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24

Global Death and Construction: Earthquakes on an Urban Planet

Dr. Roger Bilham

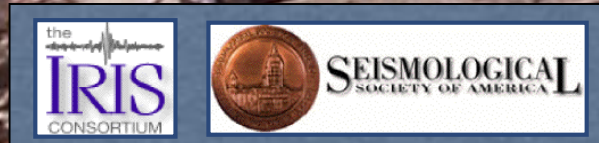
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Global Death and Construction: Earthquakes on an Urban Planet

Dr. Roger Bilham

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Road Map to Killer Buildings

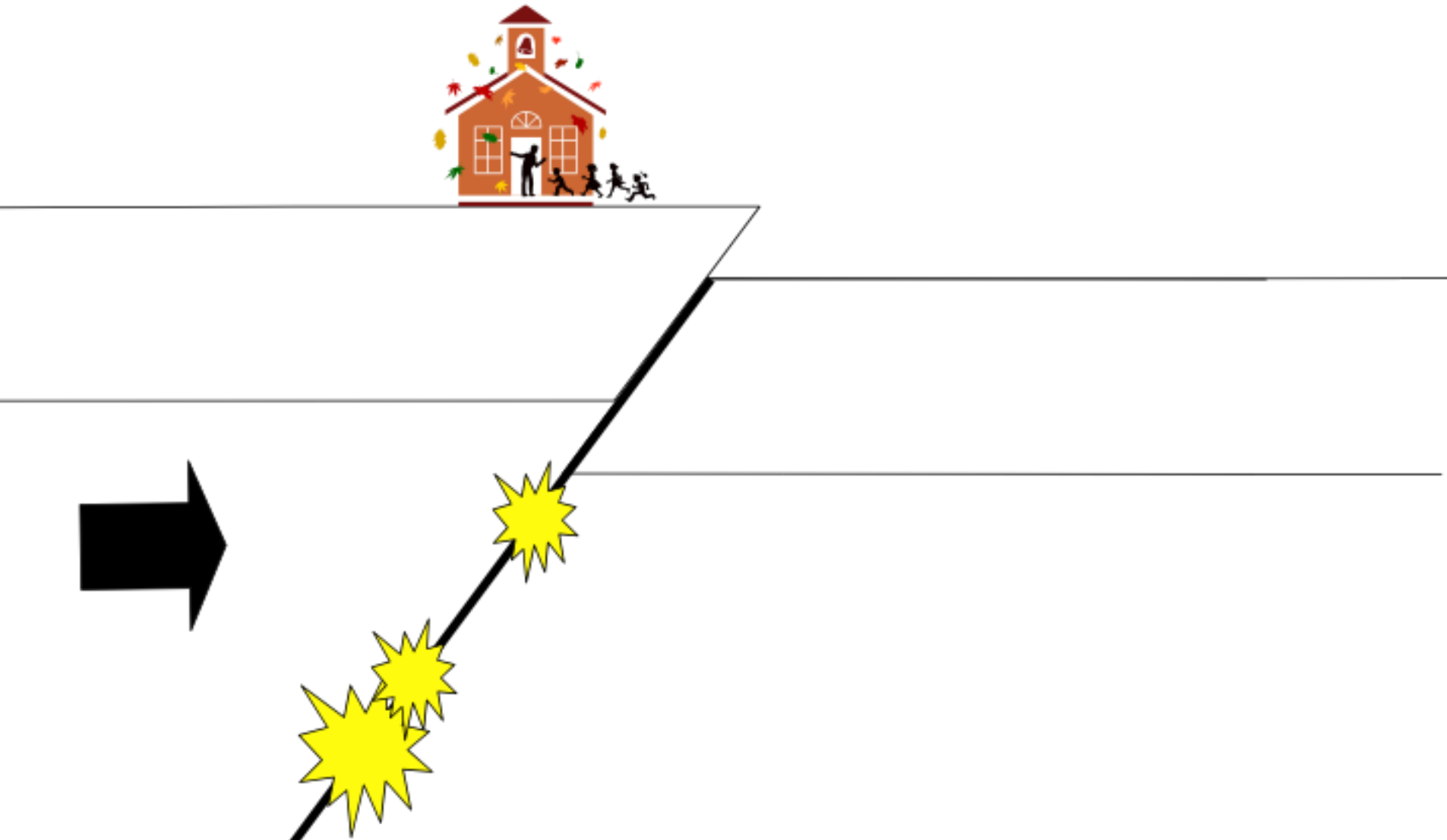
- What Causes Earthquakes
- Where People Live (recently too many people)
- Violent Deaths (8 million earthquake fatalities in the past millenium)
- Statistics and Predictions (the 1 million fatality extreme event)
- India's 500 Million at Risk (past disasters, worse to come, and why)
- How People Die (criminal contractors)
- Rooms for Optimism
(3 billion dwelling units under construction in the next 50 years)



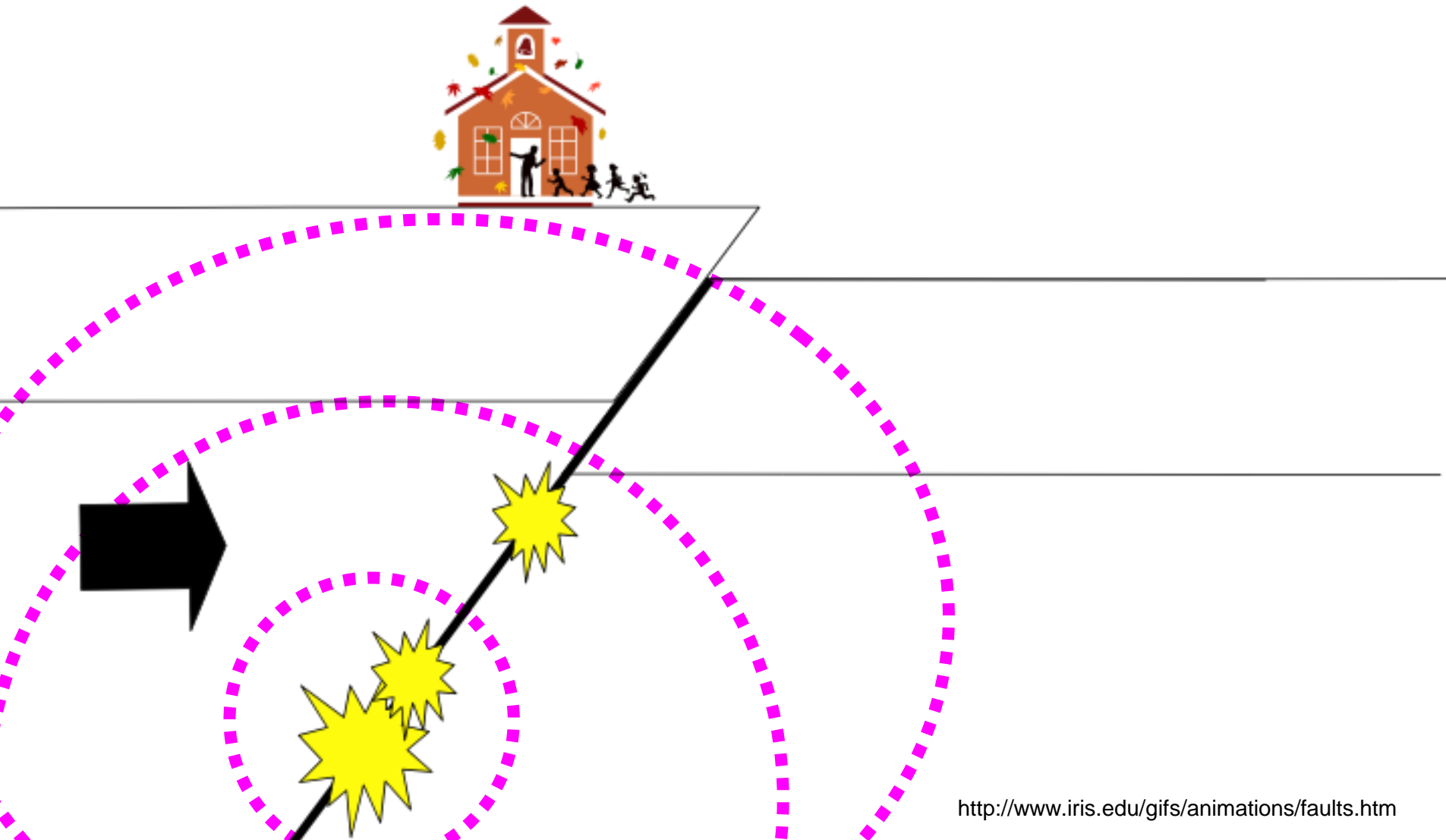
Earthquakes occur when two rock masses slide past each other.

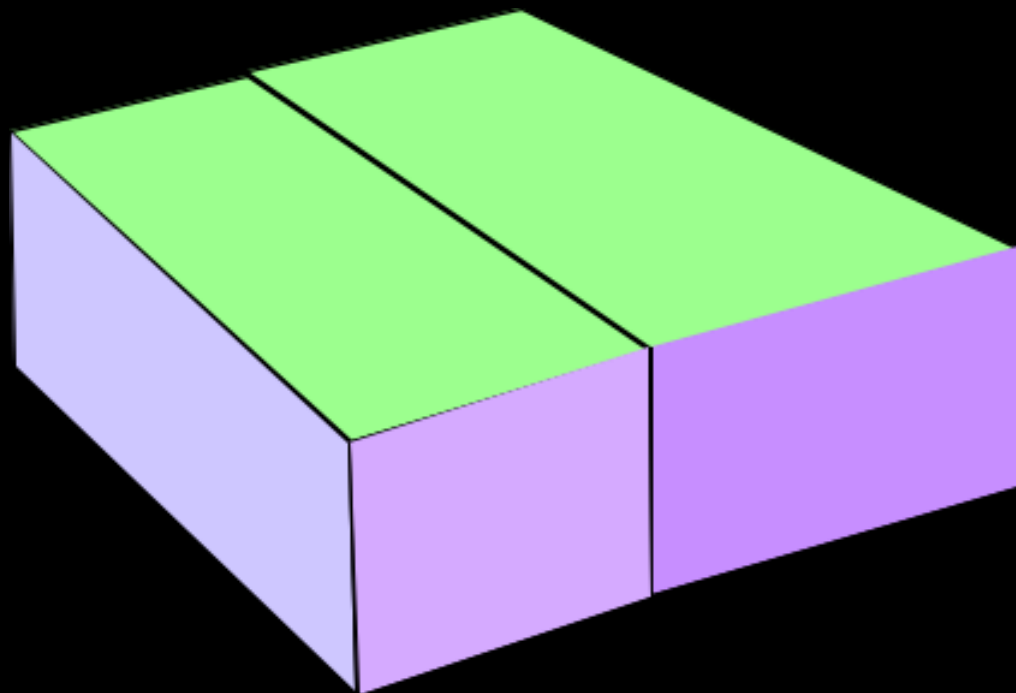


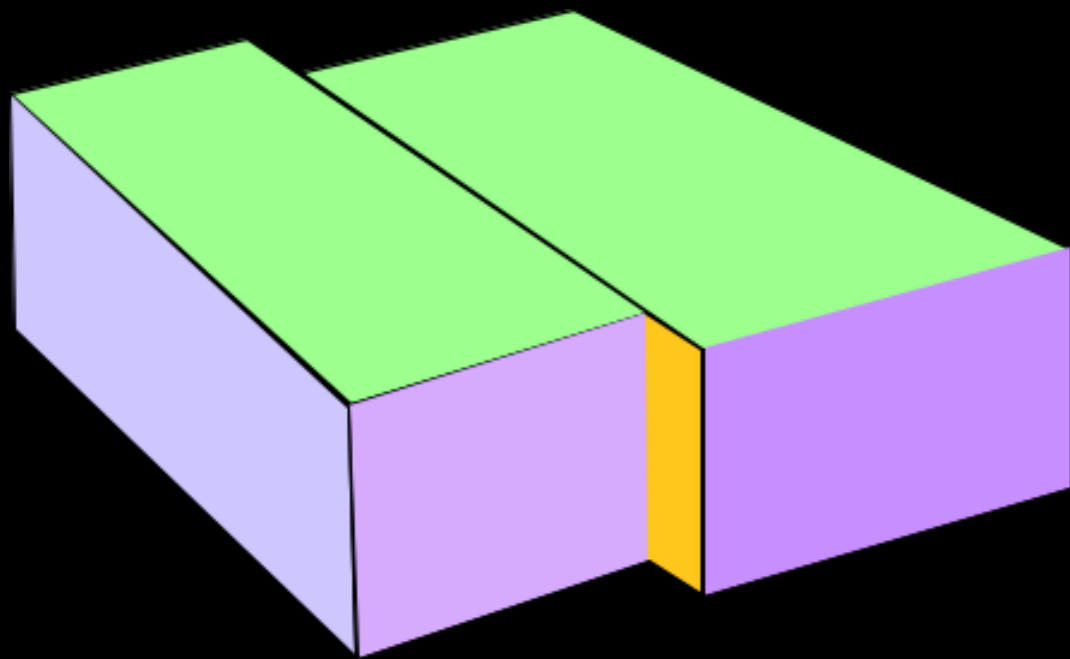
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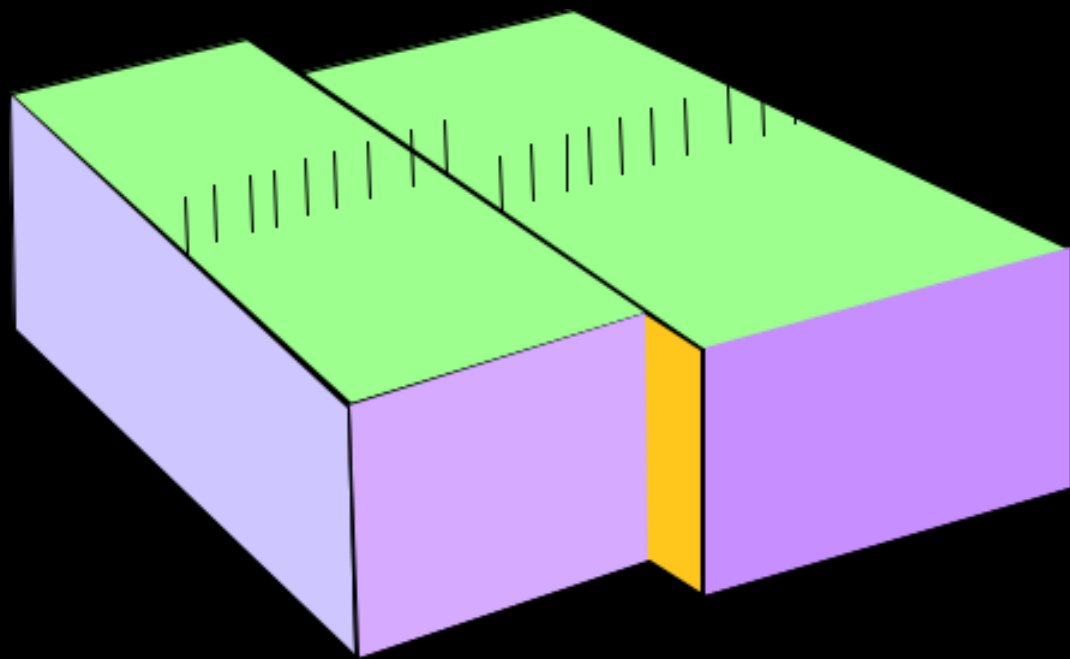


Earthquakes occur when two rock masses slide past each other.

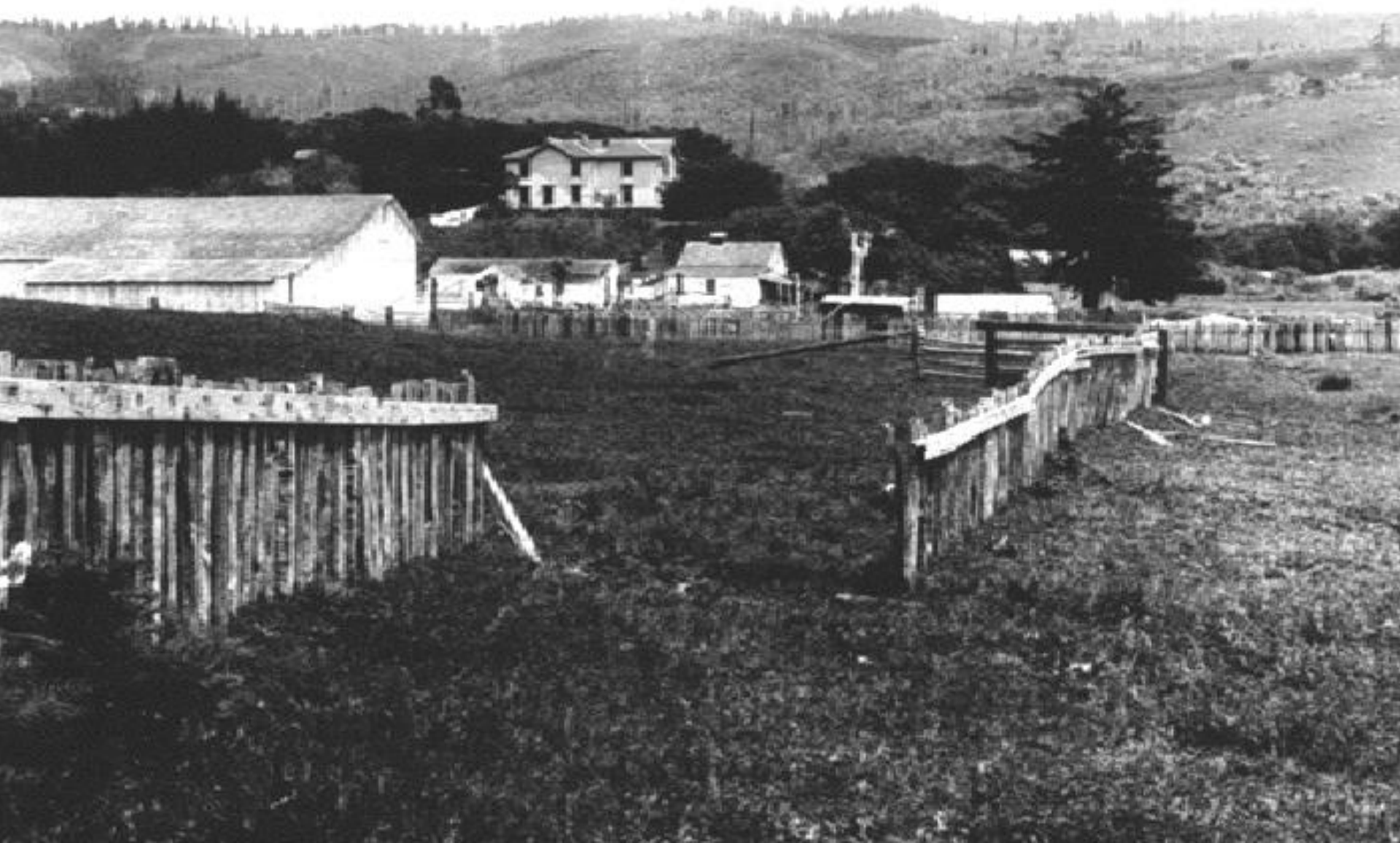








1906 San Francisco quake







ChiChi earthquake
Taiwan Sept. 1999
 $M=7.8$



Izmit earthquake
Turkey Aug. 99
 $M=7.4$

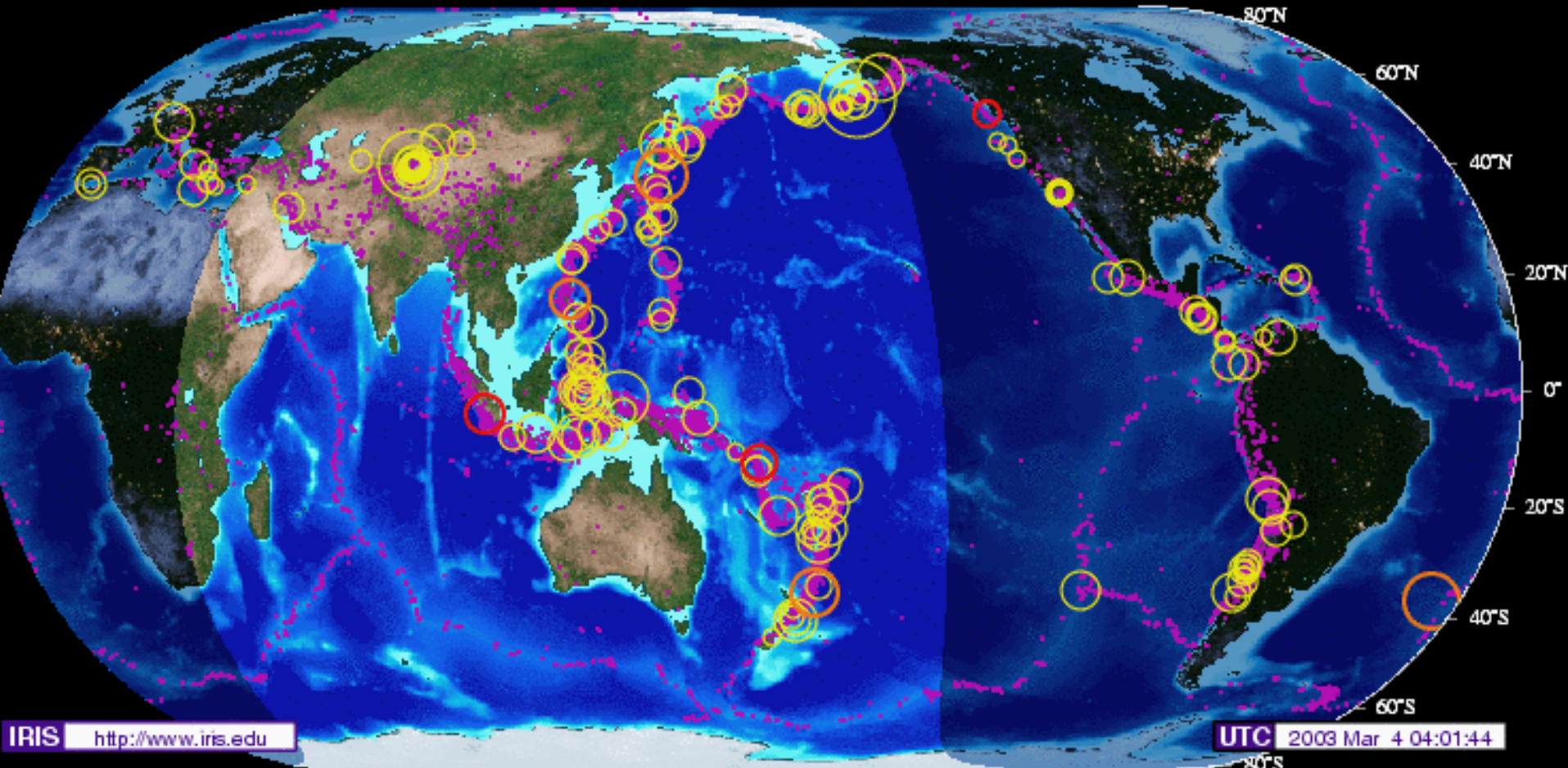
Most earthquakes happen at plate boundaries.

- the bigger the fault- the larger the quake
- fast plate motions \blacktriangle more frequent earthquakes
- can't stop earthquakes

<http://www.iris.edu/seismon/>

m8
m7
m6
24hrs
48hrs
5yrs
2wks

Seismic Monitor

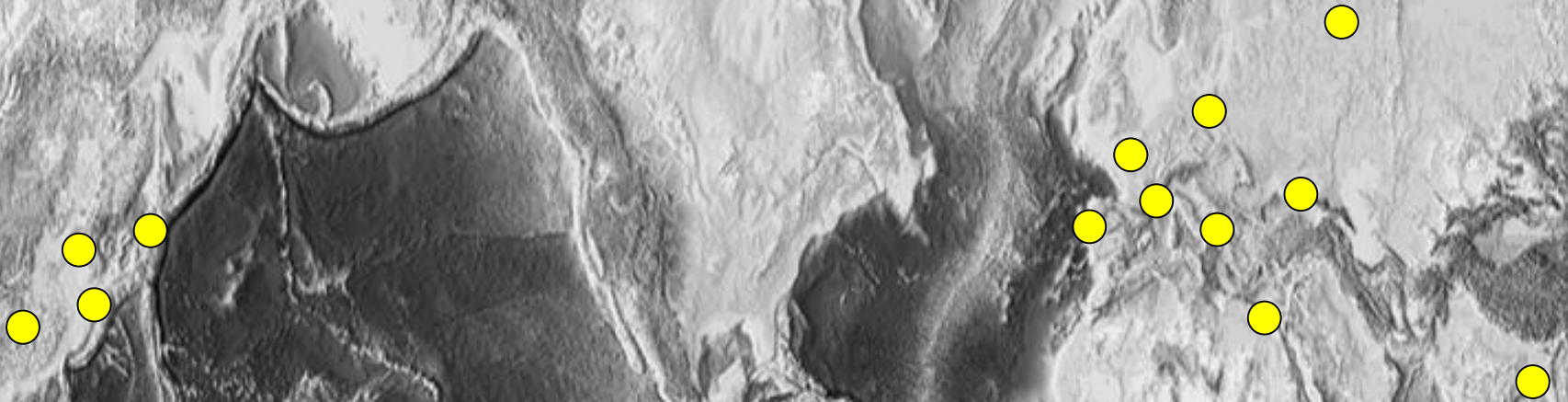




The Target: Urban Society

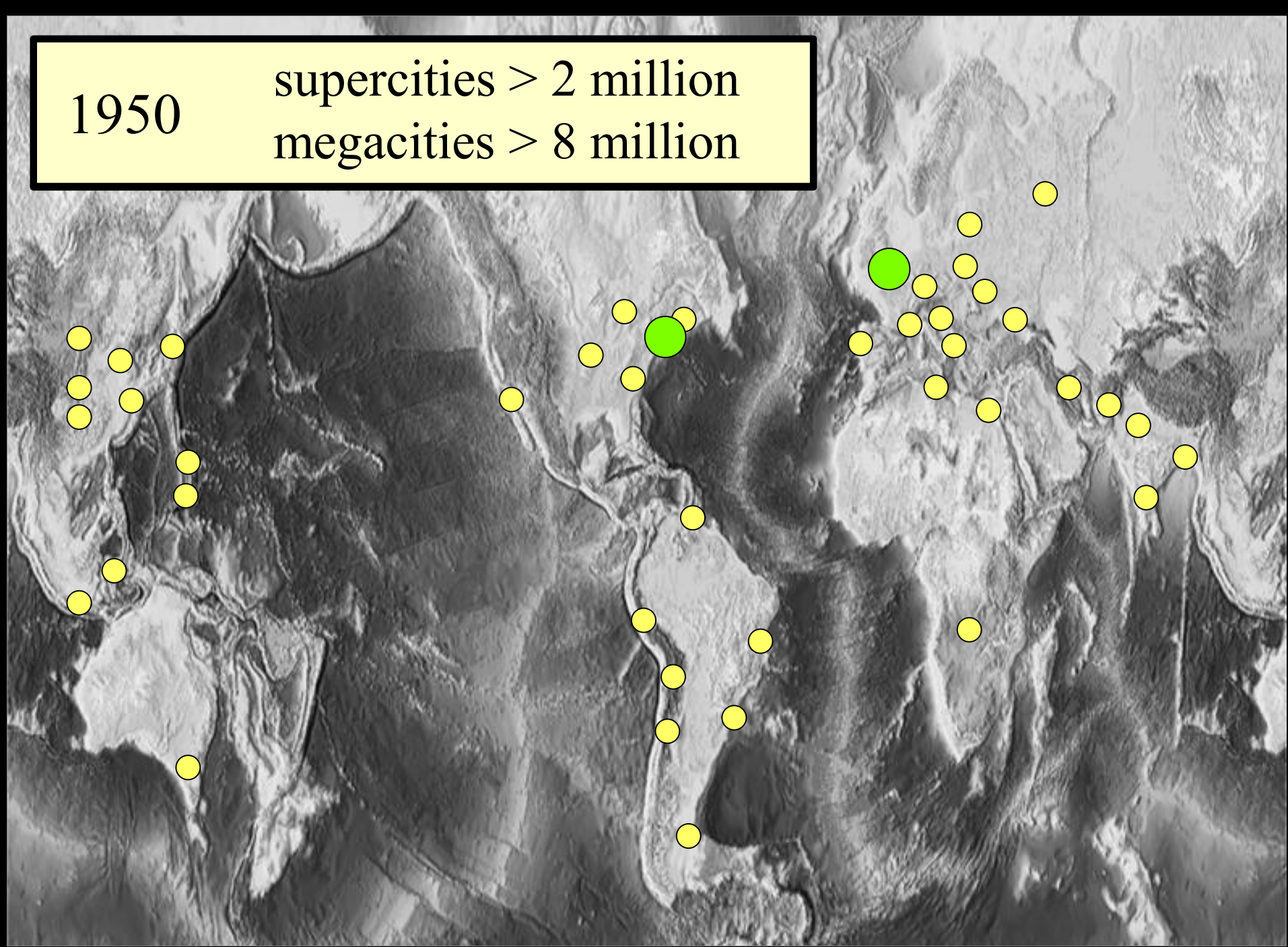
South Warke

Pre 1600 Urban agglomerations (towns > million)

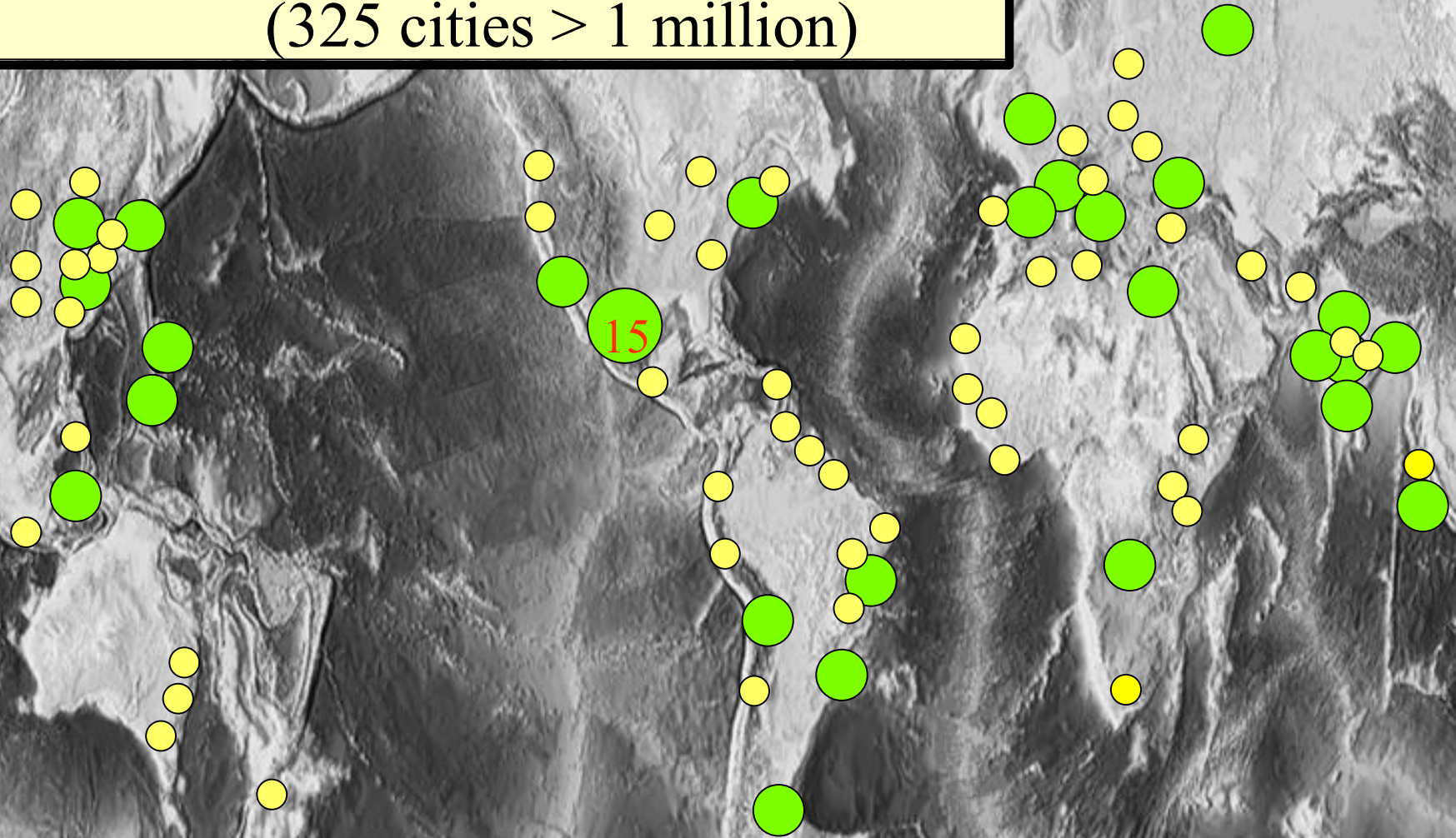


1950

supercities > 2 million
megacities > 8 million

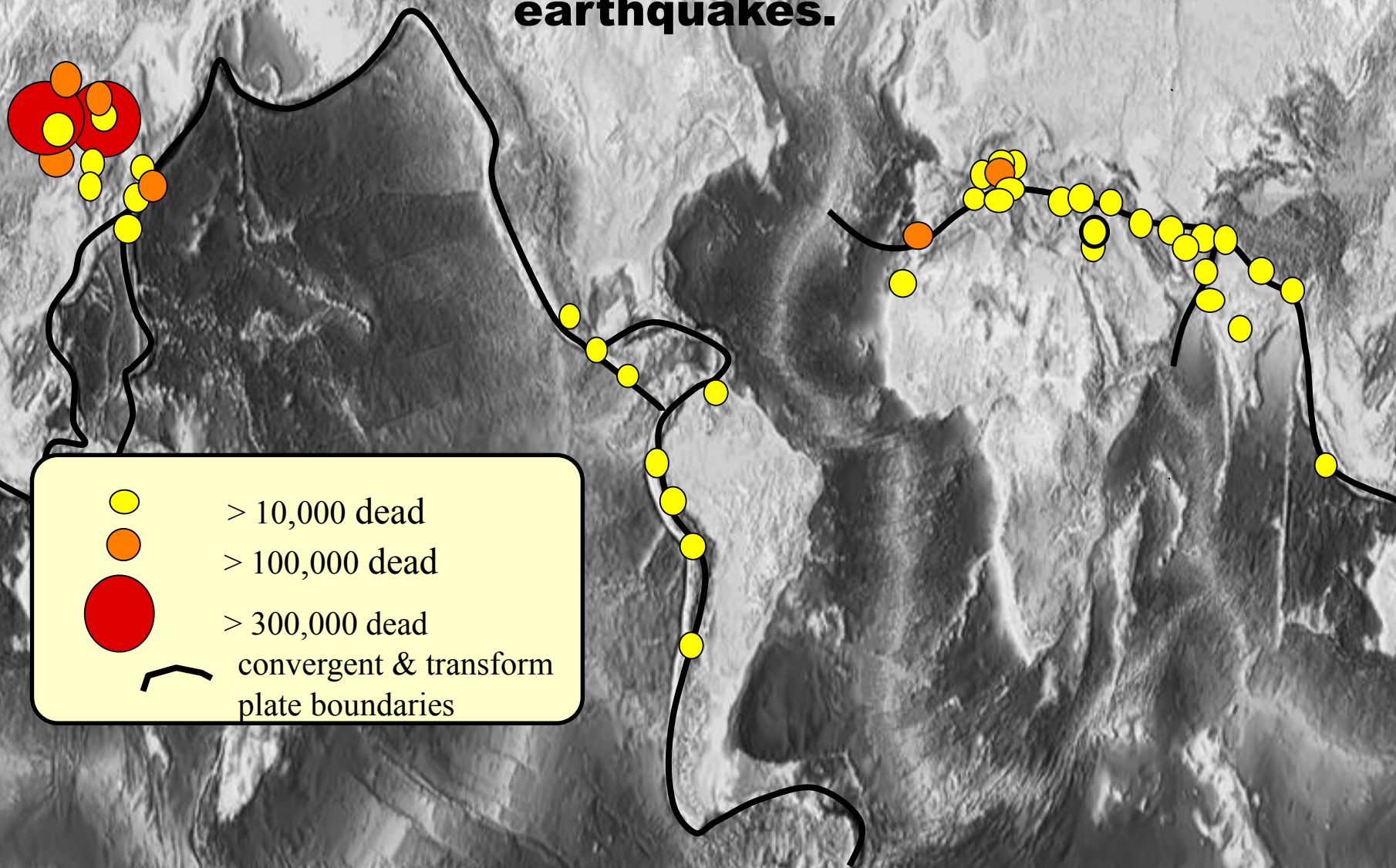


○ 140 supercities > 2 million
● 28 megacities > 8 million
(325 cities > 1 million)

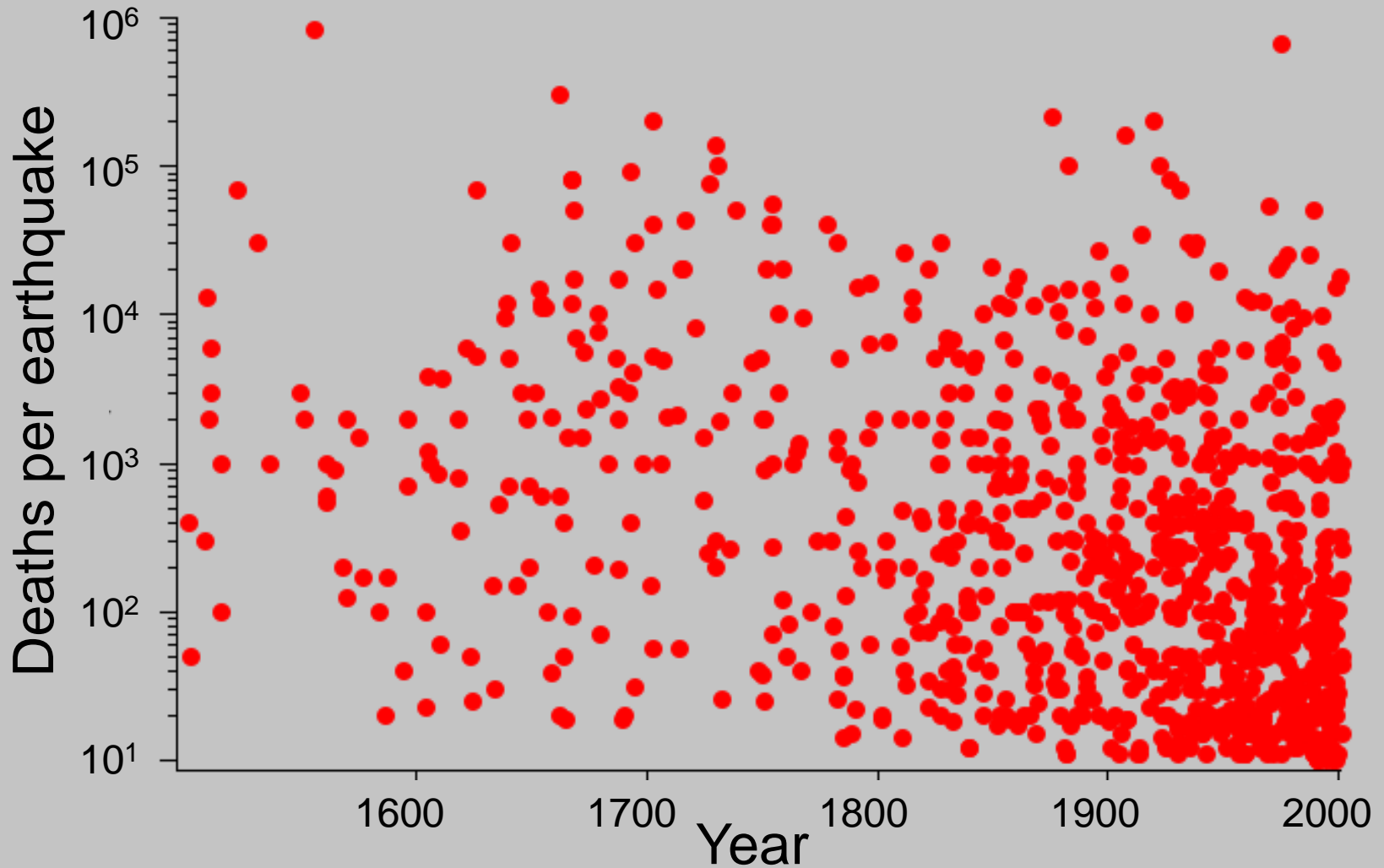


2050 urban population >5 billion (\approx half the world total).

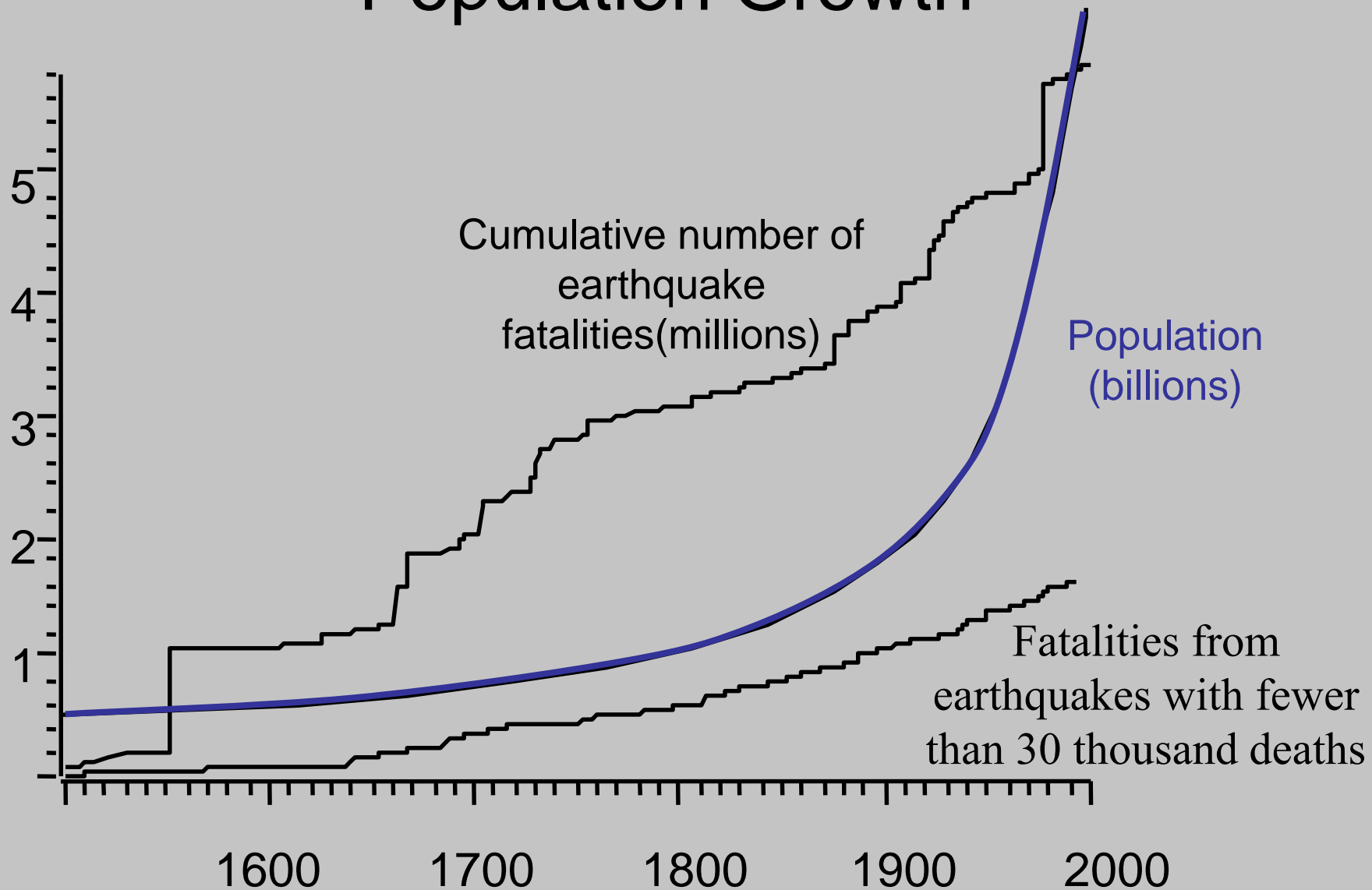
**8 million earthquake deaths in the past 1000 years.
50% world's supercities near future M>7.5
earthquakes.**



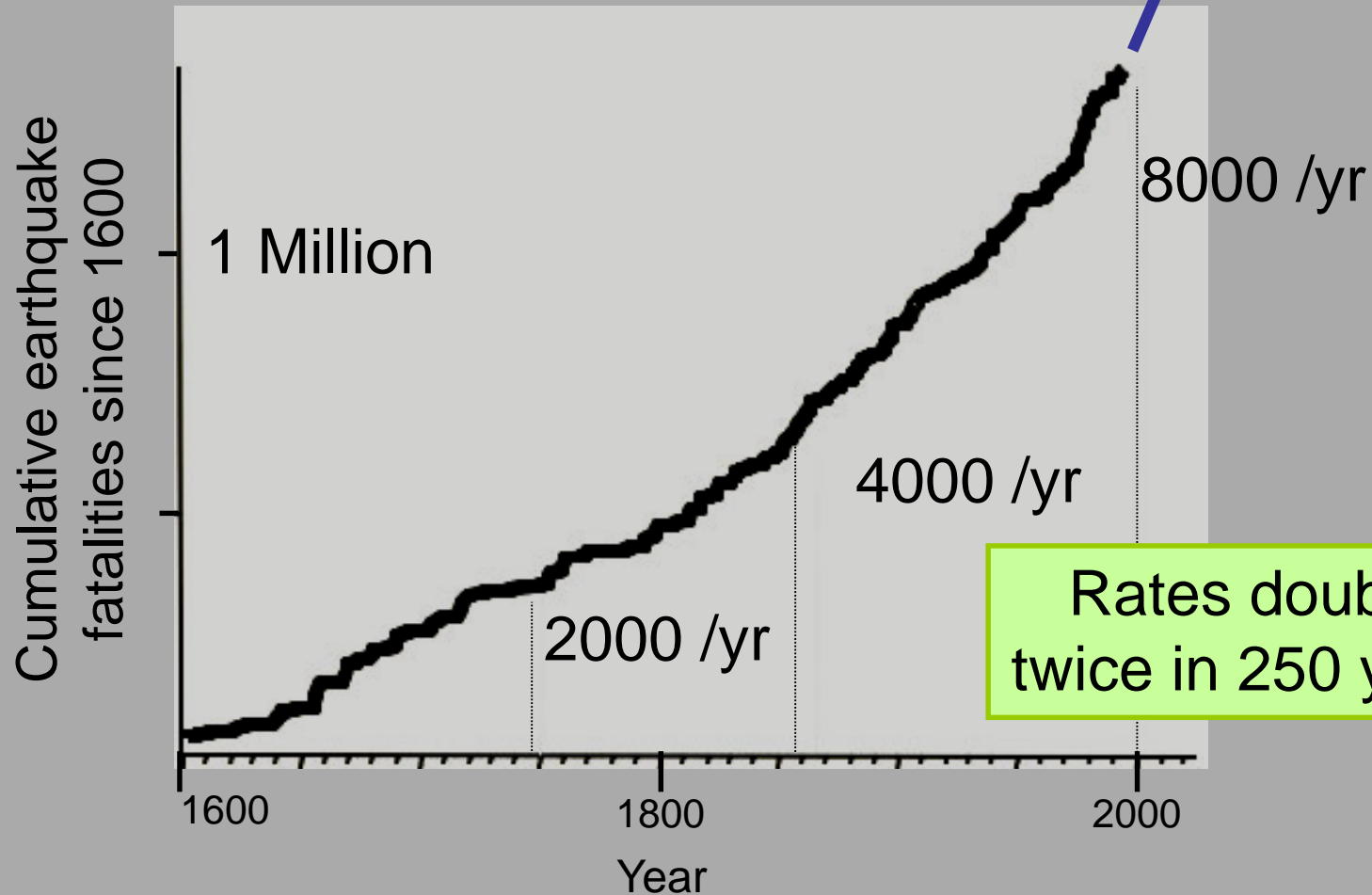
500 Years of Earthquake Fatalities



Earthquake Fatalities and Population Growth

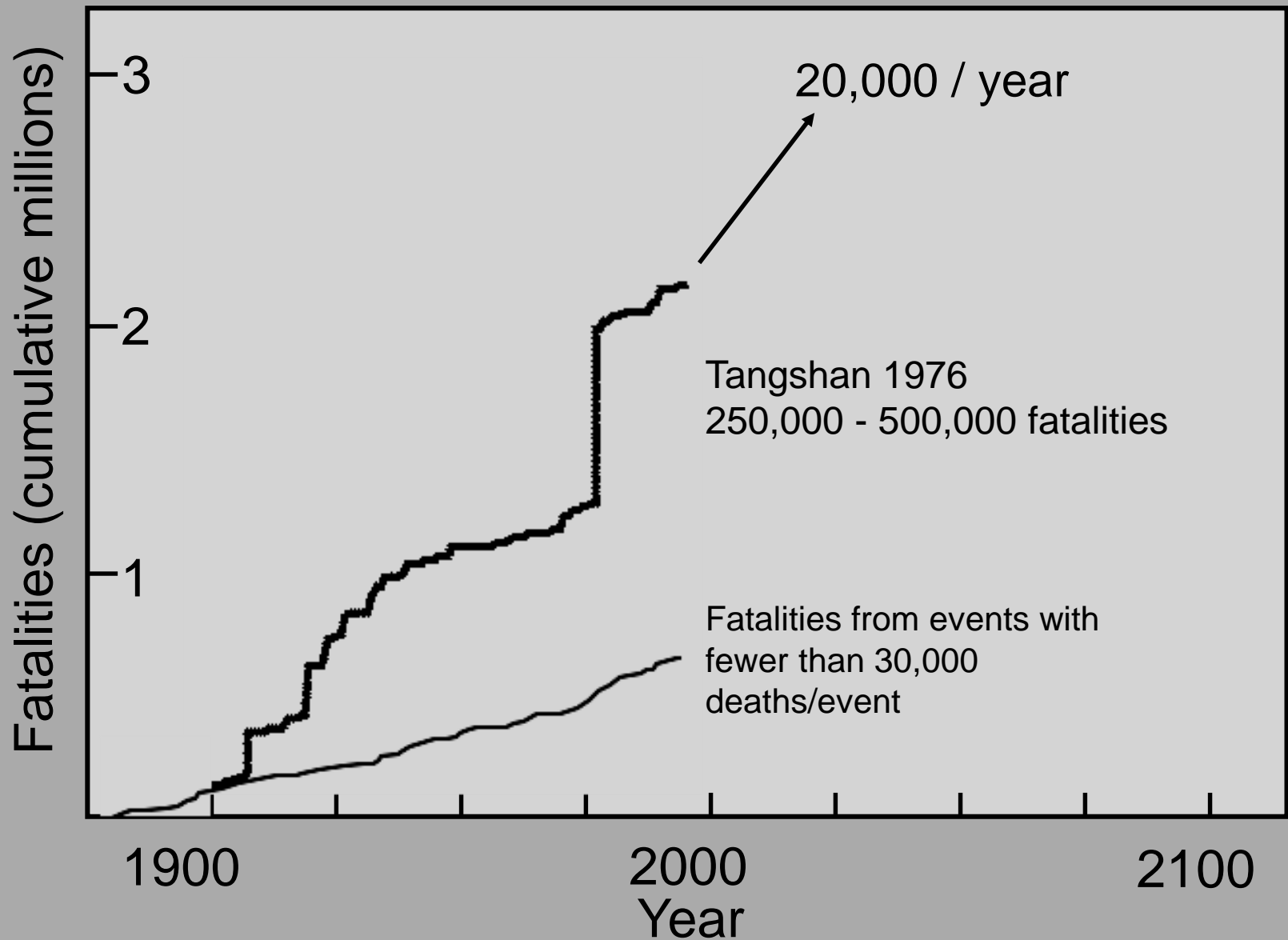


Earthquake Fatalities from Moderate Events (<30,000 deaths/event)



Prediction in 1997 was 8000 fatalities/yr:
1998-2002 average was 10,500 fatalities/yr

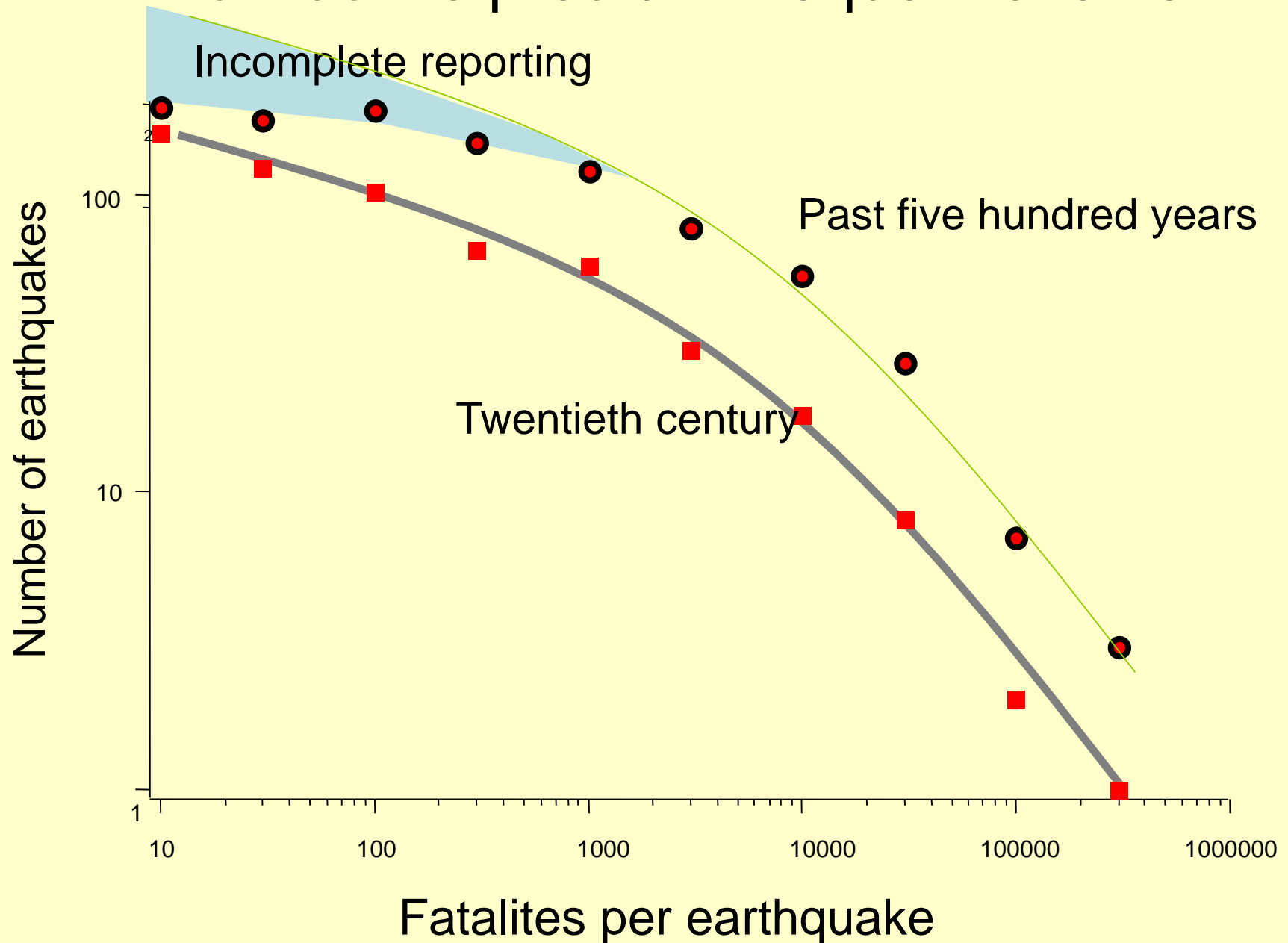
When we include highly lethal events...



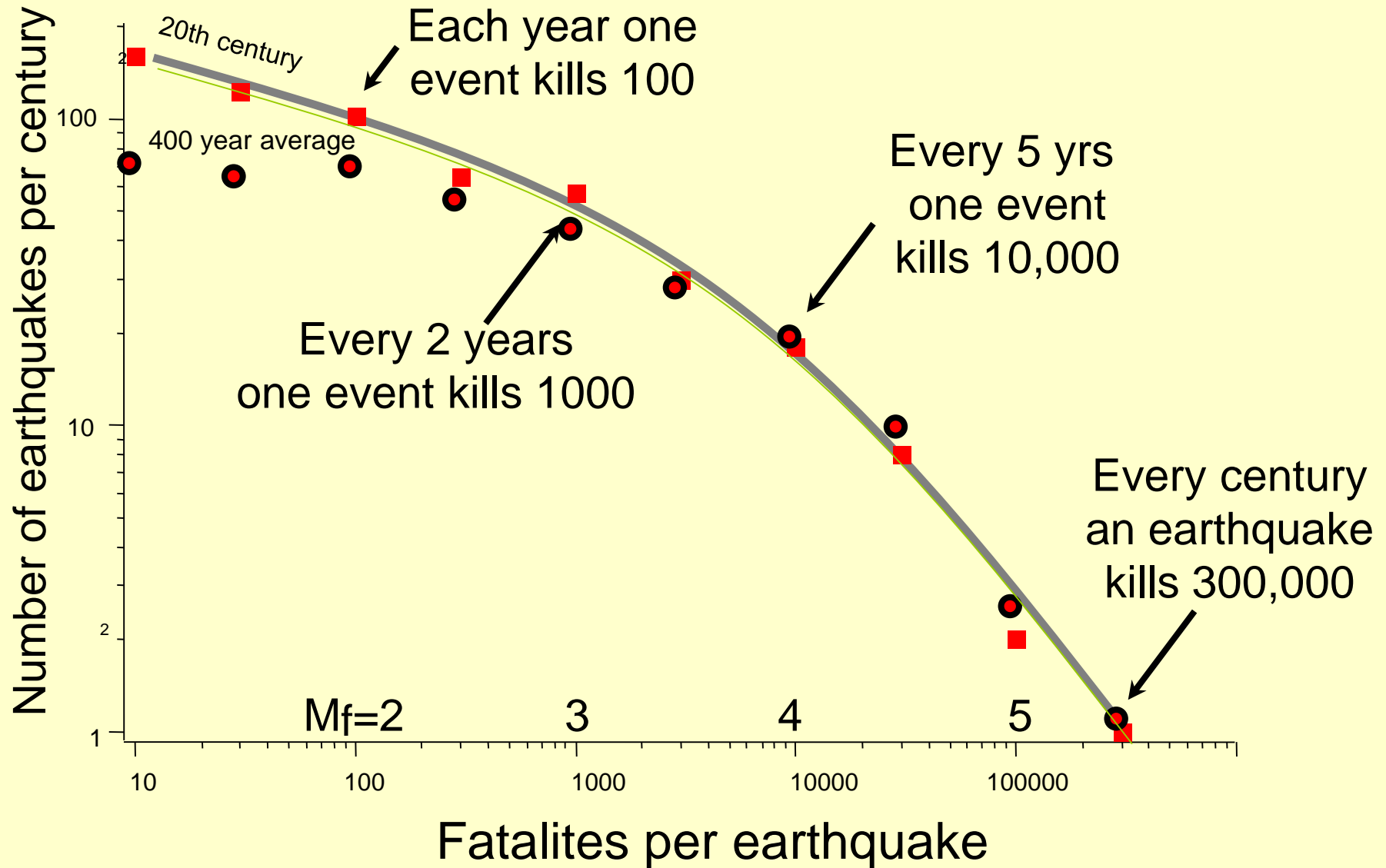


Tangshan 1976 Can we predict frequency of extreme events?

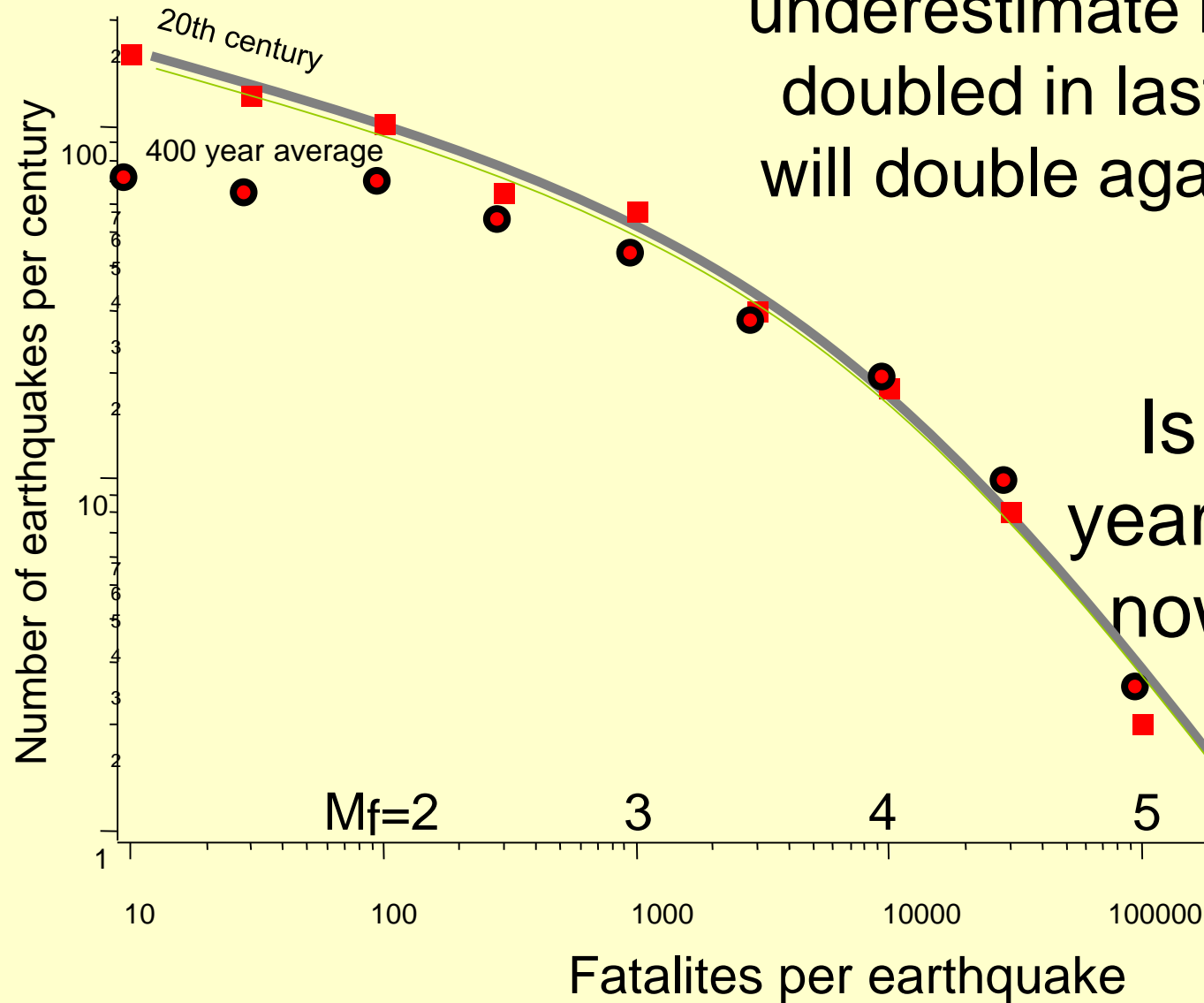
How do we predict infrequent events?



Mf predictability each century



...but 0.3M is an underestimate because cities doubled in last century and will double again in the next!

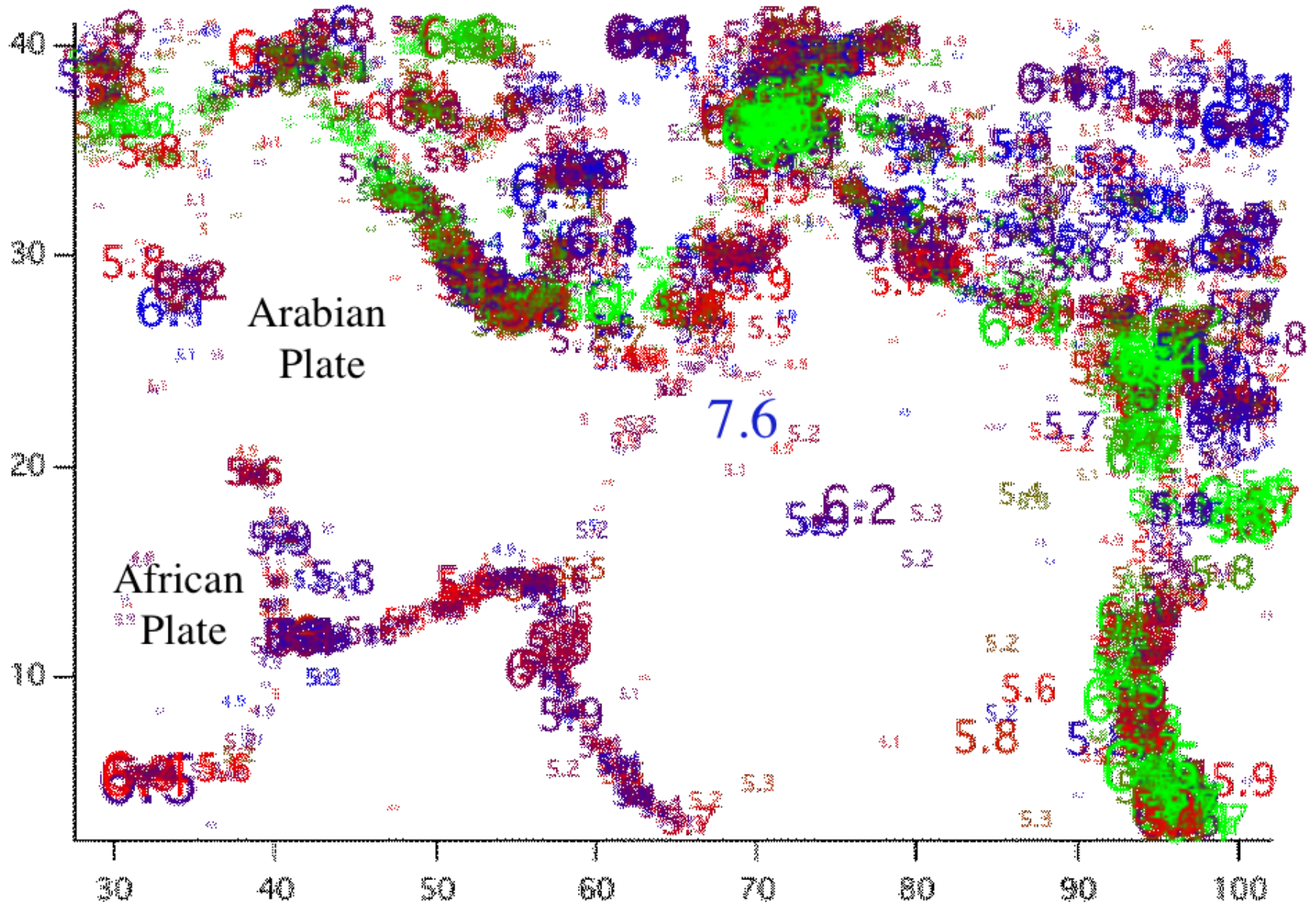


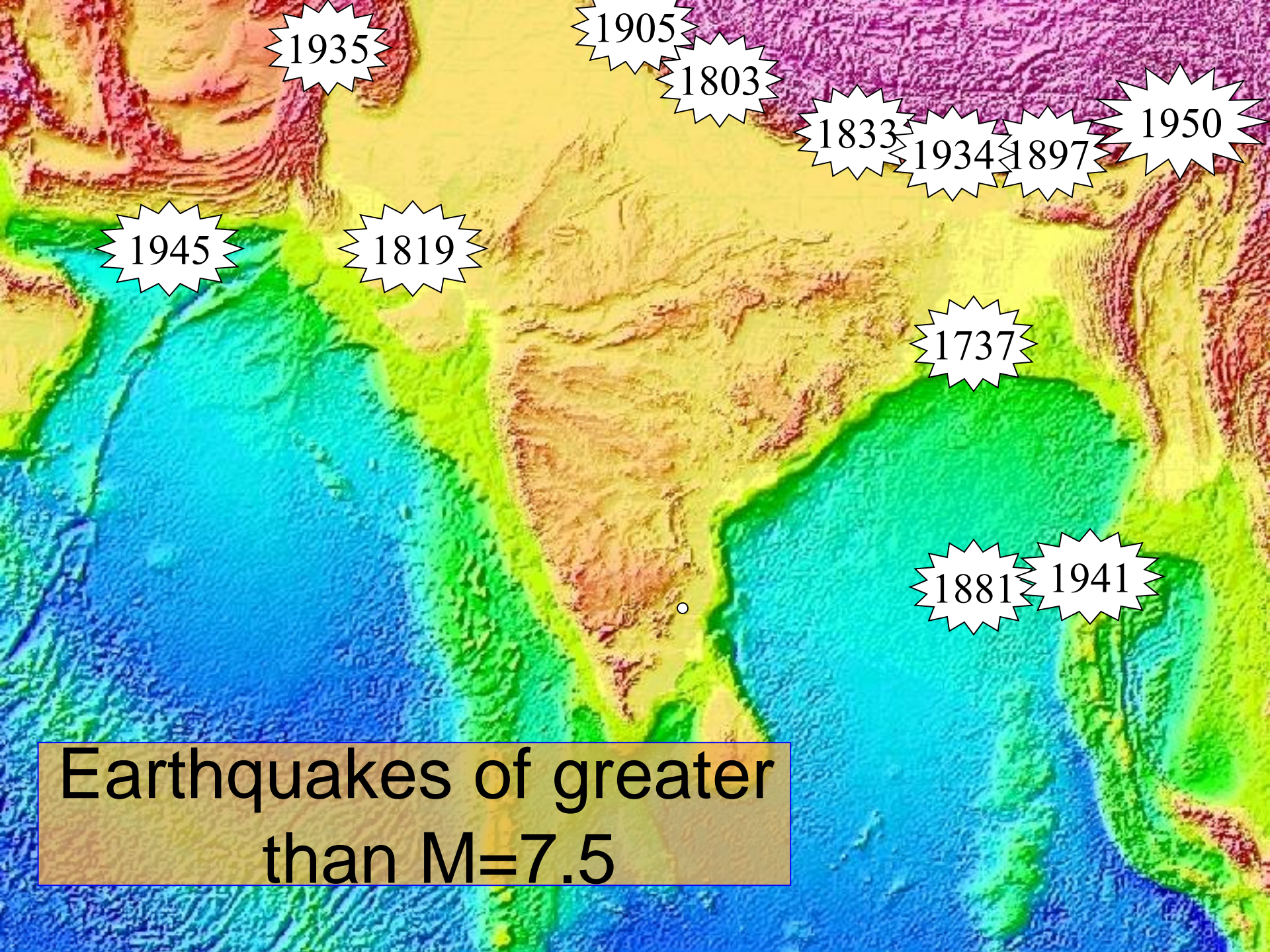
Is a hundred year megaquake now possible?

A Look Into an Urban Seismic Future
Large Populations - Large Cities

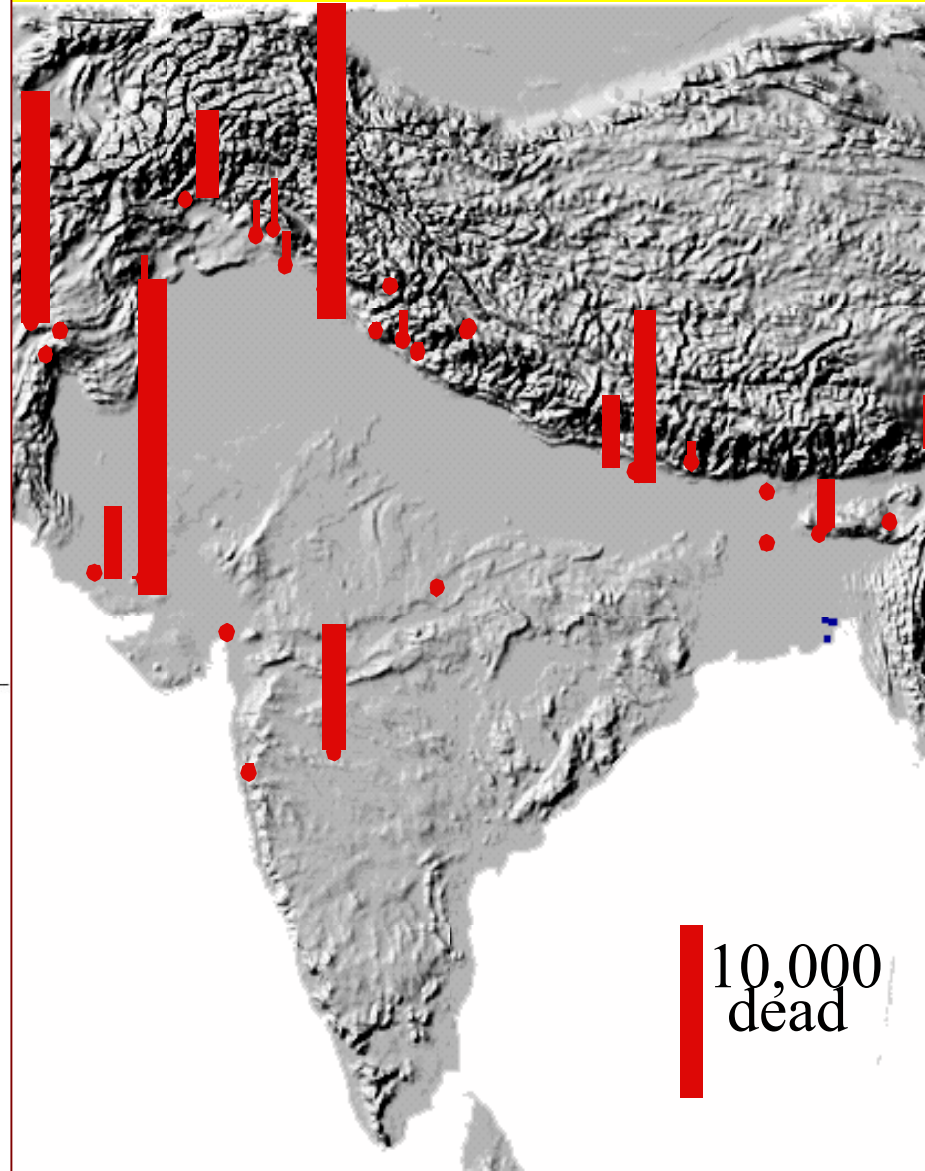
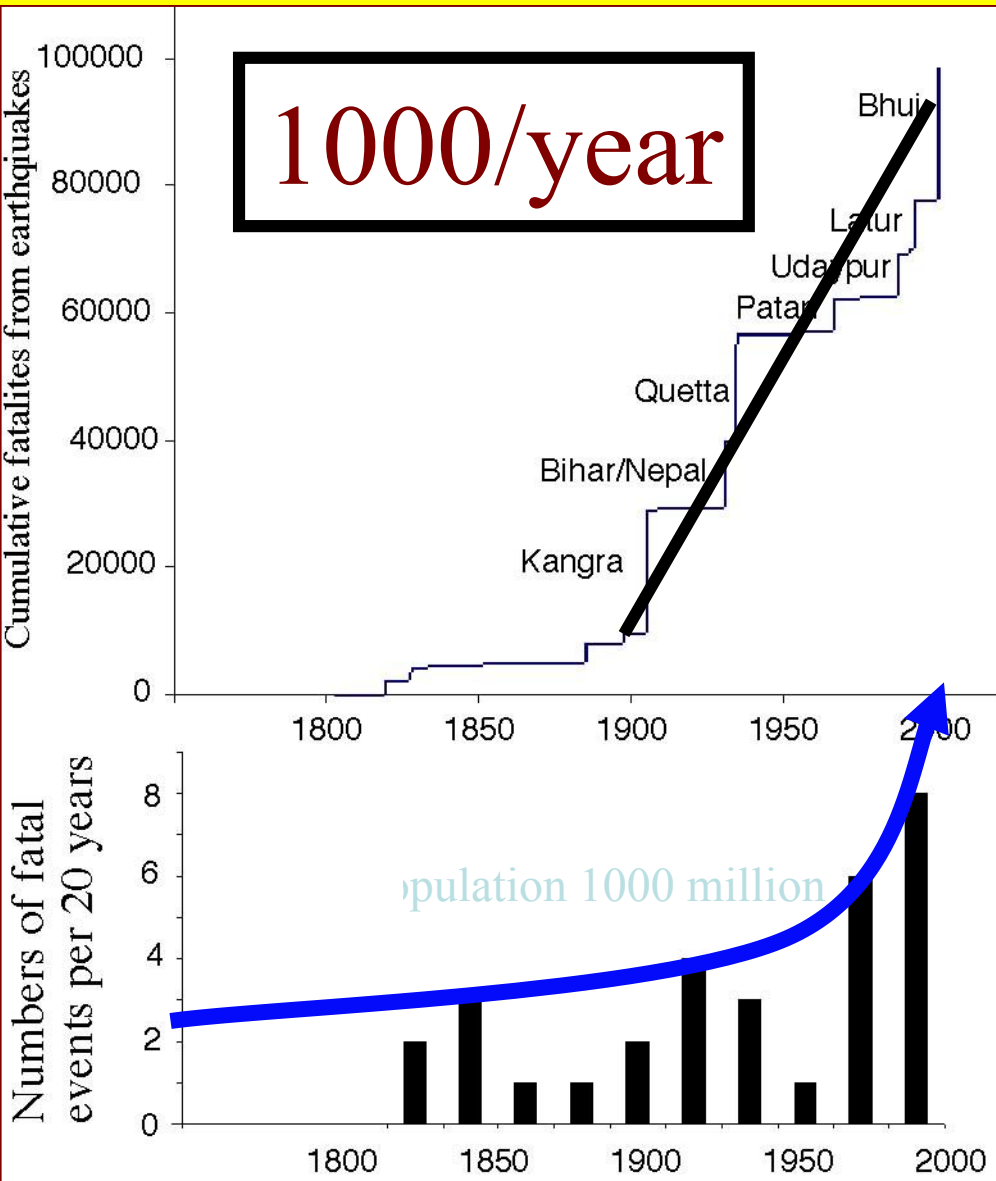
India

Indian Earthquakes in the Past 30 Years

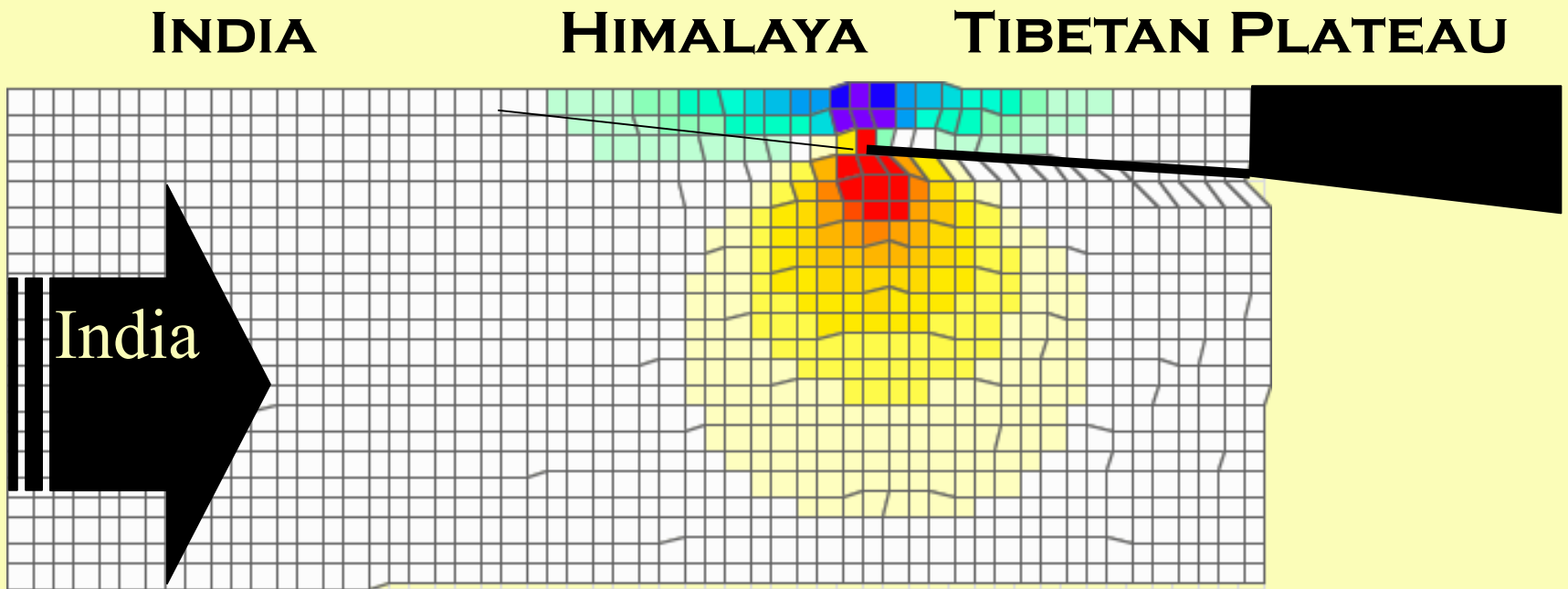




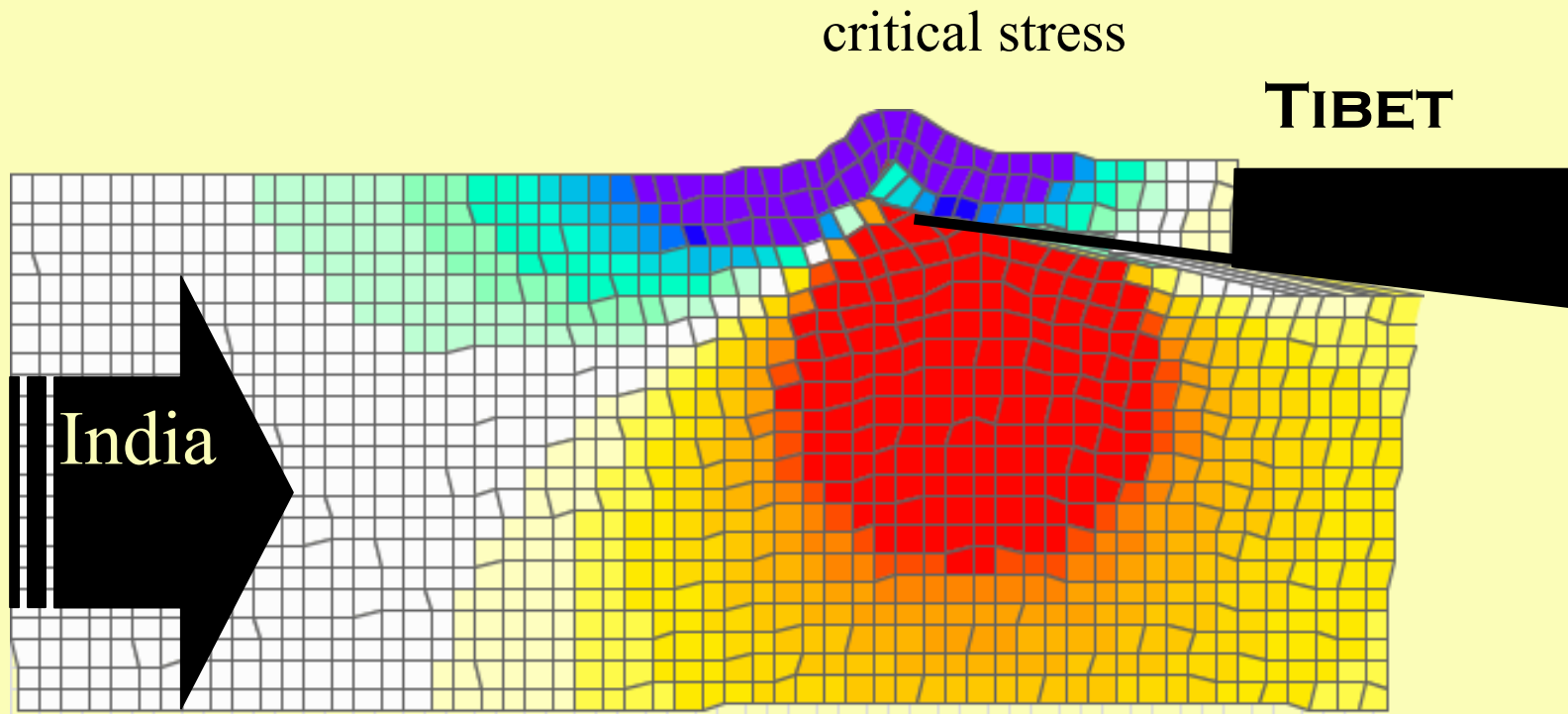
EARTHQUAKE FATALITIES: INDIA 1800-2000



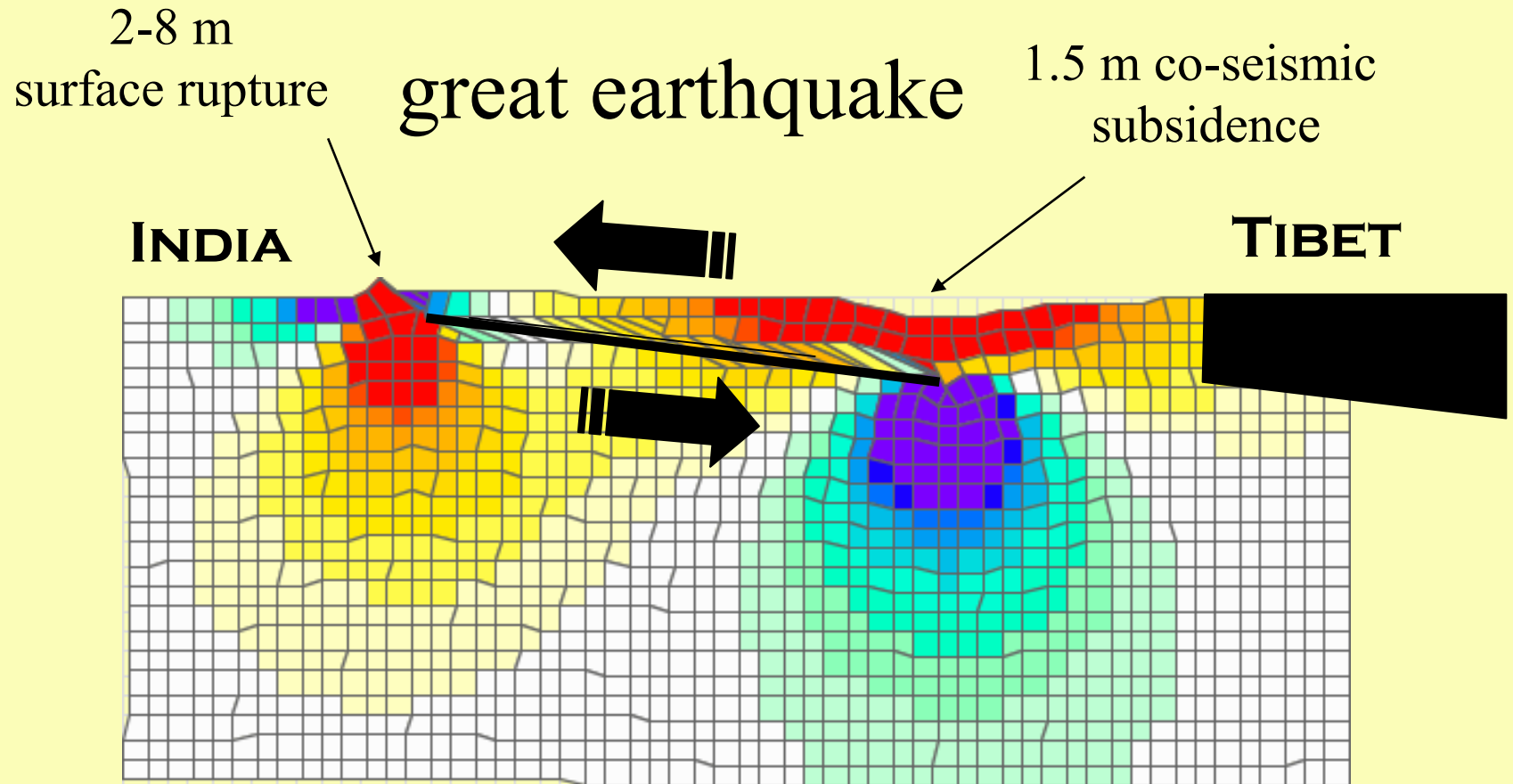
Himalayan earthquakes are caused by the slip of India beneath Tibet.



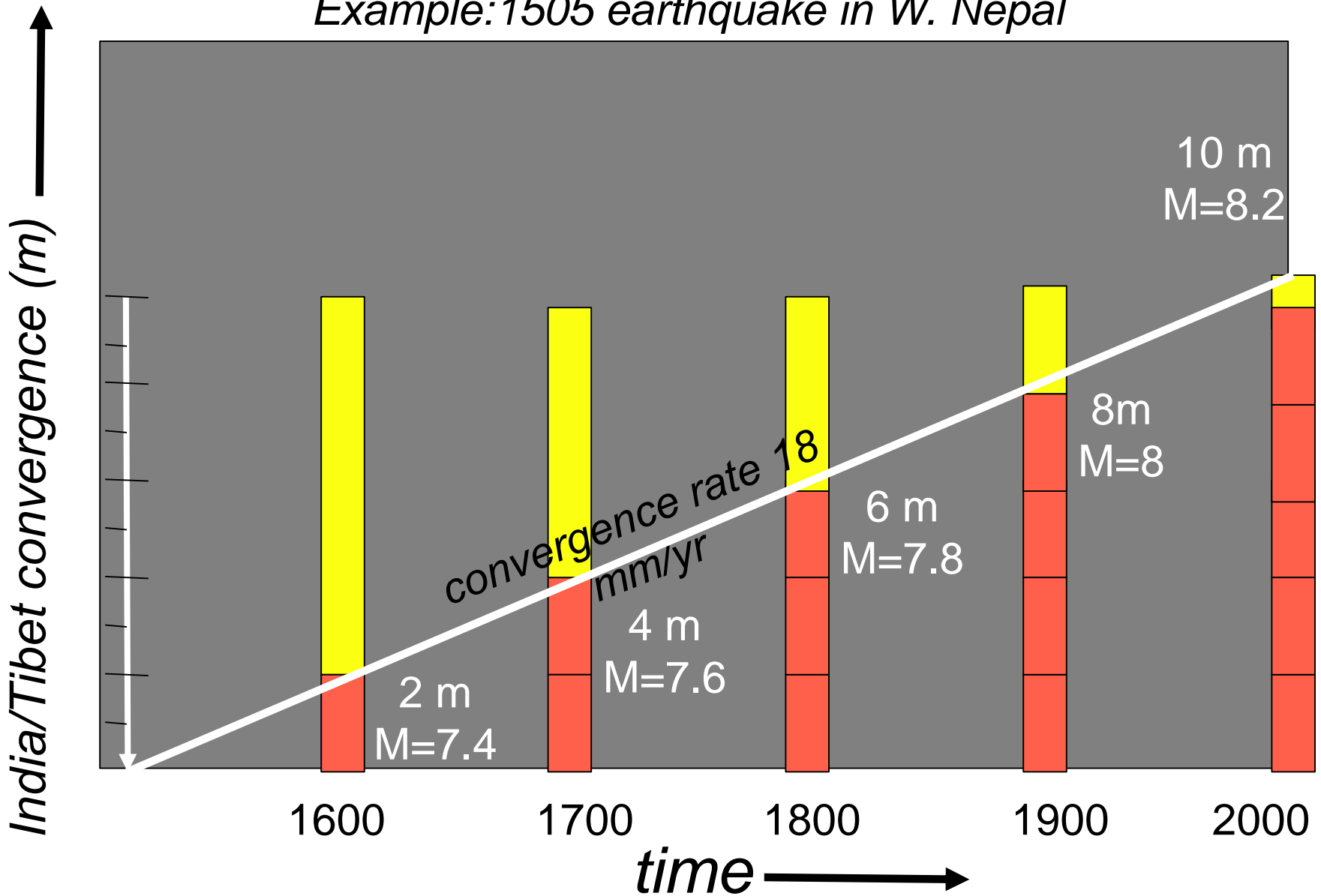
Every few hundred years part of the Himalaya approaches failure



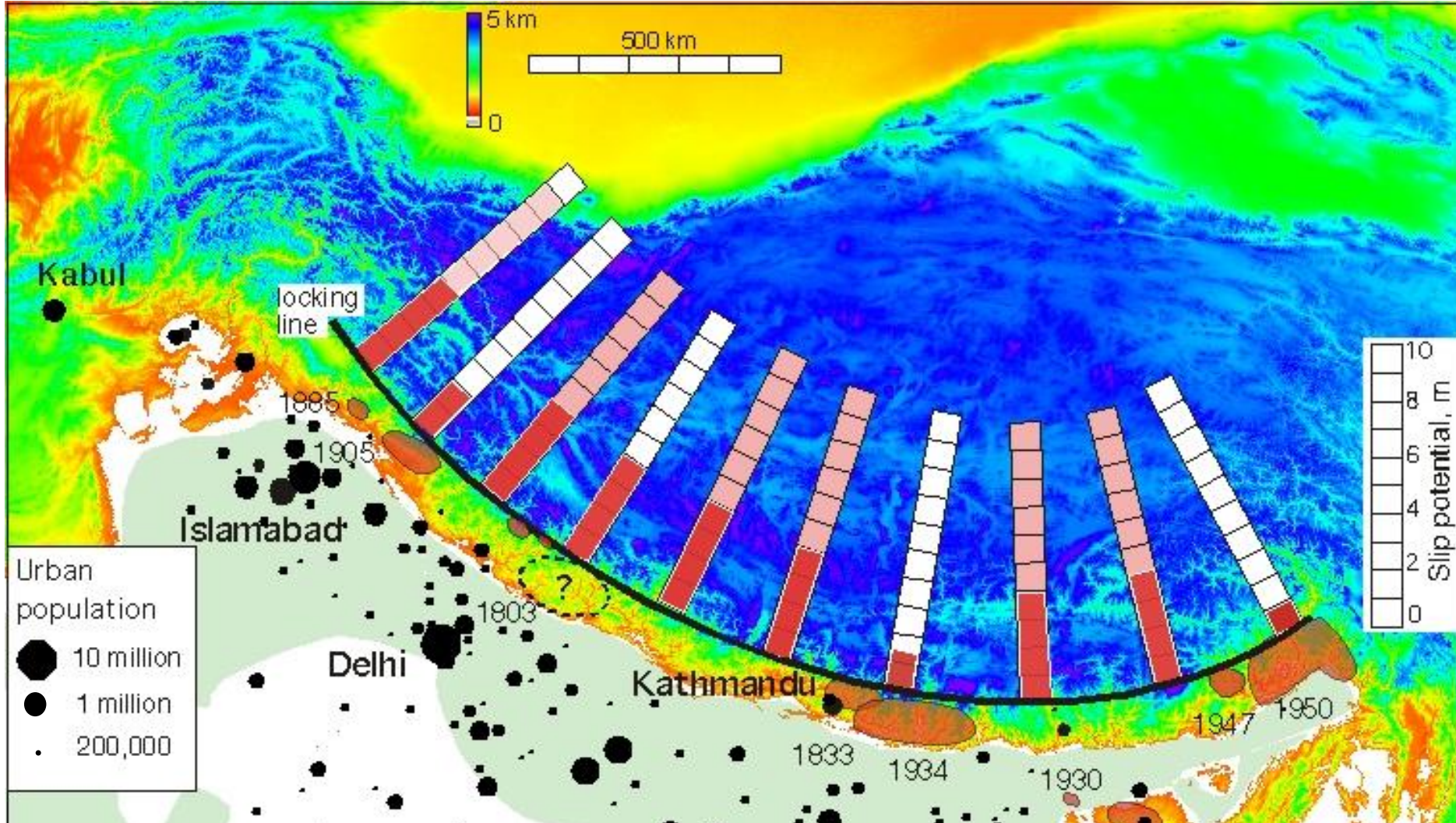
... and a great earthquake ruptures the plate boundary.



Example: 1505 earthquake in W. Nepal



The longer we wait the bigger the 'quake.



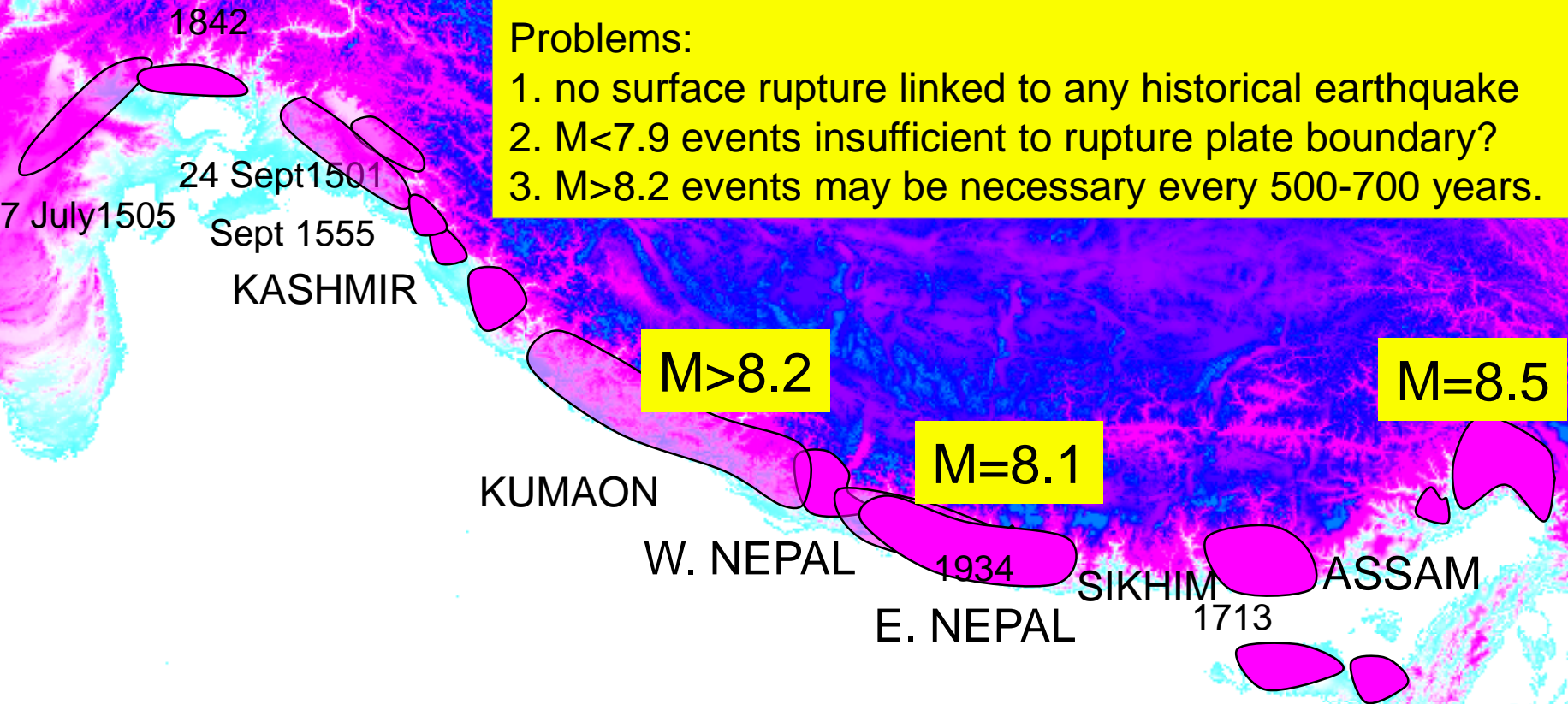
Himalayan rupture potential (200 year window)

Observations

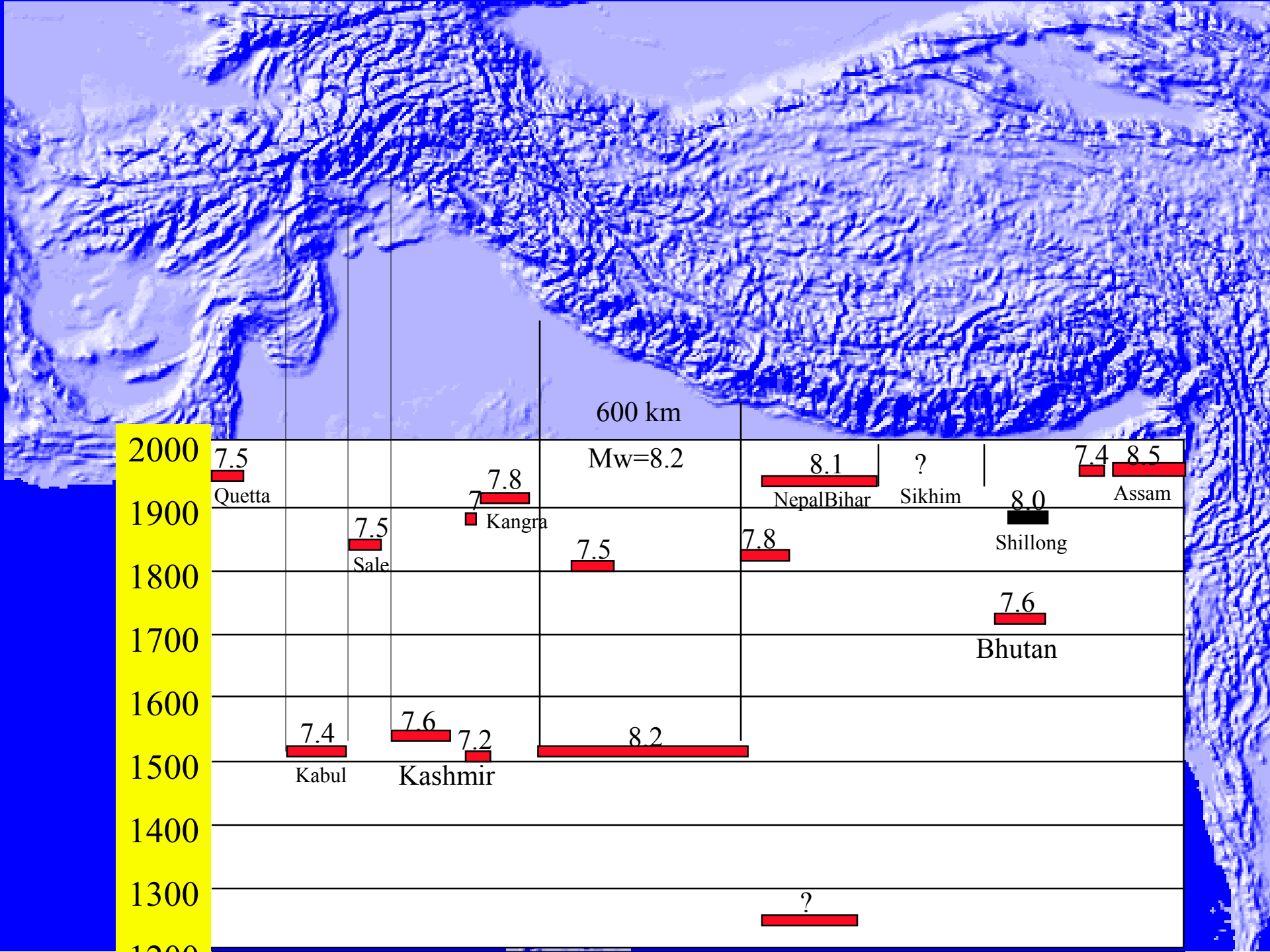
- A. Historic void - Sikkim/Assam
- B. 16th century rupture Kashmir to Kumaon
- C. Renewal rate 1.8 m/century

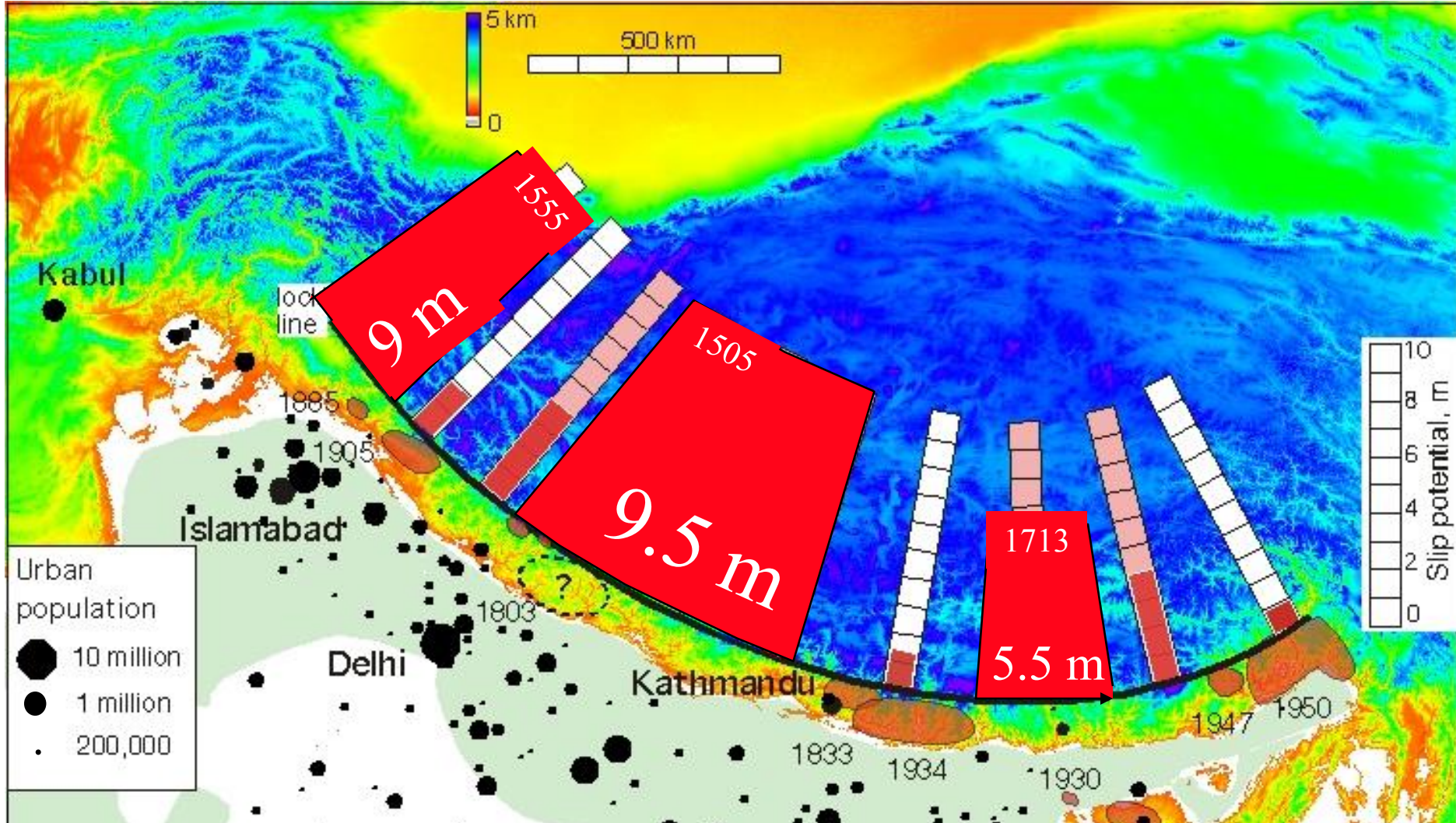
Problems:

- 1. no surface rupture linked to any historical earthquake
- 2. $M < 7.9$ events insufficient to rupture plate boundary?
- 3. $M > 8.2$ events may be necessary every 500-700 years.



Himalayan Earthquakes 1255-1950





Himalayan rupture potential (500 year window)

A grayscale map of India where darker shades represent higher population density. The map shows a high concentration of population in the northern plains and along the coast. Four major cities are highlighted with yellow labels: Delhi, Agra, Jaipur, and Kanpur. A yellow scale bar in the bottom left corner indicates a distance of 25 km.

Delhi 13 million

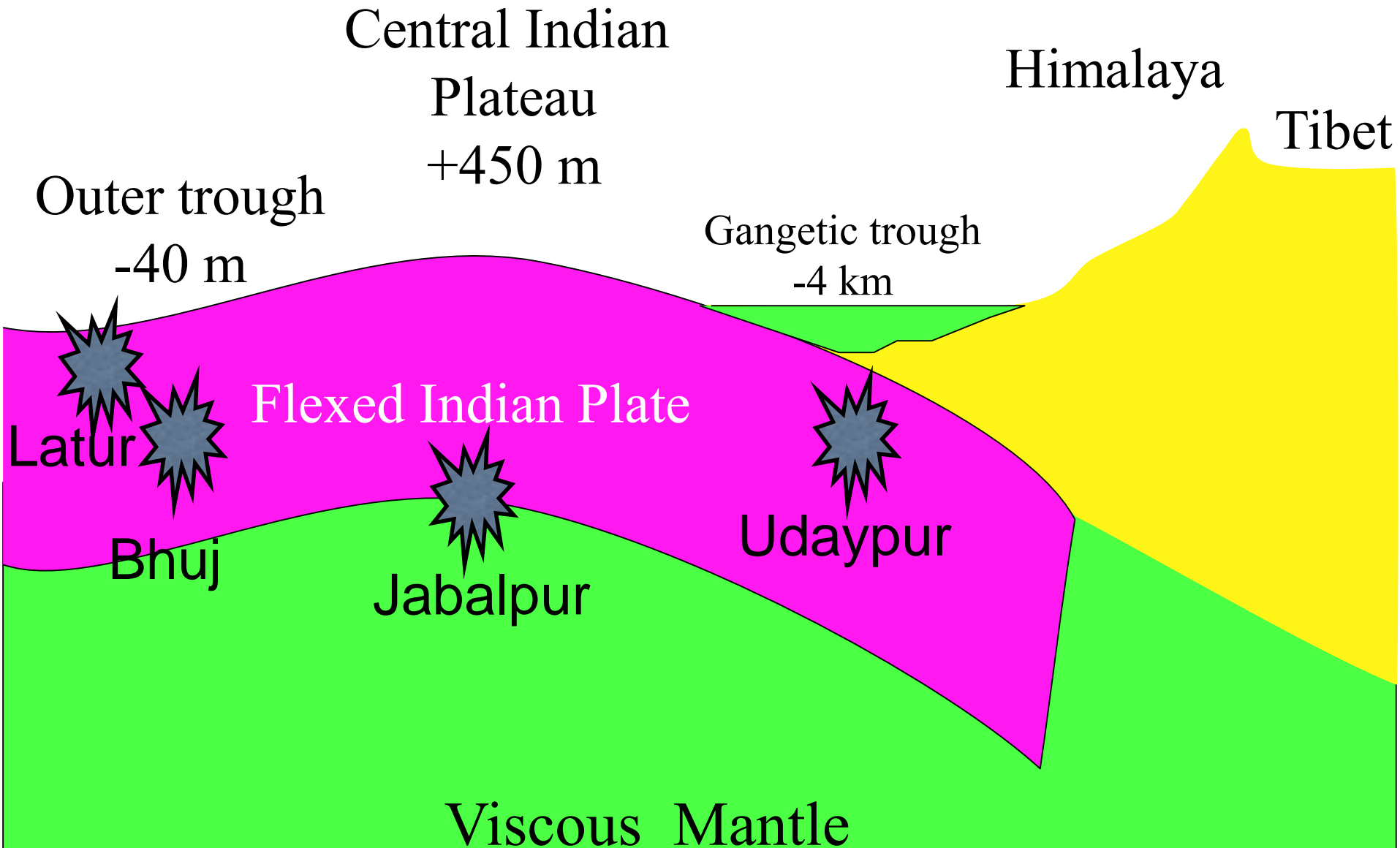
Agra

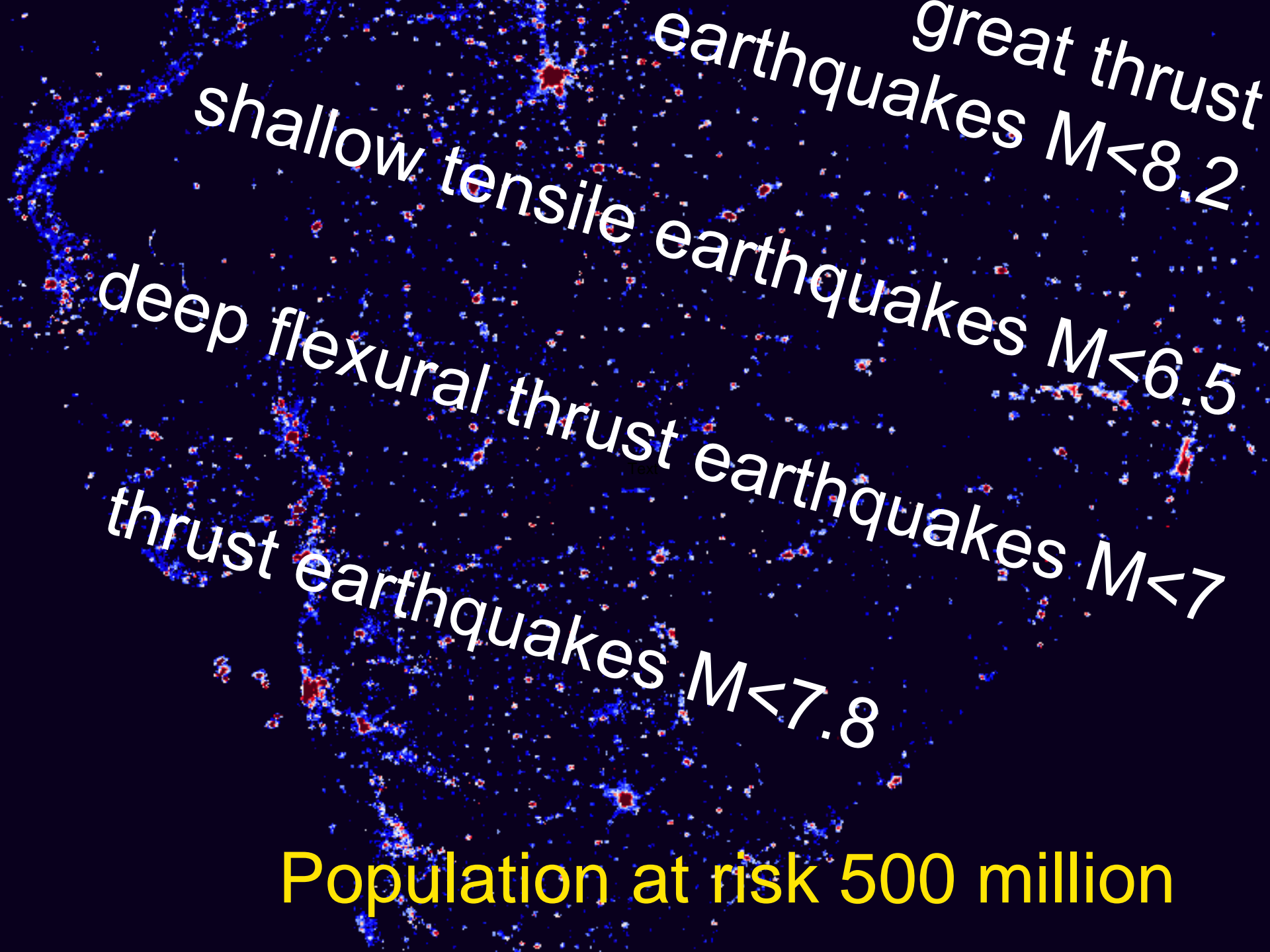
Jaipur

Kanpur 3 million

25 km

Cross Section of the Indian Plate





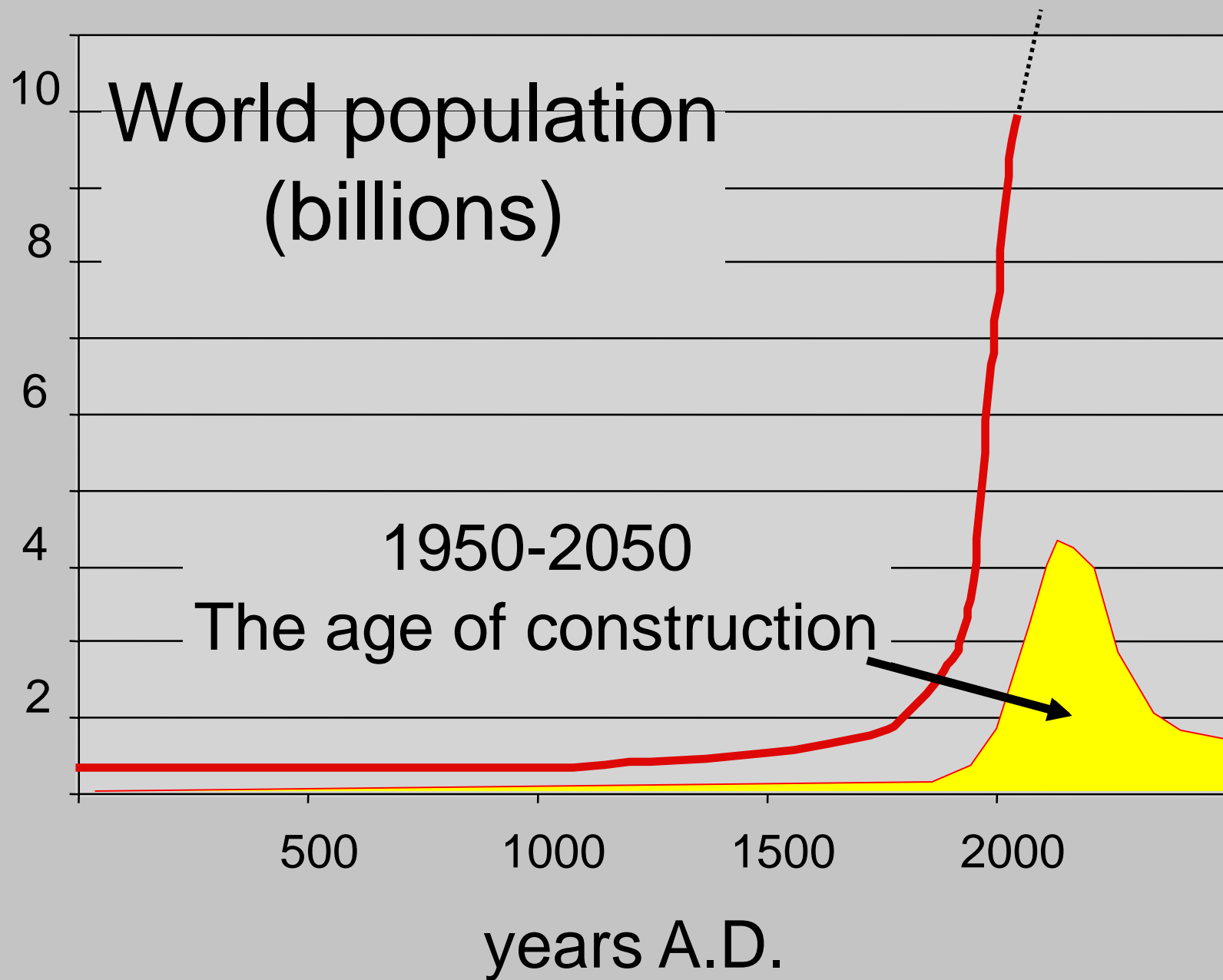
great thrust
earthquakes $M < 8.2$

shallow tensile earthquakes $M < 6.5$

deep flexural thrust earthquakes $M < 7$

thrust earthquakes $M < 7.8$

Population at risk 500 million



Adipazari

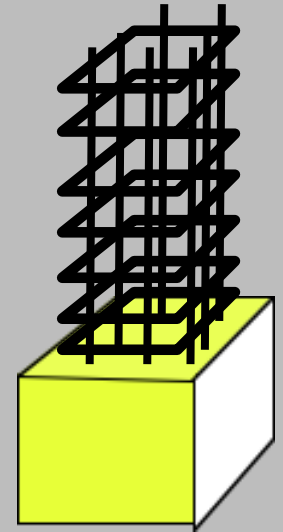
averting disaster

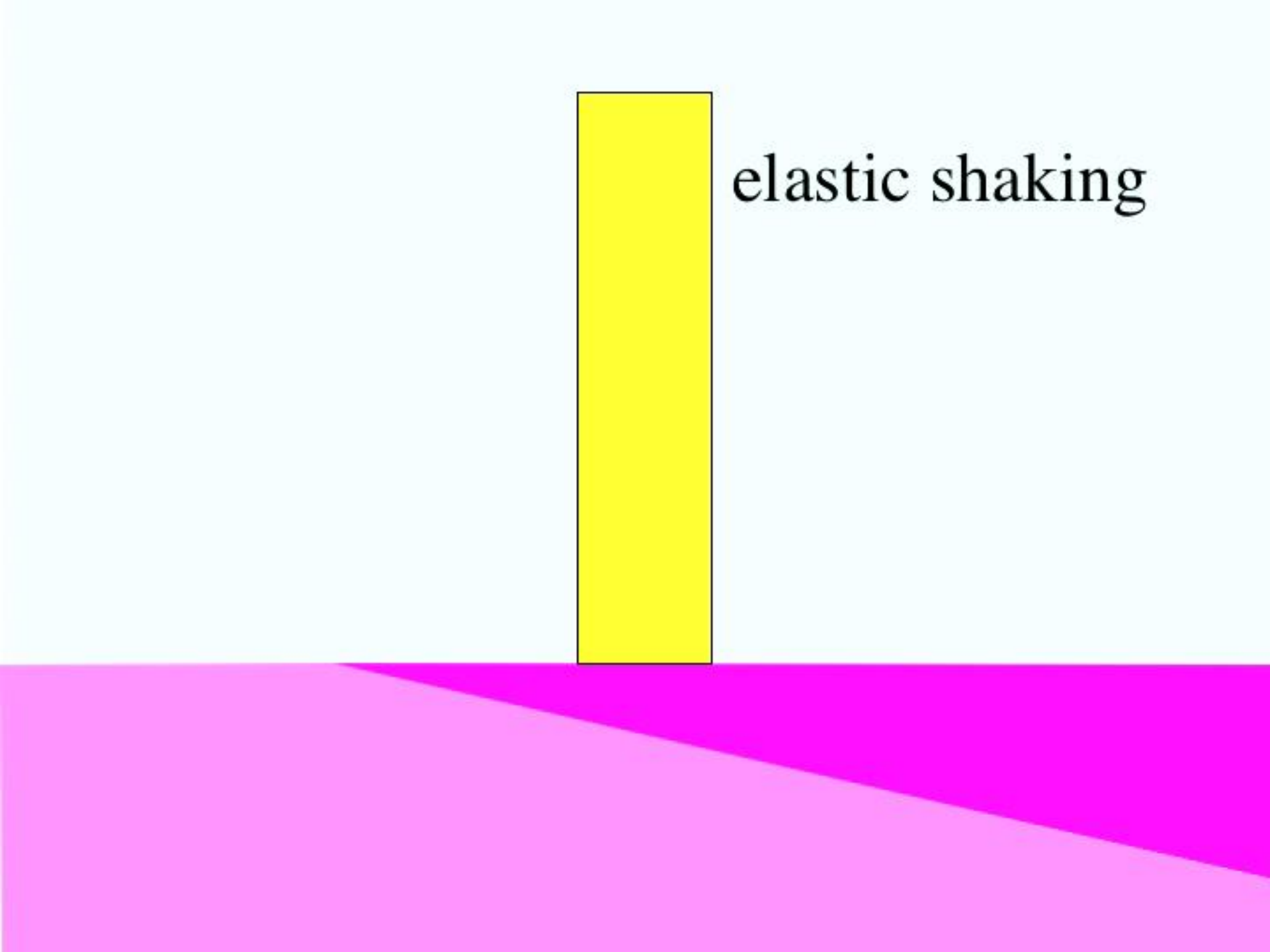




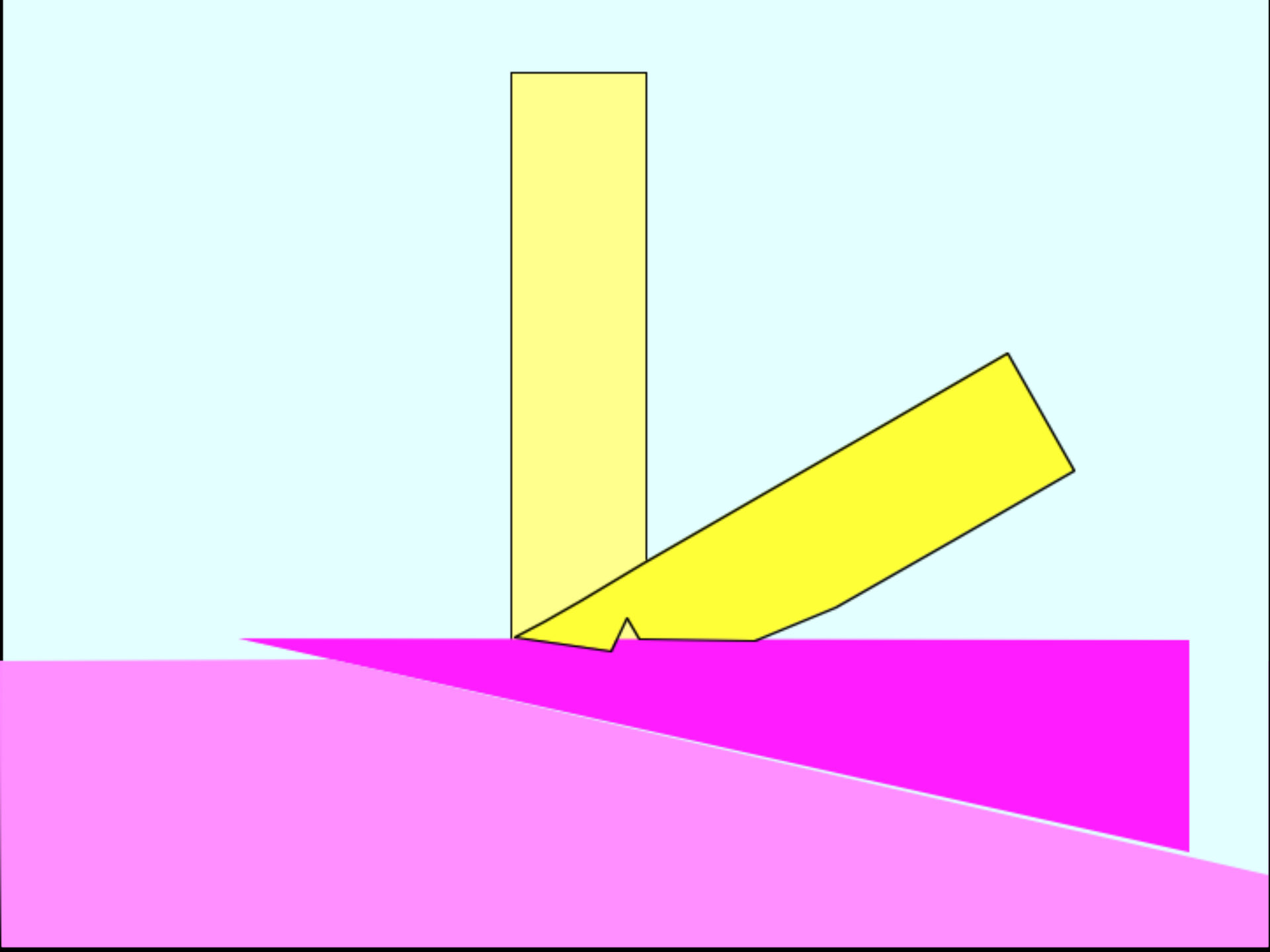


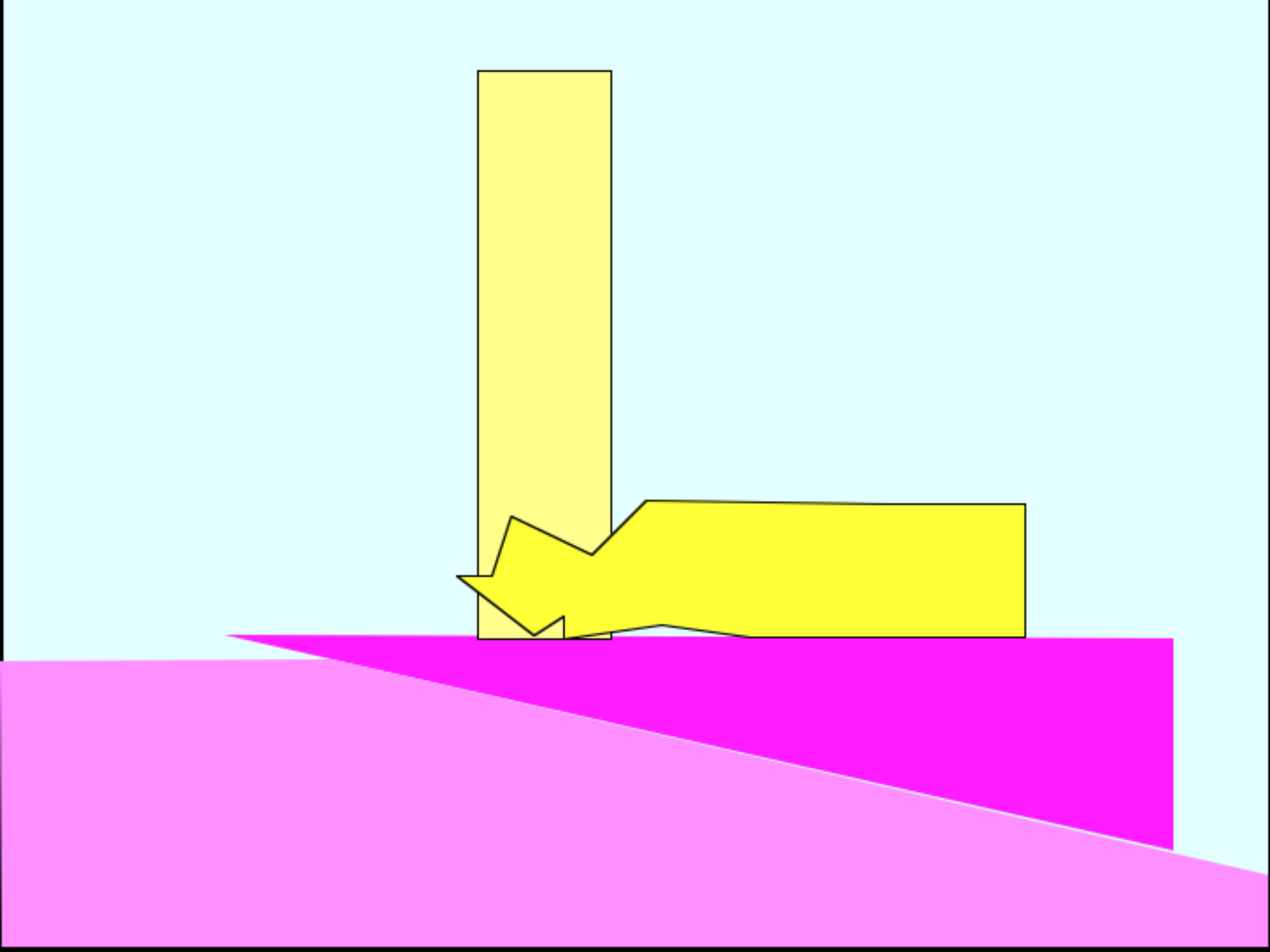
Many dwellings now collapse
due to column failure.



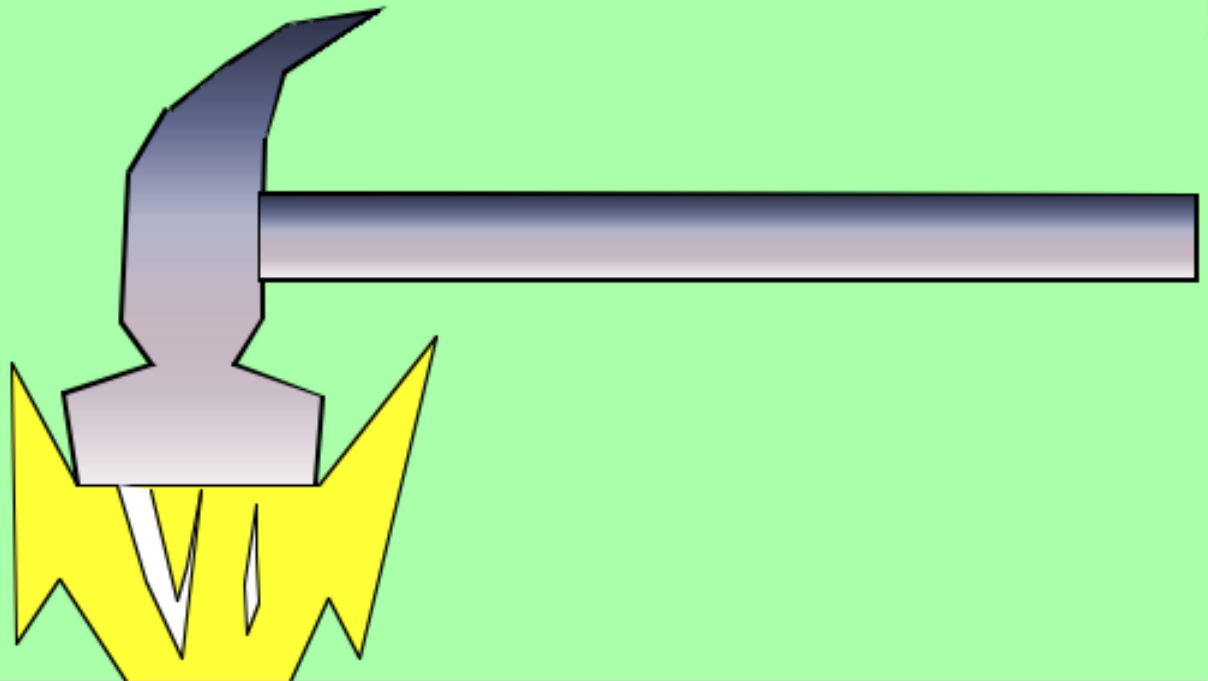
A diagram showing a vertical yellow rectangular bar standing on a pink surface. The surface is divided by a diagonal line that slopes downwards from left to right. The area above the surface is light blue, and the area below is pink. The text "elastic shaking" is written in black to the right of the bar.

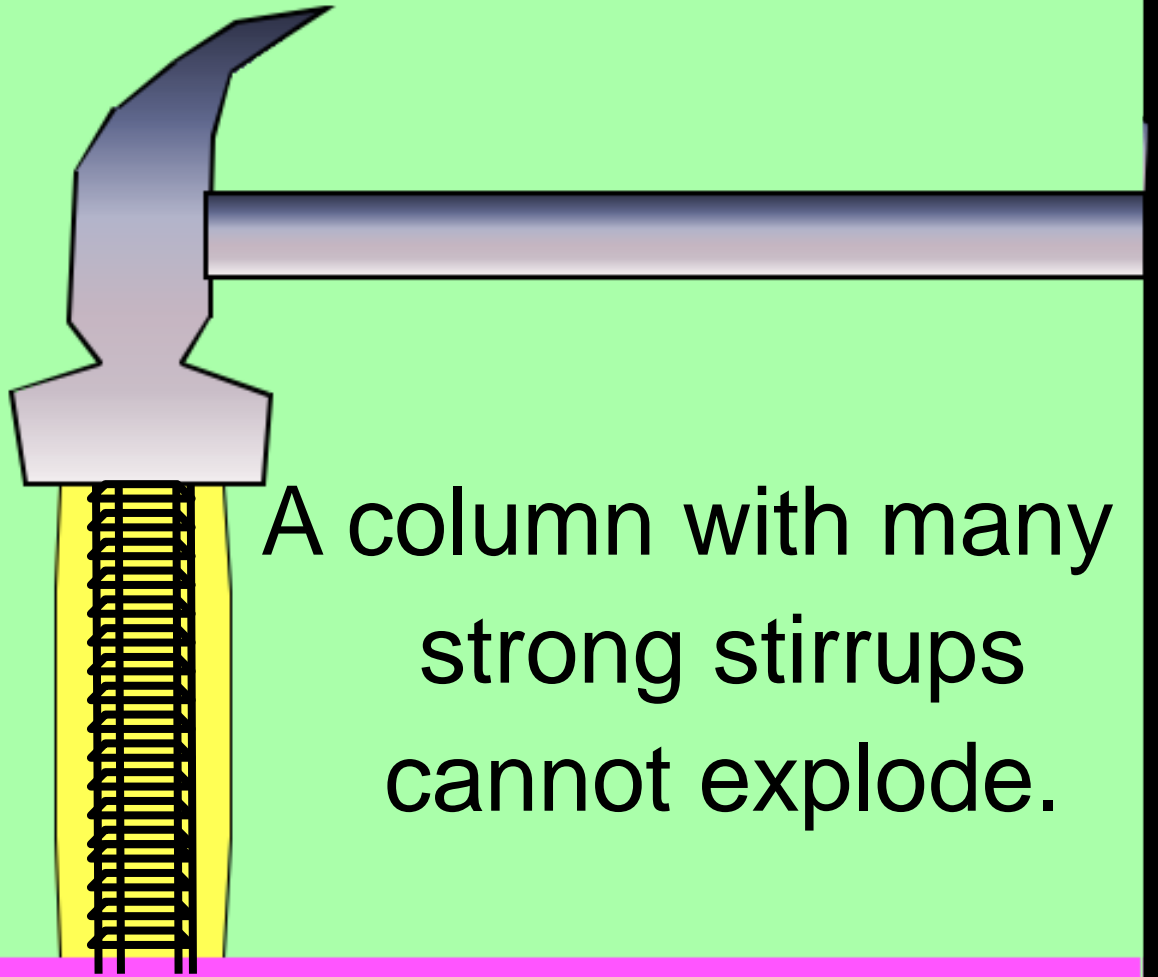
elastic shaking





Columns without stirrups can
be crushed





A column with many
strong stirrups
cannot explode.









World population (billions)

10
8
6
4
2

2000-2050

The age of construction

Three billion
dwellings !!



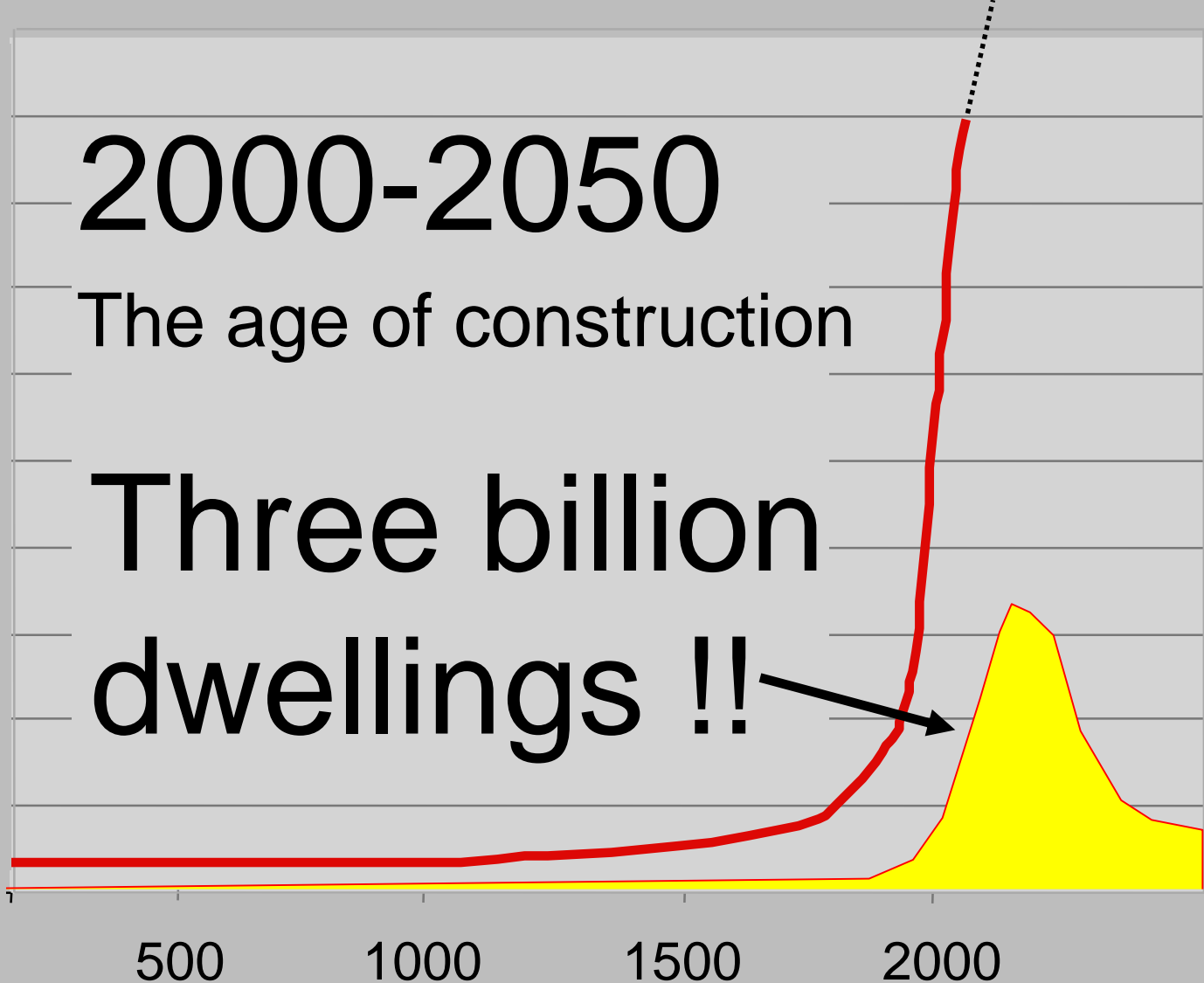
500

1000

1500

2000

Earthquakes don't kill people-
buildings do.



Acknowledgements:

- Environmental Science Institute at The University of Texas
- CIRES - Cooperative Institute for Research in Environmental Sciences
- Seismological Society of America

Dr. Roger Bilham



Dr. Roger Bilham received his Ph.D. in Geophysics from Cambridge University in 1971. Dr. Bilham's research has focused in experimental measurements of deformation of mountain ranges, volcanoes and earthquake regions (GPS, absolute-gravity, creep meters and tiltmeters) in Asia, California, New Zealand, Venezuela and Mexico, and theoretical studies of deformation mechanisms causal to plate-boundary and intraplate earthquakes. He was awarded the Guggenheim Fellowship in 2000 and the IRIS/SSA Distinguished Lecturer award in 2002.

Dr. Bilham is a member of Seismological Society of America, the American Geophysical Union, the Geological Society of America and the Royal Geographical Society. He is currently writing two books, a book on urban earthquakes, and a book on Mt. Everest. Dr. Bilham has also written articles in magazines such as Discover, Earth magazine and the Economist.