Seismic Hazard in Nepal and Experiences

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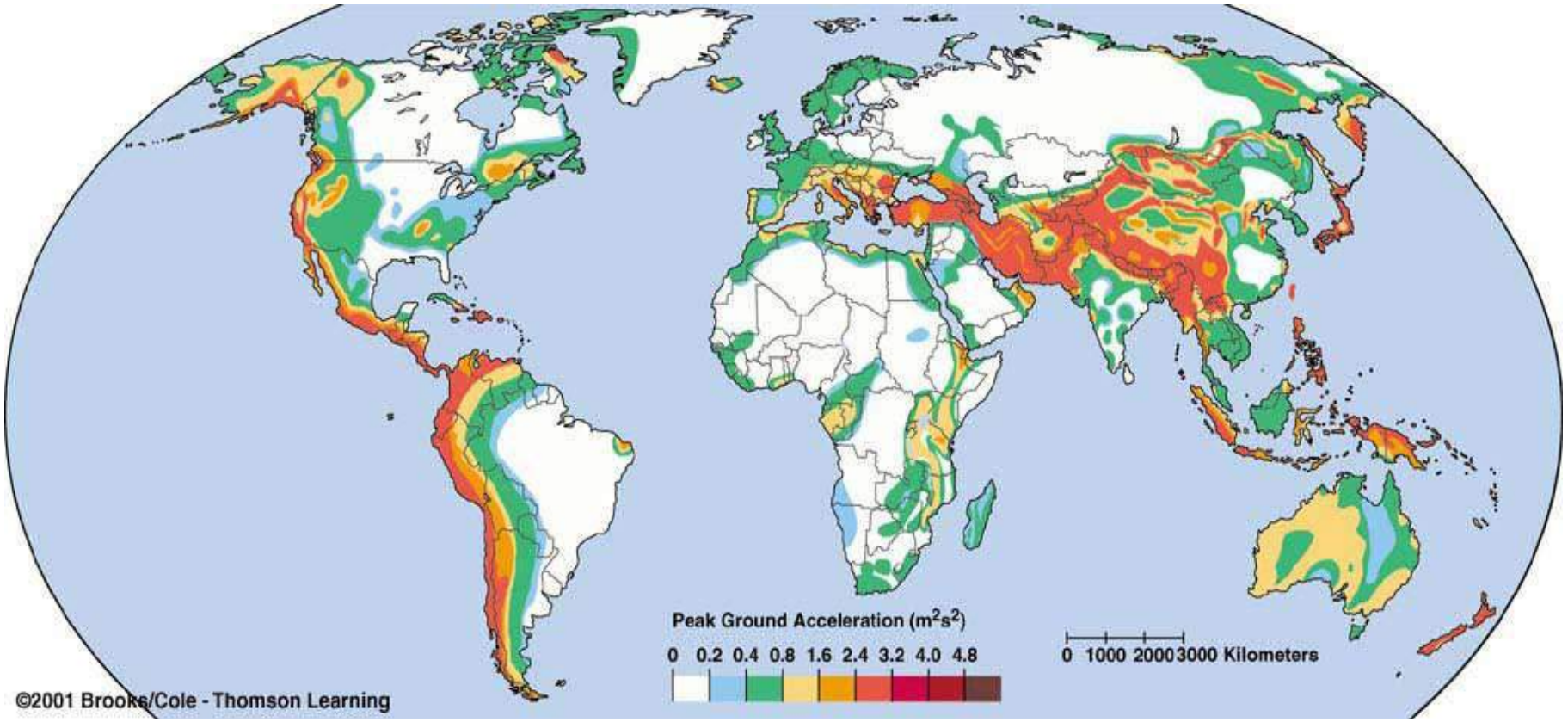
EATHQUAKE AS A HAZARD

- In the past 3 centuries over 3 million people have died due to earthquakes and earthquakes related disasters.
- The economic losses due to earthquakes are huge (Tohoku earthquake – Magnitude 9.0 – 2011 March 11 – causes US$ 365 billion economic loss)
- 2/3 of continental crust is seismically active, that means about 1 billion people are living in exposed area.

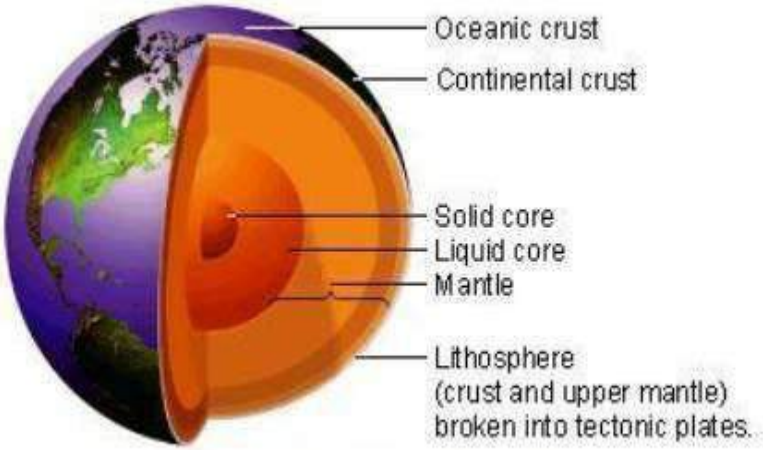
1556 AD China 8,30,000 Deaths.

In 2010 M7.0 earthquake in Haiti >3,00,000 Deaths.

Global Seismic Hazard Map

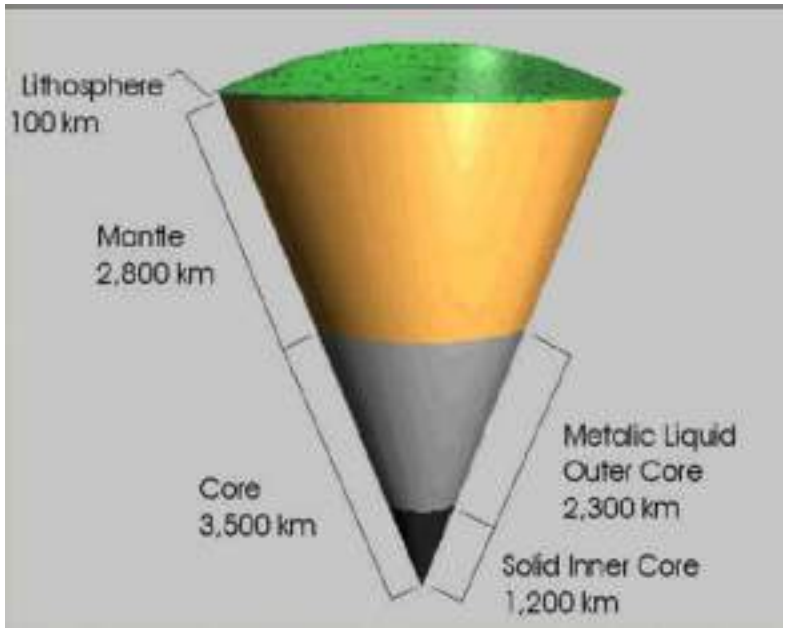


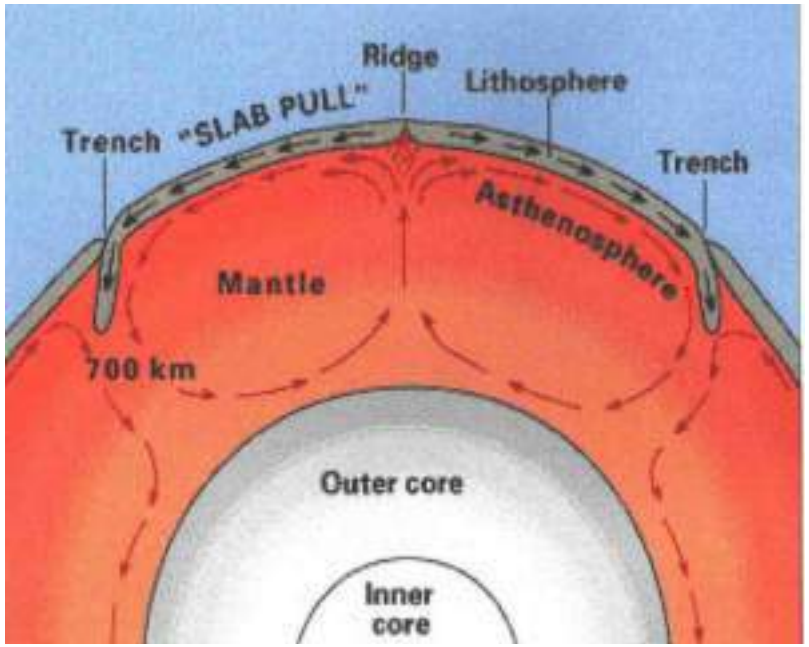
EARTH'S INTERIOR



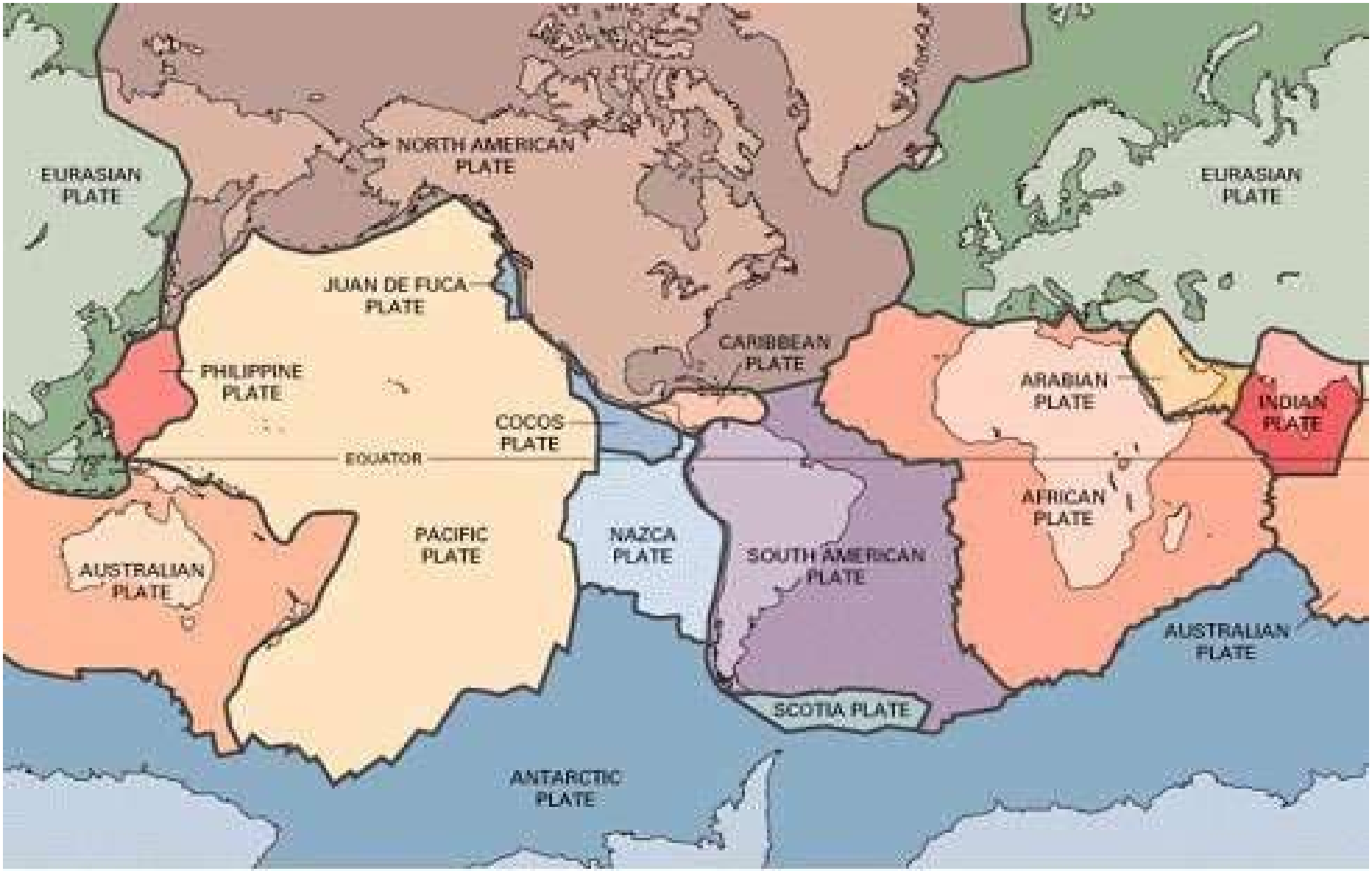
The upper 100 km thick outer part is called lithosphere.

This part is divided into a number of fragments, which are called tectonic plates.





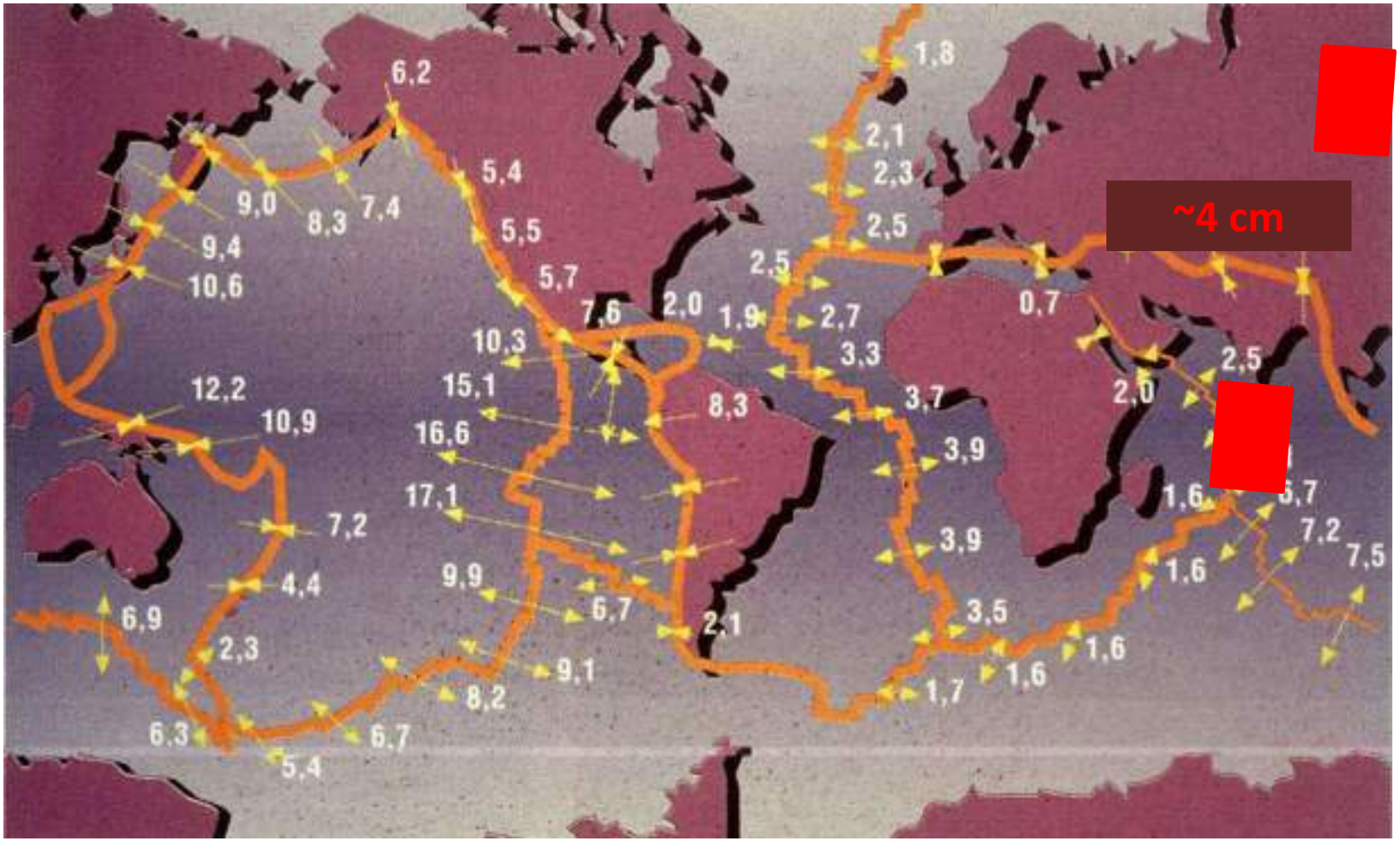
WORLD'S TECTONIC PLATES

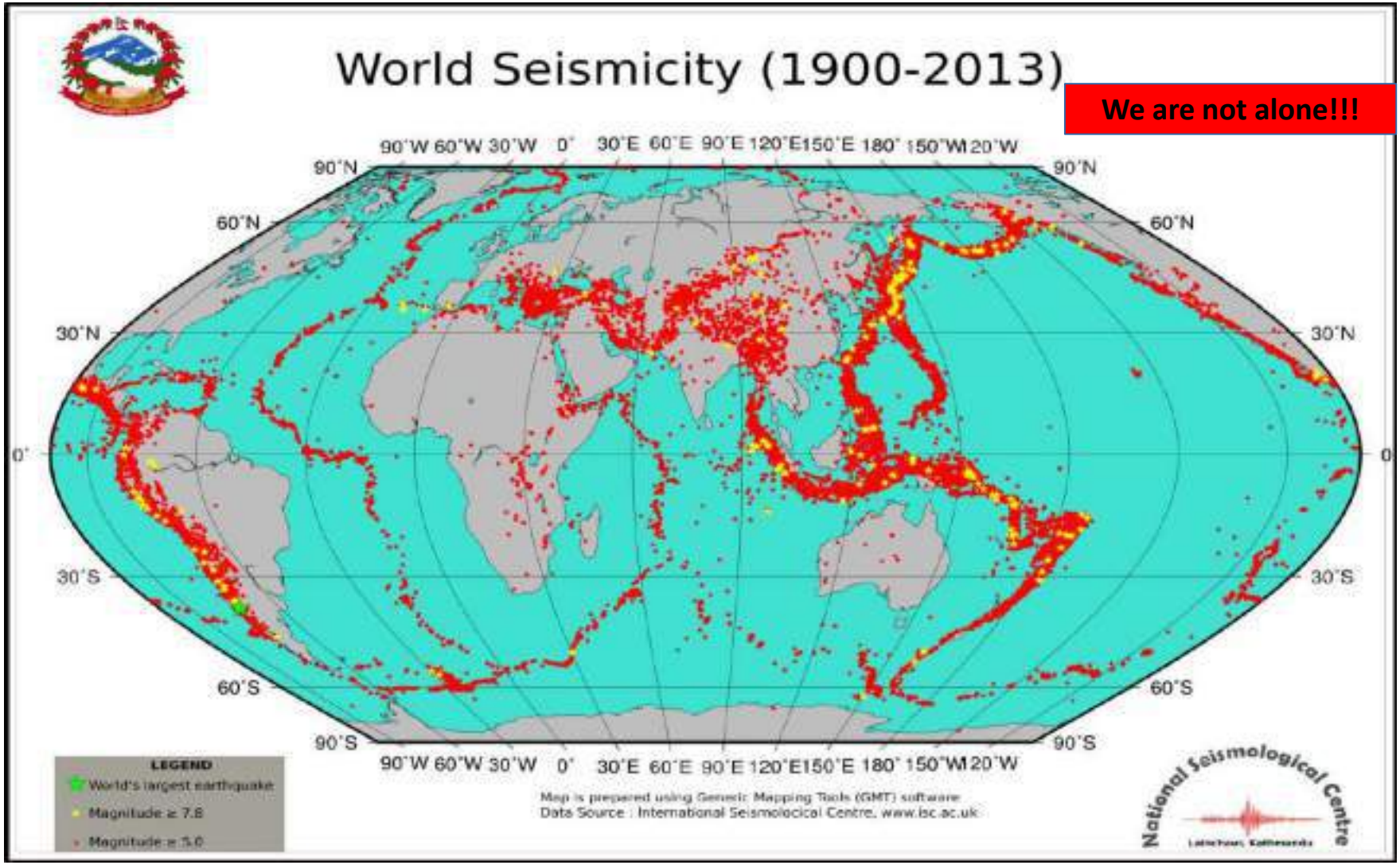


Map source: http://geology.com/plate-tectonics.shtml

The tectonic plates

Geological high speed collision between India and Eurasia



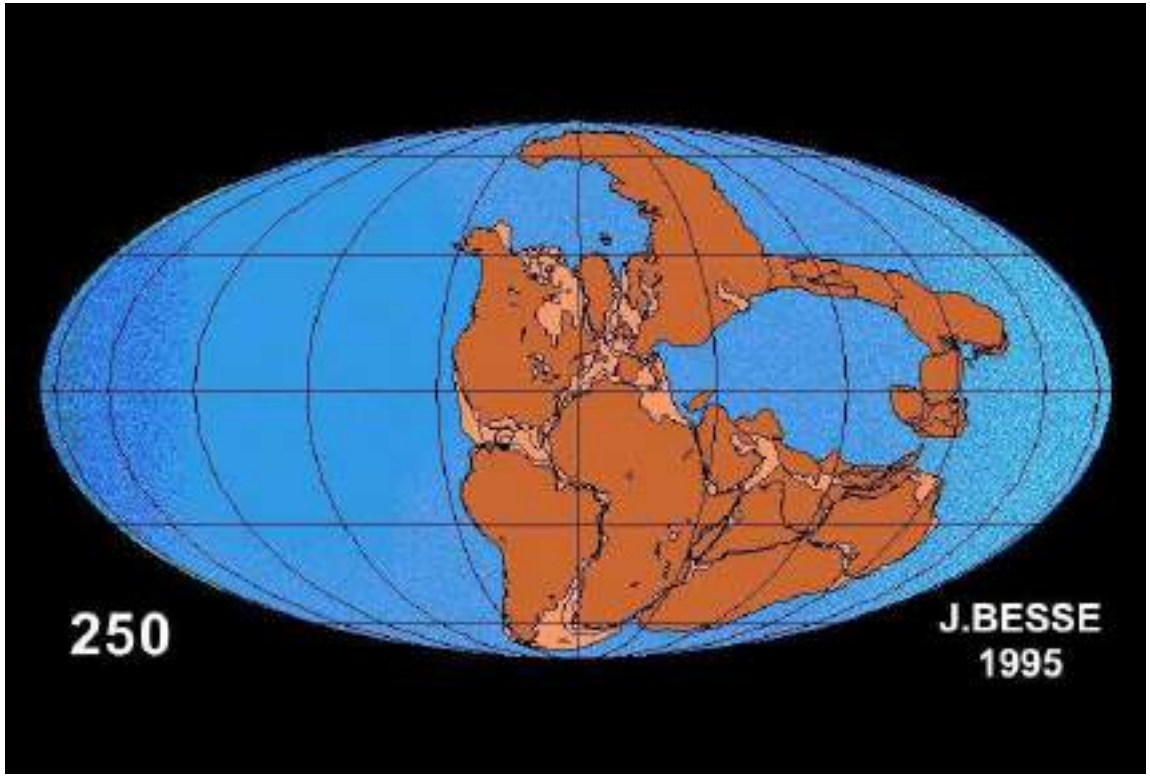

World Seismicity (1900-2013)
We are not alone!!!
90°W 60°W 30°W 0° 30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W
90°N
60°N
30°N
0°
30°S
60°S
90°S
LEGEND
World's largest earthquake
Magnitude ≥ 7.8
Magnitude ≥ 5.0
Map is prepared using Generic Mapping Tools (GMT) software
Data Source : International Seismological Centre, www.isc.ac.uk
National Seismological Centre

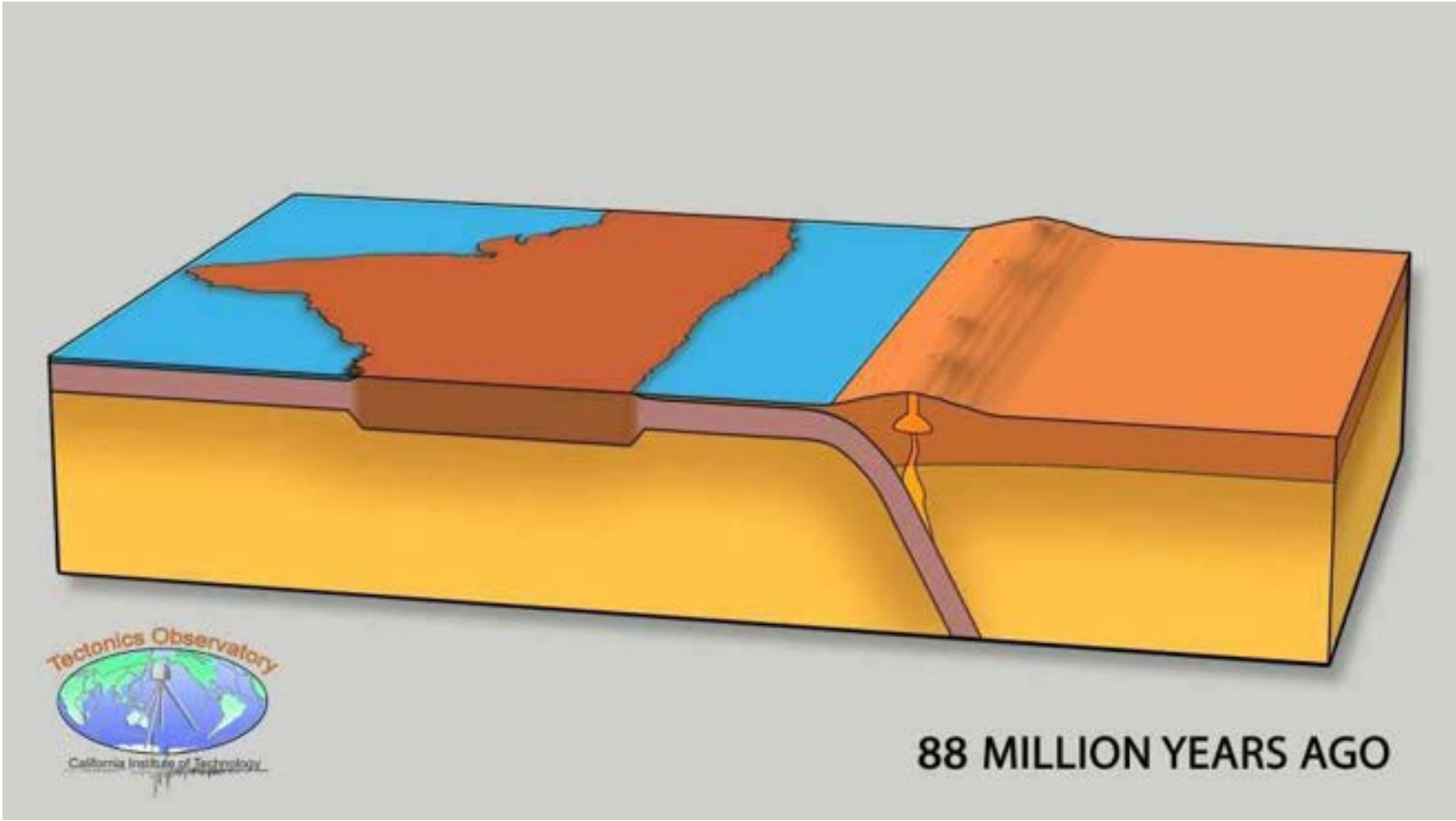
The tectonic plates

The convection makes the tectonic plates move.

Reconstitution of the last 250 million years of tectonic movements.

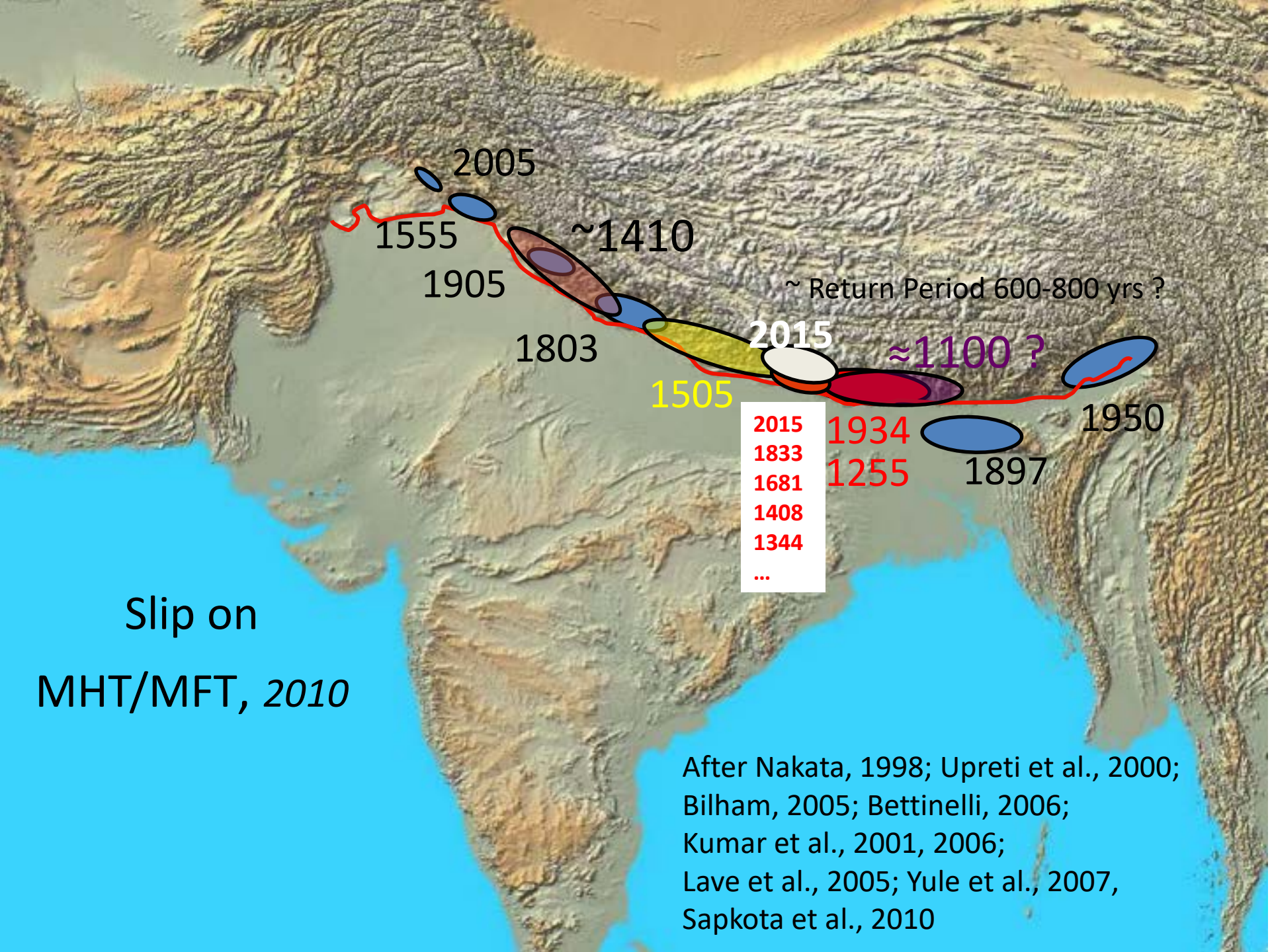
Look for the Indian continent that travels quickly up to Eurasia.

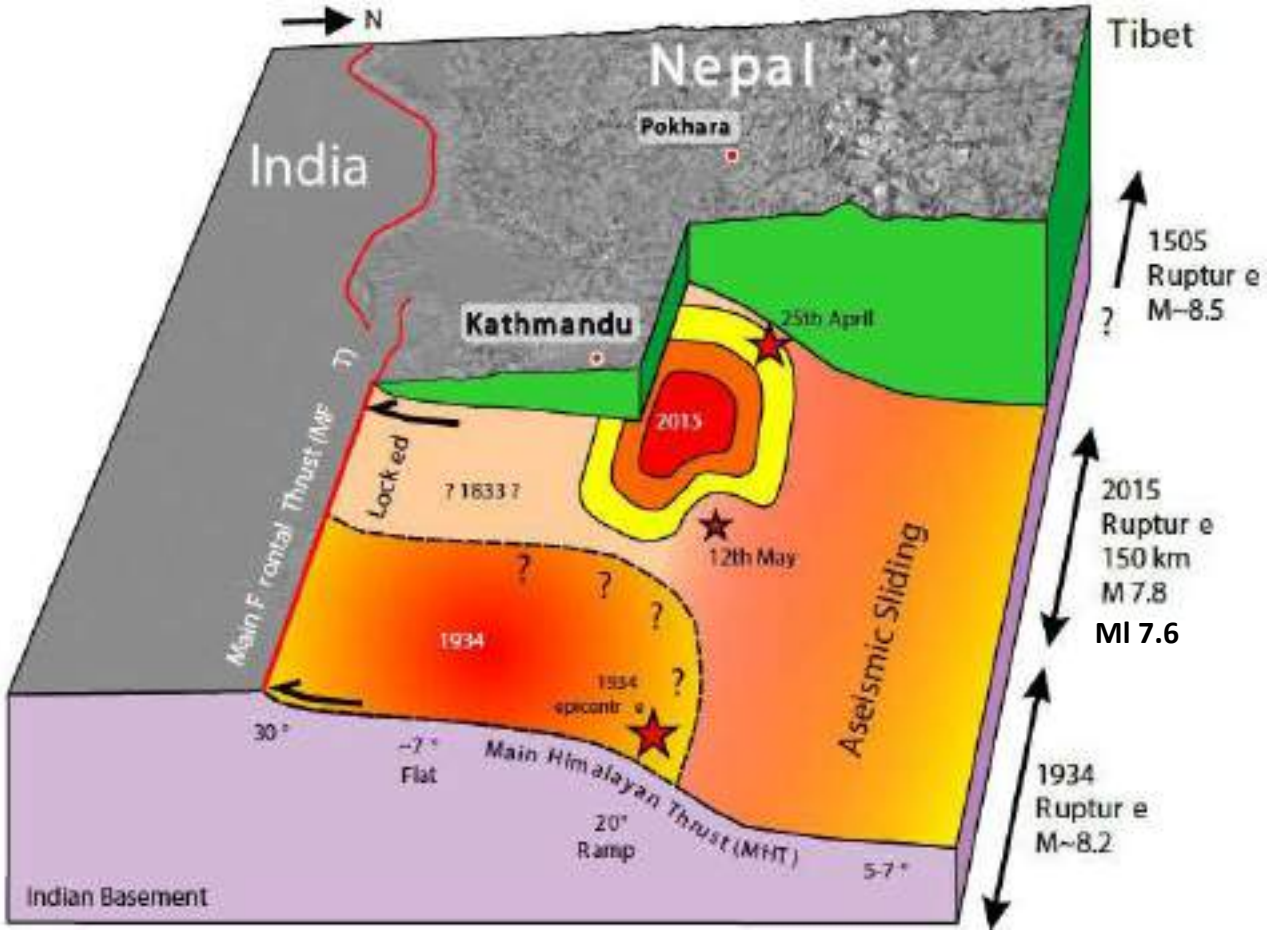



Tectonics Observatory
California Institute of Technology
88 MILLION YEARS AGO

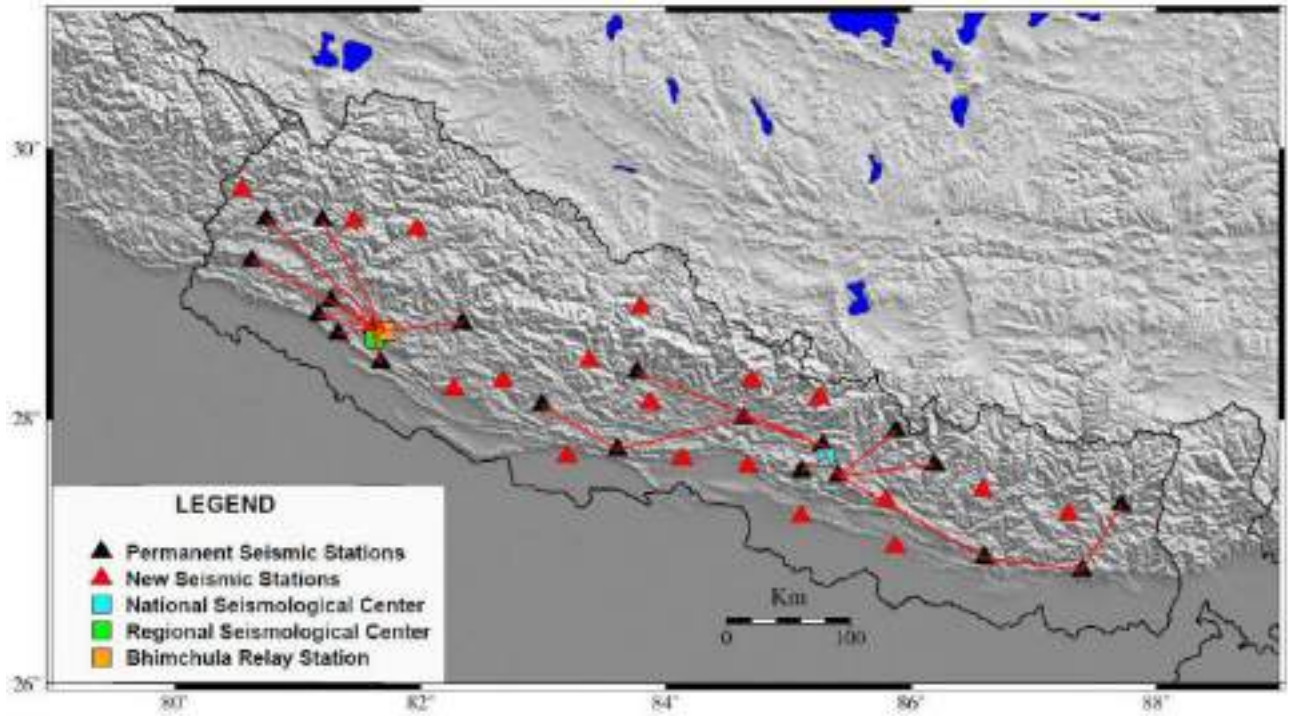
WHY EARTHQUAKES IN NEPAL?

- Nepal falls on the collision zone of the Indian Plate and the Eurasian Plate.
- The north drifting Indian Plate collided with the Eurasian Plate ~50 my before.
- The Indian Plate is still moving due north at a rate of about 4 cm/yr.
- There is accumulation of strain along the collision zone.
- This energy is released at the time of great earthquake.
- Currently the region between Terai and Higher Himalaya is locked and stress is building up at the boundary between Higher Himalaya and Lesser Himalaya at depth.
- The current seismicity is the result of strain build up in the upper part of the crust.

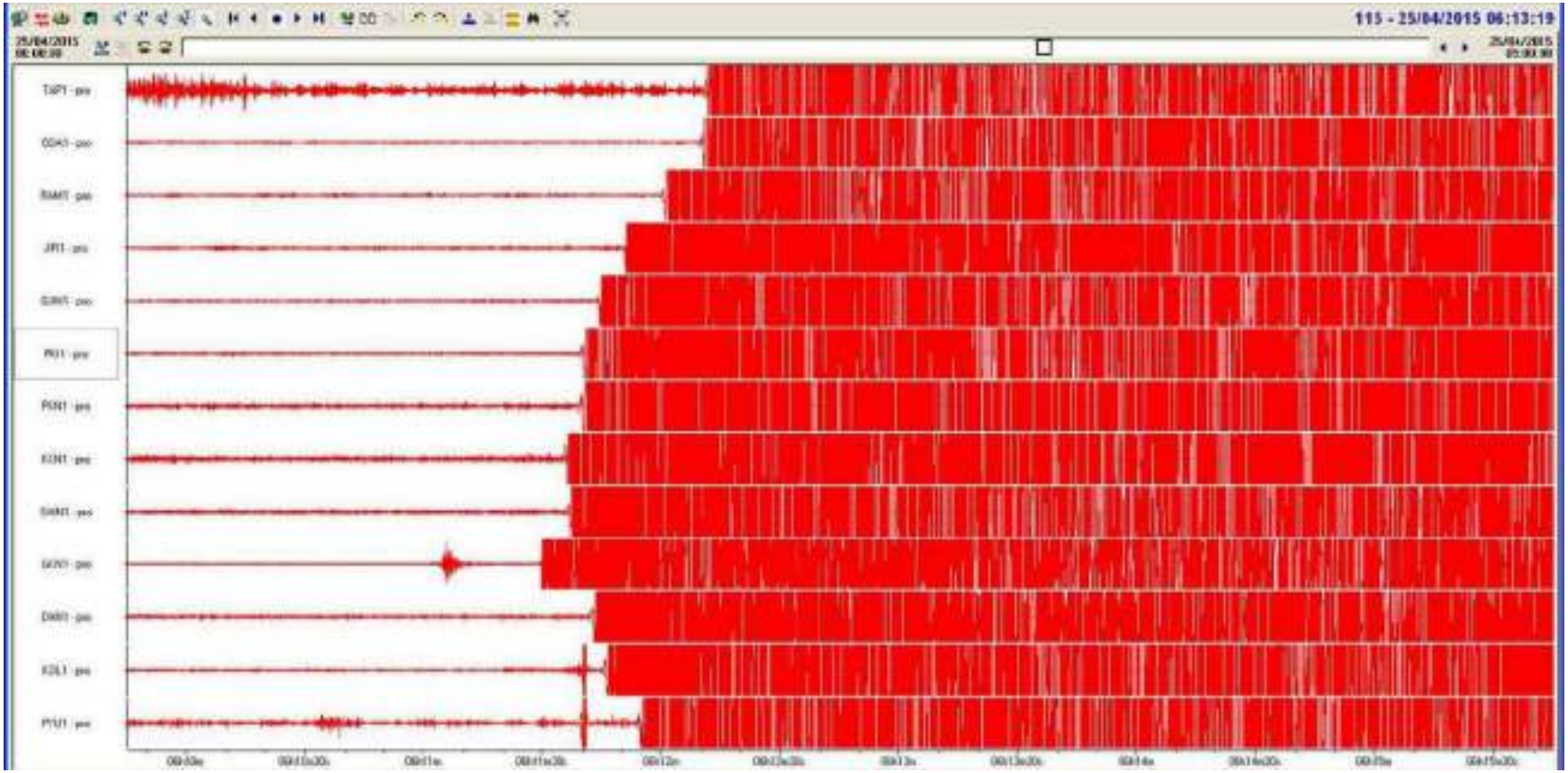

2005
1555
~1410
1905
~ Return Period 600-800 yrs ?
1803
2015
≈1100 ?
1505
1934
1950
1255
1897
2015
1833
1681
1408
1344
…
Slip on
MHT/MFT, *2010*
After Nakata, 1998; Upreti et al., 2000;
Bilham, 2005; Bettinelli, 2006;
Kumar et al., 2001, 2006;
Lave et al., 2005; Yule et al., 2007,
Sapkota et al., 2010


N
Nepal
Tibet
India
Pokhara
Kathmandu
25th April
12th May
2015
1934
1934 epicentre
Locked
? 1833 ?
Main Frontal Thrust (MFT)
Aseismic Sliding
30°
~7°
Flat
Main Himalayan Thrust (MHT)
20°
Ramp
5-7°
Indian Basement
1505
Ruptur e
M~8.5
?
2015
Ruptur e
150 km
M 7.8
Ml 7.6
1934
Ruptur e
M~8.2

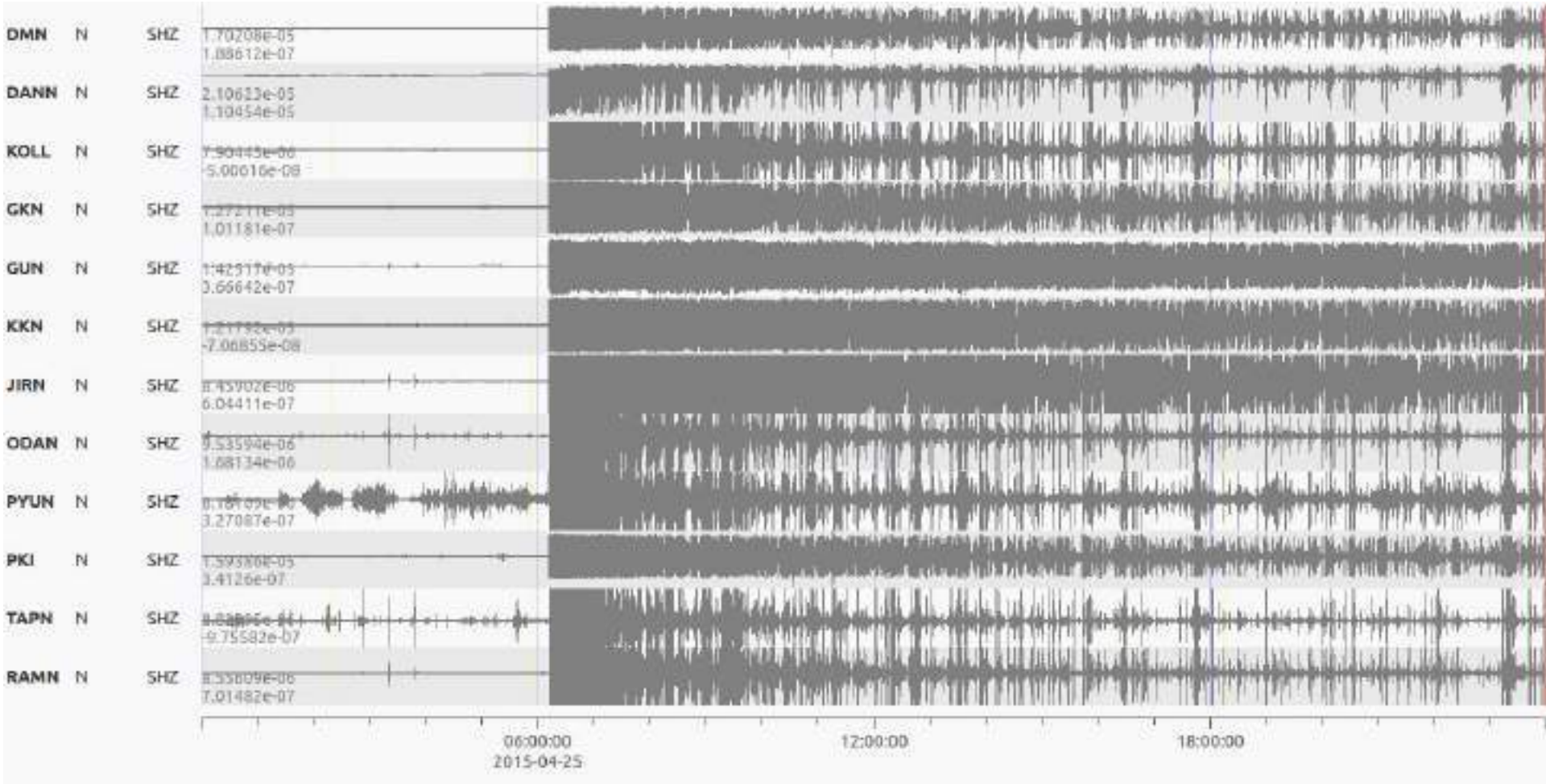
Seismic stations Seismic Vault Network



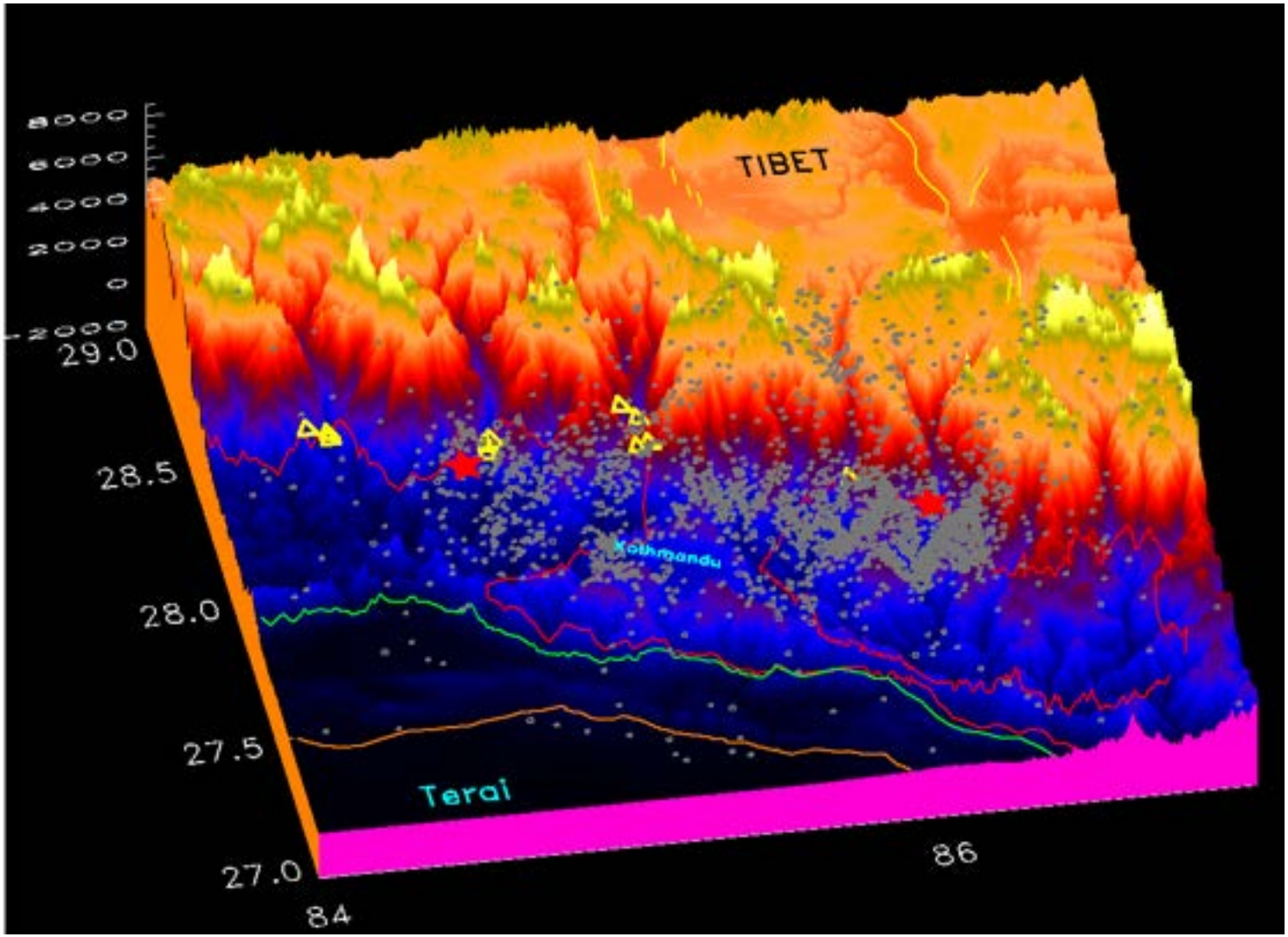
Signal of Gorkha Earthquake



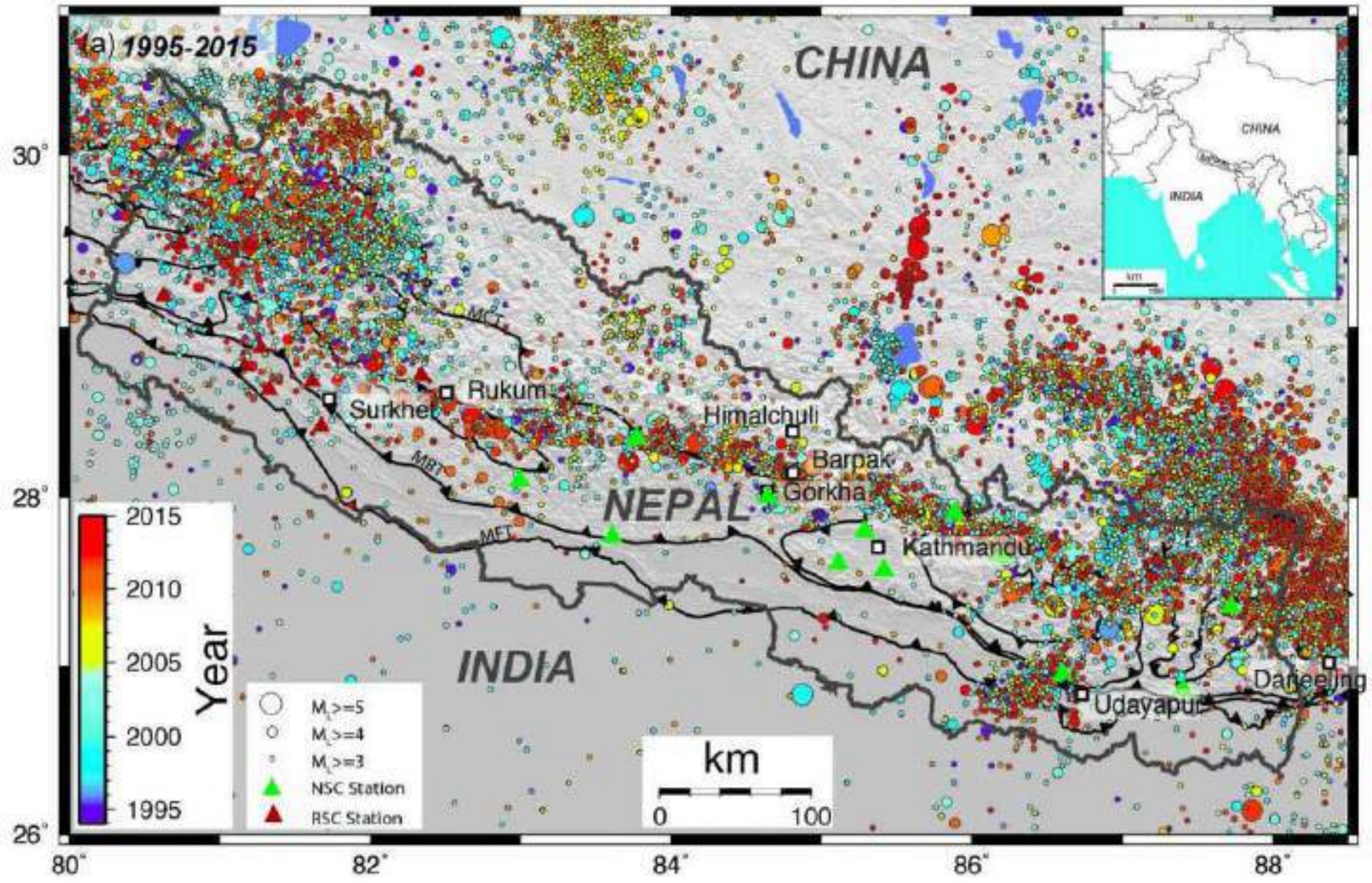
24 hours of 25 April 2015…



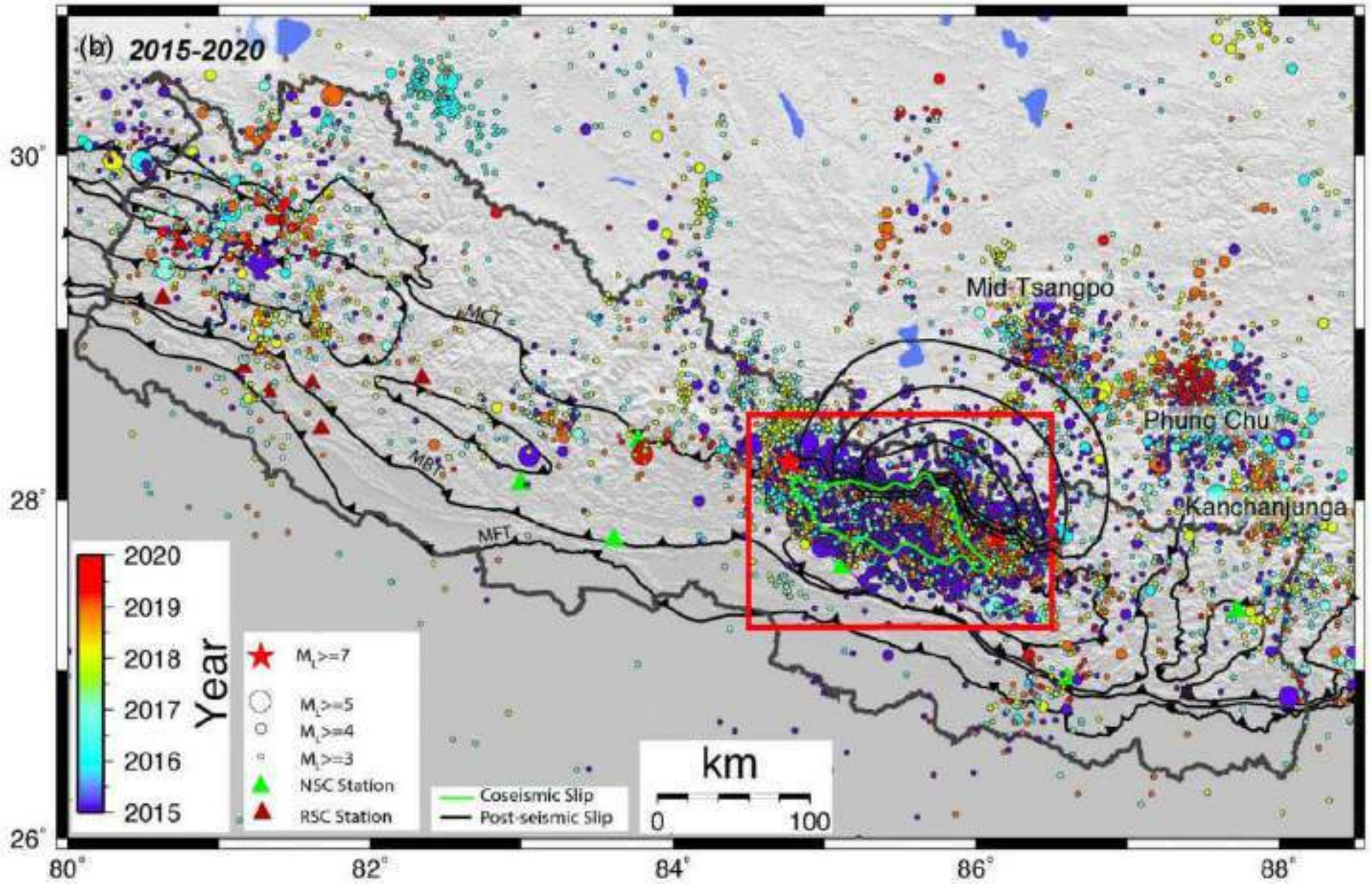
3D view of the region with main shock, largest aftershock, aftershocks and tectonic boundaries

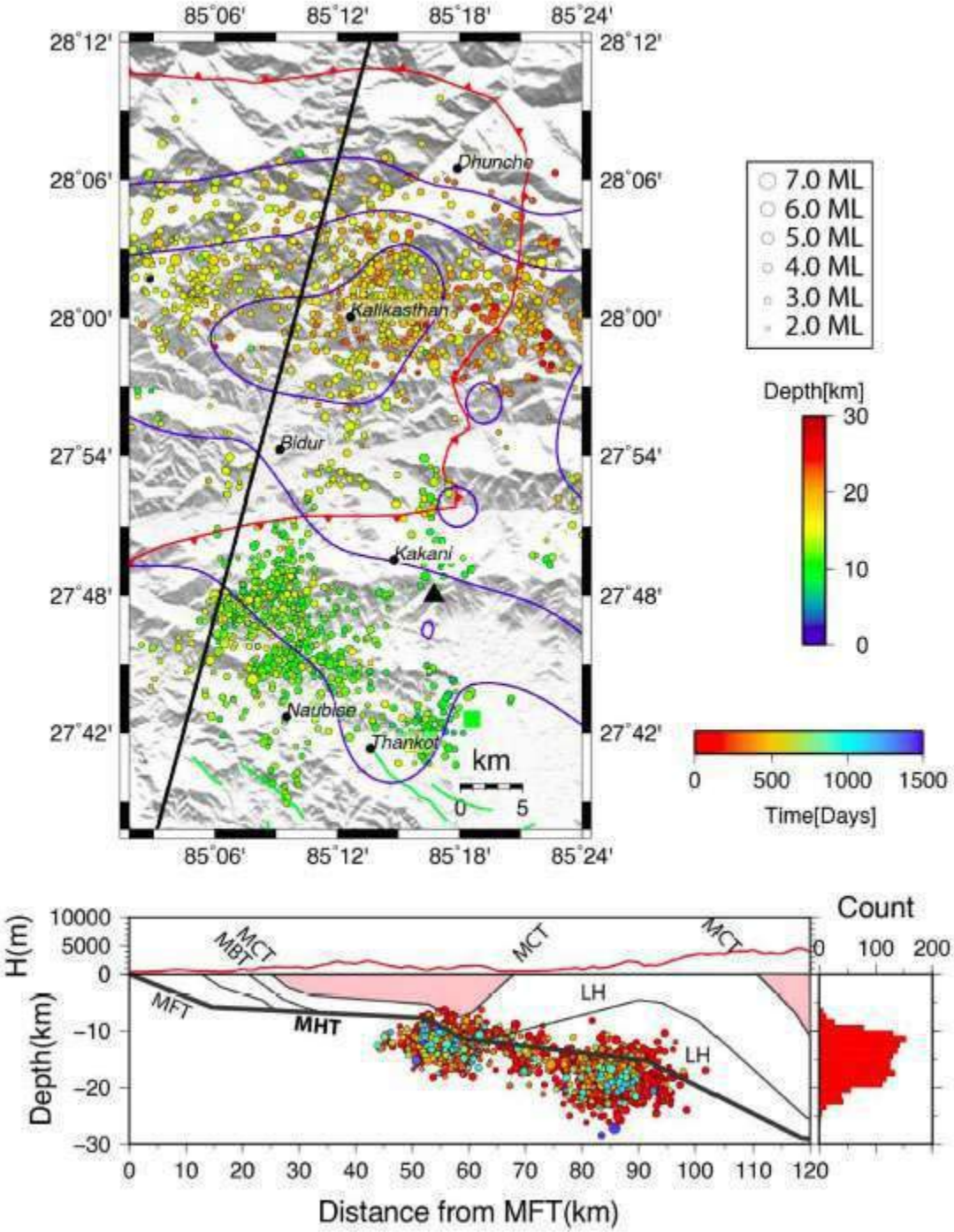


Interseismic Seismicity



Seismicity after Gorkha Earthquake

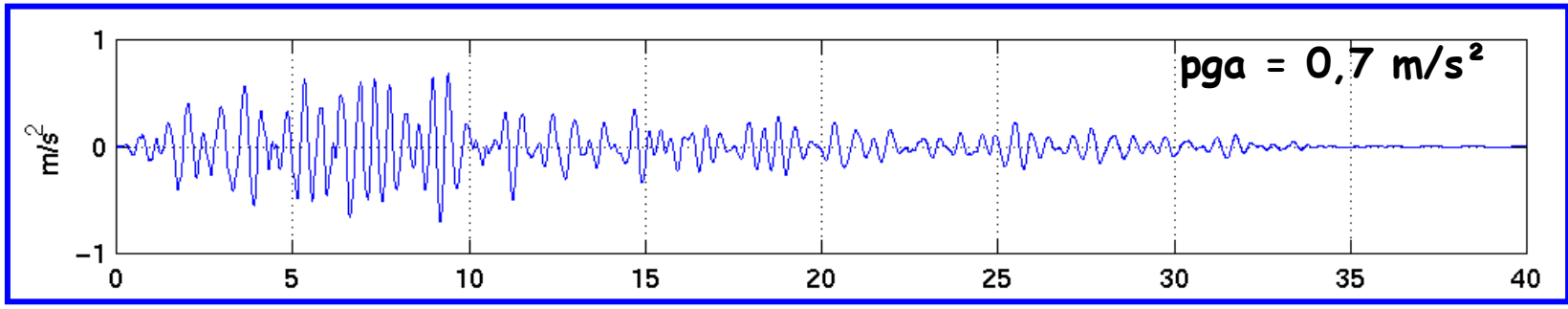



85°06'
85°12'
85°18'
85°24'
28°12'
28°06'
28°00'
27°54'
27°48'
27°42'
Dhunche
Kalikasthan
Bidur
Kakani
Naubise
Thankot
km
0
5
7.0 ML
6.0 ML
5.0 ML
4.0 ML
3.0 ML
2.0 ML
Depth[km]
30
20
10
0
0
500
1000
1500
Time[Days]
H(m)
10000
5000
0
MCT
MBT
MCT
MCT
Count
0
100
200
MFT
MHT
LH
LH
Depth(km)
-10
-20
-30
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance from MFT(km)

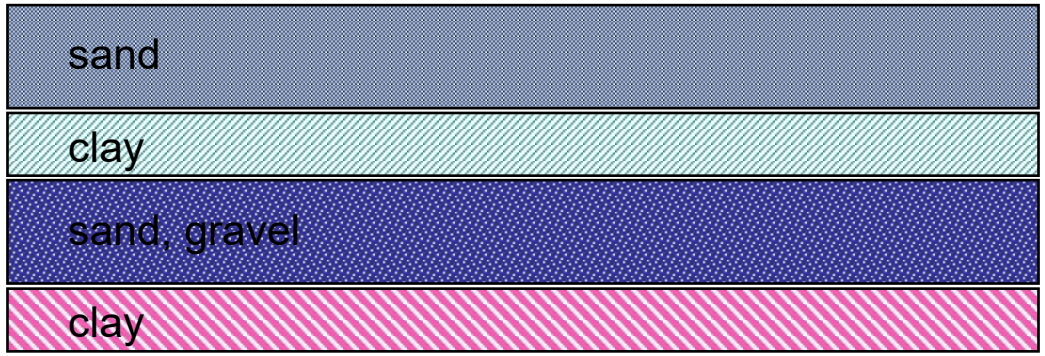
SHAKING OF EARTHQUAKE DEPENDS ON

- **Magnitude**
  - More energy released
- **Distance**
  - Shaking decays with distance
- **Local soils**
  - amplify the shaking

SITE EFFECT

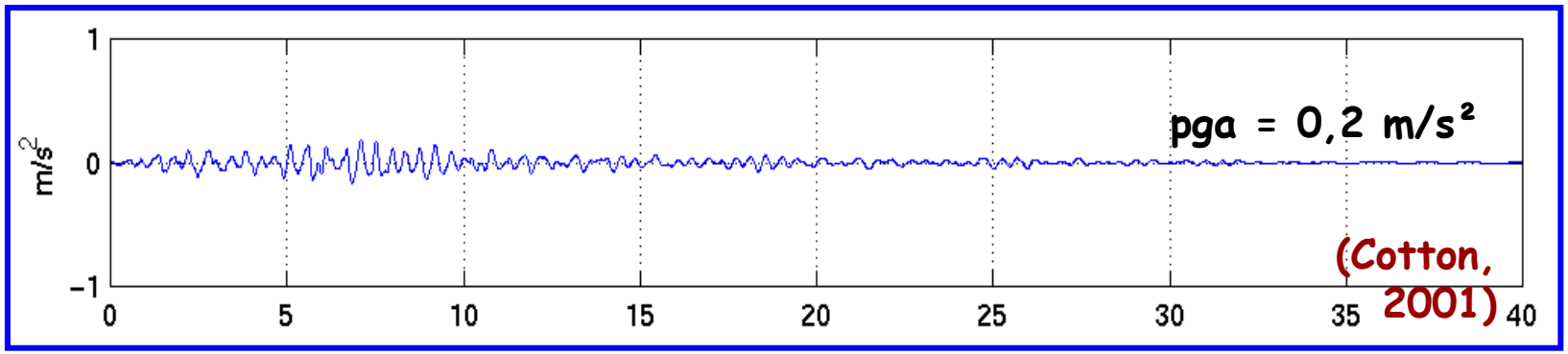


Soft/hard rocks=3.5

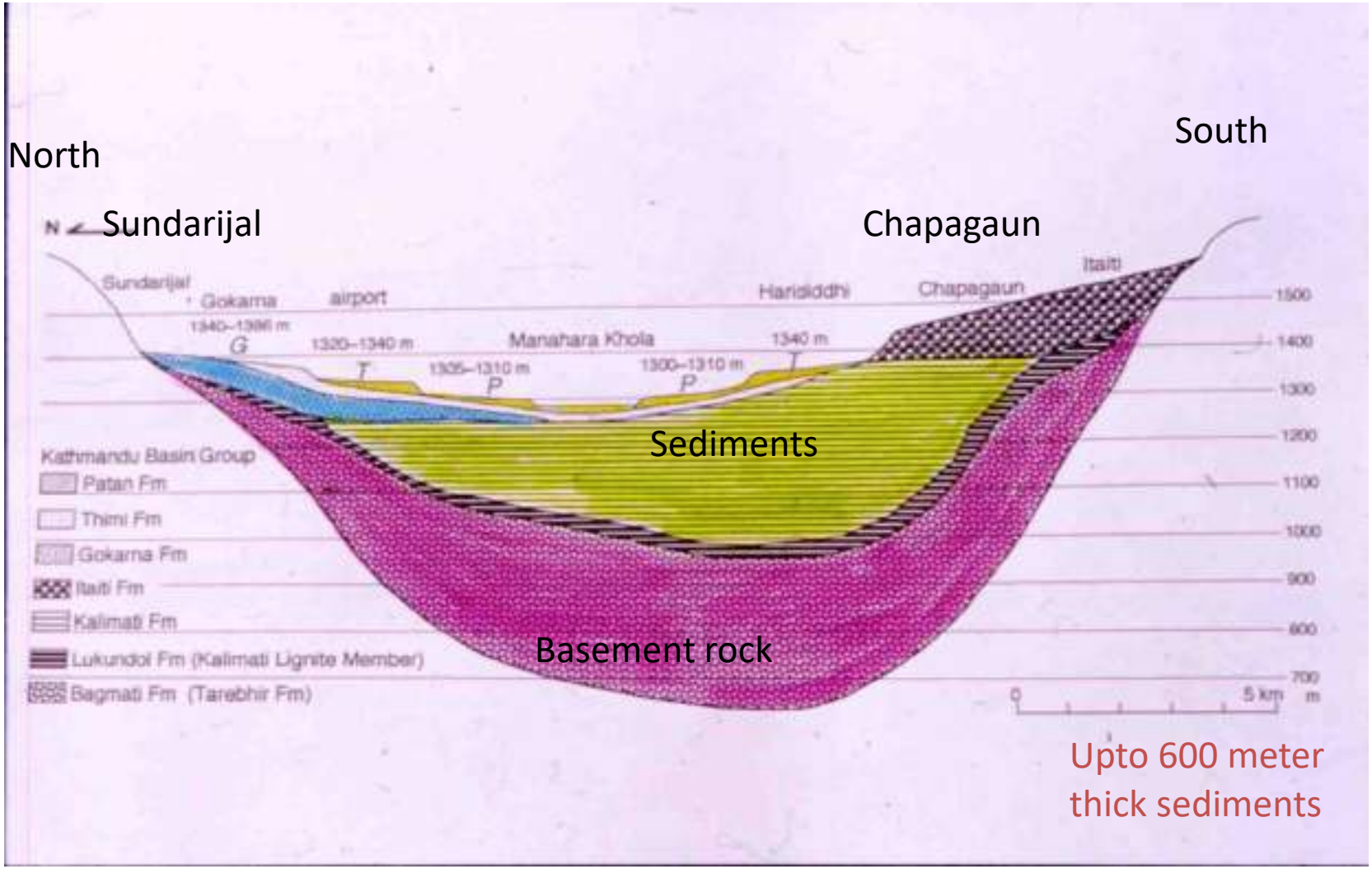


soil record

Reference rock record

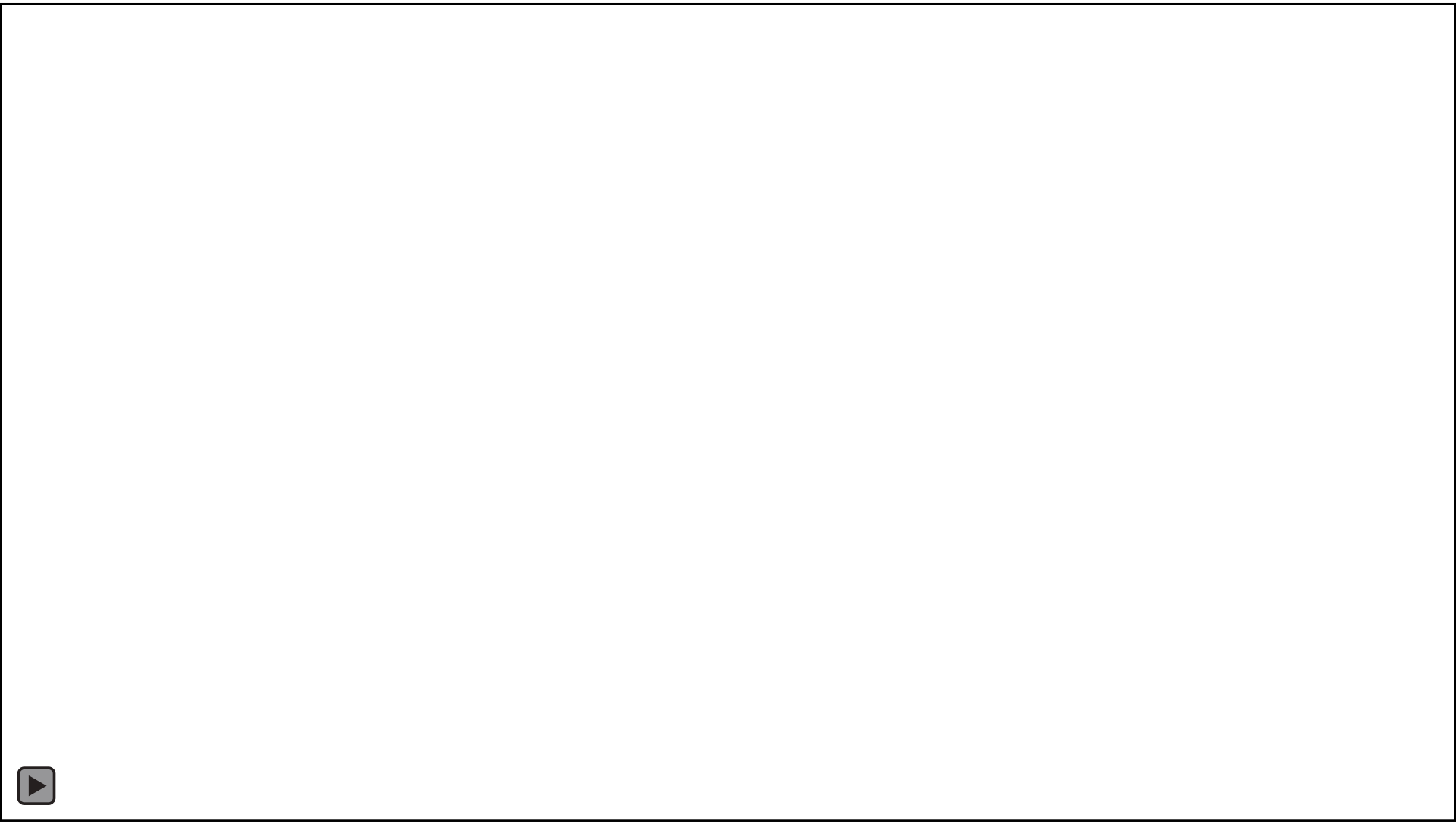


KATHMANDU VALLEY

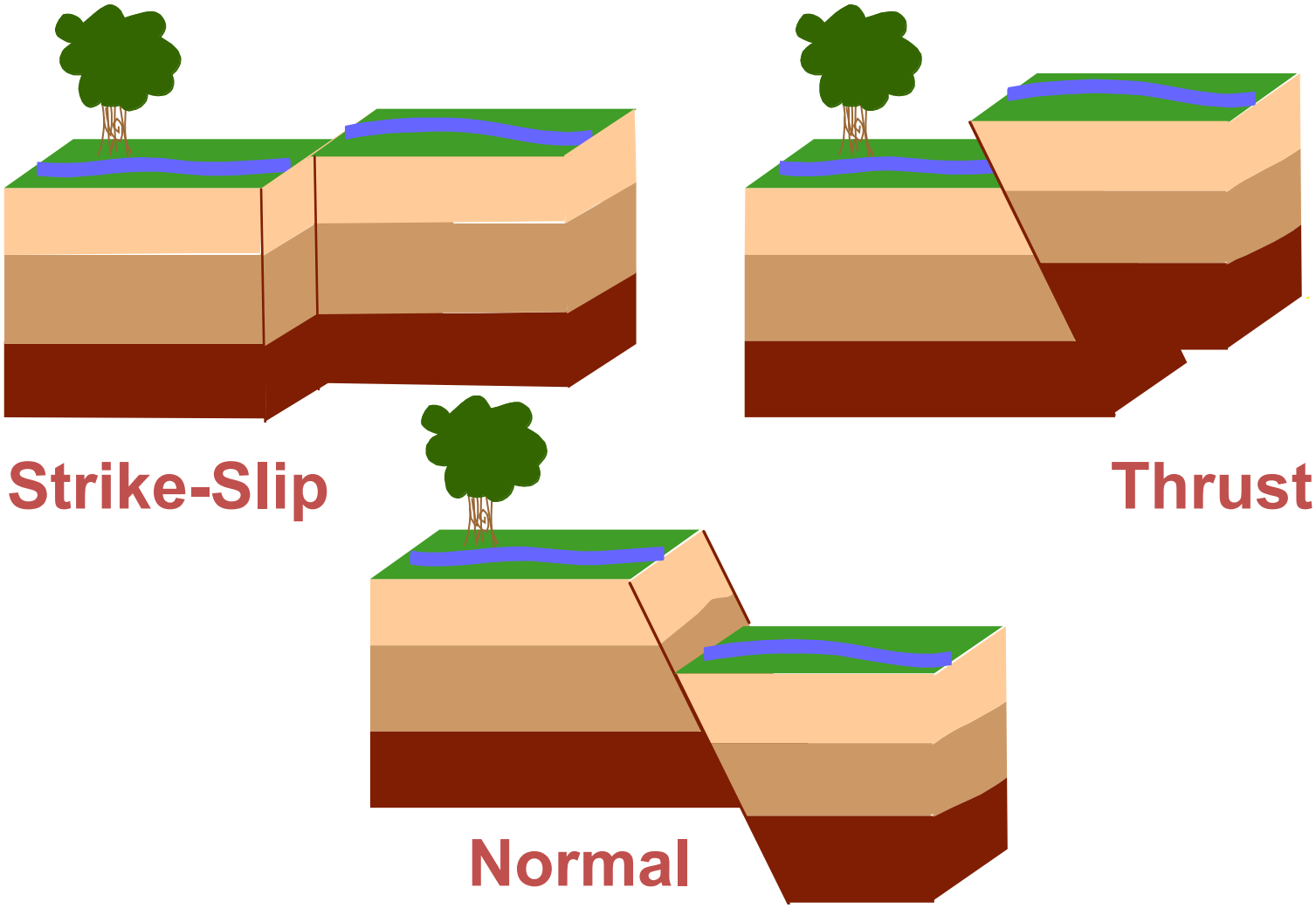


Katmandu valley is composed of soft soil (about 600 m thick in central part)
Liquefaction may be possible at several locations.

Difference in GPS site response



THREE TYPES OF FAULTS

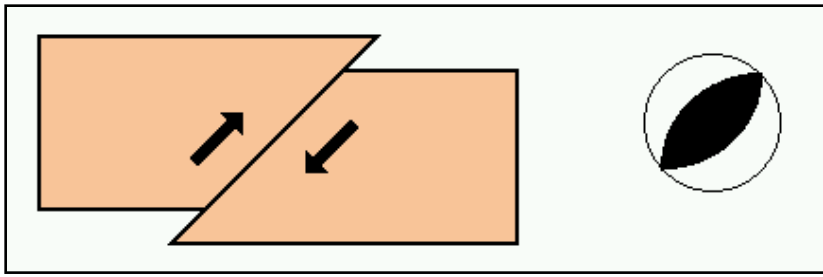


STRIKE SLIP

NORMAL FAULT

THRUST

Chi-Chi Earthquake, Taiwan



Nojima Fault, Kobe, Japan

EFFECT OF EARTHQUAKES

- Ground Shaking
- Surface Faulting
- Fire
- Landslide
- Liquefaction
- Tsunami

GROUND SHAKING

Bhaktapur's Durbar Square before (top) and after (below) the 1934 Bihar-Nepal Great Earthquake.

Ground Shaking

KOBE, JAPAN 1995

SURFACE FAULTING

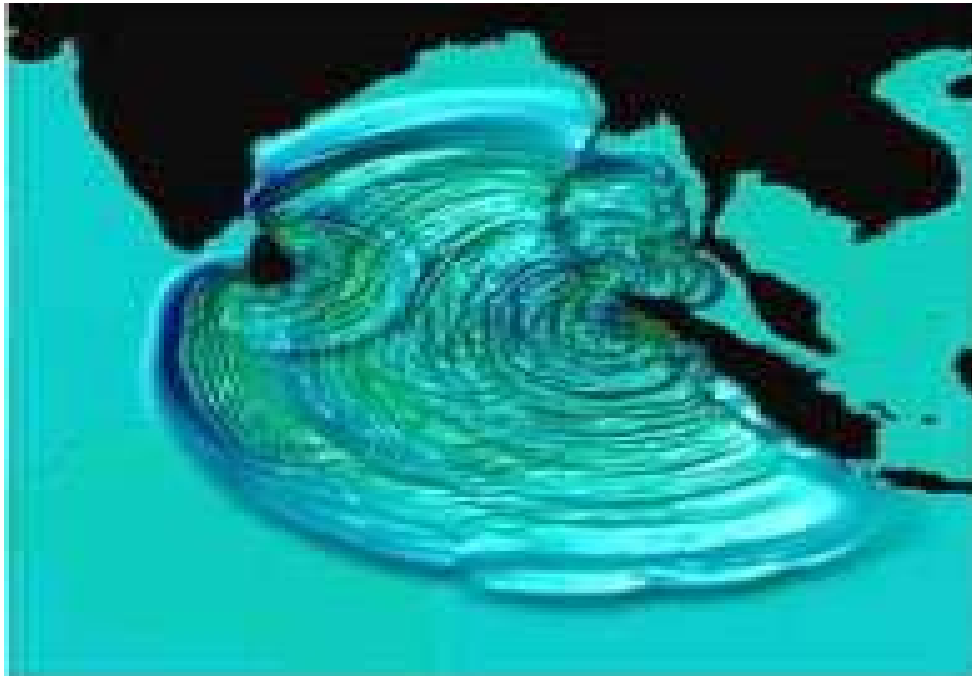
FIRE

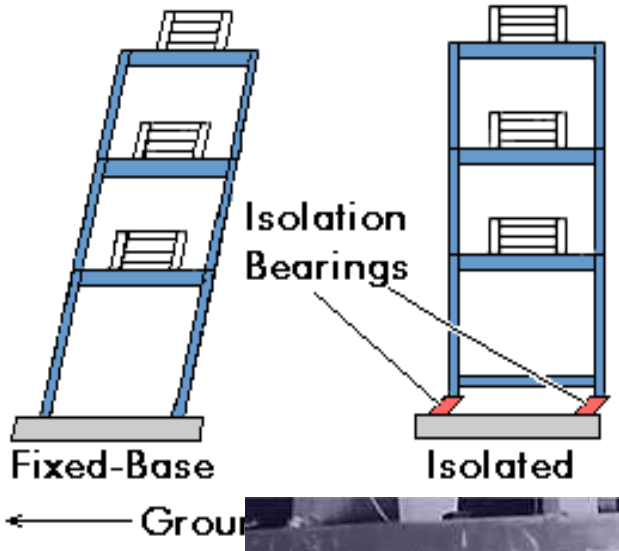
LIQUEFACTION

LANDSLIDE

April 12, 2004

TSUNAMI

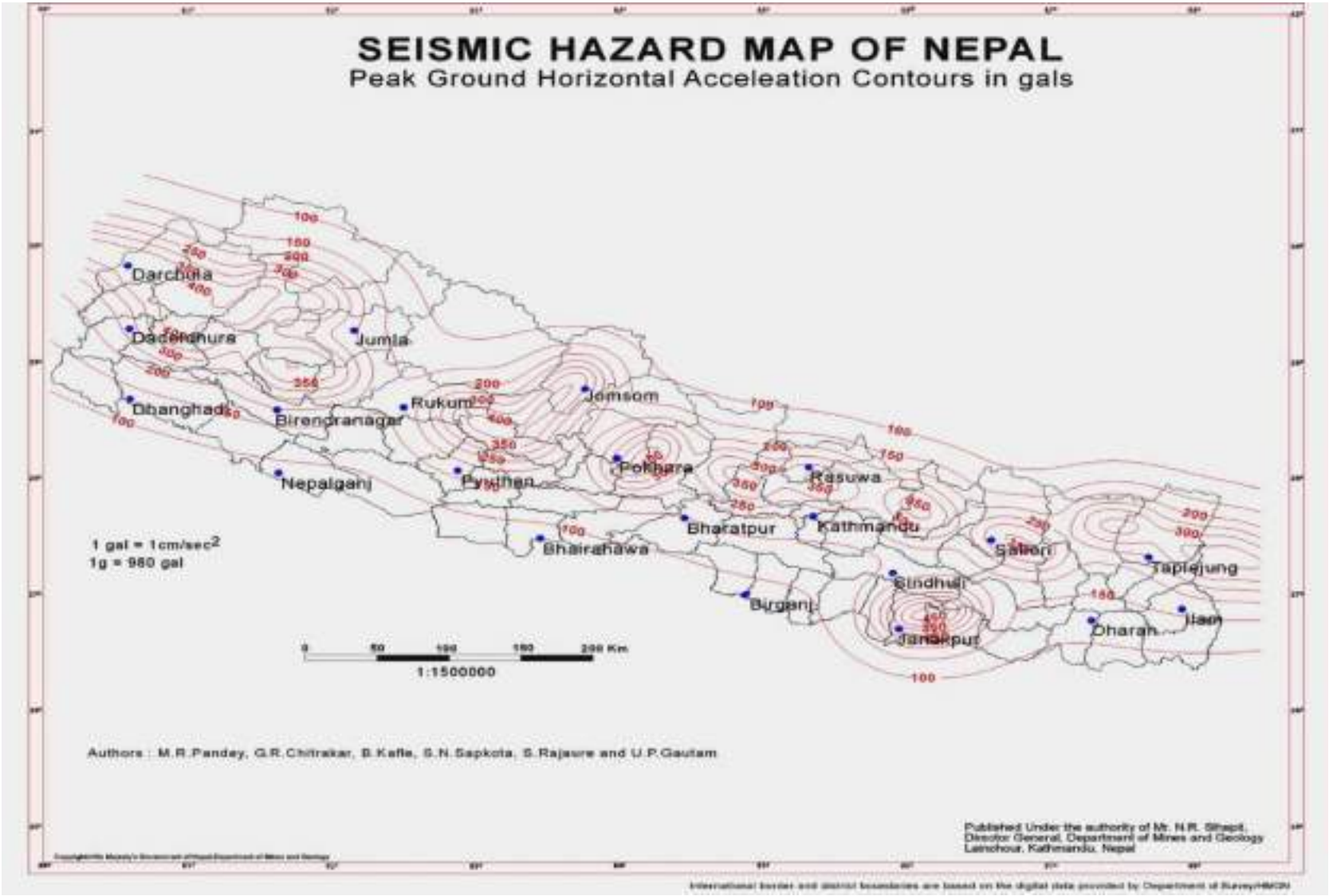




Base Isolation

RETROFITTING

OUR ENGINEERING !!!


SEISMIC HAZARD MAP OF NEPAL
Peak Ground Horizontal Acceleation Contours in gals
Darchula
Dadeldhura
Jumla
Dhanghadi
Birendranagar
Rukum
Jomsom
Nepalganj
Pyuthan
Pokhara
Rasuwa
Bharatpur
Kathmandu
Bhairahawa
Sindhuli
Siliori
Taplejung
Dharan
Ilam
Janakpur
Birganj
1 gal = 1cm/sec2
1g = 980 gal
0 50 100 150 200 Km
1:1500000
Authors : M.R.Pandey, G.R.Chitrakar, B.Kafle, S.N.Sapkota, S.Rajaure and U.P.Gautam
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Thank you