricca et al., 2021

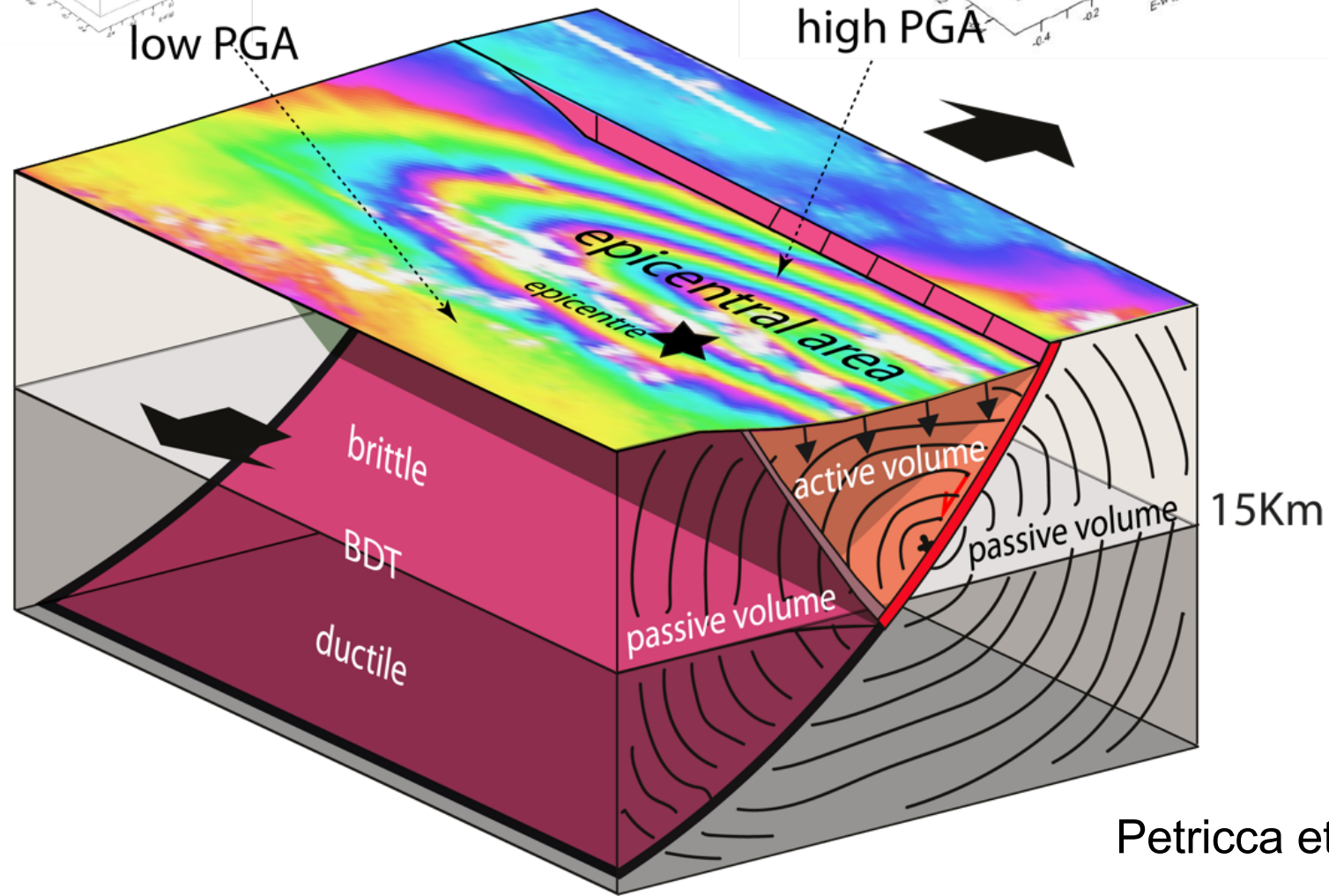


low PGA

EARTHQUAKE FINGERPRINT



high PGA



VALE

Vita

Abitazioni

Libertà

Economia

