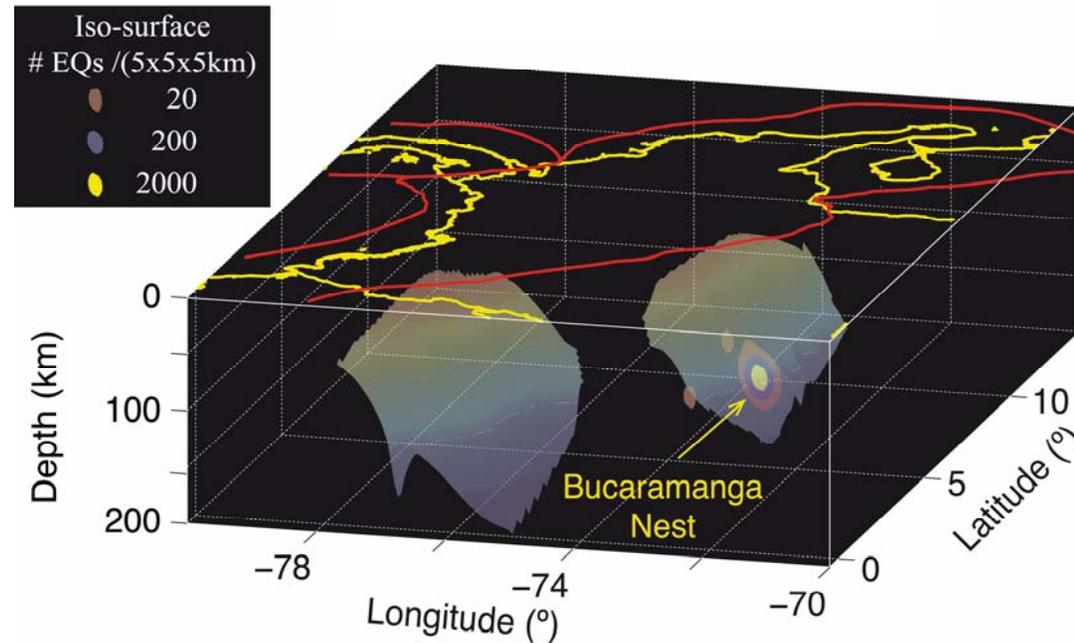


# Introducción a los terremotos y el famoso Nido de Bucaramanga

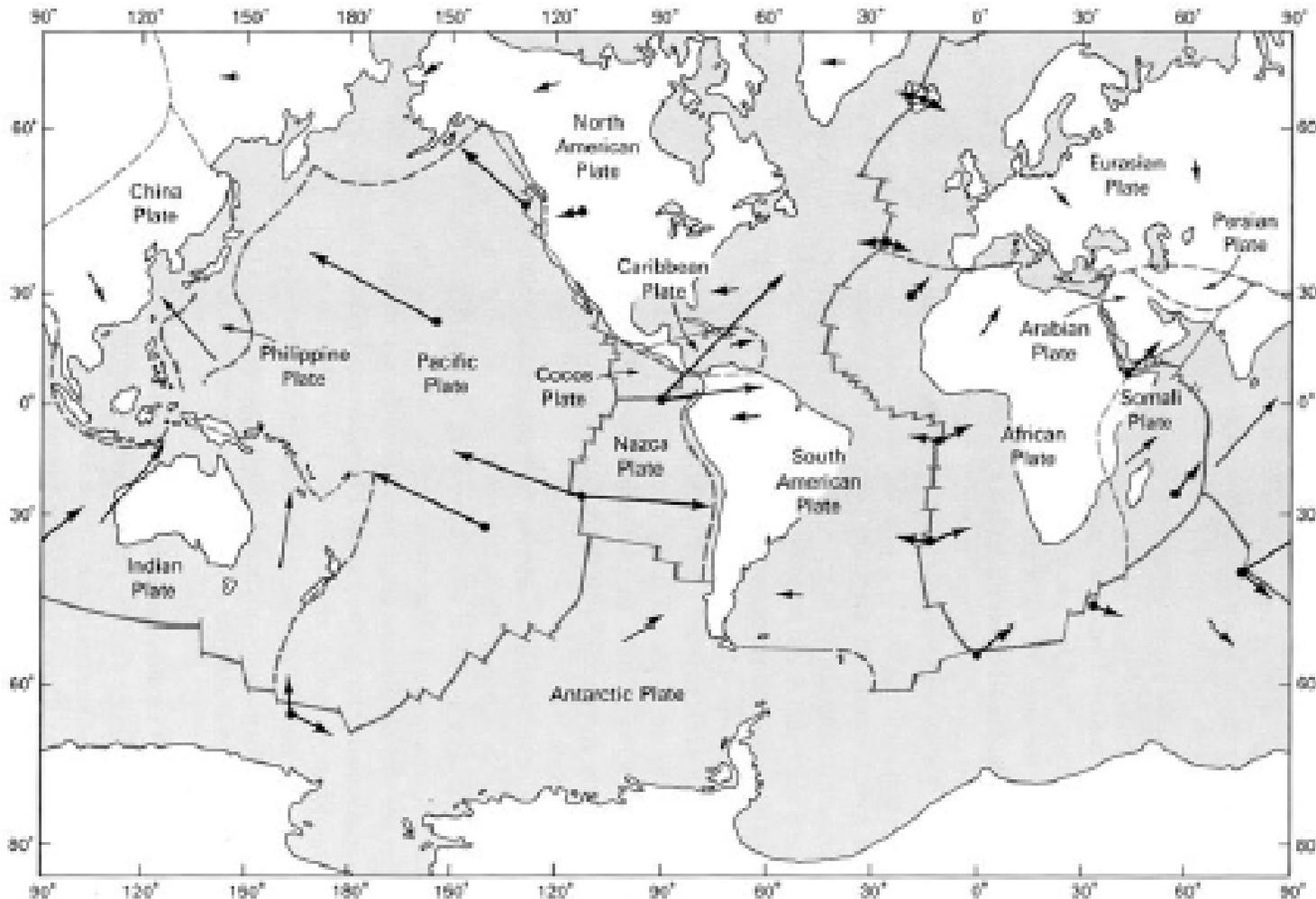


Germán A. Prieto  
Massachusetts Institute Of Technology

Foro Actividad Sísmica y su Monitoreo  
Bucaramanga, Santander



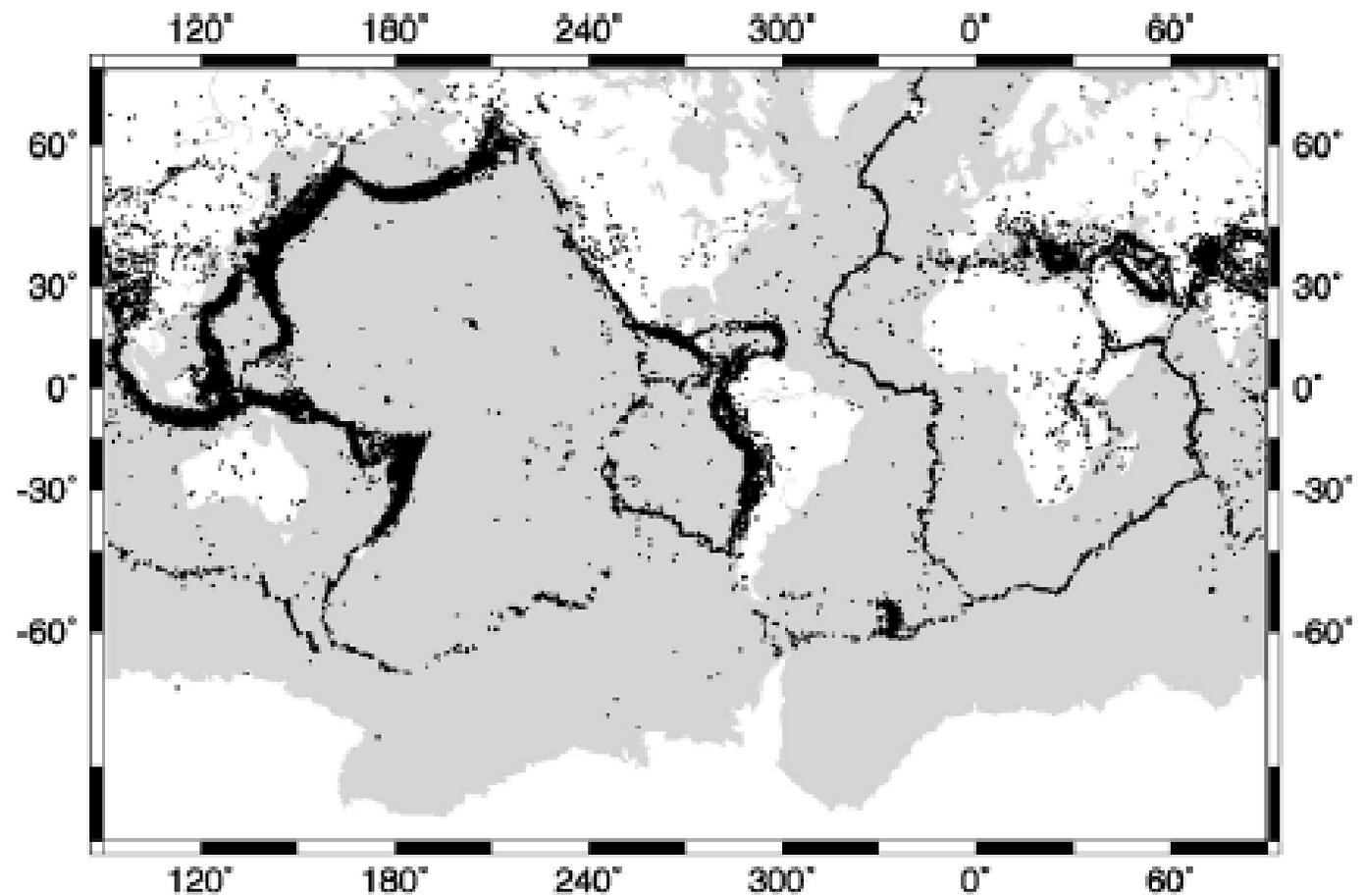
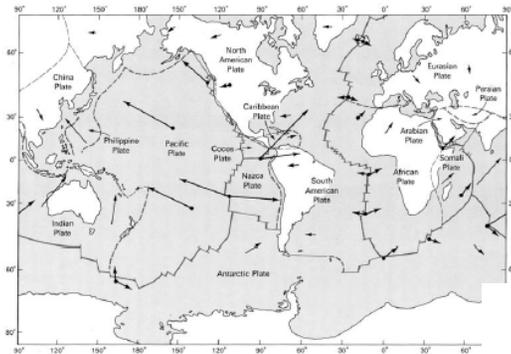
# El Planeta y los Terremotos



Superficie de la Tierra (Corteza) dividida en placas tectónicas que se mueven unas con respecto a las otras

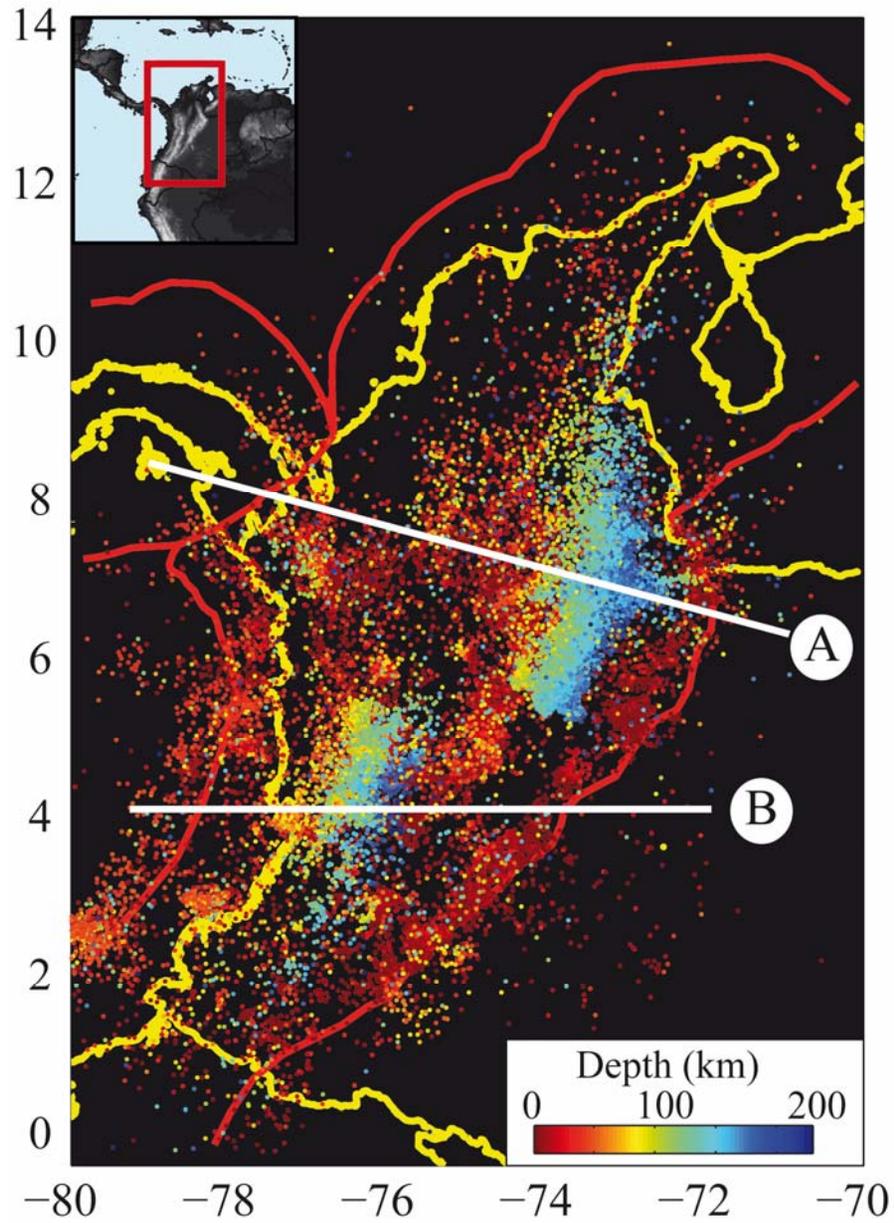


# El Planeta y los Terremotos



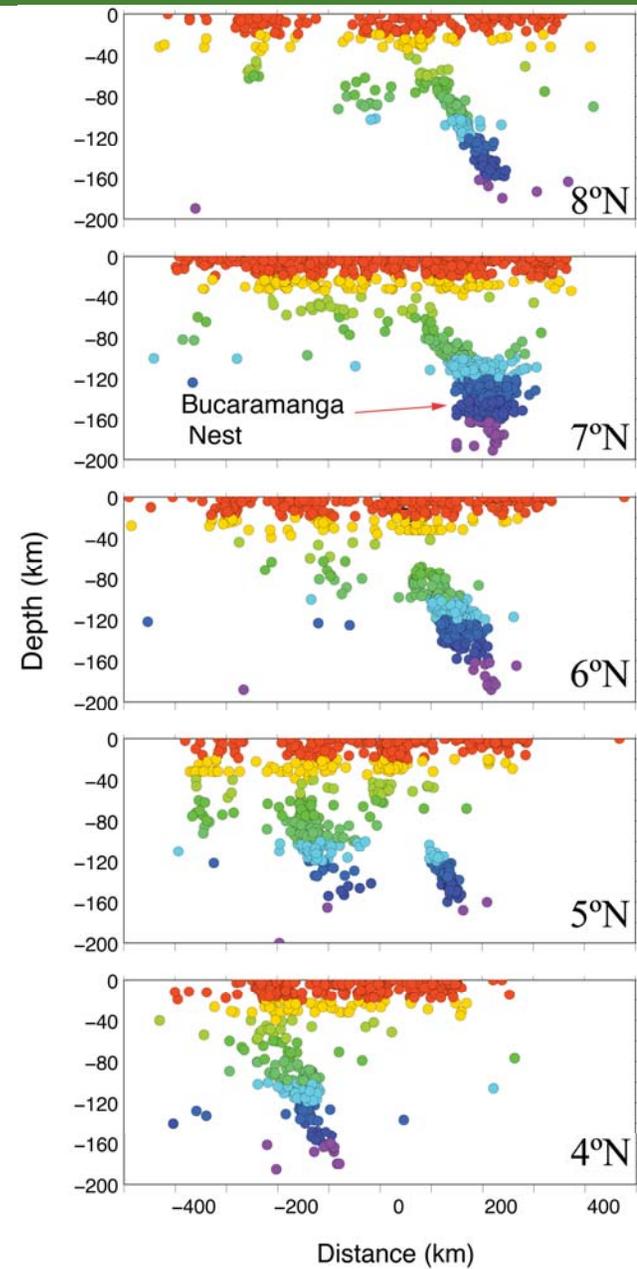
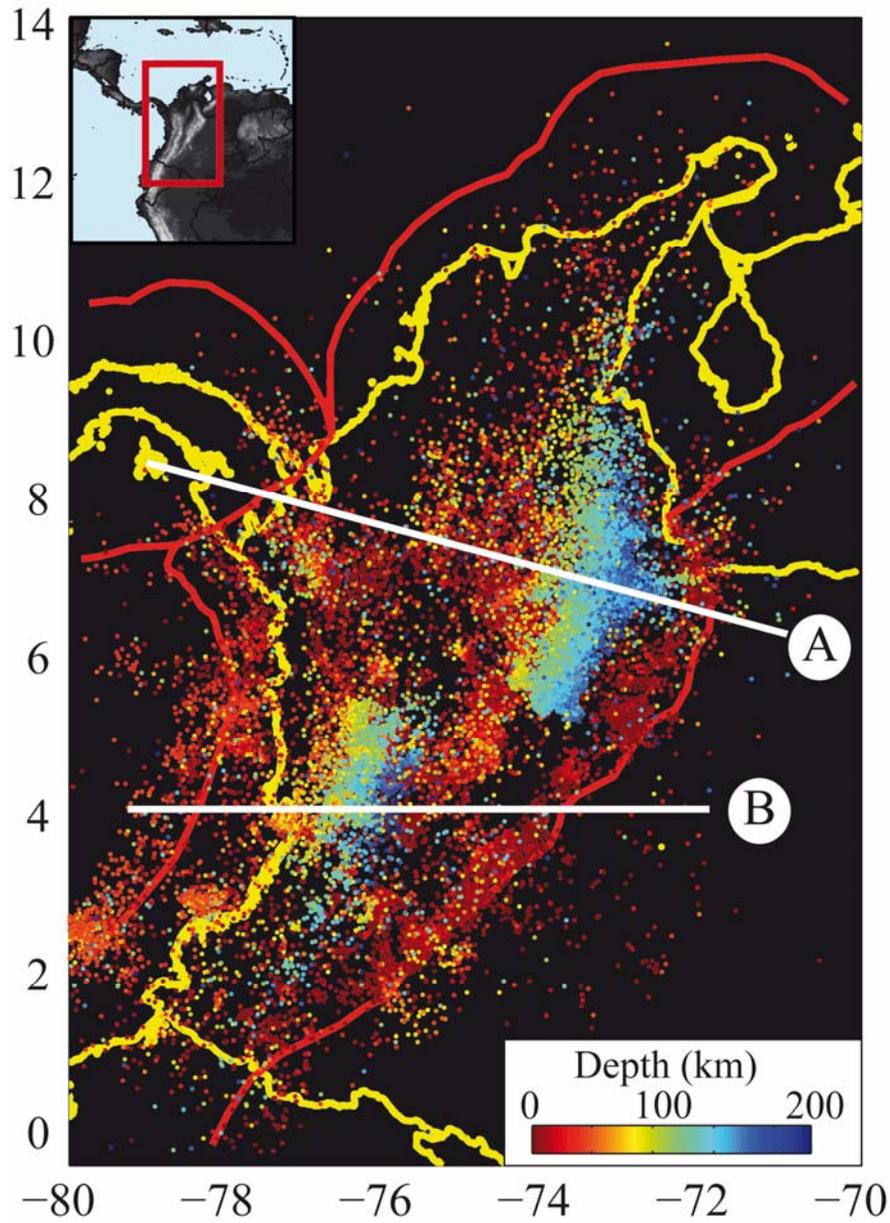


# El Caso de Colombia



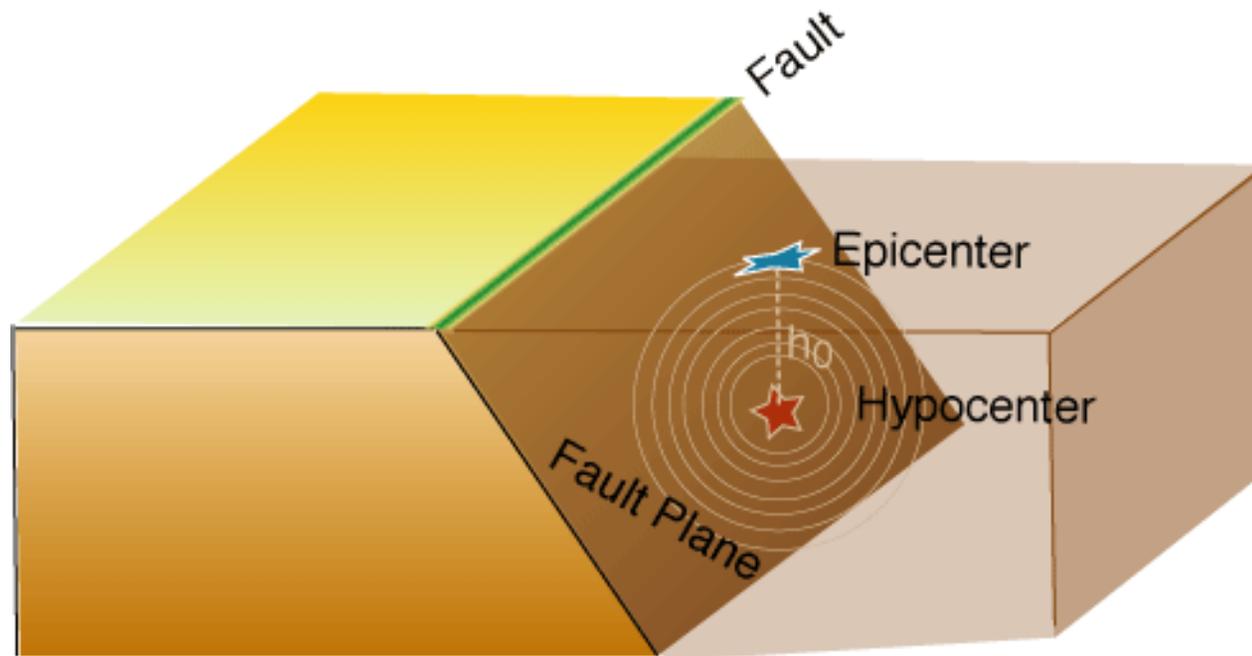


# El Caso de Colombia





# Los terremotos



**Terremotos ocurren a lo largo de fallas  
Desplazamiento de 2 bloques uno con respecto al otra.**



# Los terremotos





# Los terremotos

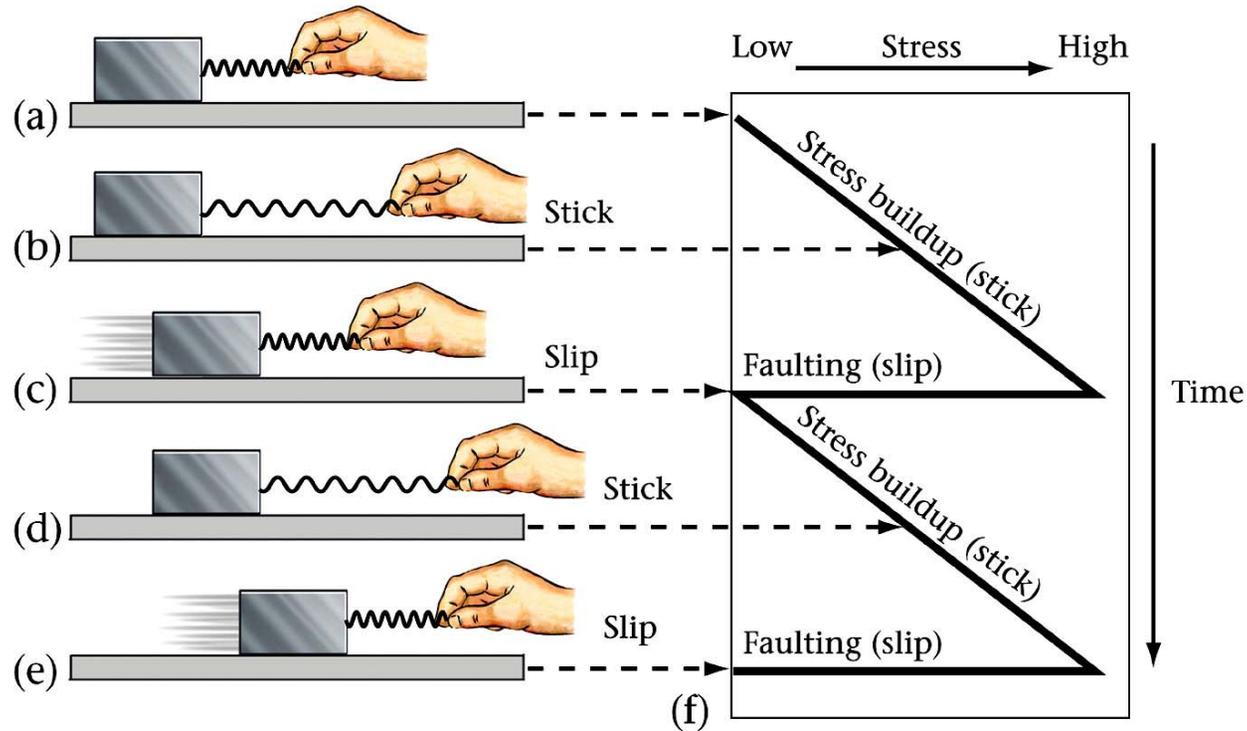


FIGURE 10.10

*Earth: Portrait of a Planet, 2nd Edition*  
Copyright (c) W.W. Norton & Company

1. Se hala el resorte, la fricción previene que el bloque se mueva
2. Esfuerzo supera la fricción -> Terremoto
3. Deslizamiento a lo largo de falla.



# Los terremotos

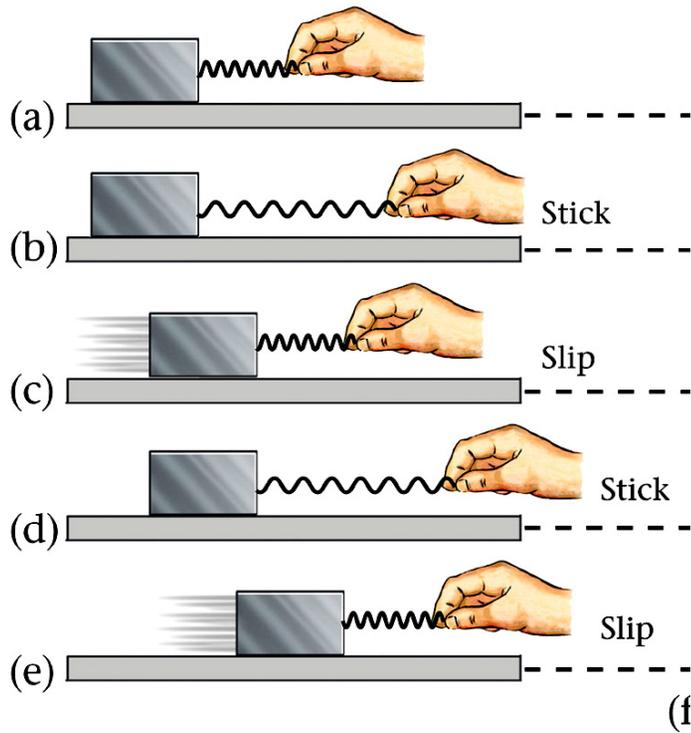
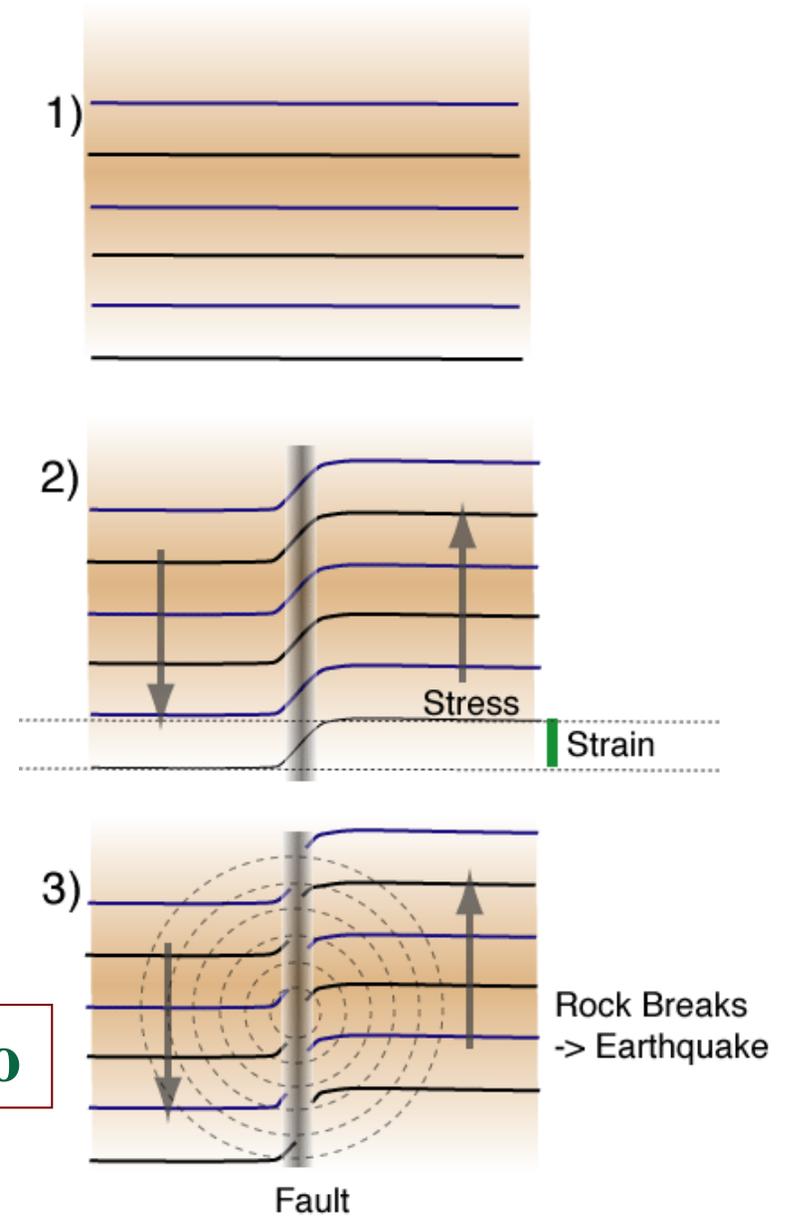


FIGURE 10.10

**Deformación es resultado del esfuerzo**

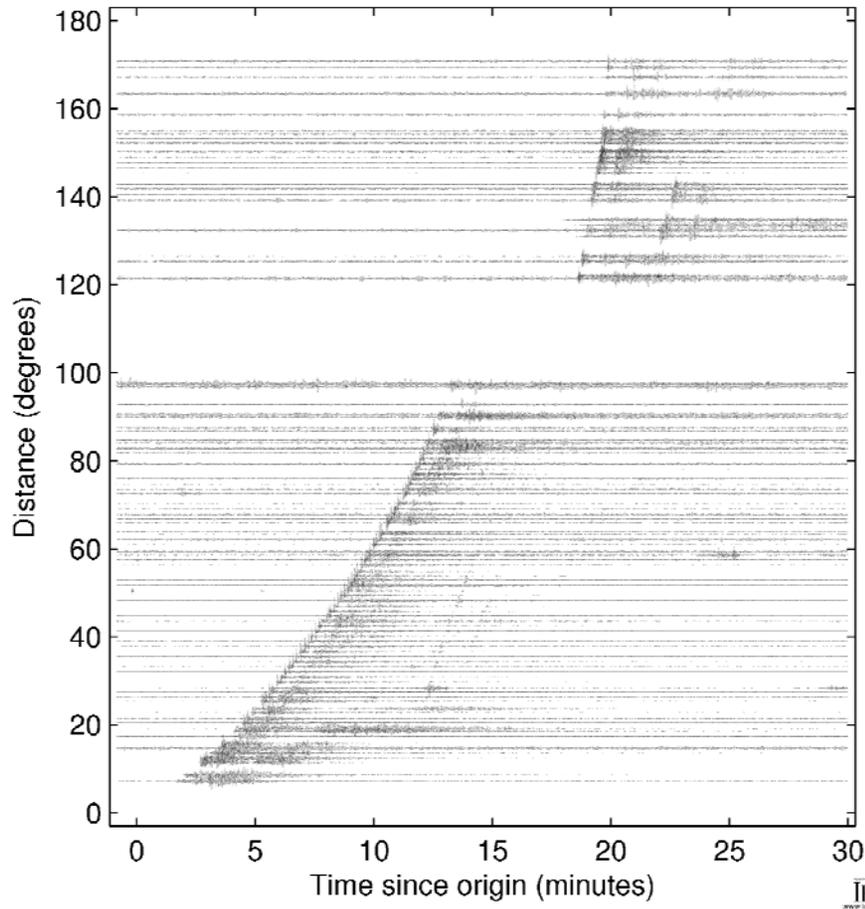




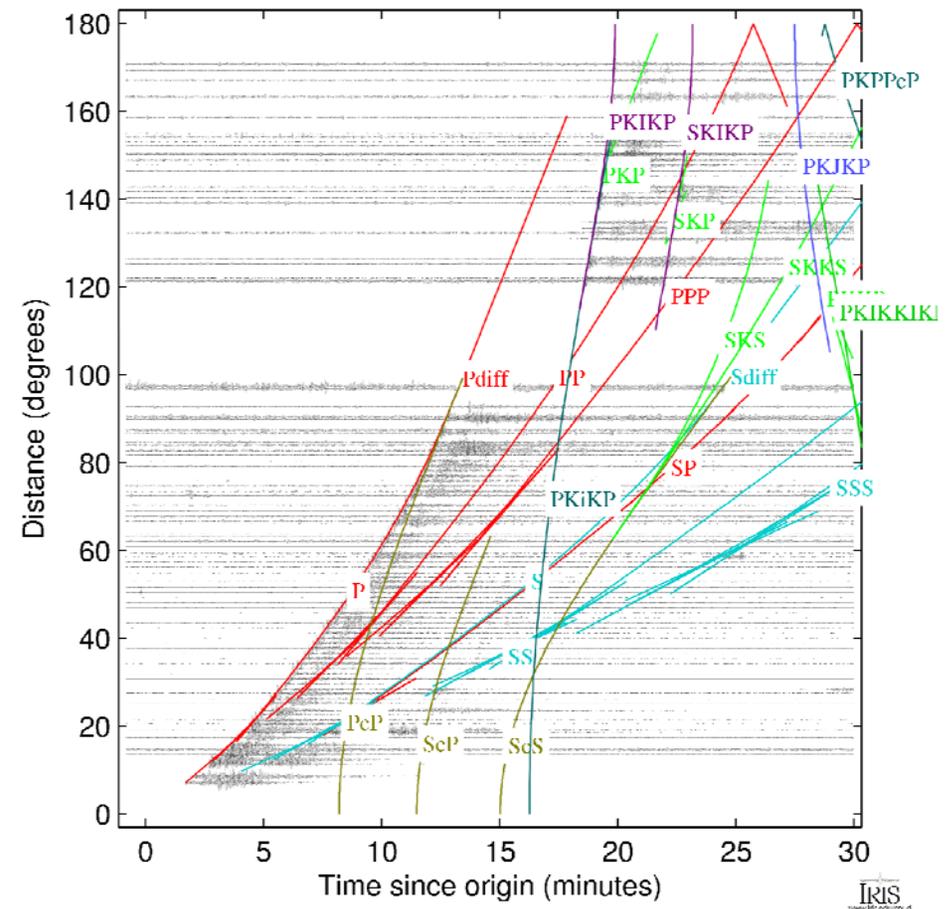
# Ubicando un terremoto



Combed and aligned on origin 0.3to1.0Hz BI1Z  
NORTHERN COLOMBIA  
2015/03/10 20:55:43 M6.2 Z=147.2km Lat=6.8266 Lon=-73.0114



Combed and aligned on origin 0.3to1.0Hz BHZ  
NORTHERN COLOMBIA  
2015/03/10 20:55:43 M6.2 Z=147.2km Lat=6.8266 Lon=-73.0114



Lo primero que se requiere son registros



# Ubicando un terremoto



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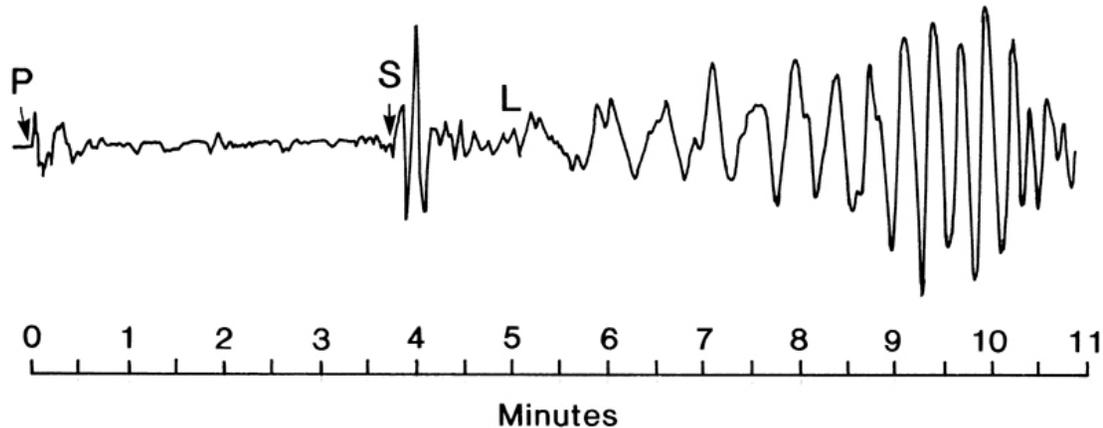


Fig. 4.22

**A diferencia de las ondas en una piscina, en la Tierra las ondas sísmica irradian de manera más complicada.**

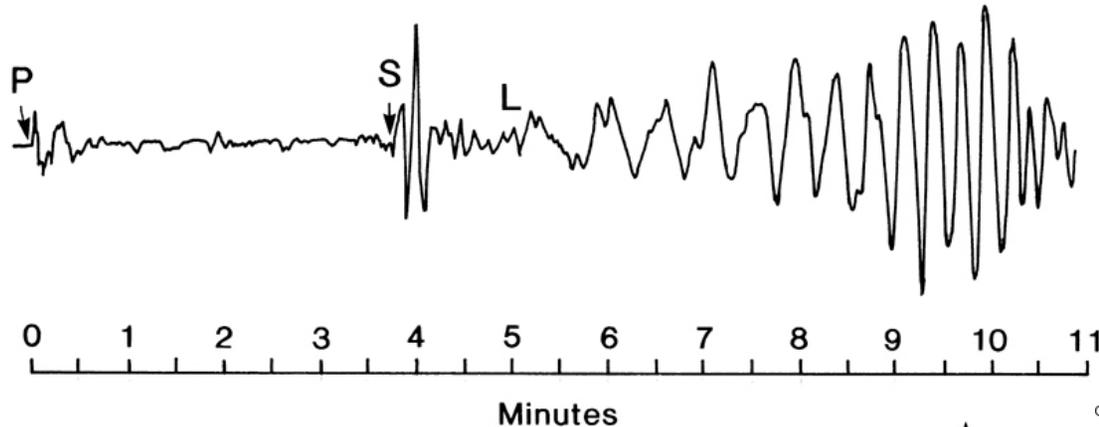




# Ubicando un terremoto



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Fig. 4.22

1. Medir diferencia arribo S-P
2. Mirar en gráfico distancia vs tiempo de llegada

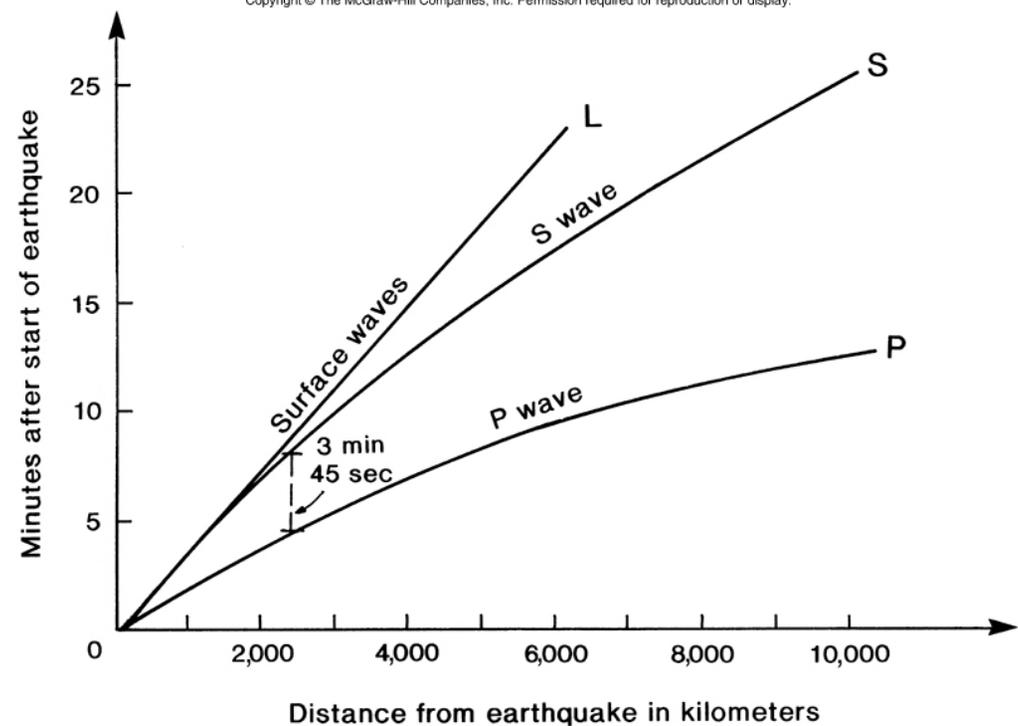


Fig. 4.21



# Ubicando un terremoto



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Fig. 4.23

3. Graficar circulo con radio prop a distancia estimada
4. Repetir para al menos 2 estaciones mas triangulación



**Se requieren**

**3 estaciones -> epicentro**

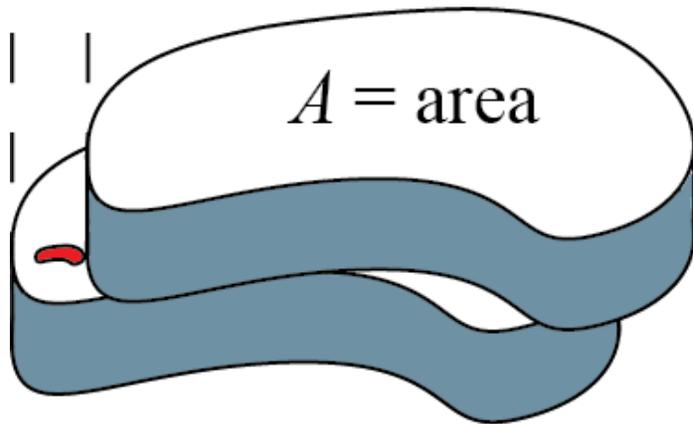
**4 estaciones -> hipocentro**



# Magnitud de un terremoto



$D$  = desplazamiento



Magnitud -  $D \times A$

## Escala de Magnitud de Richter

La más usada

No hay límite máximo, ni mínimo (ej. M-3, M7.0)

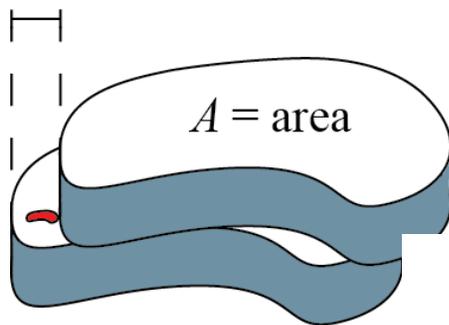
Hoy en día se usa más la Escala de Momento.



# Magnitud de un terremoto

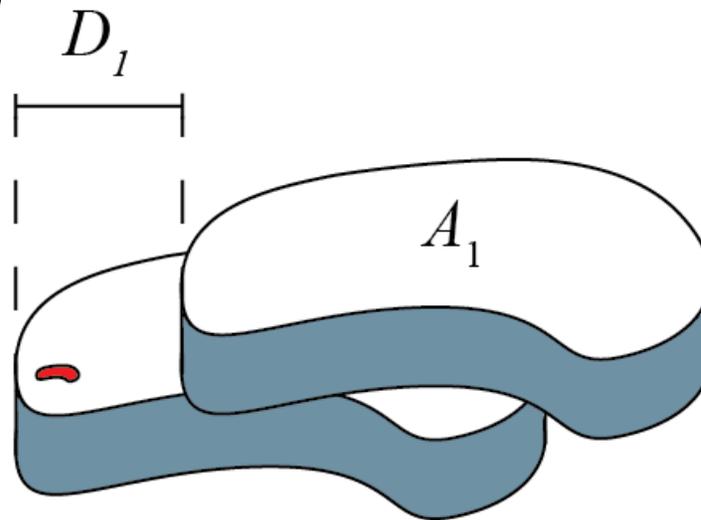


$D$  = desplazamiento



**Magnitud = Área x Desplazamiento**

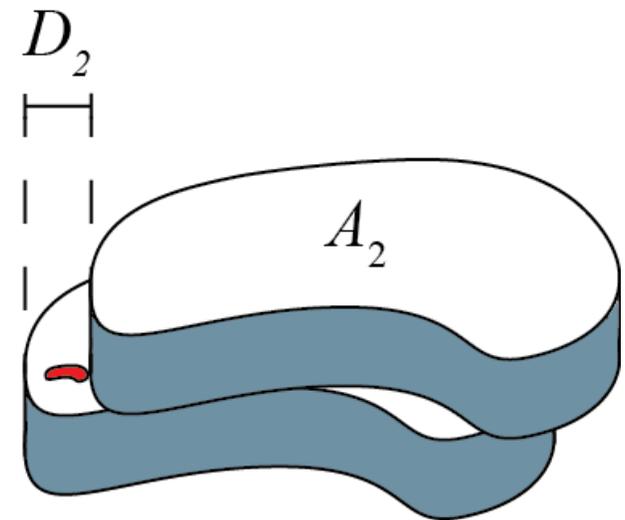
**M6.0 ~30 veces más energía que M5.0.**



$M = 6.0$

$A_1 = 10 \times 10 \text{ km}$

$D_1 = 33 \text{ cm}$



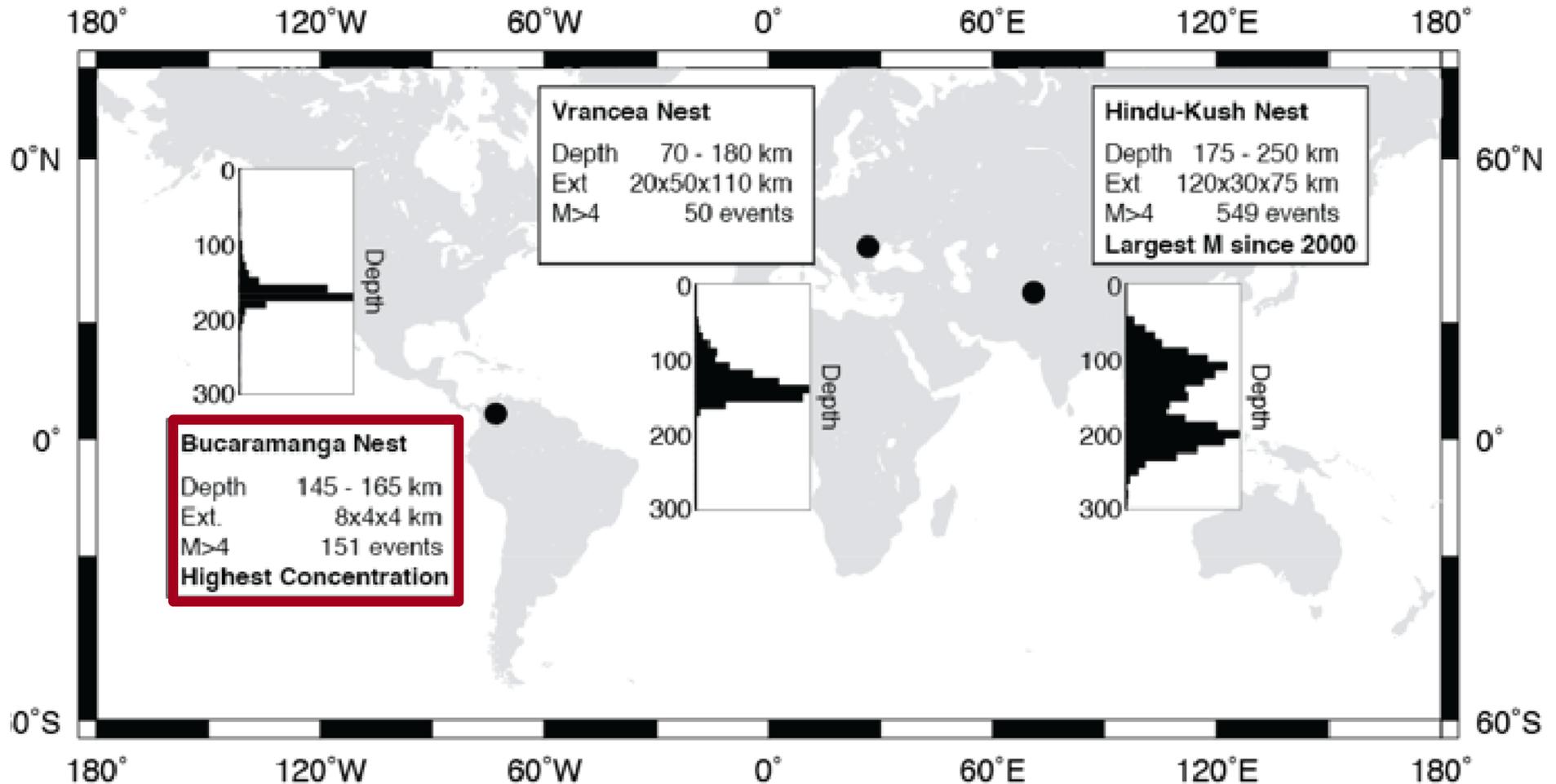
$M = 5.0$

$A_2 = 3 \times 3 \text{ km}$

$D_2 = 15 \text{ cm}$



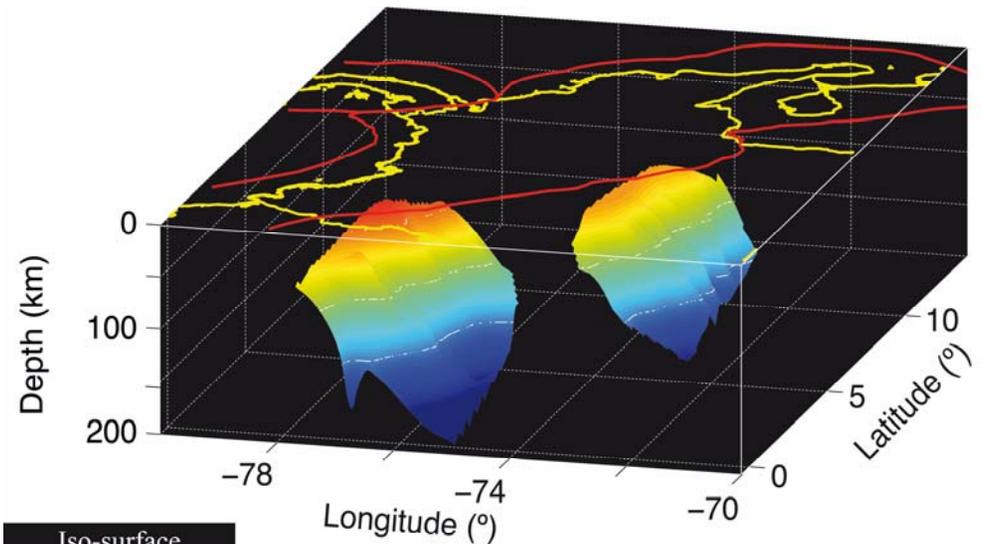
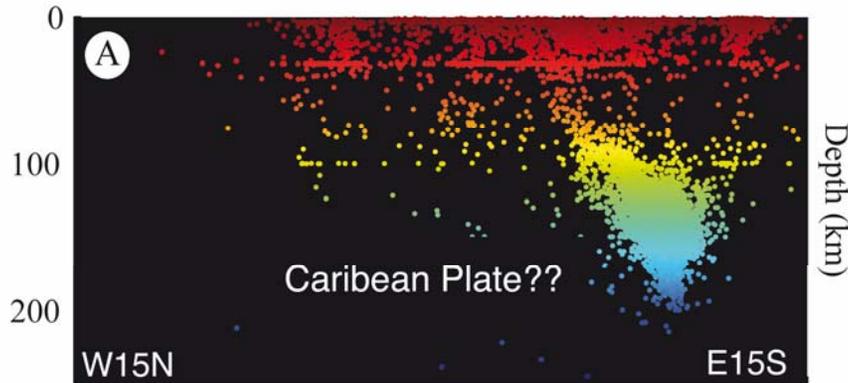
# El Nido de Bucaramanga



from Prieto et al., 2012 (Tectonophysics)



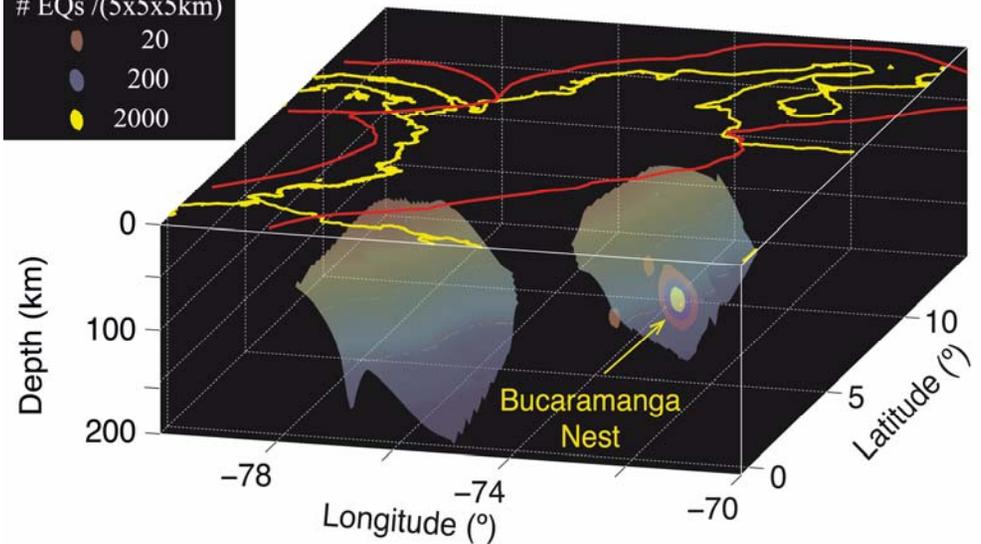
# El Nido de Bucaramanga



**Mas de 2000 terremotos en un volúmen de 5x5x5 km.**

## Bucaramanga Nest

- Depths 145 – 165 km
- Caribbean Plate?
- Most concentrated nest



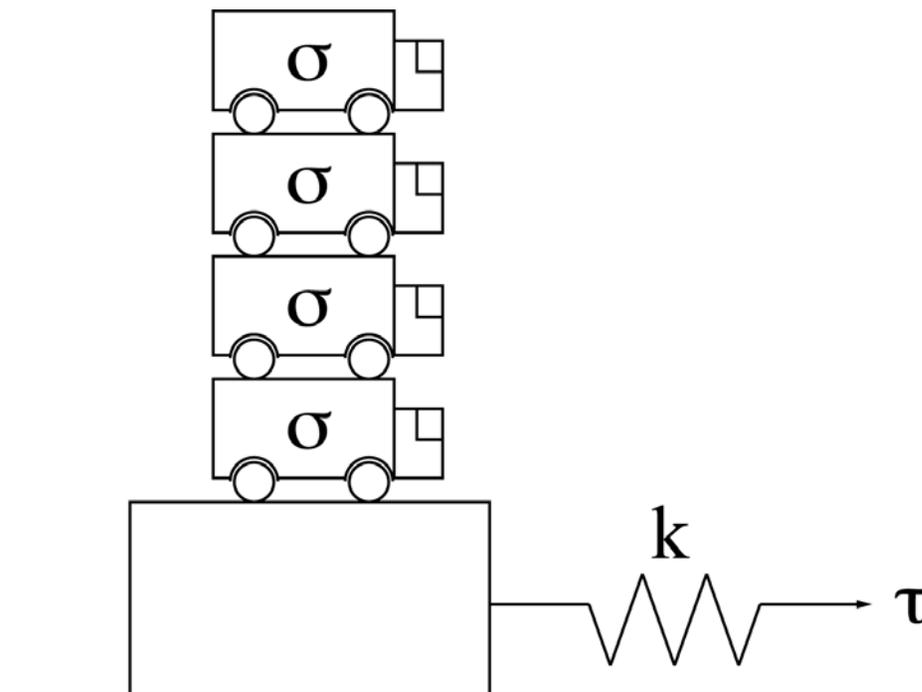


## Terremotos Profundos

Profundidad  $> 50 - 60$  km

25% de los terremotos globales

**Mecanismo no está bien definido**



Las presiones y temperaturas son demasiado altas como para que las rocas se rompan.

Como Scholz (1998)

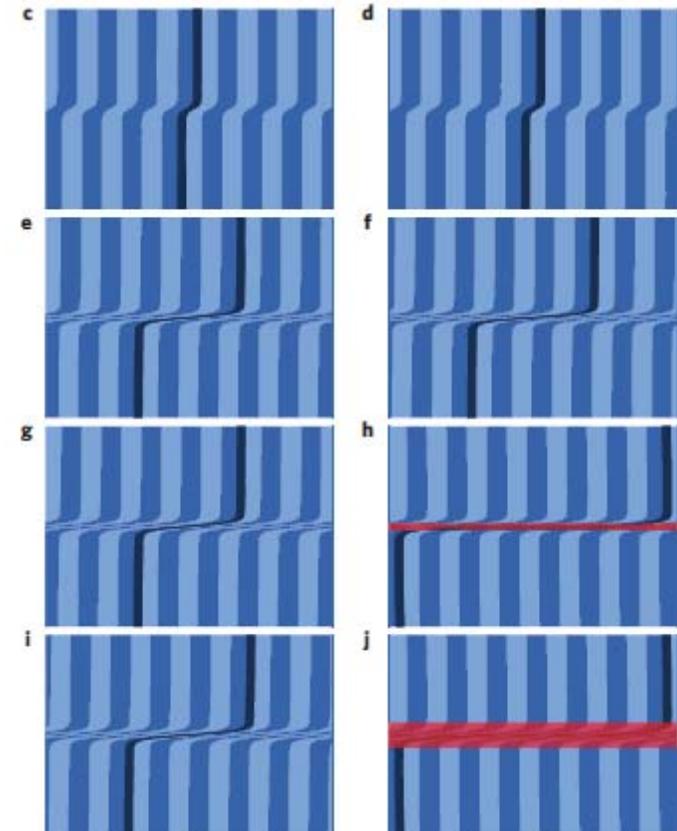
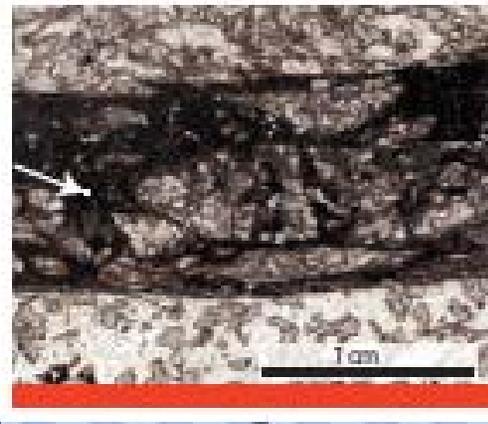


## Terremotos Profundos



Shear Zone

Pseudotachylite

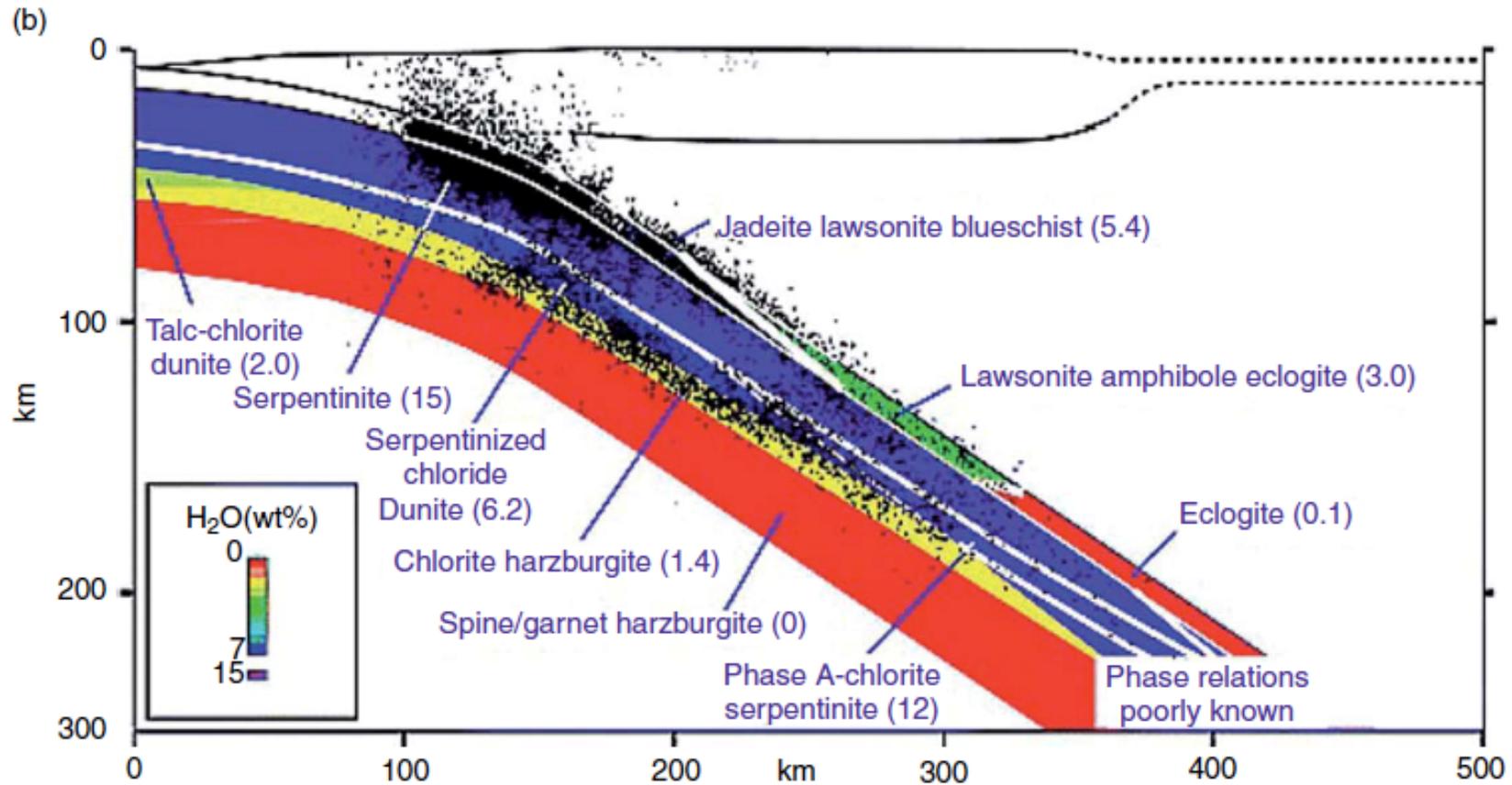


John et al., 2009  
Nature Geoscience

**“deformación dúctil lleva al calentamiento, debilitando las rocas y permitiendo un terremoto**



# El Nido de Bucaramanga



“fracturamiento de rocas por la presencia de agua debido a la deshidratación de minerales, reduciendo la presión hidrostática”



# El Nido de Bucaramanga

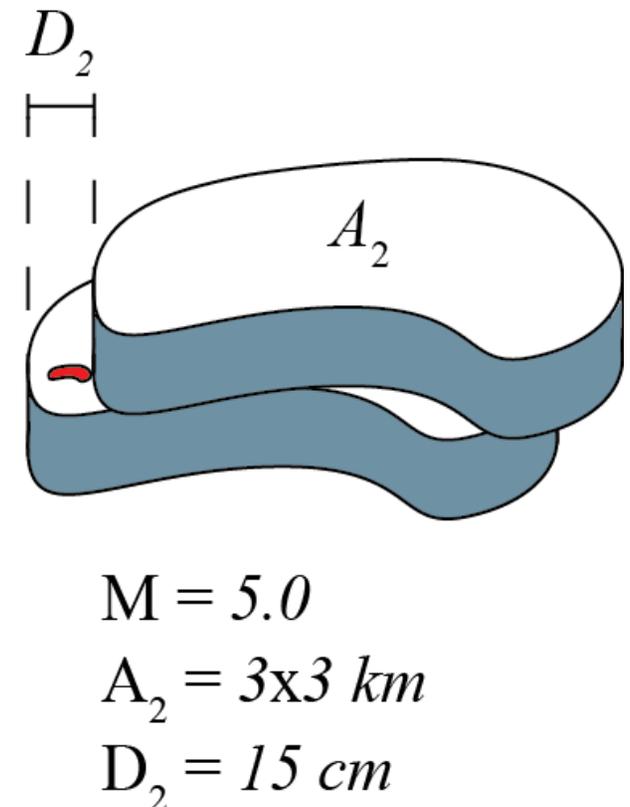
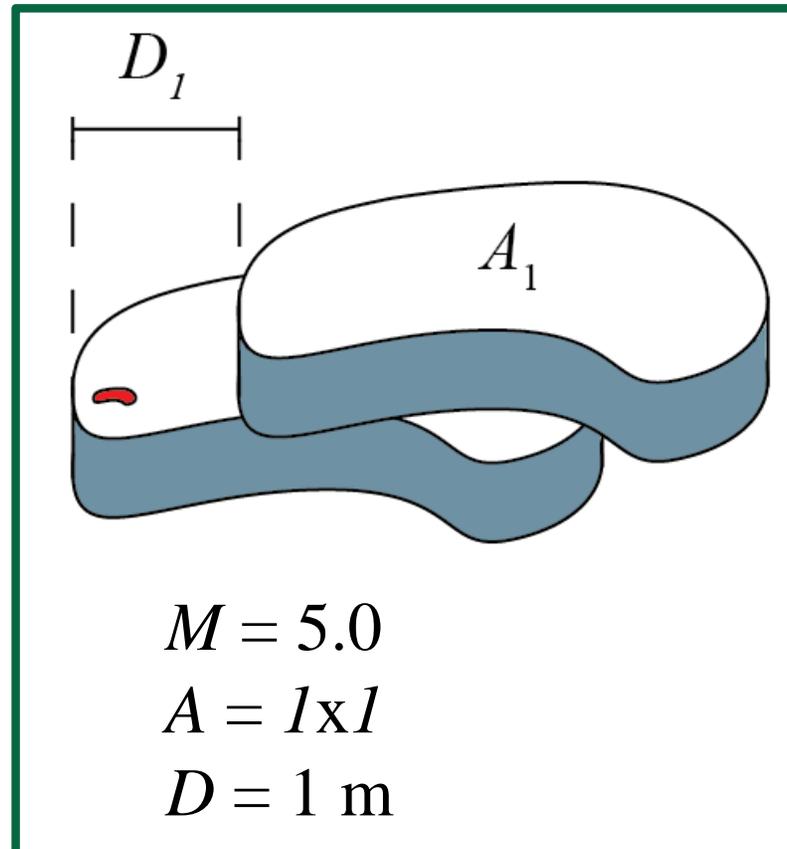


Hipótesis [Prieto et al., 2013]

Area  $A$  es muy pequeña

Desplazamiento  $D$  muy grande

Fricción genera aumento de temperatura extremo



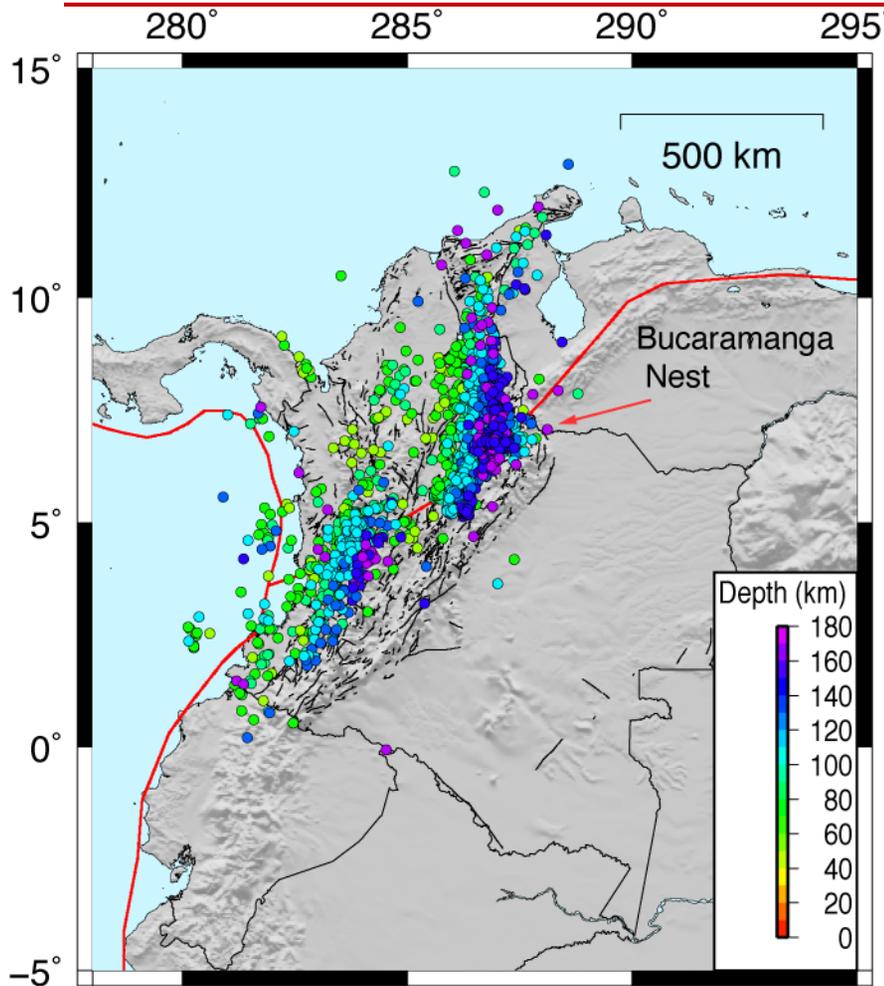


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**GRACIAS**



## Tectonics – EQ Locations



A subducting Caribbean Plate is suggested by earthquake locations

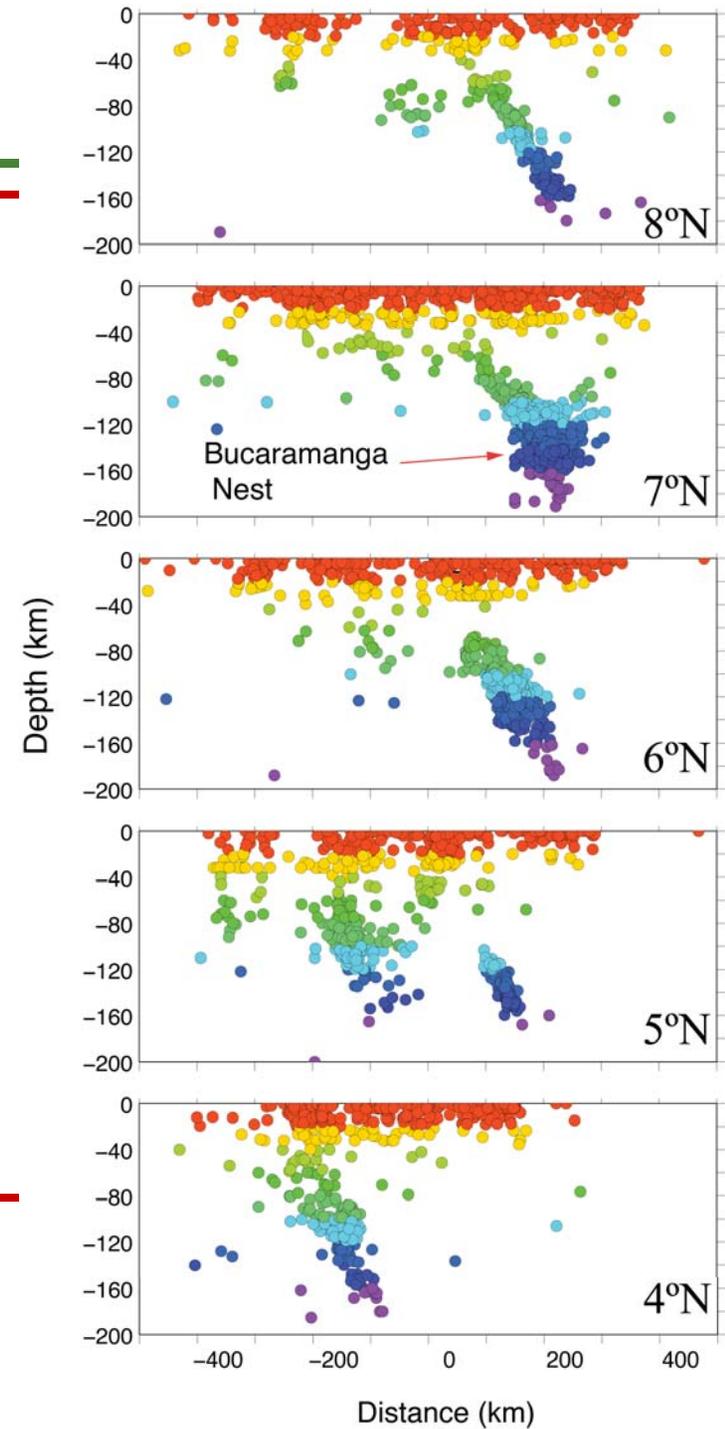


Fig. 4.25

U.S. annual energy consumption

Chile 1960

largest nuke

lightning bolt

10km Meteorite impact

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Meteorite impact (10 km diameter, 20 km/sec velocity)

Earth's daily receipt of solar energy

Earth's annual internal heat flow

U.S. annual energy consumption

Chile 1960 earthquake (M9.5)

Average annual seismic energy release on Earth

New Madrid (1811-12) earthquakes (M8.0-8.3)

Hurricane (kinetic energy)

Average annual seismicity in continent interiors

Hiroshima 1945 atomic bomb

Electrical energy of typical thunderstorm

Average tornado (kinetic energy)

Lightning bolt

Equivalent moment magnitude (M) (unitless numbers)

Average hurricane (10-day lifetime)

Hurricane

Alaska 1964

World's largest nuclear explosion

Mt. St. Helens

Hiroshima

tornado

