



# **EARTHQUAKES IN THE CLASSROOM: 'THE SEISMO-BOX: DO IT YOURSELF'**

## ***TERREMOTI IN CLASSE : 'IL SISMO-BOX : DO IT YOURSELF'***

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M = 6.0



Amatrice, 24 agosto 2016, 300 vittime



M = 4.0

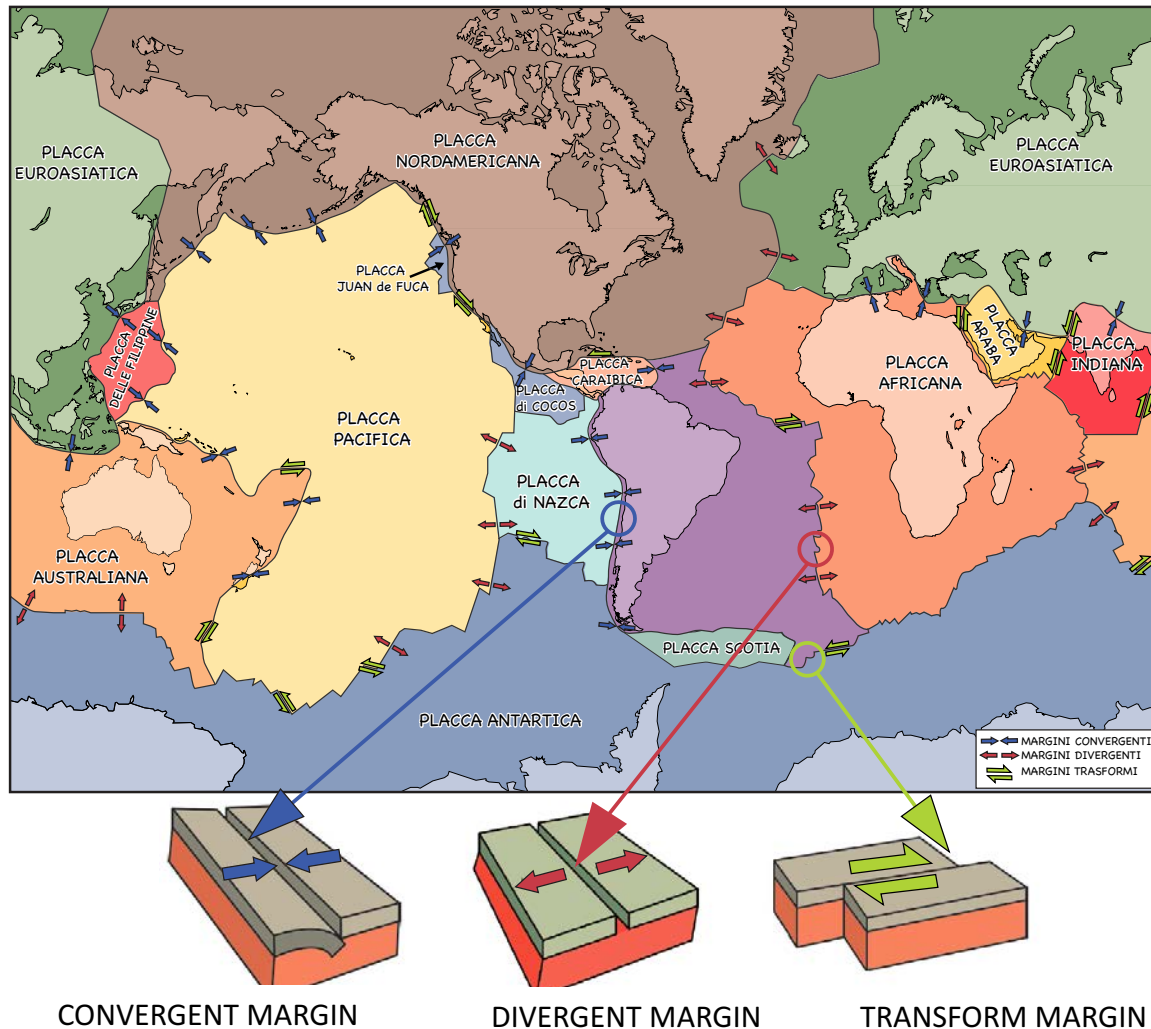


Ischia, Agosto 2017, 2 vittime

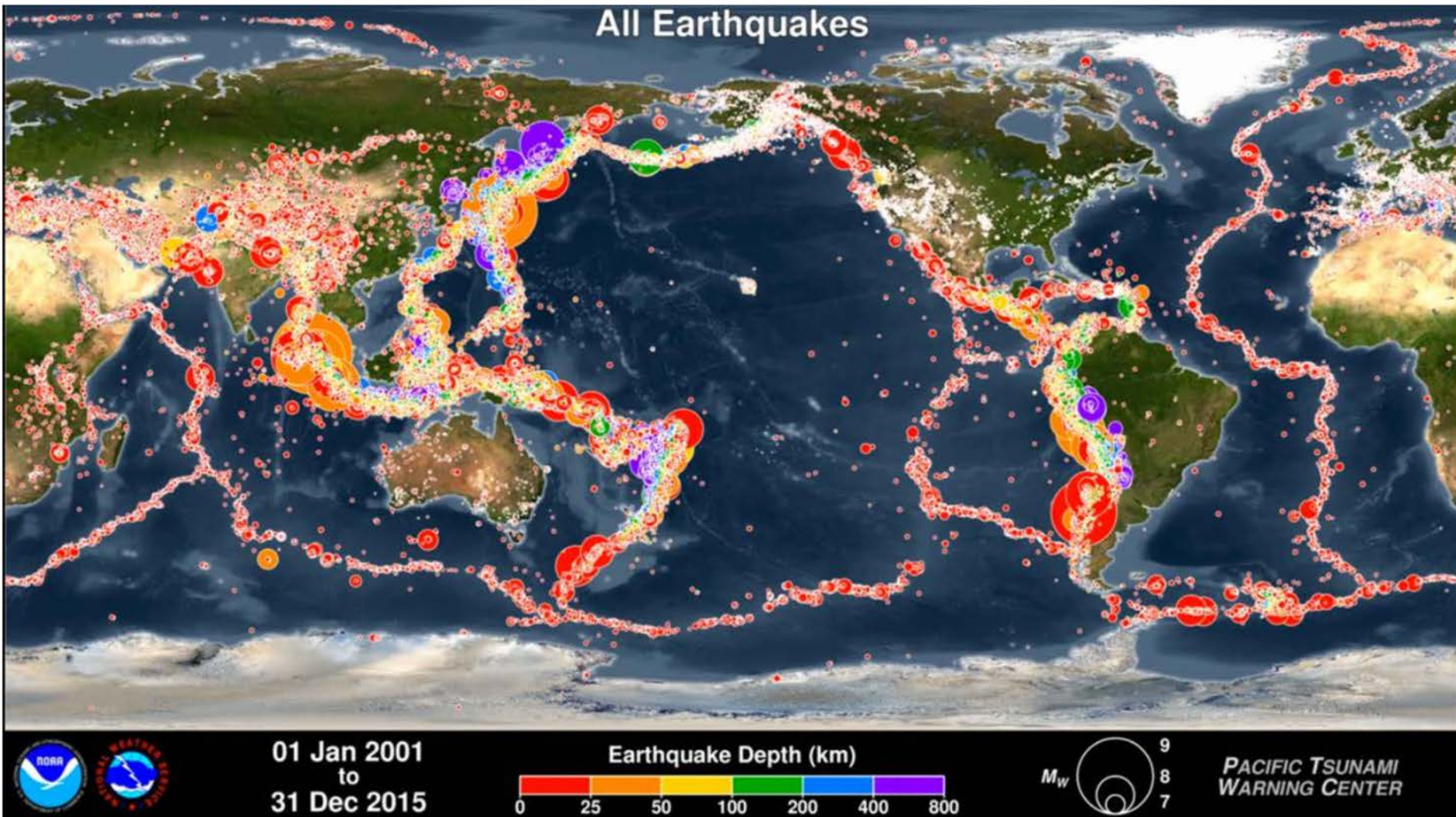
Italy is a  
seismic  
country



# THE ANSWER COMES FROM PLATES TECTONICS: THE EARTH IS a 'RESTLESS' PLANET....

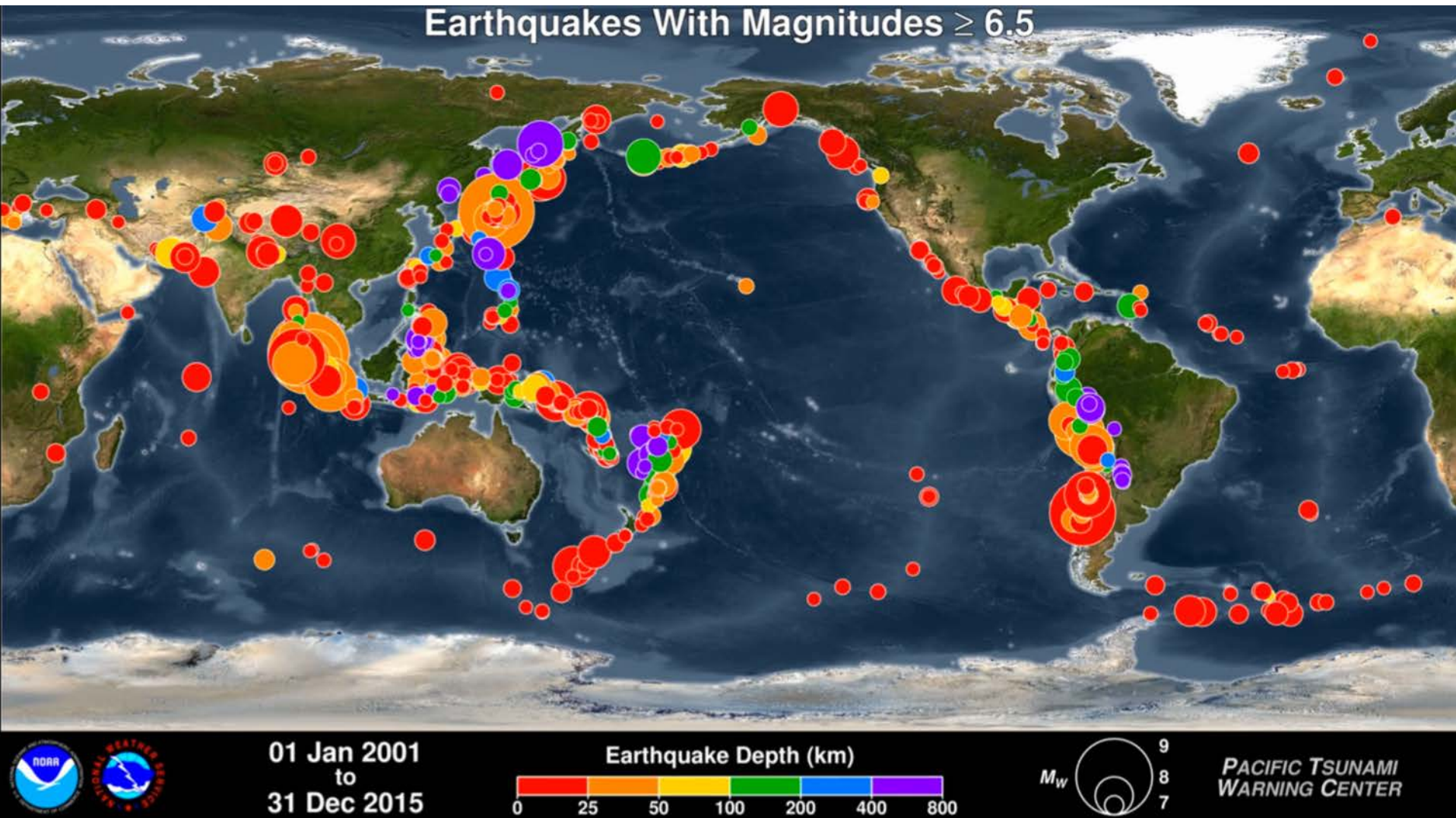






<https://www.youtube.com/watch?v=ph7Eczs-nTl>





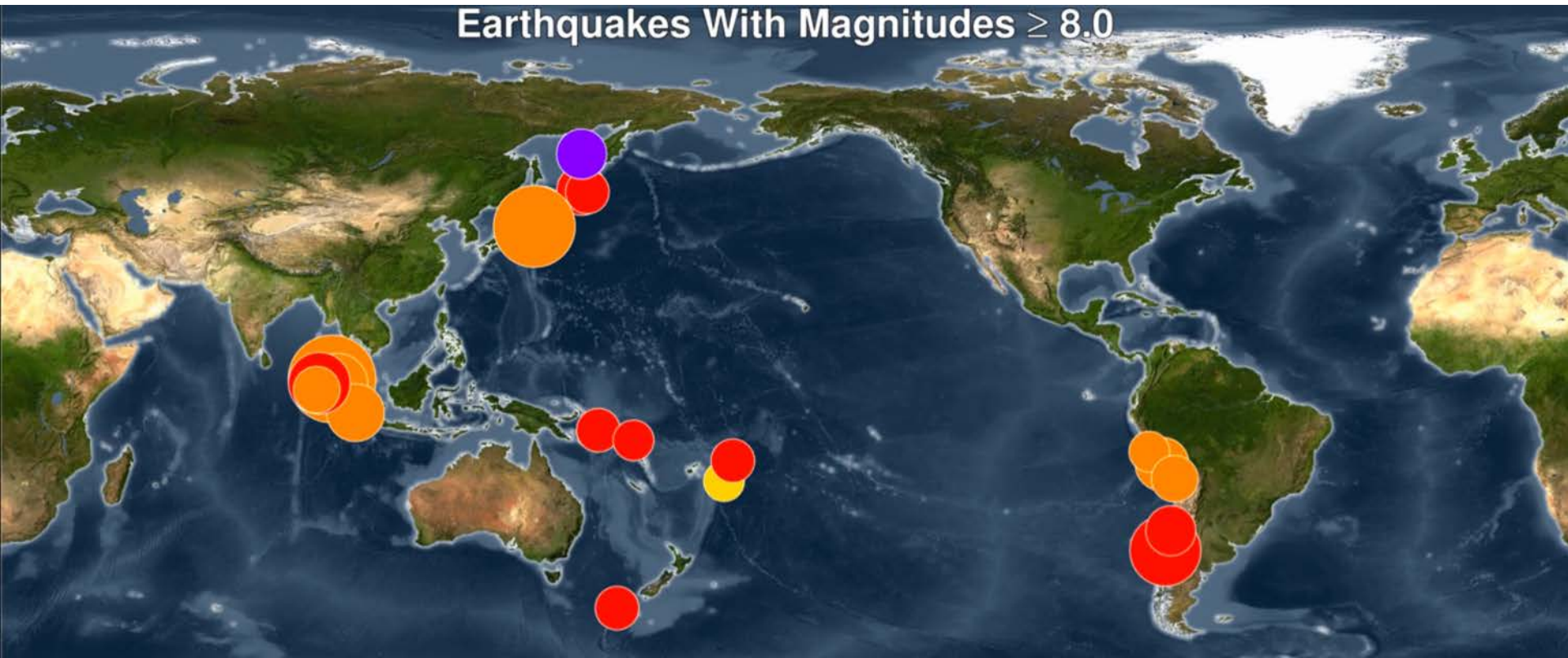
<https://www.youtube.com/watch?v=ph7Eczs-nTI>

## Earthquakes With Magnitudes $\geq 8.0$





## Earthquakes With Magnitudes $\geq 8.0$



# WHAT IS EARTHQUAKE MAGNITUDE?



01 Jan 2001  
to  
31 Dec 2015

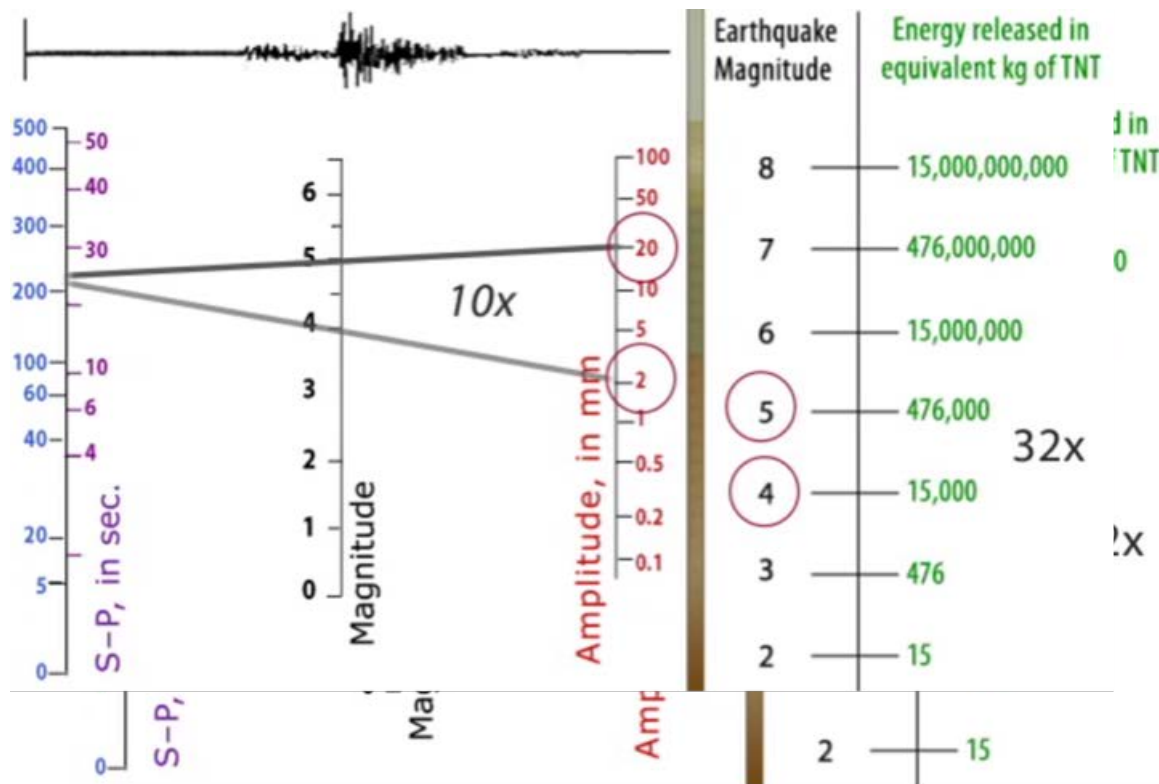


PACIFIC TSUNAMI  
WARNING CENTER

<https://www.youtube.com/watch?v=ph7Eczs-nTI>

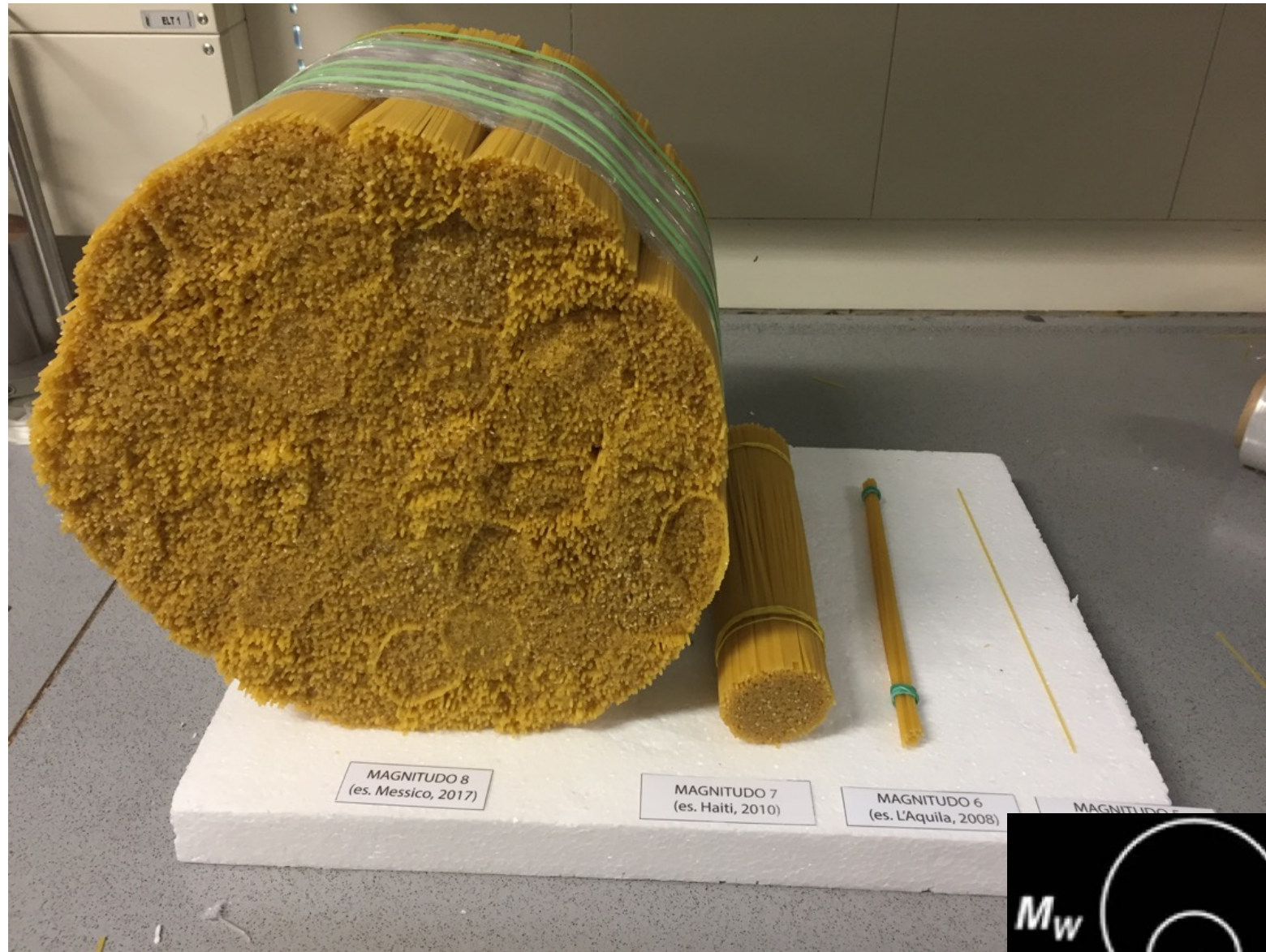


**1 degree of difference = 10 times amplitude, 32 times energy**  
**2 degree of difference = 100 times amplitude, 1000 times energy**



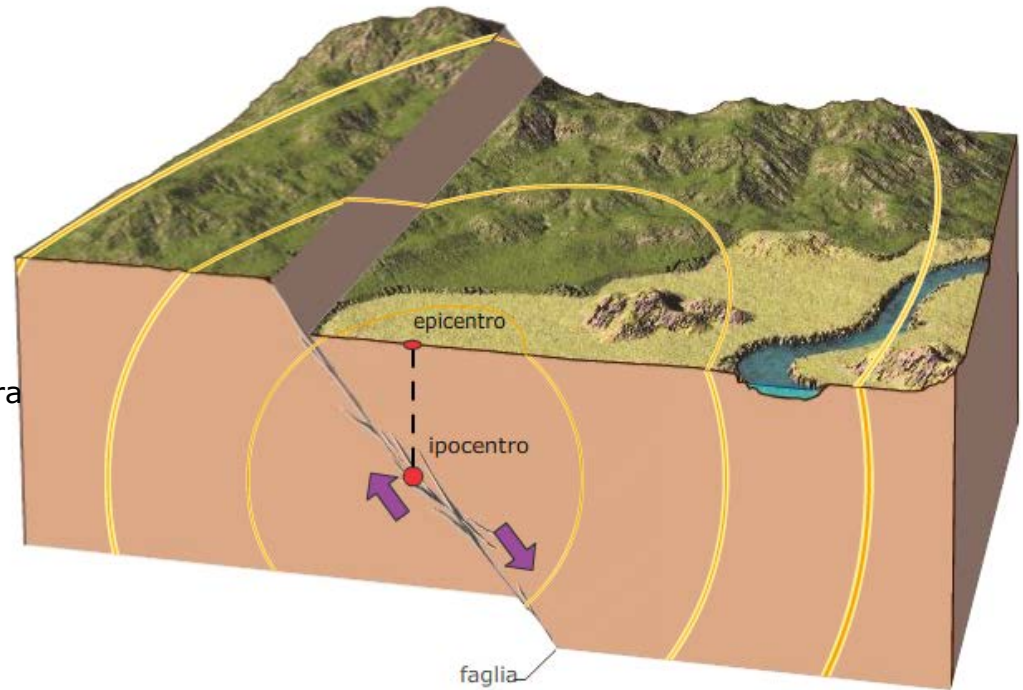
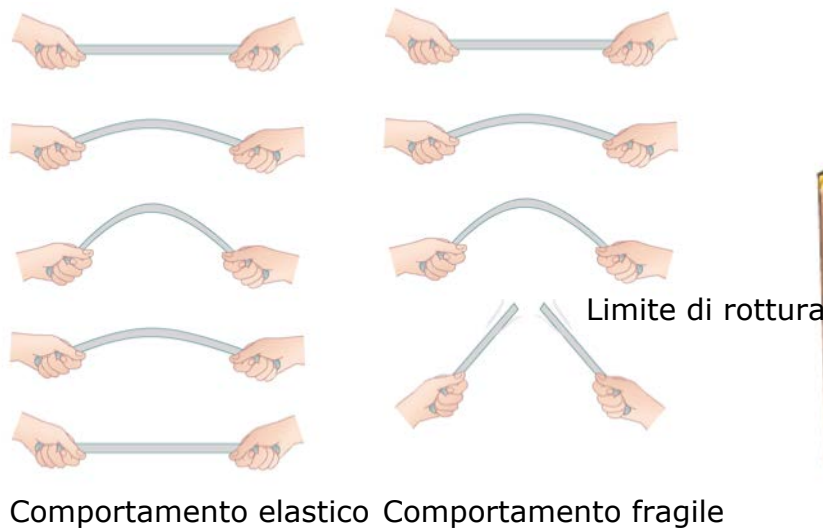


# IMPORTANCE OF LABORATORY APPROACH





# Earthquakes are natural phenomena



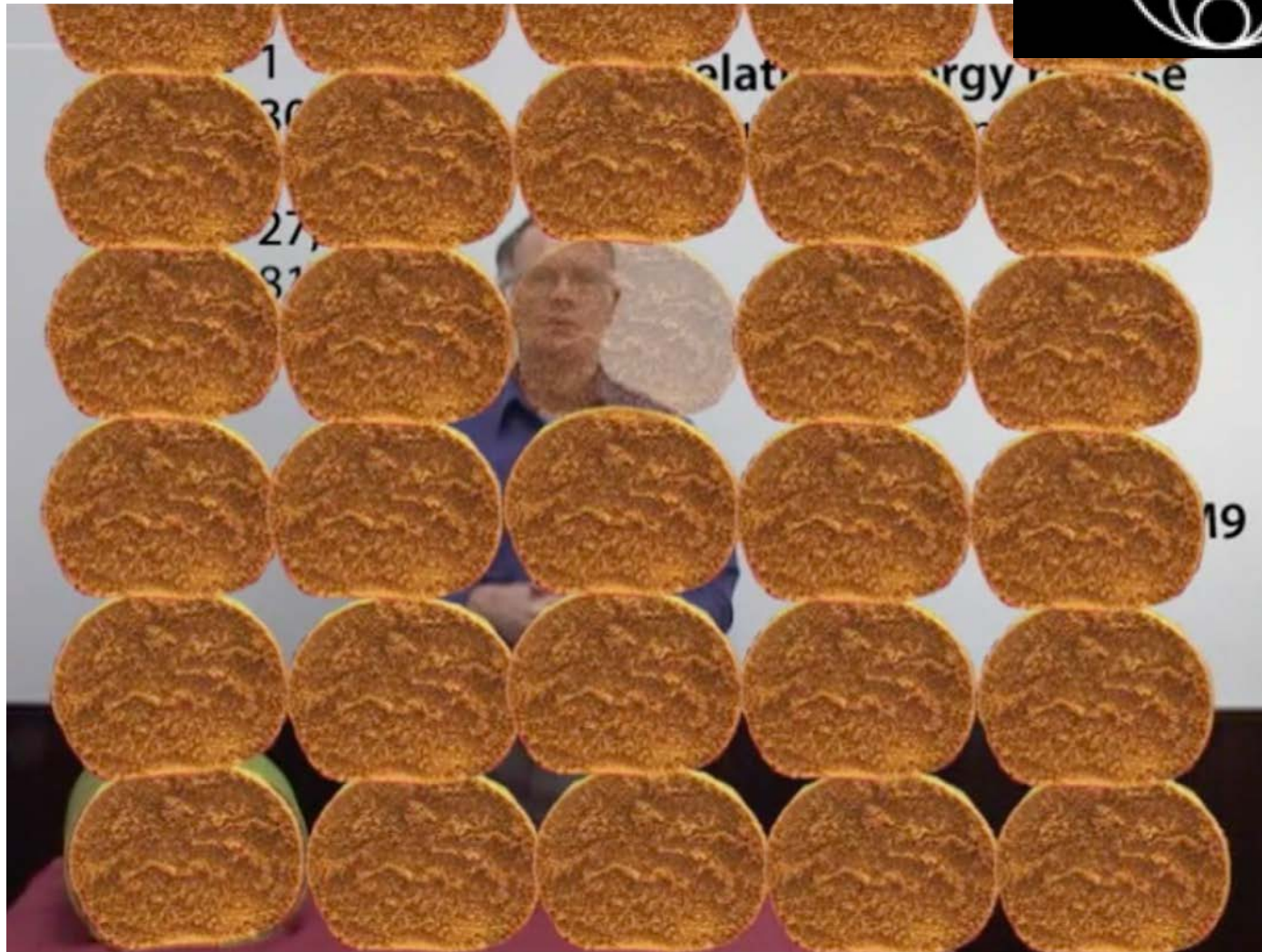
An **earthquake** is the shaking of the surface of the Earth resulting from the sudden release of energy in the Earth's lithosphere that produces **seismic waves**



# HOW BIG?



# HOW BIG?



$M = 9$   
Japan 2011

[https://www.iris.edu/hq/inclass/video/pasta\\_quake\\_modeling\\_magnitude\\_scale\\_using\\_spaghetti](https://www.iris.edu/hq/inclass/video/pasta_quake_modeling_magnitude_scale_using_spaghetti)



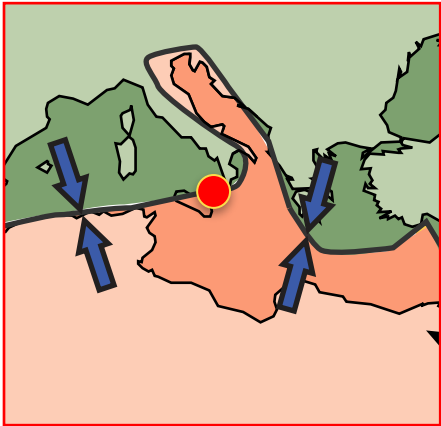


# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES





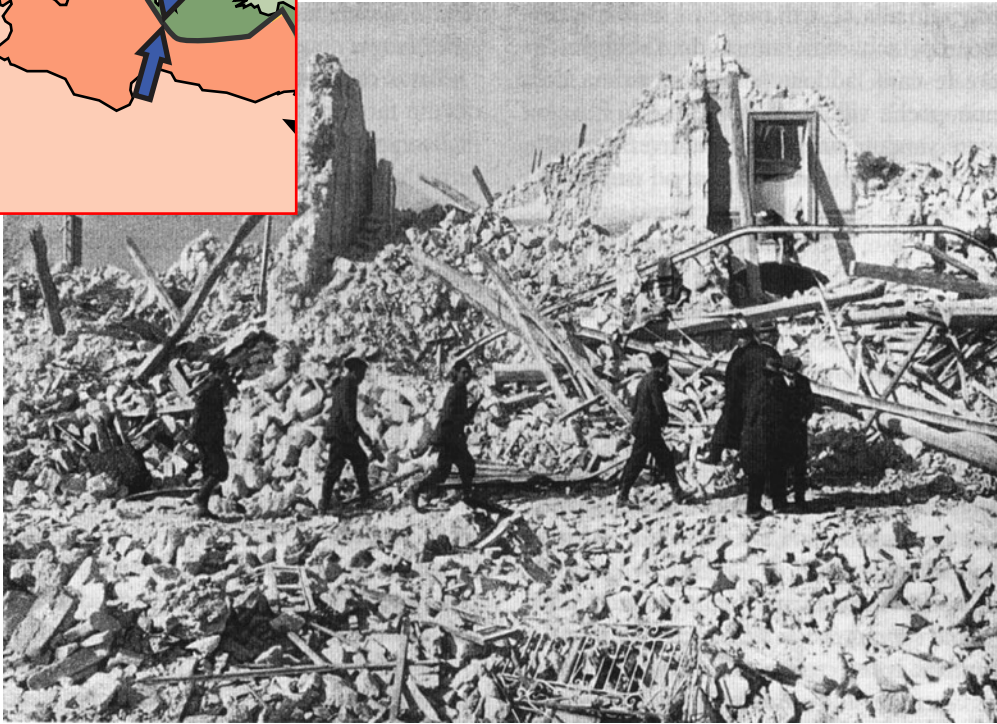
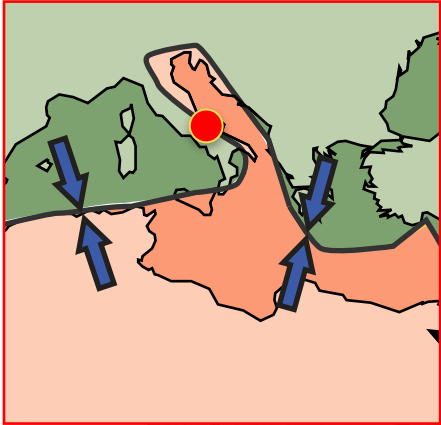
# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Reggio e Messina, 8  
Dicembre 1908  
 $M = 7.1$   
Tsunami  
Vittime : 123.000



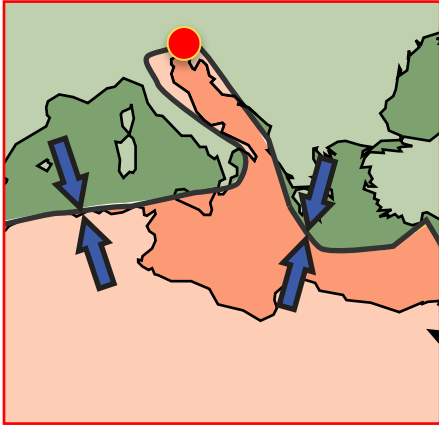
# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Avezzano, 13 Gennaio 1915  
 $M = 7$   
 Vittime : 3000



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Gemona 6 maggio e 11-15  
settembre 1976

$M = 6.4$

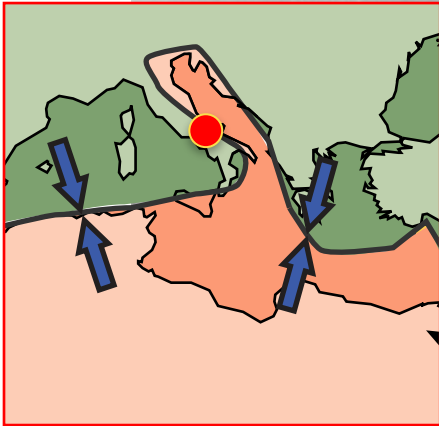
Vittime: 990

Oltre 45.000 senza tetto





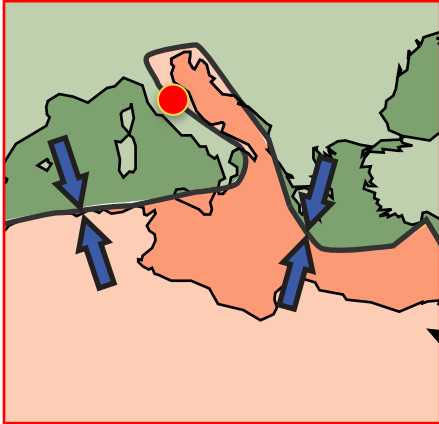
# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Irpinia 23 Novembre,  
1980  
 $M = 6.8$   
Vittime: 2914,  
feriti: 10.000  
Senza tetto: 300.000



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



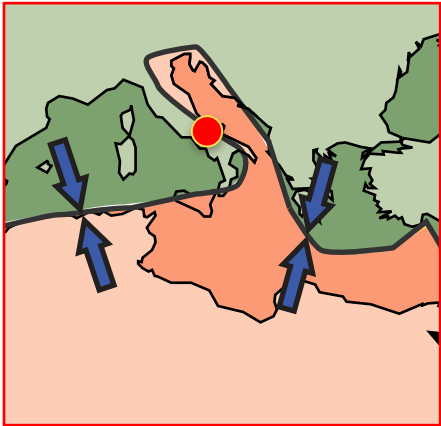
Umbria-Marche, 1997-  
1998  
 $M = 5.7$   
11 vittime  
80000 case danneggiate







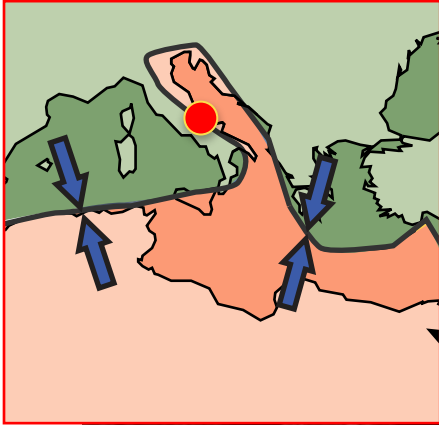
# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Molise, 31 ottobre  
2002  
 $M = 5.7$   
Vittime: 28 (27 alunni  
di una scuola e la loro  
maestra)



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES

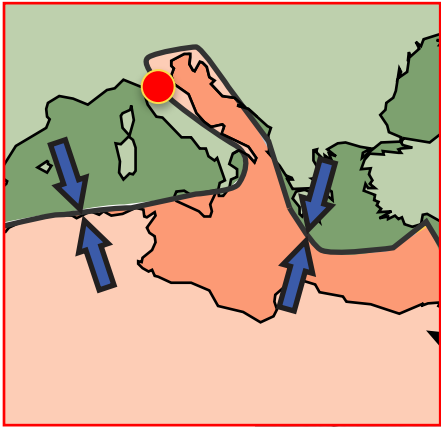


L'Aquila, 6 Aprile  
2009  
 $M = 6.3$   
Vittime : 308, feriti :  
1.500  
Senza tetto: 65.000

L'Aquila, 2009



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Emilia, 20 maggio 2012  
 $M = 5.9$   
Vittime : 26  
11 miliardi di euro di danni stimati



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES



Amatrice, 24 agosto 2016

$M = 6$

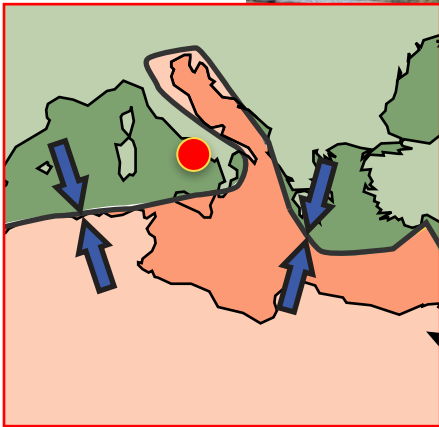
Vittime: 299, feriti: più di 400

Quasi 500 persone estratte vive dalle macerie

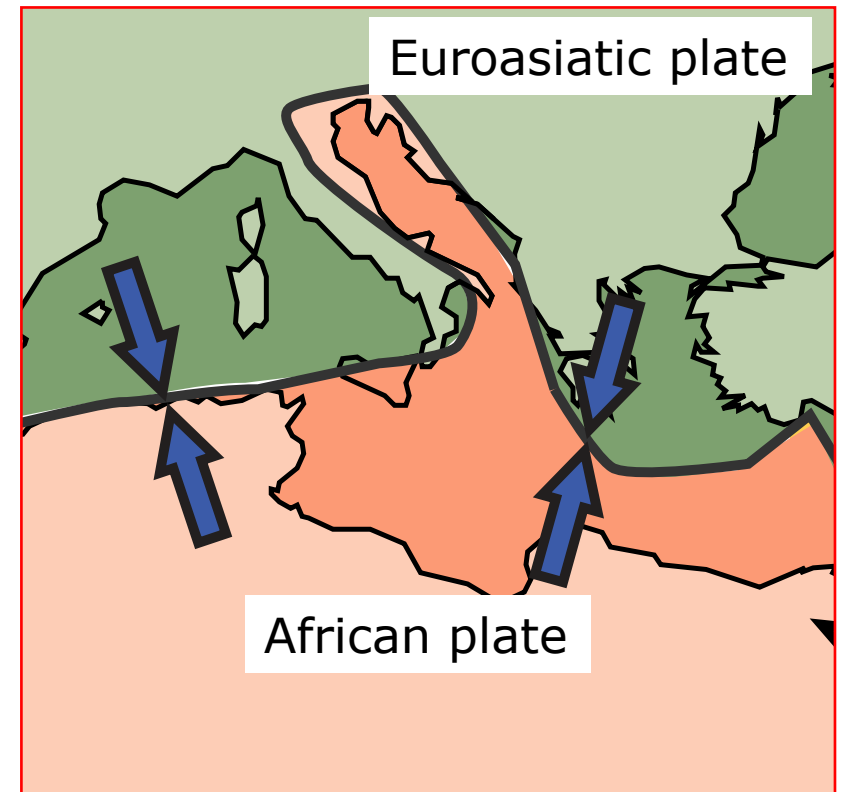
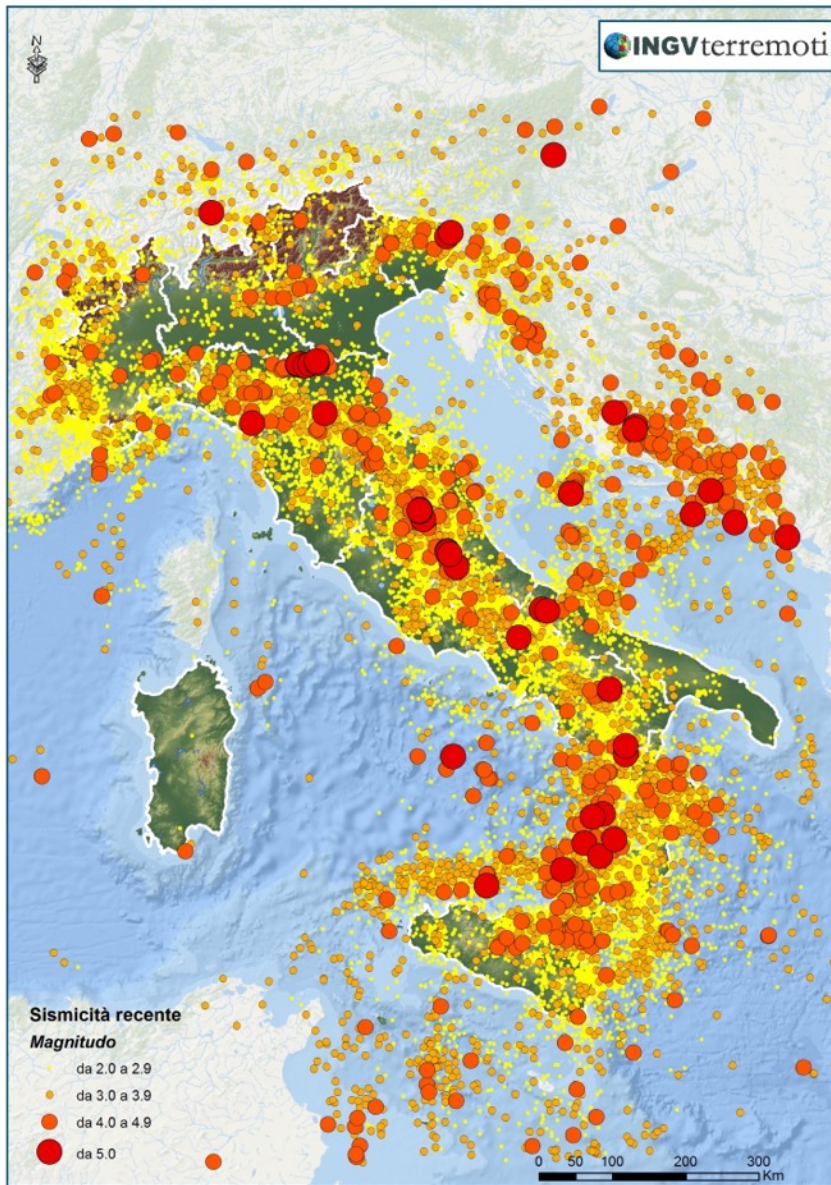
Gravemente lesionati ed evacuati Amatrice, Accumoli, Arquata, Pescara del Tronto



# SIZE AND DISTRIBUTION OF ITALIAN EARTHQUAKES

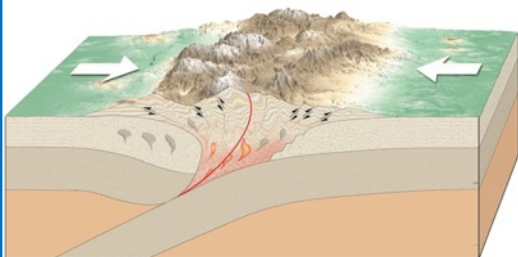


Casamicciola, 21 Agosto 2017  
 $M=4.0$   
2 vittime

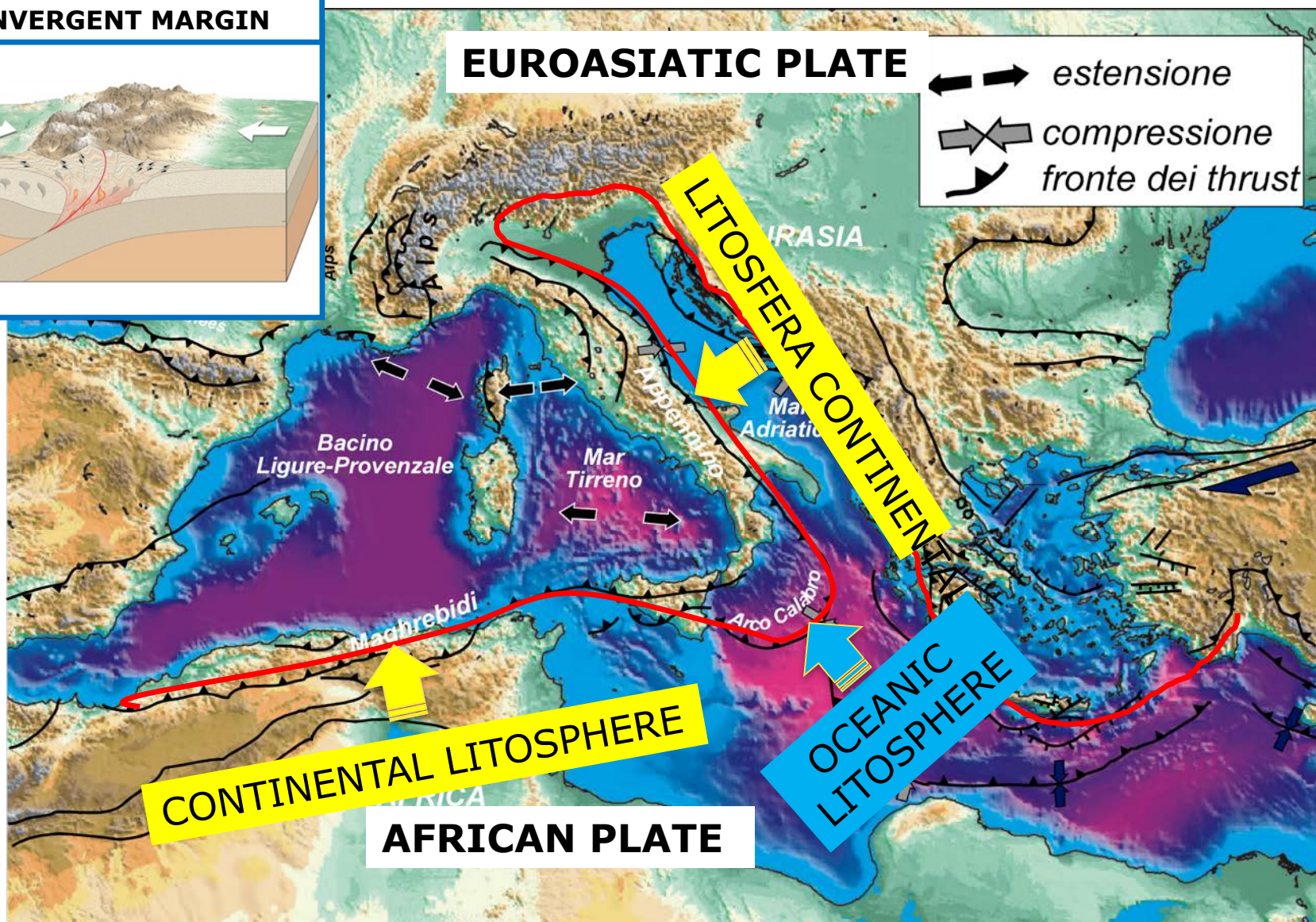
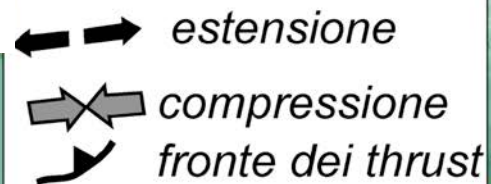




## CONVERGENT MARGIN



## EUROASIATIC PLATE

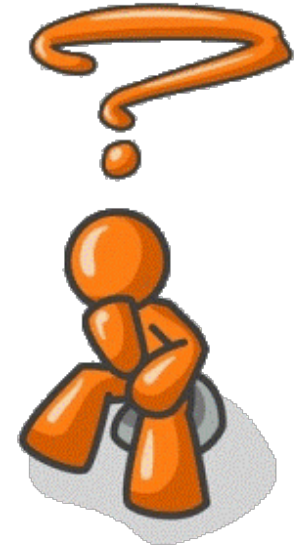




M =6.0



**Amatrice, 24 agosto 2016 (300 vittime)**



M =4.0



**Ischia, Agosto 2017, 2 vittime**

- ✓ Italy is a seismic country
- ✓ The magnitudes are not very high compared to other areas on our planet (Japan, Chile, etc.)
- ✓ The damage caused by earthquakes is always huge



# DEFINITION OF SEISMIC RISK



**Natural event  
(hazard)**

+



**densely populated areas  
(Vulnerability and exposure)**

=

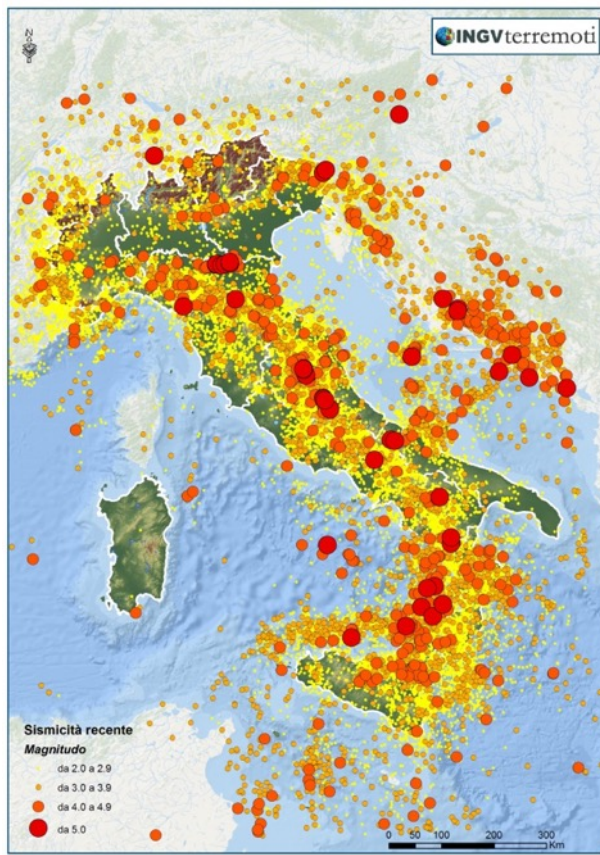


**RISK**

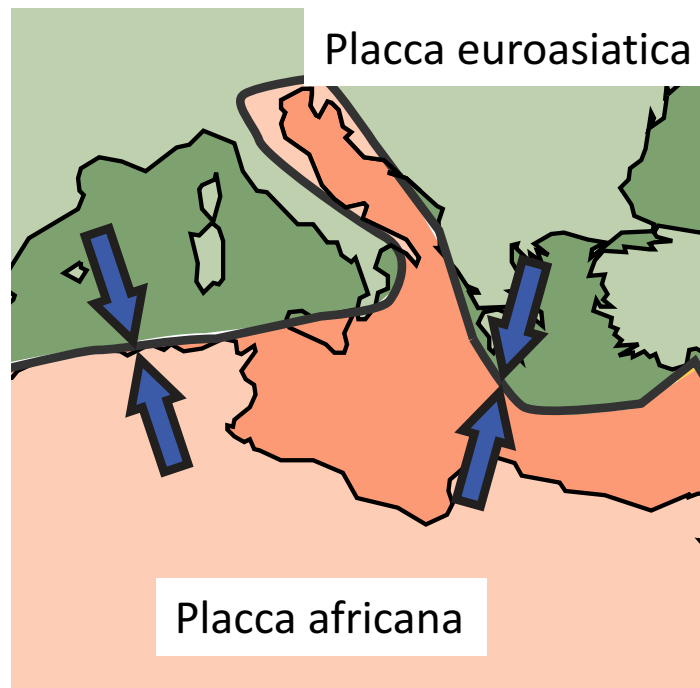
Seismic risk is the measurement of the damage expected in a given interval of time, based on the type of seismicity, the resistance of buildings and anthropisation (nature, quality and quantity of assets exposed)



**SEISMIC HAZARD** = the probability that a seismic event of a given magnitude occur in a certain interval of time



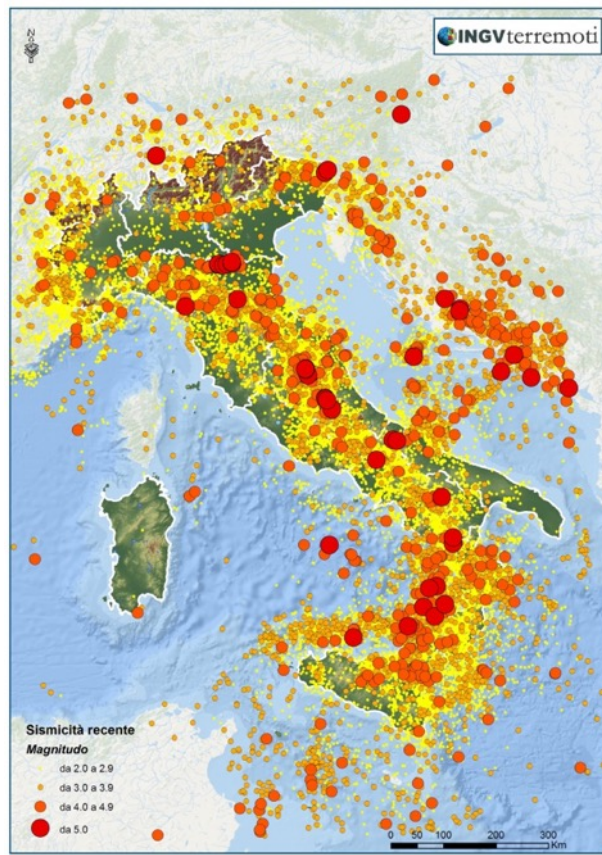
Italy has a **medium-high seismic hazard** (due to the frequency and intensity of phenomena)







**SEISMIC VULNERABILITY** = A building's potential for damage. The consequences of an earthquake also depend on the resistance of buildings to the effects of a seismic tremor. The more vulnerable a building is (due to its type, inadequate design, poor quality materials and construction methods, lack of maintenance), the greater the consequences will be.

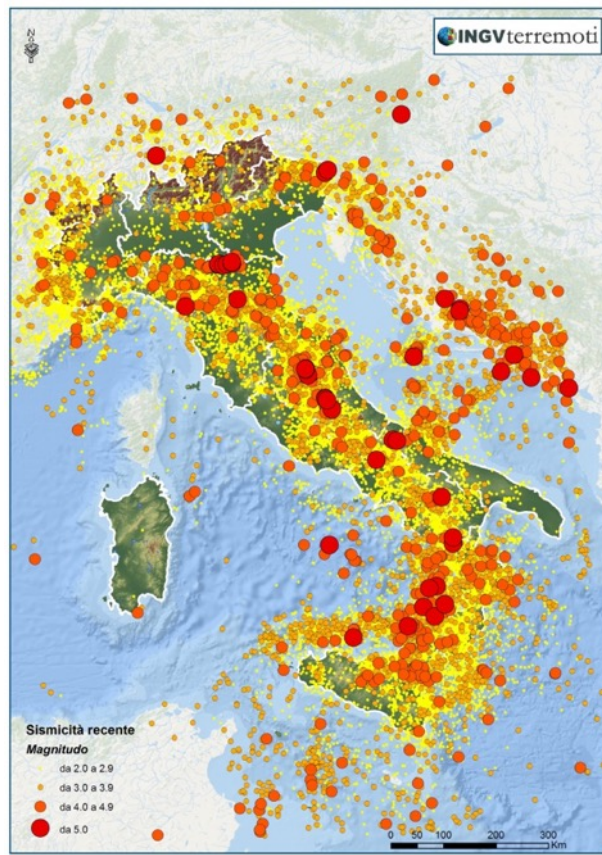


In Italy the seismic **vulnerability is very high** (due to the fragility of buildings, infrastructural, industrial, production and service assets)





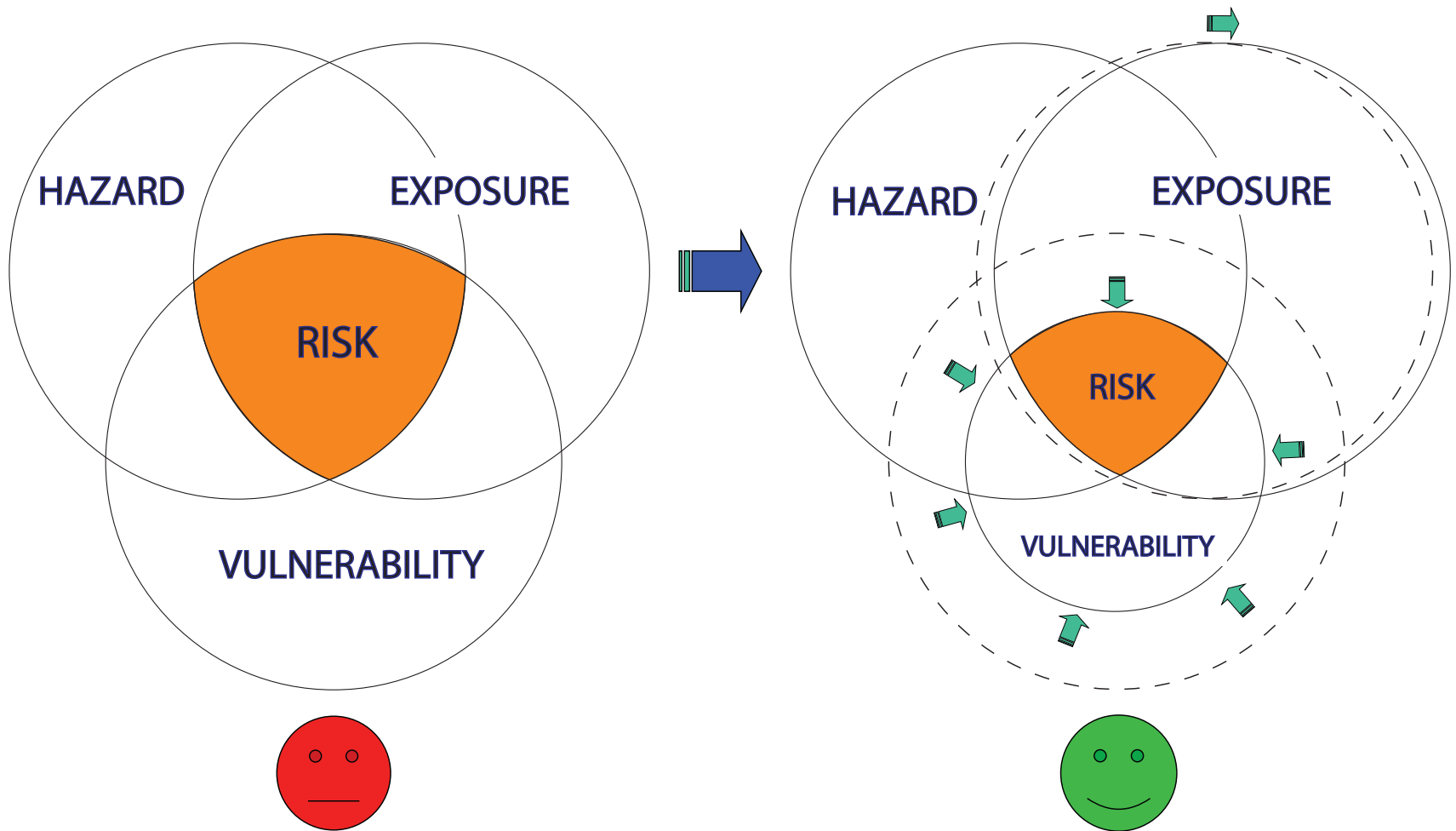
**EXPOSURE** = the number of assets exposed to risk, the possibility in other words of damage in economic terms, to cultural heritage or the loss of human lives



Italy has an **extremely high exposure** (due to population density and its historical, artistic and monumental heritage that is one of its kind in the world)







**HAZARD** → probability of occurrence of an event with the potential for destruction in a defined area and a given time interval

**VULNERABILITY** → expected degree of loss due to a destructive event

**EXPOSURE** → economic loss (people and properties)

**NATURAL HAZARDS ARE ANAVOIDABLE BUT  
NATURAL DISASTERS ARE NOT!**



## MAIN GOALS OF LABORATORIES IN CLASS

What is important to share with students?

- Understanding earthquake as a natural and physical phenomenon
- Understanding why earthquakes are not predictable
- Understanding why it is important prevention to limit the effects of earthquakes



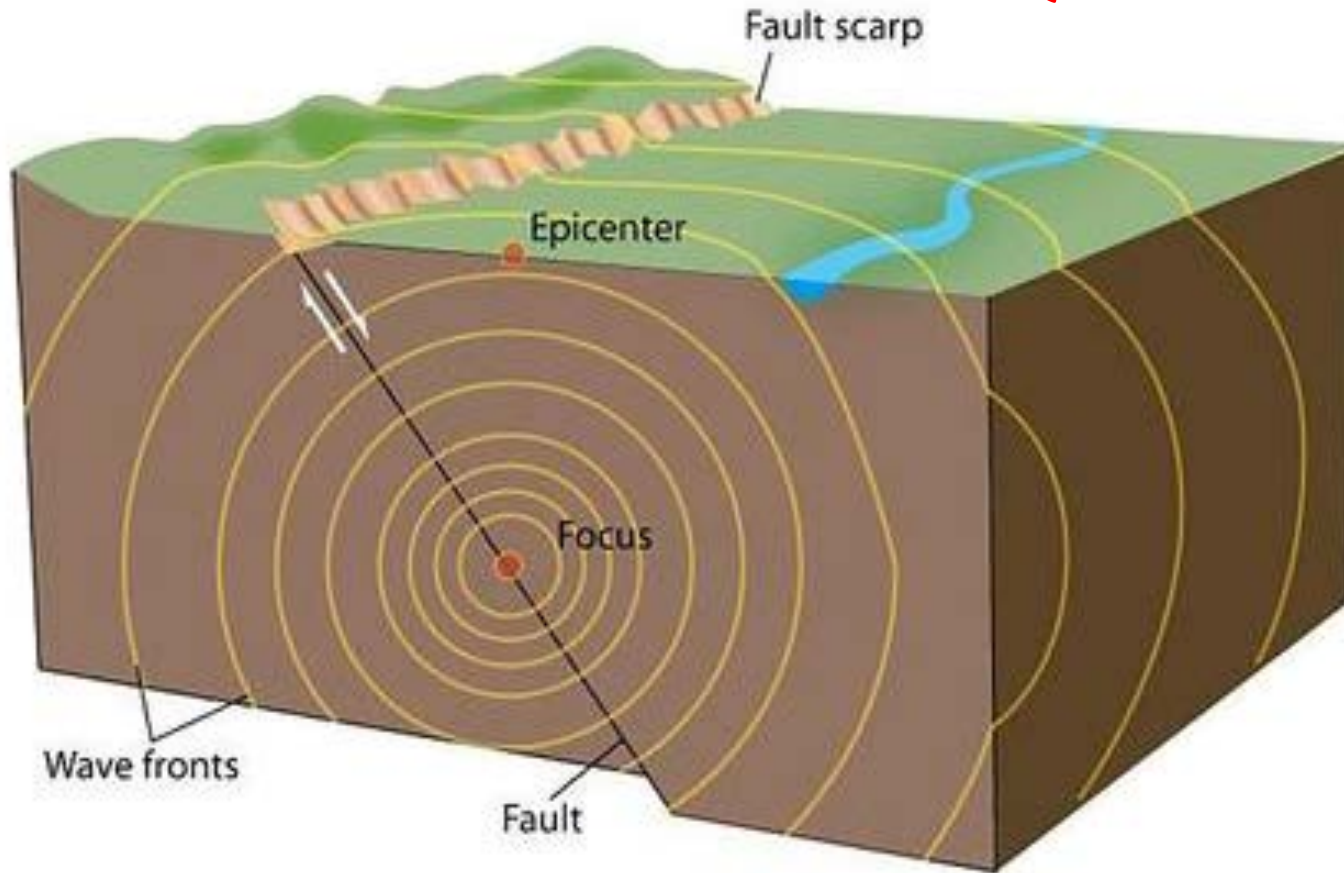
# **EARTHQUAKES**

## **WHAT IS AN EARTHQUAKE?**





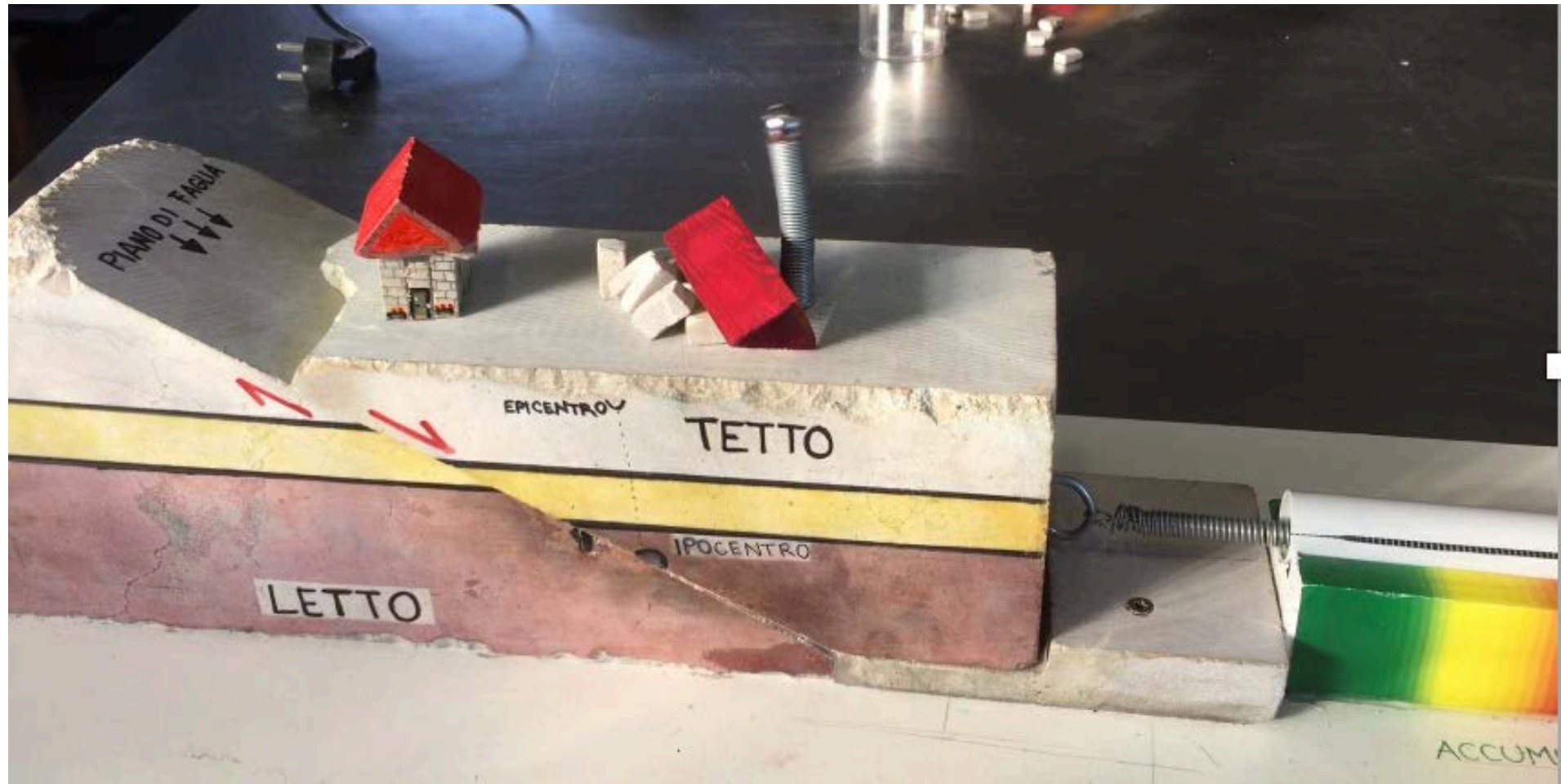
# WHAT IS AN EARTHQUAKE?



An **earthquake** is the shaking of the surface of the Earth resulting from the sudden release of energy in the Earth's lithosphere that creates **seismic waves**



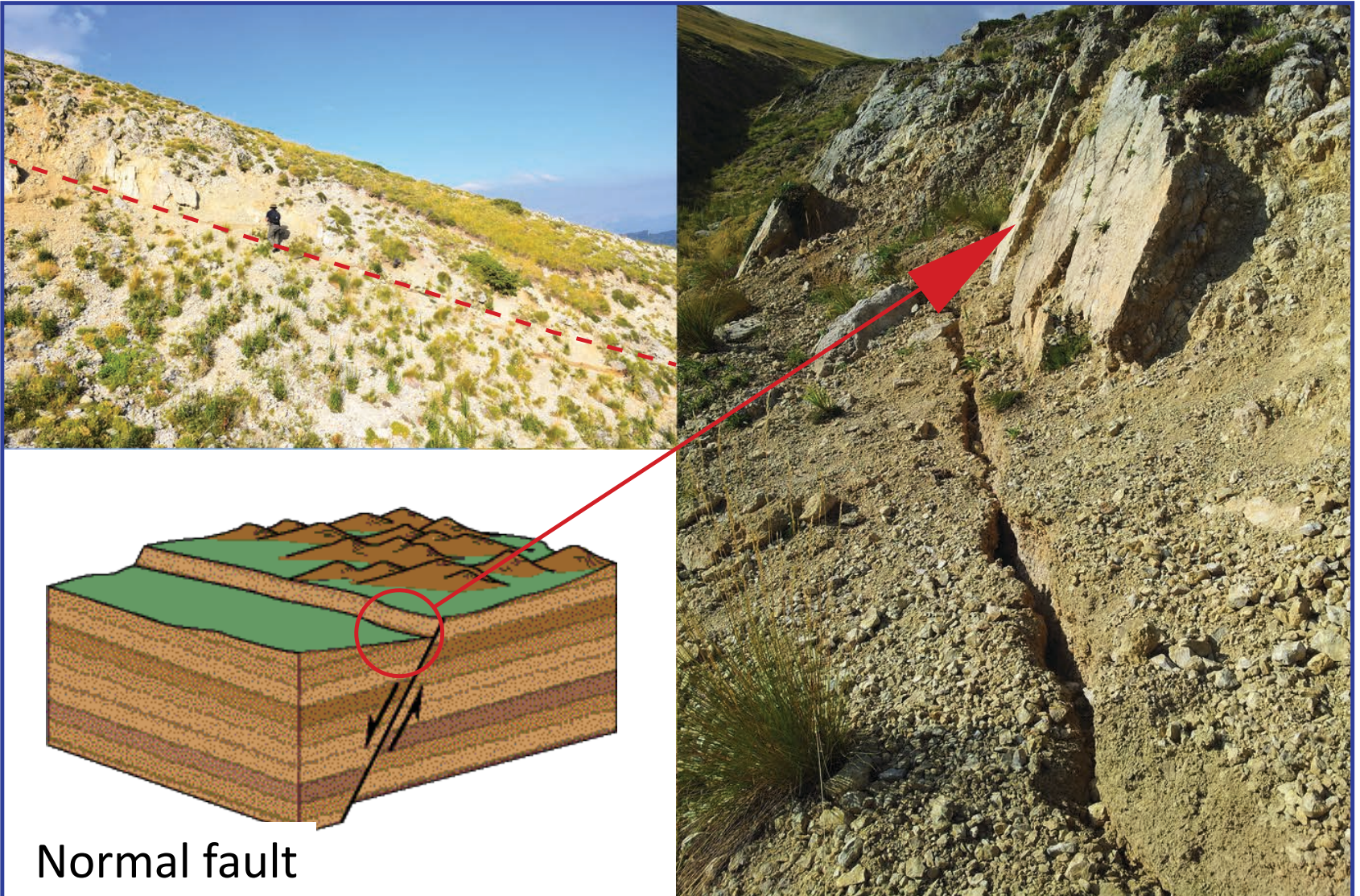
## EXTENSIONAL FAULT



[https://drive.google.com/file/d/1WBvPAh8KT\\_StBPUOZDiXfj2QmkSwUfvC/view?usp=sharing](https://drive.google.com/file/d/1WBvPAh8KT_StBPUOZDiXfj2QmkSwUfvC/view?usp=sharing)



## AMATRICE EARTHQUAKE (August 24, 2016)





## Reverse fault



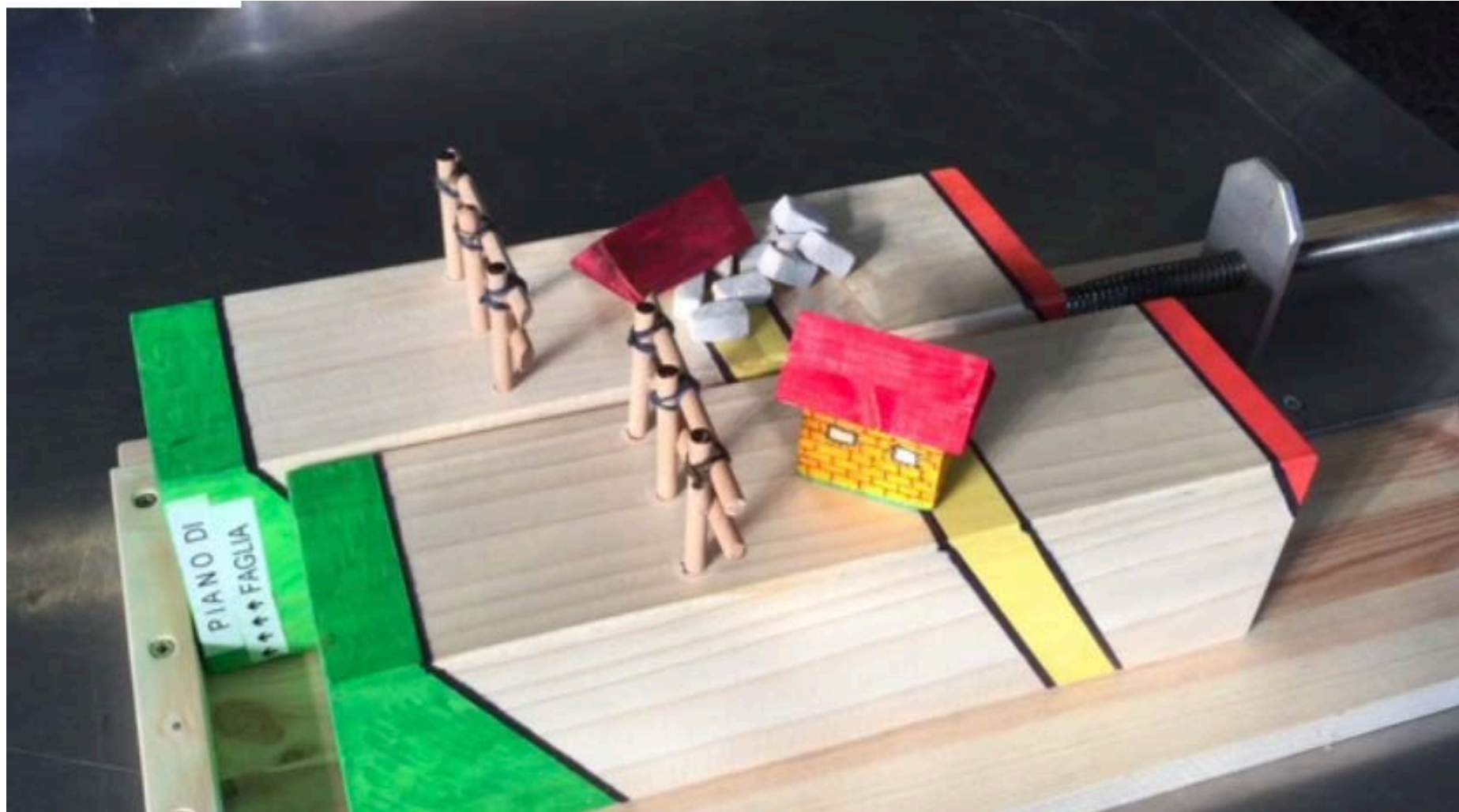
<https://drive.google.com/file/d/1926x-Ld-RTzSDgLUB0gKdUZpmgqX4kYa/view?usp=sharing>



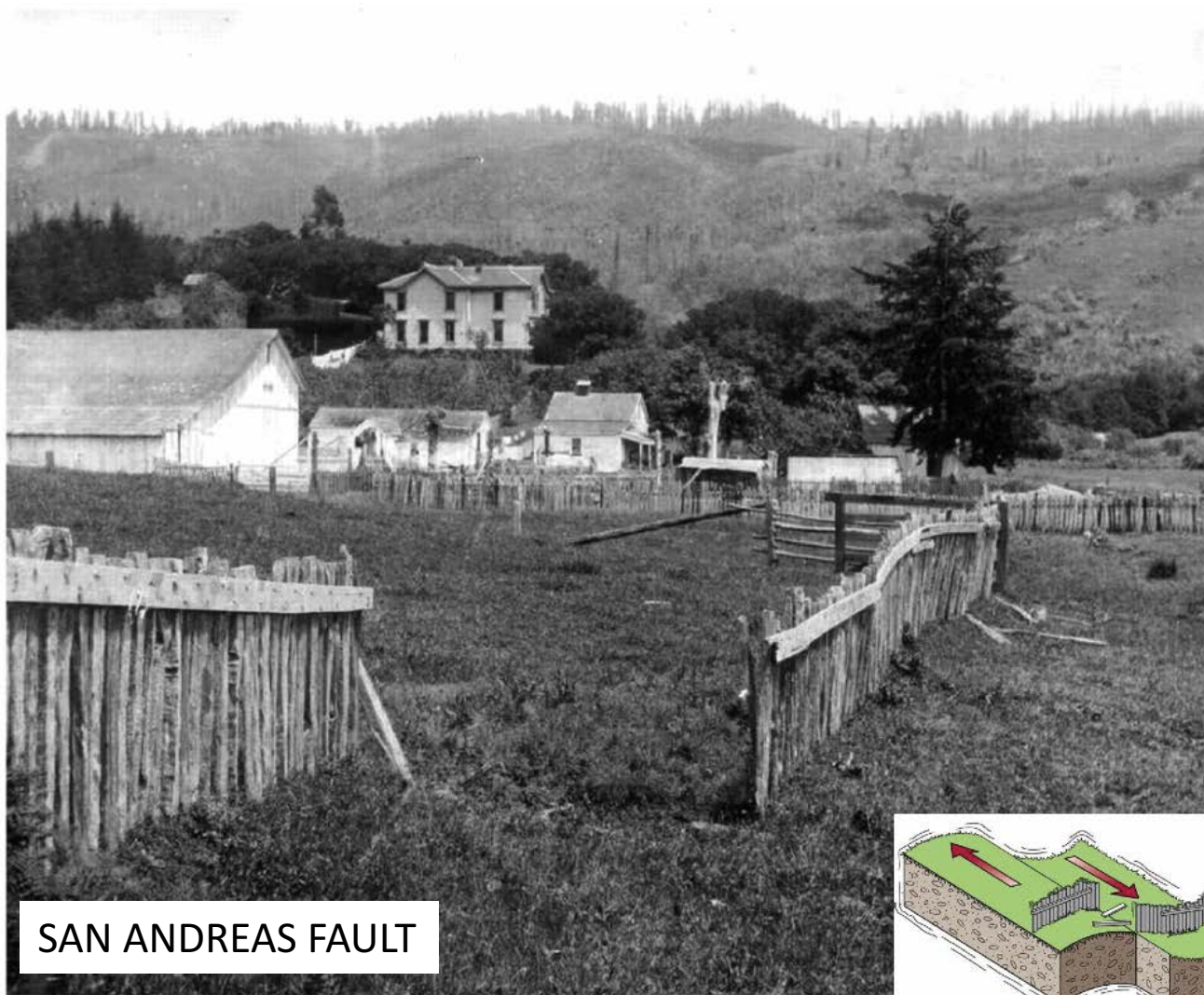
Nojima Fault Preservation Museum



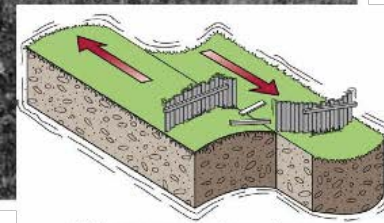
## Strike-slip fault



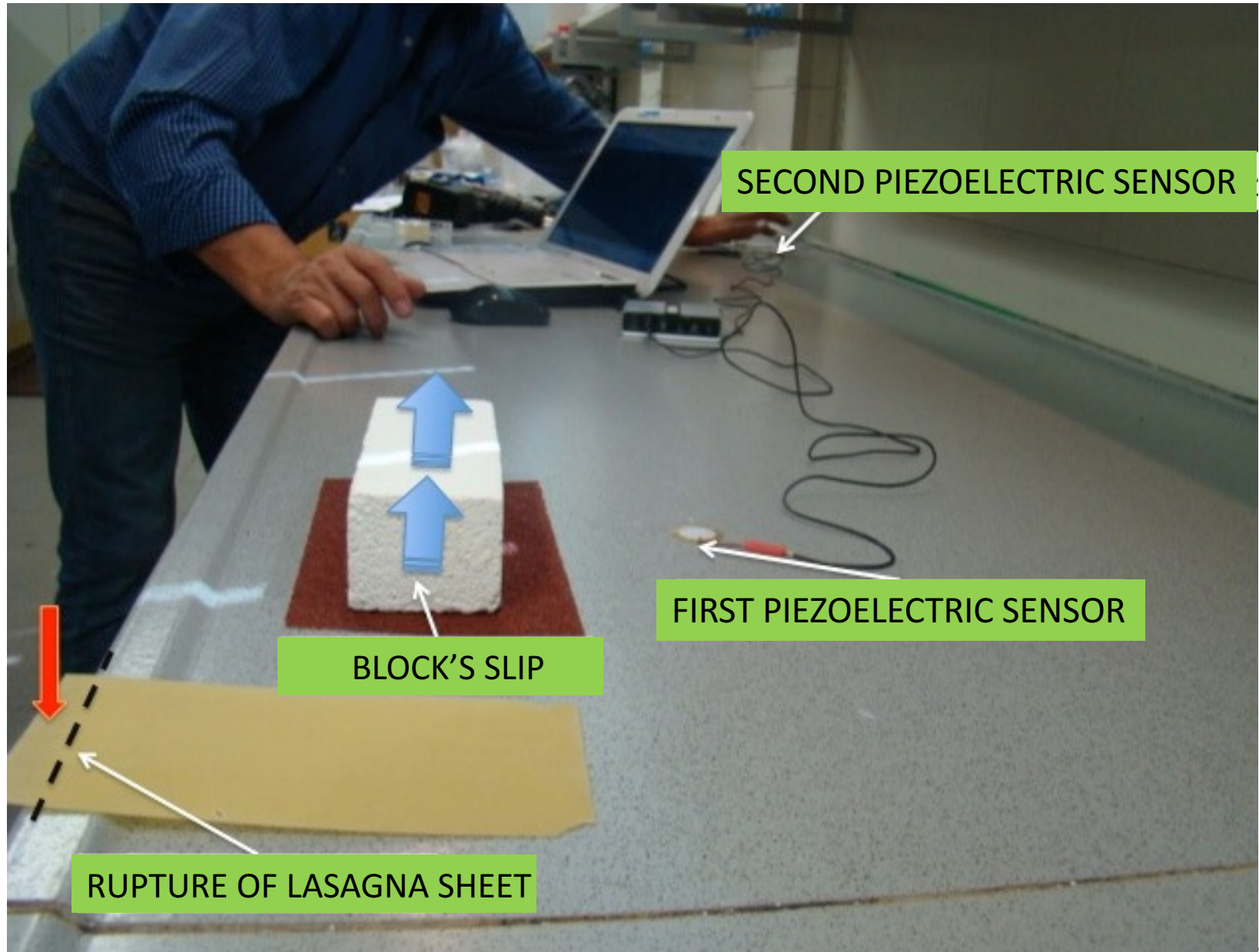
<https://drive.google.com/file/d/1Zv13JS1PMP2r9zZTlc7MjwxMbiwLRzP2/view?usp=sharing>



SAN ANDREAS FAULT

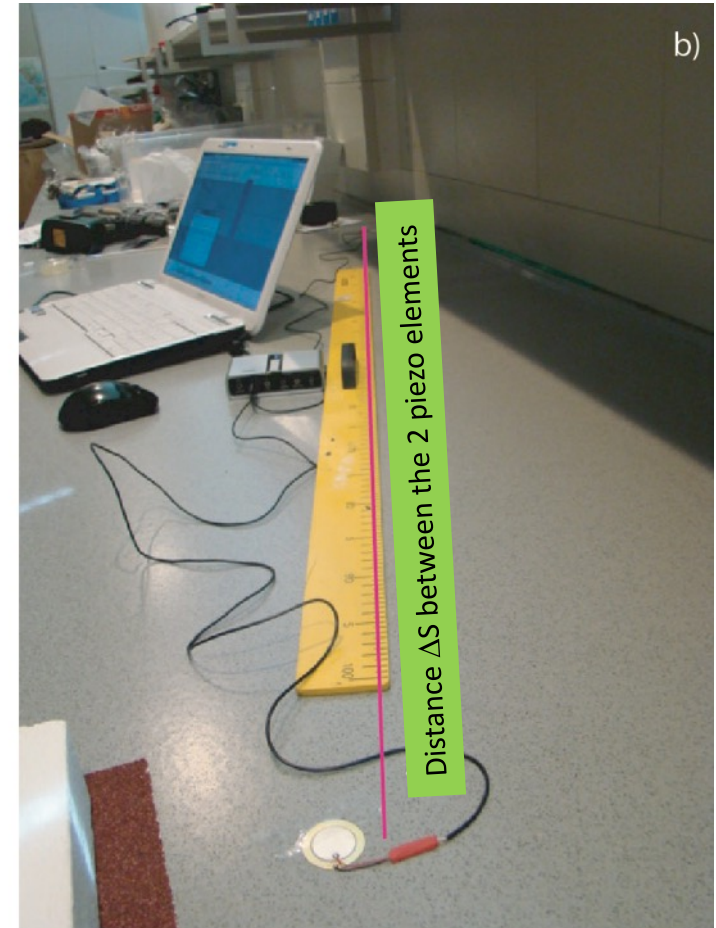
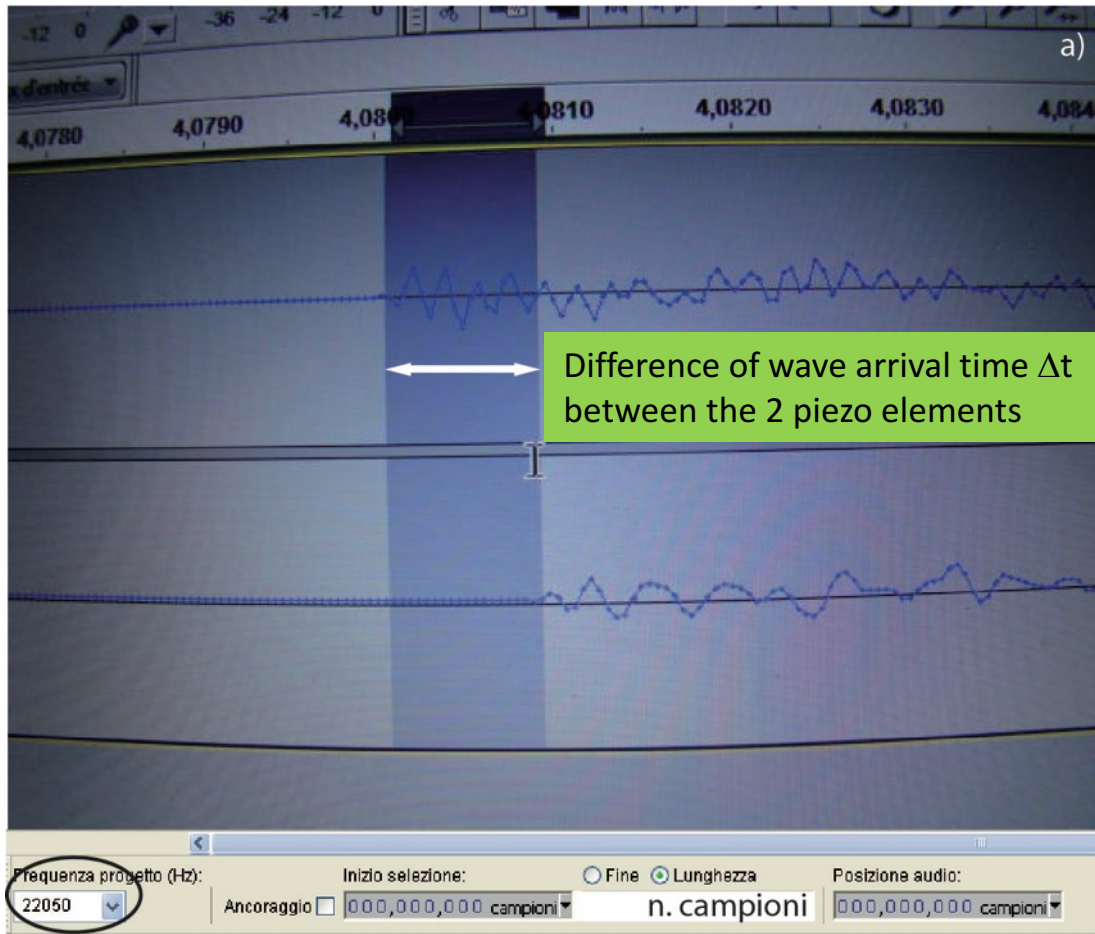






$$v = \frac{\Delta S}{\Delta t}$$

*Audacity software*



It is possible to calculate the wave speed in different materials!!





# ~~EARTHQUAKES~~ ~~EARTH~~

WHAT IS AN EARTHQUAKE?

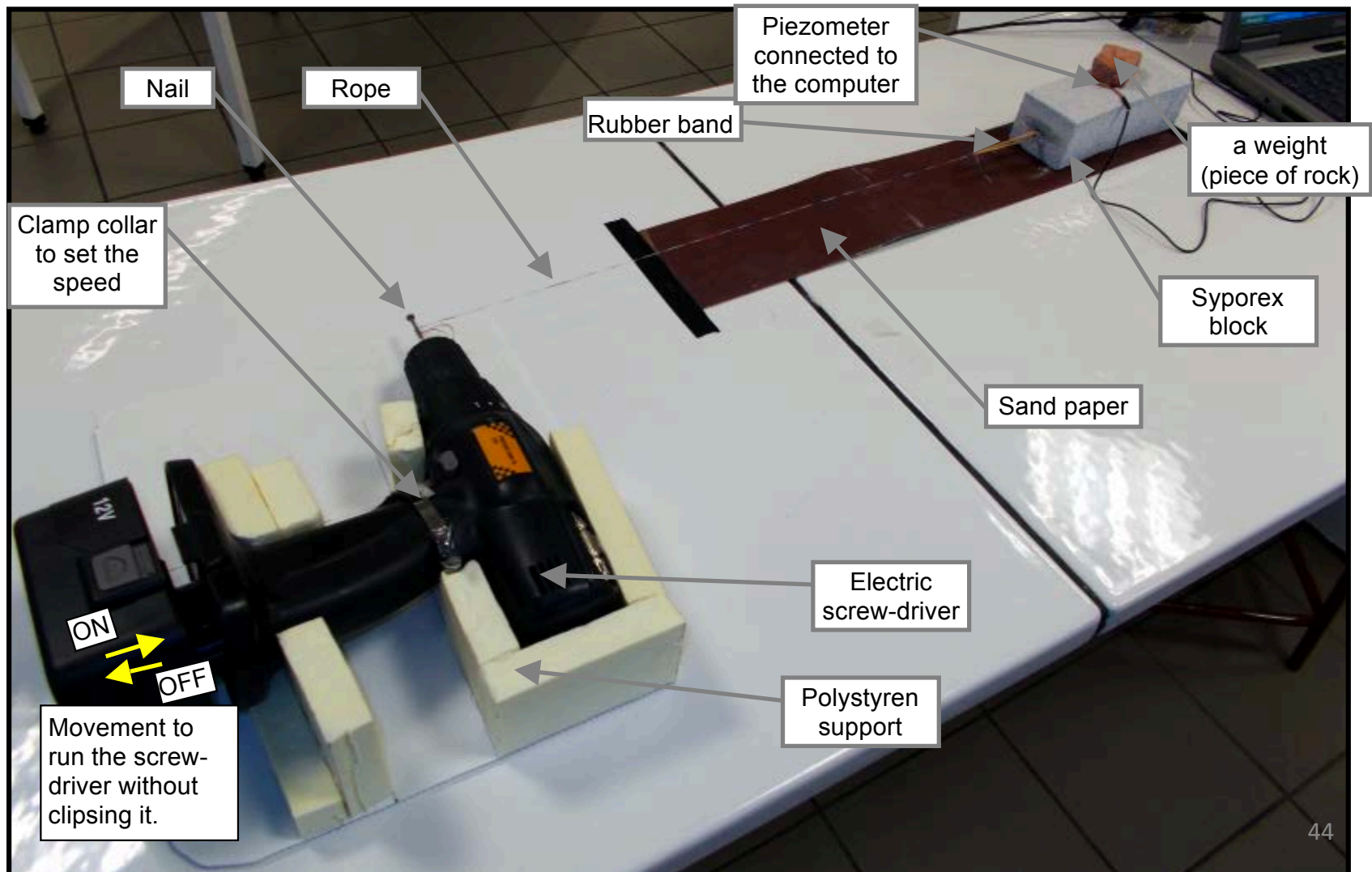


⇐ ~~EARTHQUAKES~~  
IS AN EARTHQUAKE PREDICTABLE?

One of the most common questions that students  
(and in general people) ask is:  
**When, where, and how big the next earthquake will be?**

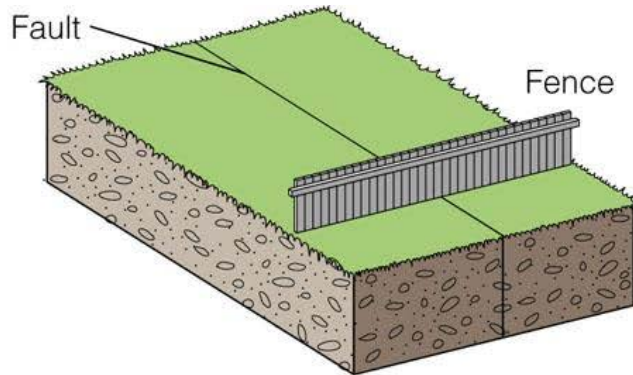
# IS IT POSSIBLE TO PREDICT EARTHQUAKES?

[www.sismobox.com](http://www.sismobox.com)

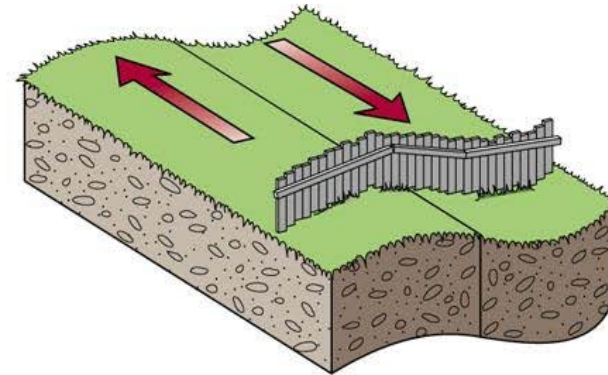




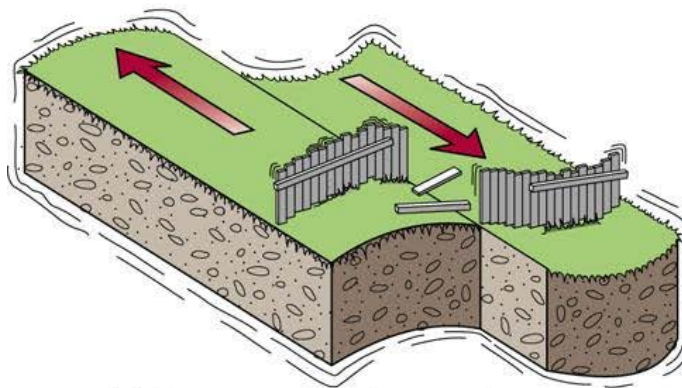
# THE SEISMIC CYCLE



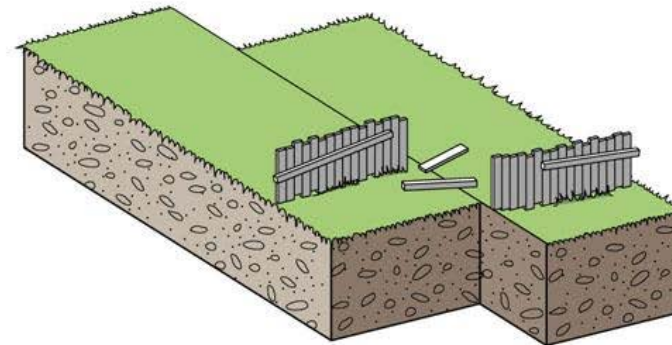
(a) Original position



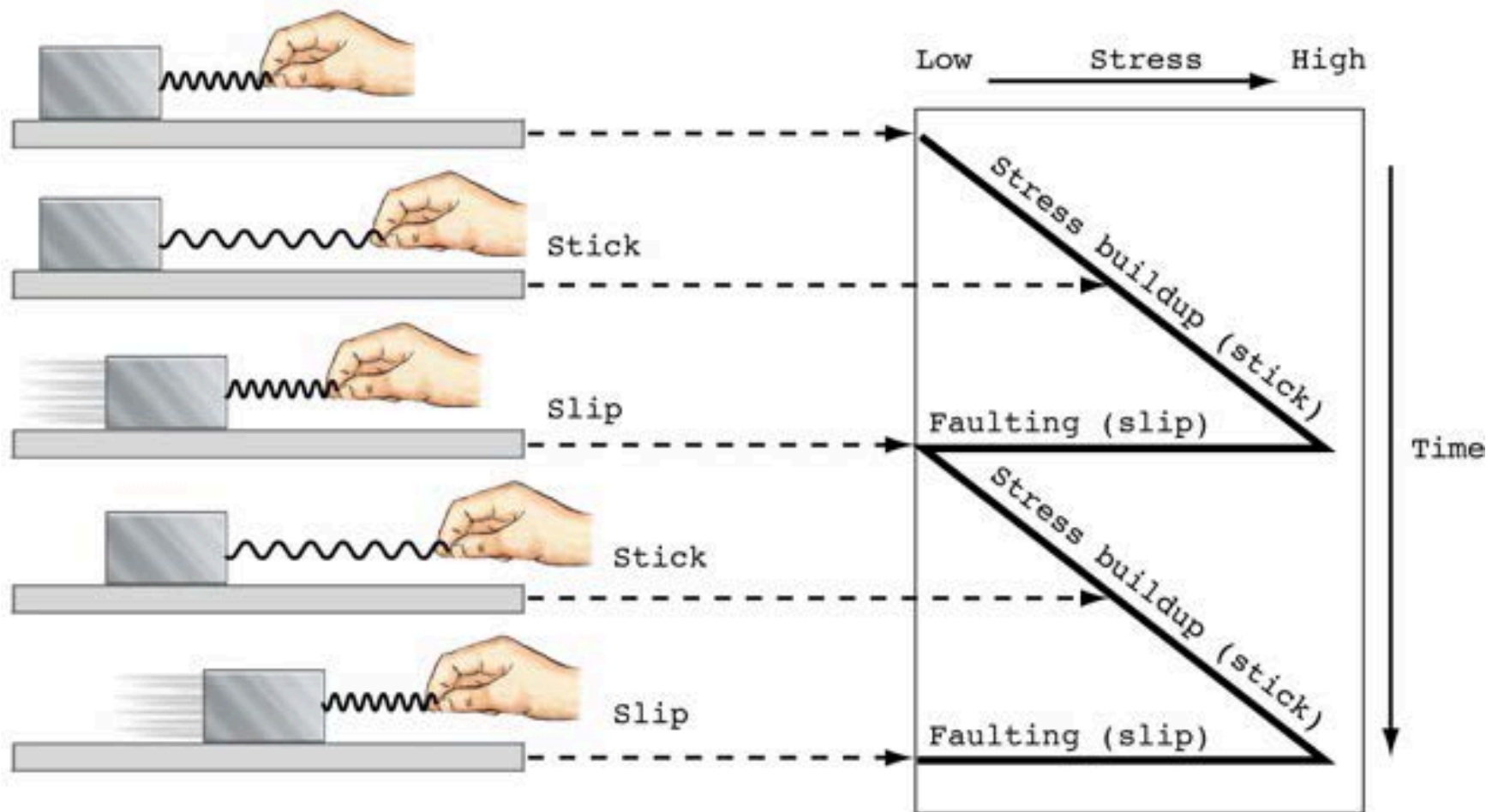
(b) Deformation



(c) Rupture and release of energy



(d) Rocks rebound to original undeformed shape







<https://drive.google.com/file/d/1ab7fojNEf7C8p7rpJSG83W3JELP-Gfp8/view?usp=sharing>



- ✓ In an active fault, energy is slowly stored and is released **unpredictably** (no possibility to forecast when and how big)
- ✓ It is not possible to predict when and how big an earthquake will occur. We can know where probably an earthquake will occur (in seismogenetic areas) and there make a **prevention** planning in order to lower the possible damages to people and properties (risk assessment)





# ~~EARTHQUAKES~~

## EARTHQUAKES

WHAT IS AN EARTHQUAKE?



# ~~EARTHQUAKES~~

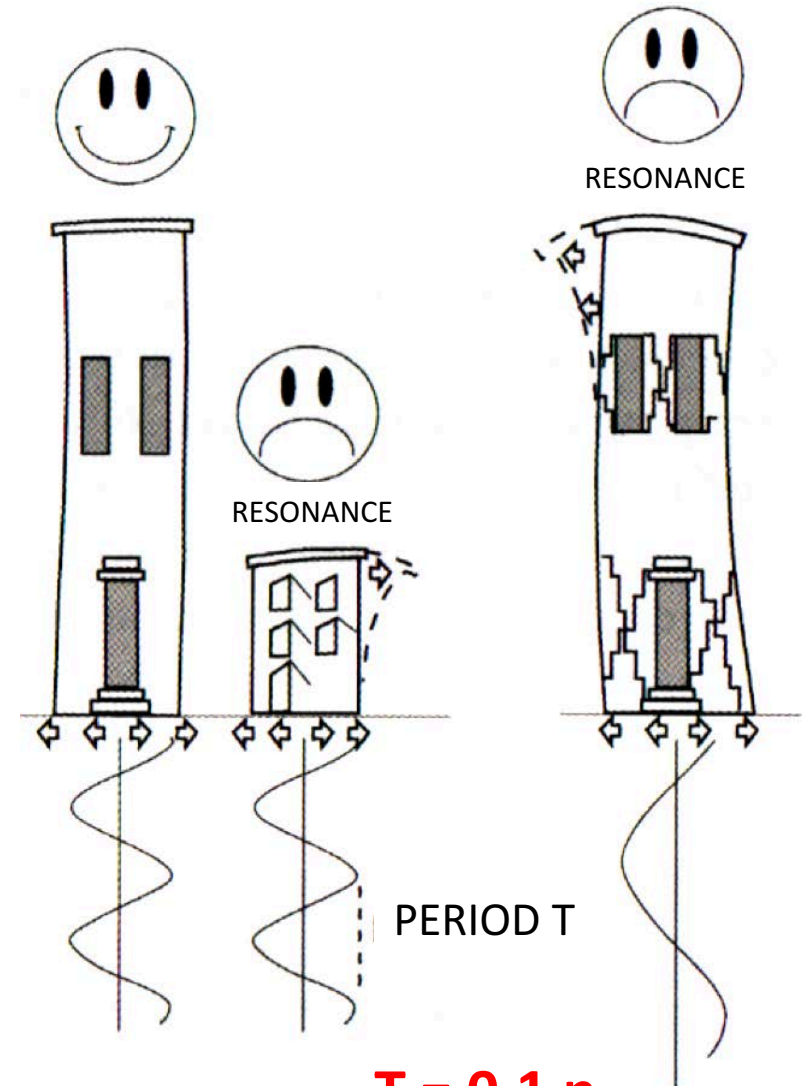
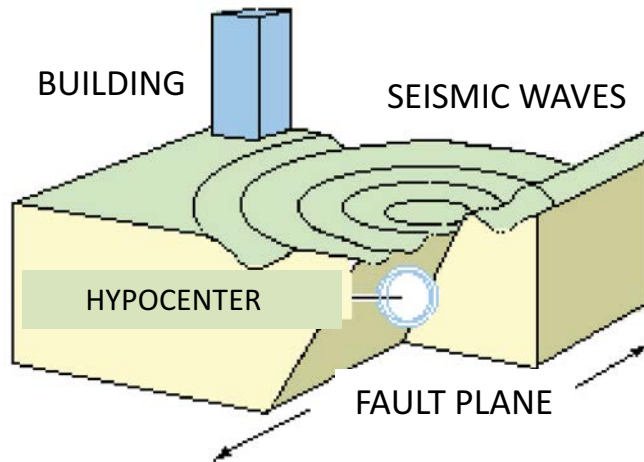
IS AN EARTHQUAKE PREDICTABLE?

# ~~EARTHQUAKES~~

## CONSEQUENCES OF AN EARTHQUAKE?



# BUILDING RESONANCE



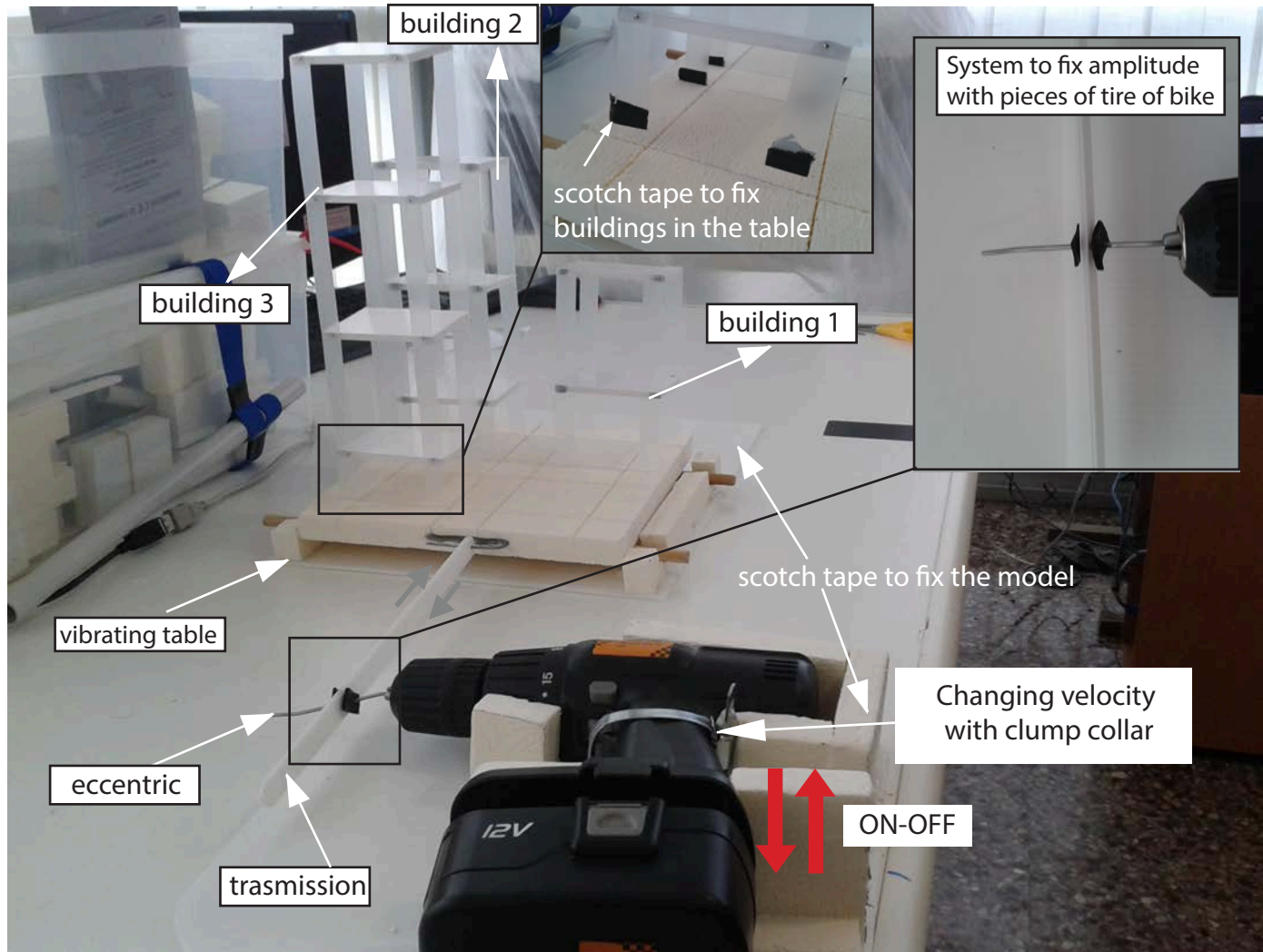
The RESONANCE FREQUENCY of any given system is the frequency at which the maximum-amplitude oscillation occurs

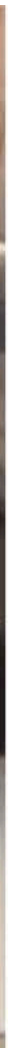
$$T = 0.1 n$$

$n$  = number of floors



# BUILDING RESONANCE



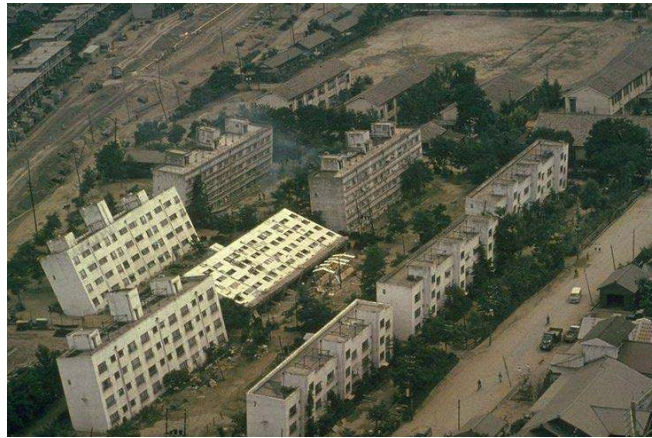


<https://drive.google.com/open?id=1q0ZvuvtWhnjWMPfTIKs1nrXOftGKwBic>

[www.sismobox.com](http://www.sismobox.com)



# SOIL LIQUEFACTION



# Soil liquefaction

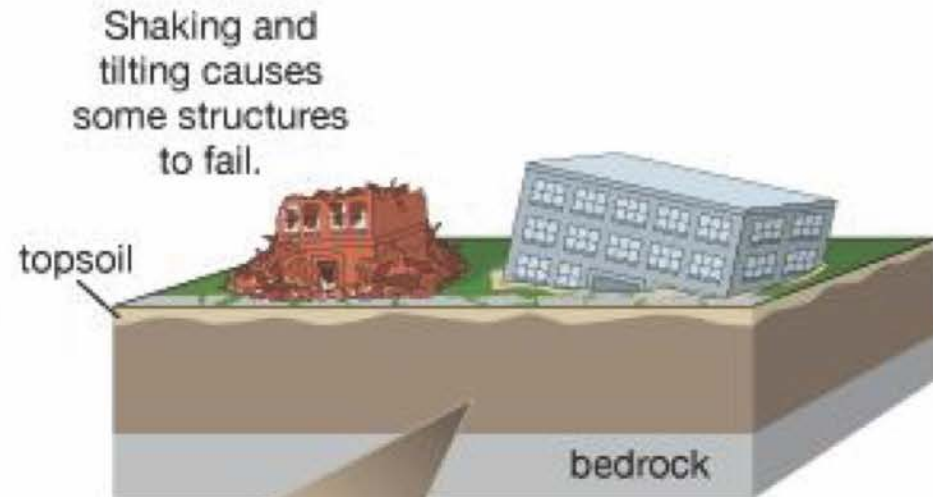
stable soil



Building stands erect  
on stable soil.

Loosely packed grains  
of soil are held together  
by friction. Pore spaces  
are filled with water.

liquefied soil



Shaking and  
tilting causes  
some structures  
to fail.

Building tilts  
and sinks as  
soil stability  
declines.

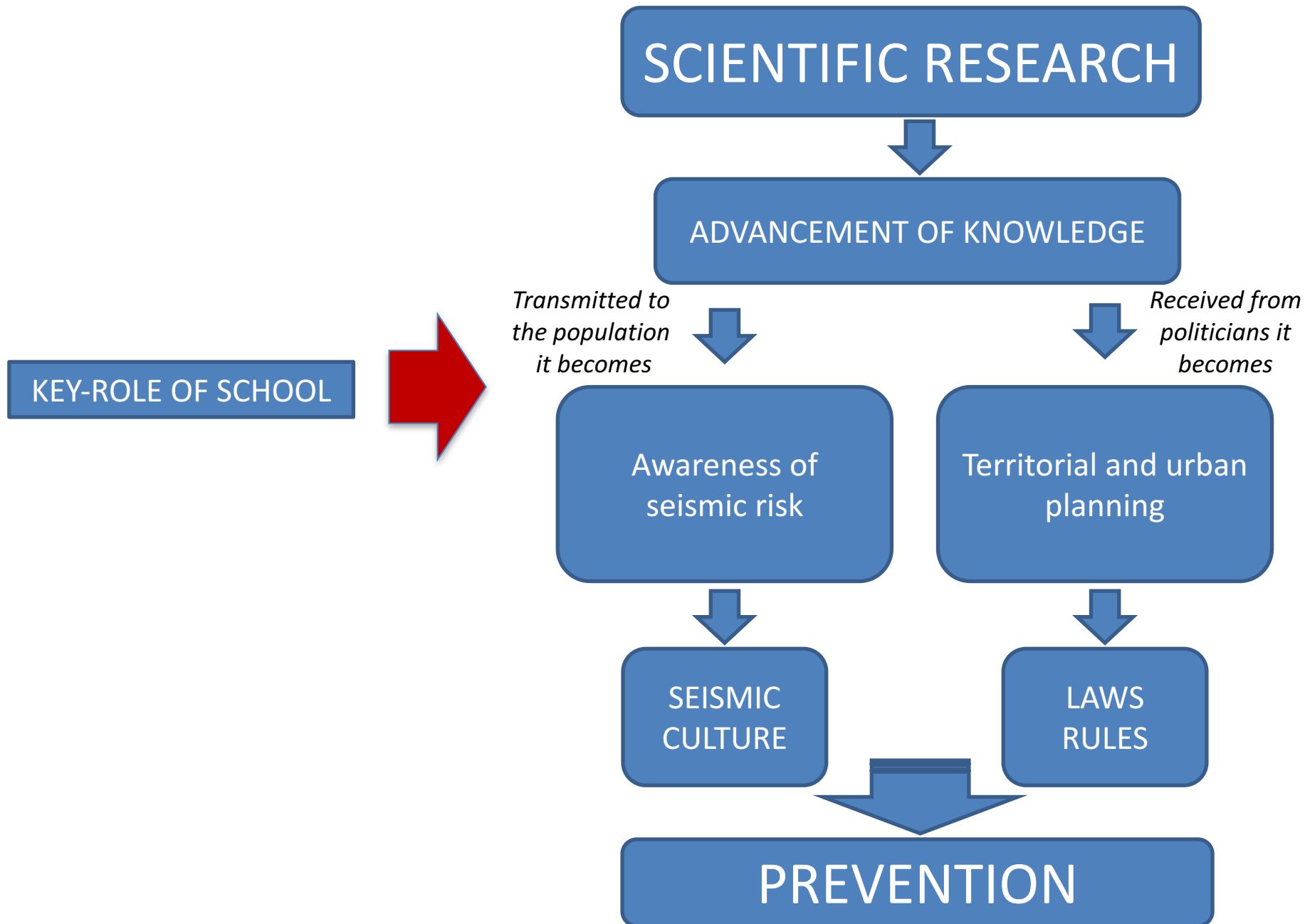
Shaking destabilizes  
the soil by increasing the  
space between grains.  
With its structure lost,  
the soil flows like a liquid.





[https://drive.google.com/open?id=10ayAf8ySH\\_wkhrU9NxtLC8NOQRHgxL0p](https://drive.google.com/open?id=10ayAf8ySH_wkhrU9NxtLC8NOQRHgxL0p)

[https://drive.google.com/open?id=1Z0RUI\\_z\\_3Pj15DJEaFOxyyNvvEIRixZU](https://drive.google.com/open?id=1Z0RUI_z_3Pj15DJEaFOxyyNvvEIRixZU)







**THANKS FOR YOUR ATTENTION**

