



The Abdus Salam
International Centre
for Theoretical Physics

ICTP Diploma Programme

Earth System Physics

Seismology

Seismic hazard

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Some basic definitions:

- **Seismic Hazard:** describes the potential for dangerous, earthquake related phenomena, such as ground shaking, fault rupture or soil liquefaction.
- **Seismic Risk:** probability of occurrence of these consequences.

Some basic definitions

- **Seismic Hazard:** any physical phenomenon (e.g. shaking) associated with an earthquake that may cause an adverse effect on human activity.
- **Seismic Risk:** a probability that social or economic consequences will exceed a specified value.

Some basic definitions

- **Seismic Hazard:** a physical effect associated with an earthquake, such as ground shaking, that **MAY** produce adverse effects.
- **Seismic Risk:** the probability that consequences of an earthquake, such as structural damage, will equal or exceed specified values in a specified period of time.

Hazard, Risk & Vulnerability

$$\text{Risk} = \text{Hazard} * \text{Vulnerability}$$

Nature decided, and can be assessed

Man decided, and can be reduced

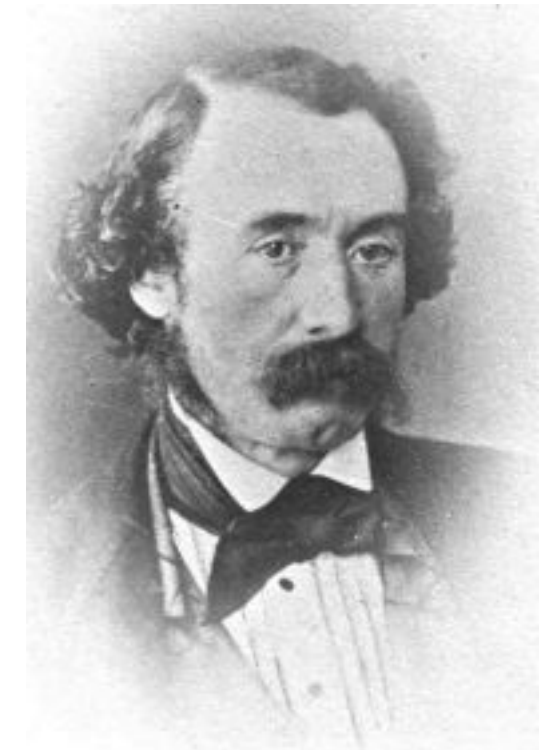
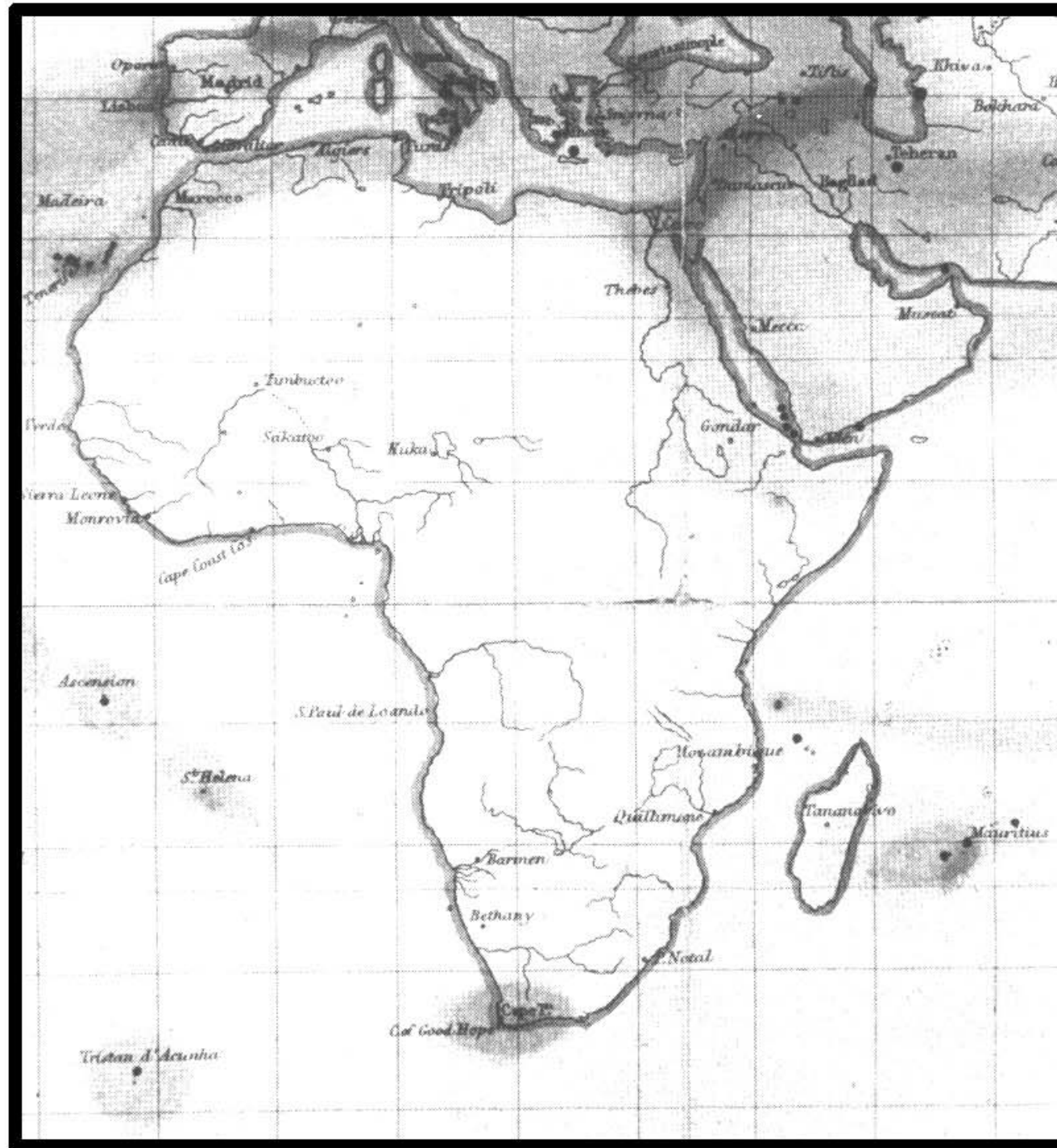
$$R = \langle N_i, P_i, C_i \rangle$$

set of i-events with possible adverse consequences

associated probabilities of their occurrence

associated intolerable consequences

Earthquake zoning - history



Oldest seismic hazard map,
compiled by Mallet in 1853-1855

Earthquake zoning - history

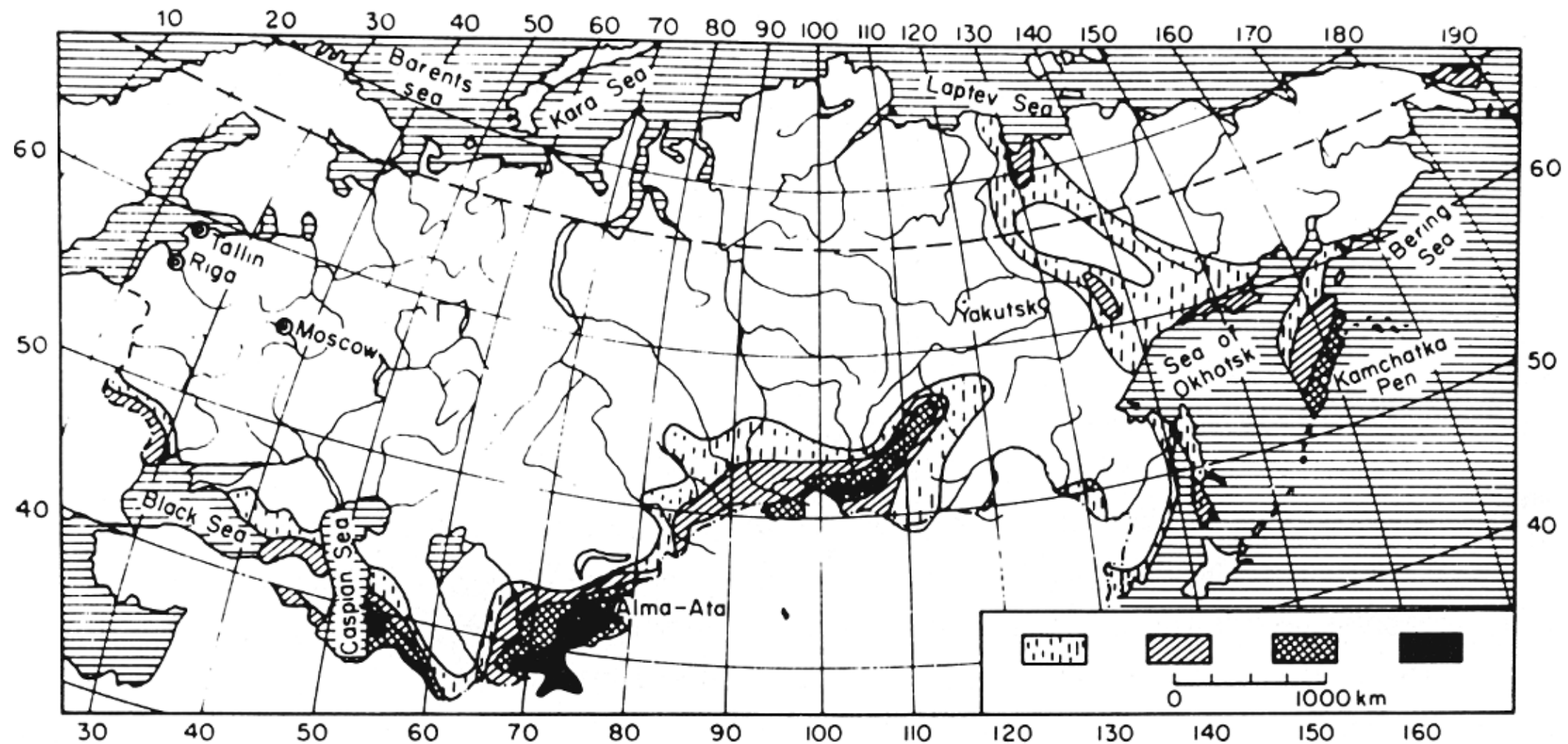


Fig.9.1. Earthquake zoning map of the U.S.S.R. (Normy i pravila stroitel' stva v seismicheskikh raionakh SN8-57, Stroiizdat, 1958).

Moscow Institute of Physics of the Earth, 1937

These maps were first incorporated into the building code for the Russian Federative Republic. Later, the Institute of Physics of the Earth prepared more detailed maps, which were incorporated in the 1957 Zoning (Rayonirovanye) of the Soviet Union. These maps became an official part of the Earthquake Building Code SN8-57 of the U.S.S.R.

SHA dualism: P & D

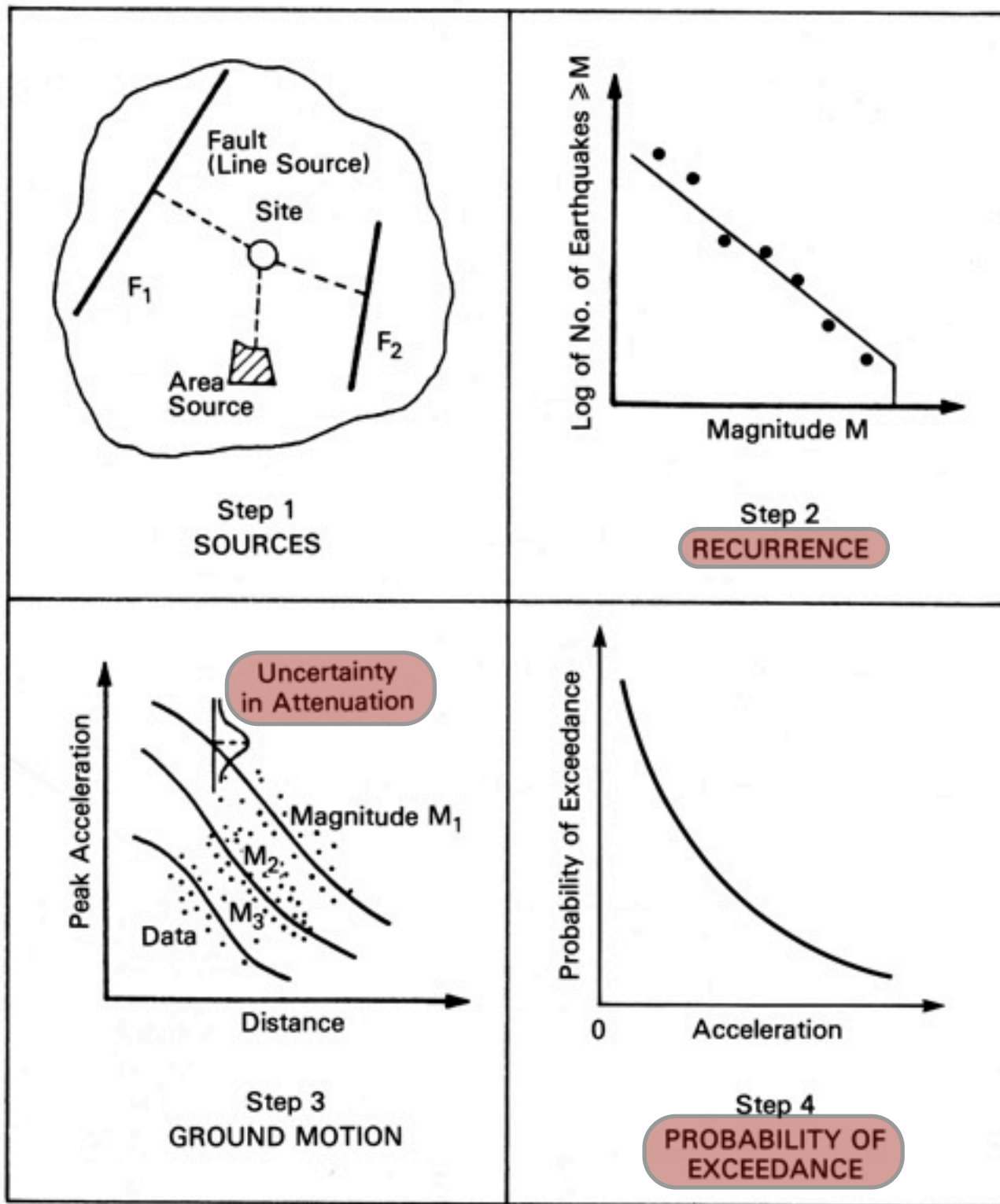


FIGURE 10.2 Basic steps of probabilistic seismic hazard analysis (after TERA Corporation 1978).

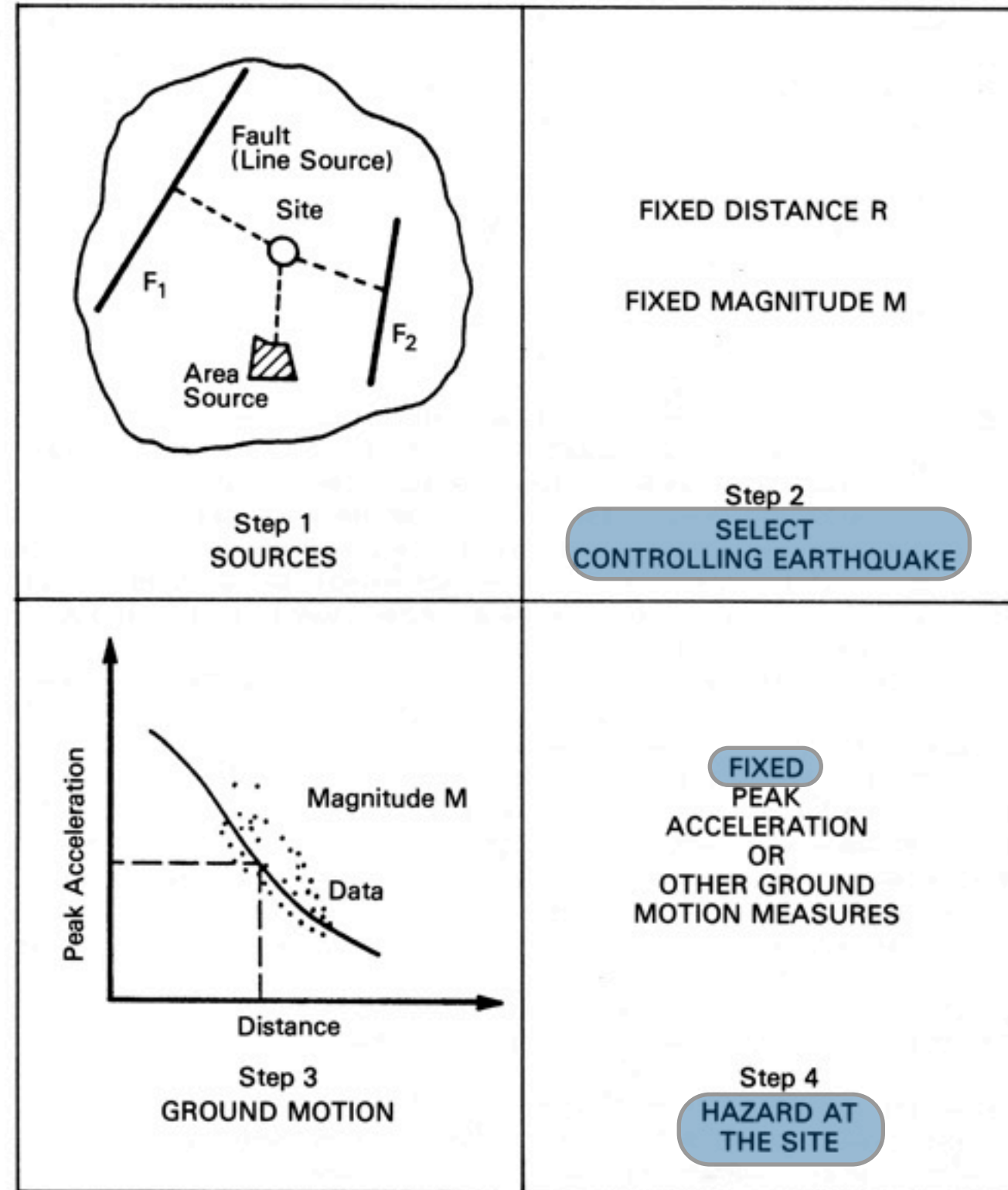
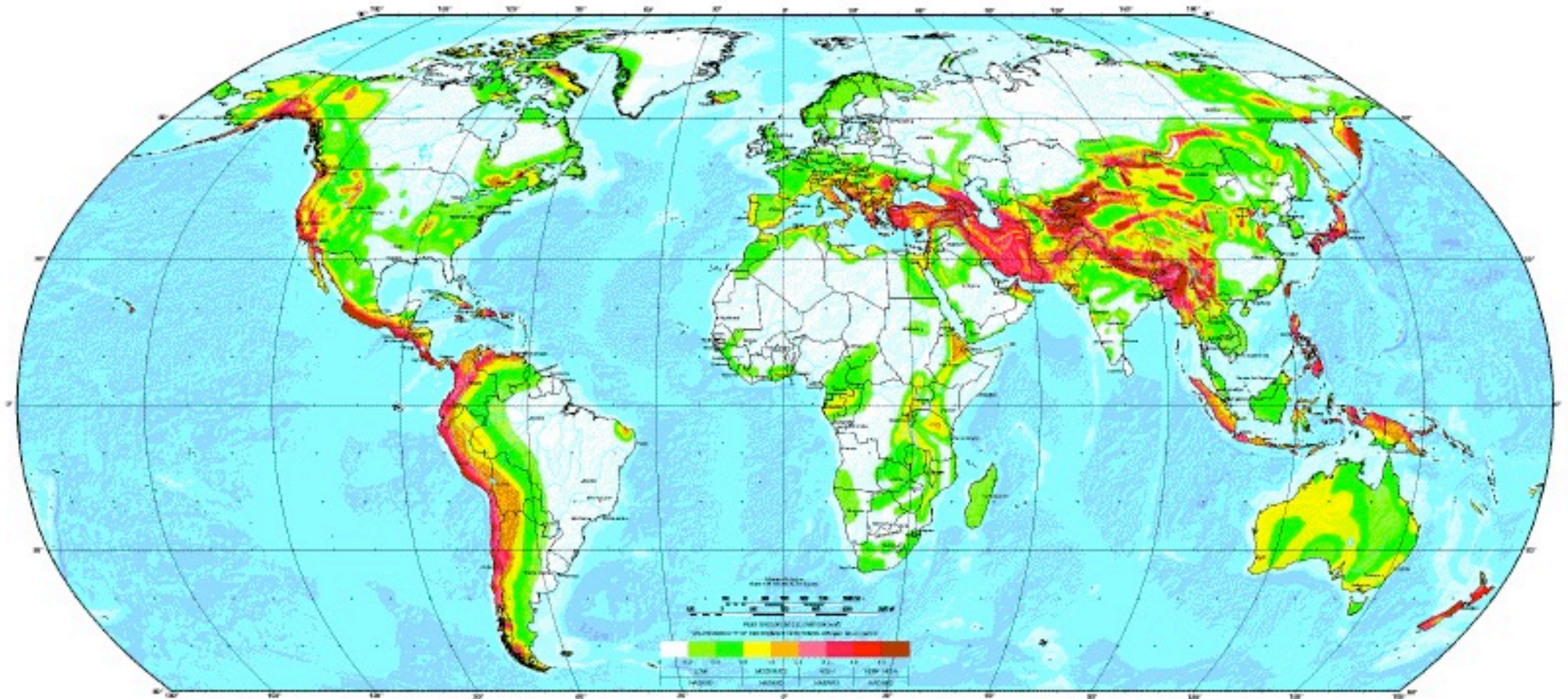


FIGURE 4.1 Basic steps of deterministic seismic hazard analysis (after TERA Corporation 1978).

“Earthquake Hazard Analysis”, Reiter, 1990

SHA global map

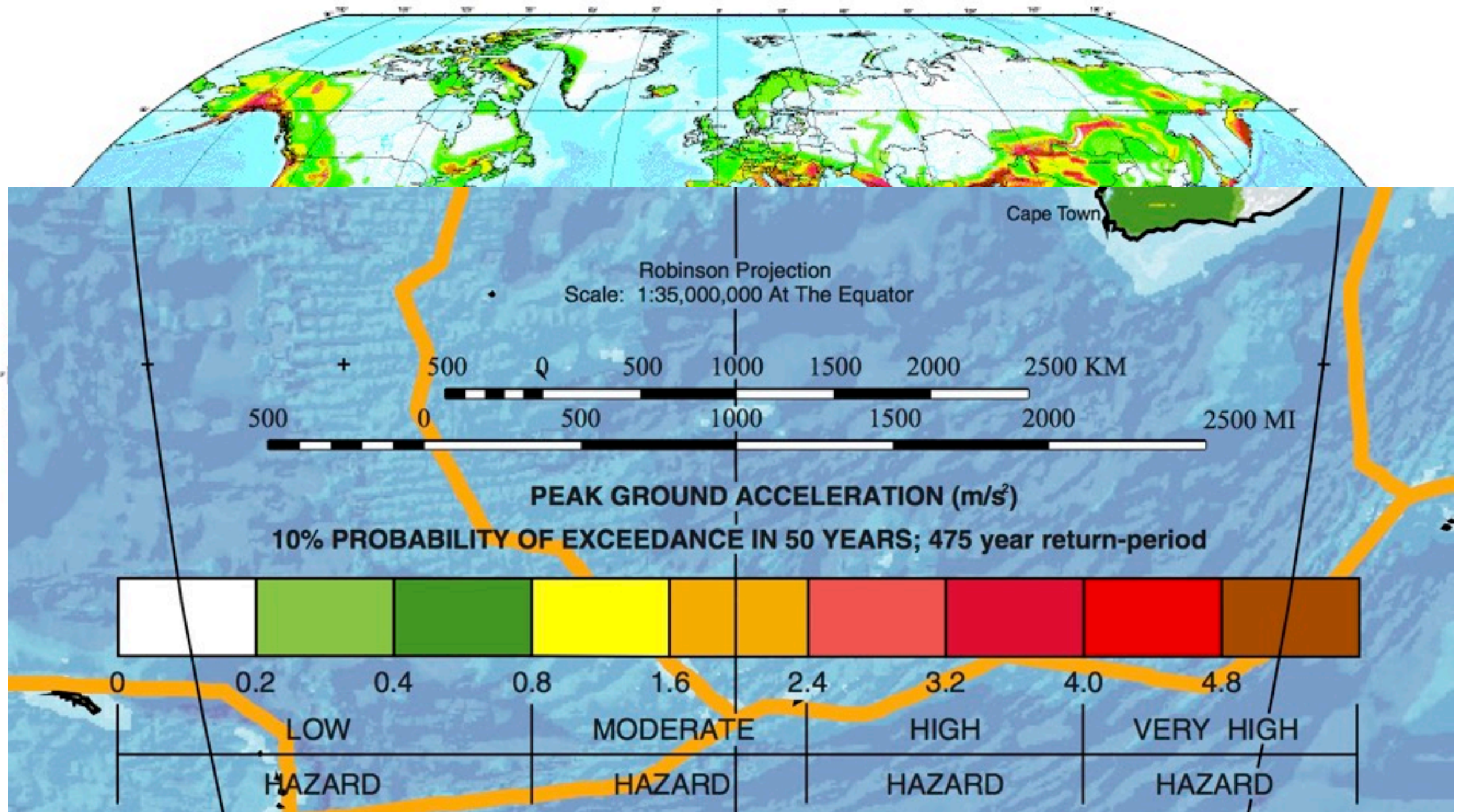
GLOBAL SEISMIC HAZARD MAP



<http://www.seismo.ethz.ch/static/GSHAP/>

SHA global map (1999)

GLOBAL SEISMIC HAZARD MAP



Response spectra

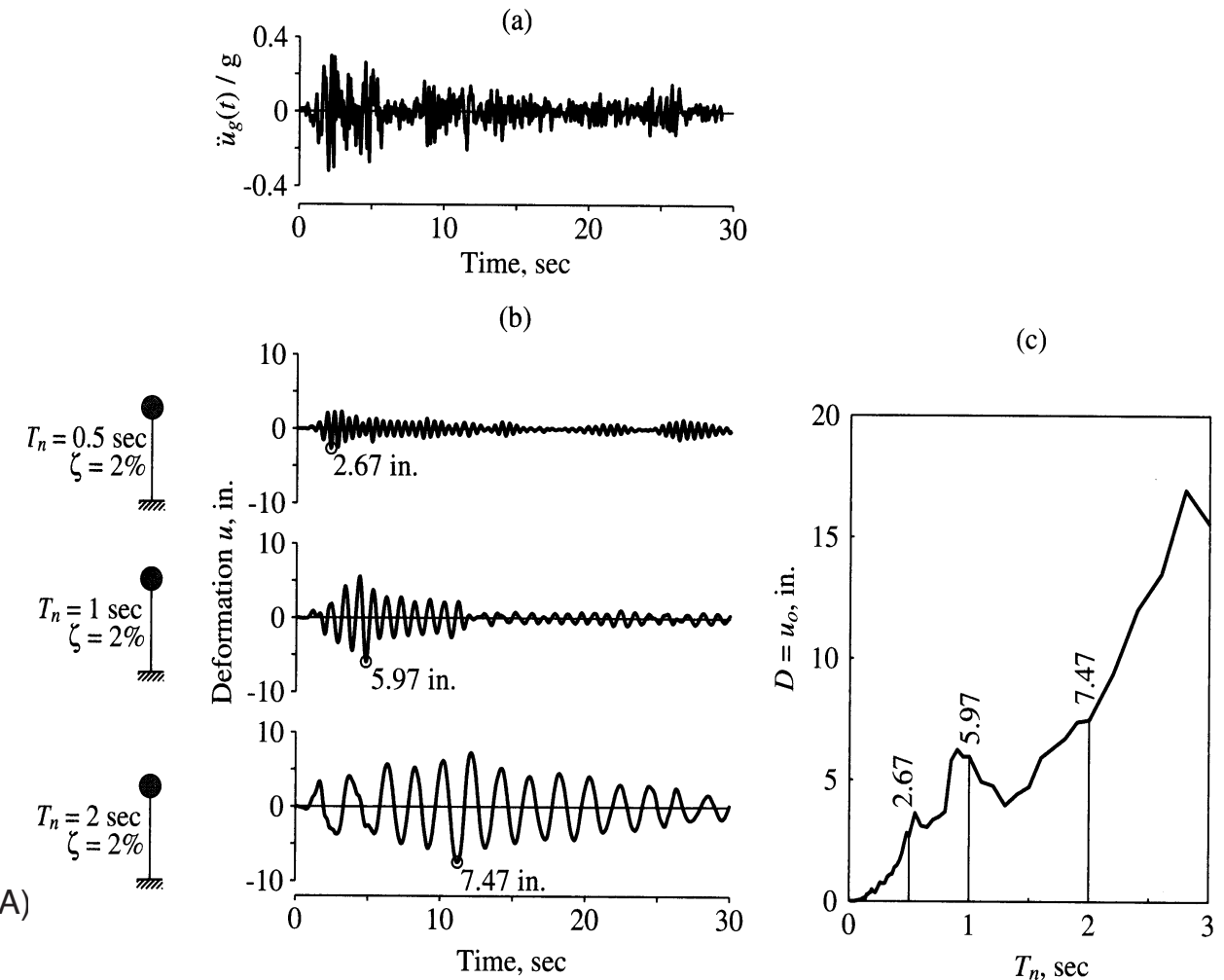
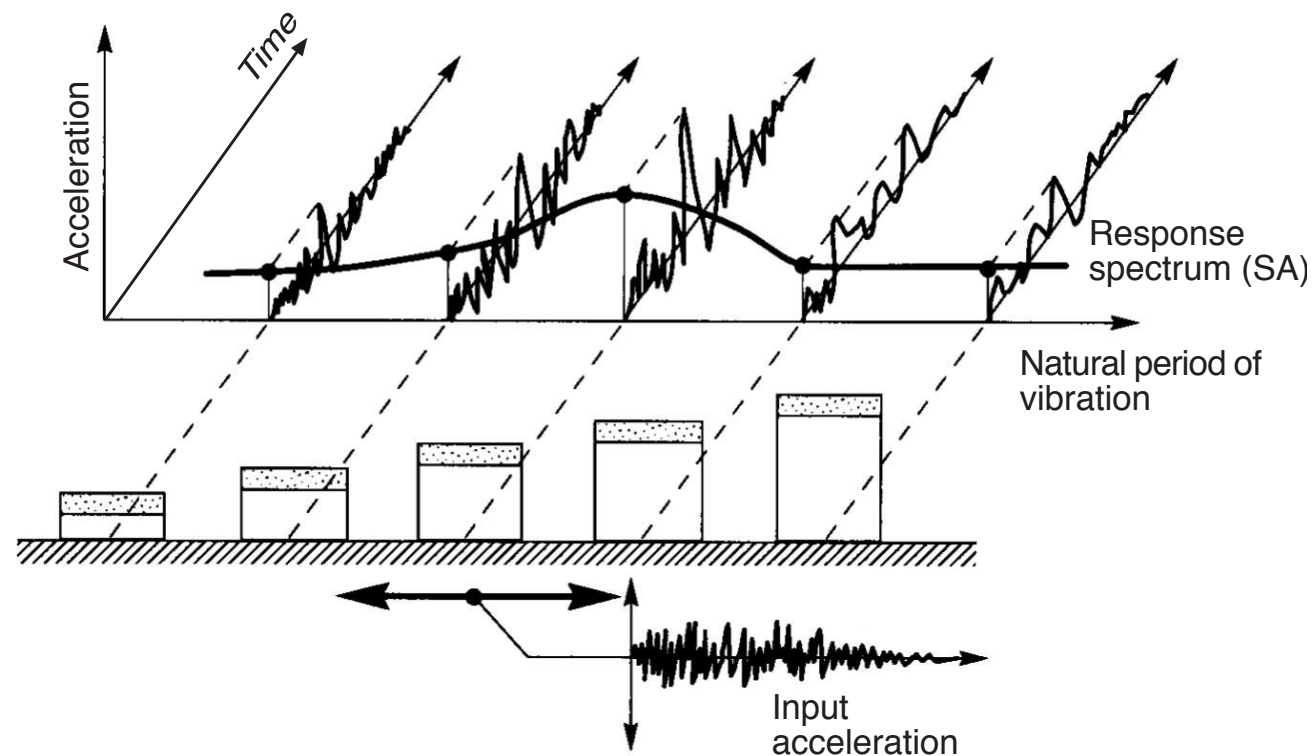
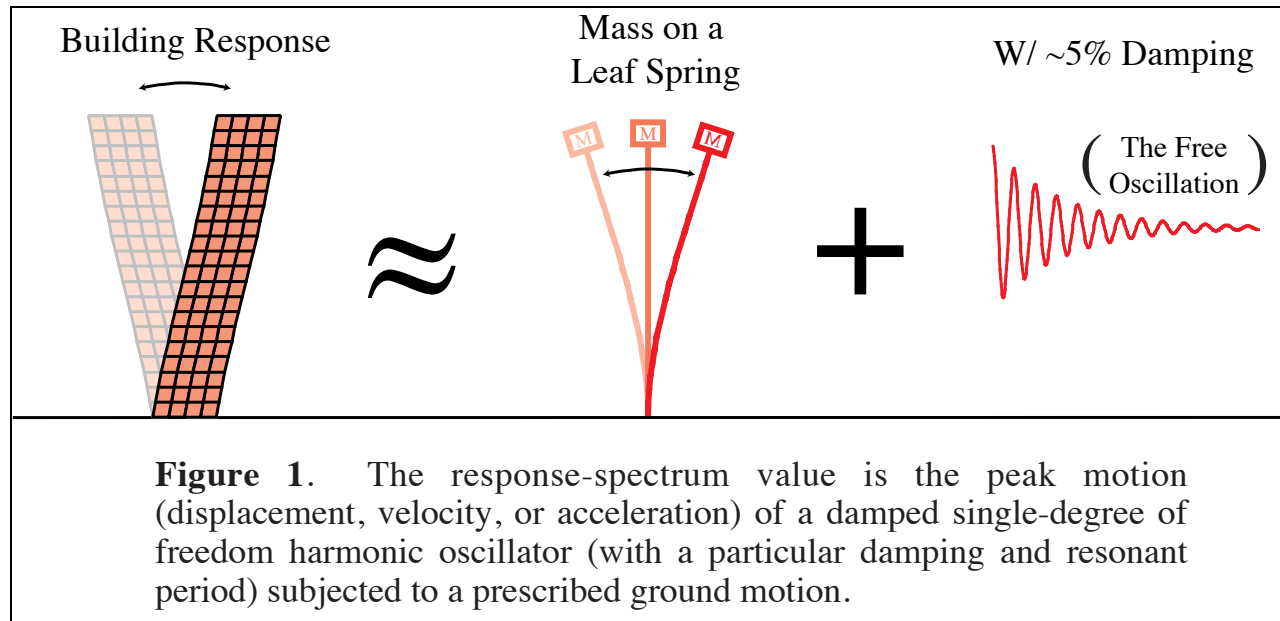
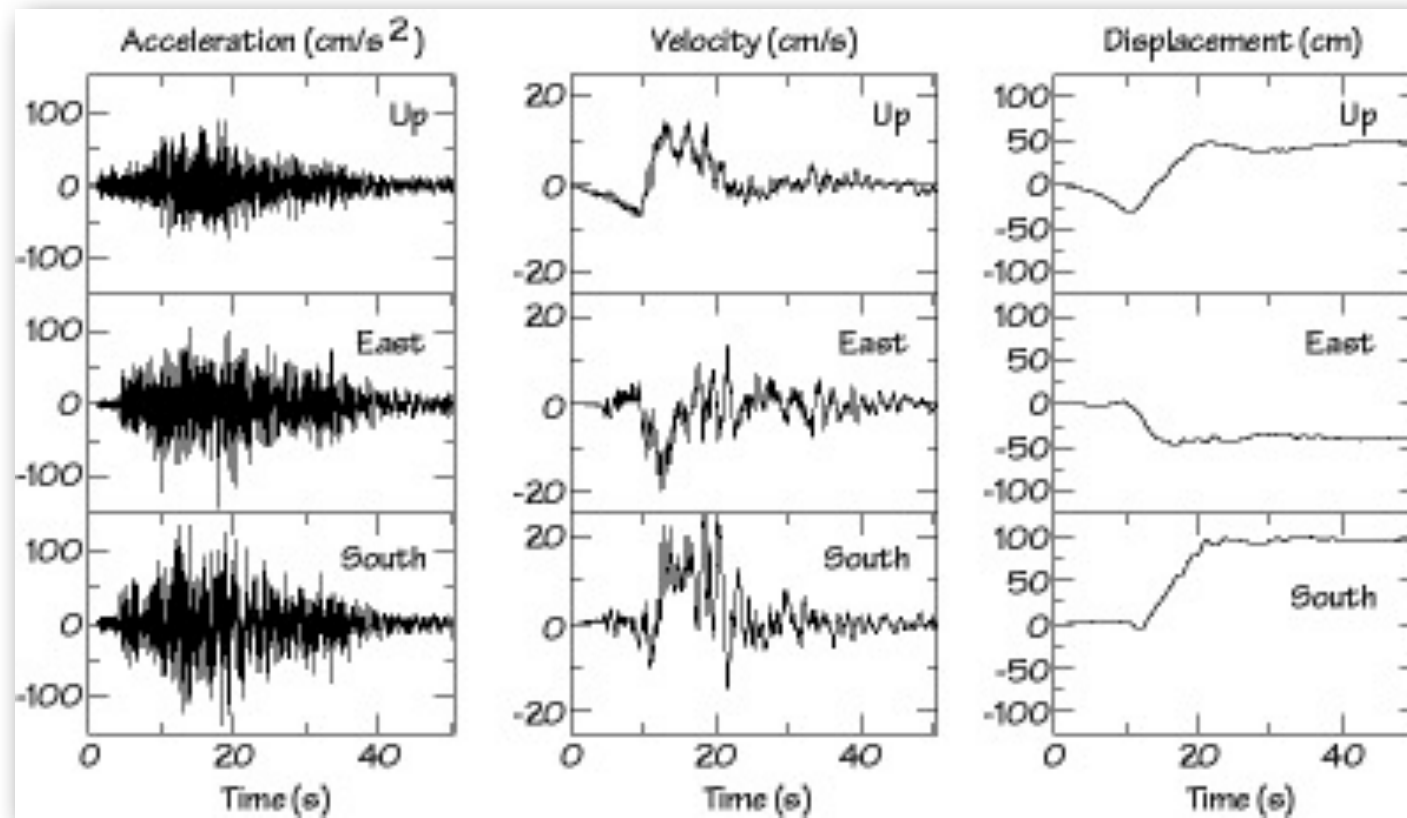


Figure 6.6.1 (a) Ground acceleration; (b) deformation response of three SDF systems with $\zeta = 2\%$ and $T_n = 0.5, 1,$ and 2 sec; (c) deformation response spectrum for $\zeta = 2\%$.

Source effects...



Michoacan, 1985

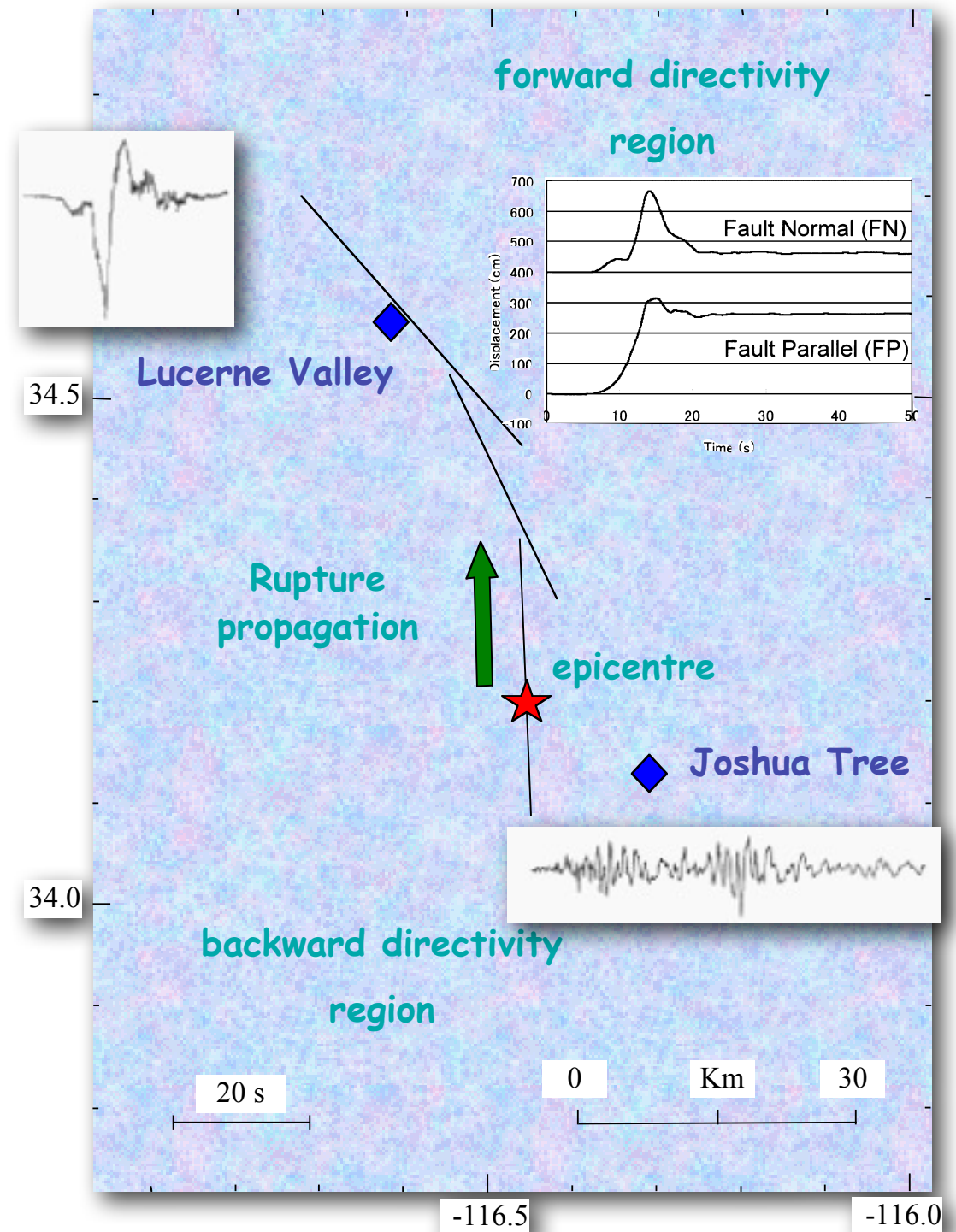
Fling & Directivity aka Near-field & Near-source



Sir Georges Stokes

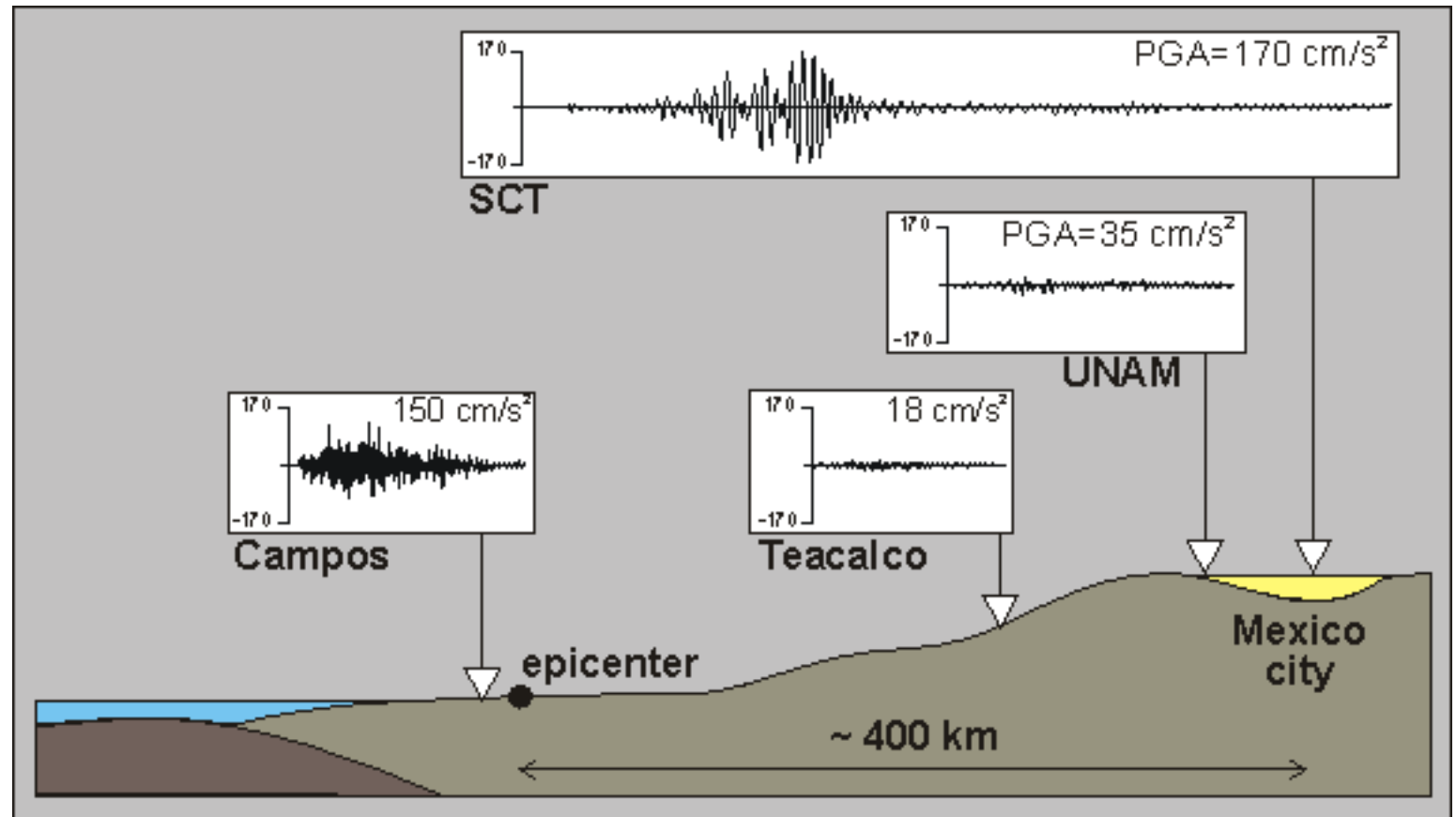
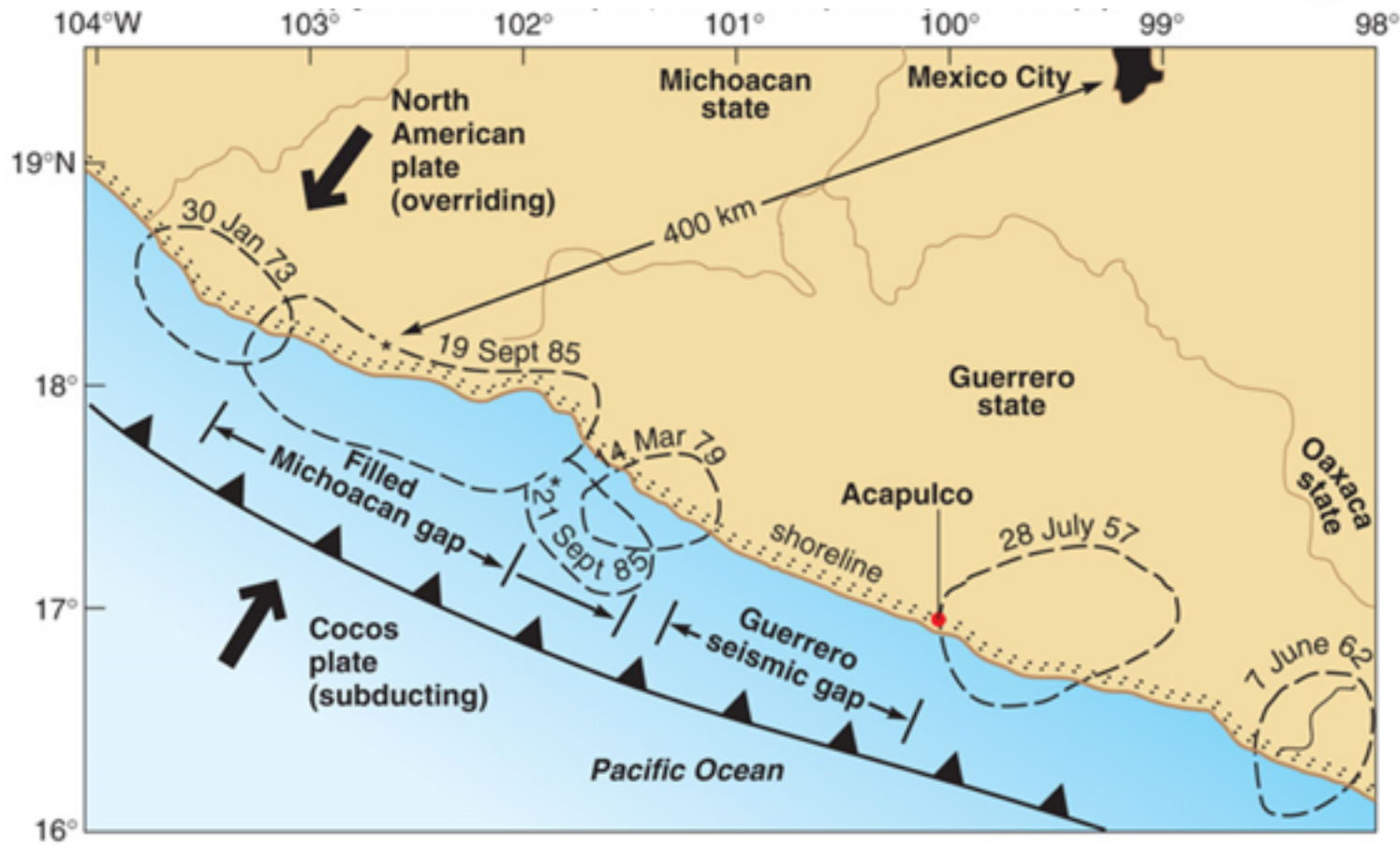


Hugo Benioff

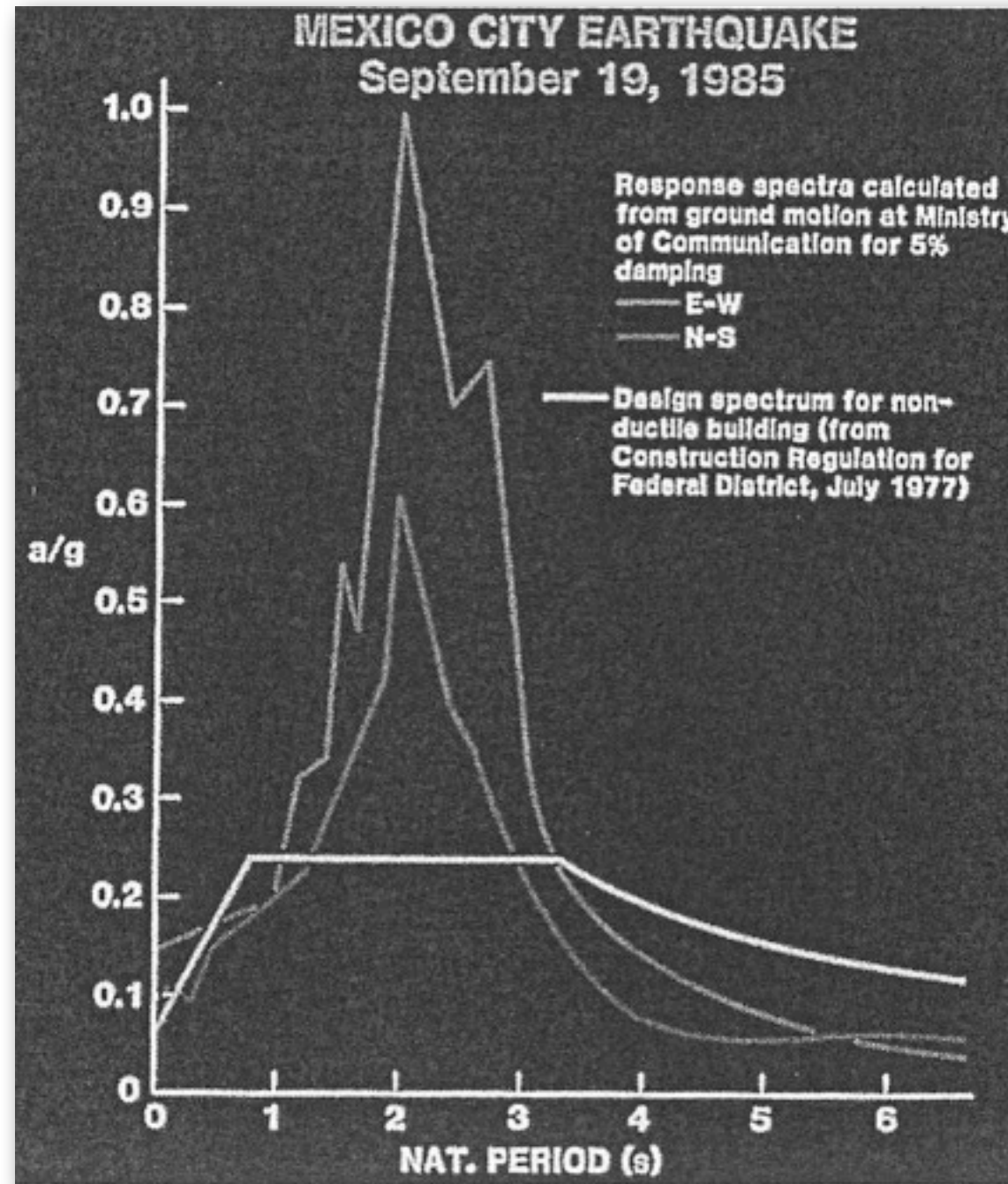


Landers, 1992

Michoacan 1985 event: way to DF..



Michoacan 1985 event: RSA in DF at SCT



Tenochtitlan and Mexico City (DF)

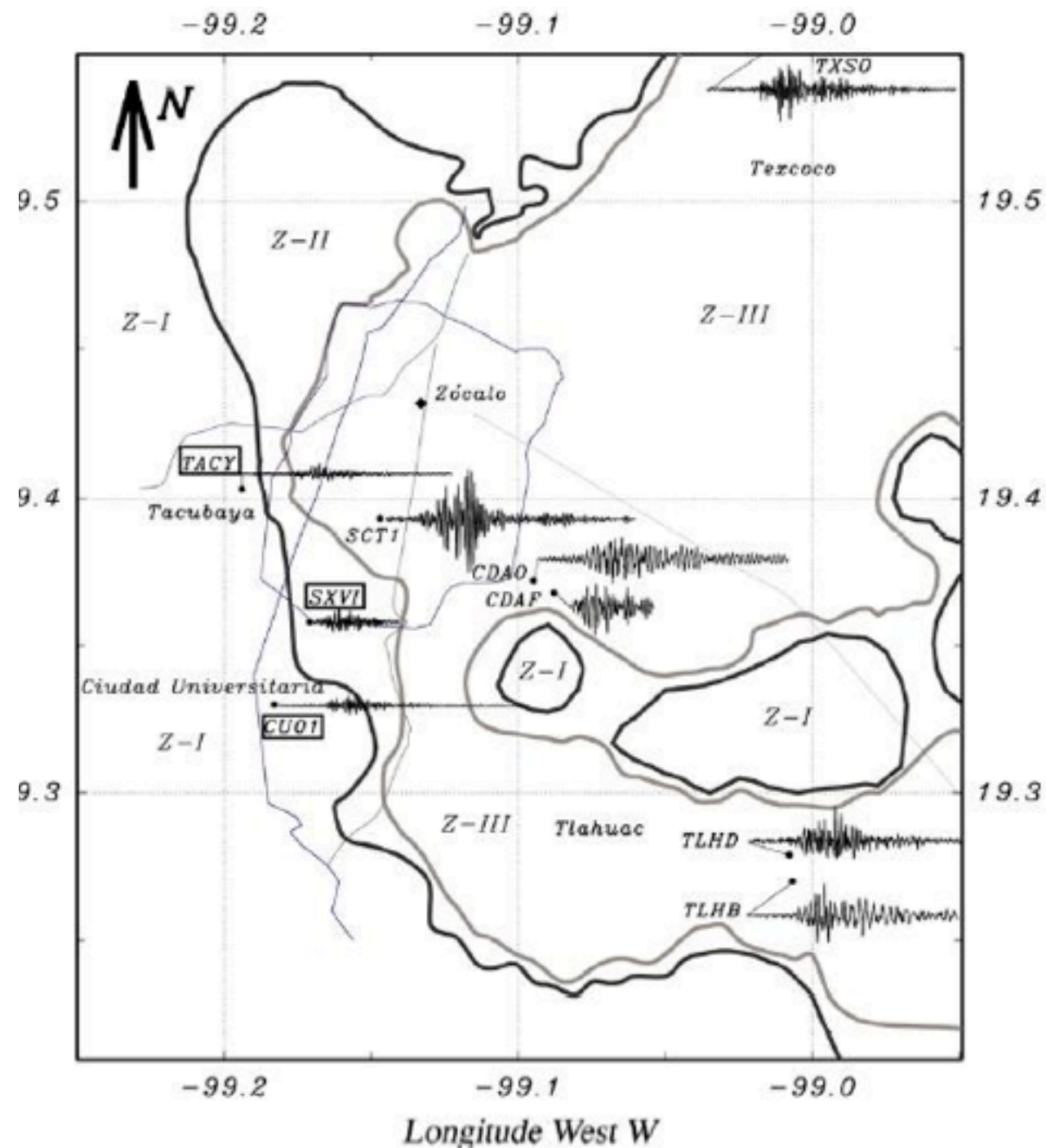
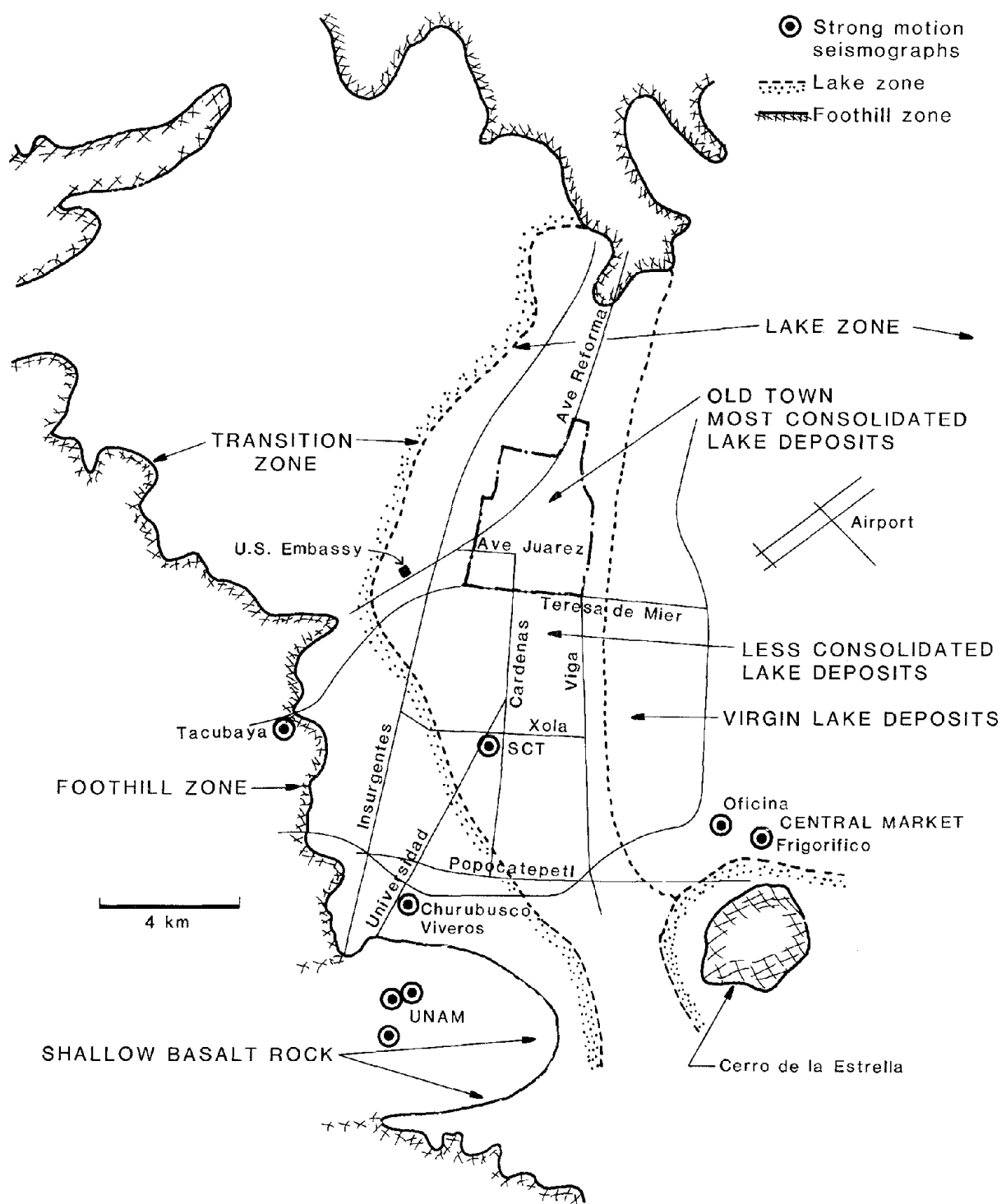


La ciudad de Tenochtitlan y su entorno en el siglo XVI Pintura de Miguel Covarrubias, Museo Nacional de Antropología, México DF



The actual boundaries of the World Heritage Property follows the boundaries of the Historical Monuments Zones, according to the limits of the city in the 19th century (perimeter A), and a buffer zone (perimeter B)

Michoacan 1985 event: GM in DF



Michoacan 1985 event: damage in DF



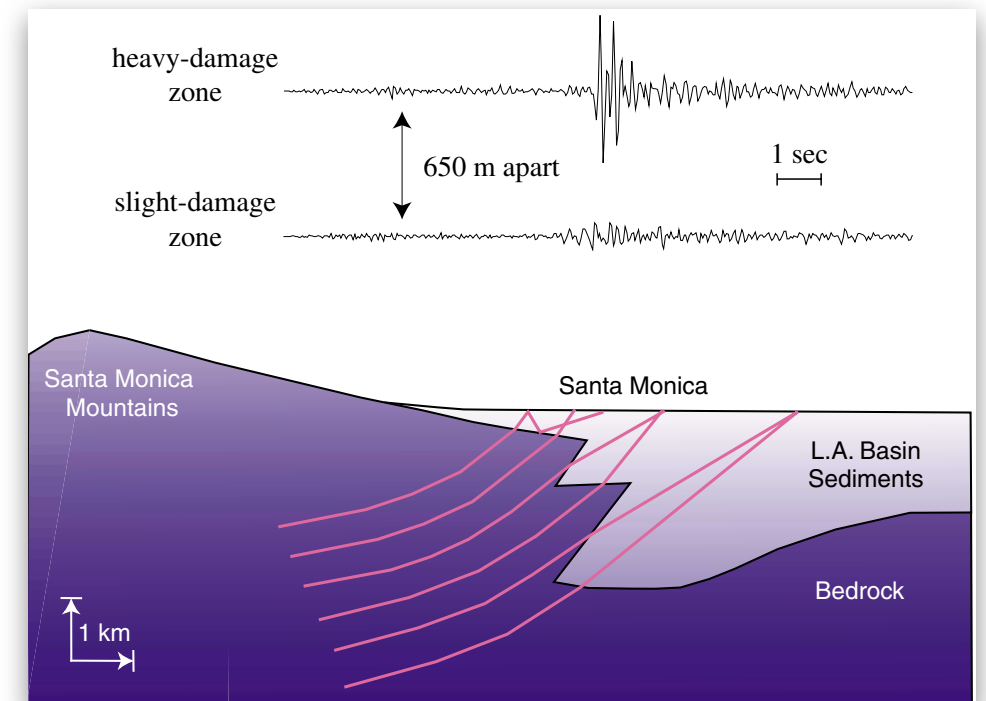
Wreckage of a twenty-one-story building in
Conjunto Pino Suarez Complex



Totally destroyed office building in the foreground,
while the 44-floor Torre Latinoamericana office
building, in the background on the right, stands

Important issues in SRE

- Near surface effects: impedance contrast, velocity
- geological maps, v_{30}
- Basin effects
- Basin-edge induced waves
- Subsurface focusing



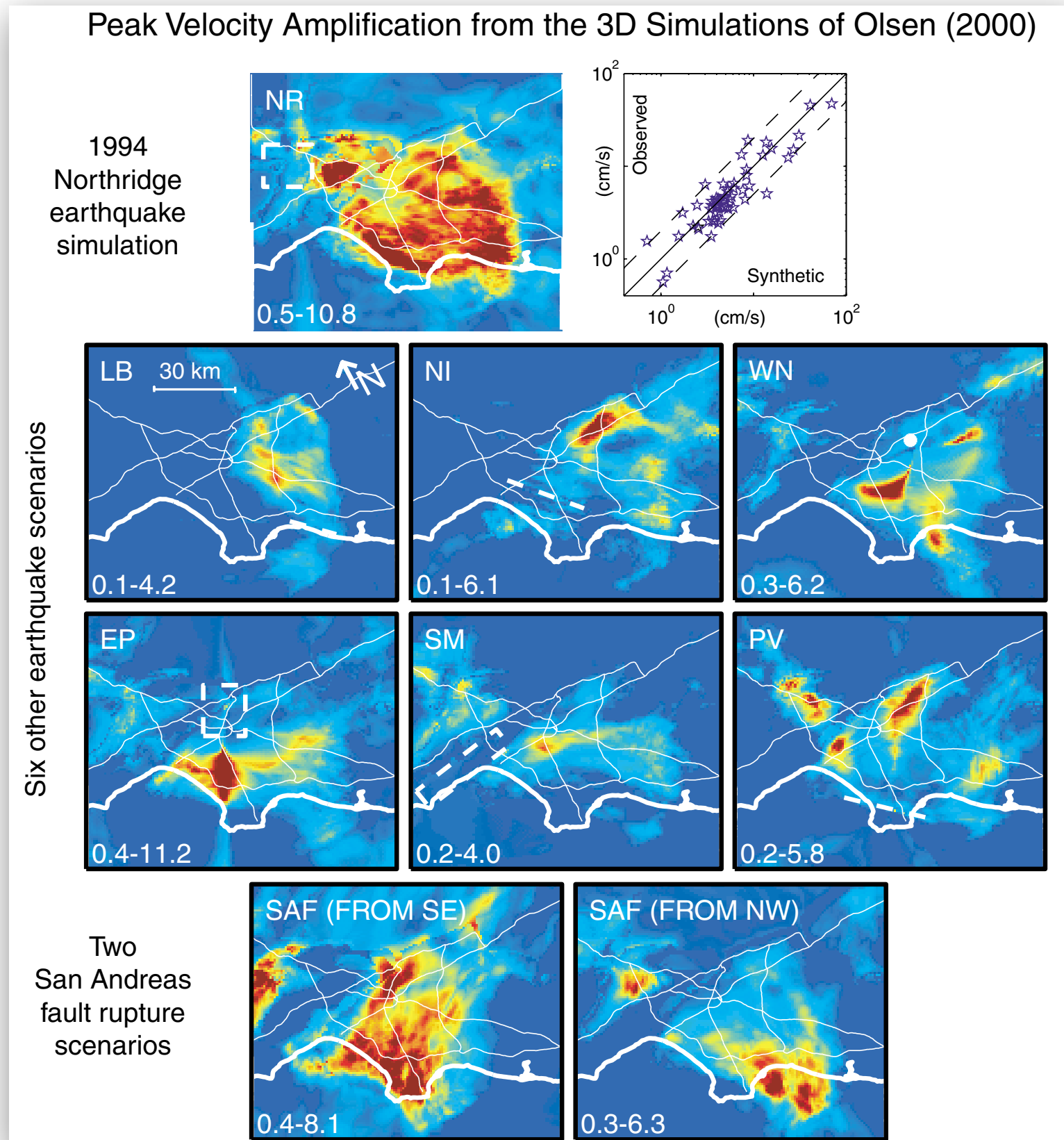
In SHA the site effect should be defined as the average behavior, relative to other sites, given all potentially damaging earthquakes.

This produces an **intrinsic variability** with respect to different earthquake locations, that cannot exceed the difference between sites

Amplification patterns...

...may vary greatly among the earthquake scenarios, considering different source locations (and rupture ...)

SCEC
Phase 3
Report



PGA as a demand parameter...

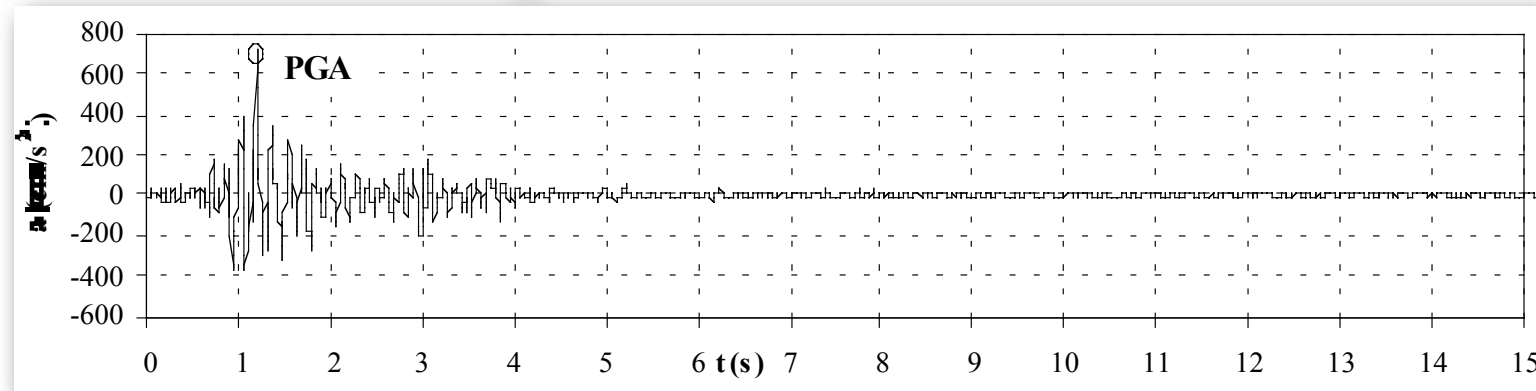


Figure 1 – Acceleration time history. Rocca NS record. 1971 Ancona earthquake ($M_L=4.7$)

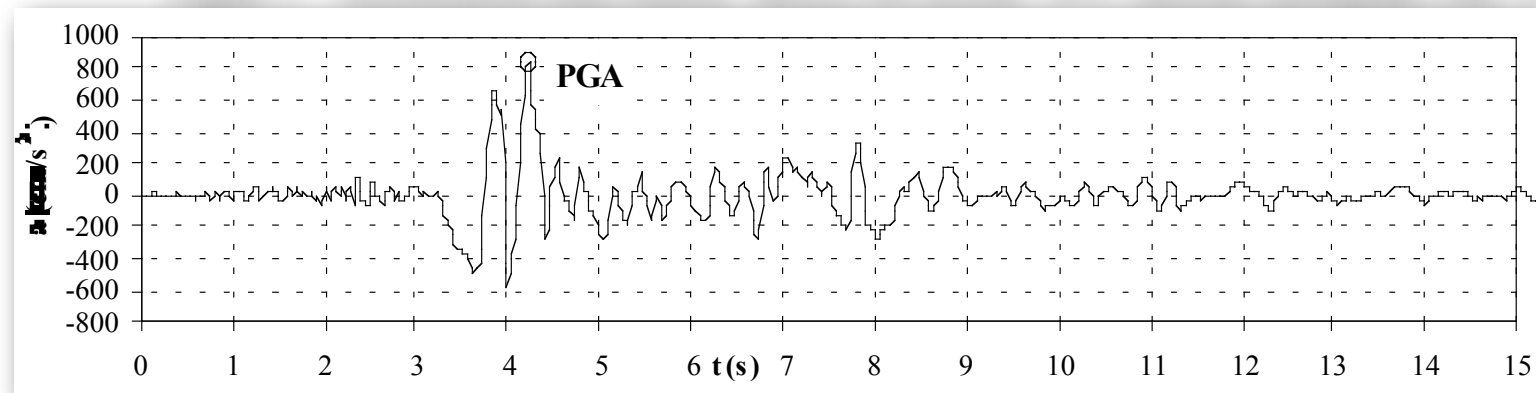
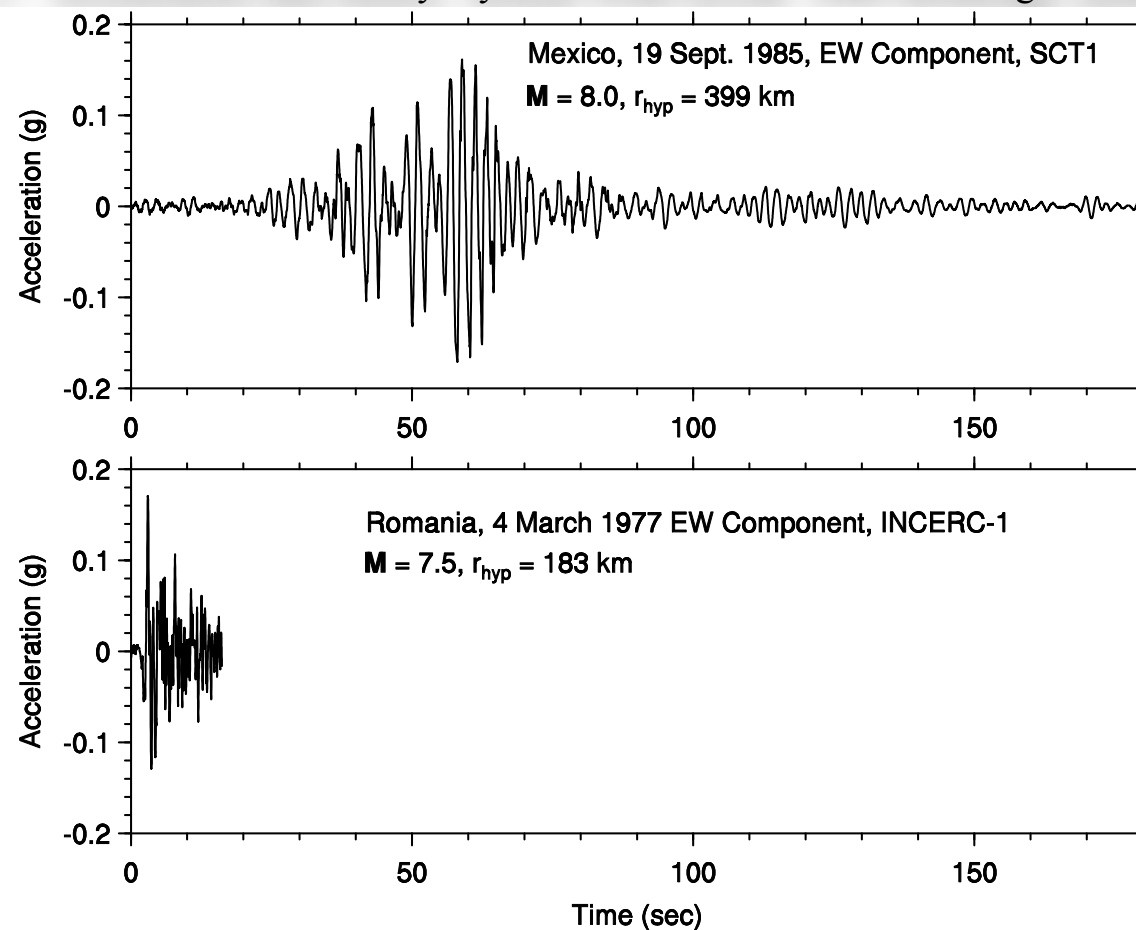
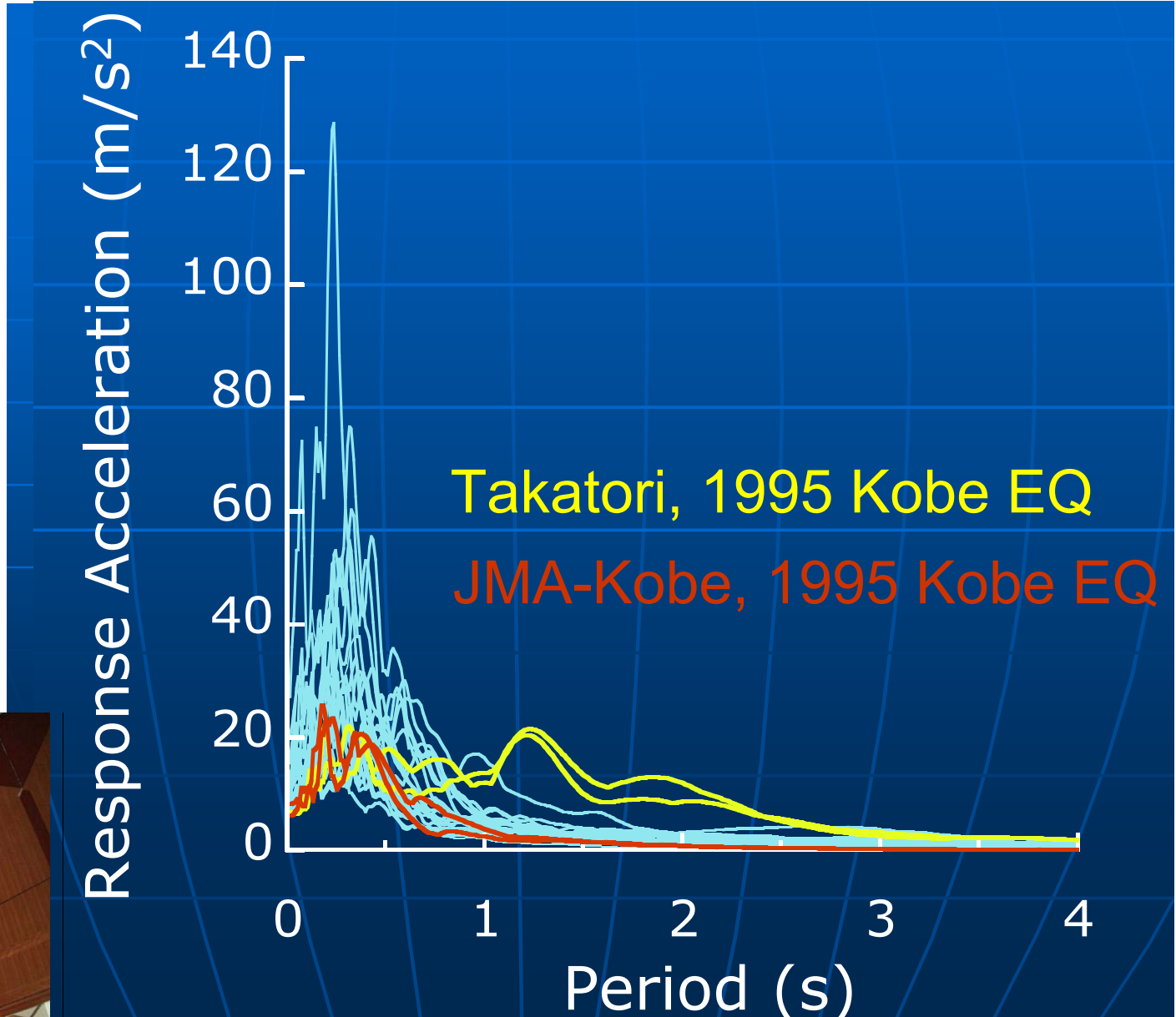
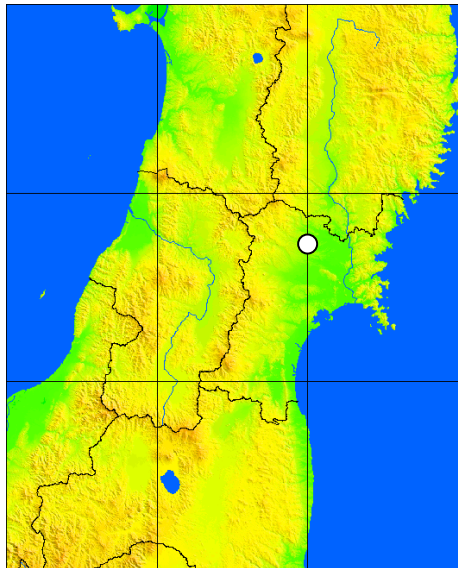


Figure 2 – Acceleration time history. Sylmar N360 record. 1994 Northridge earthquake ($M_w=6.7$)



Tsukidate



(a) Overall view of the Kurihara City Municipal Office Building



(b) Fall of ceiling of Municipal Assembly Hall (1)

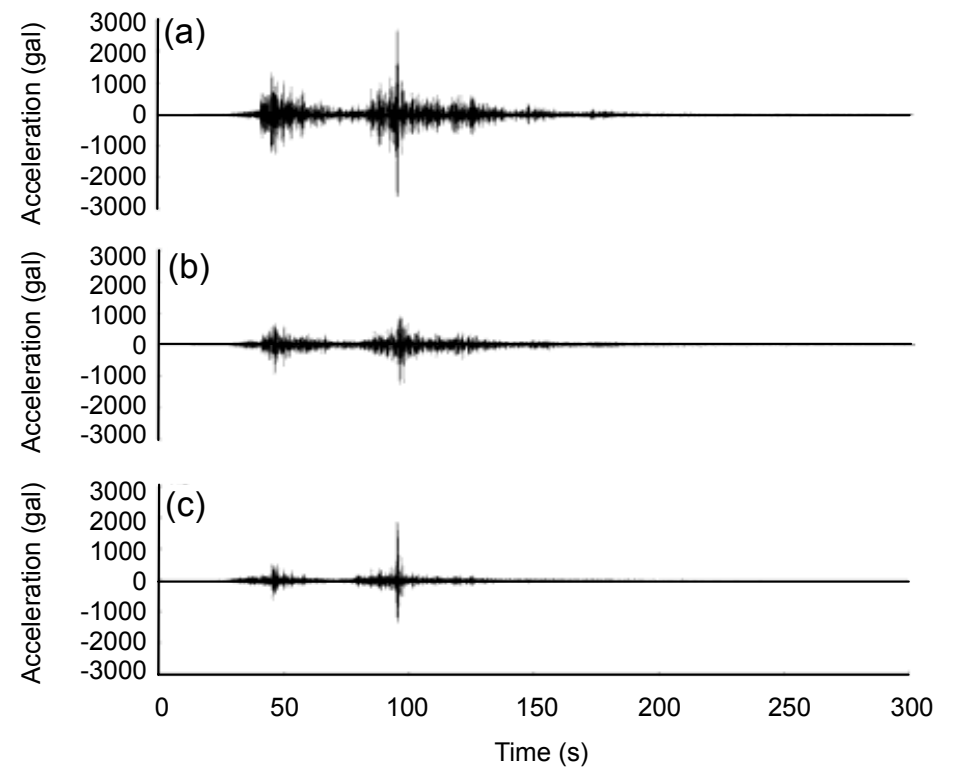


(c) Fall of finishing tiles on a column



(d) Fall of ceiling of Municipal Assembly Hall (2)

Photo 1: Kurihara City Municipal Office Building and non-structural damage



Time & Space scales... and actions

MYrs Decades Seconds
Geodynamics Geodesy Seismology
Strain rates Slip rates

Time	Space	Action
No	National	Seismic Codes
Decades	Regional	IT alerts
Seconds	Urban	Red Alert