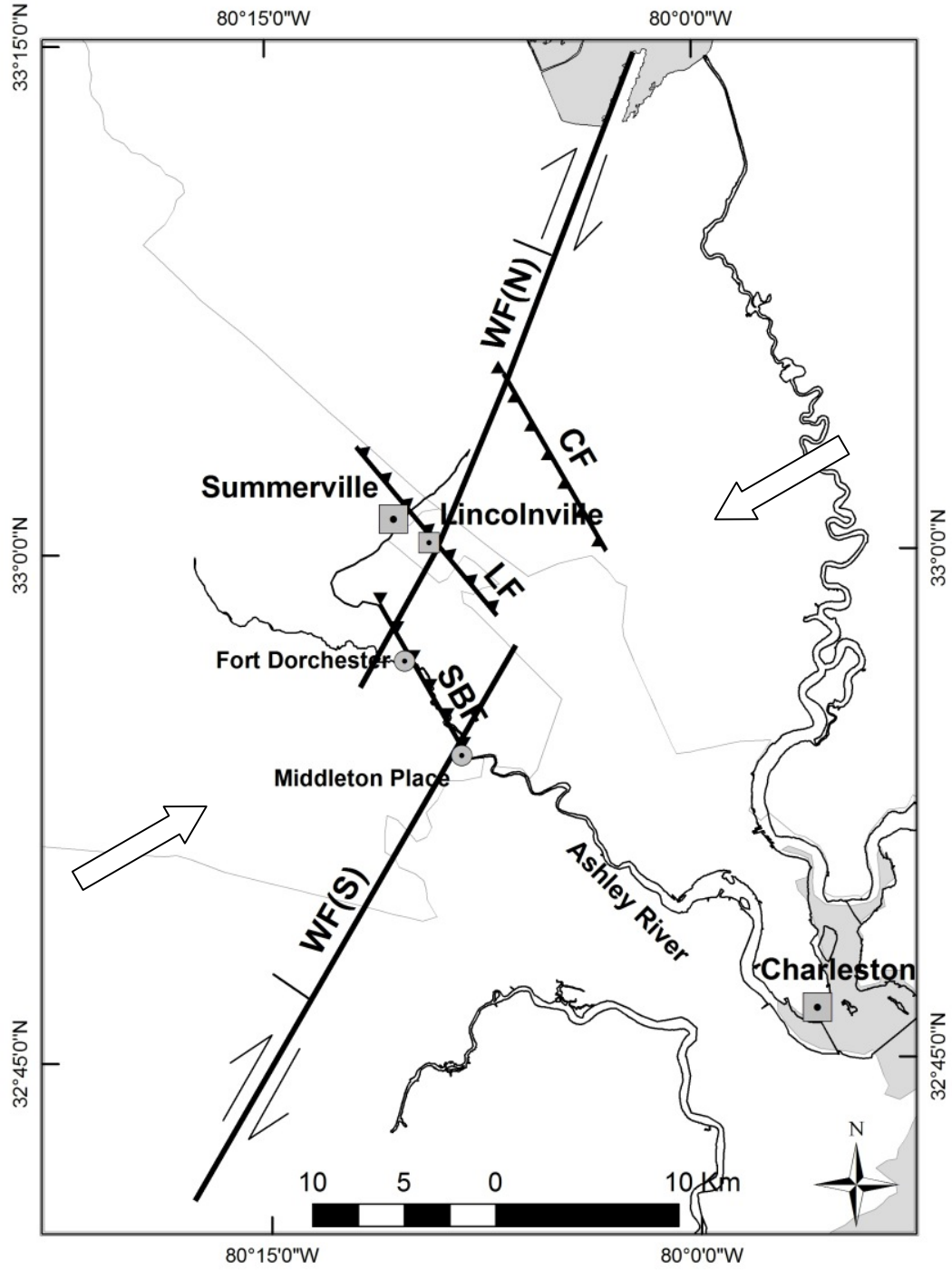
Revisiting Charleston

- Is Charleston Unique ?
  - Reassessing Mmax

Is Charleston Unique??



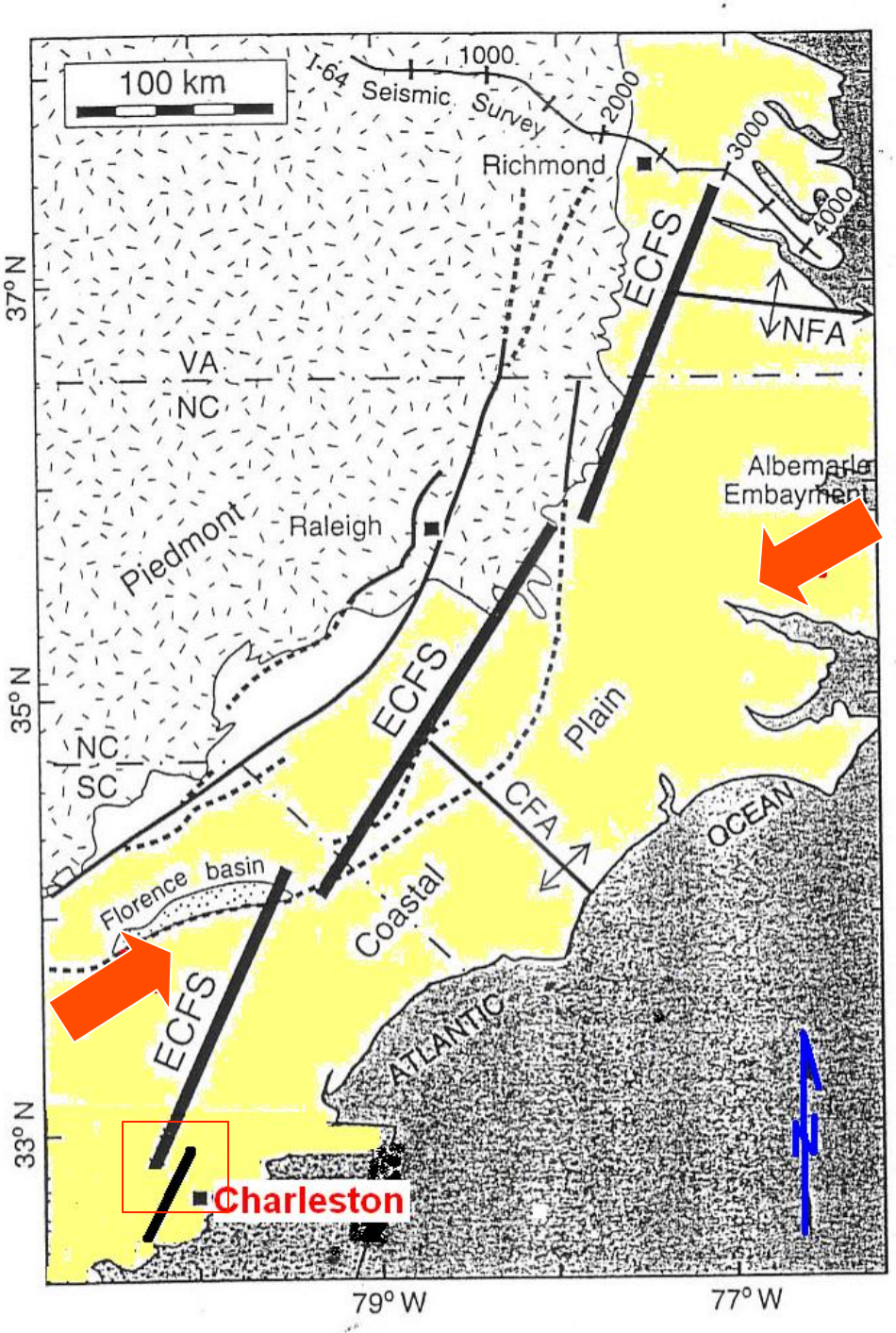
SEISMOTECTONIC FRAMEWORK

Some Clues

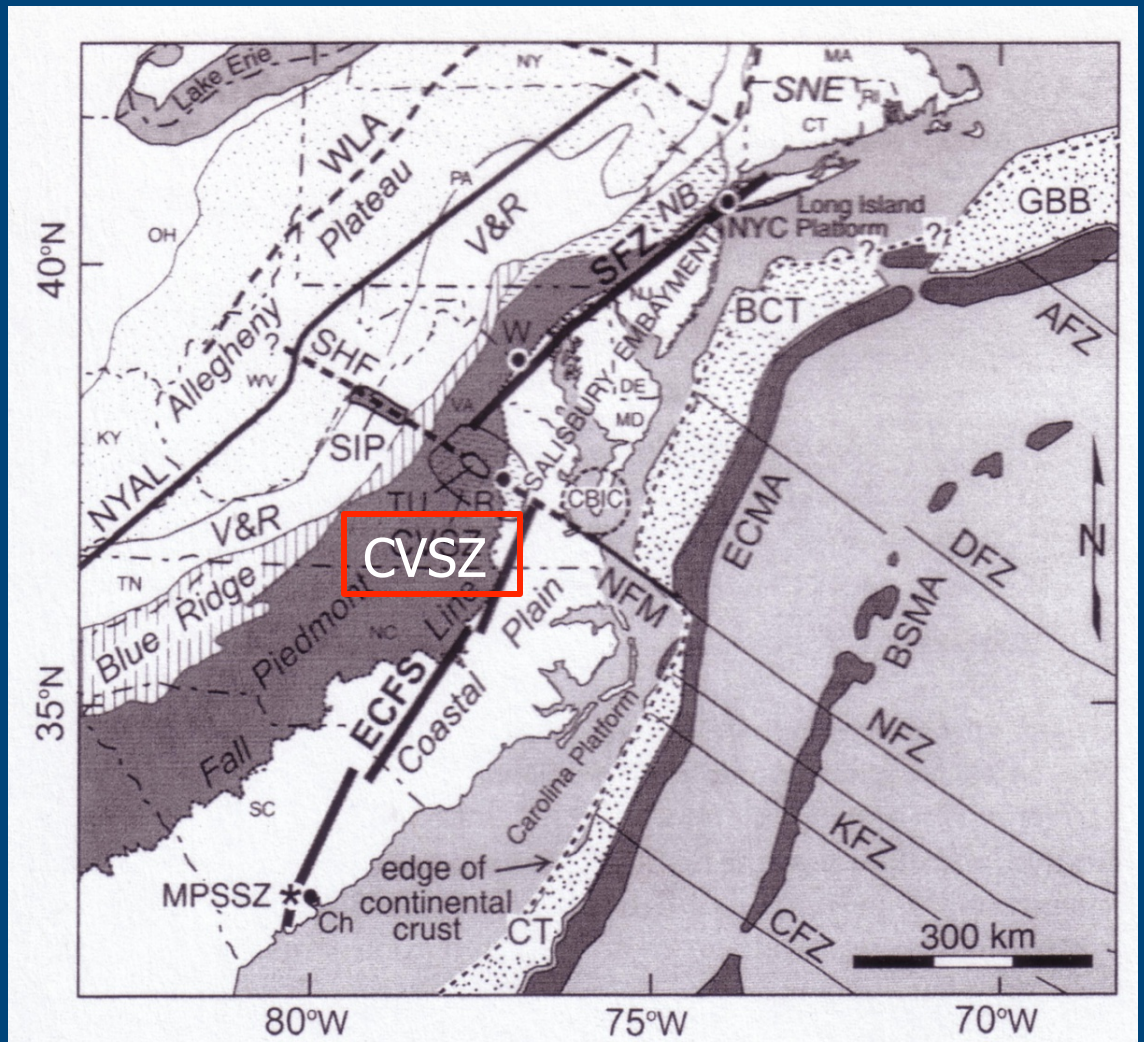
- Left-step in the East Coast fault system
- Radiating dikes from Charleston
- Absence of layer-cake stratigraphy
- NEED FURTHER STUDIES

MPSSZ and the ECFS

- Seismicity occurs at the **compressional left step near Charleston.**
- The right dilational steps between ECFS(S) and ECFS(C), and between ECFS(C) and ECFS(N) are associated with aseismic pull apart basins.

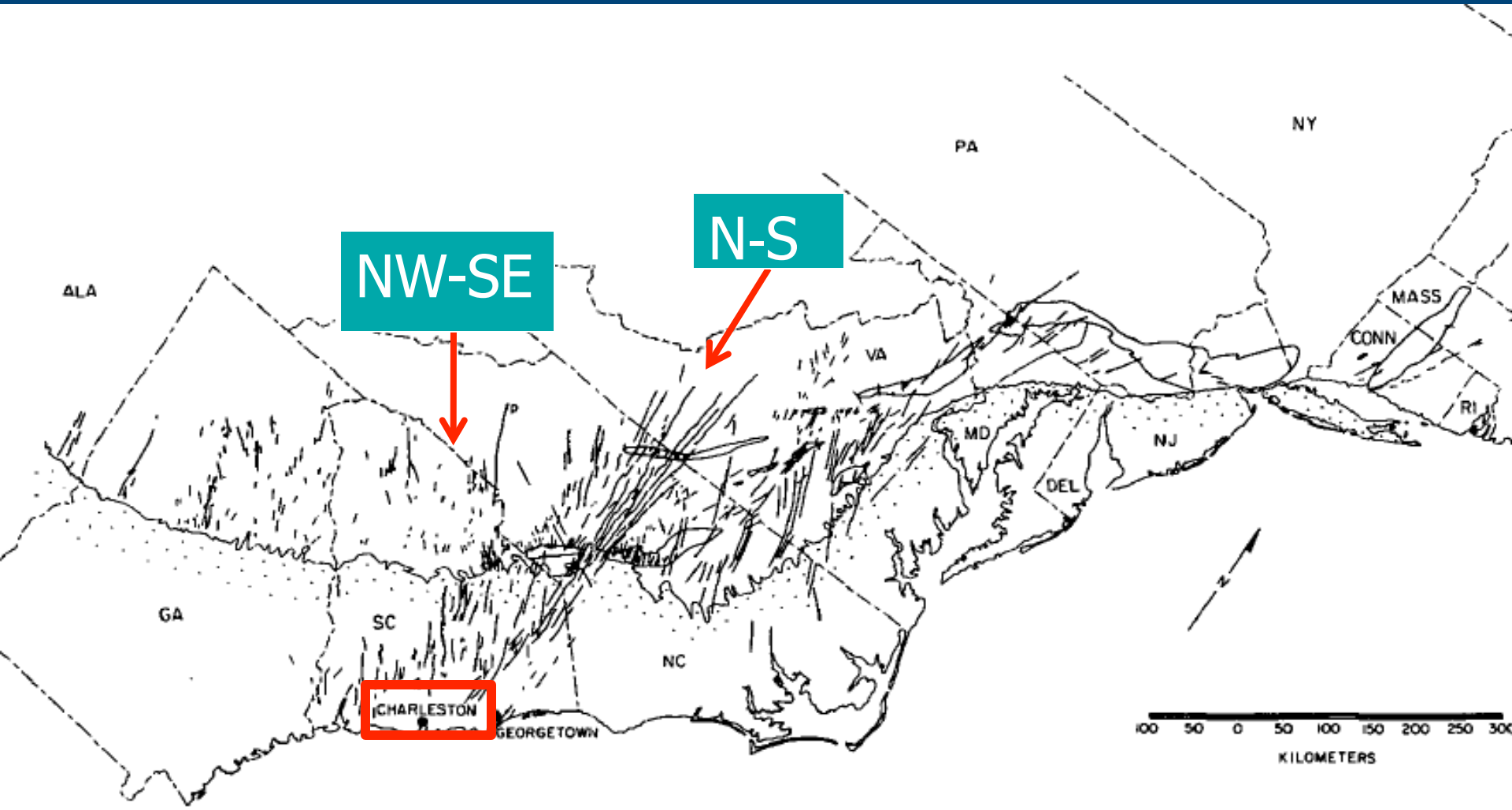


Next left step is at the ECFS-SFS



Radiating dikes out of Charleston

Diabase dikes in ENA (Ragland et al., 1983)



Location of Dikes in SE US

Beutel, 2009

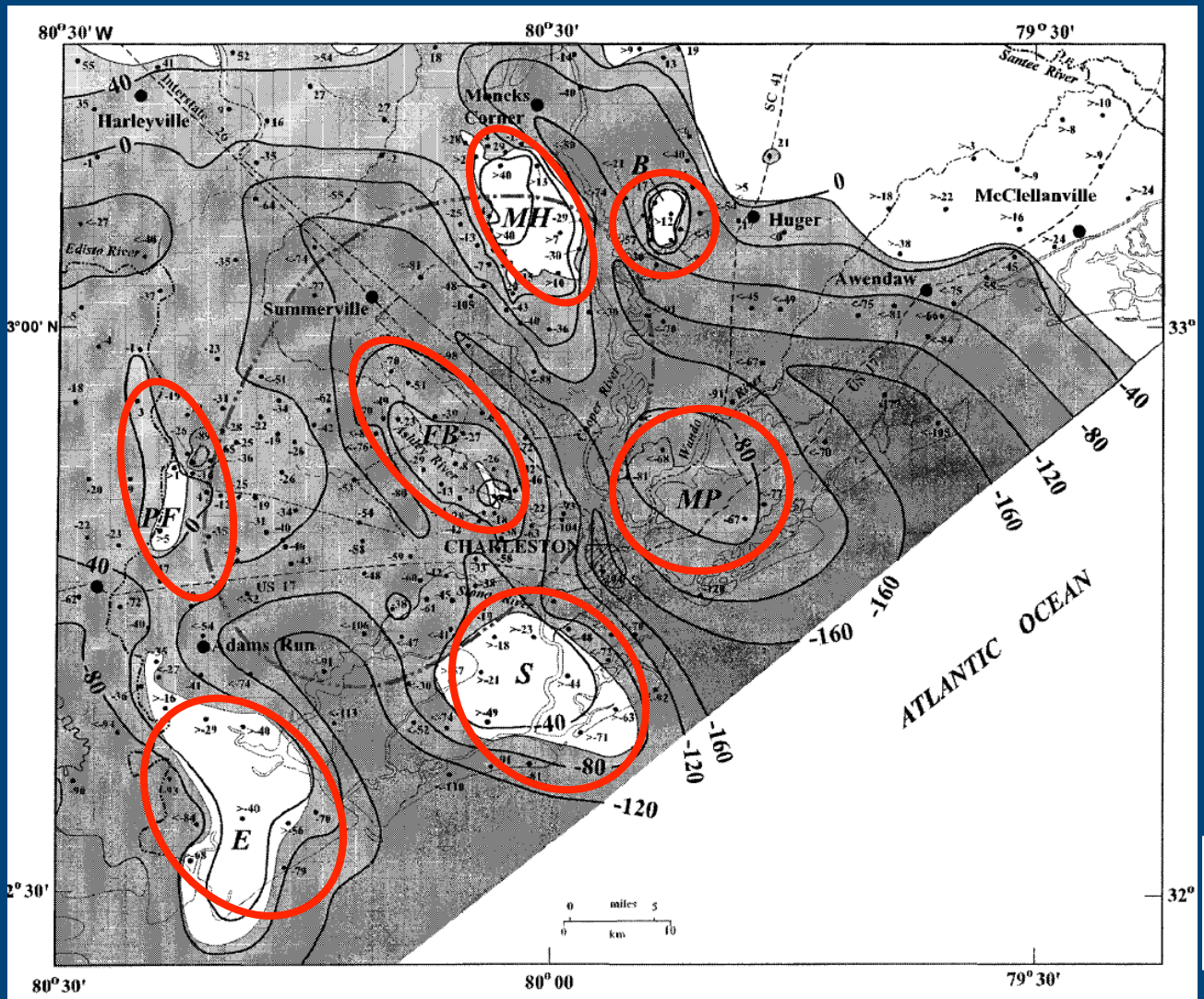
- Ragland et al., (1983) pointed out that there were two sets of dikes, trending N-S and NW-SE radiating out of the Charleston magnetic high, and suggested causal association with the Charleston seismic source.

Results of detailed study of shallow stratigraphy

Structural and tectonic setting of the Charleston, South Carolina, region: Evidence from the Tertiary stratigraphic record

Robert E. Weems*
William C. Lewis
U.S. Geological Survey, M.S. 928 National Center, 12201 Sunrise Valley Drive, Reston, Virginia 20192, USA

Structure contours on base of Ashley formation define 7 domes



Weems and Lewis,2002

- The domes are unique to the Mezoseismal area of the Charleston earthquake.
- There is complete absence of
- layer-cake stratigraphy.
- Not seen in other parts of the Coastal Plain from Florida to Virginia (Weems, Pers. Comm. 2010)

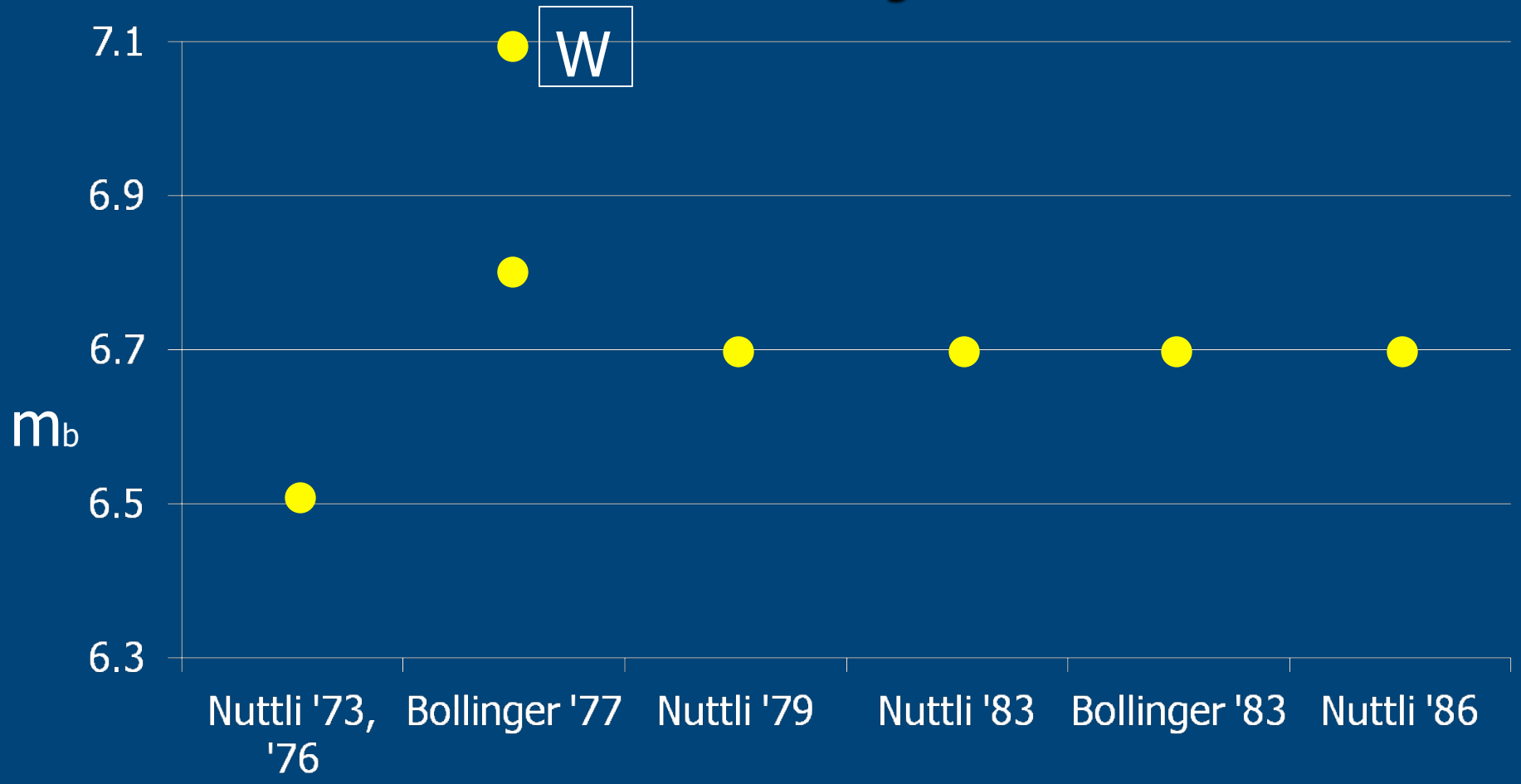
Conclude that observations of

- Compressional left –step in ECFS
- Radiating dikes
- Absence of layer-cake stratigraphy
- Ongoing seismicity
- ALL SUGGEST THAT CHARLESTON MAY BE UNIQUE.
- NEED FURTHER STUDIES

Magnitude estimates for the Charleston earthquake

Estimated Magnitudes for 1886 Charleston Earthquake

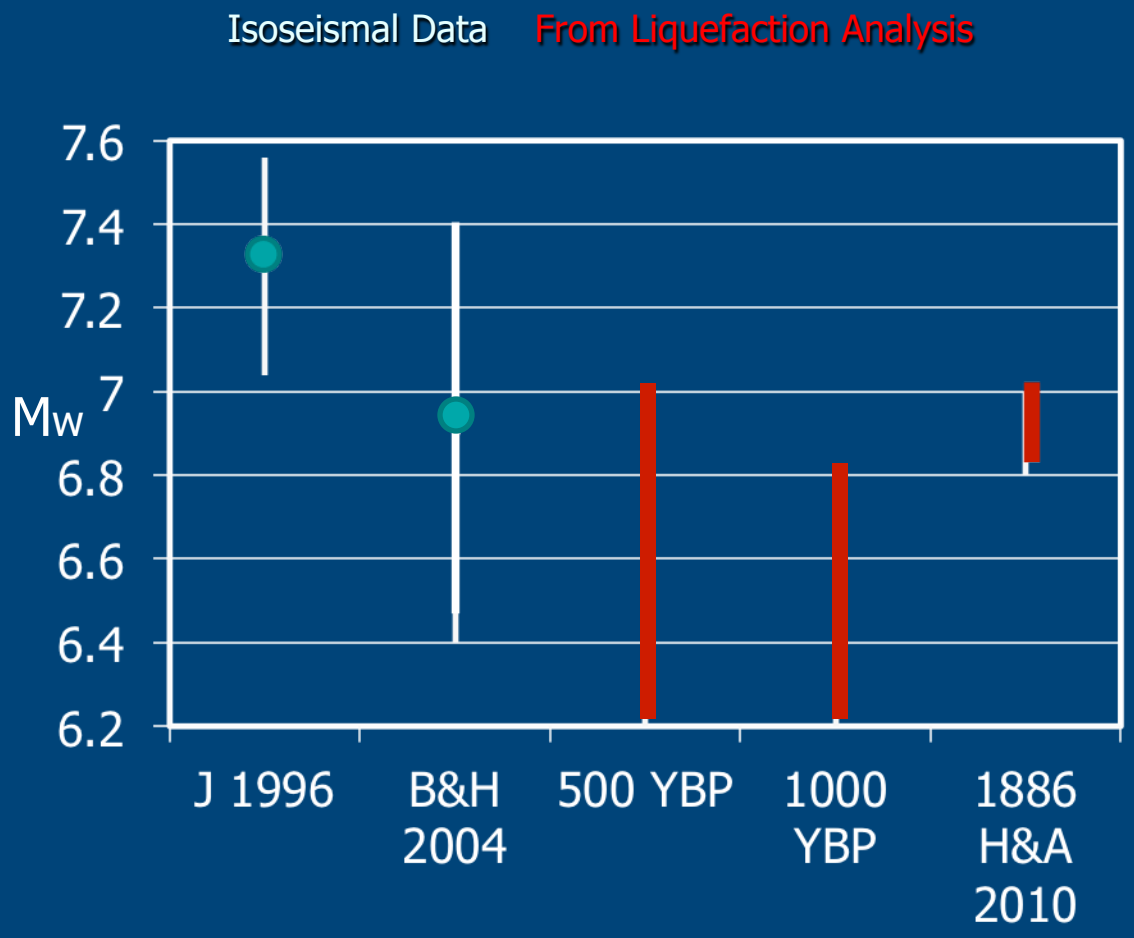
From earlier seismological studies



None of these studies considered in situ soil conditions

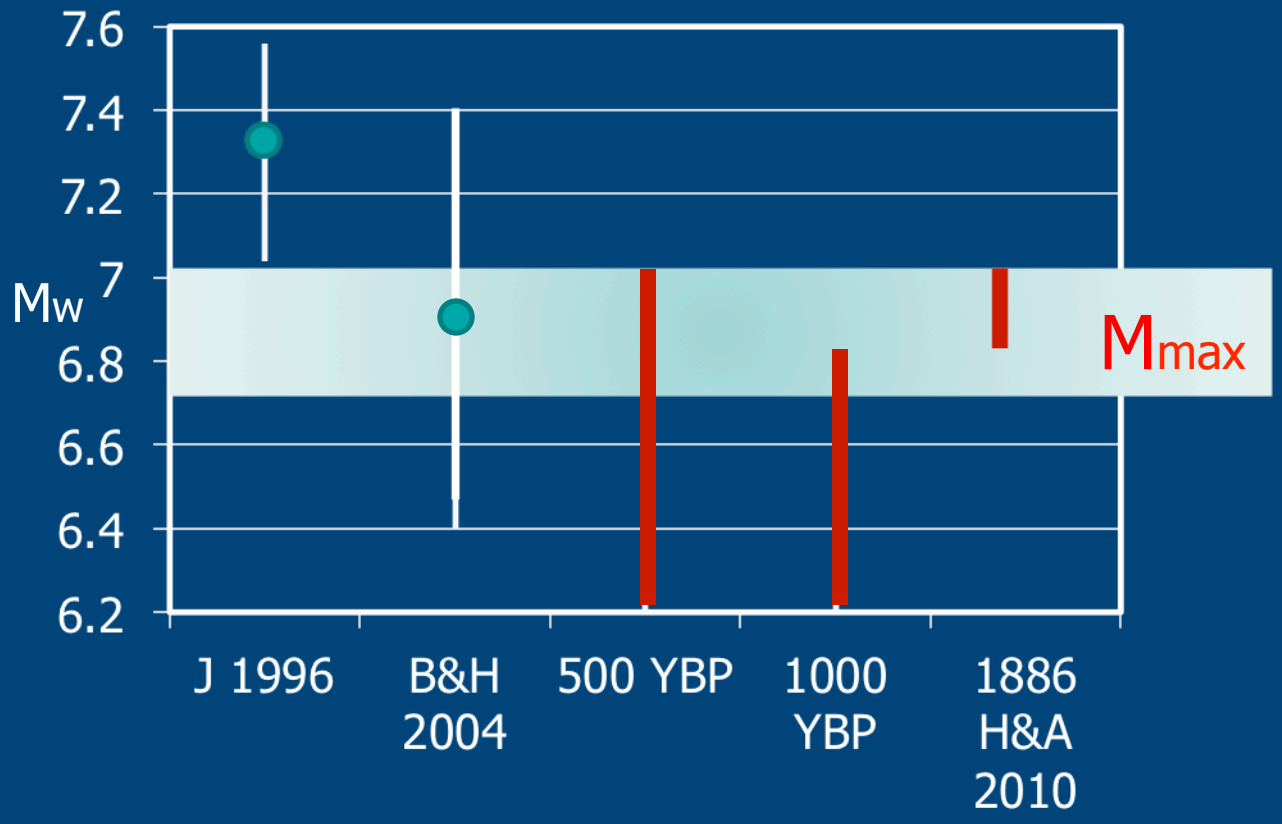
Magnitudes and accelerations of pre-historic earthquakes were estimated from in situ geotechnical data and compared with those from isoseismal data.

Estimated Magnitudes for 1886 Charleston Earthquake:



Mmax for Charleston Earthquakes 6.7-7.0

Isoseismal Data From Liquefaction Analysis



THANK YOU

Estimates of Magnitudes of Prehistoric S.C. Earthquakes associated with liquefaction from in situ SPT data (Energy Stress Method, Hu et al., 2002)

Location of sand blow	Inferred seismic source	Date of eq. YBP	Estimated magnitude	Reference
Sam-02	Charleston	~500	6.2 to 7.0	Leon et al. 2005
Sam-04	Charleston	~1000	6.2 to 6.8	
Sam-05	Northeast	~1650	5.1 to 6.4	
	or Charleston	~1680	6.4 to 7.2	
Gap-02	Charleston	~3500	5.6 to 6.4	
Gap-03	Northeast	~5000	4.3 to 5.6	
	or Charleston	~5000	5.5 to 6.2	
FD*	Sawmill Brach fault	Pre 1886	$\leq$ 5.6	Talwani et al. 2011

Results of geotechnical investigations in the Charleston area

Estimated **M** 6.8 – 7.0 for the 1886 Charleston earthquake from cone penetration and liquefaction observations in Charleston and Mount Pleasant.

Heidari & Andrus, 2010

Mmax of Charleston Earthquakes

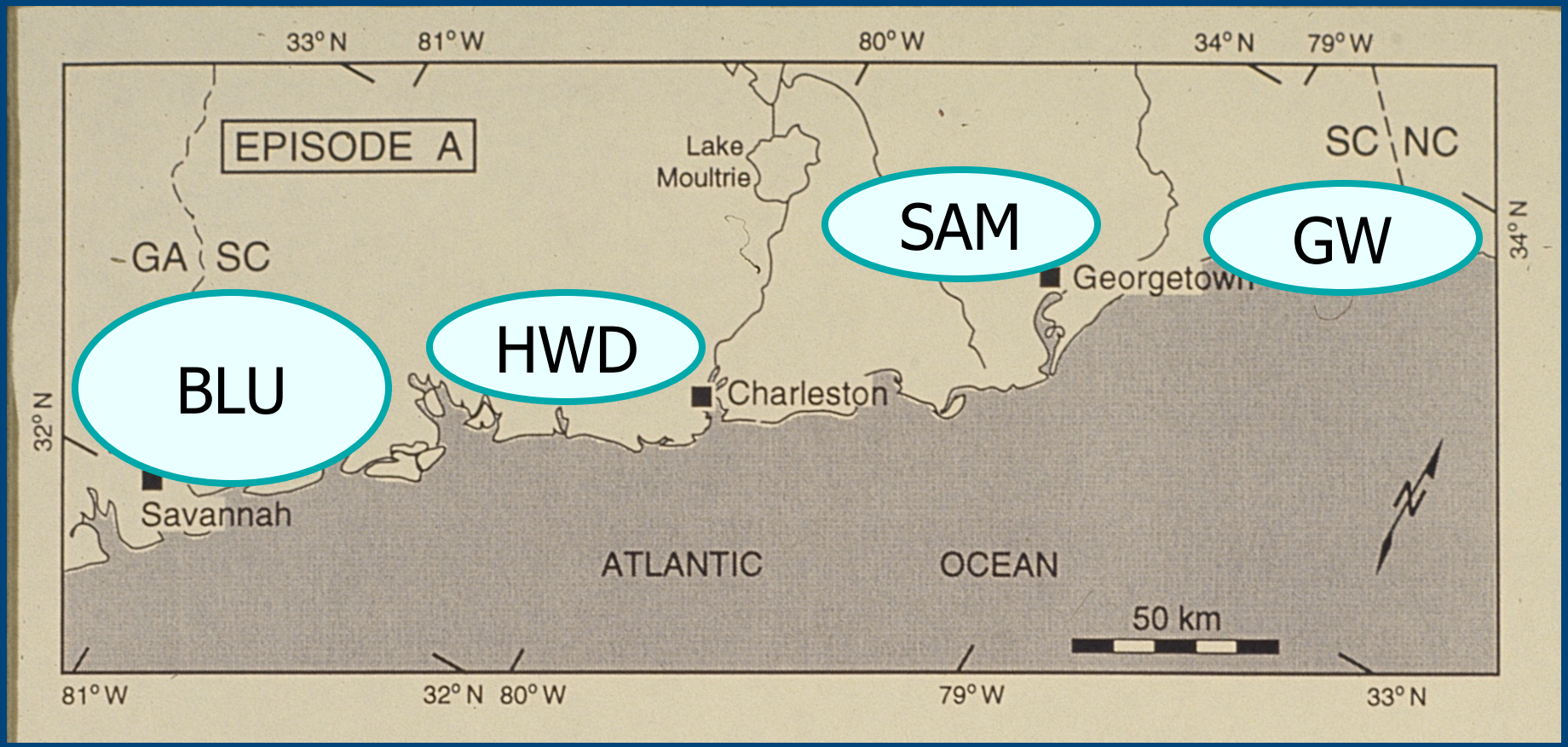
- Estimates based on recursion relations between felt areas and Magnitude suggest a Mmax ~ 6.9 to 7.3
- Mmax back-calculated from geotechnical data suggest Mmax between 6.7 and 7.0

- A careful reevaluation of Mmax is needed.

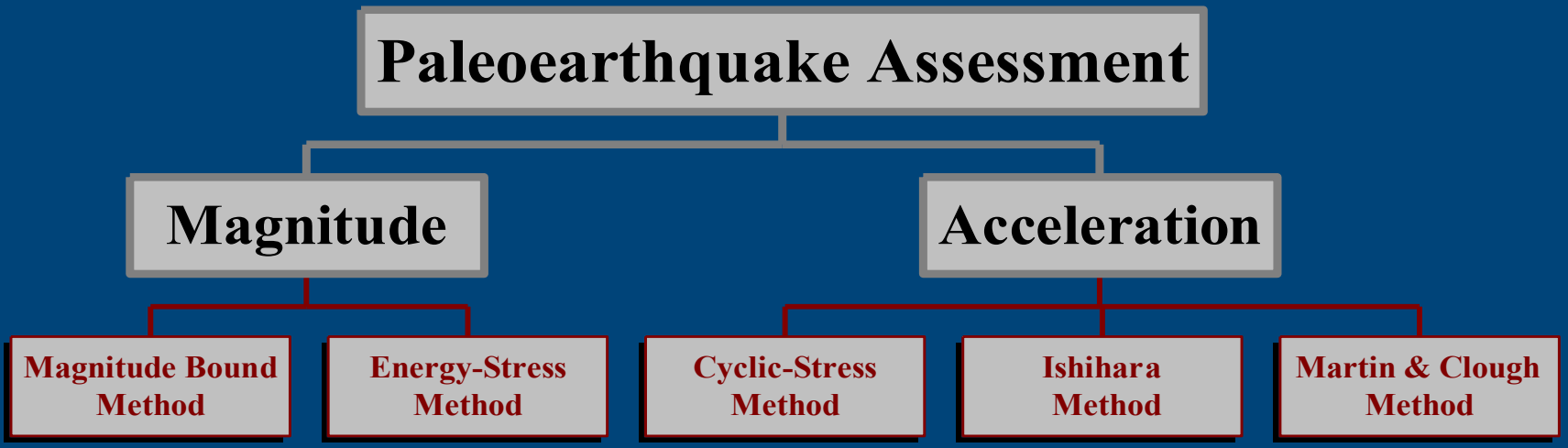
Estimates of Magnitude of the 1886 Charleston SC Earthquake from Intensity Data

Author(s)	Magnitude	Remarks:
Nuttli (1973, 1976)	m_b 6.5	m_{bLg} relation
Bollinger (1977)	m_b 6.8	Particle velocity EUS
	m_b 7.1	Particle velocity WUS
Nuttli et al. (1979)	m_b 6.6 to 6.9 Wt. av. 6.7*	1 Hz Lg ground motion 33 WUS, 8 CUS eq.
Nuttli (1983)	m_b 6.7	Source characteristics
Bollinger (1983)	m_b 6.7	Nuttli et al., 1979.
Nuttli et al. (1986)	m_b 6.7	New seismicity data
Johnston (1996)	M_w 7.3 ± 0.26	SCR data
Bakun & Hopper (2004)	M_w 6.4 to 7.2 M_w 6.9 *	Intensity magnitude algorithm

LOCATIONS OF SANDBLOWS ASSOCIATED WITH EPISODE A



Methodology



Methods based on in-situ geotechnical data:

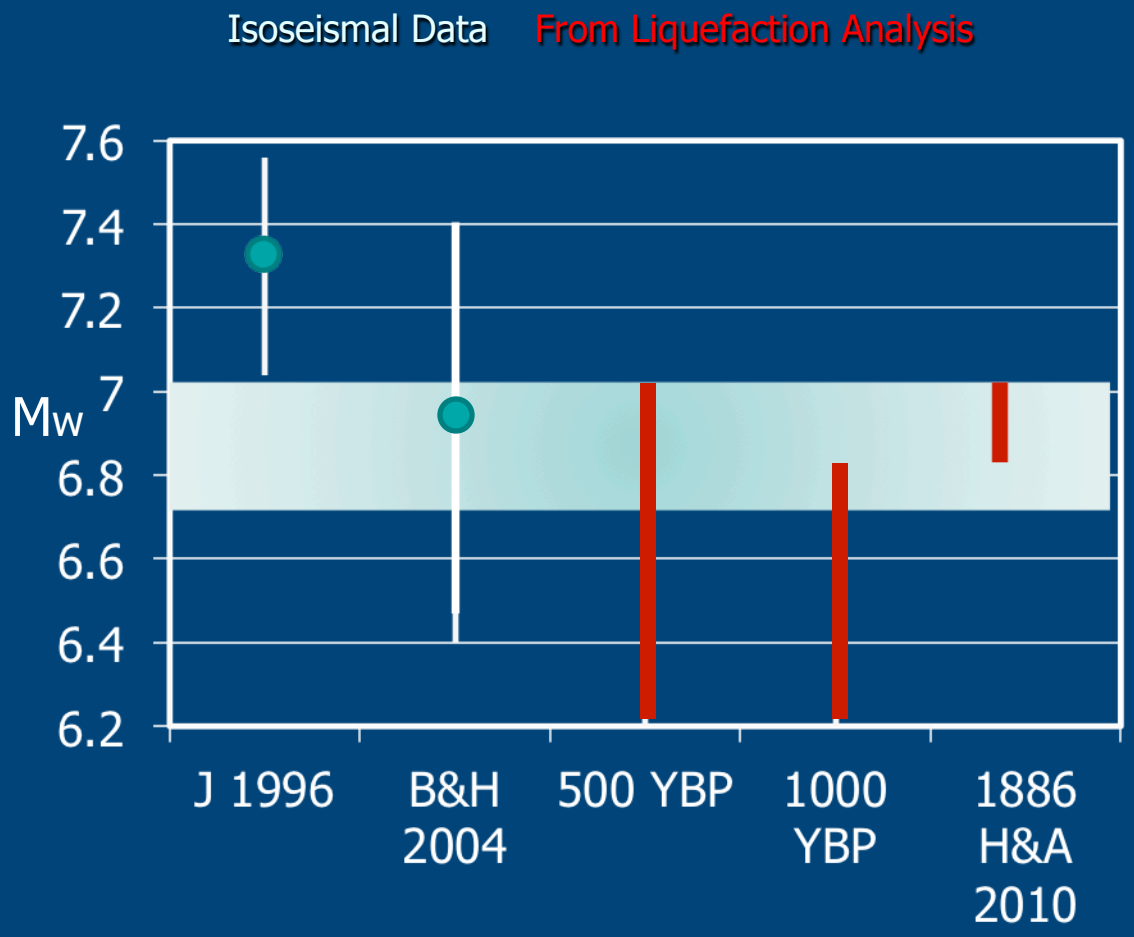
§ Energy-Stress Method

§Cyclic-Stress Method (SPT, CPT, V_s)

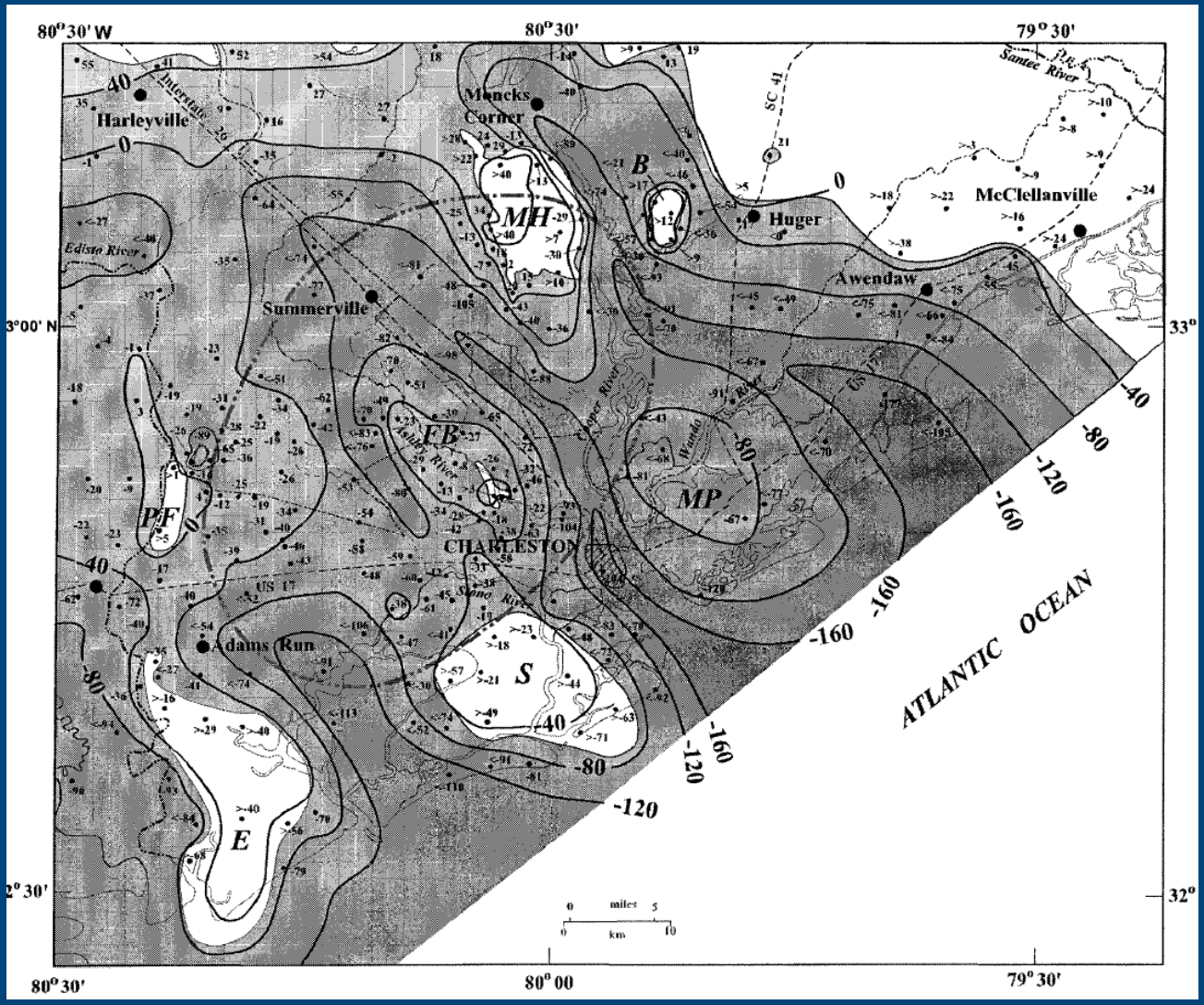
§Ishihara Method

§Martin & Clough Method

Estimated Magnitudes for 1886 Charleston Earthquake:



Structure contours on base of Ashley formation define 7 domes



Weems and Lewis,2002