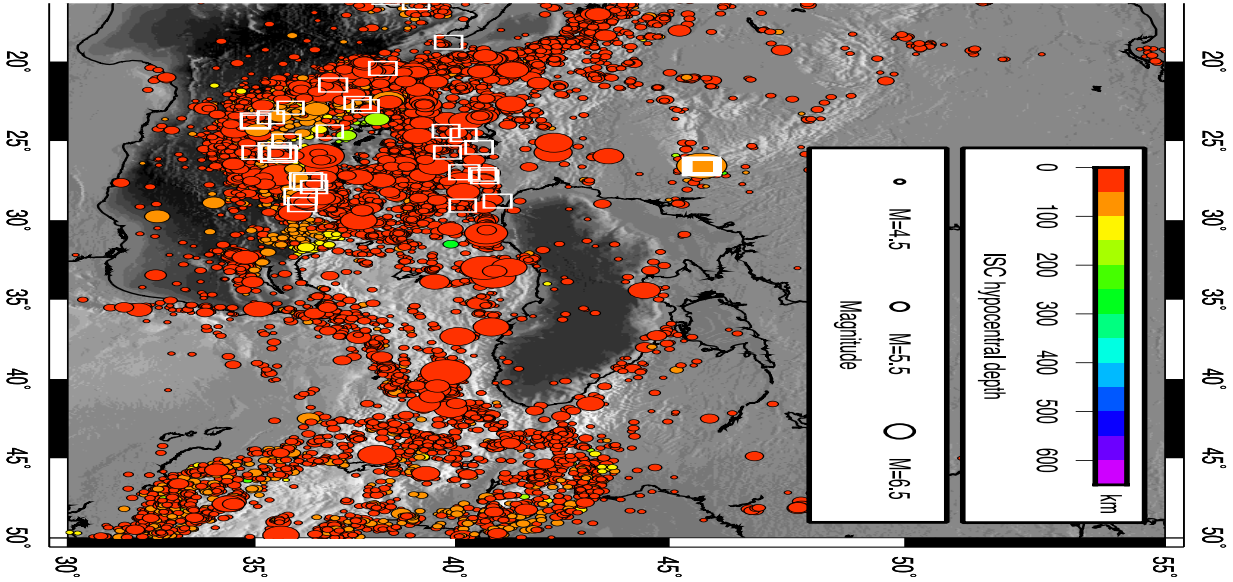
GIFT WORKSHOP, Vienna, 23-26 April 2017

Looking at the Mediterranean region through earthquakes

Claudia Piromallo
INGV, Rome

Seismicity in the Mediterranean region



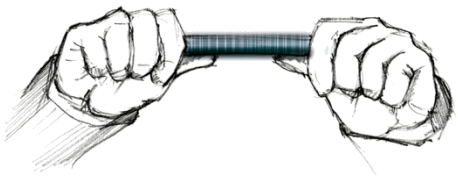
1900-2016 - International Seismological Centre On-line Bulletin (2013) and ISC-GEM Global Instrumental Earthquake Catalogue (Storchak et al., 2013)

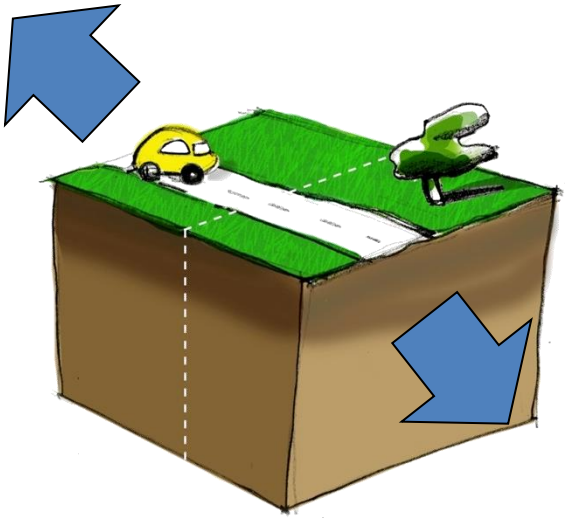
+

1000-1899 - Historical (non-instrumental) earthquakes with M≥6.5 – SHARE European Earthquake Catalogue (SHEEC, Stucchi et al., 2012)

How do earthquakes occur?

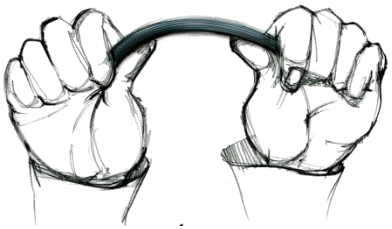
1

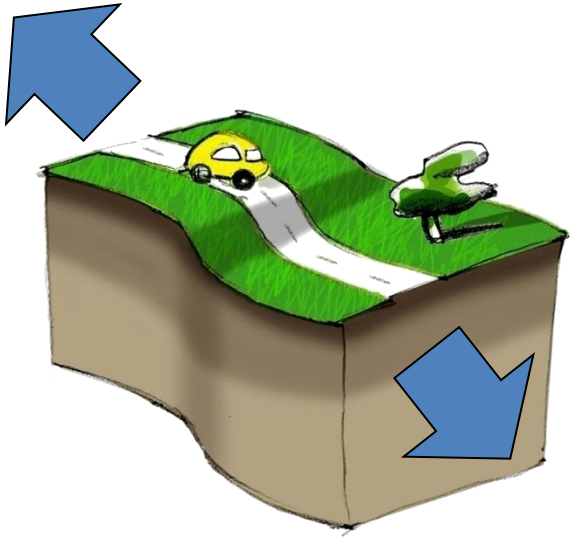




applying a force

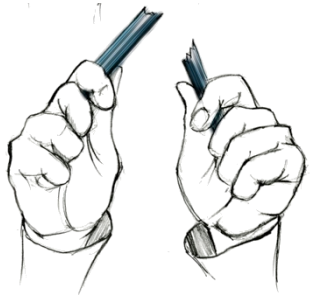
2

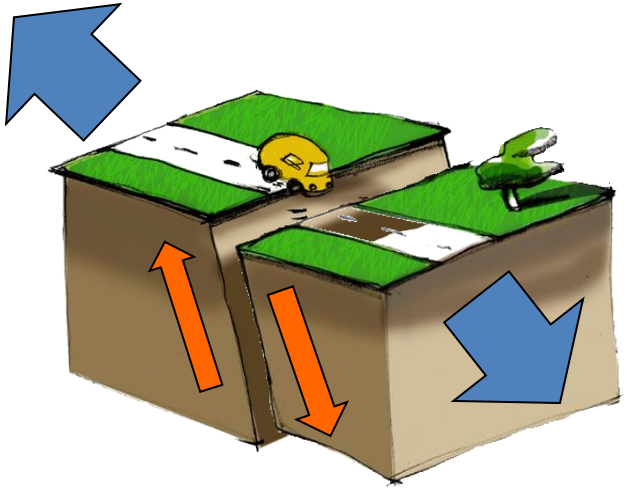




energy builds up
(deformation)

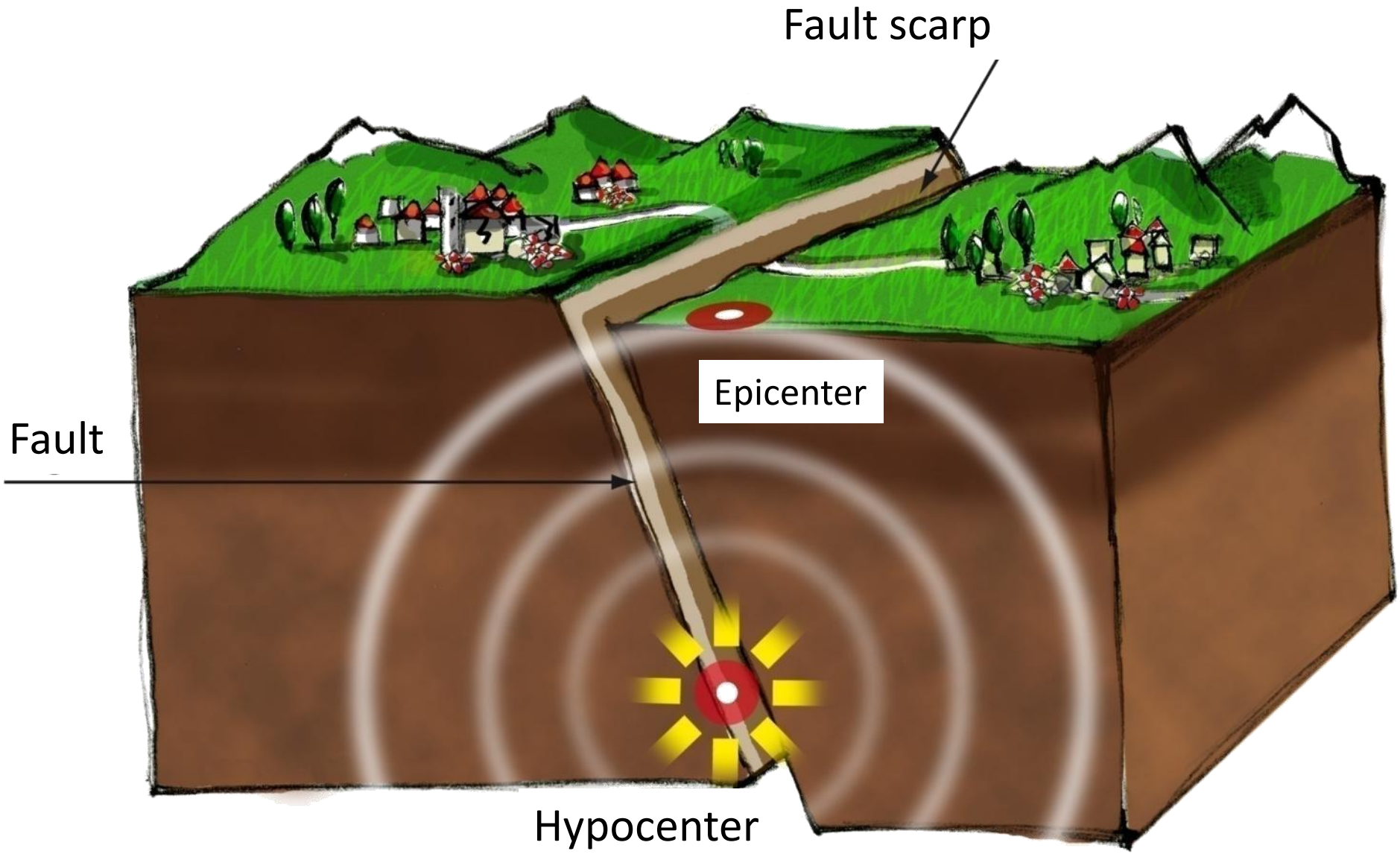
3



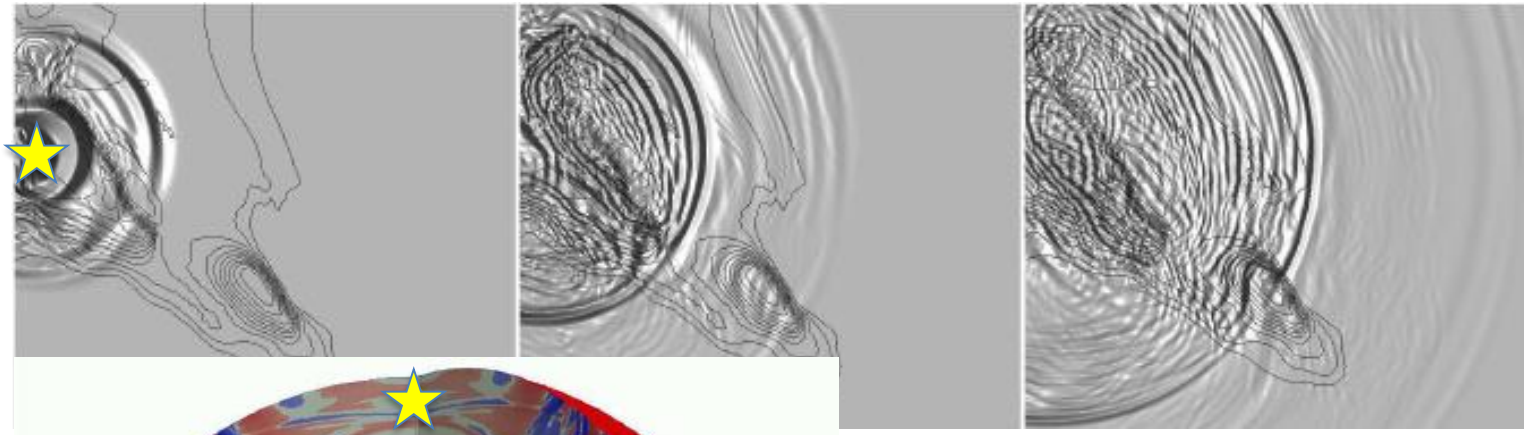


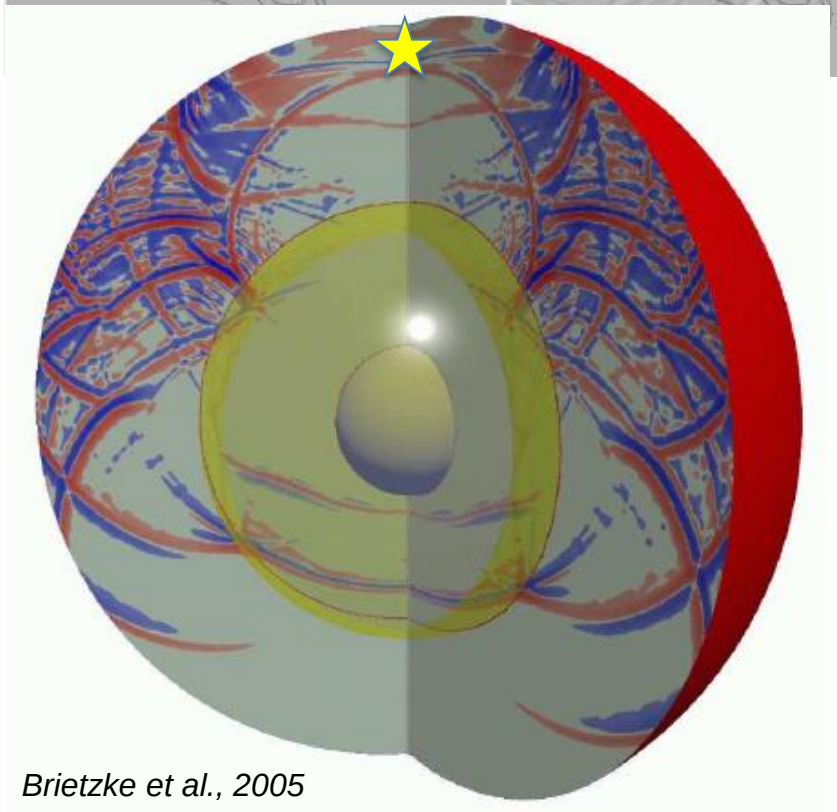
energy is released
(vibrations, sound,…)

Earthquake anatomy



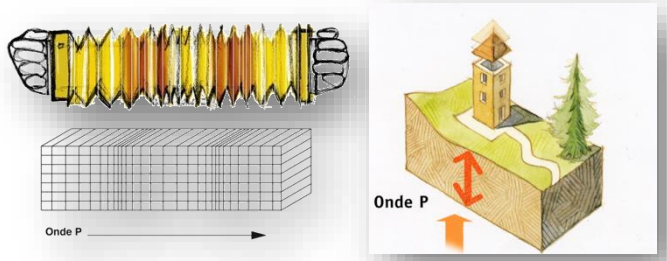
Seismic waves propagation



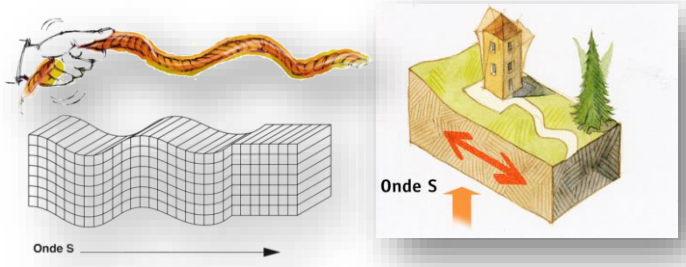


Brietzke et al., 2005

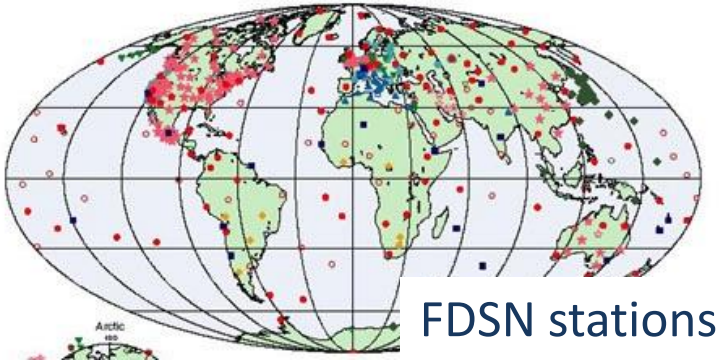
P waves



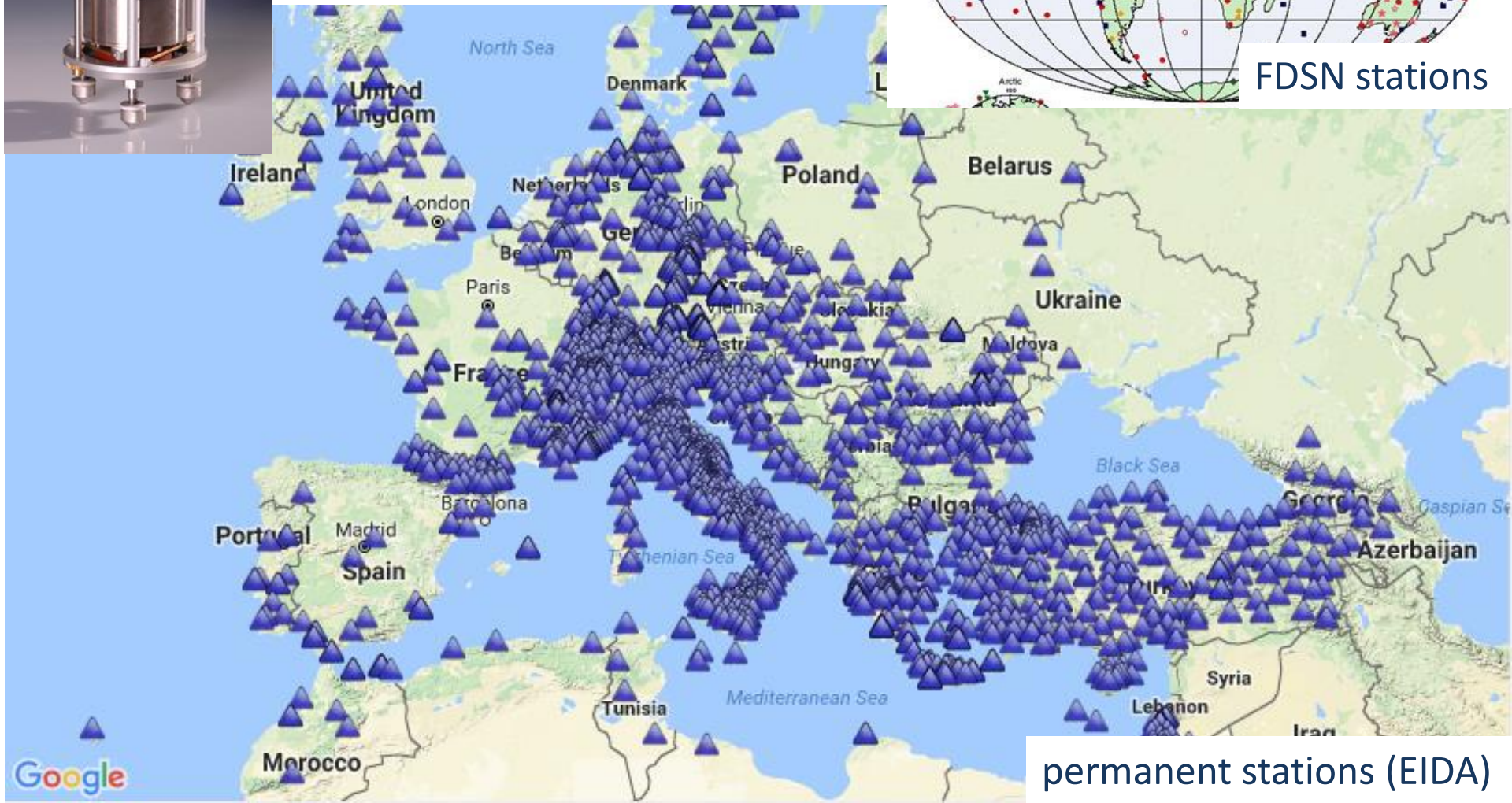
S waves



Detecting earthquakes

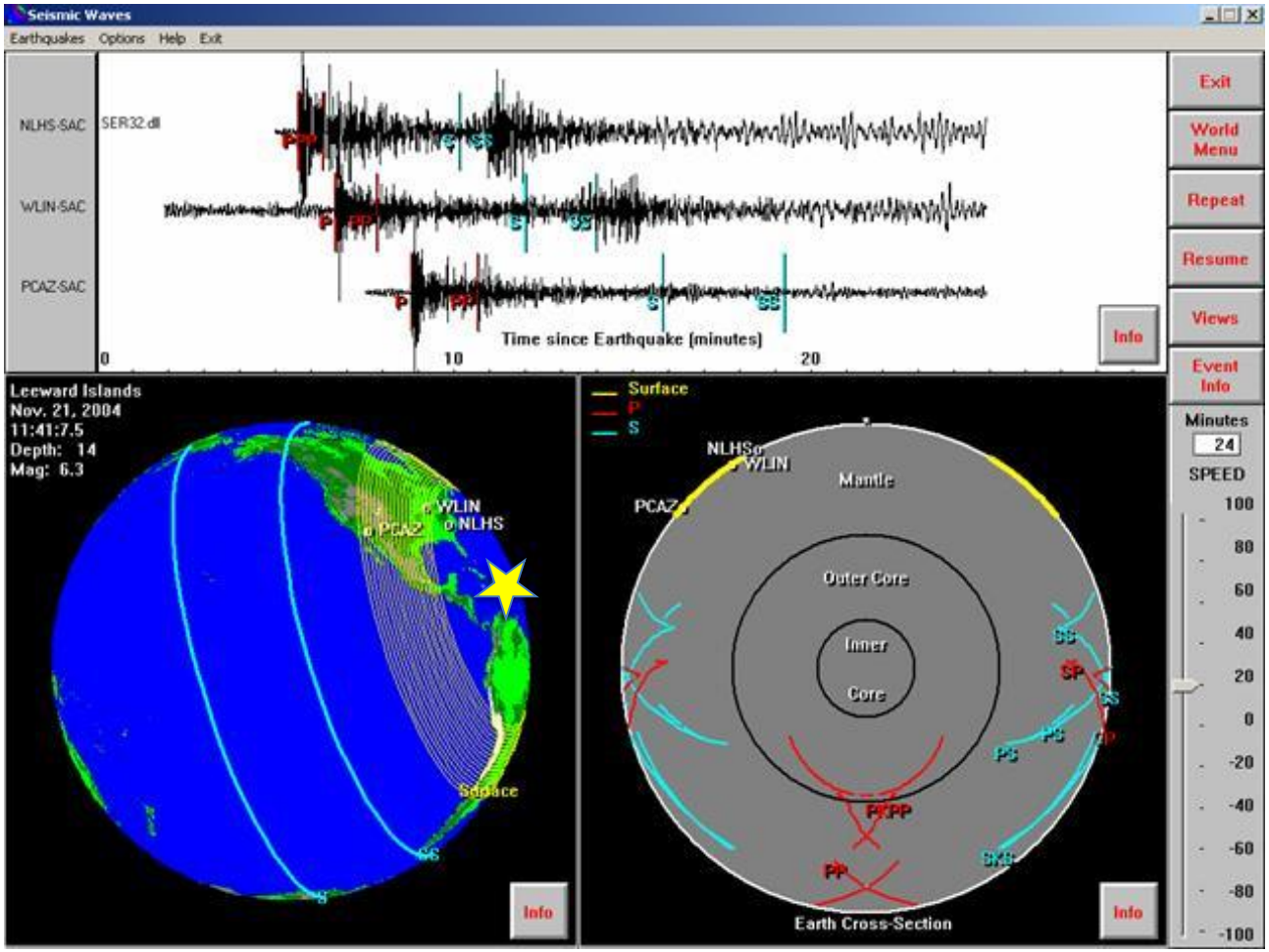


FDSN stations



permanent stations (EIDA)

Seismograms

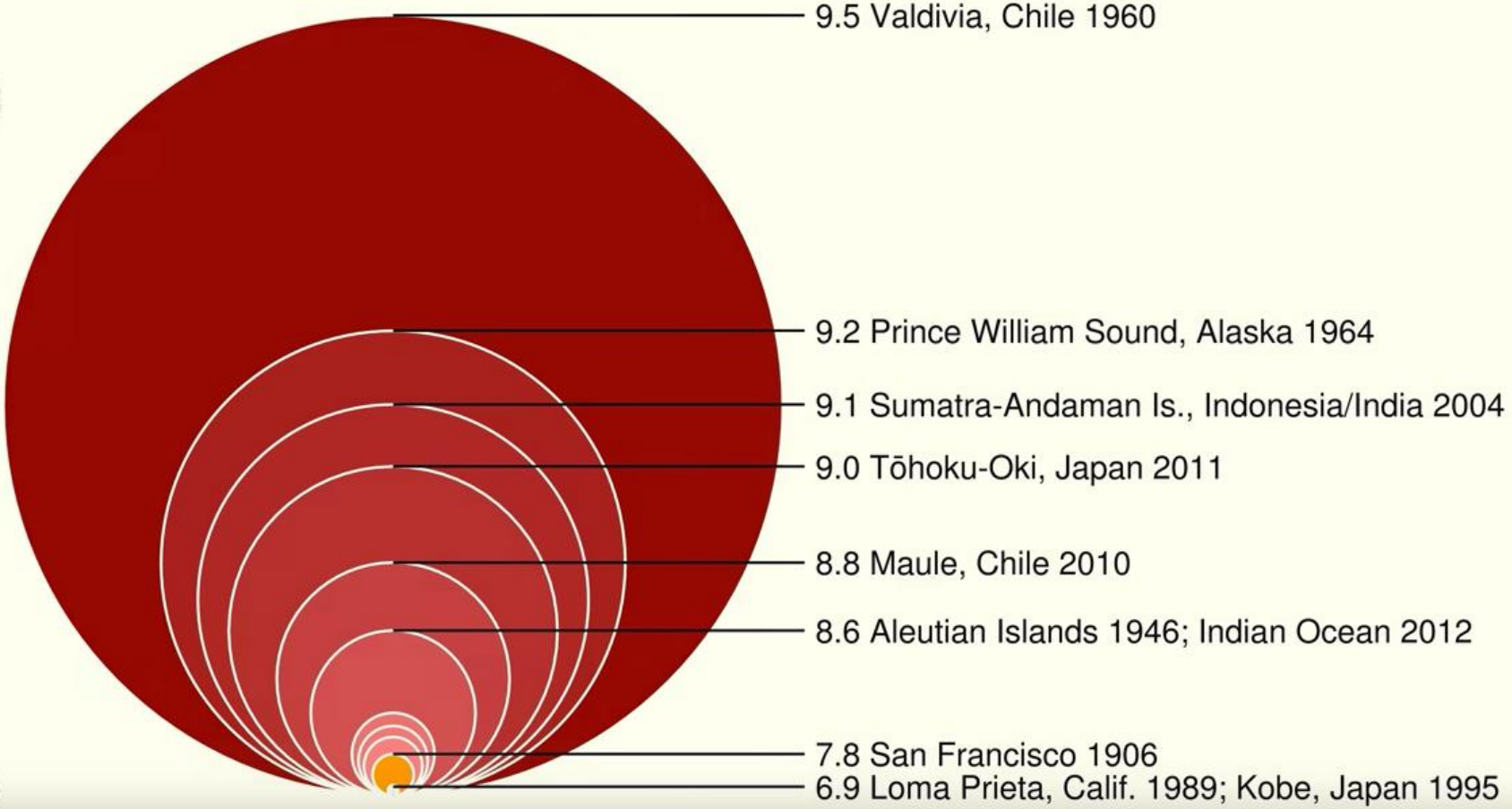


Seismograms from many stations to LOCATE and MEASURE earthquakes

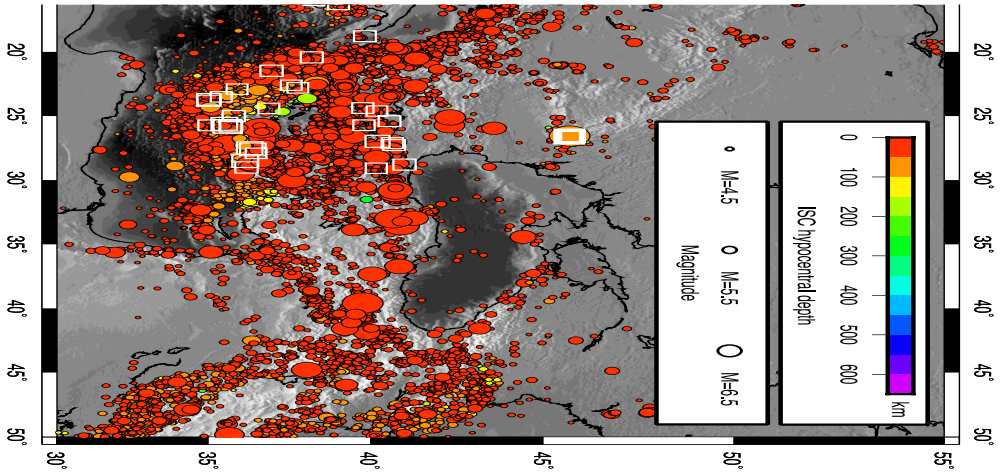
http://web.ics.purdue.edu/~braile/edumod/as1lessons/UsingAmaSeis/UsingAmaSeis.htm

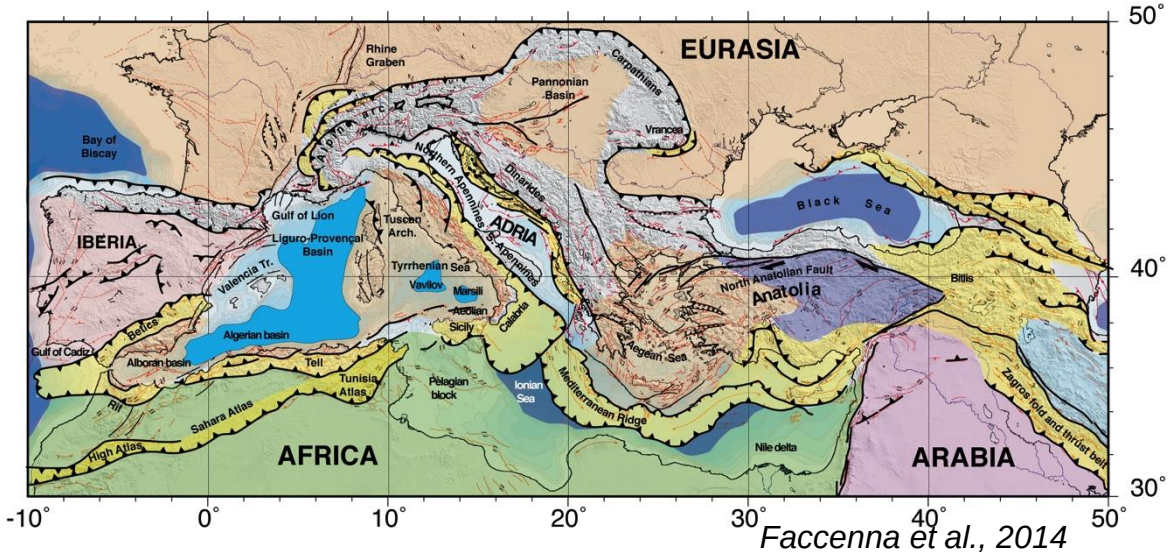
The size of an earthquake: MAGNITUDE

Comparison of Recent and Historic Earthquakes by Energy Release



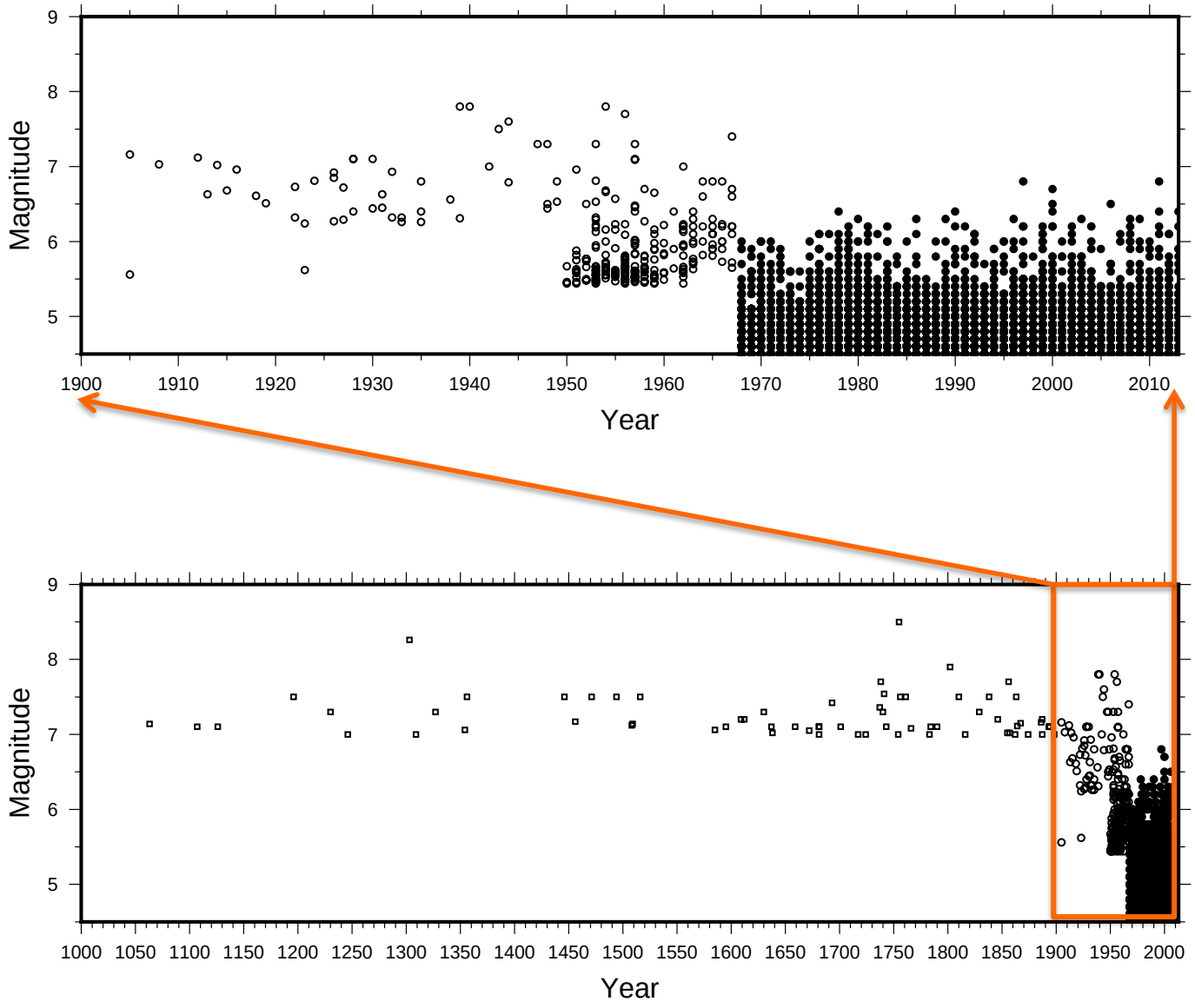
Mediterranean earthquakes in space…





Faccenna et al., 2014

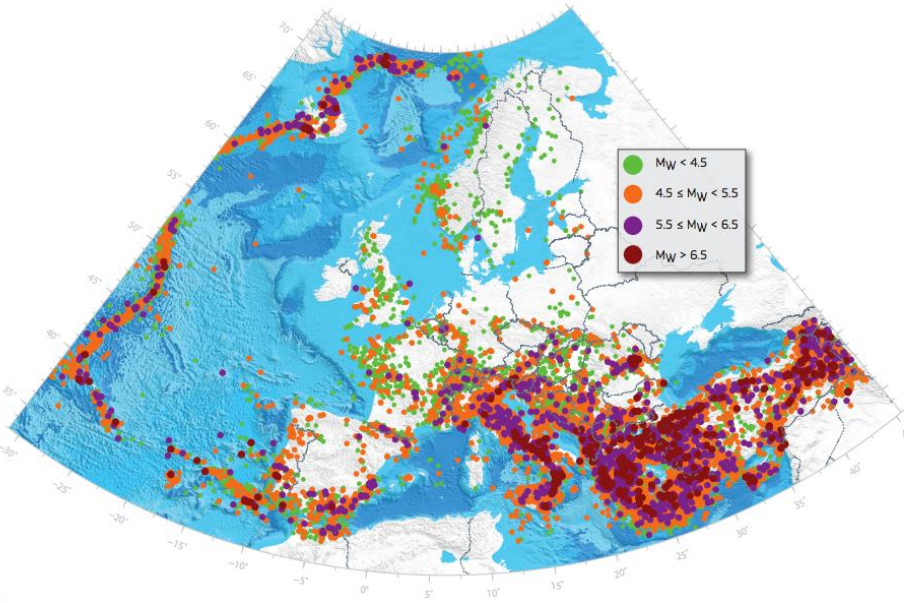
…and time


Magnitude
9
8
7
6
5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Magnitude
9
8
7
6
5
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
Year

even moderate magnitude events have caused large losses

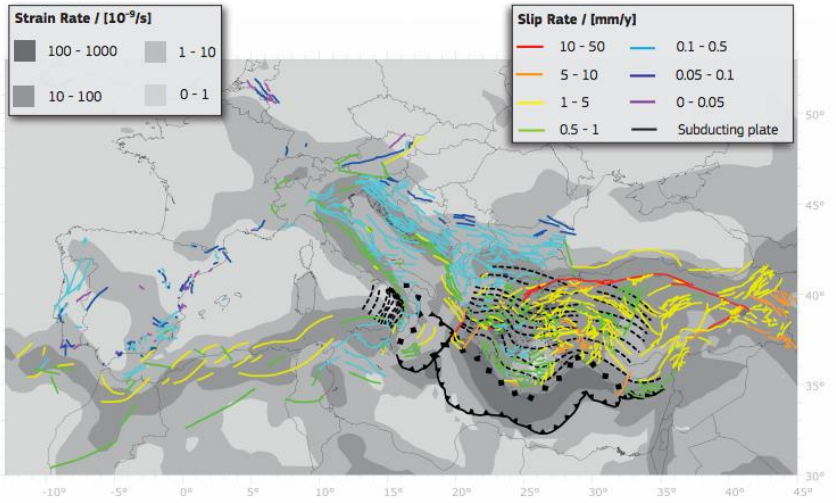
Seismicity and active faults catalogs

Earthquake History in Europe



Distribution of over 30,000 earthquakes with magnitudes larger or equal to 3.5 for the period 1000 – 2007, documented by their damaging effec through history or recorded with modern instrumental seismic networks.

Active Faults in Euro-Mediterranean Region

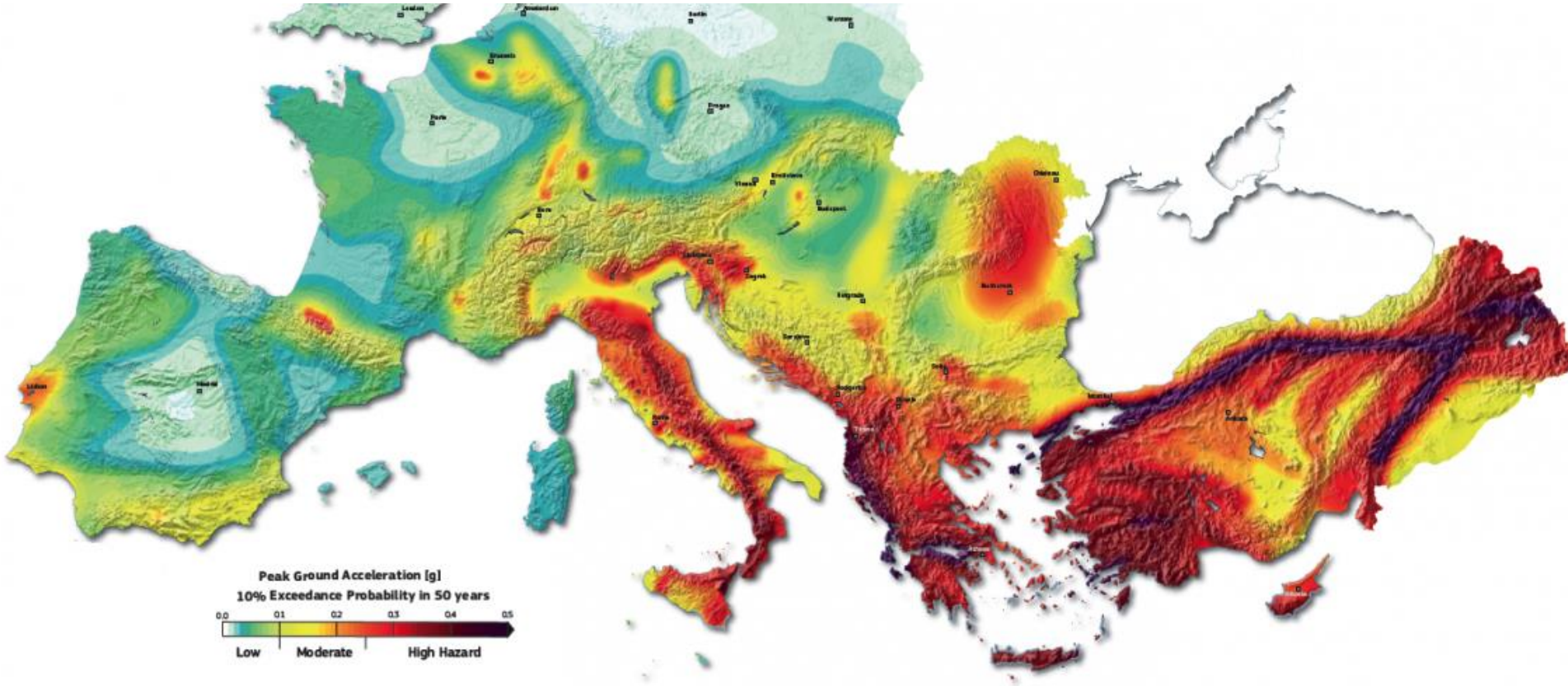


Active faults and subucting plates in the Euro-Mediterranean region, differentiated by color from rapidly slipping (red) to slowly slipping (violet). Over 1,100 active faults have been mapped, covering more than 64,000 km of fault length. The background depicts the estimated rate of deformation of the Earth's crust derived from geologic and geodetic data.

Giardini et al., SHARE, 2013

input to build…

Seismic Hazard Maps



European Seismic Hazard Map

Giardini et al., SHARE, 2013

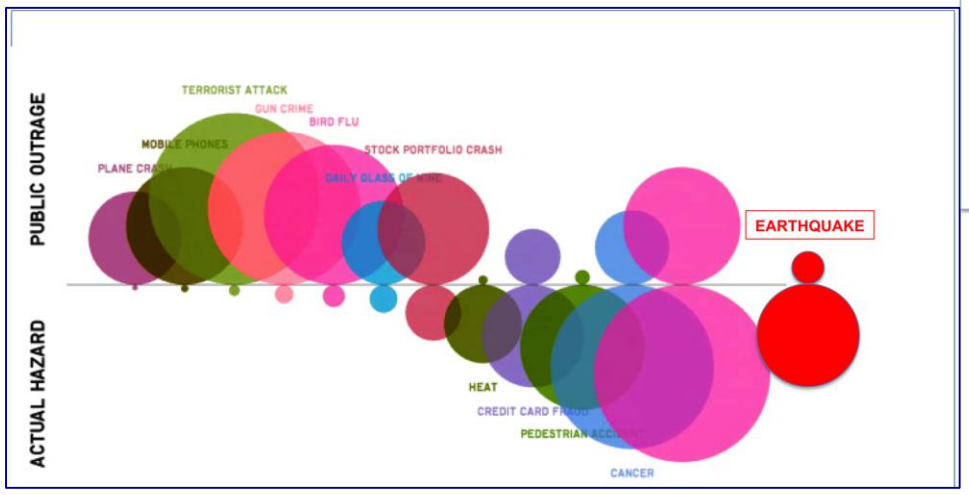
Ground motion (i.e. the Peak Ground Acceleration PGA) expected to be reached or exceeded with a 10% probability in 50 years

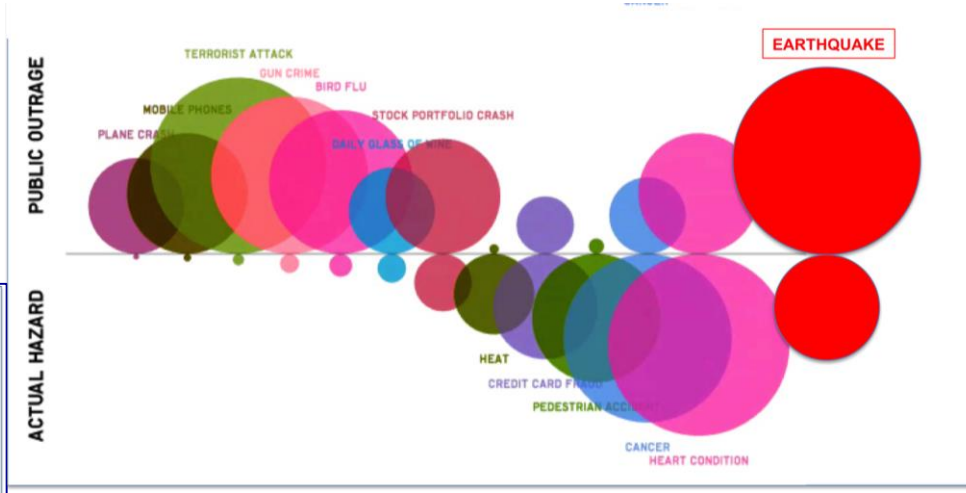
Why is hazard assessment relevant?

RISK=HAZARD x EXPOSURE x VULNERABILITY

Except when there is a strong shock around or a swarm nearby

Seismic hazard and risk are generally underestimated in Italy

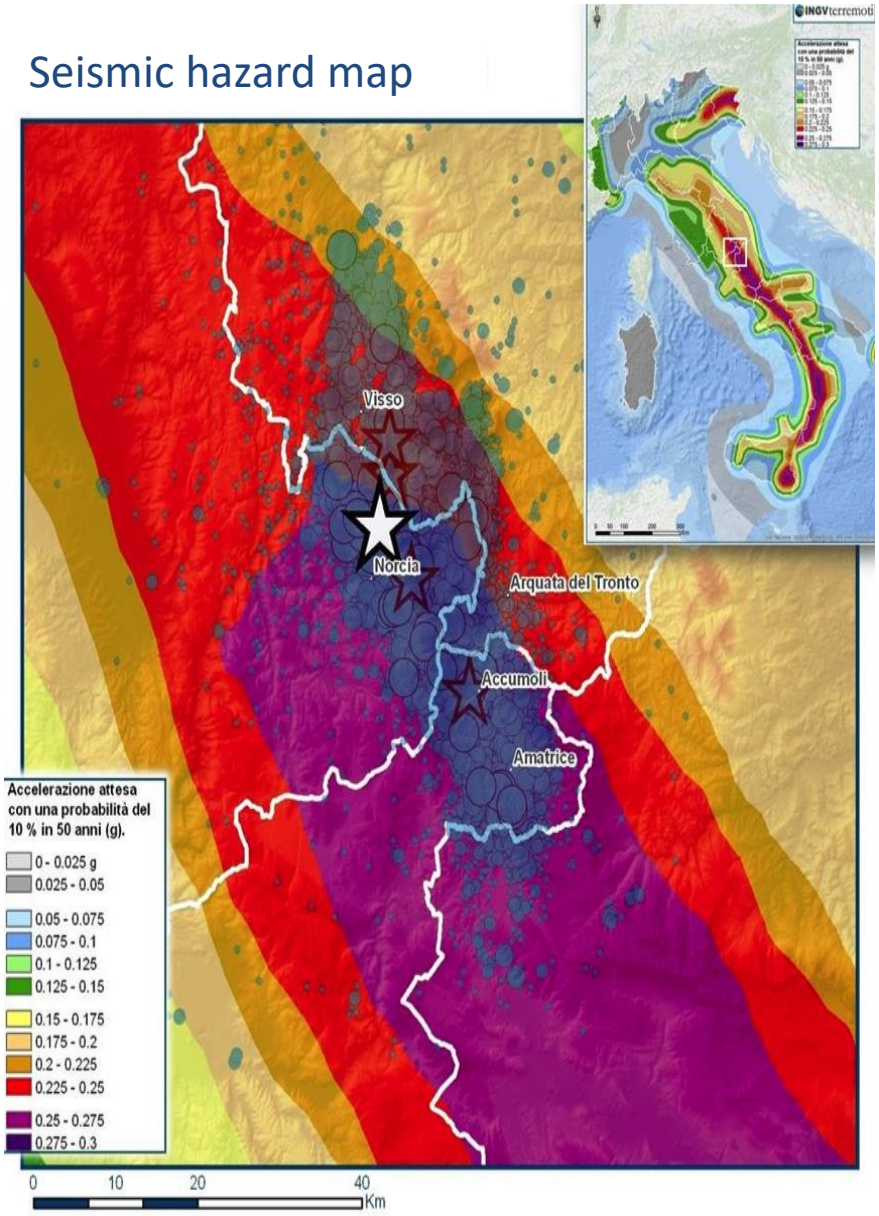




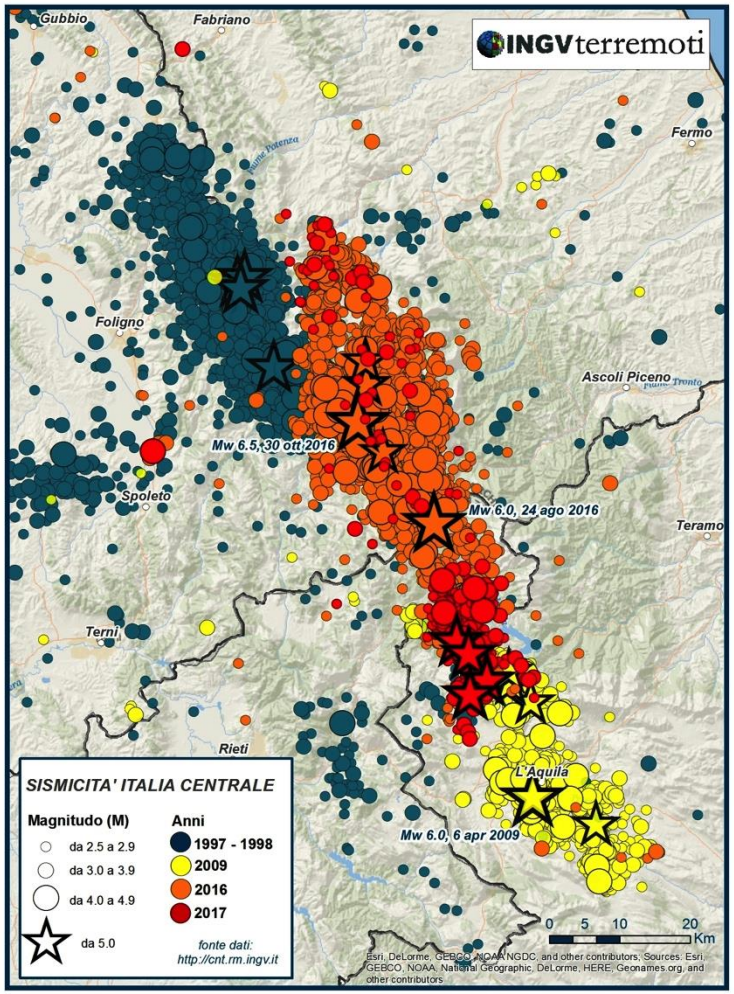
Crescimbene and La Longa, 2015

Amatrice seismic sequence (2016-2017)

Seismic hazard map



Central Italy seismic sequences (1997-2017)



Terra Nova

doi: 10.1111/j.1365-3121.2011.01013.x

Do earthquake storms repeat in the Apennines of Italy?

Claudio Chiarabba, Pasquale De Gori and Alessandro Amato

Istituto Nazionale di Geofisica and Vulcanologia, CNT, Rome, Italy

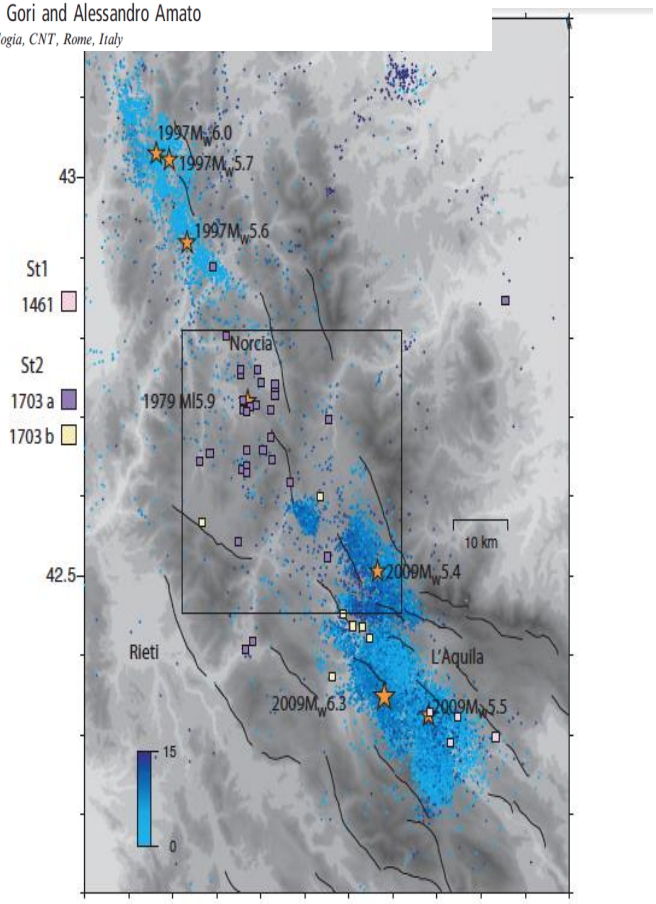
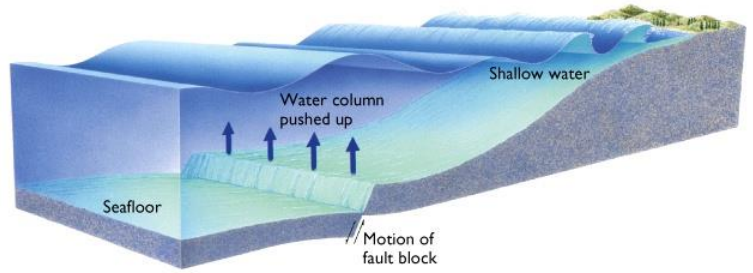
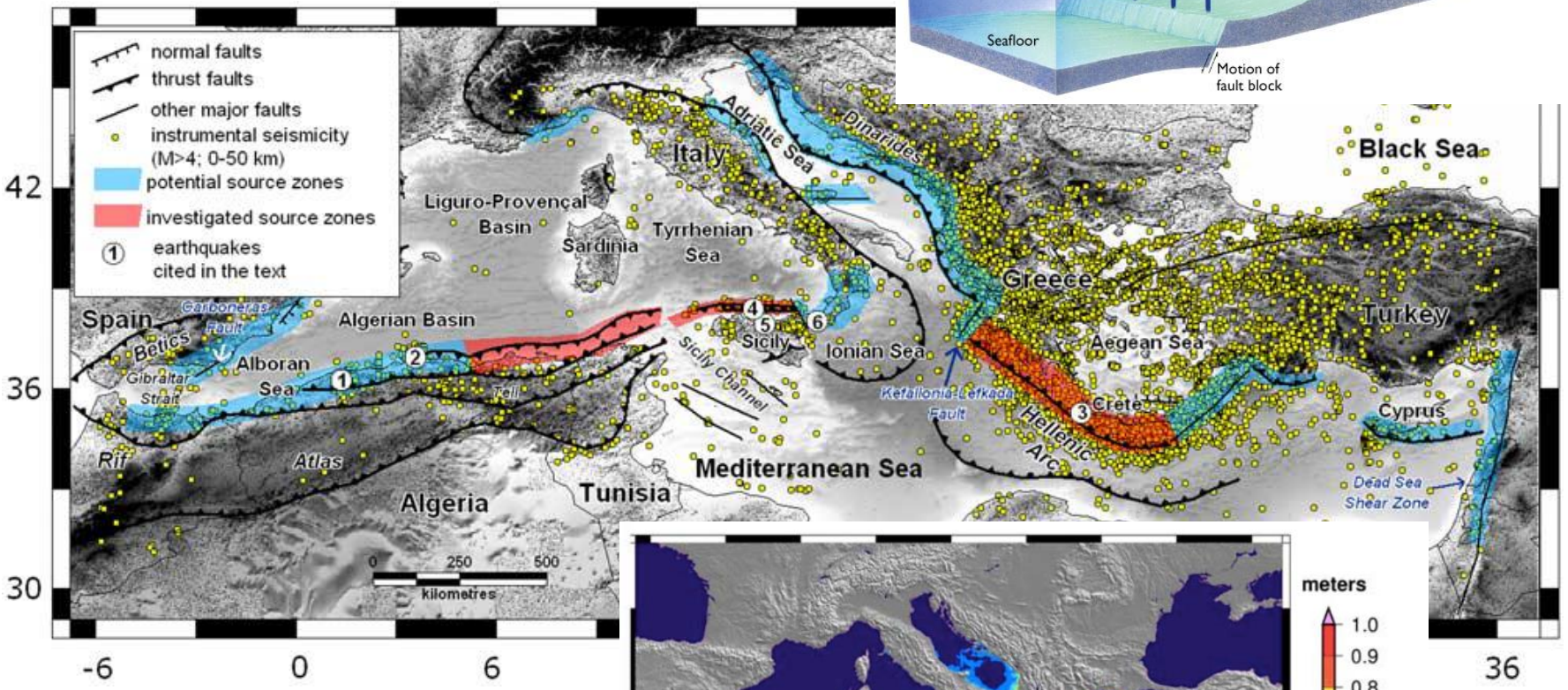
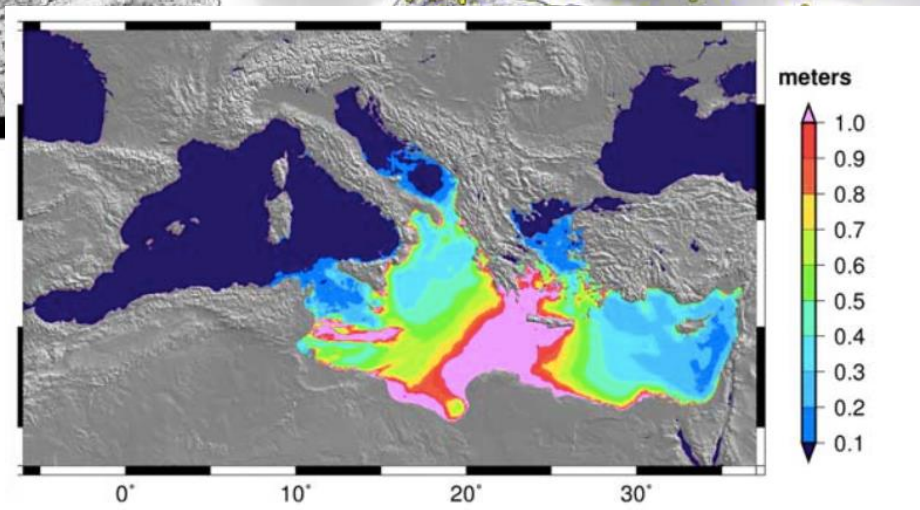


Fig. 3 Central Apennines fault system. The background seismicity shown occurred between 2003 and 2009. Main shocks (stars) and aftershocks (circles) are locations of the 1997 and 2009 seismic sequences (see Chiarabba *et al.*, 2009a,b). Squares are sites of reported X MCS intensity degrees for relevant historical earthquakes. The locked central portion of the fault system lacks a major event in the past 300 years. Fault traces at the surface from Galli *et al.* (2008) and Roberts and Michetti (2004). The

Tsunami generating earthquakes







Lorito et al., 2008

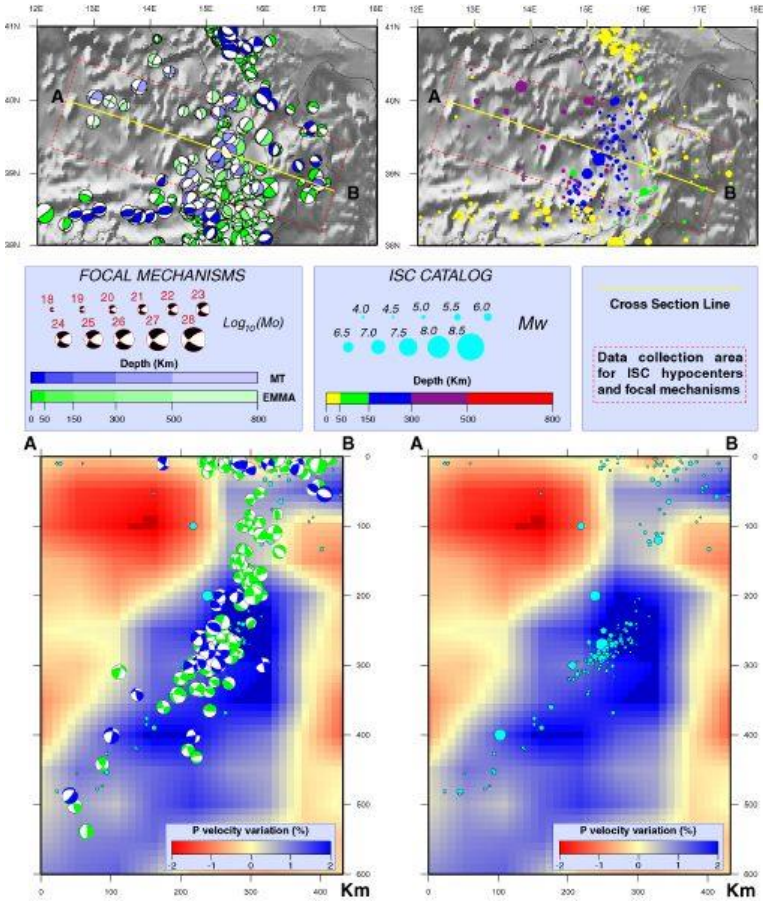
M_w=7.1 Messina 1908 (Italy), c. 80000

M=8.5+ Crete 365 (Greece)

M=8.5+ Lisbon 1755 (Portugal)

Earthquakes: tools to probe Earth's structure

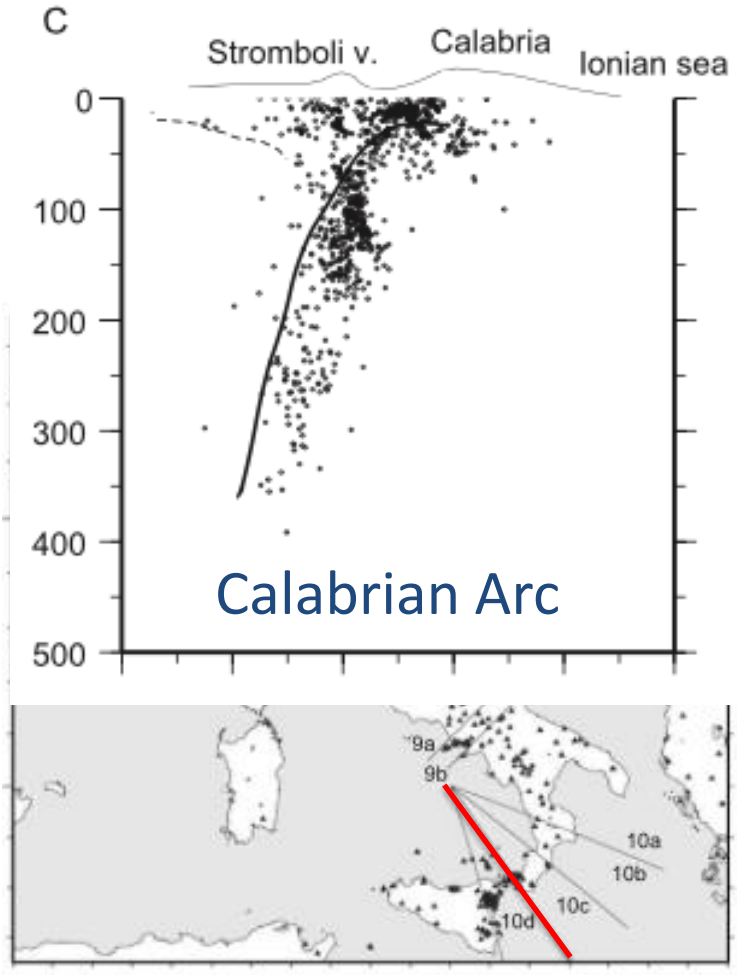
1. Seismicity



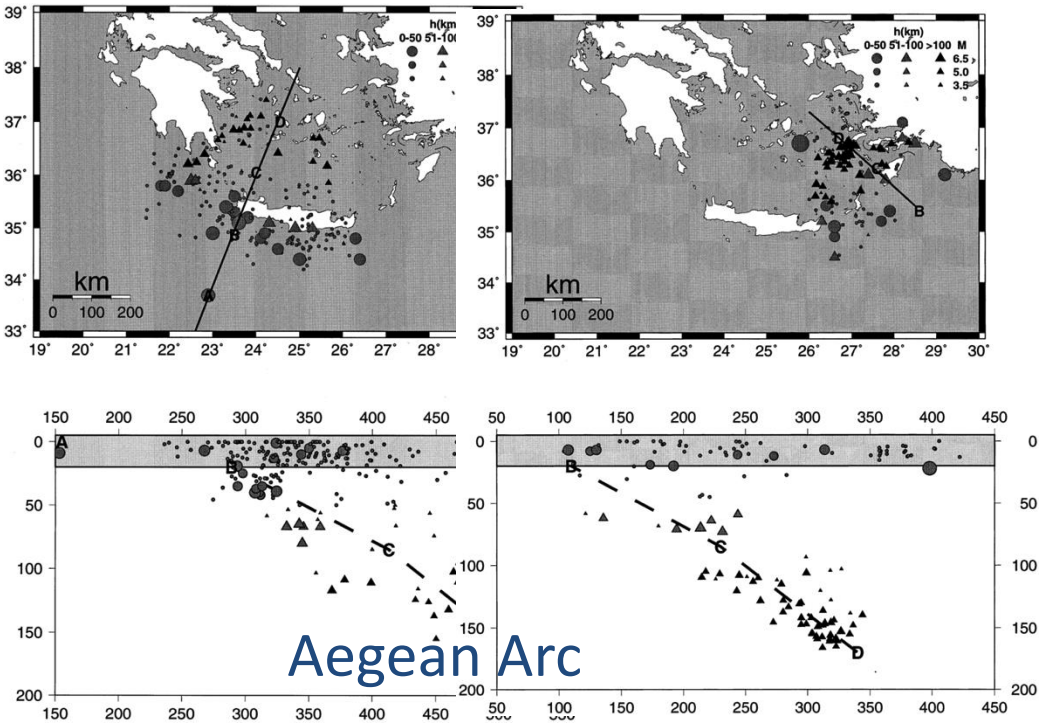
Vannucci et al., 2005

Seismicity distribution
Seismic source properties

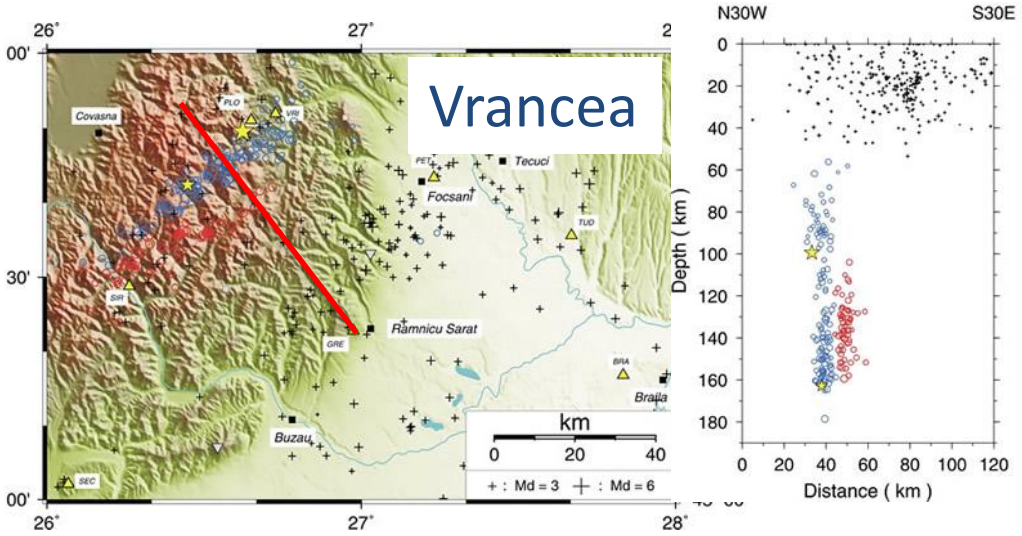
→ tectonic activity &
present-day state of stress



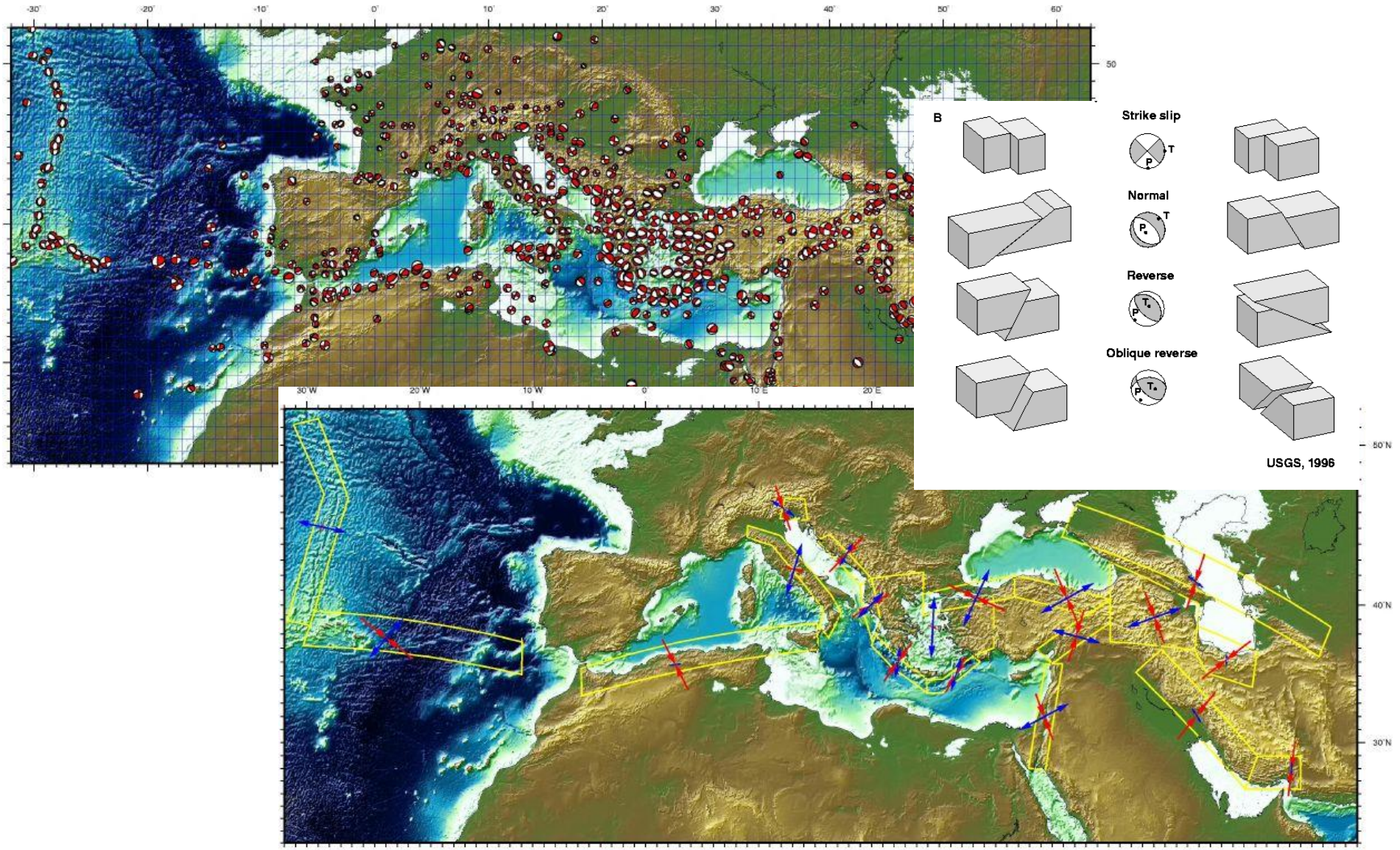
Chiarabba et al.., 2007



Papazachos et al.., 2000



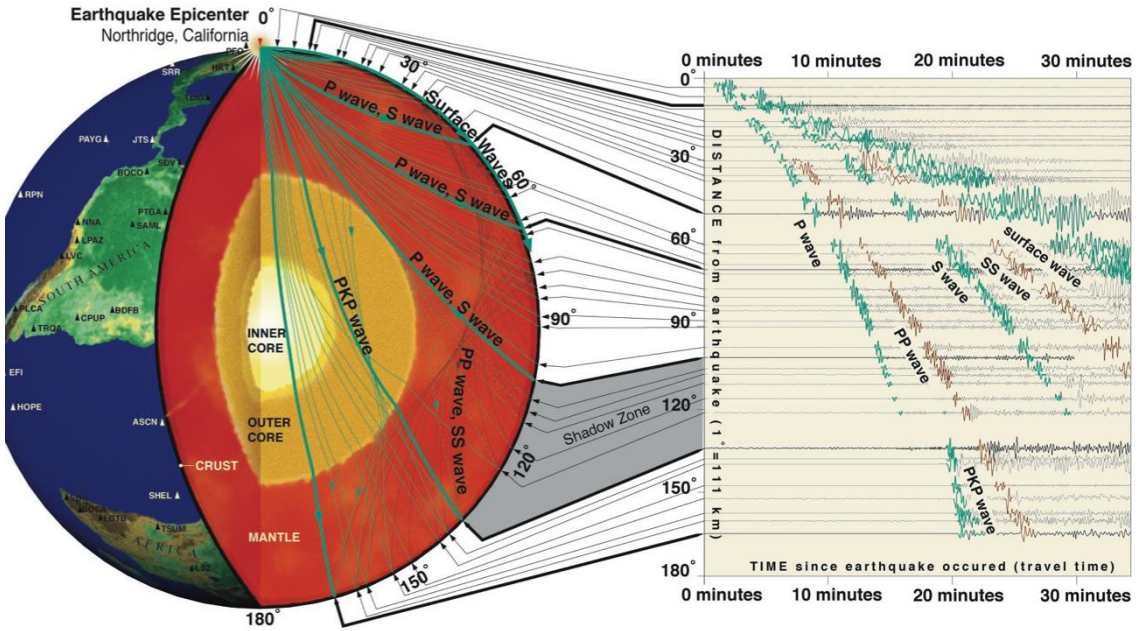
Radulian et al.., 2007



Vannucci et al., 2005

Earthquakes: tools to probe Earth's structure

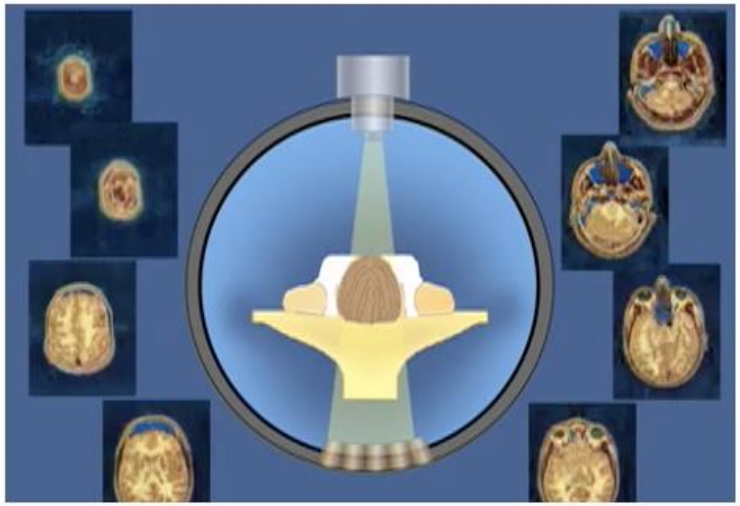
2. Seismic waves propagation



Seismic Tomography
Seismic Anisotropy
Seismic Attenuation
Waveform analyses

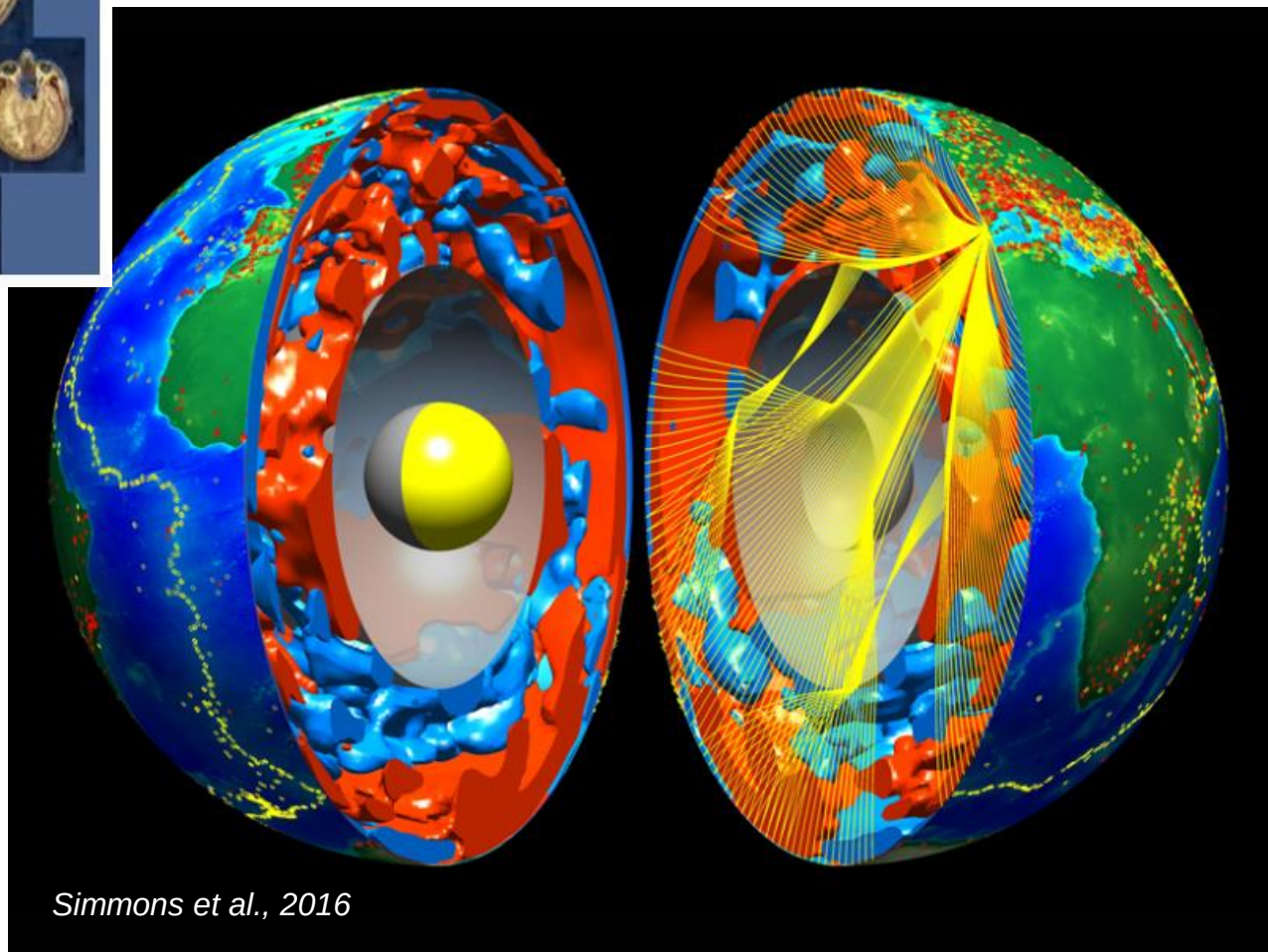
→ snapshots of present-day structure of lithosphere and mantle

Probing Earth's interior with seismic waves



www.iris.edu

CT-SCAN of Earth
SEISMIC TOMOGRAPHY

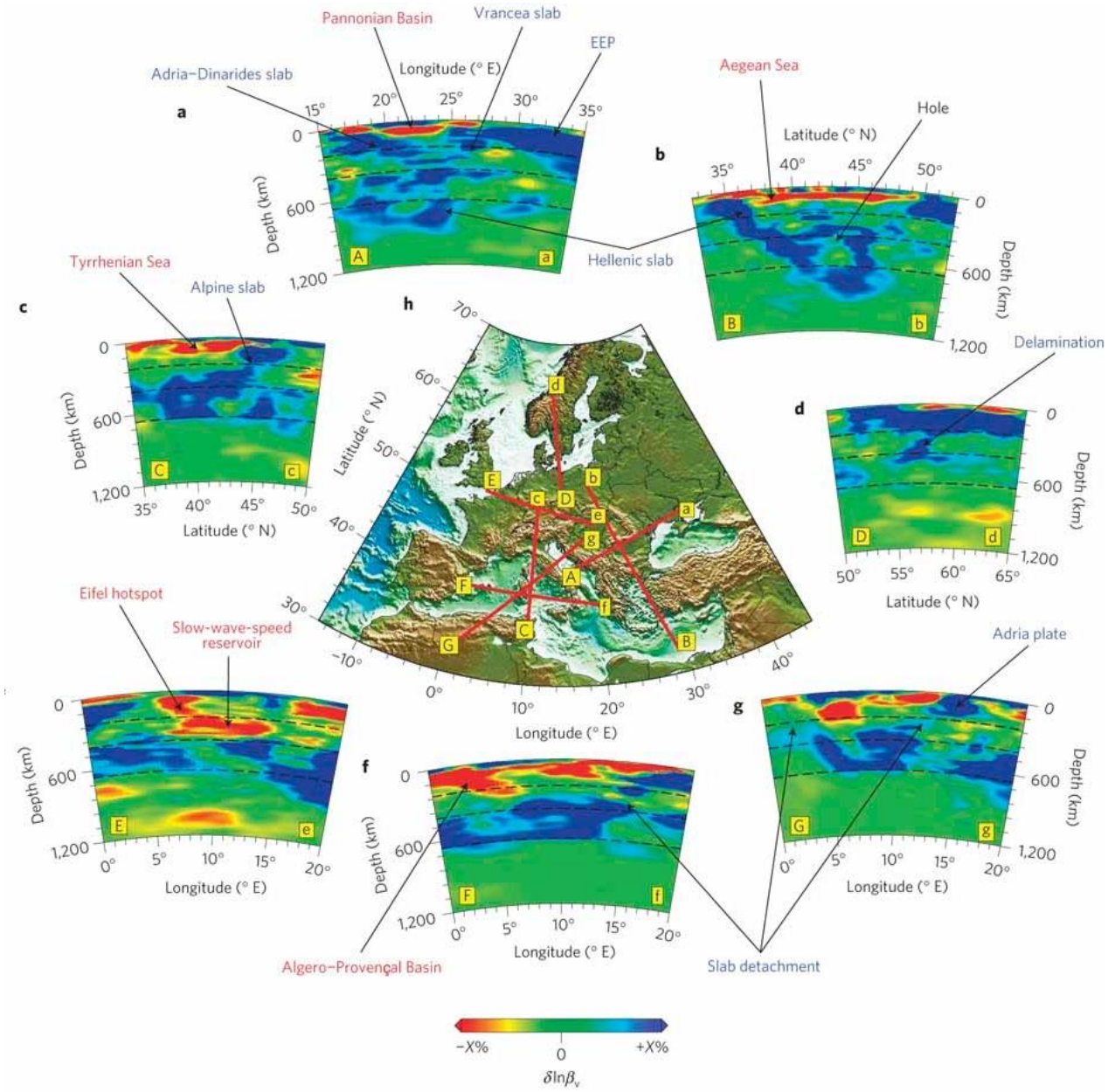


Simmons et al., 2016

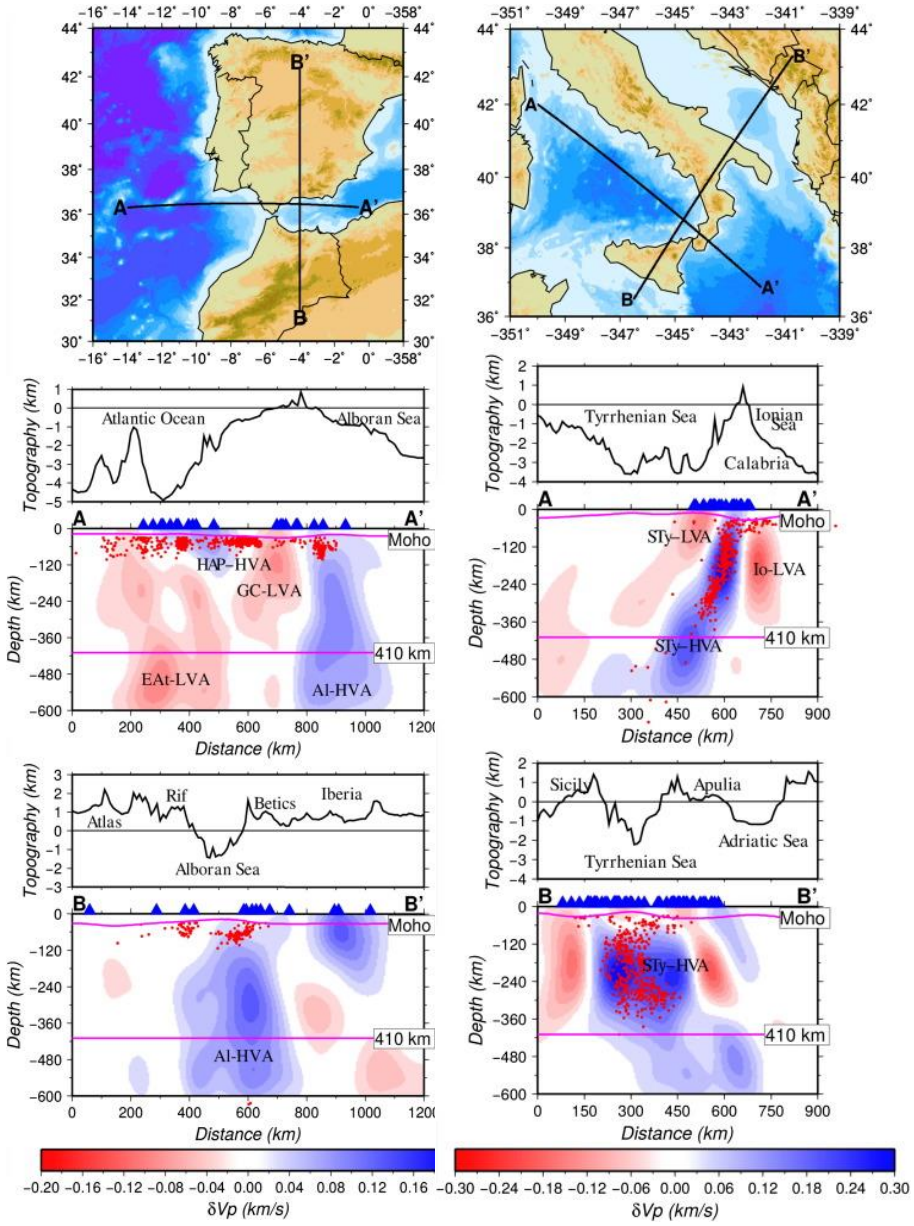
Seismic waves travel with different velocities through different materials

BLUE=FAST=COLD
RED=SLOW=HOT

Seismic tomography of the Mediterranean

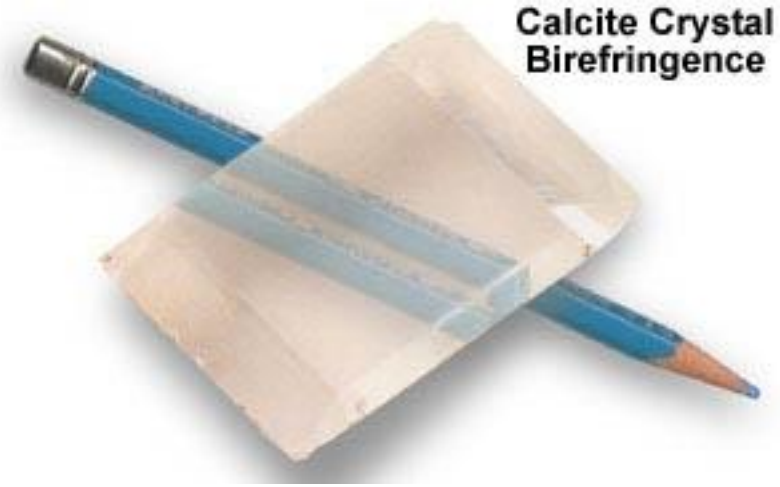


Zhu et al., 2012

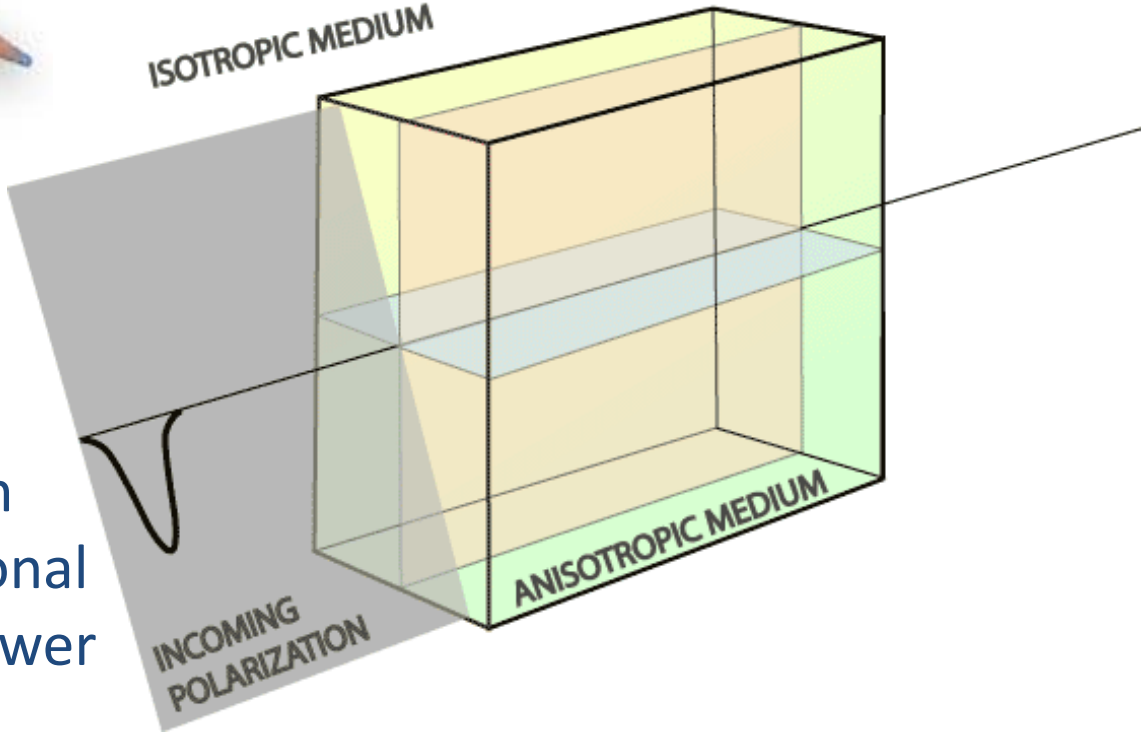


Argnani et al., 2016

Probing Earth's interior with seismic waves



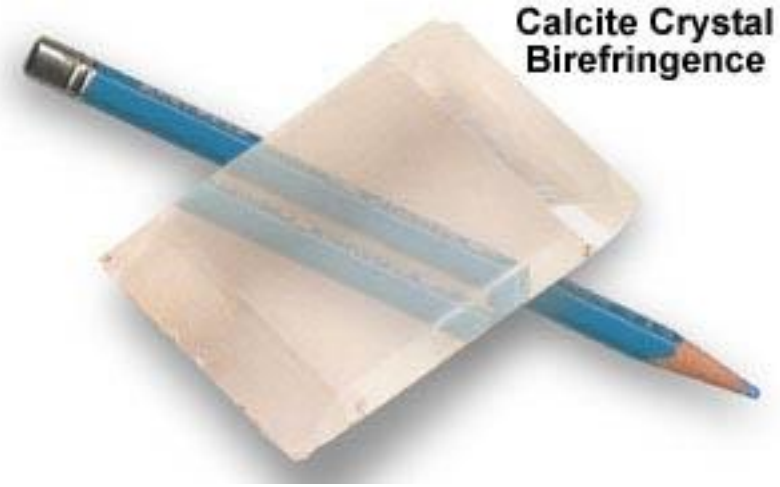
Seismic waves birefringence
SEISMIC ANISOTROPY



Seismic waves travelling through anisotropic medium are polarized in two orthogonal directions, a faster and a slower one

http://garnero.asu.edu/research_images/

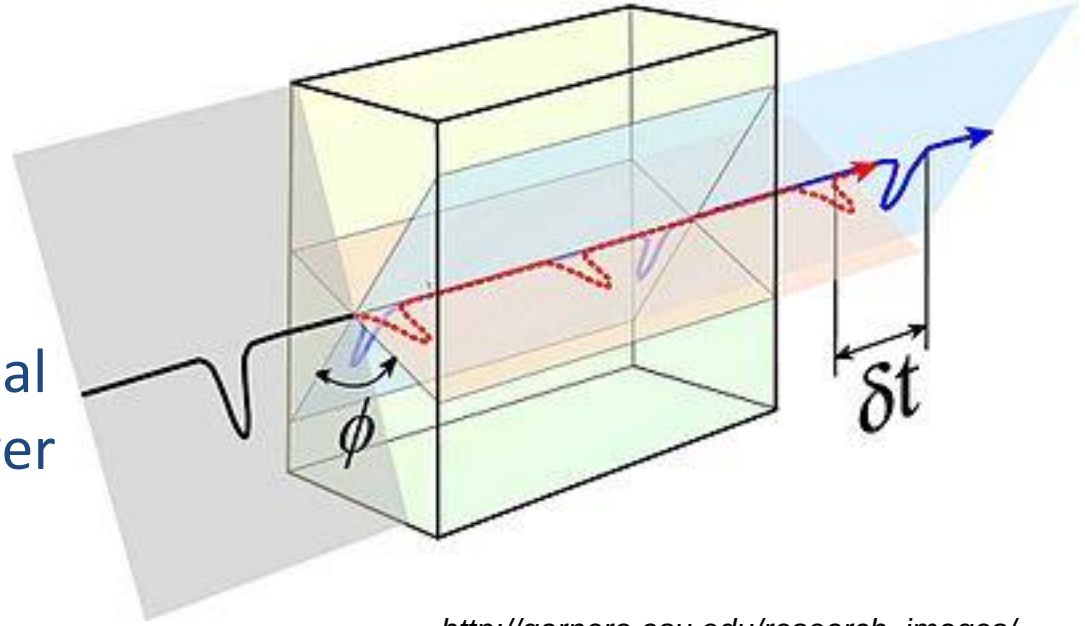
Probing Earth's interior with seismic waves



Seismic waves birefringence
SEISMIC ANISOTROPY

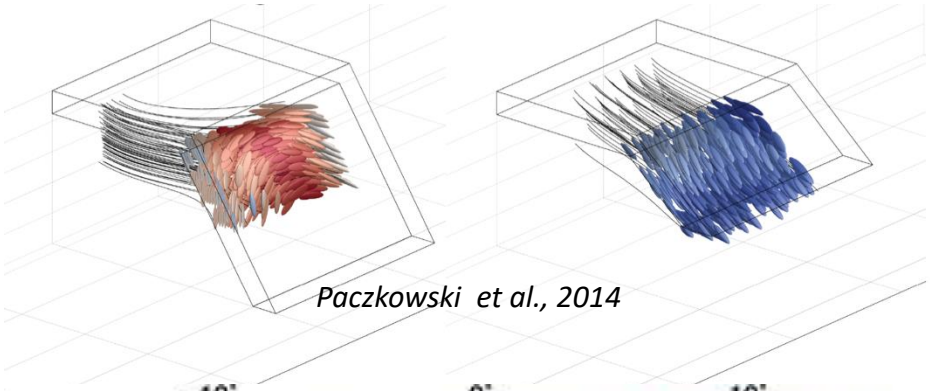
Shear wave splitting in anisotropic media

Seismic waves travelling through anisotropic medium are polarized in two orthogonal directions, a faster and a slower one

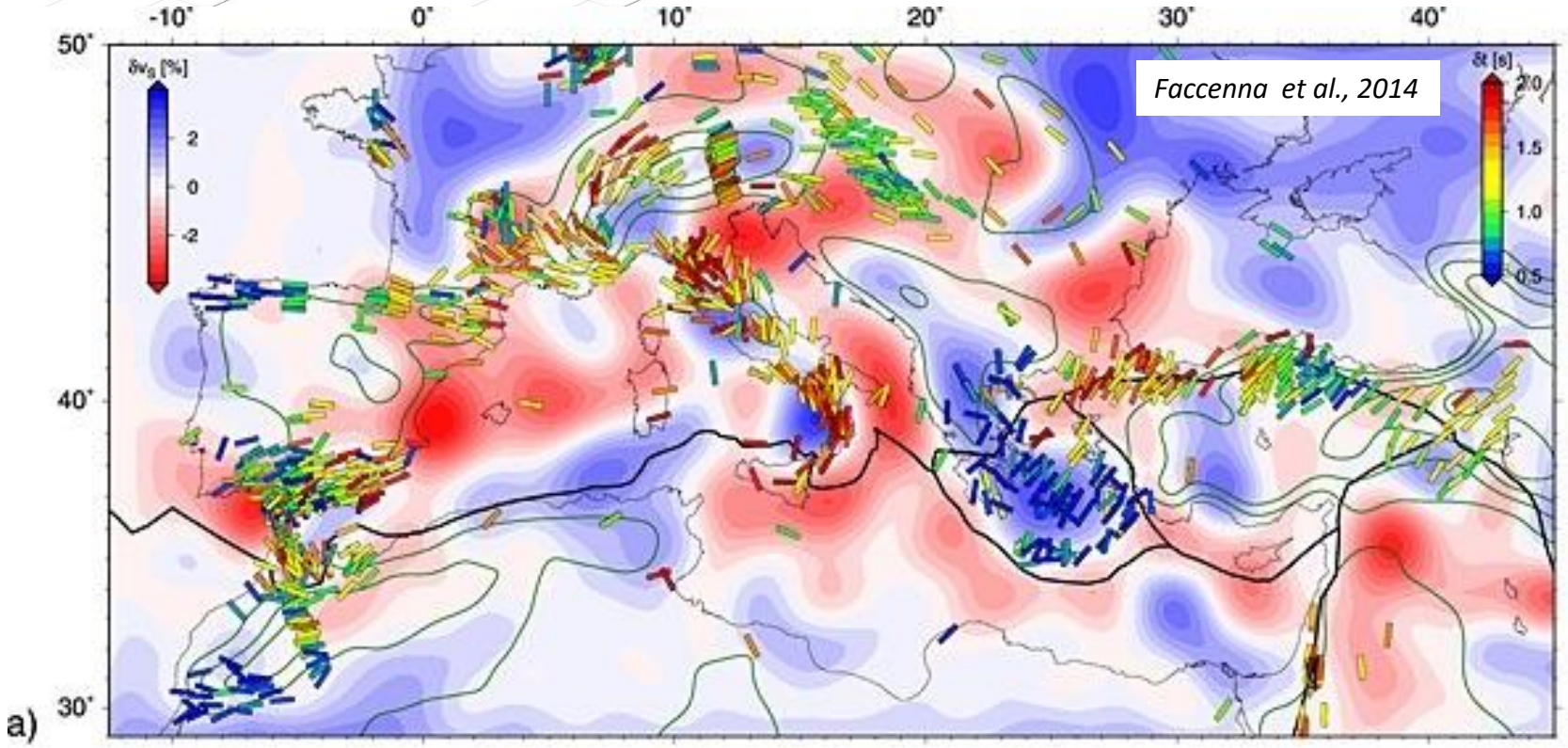


http://garnero.asu.edu/research_images/

Seismic anisotropy in the Mediterranean



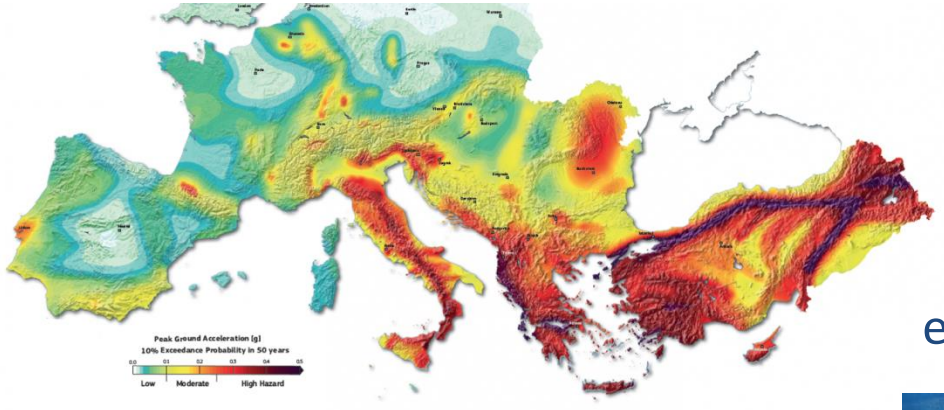
Paczkowski et al., 2014



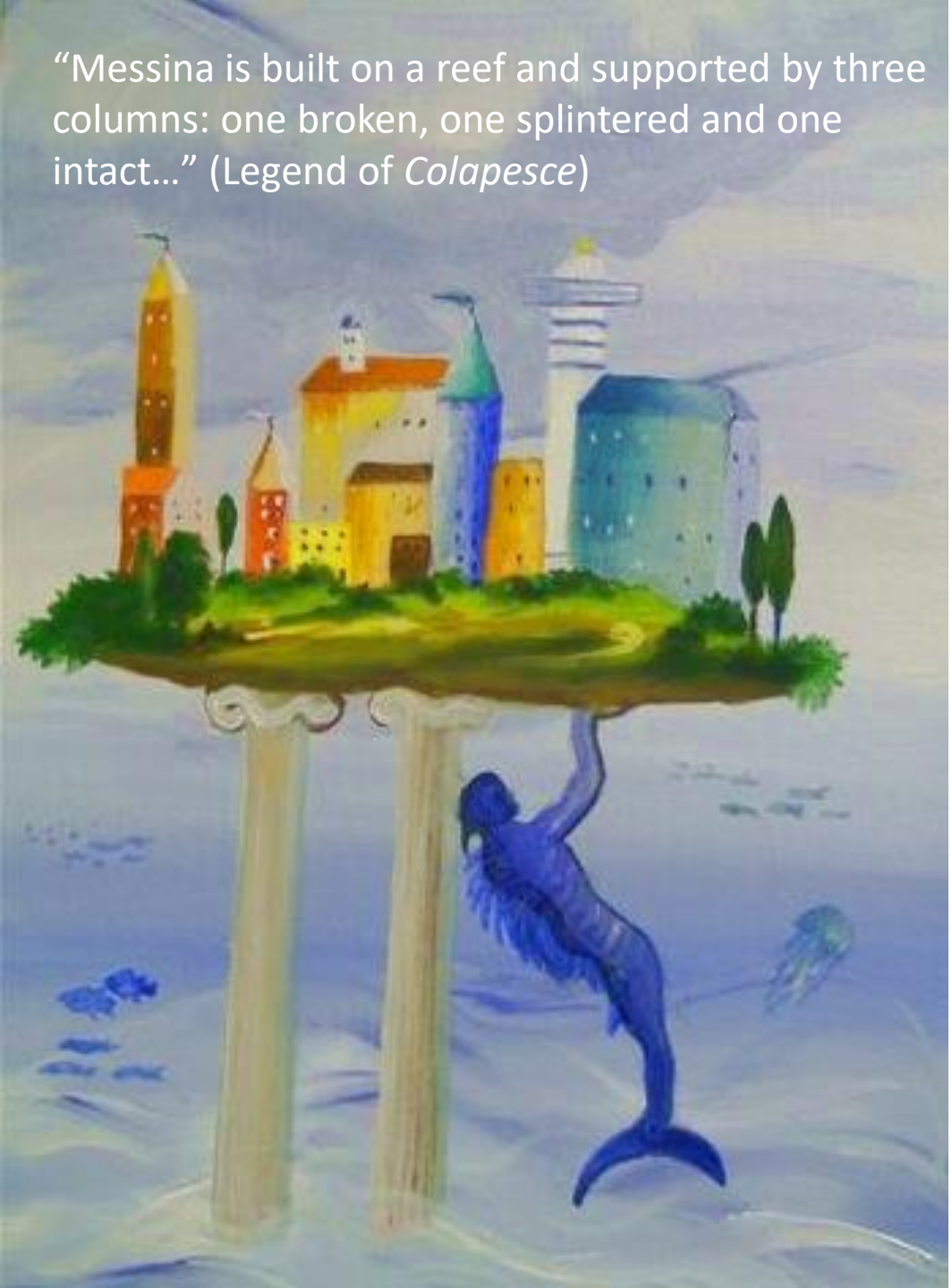
Faccenna et al., 2014

Why studying earthquakes?

impact on society and lives



efficient TOOLS to inspect the underworld


“Messina is built on a reef and supported by three columns: one broken, one splintered and one intact…” (Legend of *Colapesce*)

Thank you!