Paleoseismic Investigations for Determining the Design Ground Motions for Nuclear Power Plants

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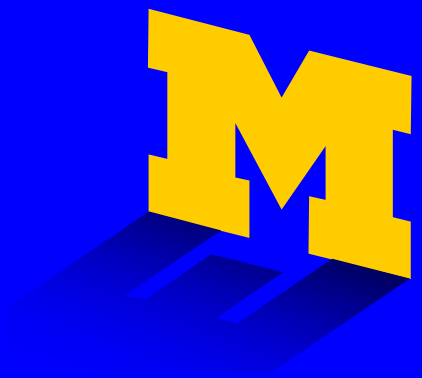

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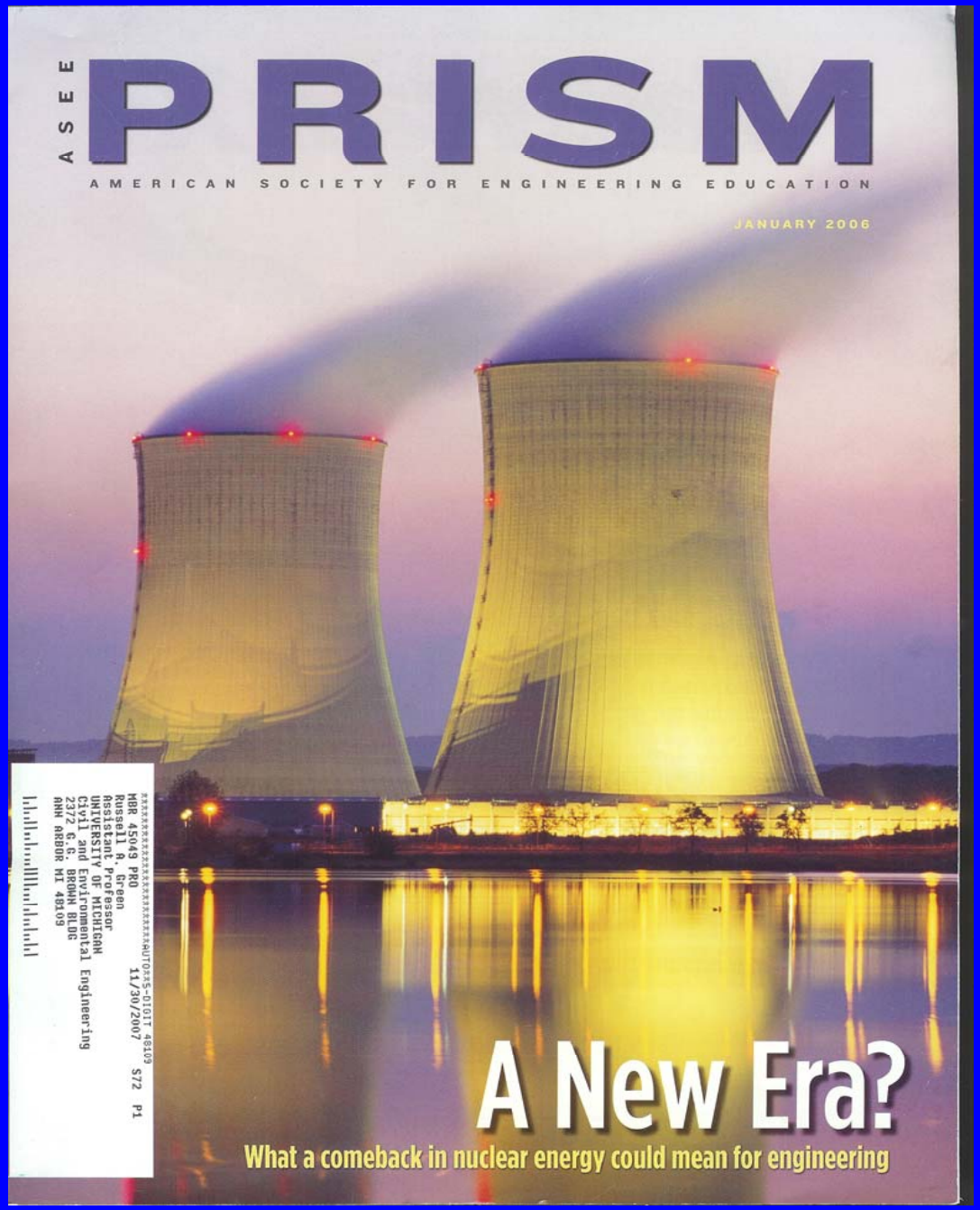
Collaborators:

- Dr. Scott M. Olson, University of Illinois
- Dr. Stephen Obermeier, US Geological Survey, retired
- Ms. Kate Gunberg, PhD Student, University of Michigan

Funding:

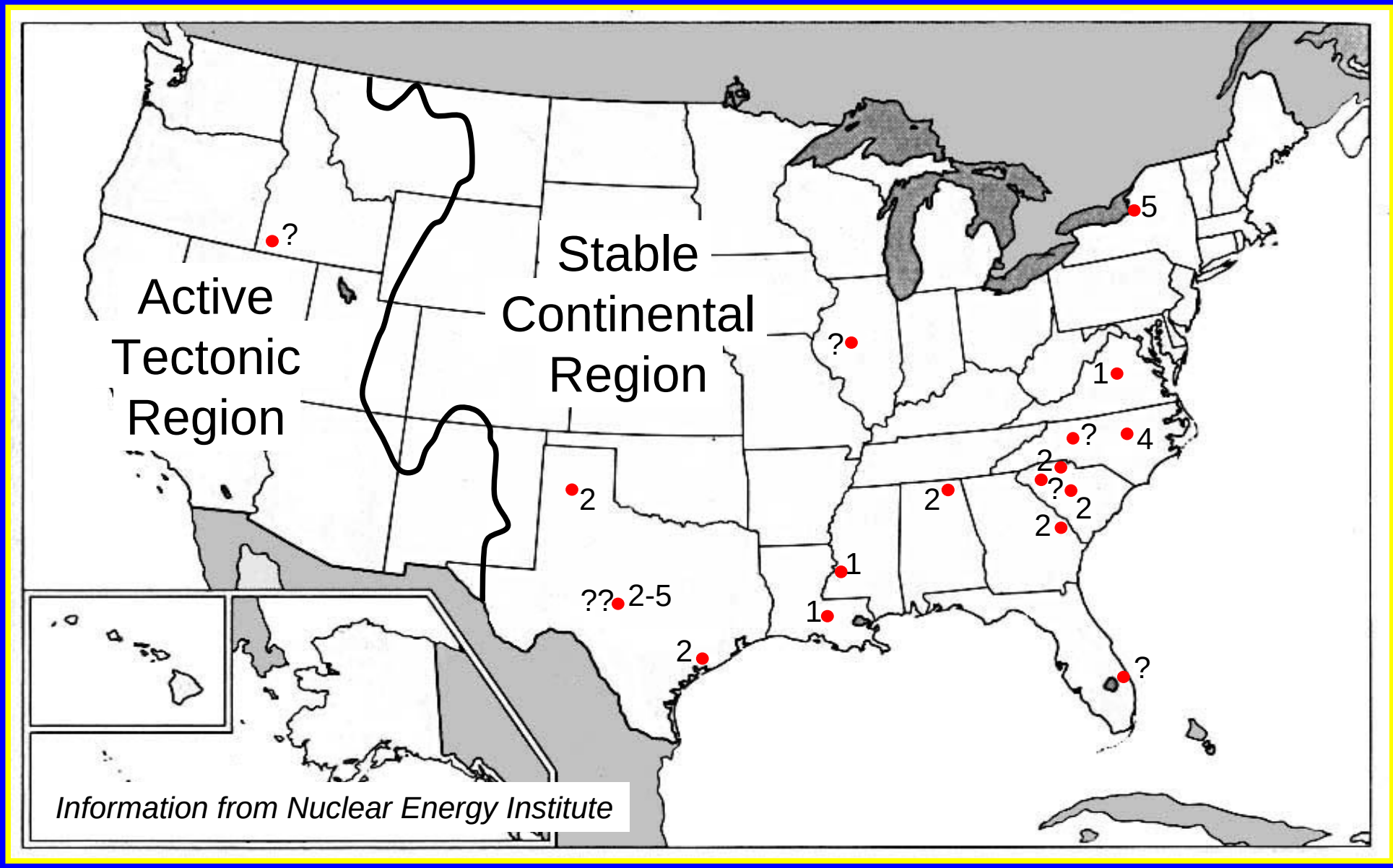
- US National Science Foundation

Renewed Interest in Nuclear Power in the US



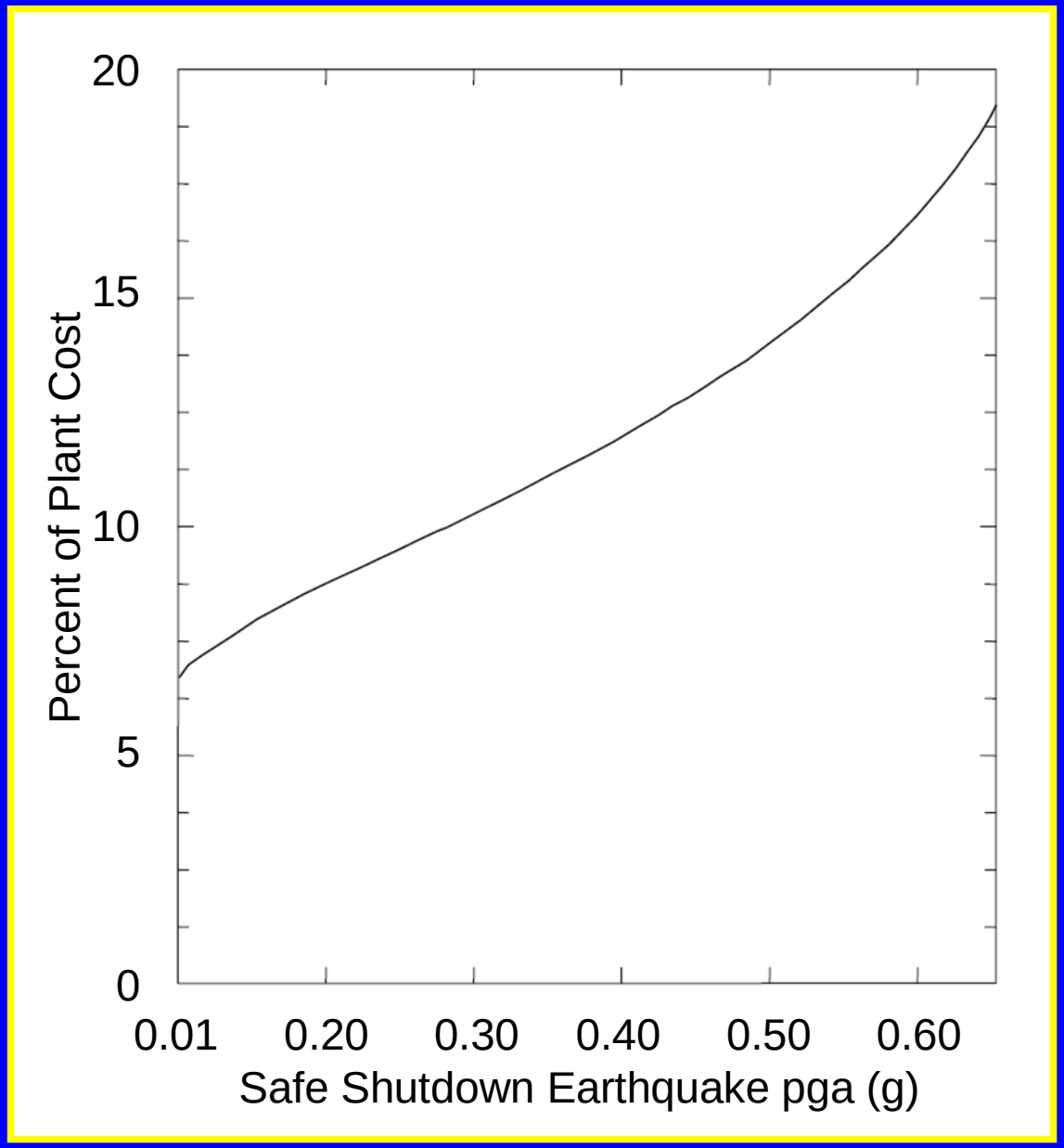
(January 2006)

Locations of Newly Proposed Nuclear Reactors



At least 26 new commercial nuclear reactors at least 16 different sites in at least 12 different states

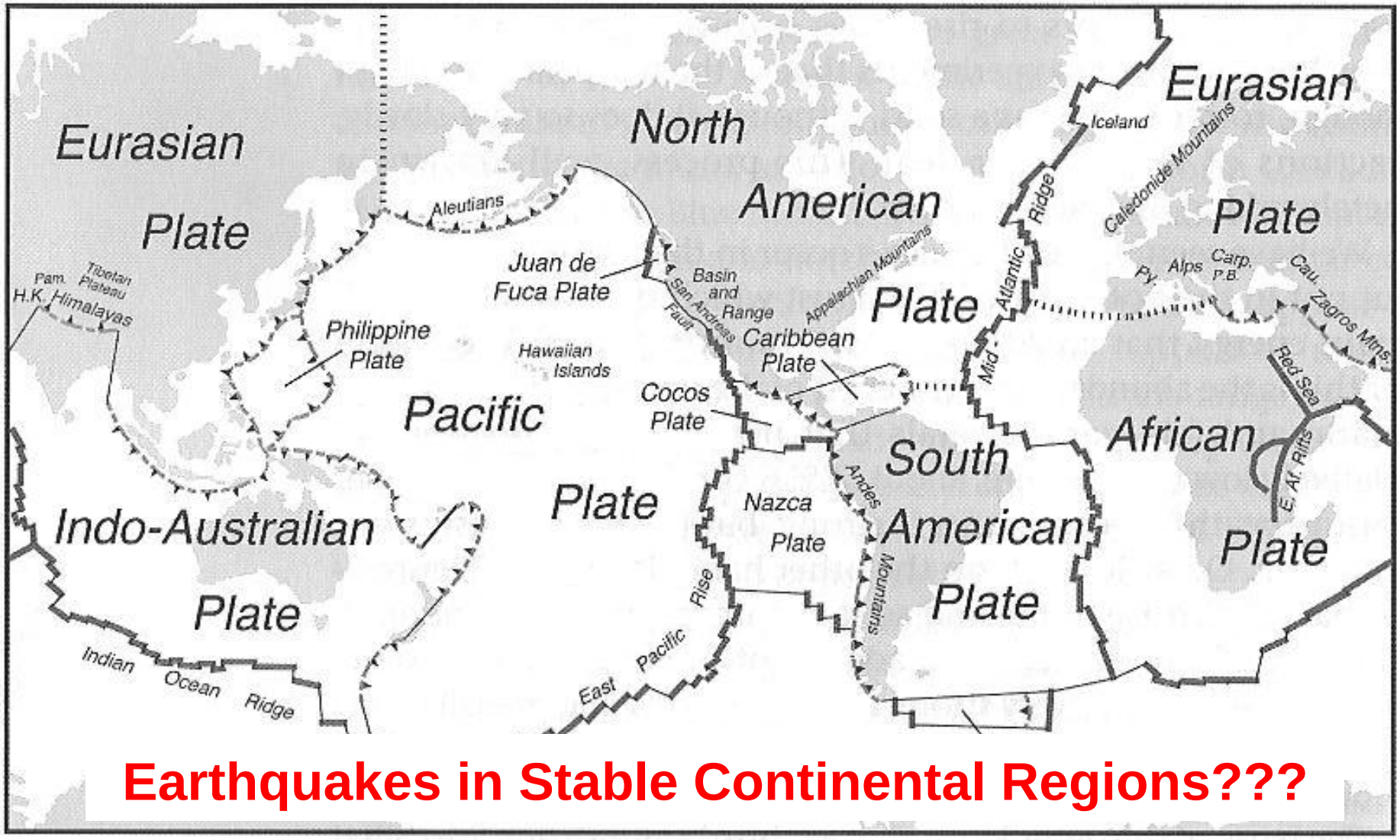
Percent Cost of a Nuclear Plant vs. Earthquake Ground Acceleration



(Stevenson 2003)

Review of Earthquake Geology and Engineering Seismology

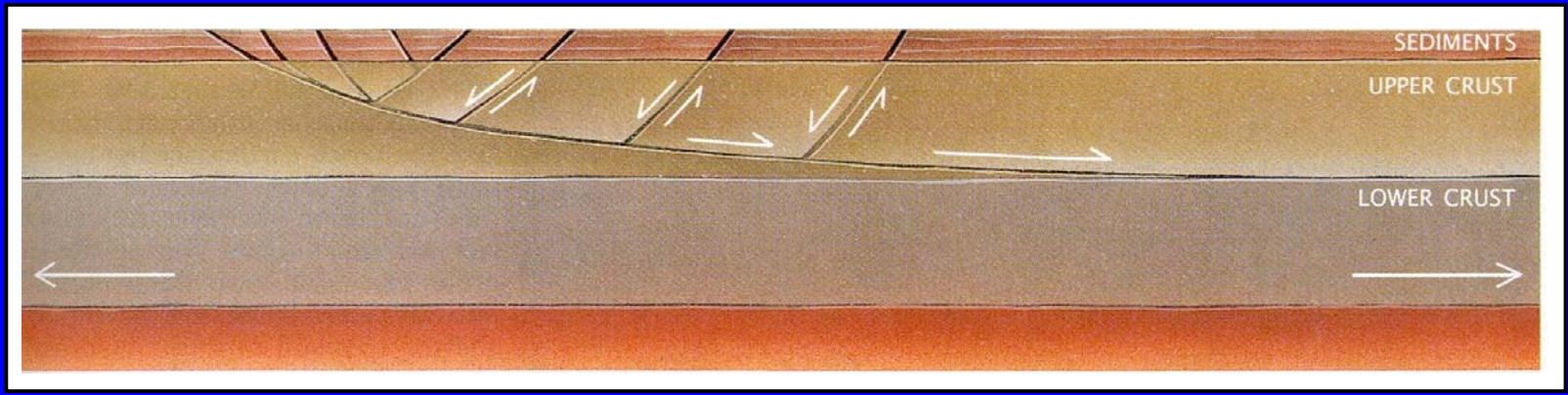
Geology of Earthquakes

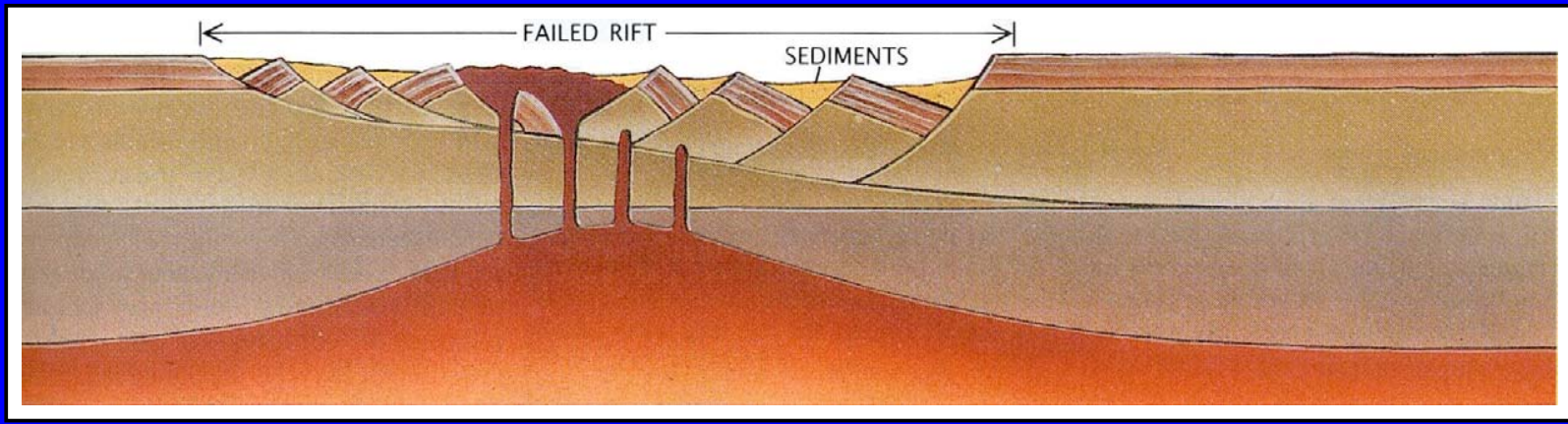


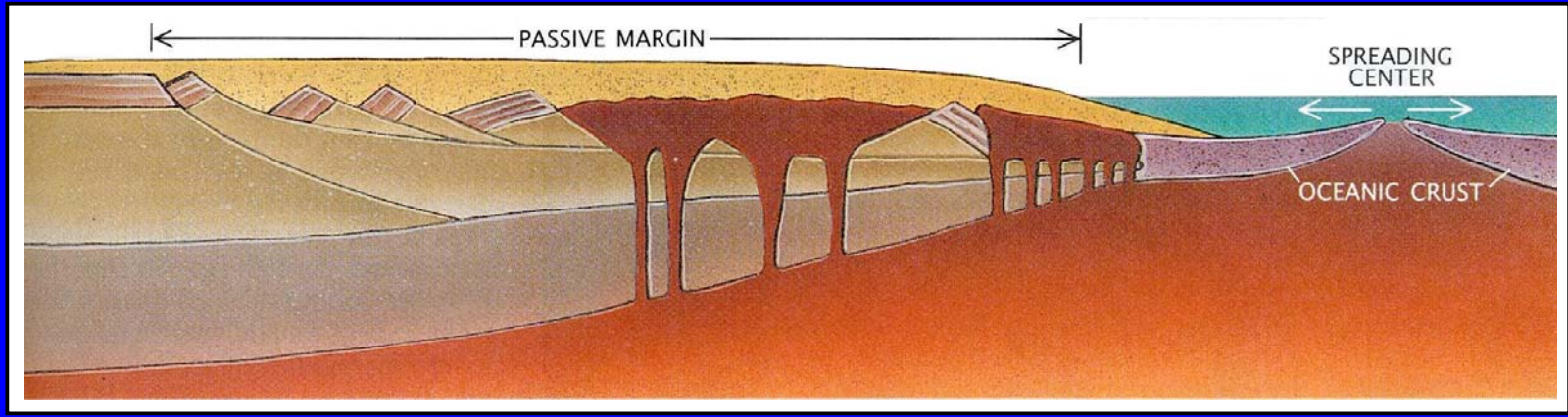
Earthquakes in Stable Continental Regions???

Plate Boundaries: Divergent | Convergent "Teeth" on Overriding Plate | Transform | Poorly Defined

Geology of Earthquakes in Stable Continental Crust

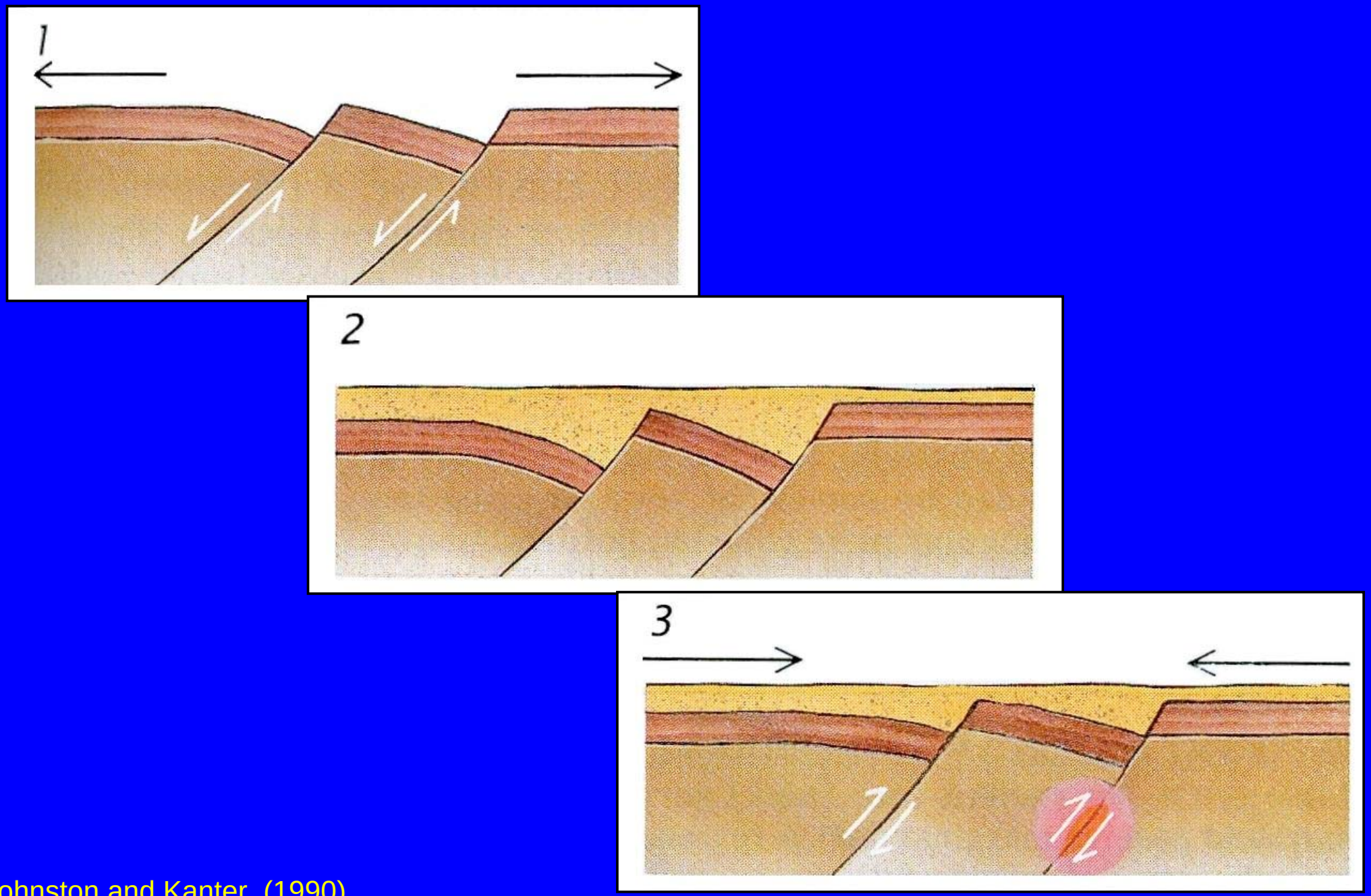






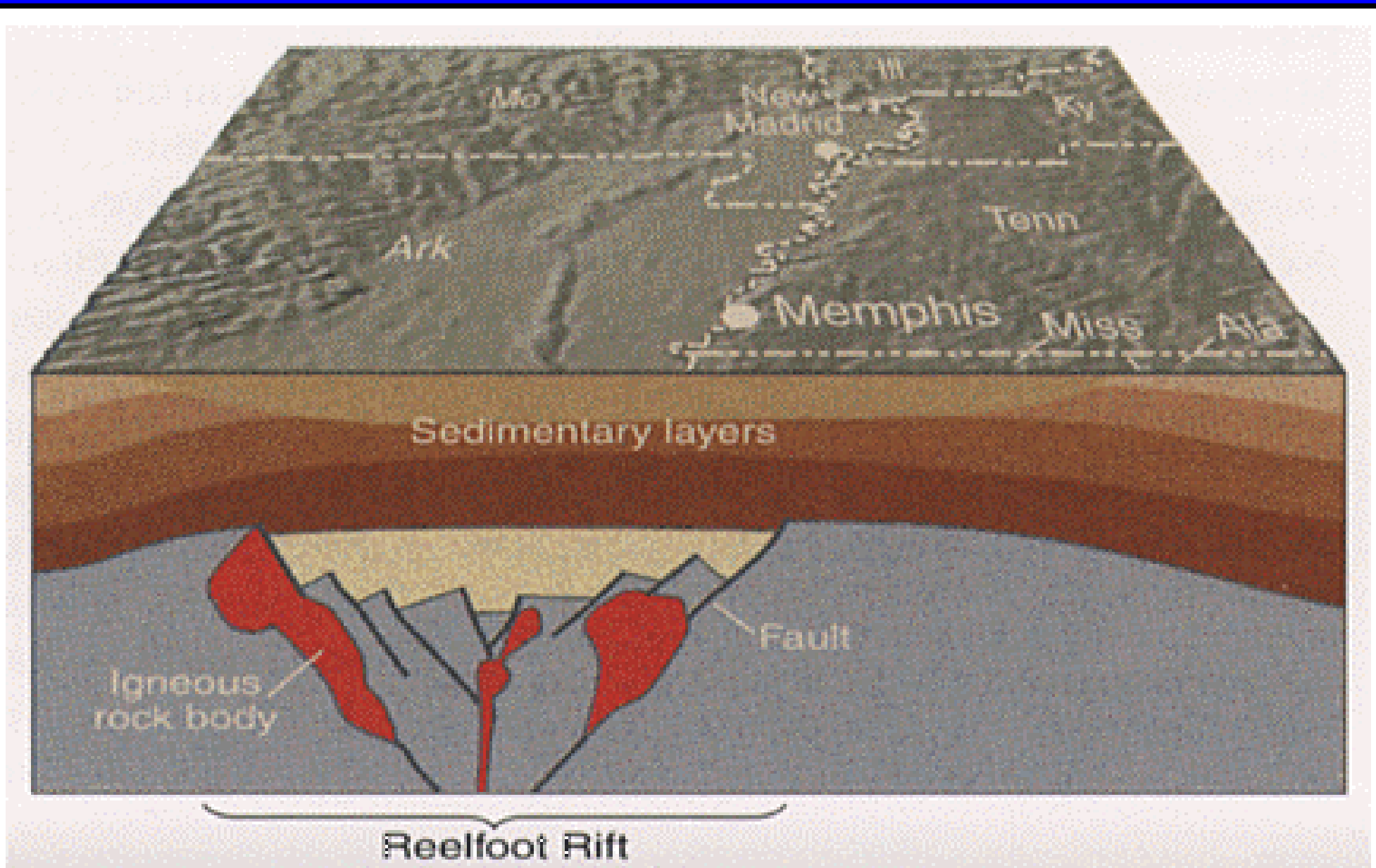
Johnston and Kanter (1990)

Geology of Earthquakes in Stable Continental Crust

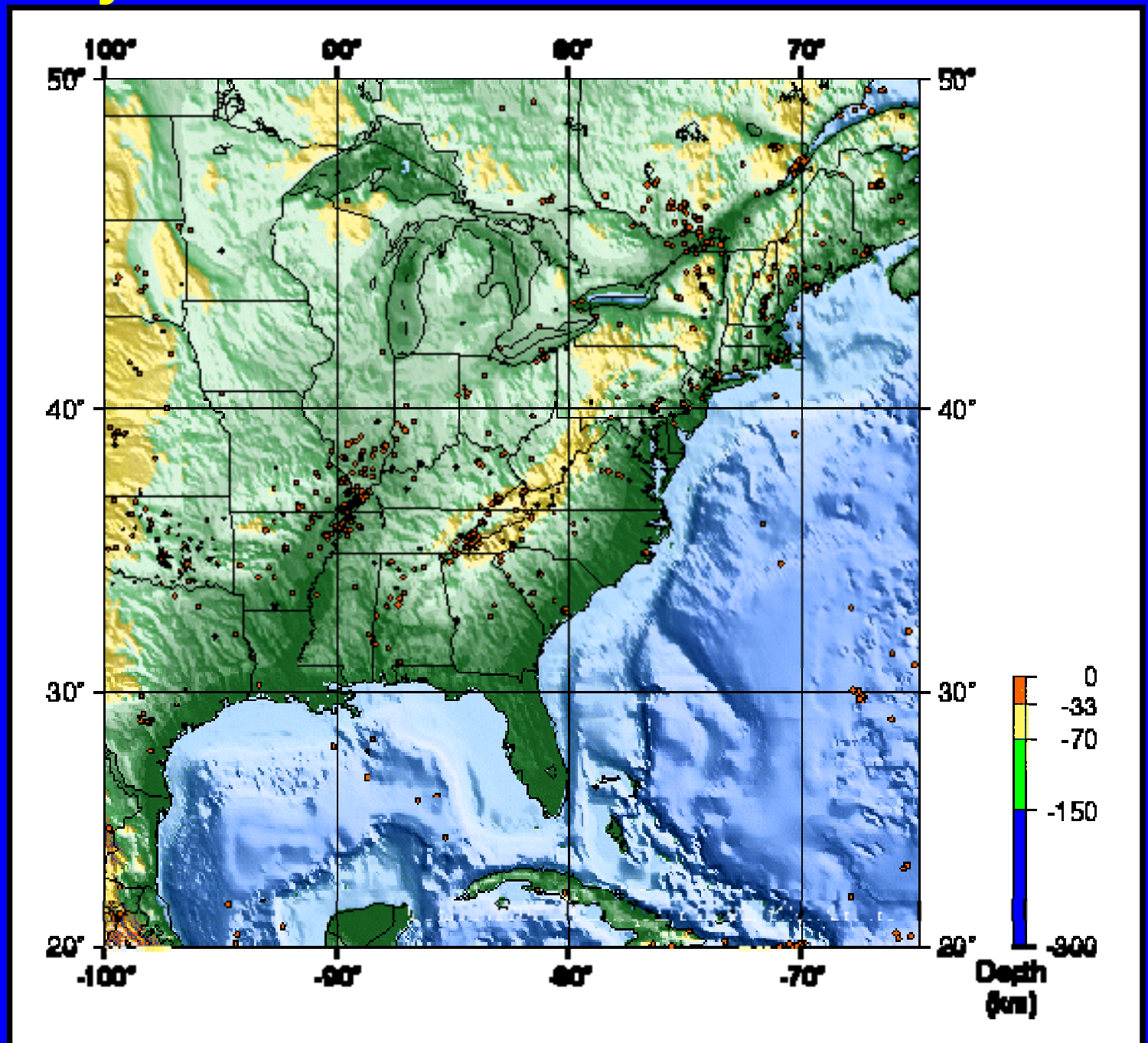


Johnston and Kanter (1990)

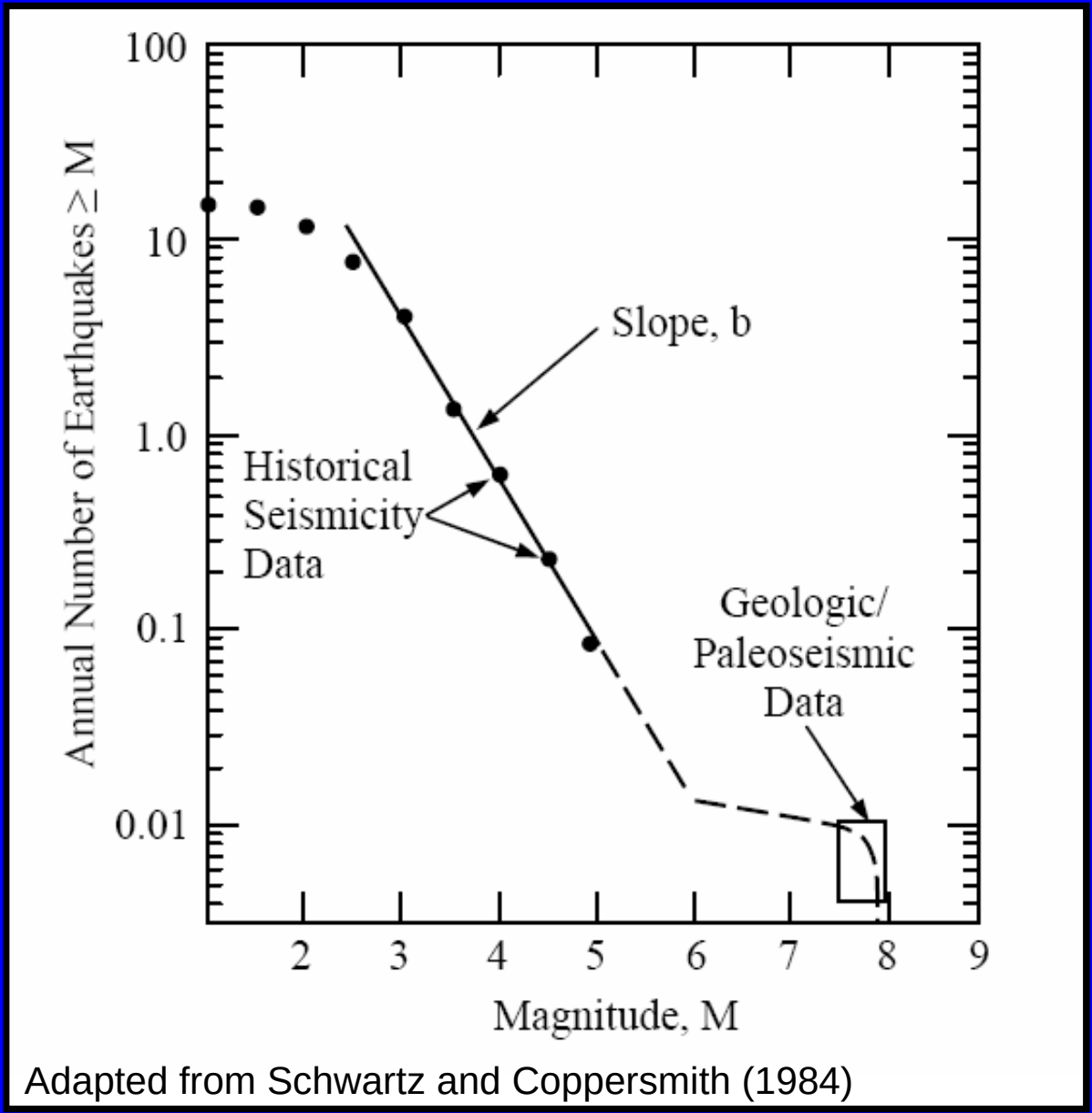
Reelfoot Rift



Seismicity of the Eastern United States: 1977 - 1997



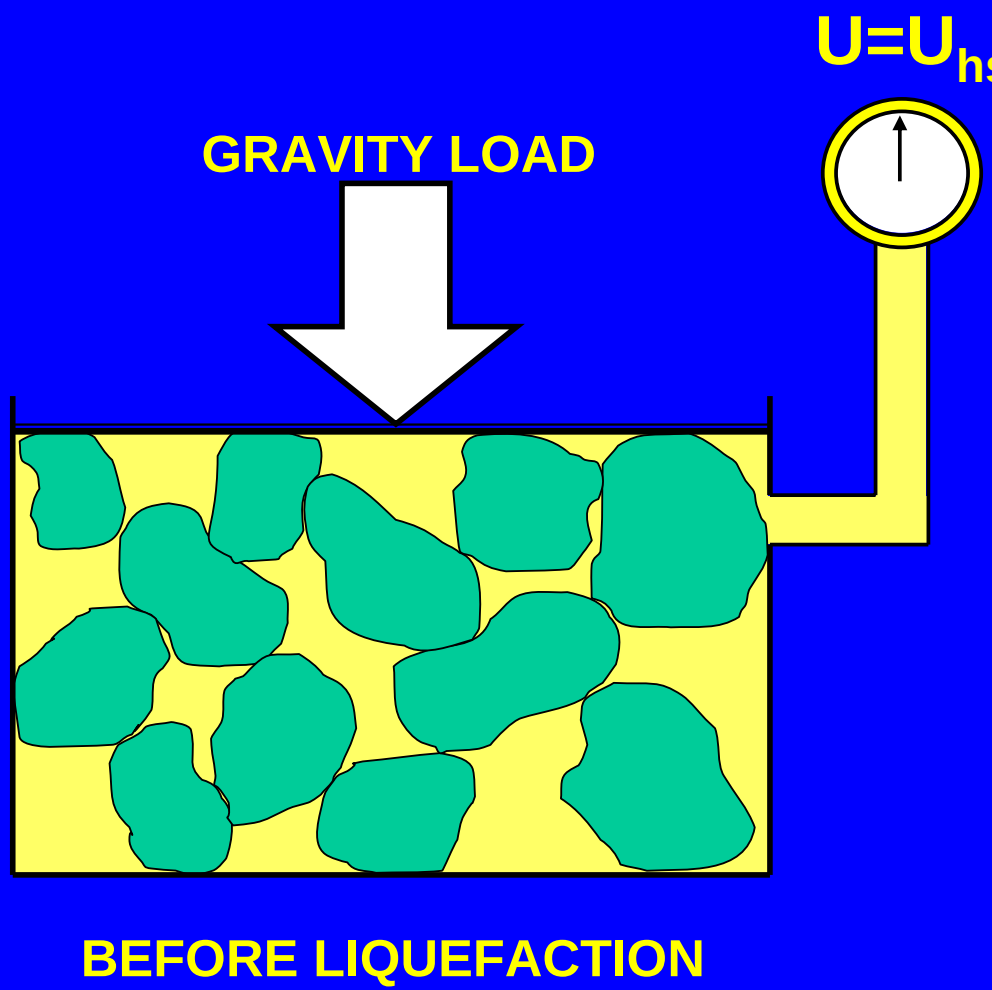
Gutenberg-Richter Magnitude Recurrence Relationship (b-line)



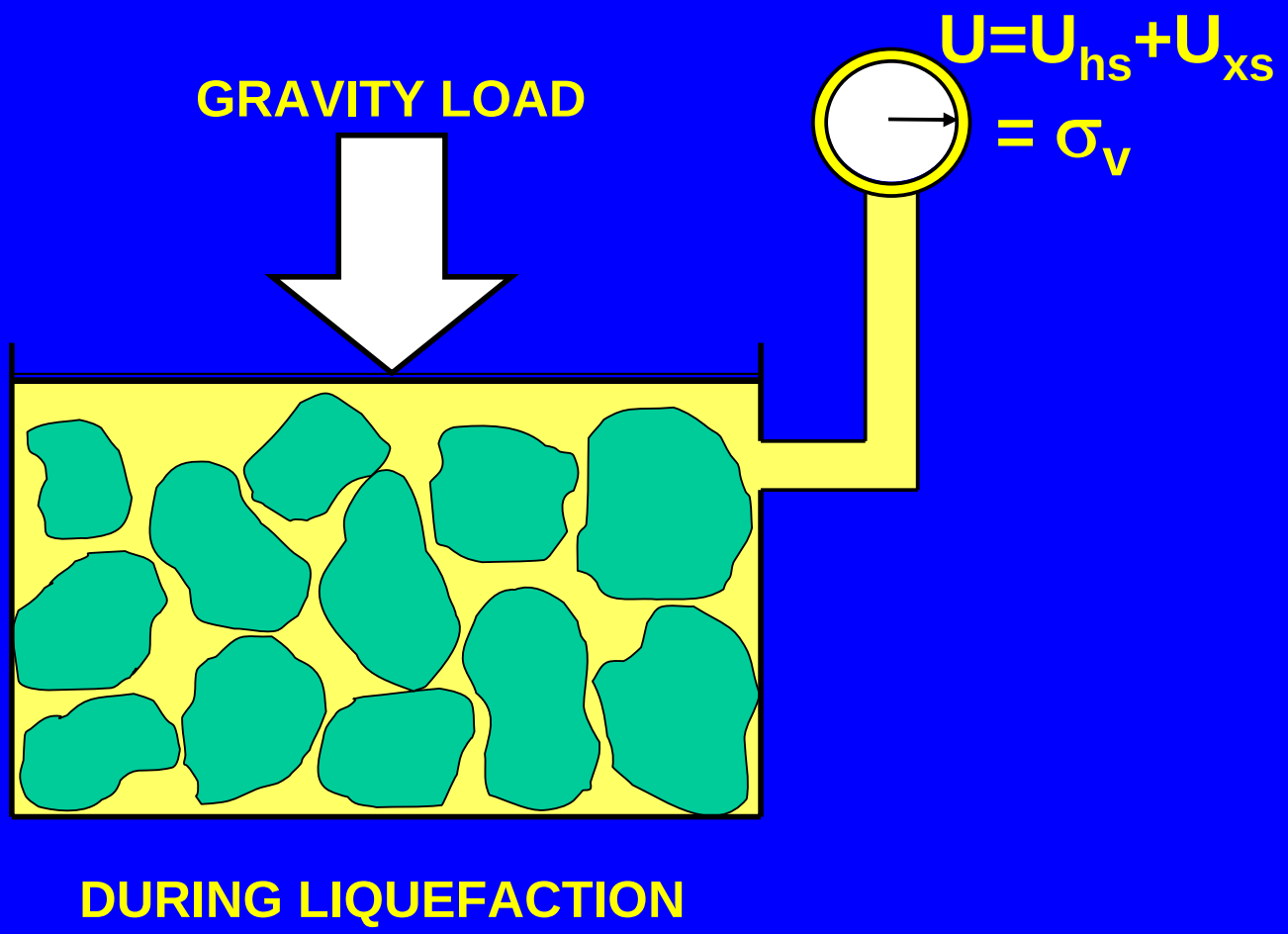
Adapted from Schwartz and Coppersmith (1984)

Paleoliquefaction Features -- Secondary Evidence

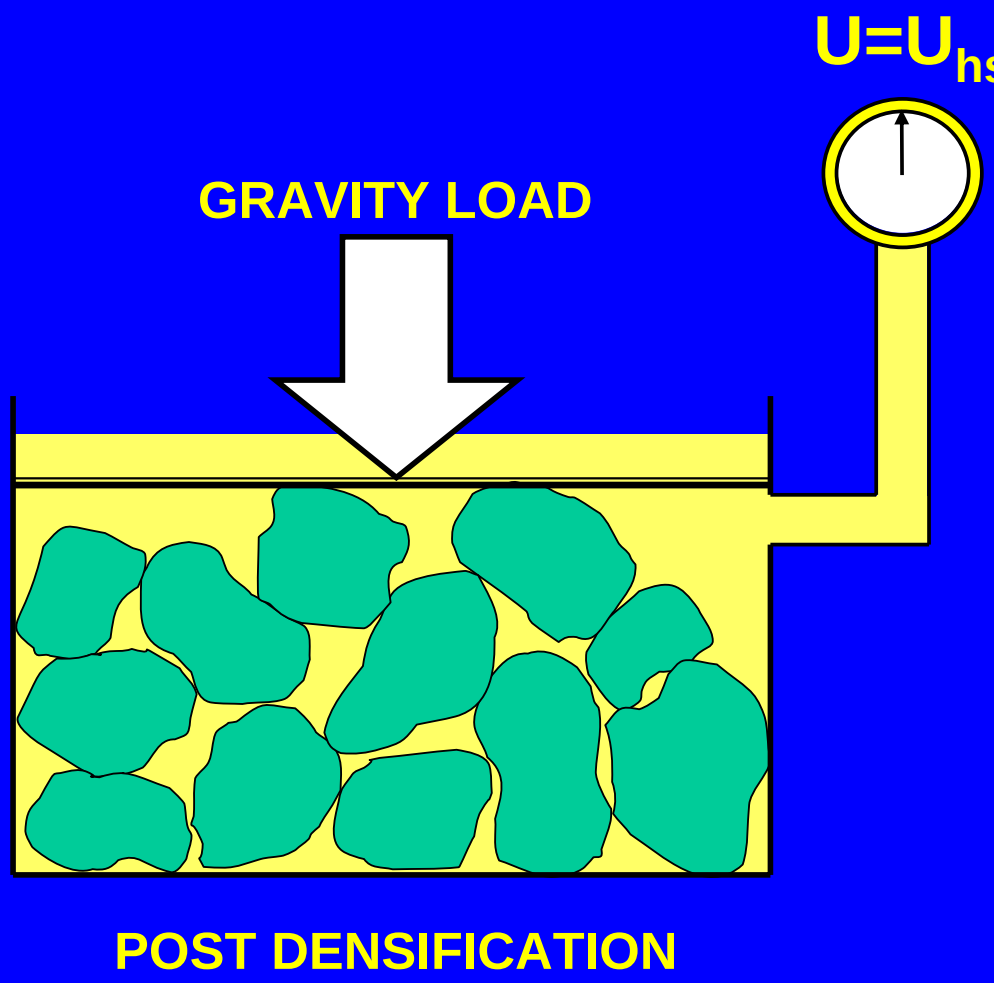
Review of Liquefaction Phenomenon



Review of Liquefaction Phenomenon



Review of Liquefaction Phenomenon



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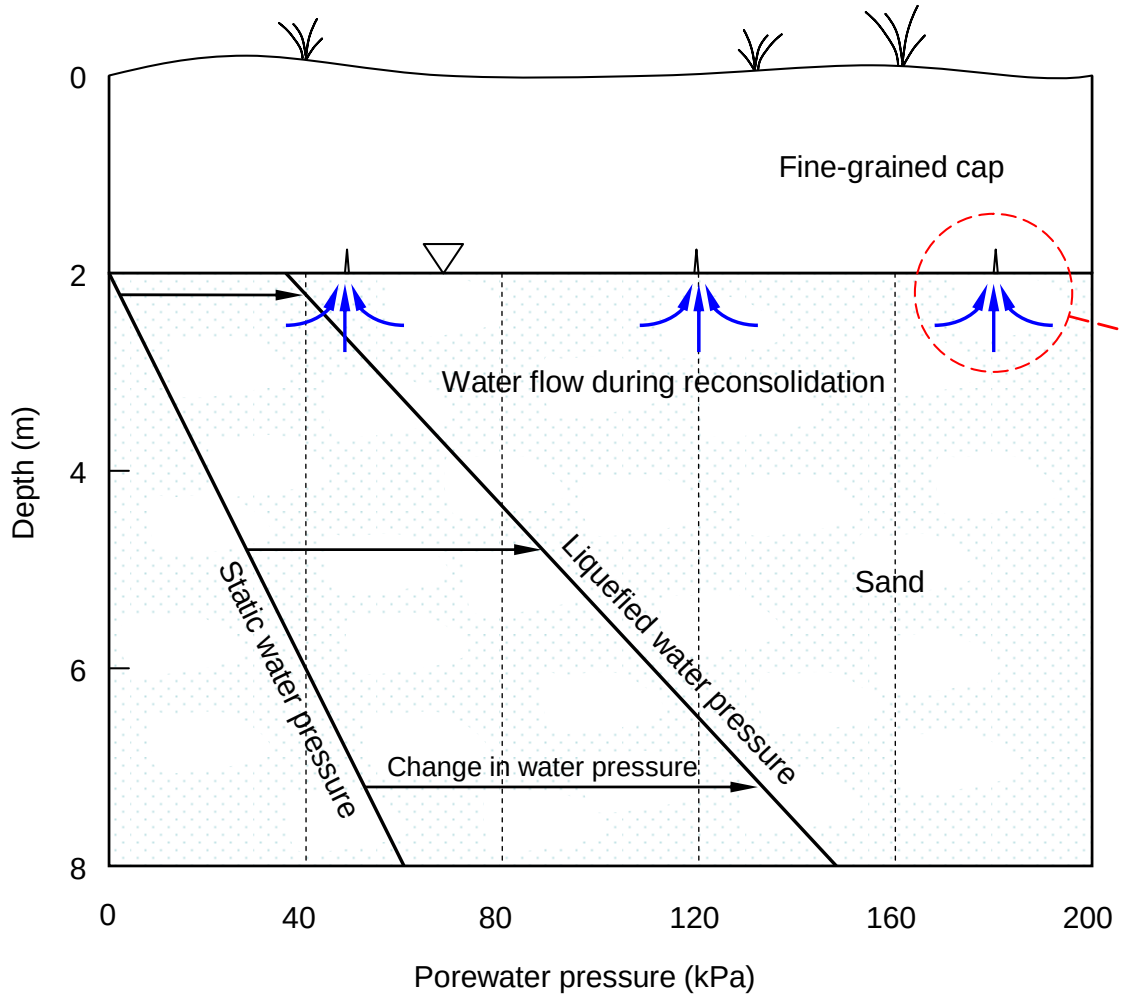
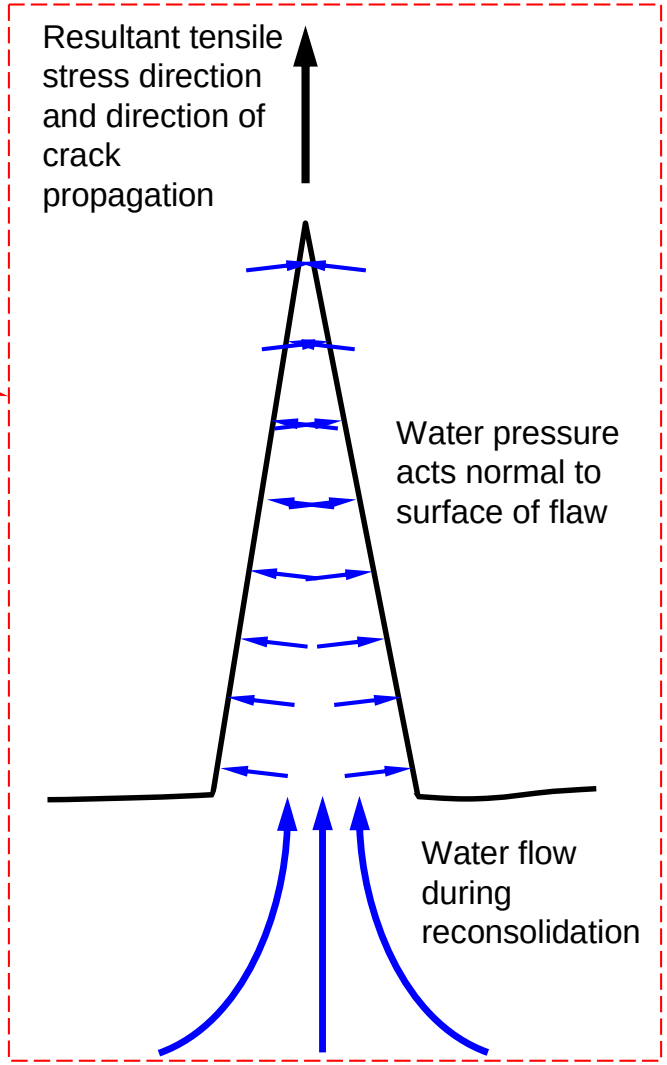
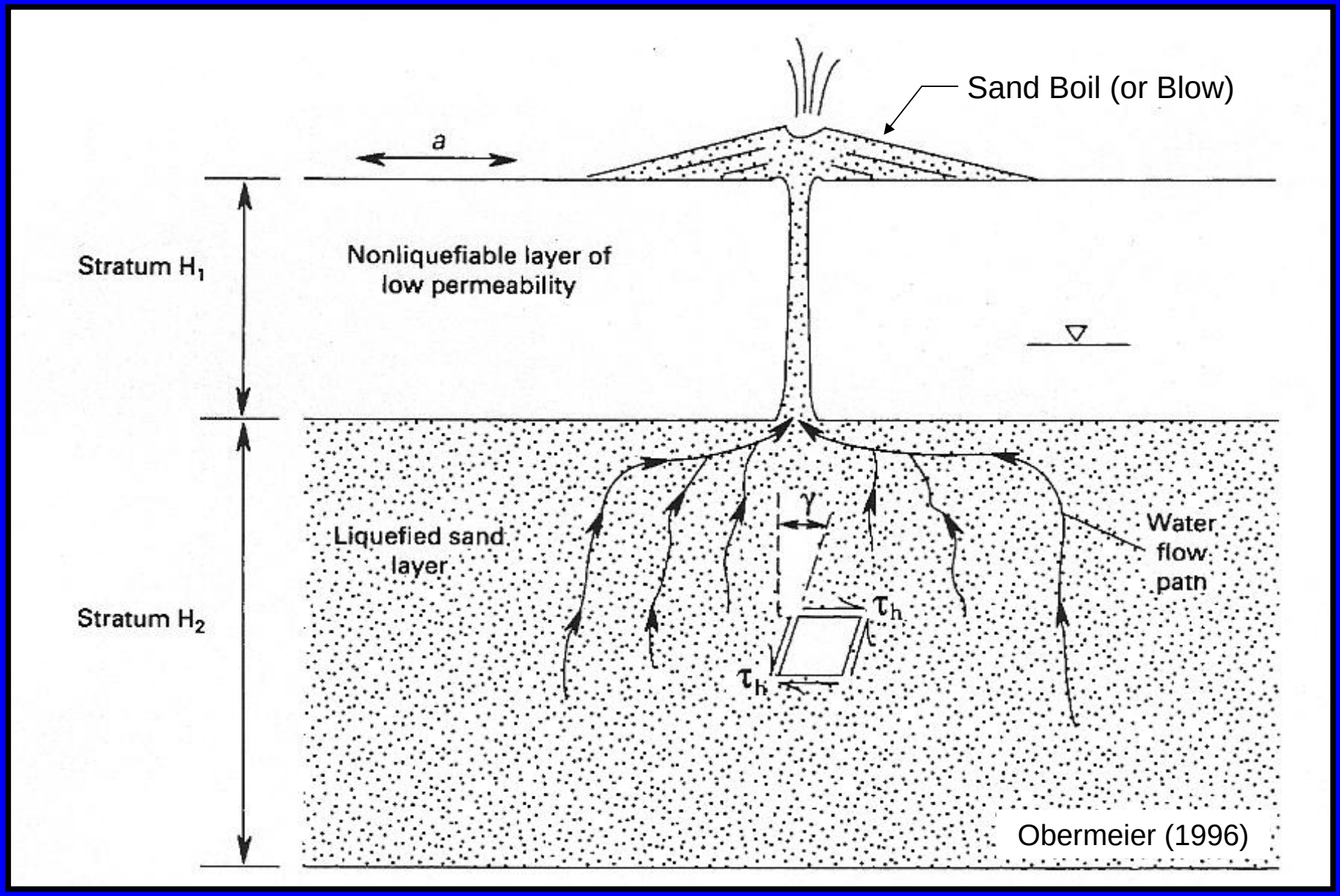




Olson et al. (2007)

Review of Liquefaction Phenomenon

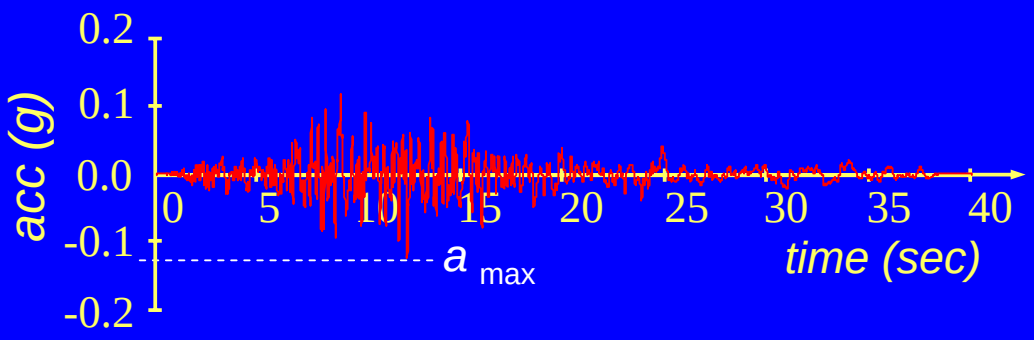


Geologic Evidence of Earthquakes - Liquefaction

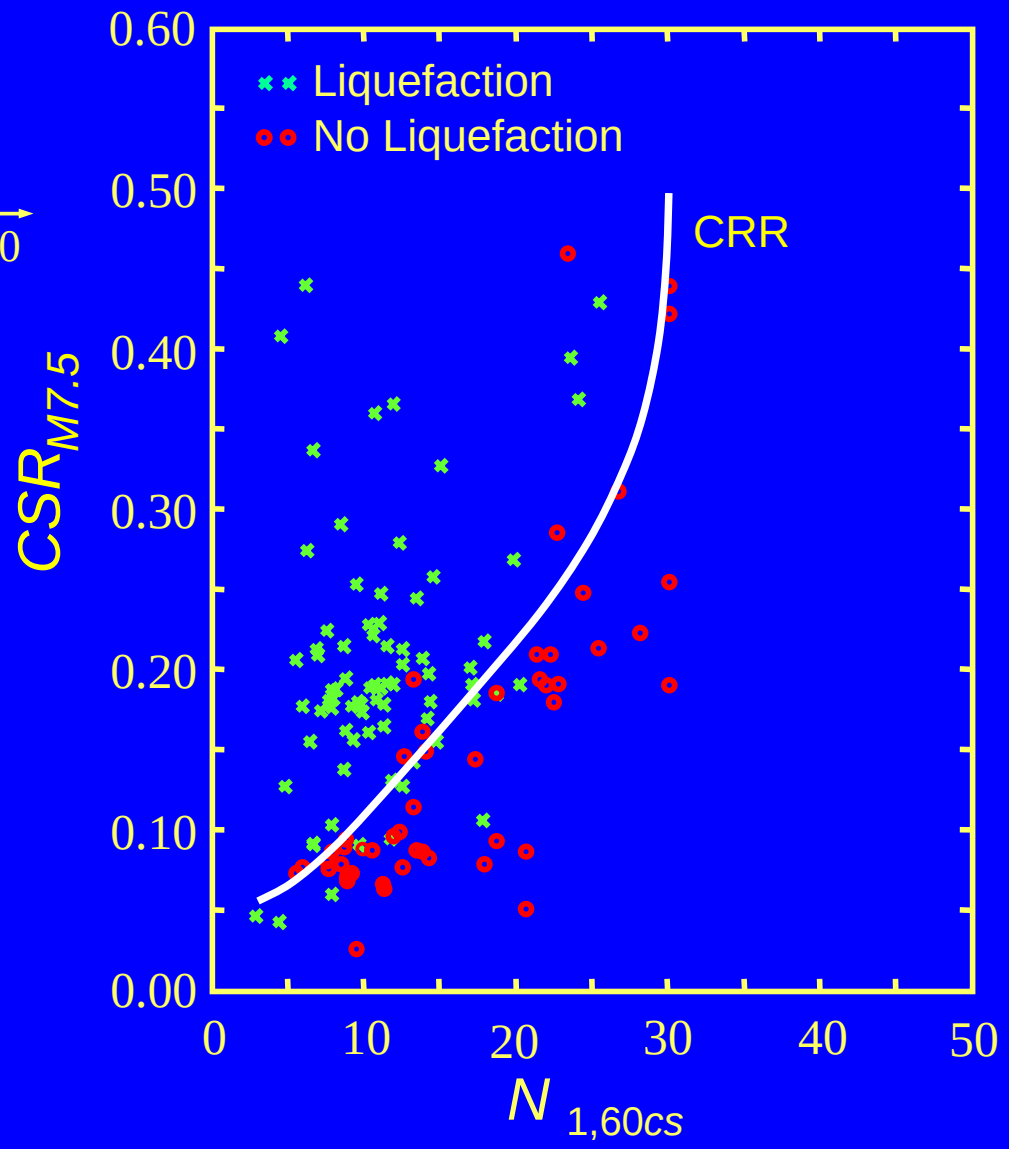
1964 Niigata, Japan
(Steinbrugge Collection)

Crater formation & Spreading of Sand at Ten-Mile Hill
1886 Charleston Earthquake (from Dutton 1889)

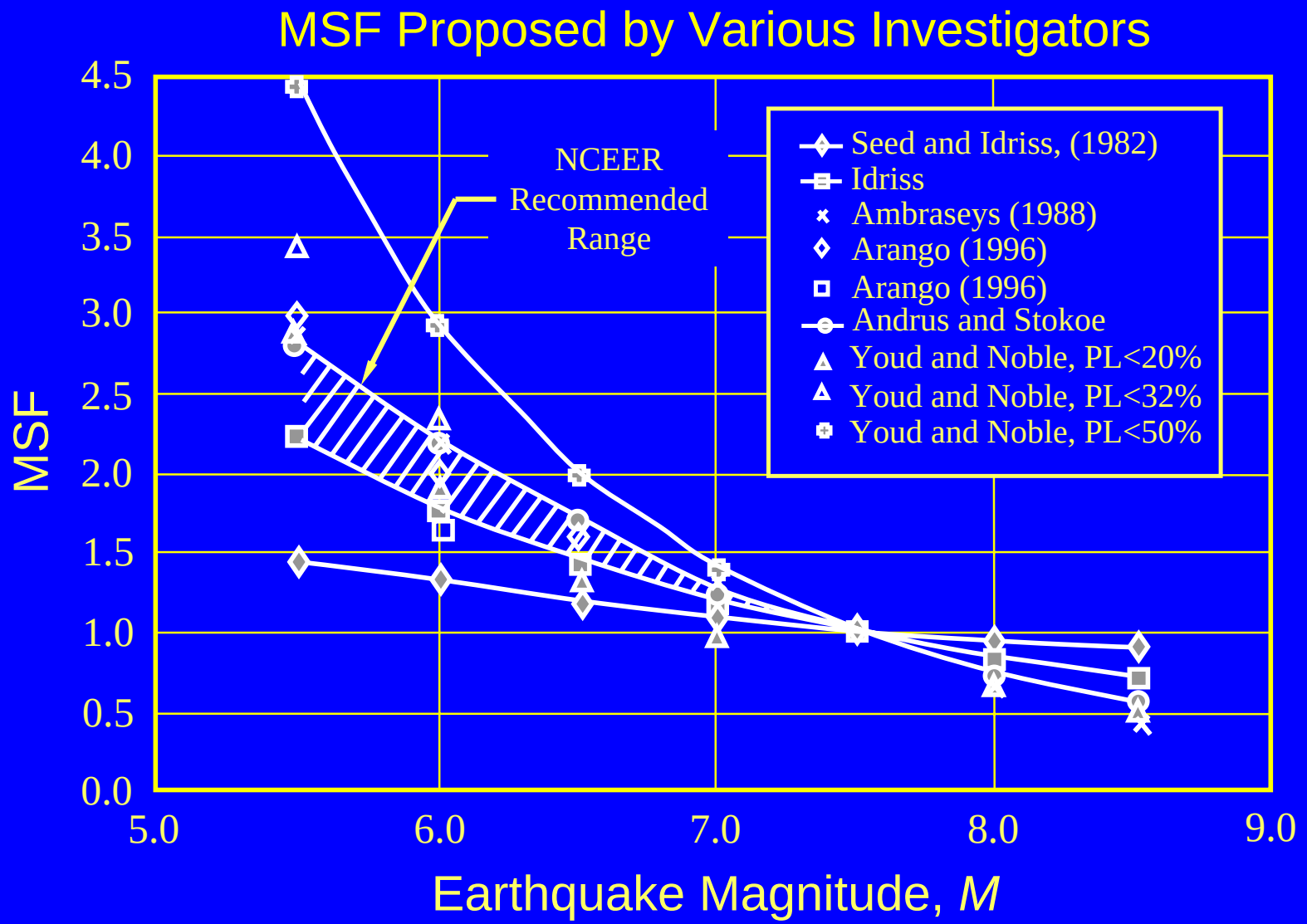
Review of "Simplified" Liquefaction Evaluation Procedure



$$CSR_{M7.5} = 0.65 \underbrace{\frac{a_{max}}{g} \frac{\sigma_v}{\sigma'_{vo}} r_d}_{\text{amplitude}} \underbrace{\frac{1}{MSF}}_{\text{duration}}$$



Review of "Simplified" Liquefaction Evaluation Procedure

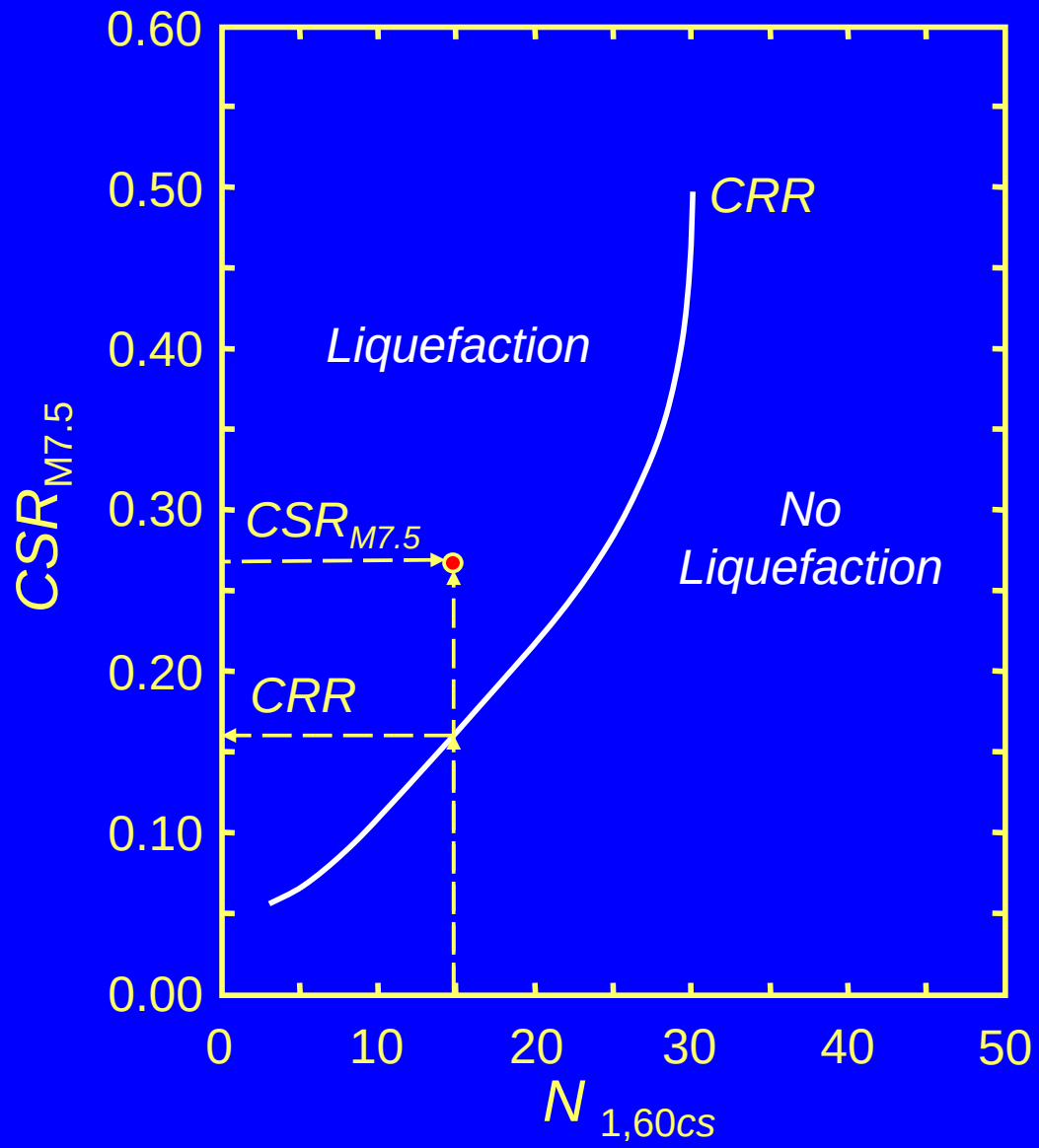


(NCEER 1997)

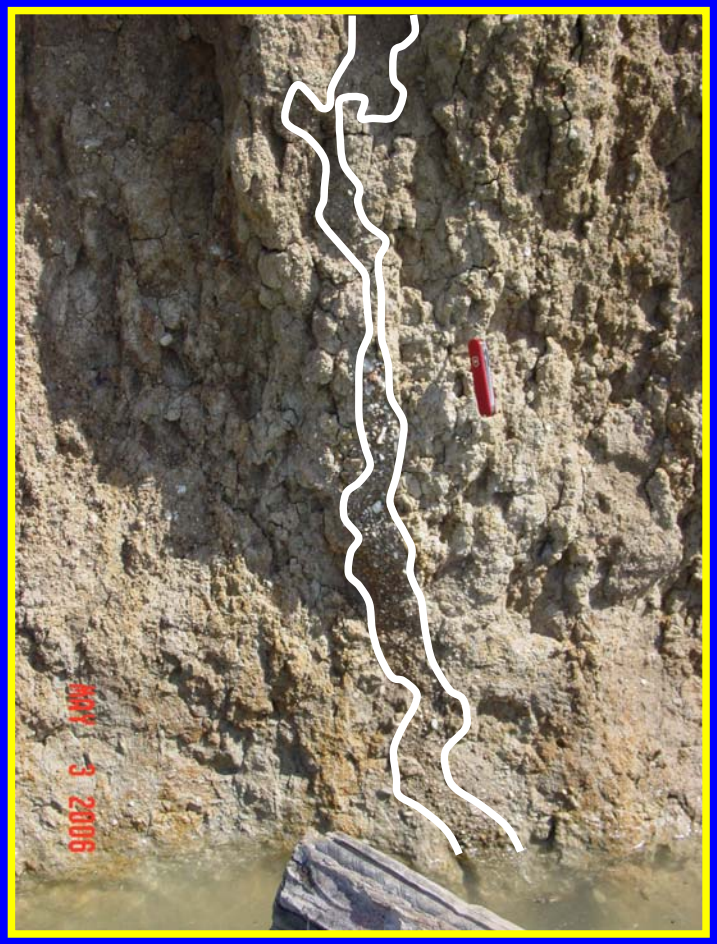
Review of "Simplified" Liquefaction Evaluation Procedure

Factor of Safety Against Liquefaction:

$$FS = \frac{CRR}{CSR_{M7.5}}$$



Evidence of Large Paleoearthquakes in the Wabash Valley



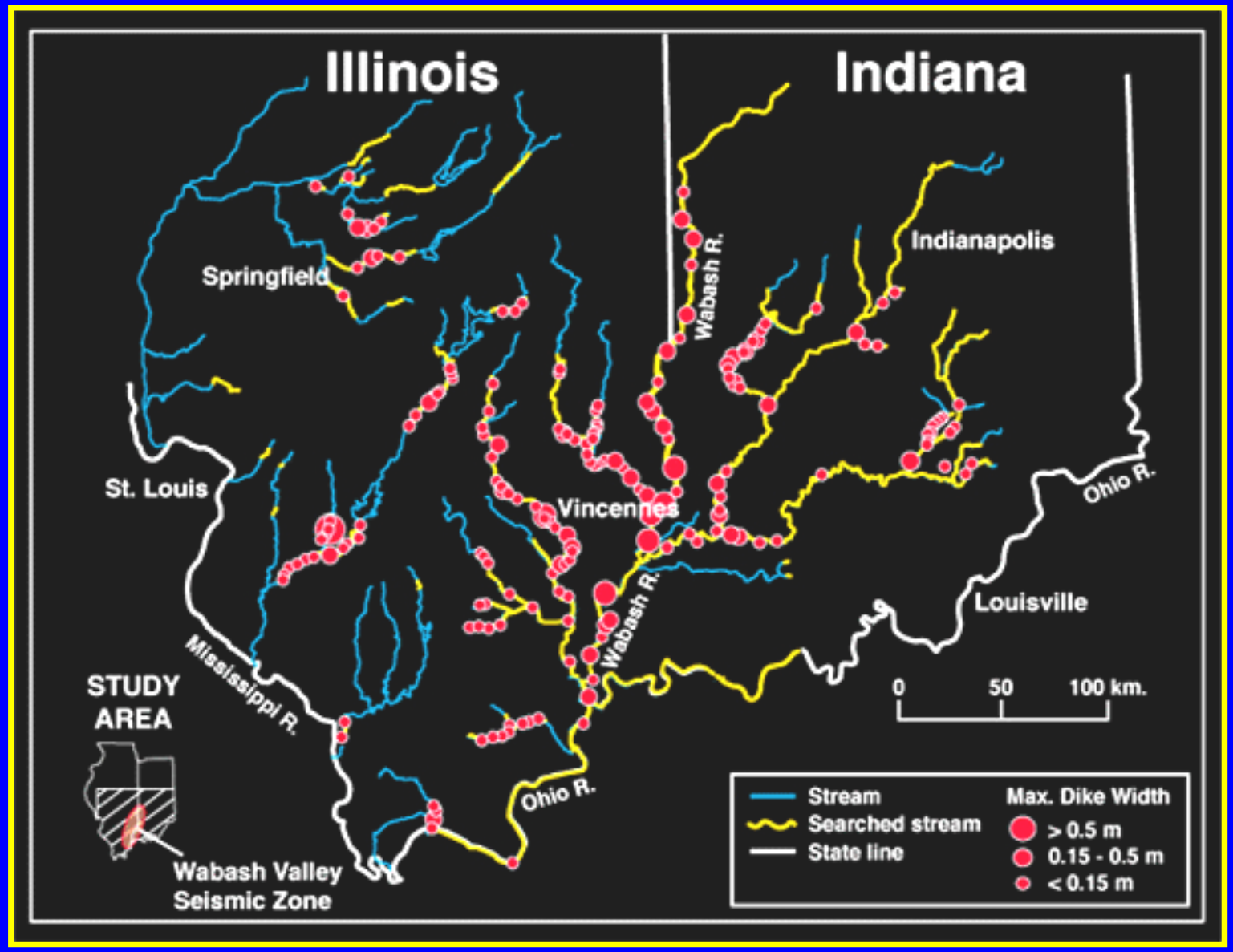
Paleoliquefaction in the Wabash Valley

(Obermeier 1998)

Paleoliquefaction in the Wabash Valley

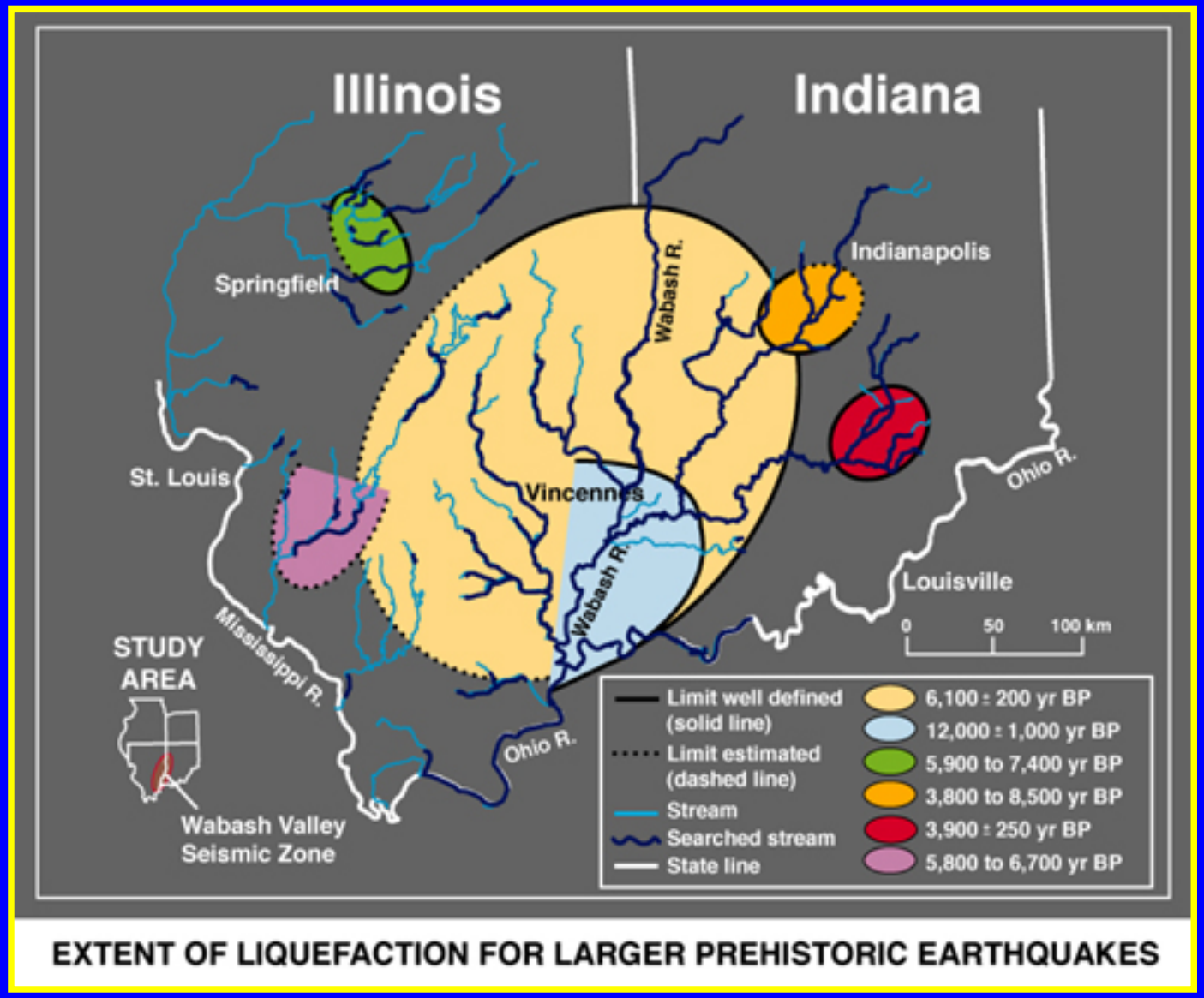
(Obermeier 1998)

Paleoliquefaction in the Wabash Valley



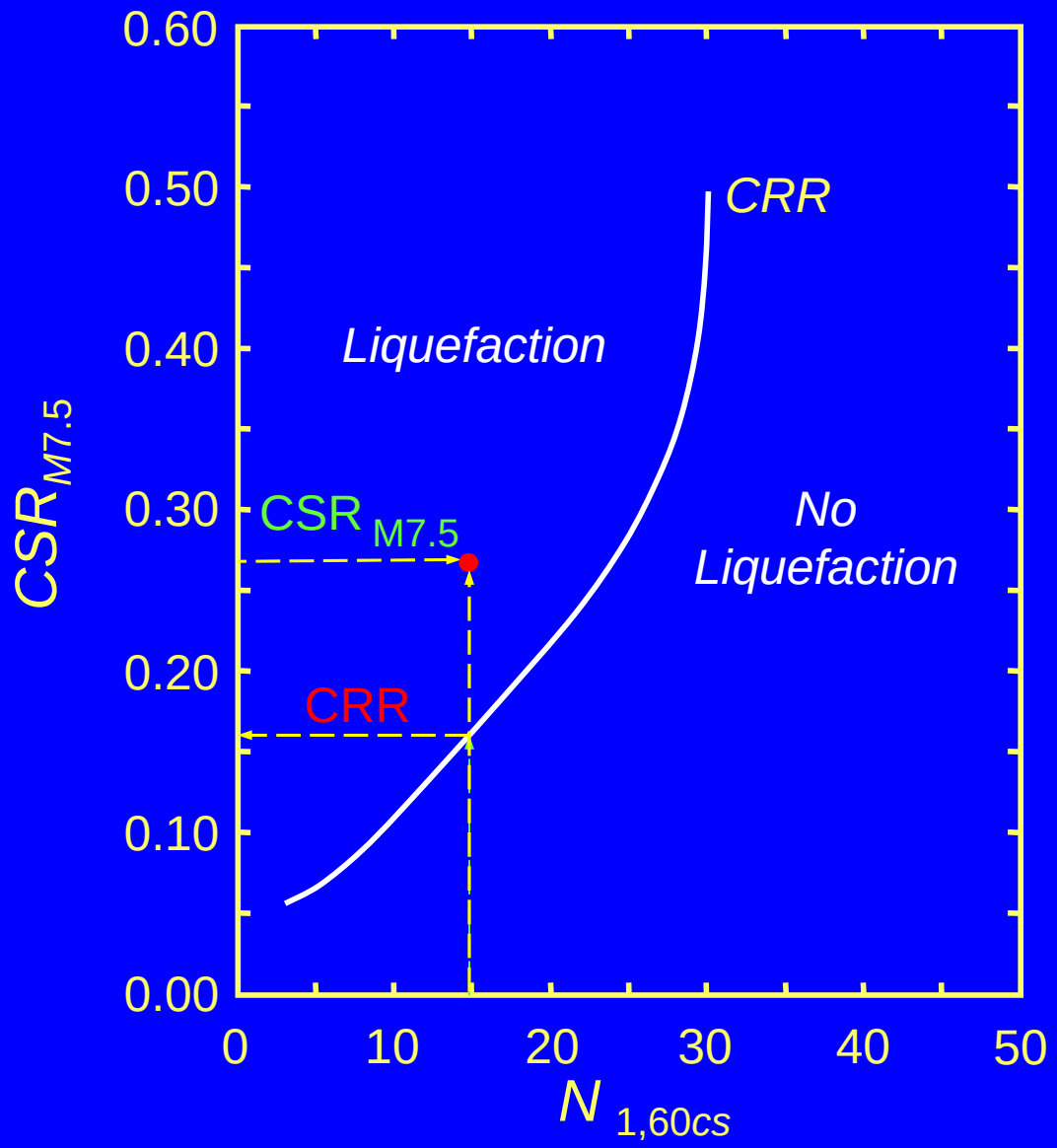
(Obermeier 1998)

Paleoliquefaction in the Wabash Valley



(Obermeier 1998)

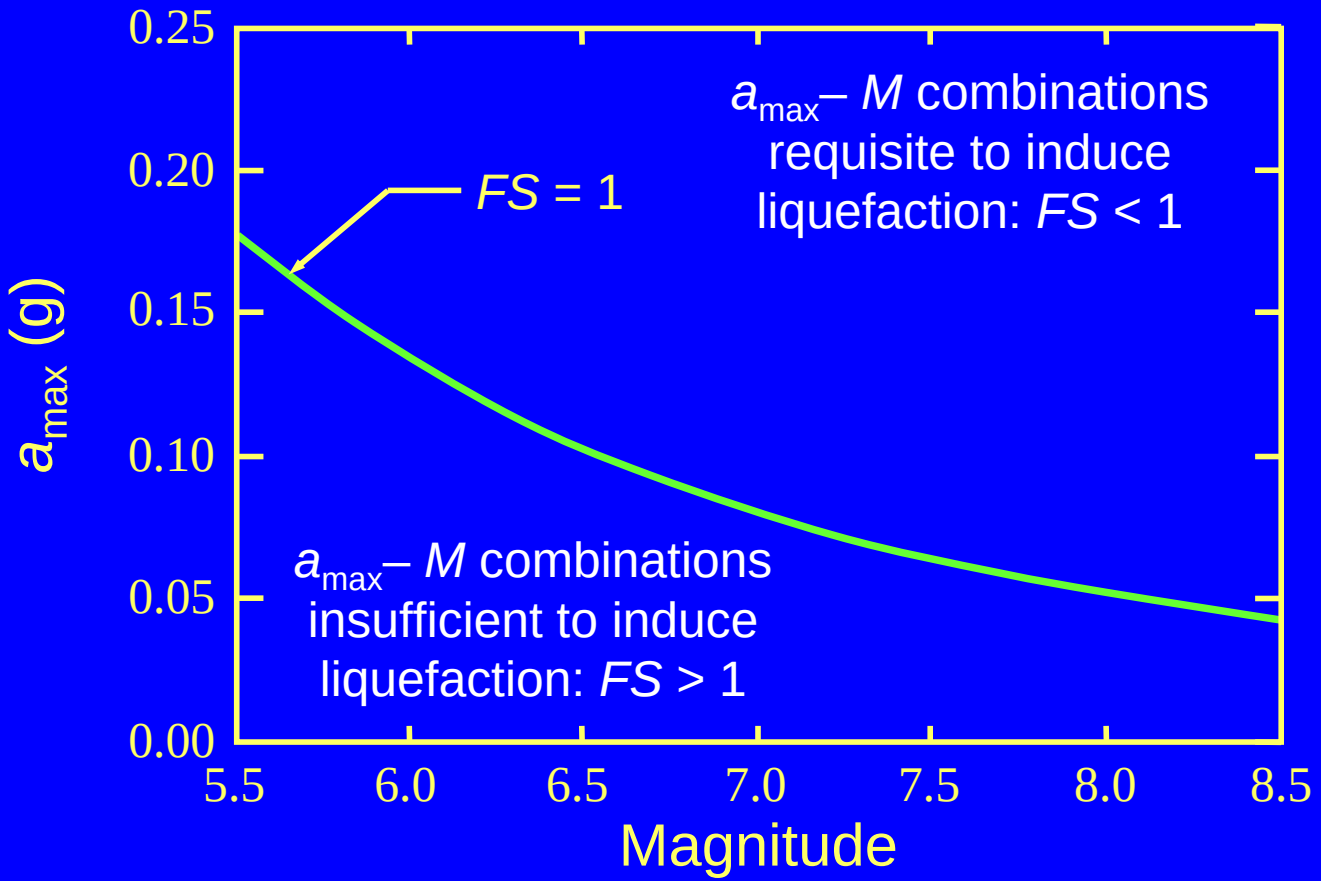
Simplified Liquefaction Evaluation Procedure



$$FS = \frac{CRR}{CSR_{M7.5}}$$

Back Analyses (simplified procedure)

$$FS = \frac{CRR}{CSR_{M7.5}} = 1 \quad \Rightarrow \quad a_{max} = CRR \; MSF \; \frac{g \; \sigma'_{V\,o}}{0.65 \; \sigma_V \; r_d}$$



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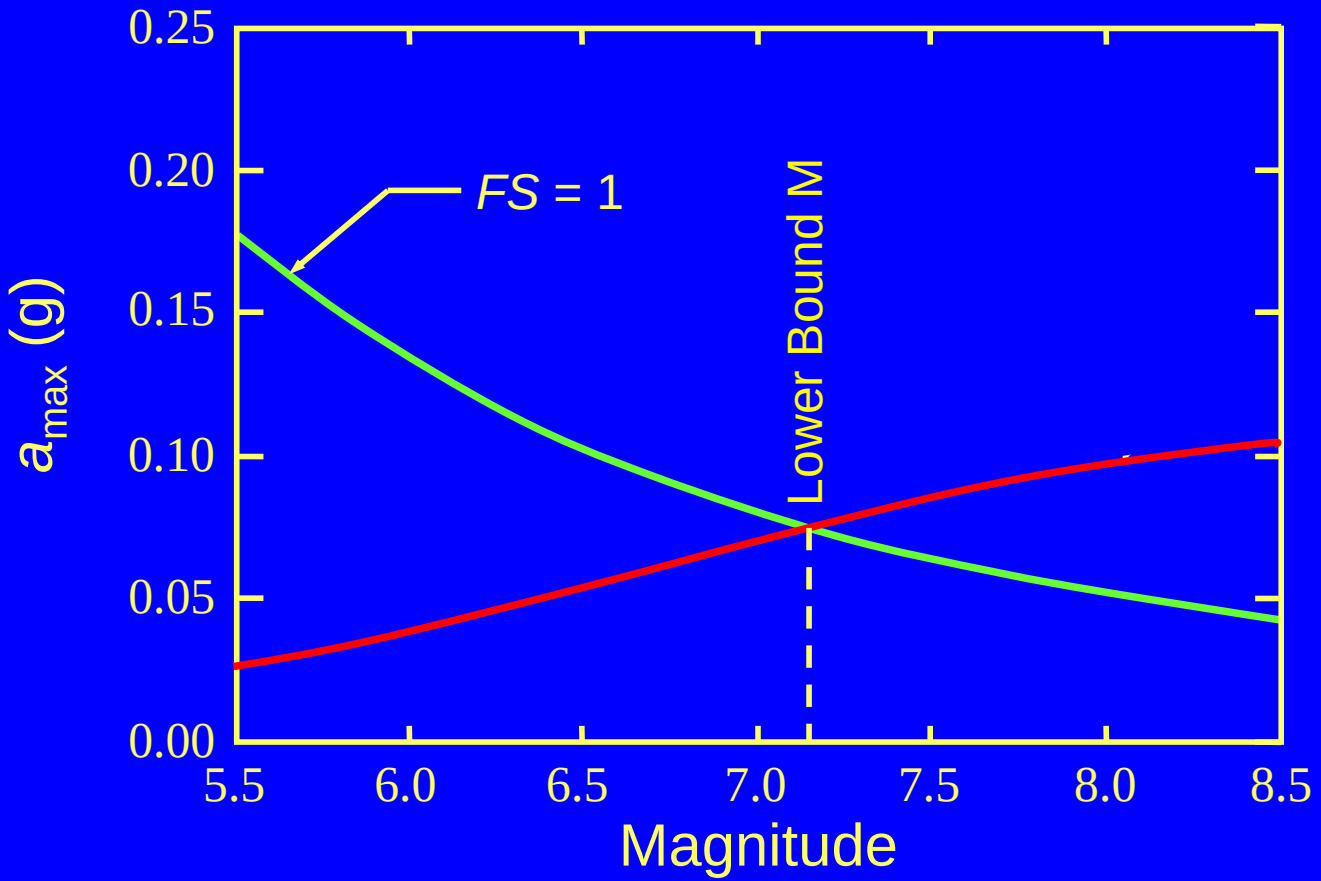
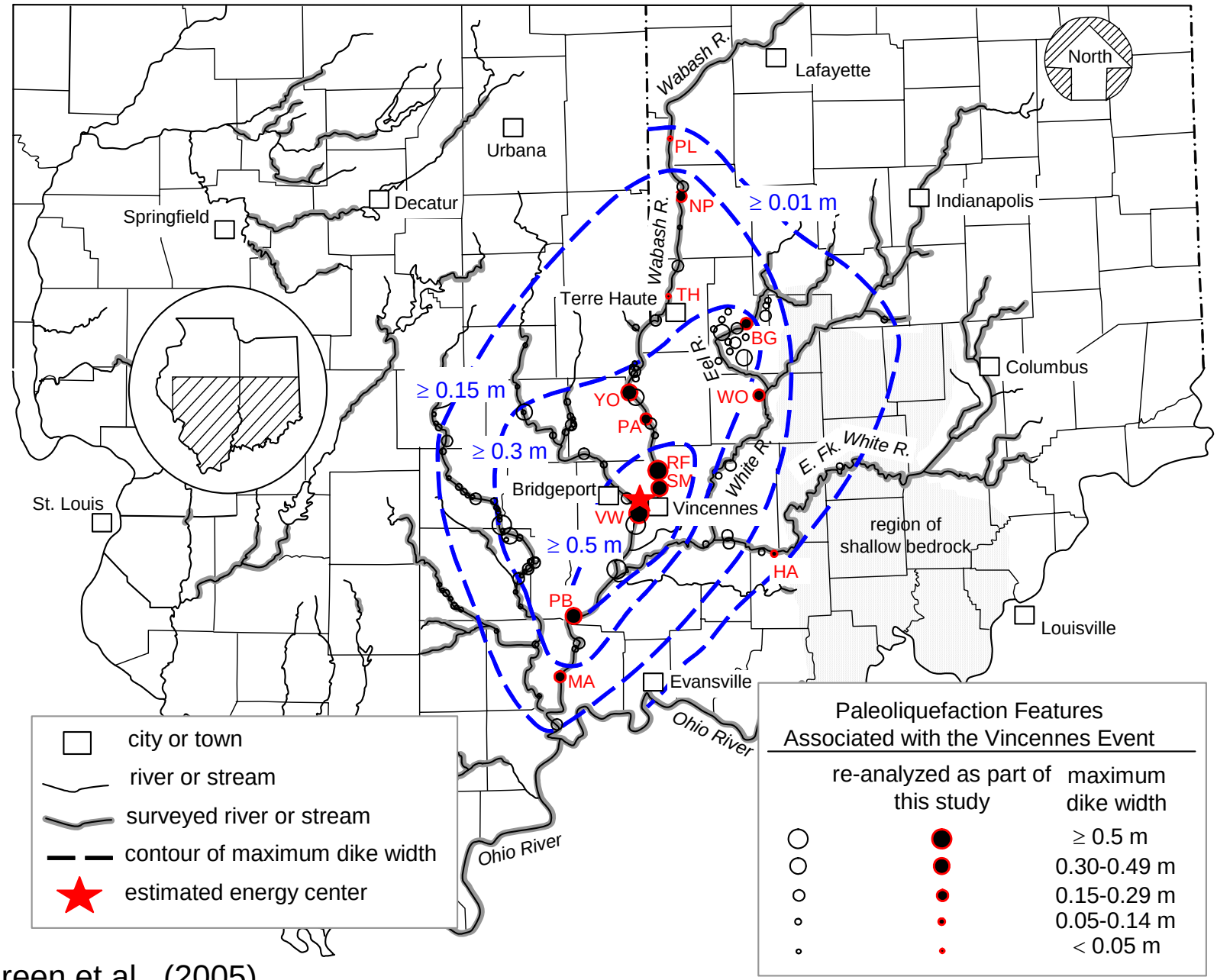


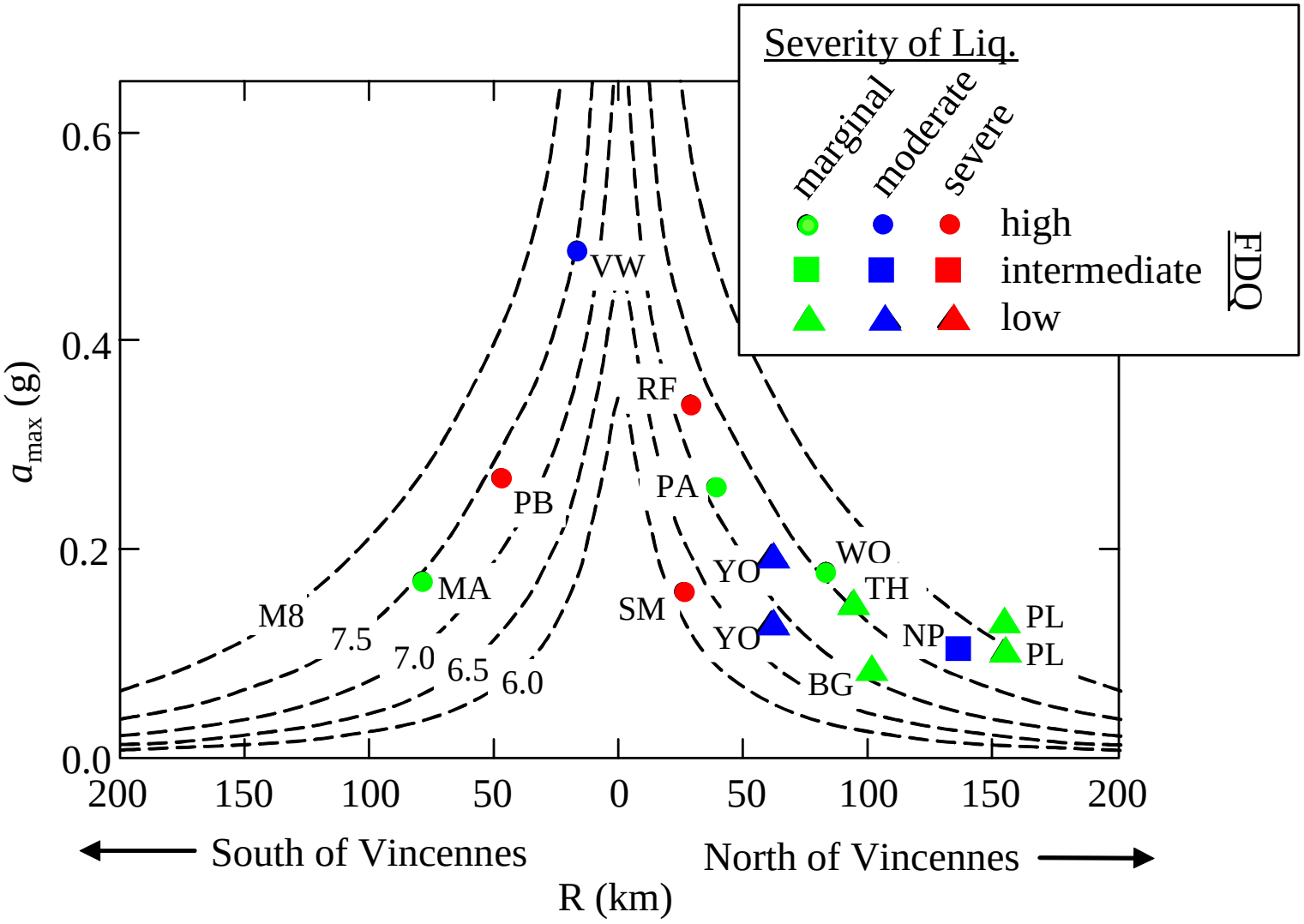
Wabash Valley Seismic Zone



Green et al. (2005)

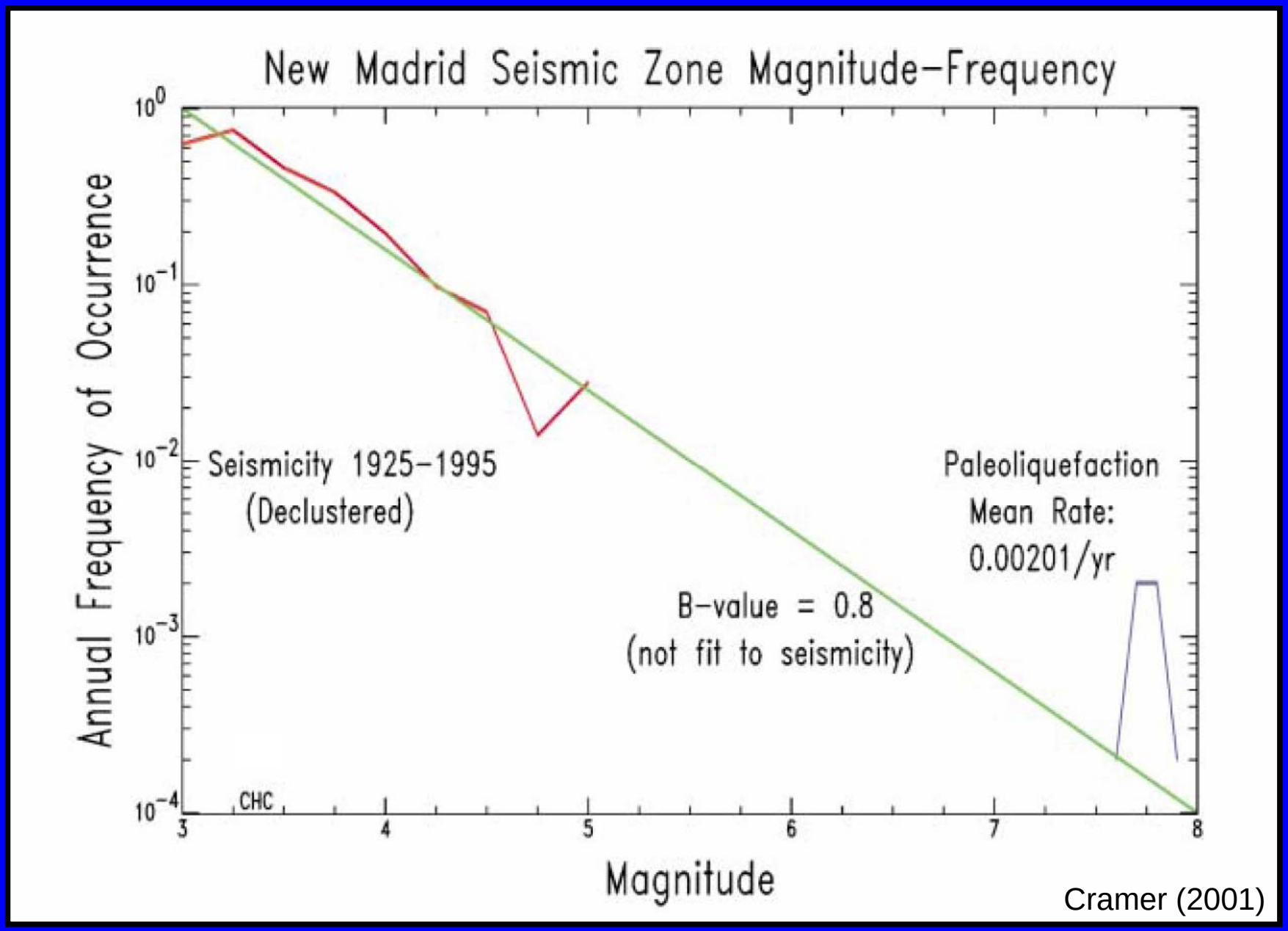
Wabash Valley Seismic Zone

Regional Integration of Data



Green et al. (2005)

New Madrid Seismic Zone



Cramer (2001)

Summary

- The renewed interest in nuclear power will require the accurate quantification of the earthquake hazard.
- In the low-to-moderate seismic zones, paleoliquefaction studies have proven to be a valuable tool in determining the recurrence time of moderate-to-large earthquakes.

The End!!

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Steinbrugge Collection: http://nisee.berkeley.edu/visual_resources/steinbrugge_collection.html