ရန်ကုန်နည်းပညာတက္ကသိုလ်
YANGON TECHNOLOGICAL UNIVERSITY

SATREPS
Science and Technology Research Partnership for Sustainable Development

JICA

Acquisition of Ground Information (Site Effects) in Downtown Yangon for Earthquake Hazard Mitigation

Prof/ Dr. Tun Naing

Workshop in
Lanmataw Township
Latha Township
Pabedan Township

13-15. 5. 2019

General Agenda

1. Seismic Hazard of Myanmar
2. Site Effect during the Earthquakes
3. Site Effect Determination
4. Conclusion

Seismic Hazard of Myanmar

Earthquakes in Myanmar

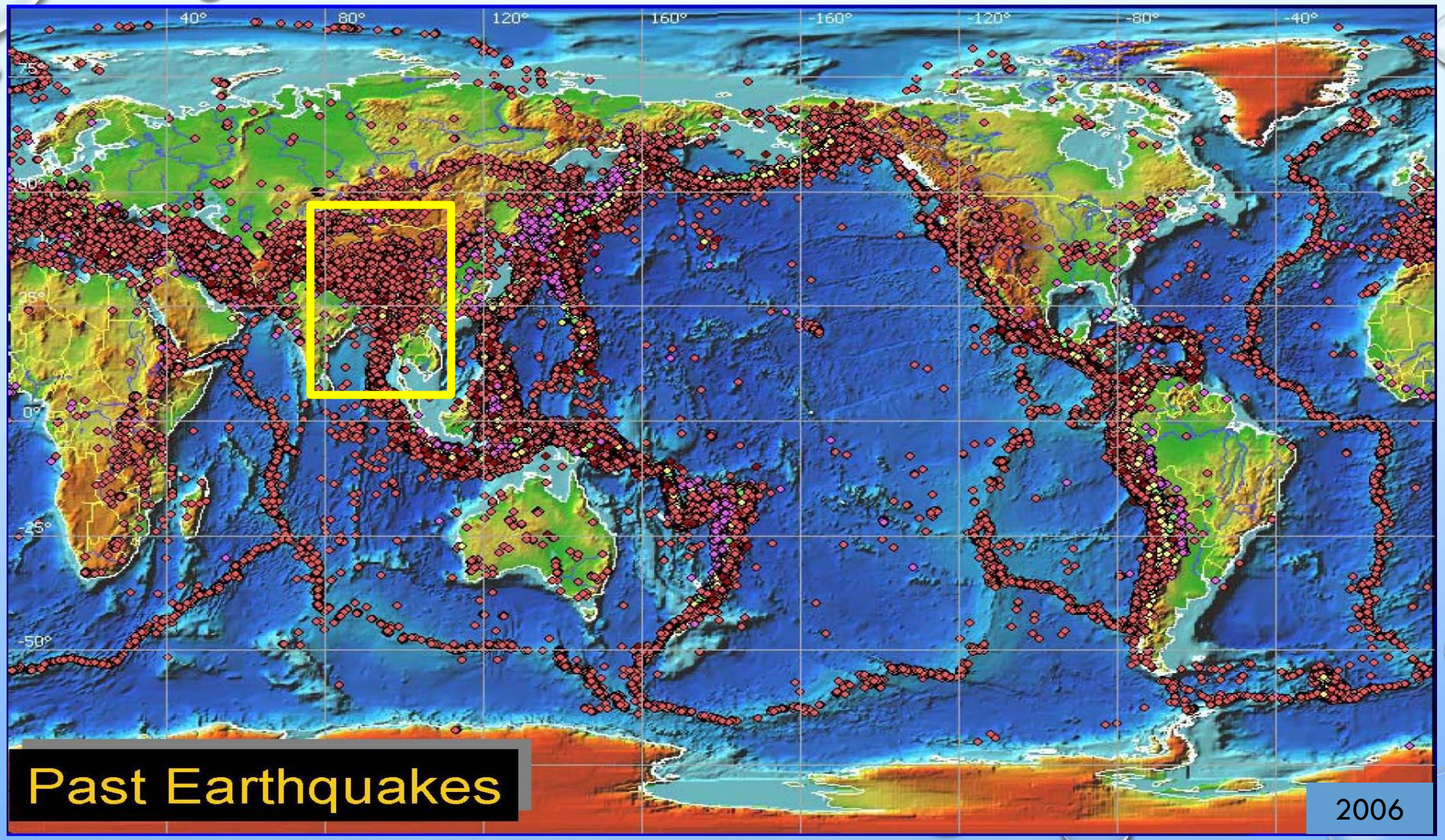
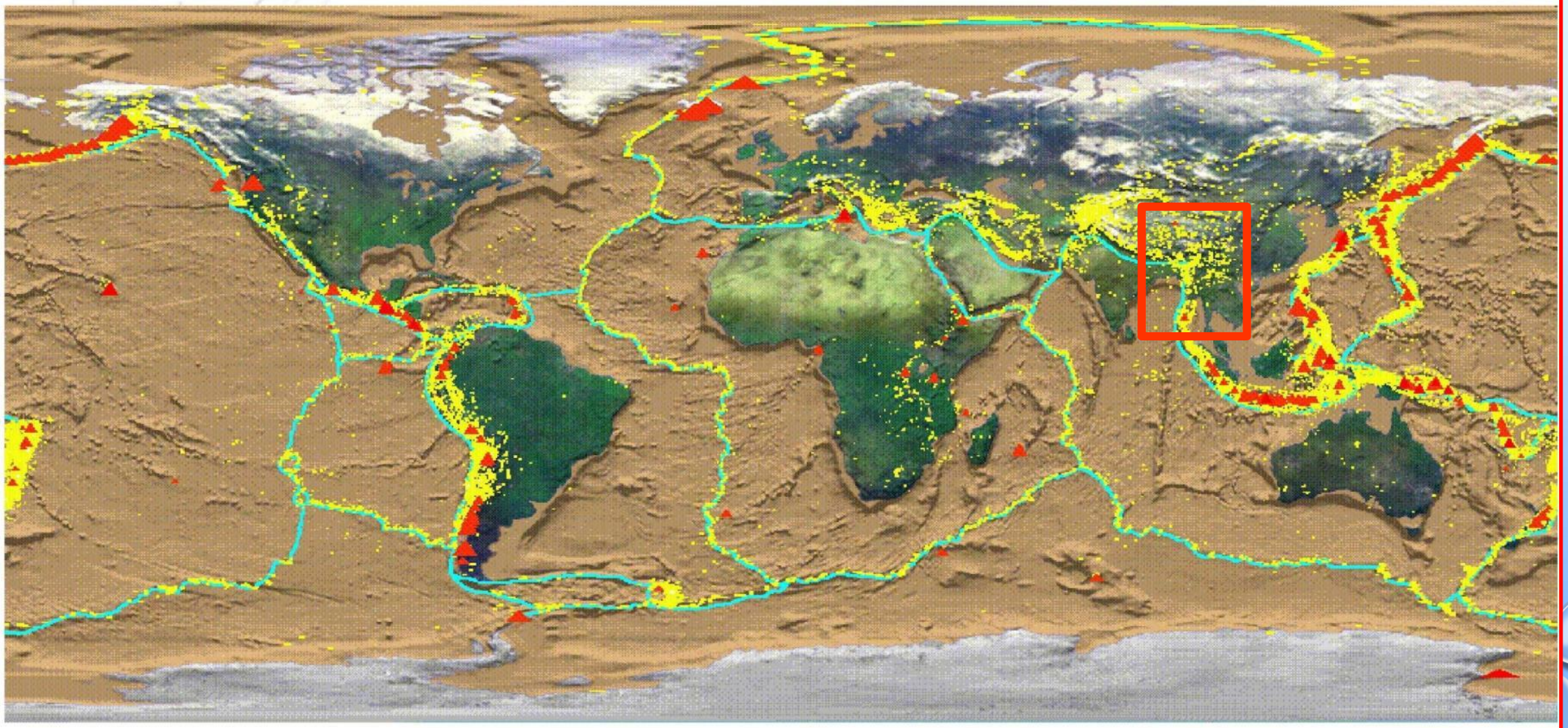
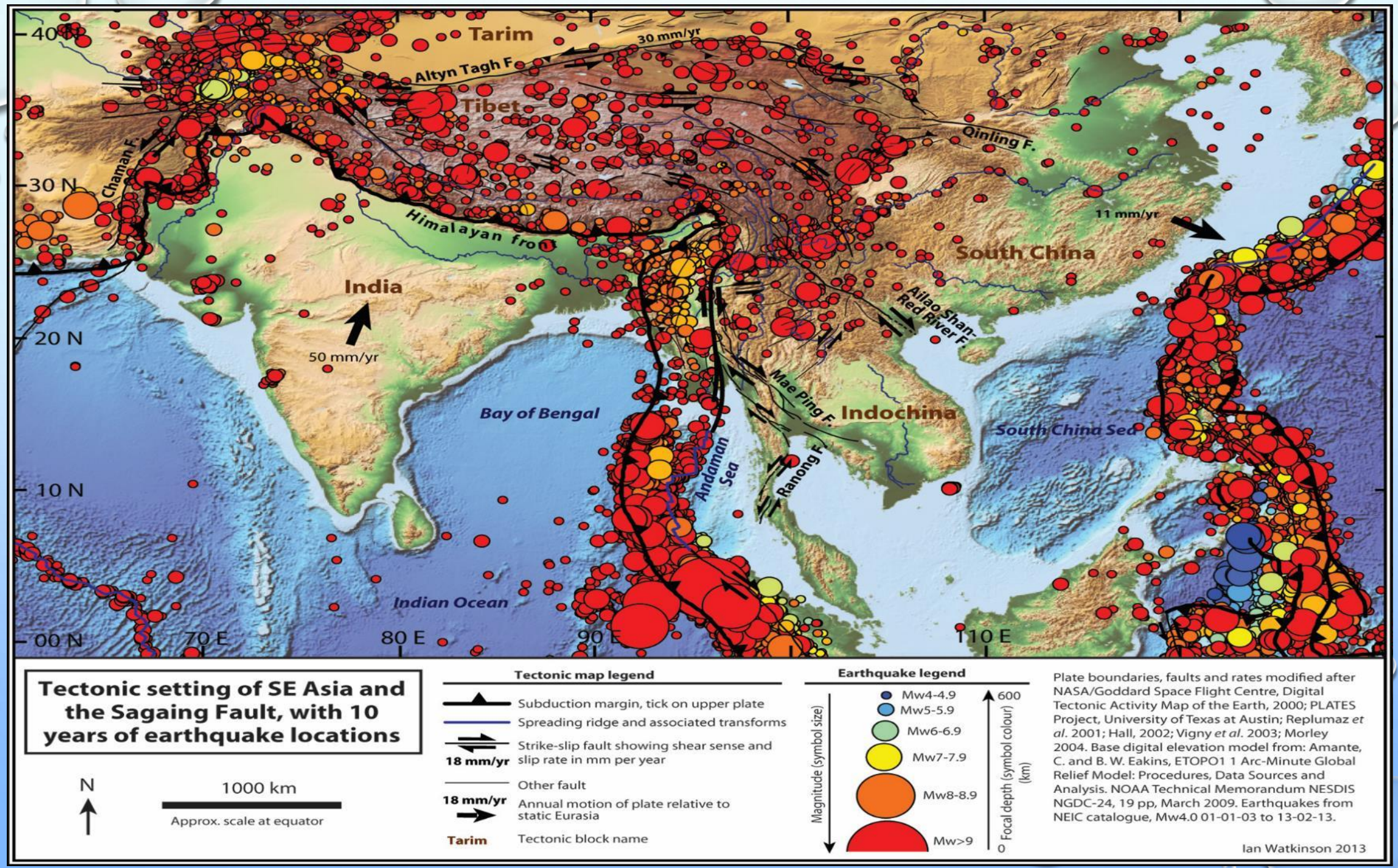
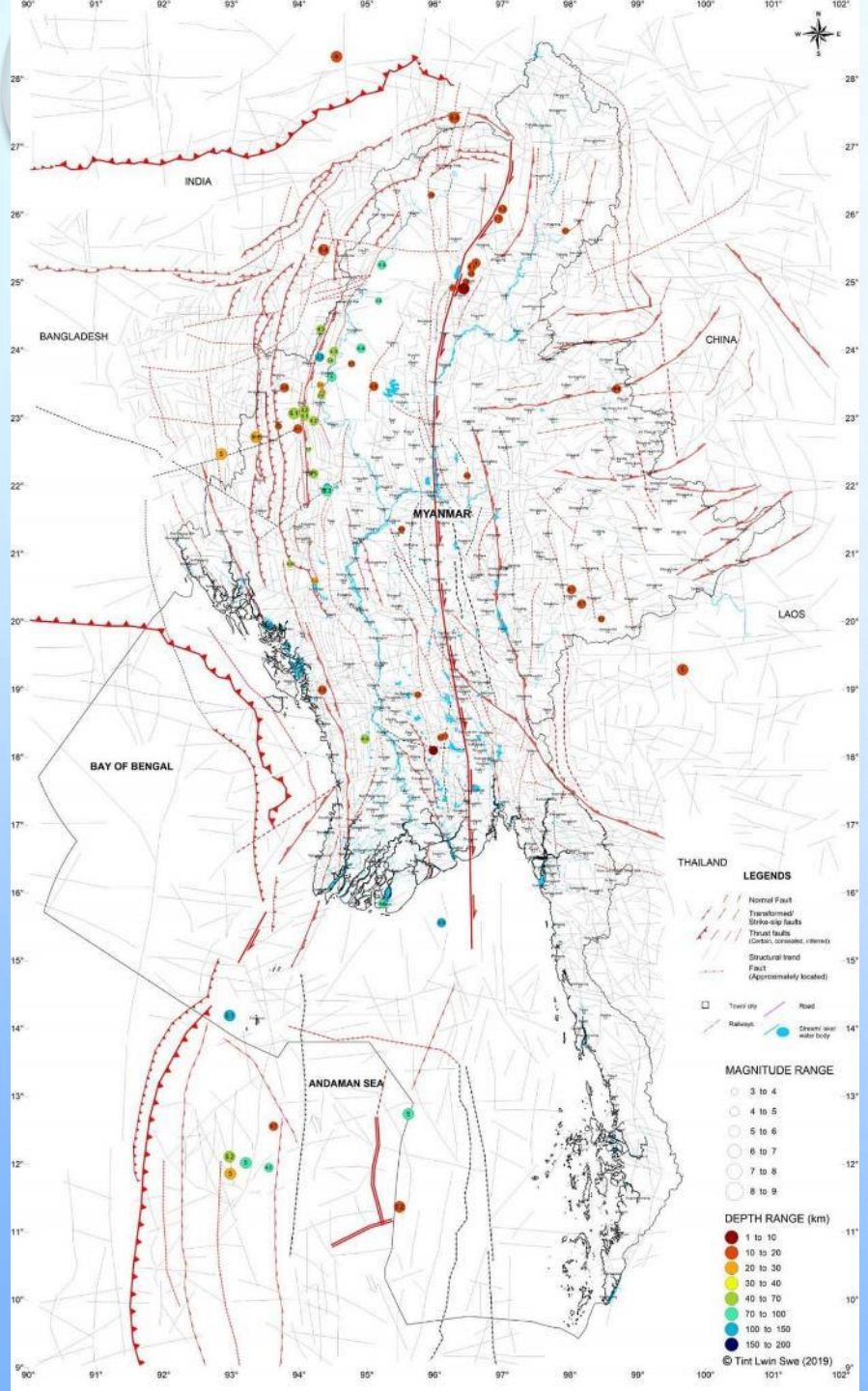


Plate boundaries, earthquakes (yellow) and volcanoes (red)




Tarim
30 mm/yr
Altyn Tagh F.
Tibet
Qinling F.
Chaman F.
Himalayan front
11 mm/yr
South China
India
50 mm/yr
Ailao Shan-Red River F.
Mae Ping F.
Indochina
Bay of Bengal
South China Sea
Andaman Sea
Ranong F.
Indian Ocean
40 N
30 N
20 N
10 N
00 N
70 E
80 E
90 E
110 E
Tectonic setting of SE Asia and the Sagaing Fault, with 10 years of earthquake locations
N
1000 km
Approx. scale at equator
Tectonic map legend
Subduction margin, tick on upper plate
Spreading ridge and associated transforms
18 mm/yr
Strike-slip fault showing shear sense and slip rate in mm per year
Other fault
18 mm/yr
Annual motion of plate relative to static Eurasia
Tarim
Tectonic block name
Earthquake legend
Magnitude (symbol size)
Mw4-4.9
Mw5-5.9
Mw6-6.9
Mw7-7.9
Mw8-8.9
Mw>9
600
0
Focal depth (symbol colour) (km)
Plate boundaries, faults and rates modified after NASA/Goddard Space Flight Centre, Digital Tectonic Activity Map of the Earth, 2000; PLATES Project, University of Texas at Austin; Replumaz et al. 2001; Hall, 2002; Vigny et al. 2003; Morley 2004. Base digital elevation model from: Amante, C. and B. W. Eakins, ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24, 19 pp, March 2009. Earthquakes from NEIC catalogue, Mw4.0 01-01-03 to 13-02-13.
Ian Watkinson 2013



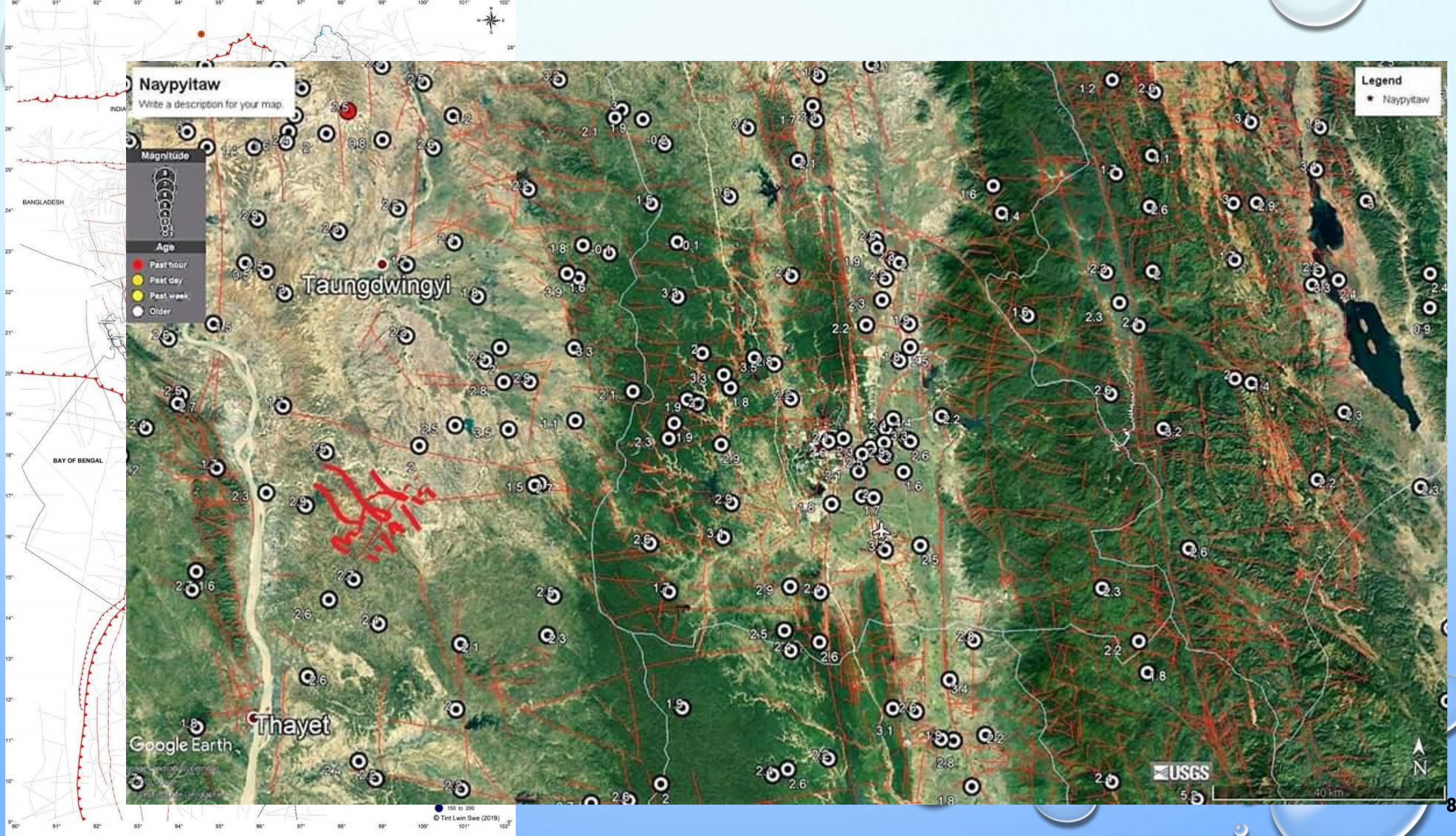
During January 2019 to April

Total Earthquake = 65

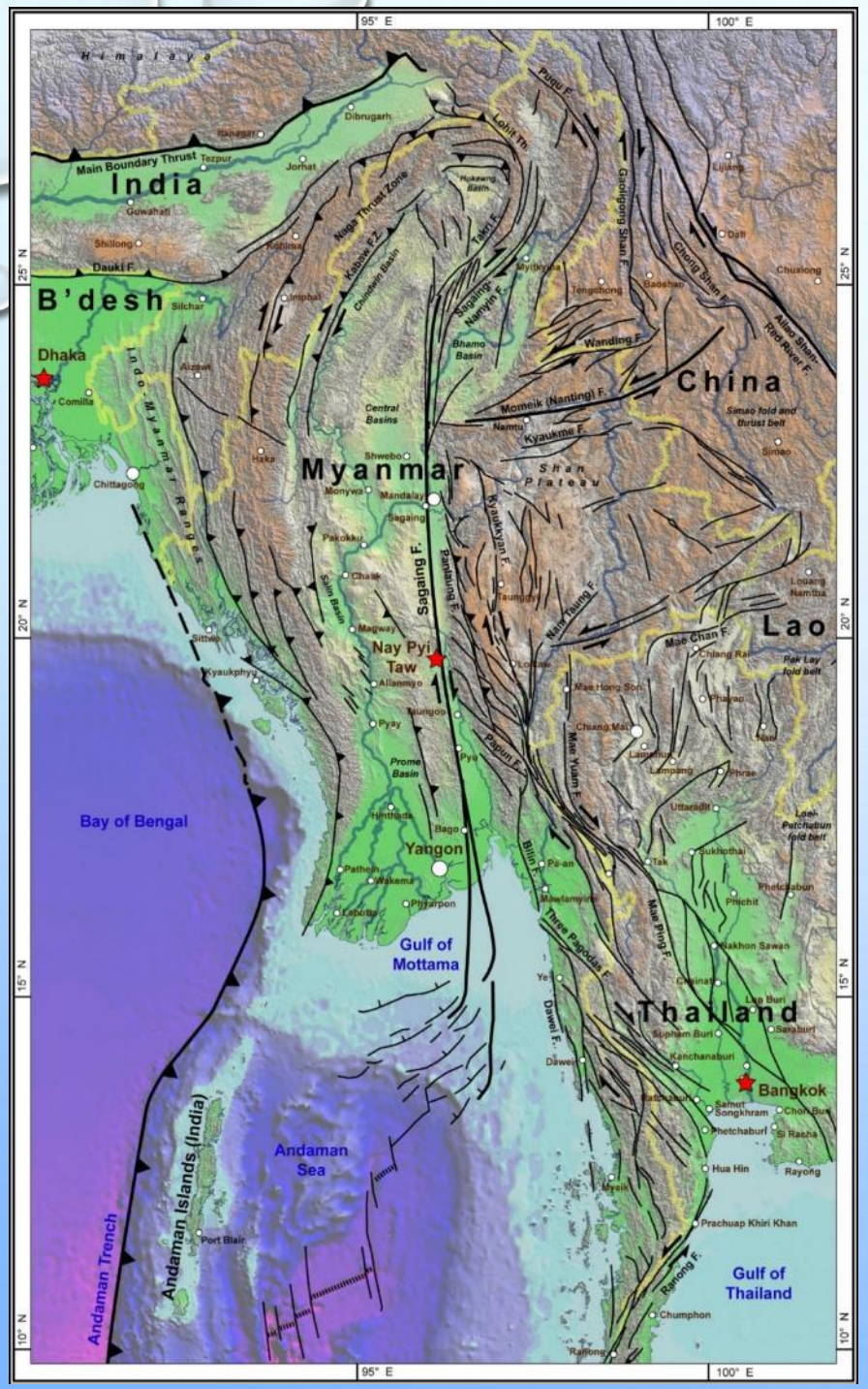
<4M (22)

4M – 5M (28)

>5M (15)


Naypyitaw
Write a description for your map.
Magnitude
Age
Past hour
Past day
Past week
Older
Legend
Naypyitaw
Taungdwingyi
Thayet
BANGLADESH
BAY OF BENGAL
Google Earth
USGS
N
40 km
© Tint Lwin Swe (2019)

Tectonic Setting of Myanmar



Subduction margin, tick on upper plate

Spreading ridge

Strike-slip fault showing shear sense

Normal fault. Tick on hanging wall

Thrust fault. Tick on hanging wall

Other fault

Major river

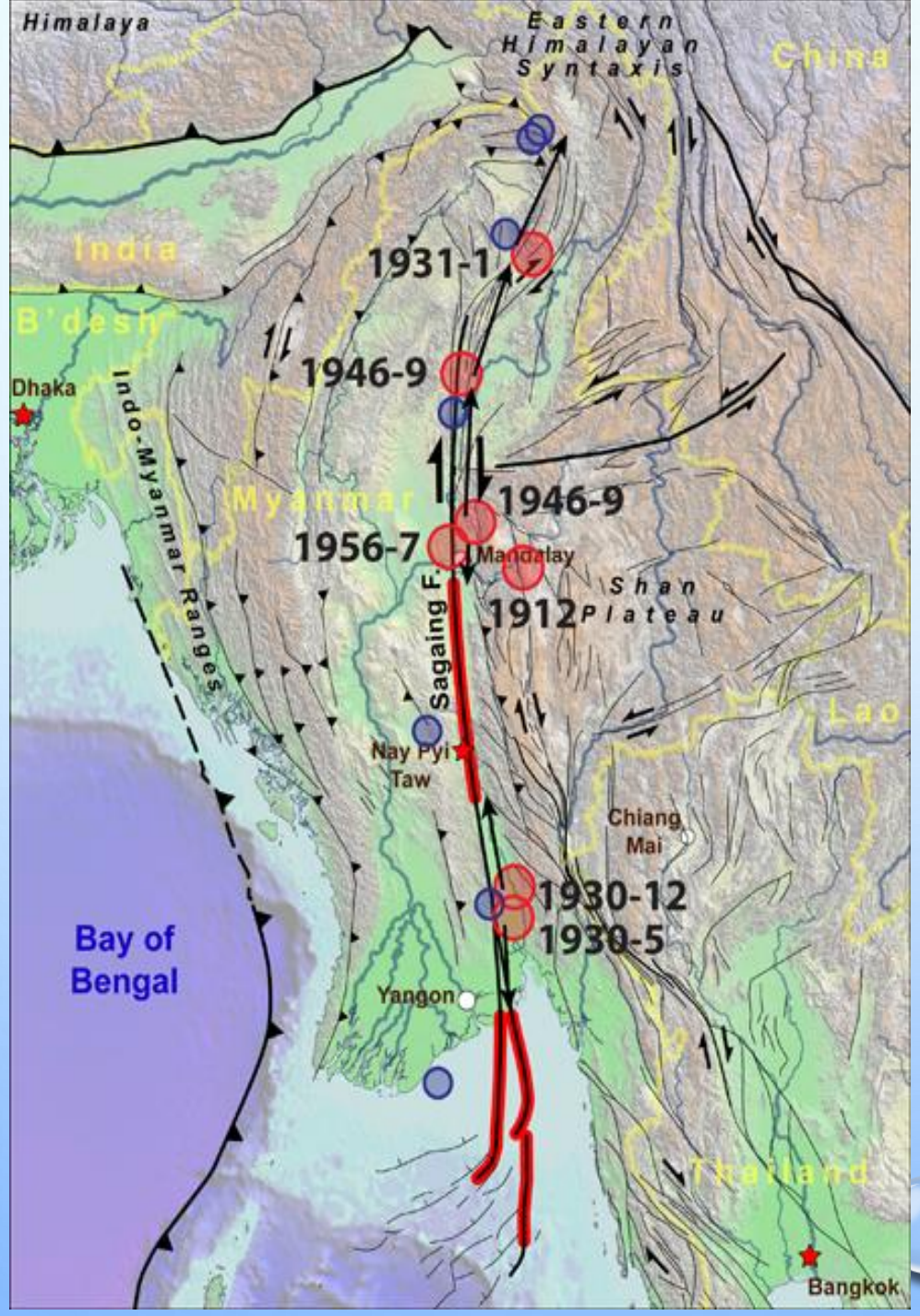
National boundary

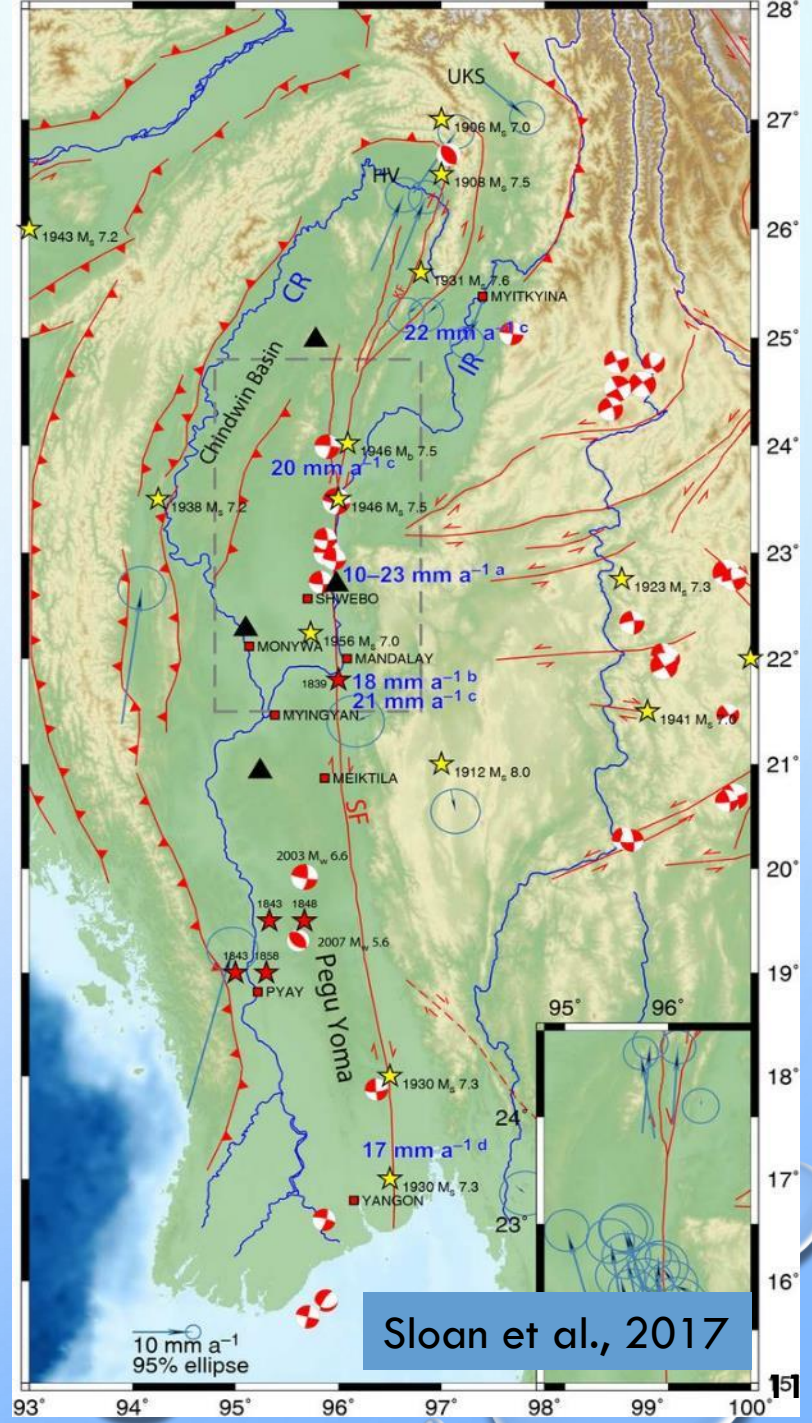
Faults modified after Morley (2004); Mitchell *et al.* (2007); Searle and Morley (2011); Watkinson *et al.* (2011); Soe Thura Tun and Maung Thein (2012); Ridd and Watkinson (2013). Base map is a digital elevation model (DEM) compiled from SRTM V2 1 degree tiles onshore (ftp://e0srp01u.ecs.nasa.gov/) and GTOPO30 tiles offshore (http://topex.ucsd.edu/WWW_html/srtm30_plus.htm). Other cultural and physical data from Natural Earth: Free vector and raster map data @ naturalearthdata.com.

Significant Earthquakes in Myanmar

Significant Earthquakes

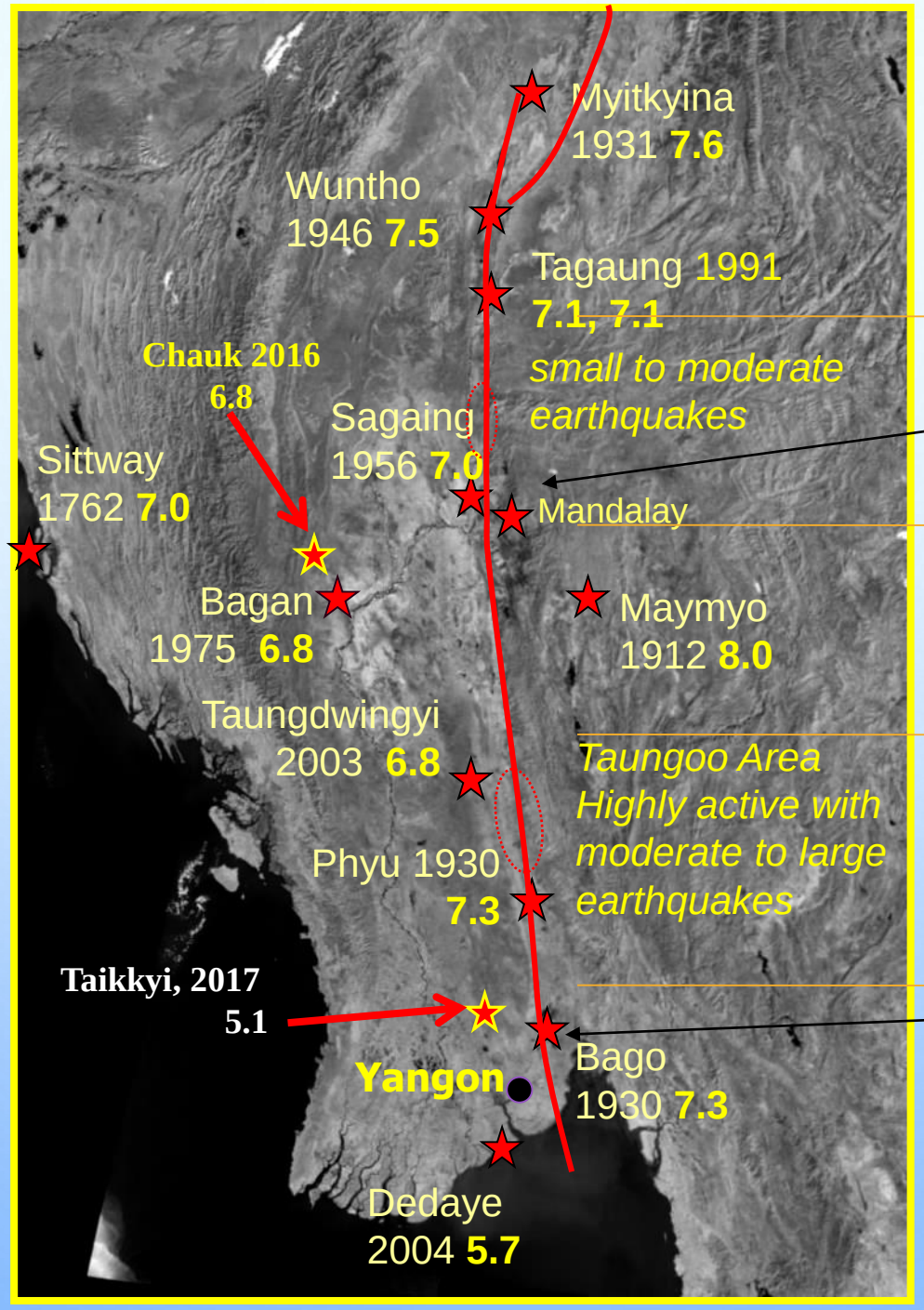
(*Hurukawa and Phyo Maung Maung , 2011*)





Sloan et al., 2017

Significant Earthquakes



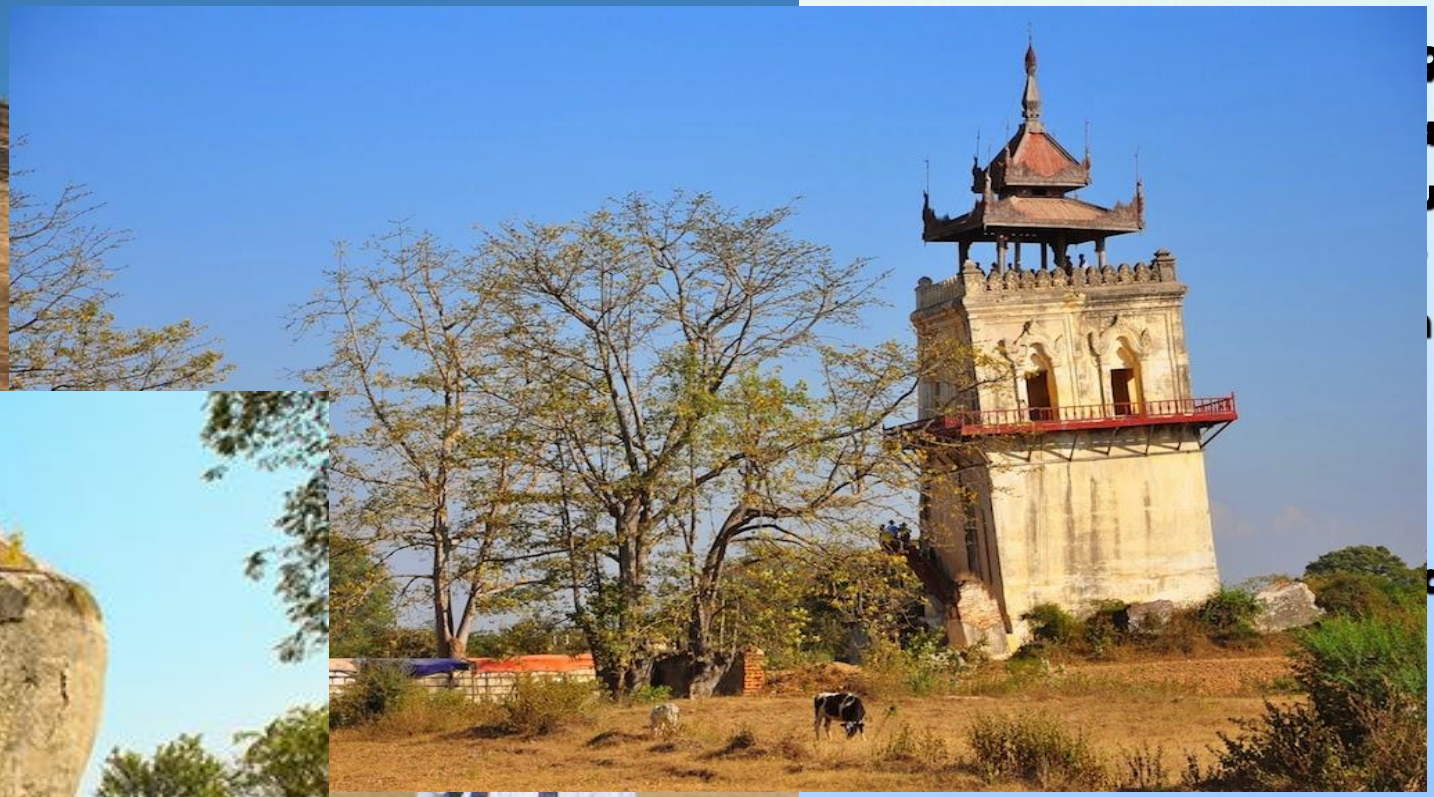
Historic earthquakes in Sagaing-Mandalay

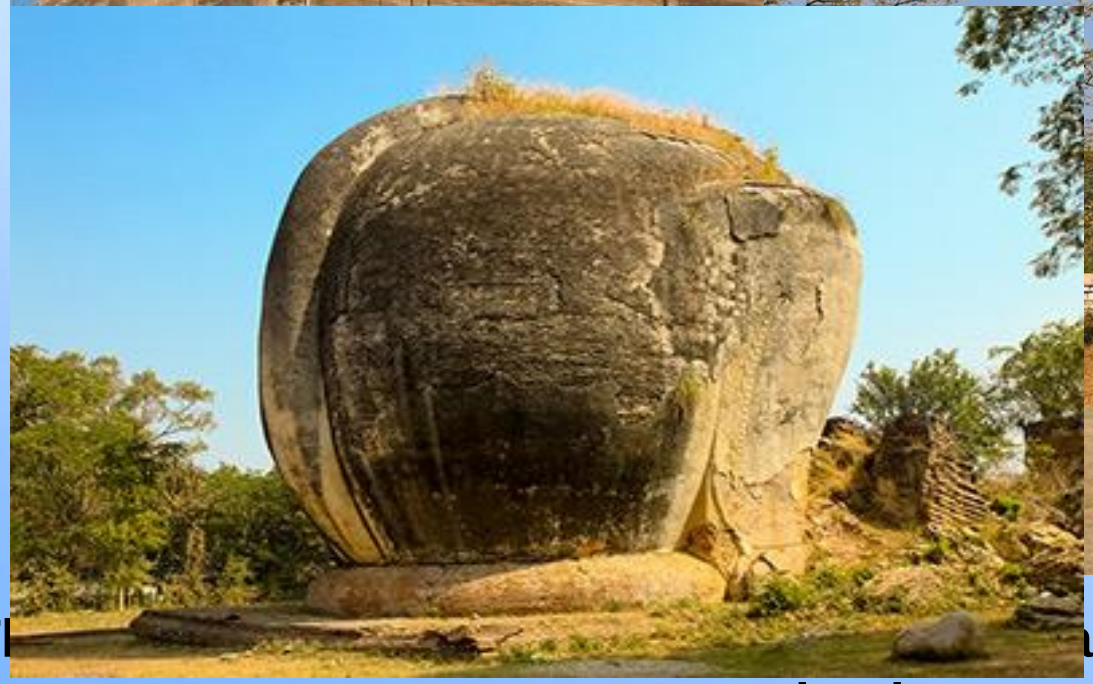
1429, 1467, 1501, 1602, 1696, 1762, 1771, 1776, 1830, 1839

Historic Earthquakes in Yangon- Bago

868, 875, 1564, 1567, 1582, 1588, 1590, 1757, 1768, 1830, 1888, 1913, 1917, 1920, 1930

MINGUN PAGODA, MANDALAY AREA
(NOW A KIND OF EARTHQUAKE HAZARD MEMORIAL MONUMENT)





9 Inn-
ups one
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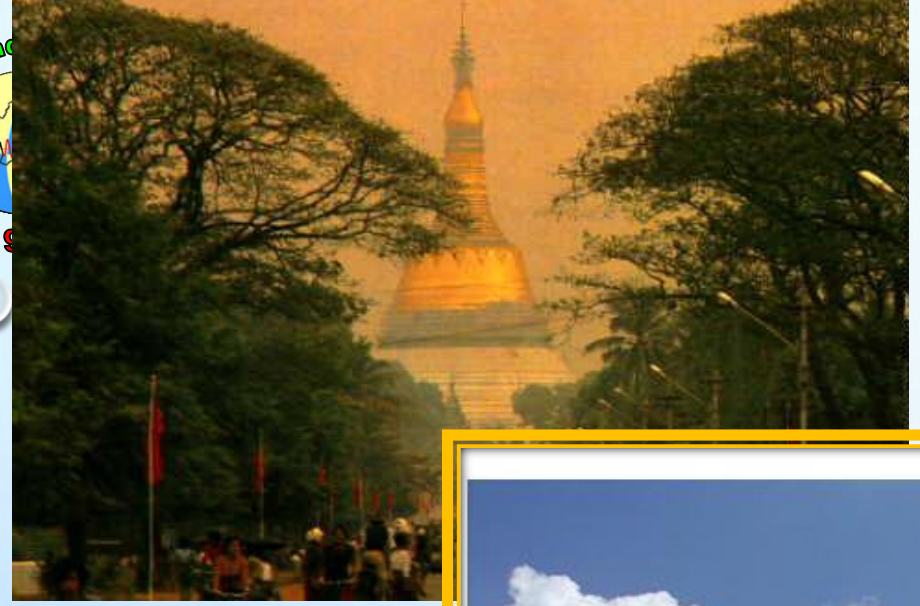
not
again

Th amaging earthquakes since 1429 AD, as indicated by damages of the pagodas

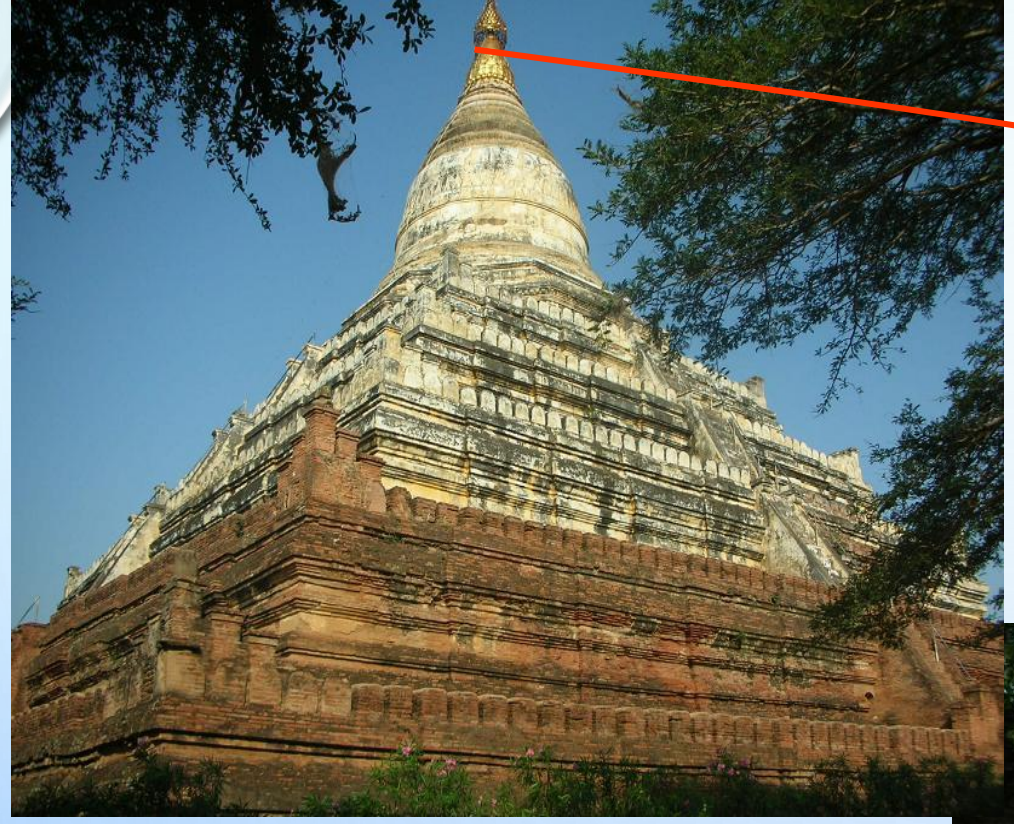


BAGO EARTHQUAKES

Historical Earthquakes in Bago (AD)

868, 875, 1564, 1567, 1582, 1588, 1590, 1757, 1768, 1830, 1888, 1913, 1917, 1920, 1930

Top portion of the pagoda fallen down by 1917 Bago Earthquake



Bagan Earthquake, July 1975 (Mw 6.8)

Top of the Pagoda toppled down by the 1975 Bagan earthquake

TAUNGDWINGYI EARTHQUAKE

Taungdwingyi Earthquake
22 September, 2003
00:46:54 MST
6.8 on magnitude Scale
7 death, 42 Injure, 180 houses damaged, 182 Pagodas collapsed

TAIKKYI EARTHQUAKE

4 January 2006

Magnitude 4.4

Mainly affected in monumental buildings

People frightened

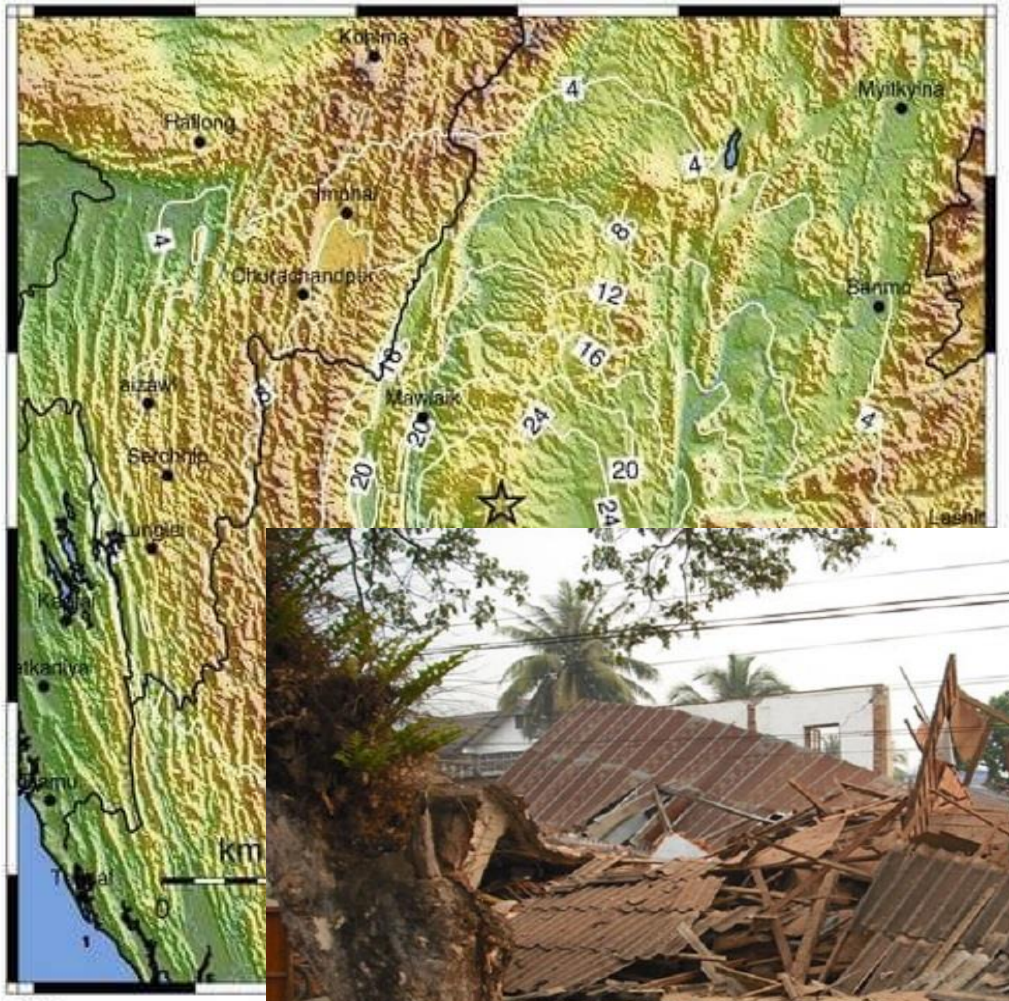
TARLAY EARTHQUAKE

24 March 2010

Magnitude 6.8

THABEIKKYIN EARTHQUAKE

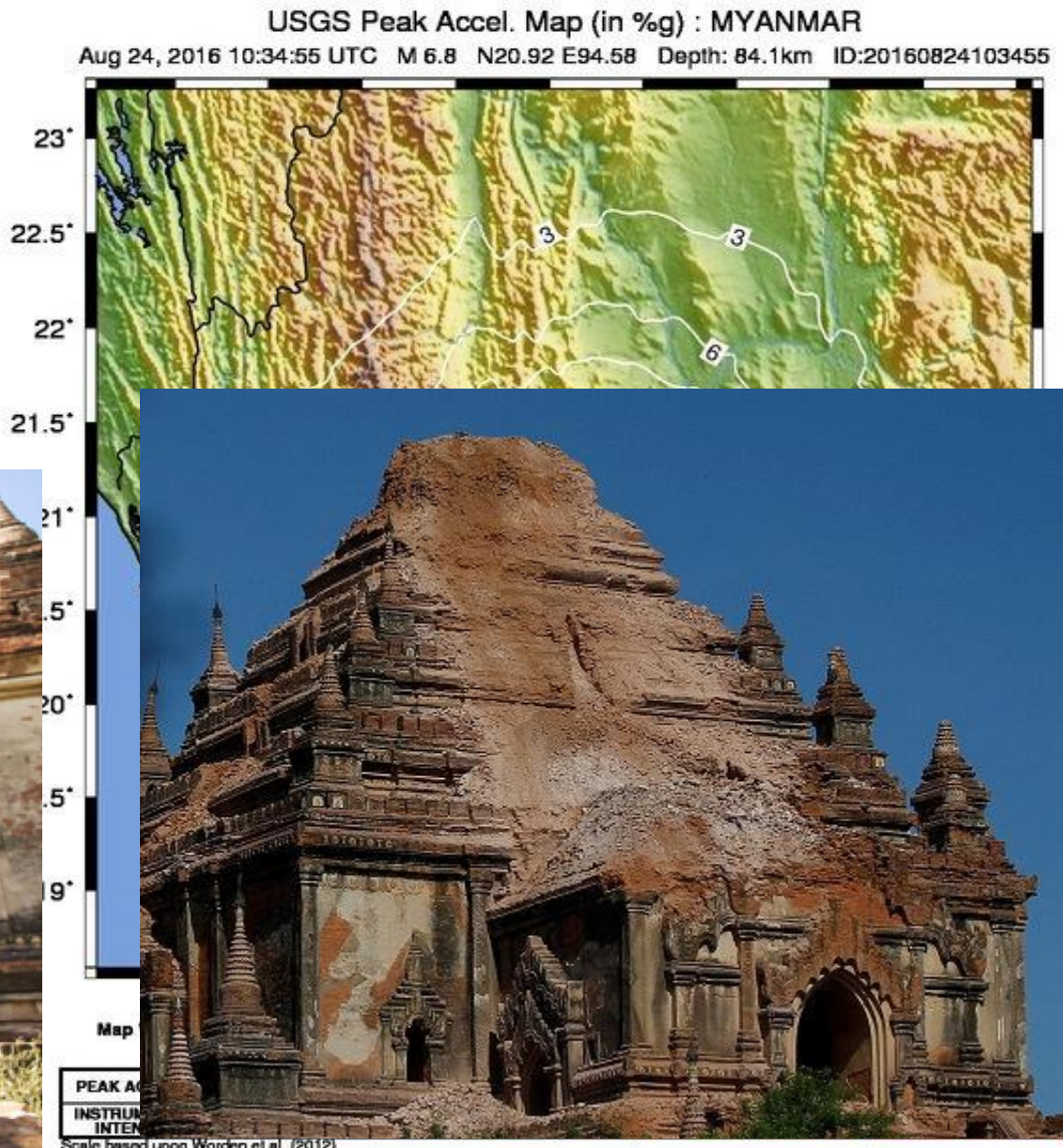
74 km SE of Mawlaik



M 6.8 - 26km W of Chauk, Burma

2016-08-24 10:34:54 UTC20.923°

82.0 km depth

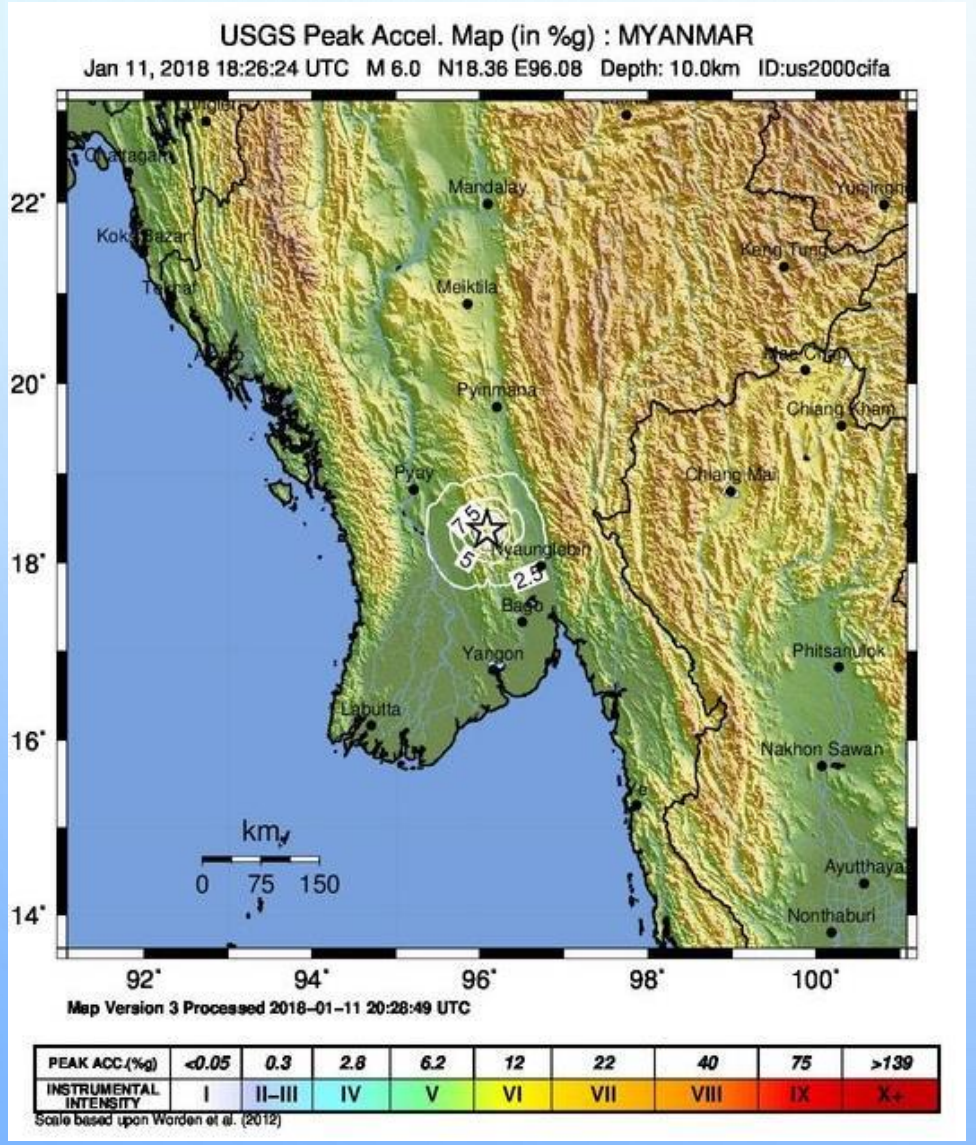


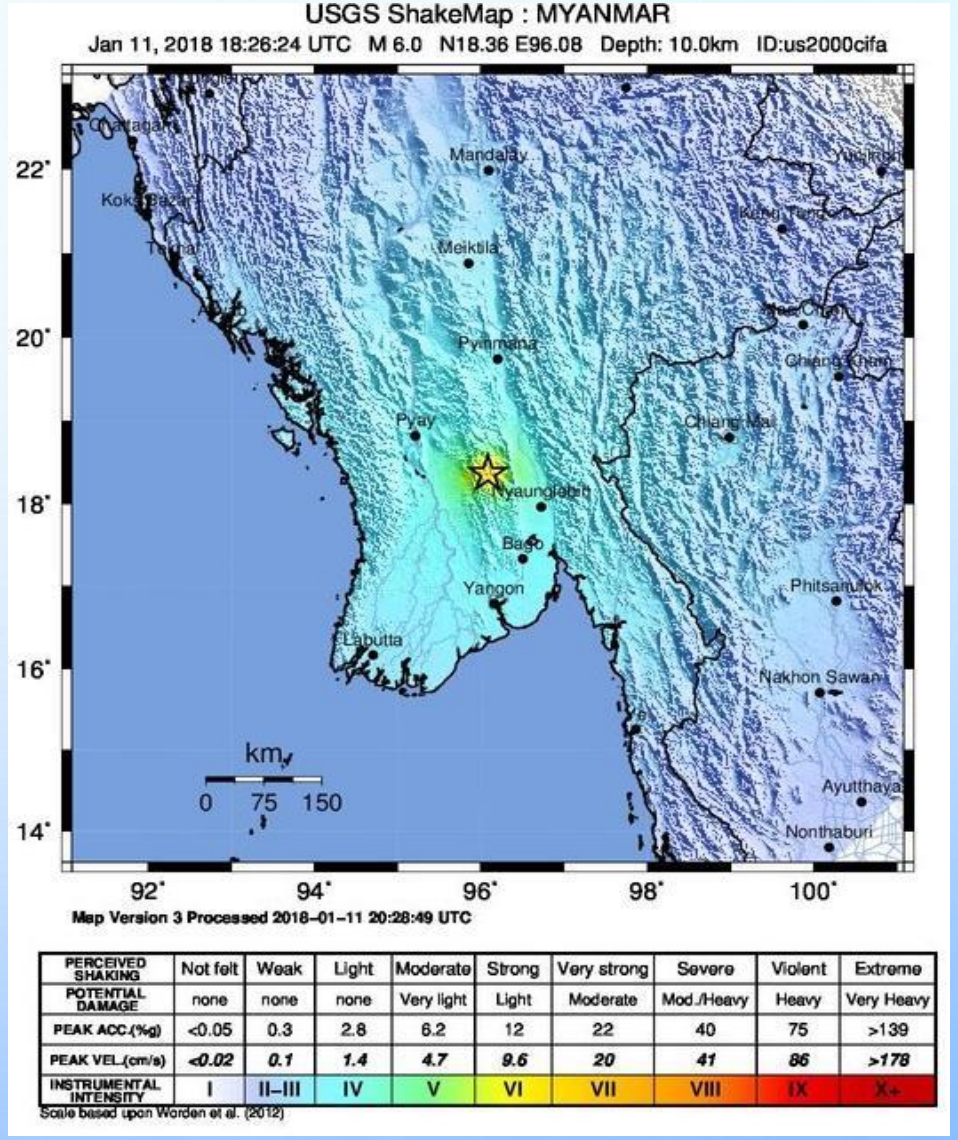
Tike Gyi Earthquake

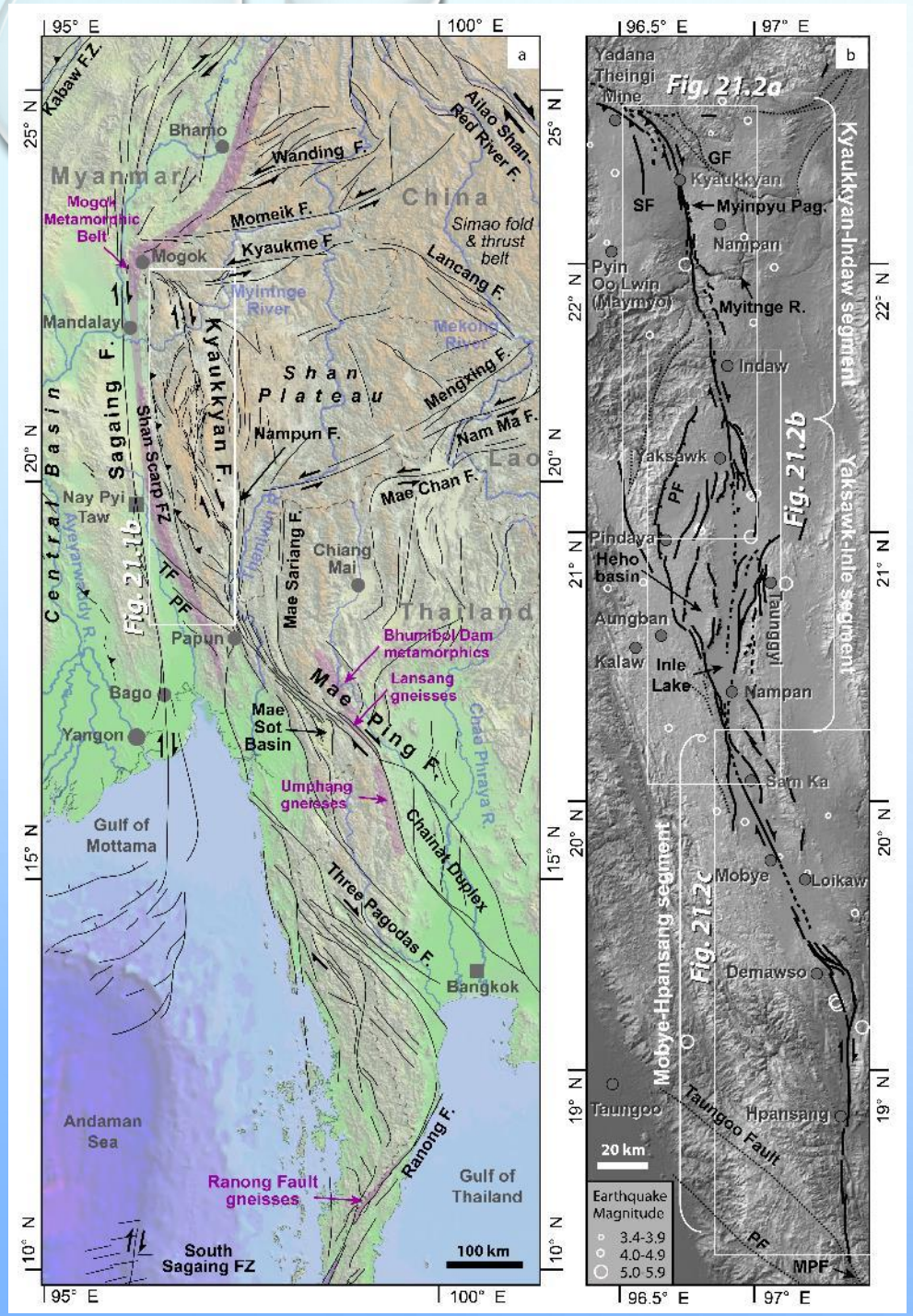
March, 13, 2017
Magnitude : 5.1
Local Time (conversion only below land) : 2017-03-13 20:49:08
GMT/UTC Time : 2017-03-13 14:19:08
Depth (Hypocenter) : 10 km

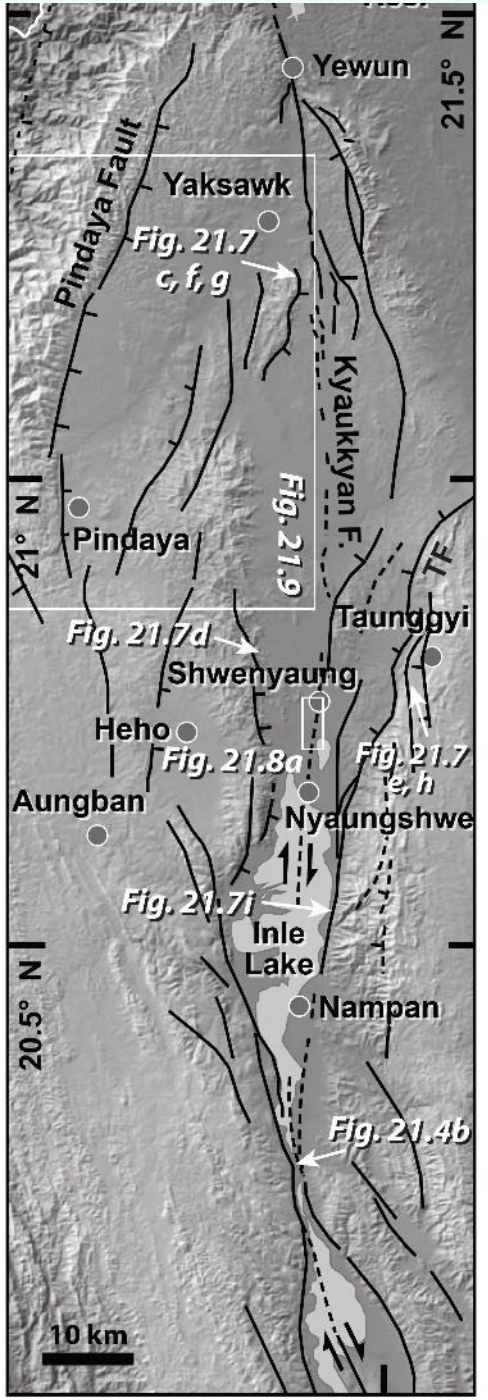
M 6.0 - 39km SWW of Pyu, Burma

2018-01-11 18:26:24 UTC18.363°N 96.080°E10.0 km depth









Maymyo Earthquake

May 23rd, 1912

Magnitude : 8.0 M

Depth (Hypocenter) : ???

- **Largest instrumentally recorded EQ in Myanmar**
- **Largest recorded strike-slip EQ on earth**

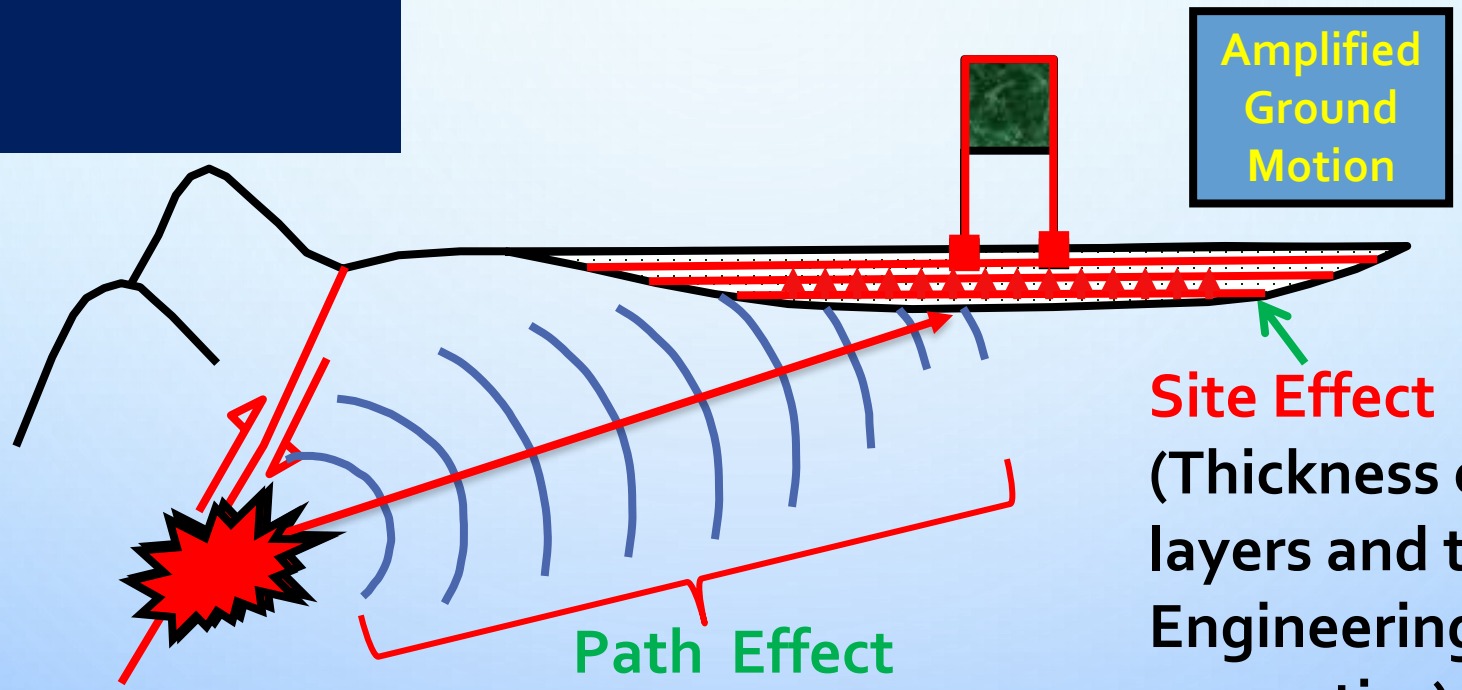
Site Effect During the Earthquake

Earthquake Effects

1. Source Effect
2. Path Effect
3. Site Effect

Site Effect

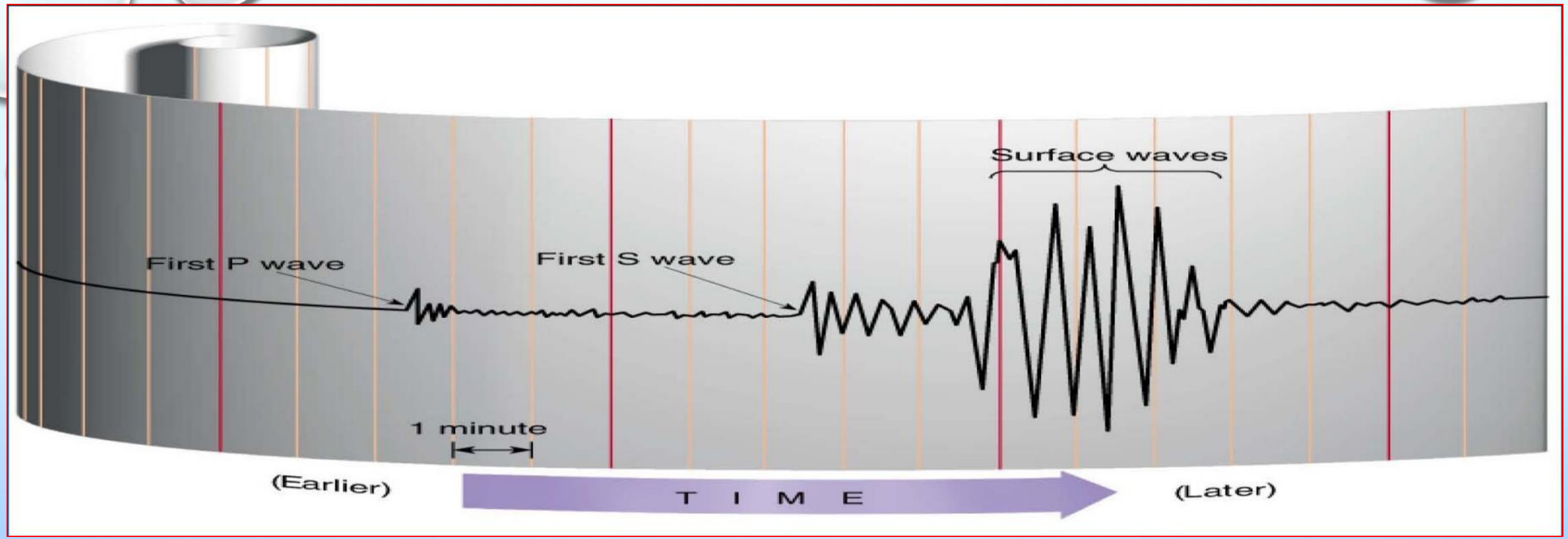
After 1985 Mexico City (8.1M)
1995 Kobe earthquake (6.9Mw)



Site Effect
(Thickness of Soil layers and their Engineering properties)

Path Effect
(Attenuation of seismic wave)

Source Effect
(Mode of faulting, Geometry, Magnitude, Seismic Moment)



P-wave arrive first

S-wave arrive second

Body Waves

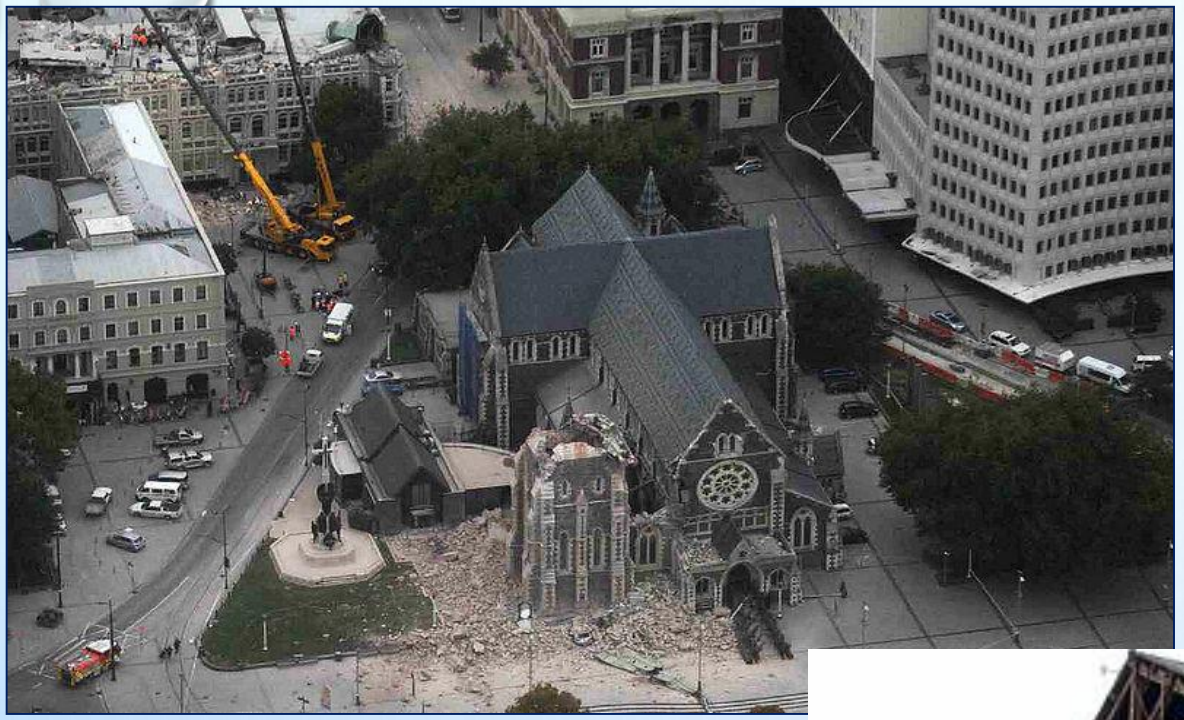
Surface waves arrive last

Seismic Wave

24 March 2010

Magnitude 6.8

TARLAY EARTHQUAKE



WORLD'S EARTHQUAKE

WORLD'S EARTHQUAKE

Site Effect Determination in West Downtown Yangon

1. Lanmataw Tsp.
2. Lathar Tsp.
3. Pabedan Tsp.
4. Kyauktada Tsp.

Microtremor: A Tool for Site Effect Determination

- **SMAR-6A3P Seismograph and LS-8800 Data Logger for Continuous Recording.**
- **GPS Time Composition and 200Hz/s Sampling for Observation.**

- **Microtremor:** low amplitude vibrations generated by natural disturbances such as wind, sea tides or by man-made origins such as traffic, industrial machinery, household appliances, etc.
- **Pioneer work:** Kanai and Tanaka (1954) - microtremors (ambient seismic noises) have been studied as a tool to estimate seismic response of underlying soil layers **(site effects).**
- It has been regarded that the fundamental resonance frequency and the period of microtremor has a reasonable relationship with the nature of local soil deposits and dynamic characteristic of the subsoil.

Lanmadaw Tsp. – 37 sites

Latha Tsp. – 19 sites

Papedan Tsp. – 20 sites

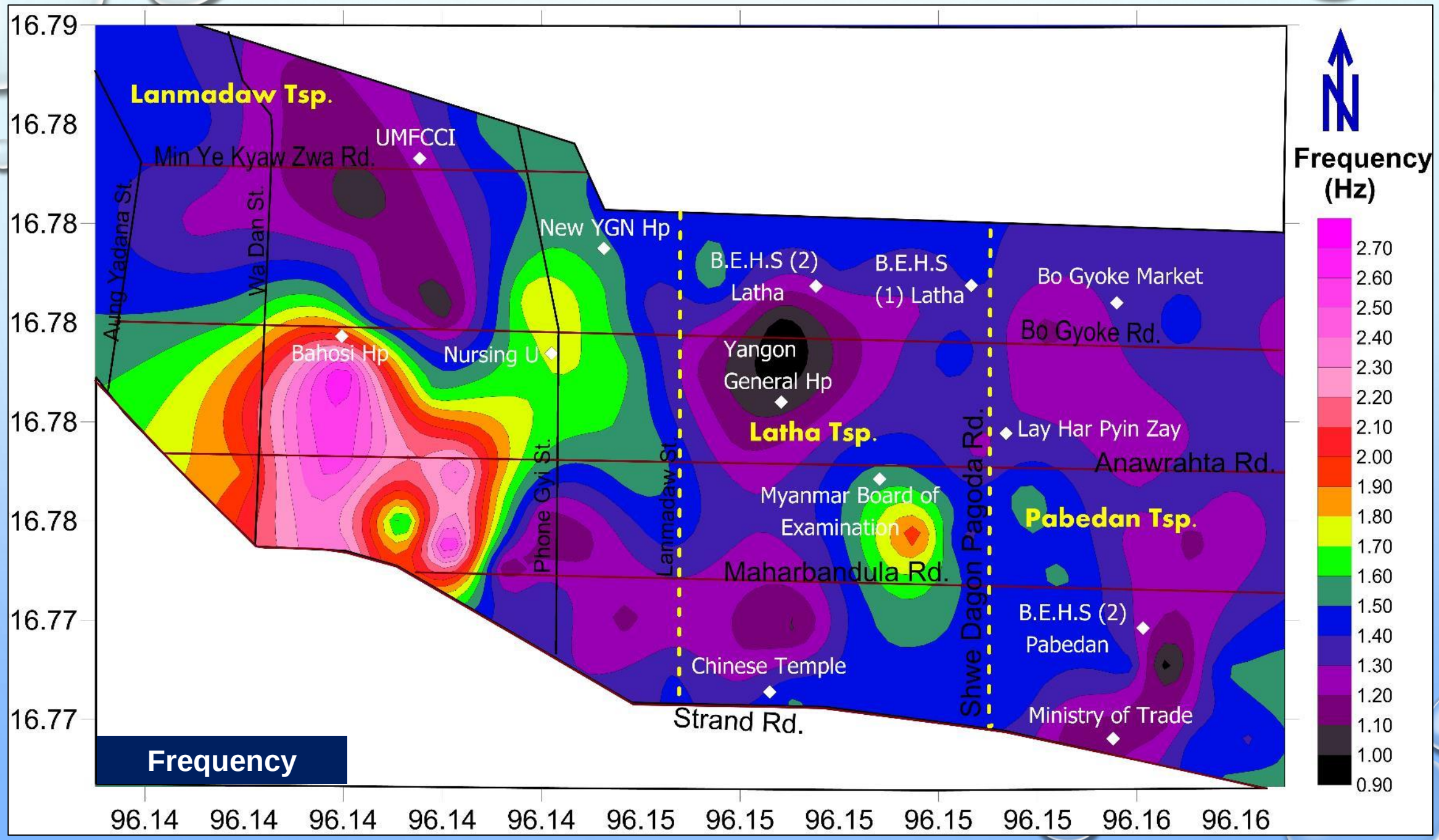
Kyauktahta Tsp. – 20 sites

Total = 164

Botahtaung Tsp. – 48 sites

Pazuntaung Tsp. – 20 sites

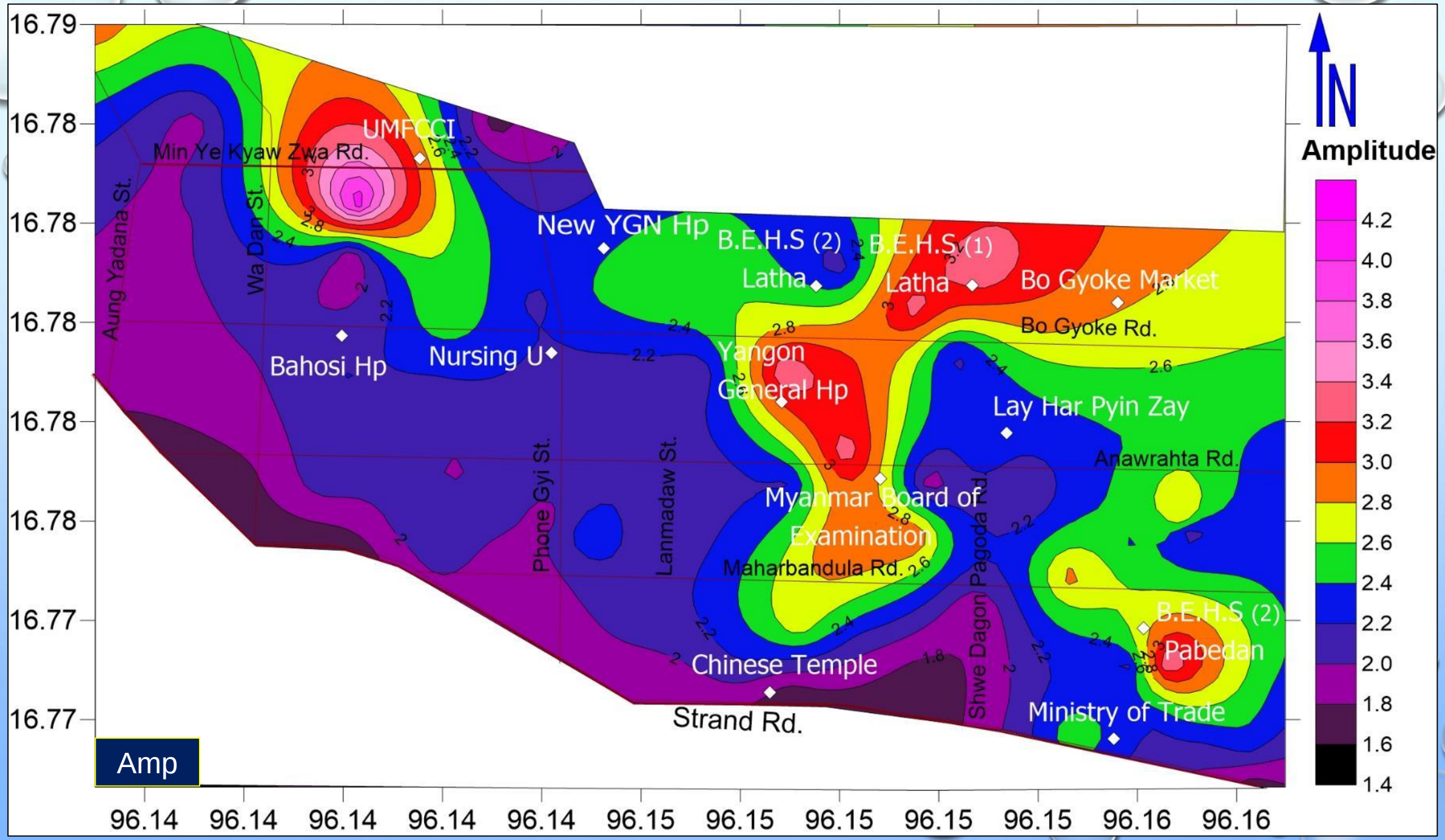
1.Frequency of Underlying Soil


Lanmadaw Tsp.
UMFCCI
Min Ye Kyaw Zwa Rd.
Aung Yadana St.
Wa Dan St.
New YGN Hp
Bahosi Hp
Nursing U
Phone Gyi St.
Lanmadaw St.
B.E.H.S (2) Latha
B.E.H.S (1) Latha
Yangon General Hp
Latha Tsp.
Myanmar Board of Examination
Maharbandula Rd.
Chinese Temple
Strand Rd.
Shwe Dagon Pagoda Rd.
Bo Gyoke Market
Bo Gyoke Rd.
Lay Har Pyin Zay
Anawrahta Rd.
Pabedan Tsp.
B.E.H.S (2) Pabedan
Ministry of Trade
Frequency
Frequency (Hz)
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
16.79
16.78
16.78
16.78
16.78
16.78
16.77
16.77
96.14
96.14
96.14
96.14
96.14
96.15
96.15
96.15
96.15
96.15
96.16
96.16

Lower Fundamental Frequency: Thicker Sediment
Higher Predominant Period
Dangerous place for High-rise Buildings

Higher Fundamental Frequency: Thinner Sediment
Lower Predominant Period
Dangerous place for Low-rise Buildings

2. Potential Soil Amplification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N
Amplitude
4.2
4.0
3.8
3.6
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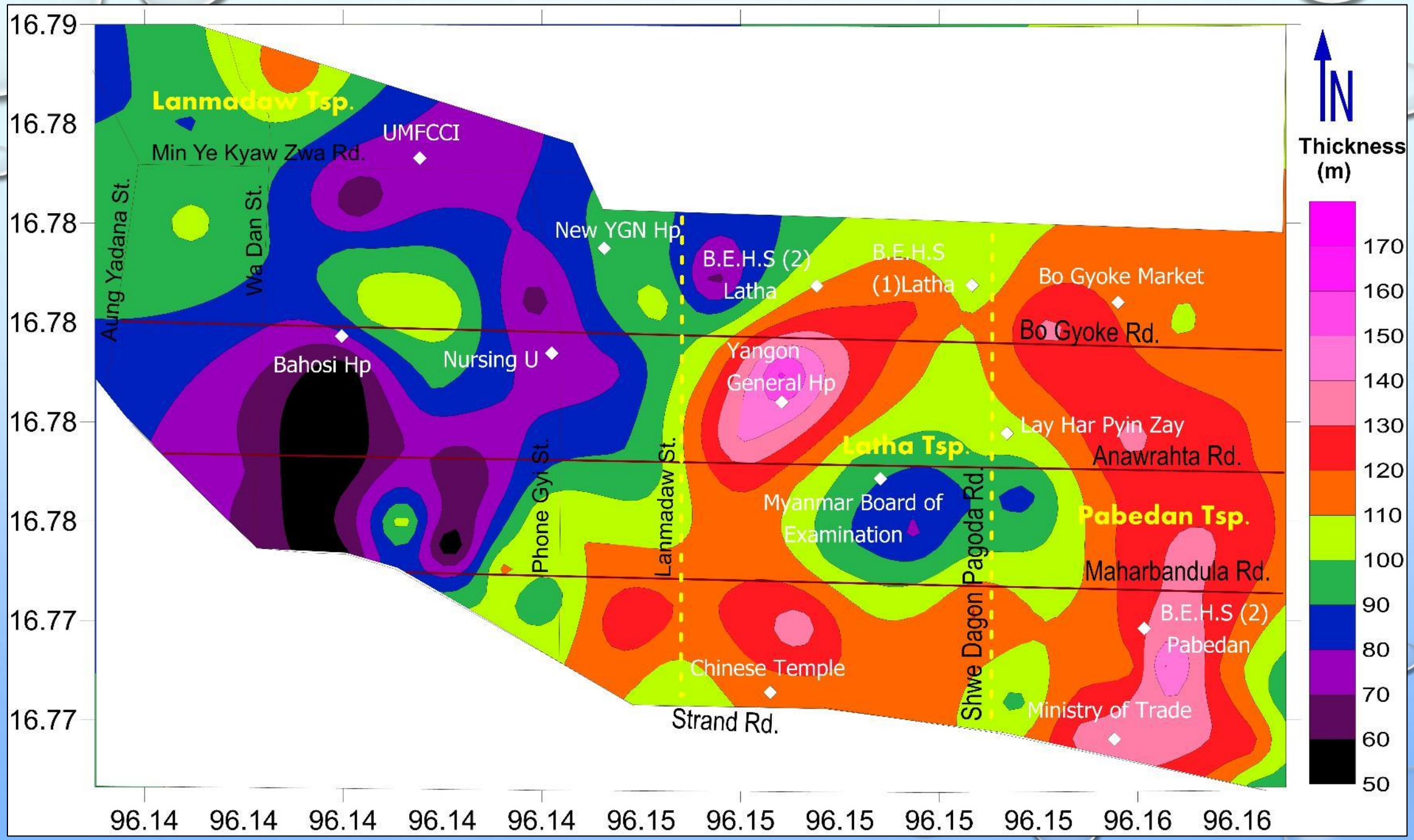
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
UMFCCI
Min Ye Kyaw Zwa Rd.
Aung Yadana St.
Wa Dan St.
New YGN Hp
B.E.H.S (2)
B.E.H.S (1)
Latha
Latha
Bo Gyoke Market
Bo Gyoke Rd.
Bahosi Hp
Nursing U
Yangon General Hp
Lay Har Pyin Zay
Anawrahta Rd.
Phone Gyi St.
Lanmadaw St.
Myanmar Board of Examination
Maharbandula Rd.
Shwe Dagon Pagoda Rd.
B.E.H.S (2)
Pabedan
Chinese Temple
Strand Rd.
Ministry of Trade
Amp

Lower Amp: Denser Sediment
Weaker Ground Motion

Higher Amp: Softer Sediment
Stronger Ground Motion

3. Potential Soil Thickness


16.79
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96.14
96.14
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96.16
96.16
Lanmadaw Tsp.
Min Ye Kyaw Zwa Rd.
UMFCCI
Aung Yadana St.
Wa Dan St.
New YGN Hp
B.E.H.S (2)
Latha
B.E.H.S
(1)Latha
Bo Gyoke Market
Bo Gyoke Rd.
Bahosi Hp
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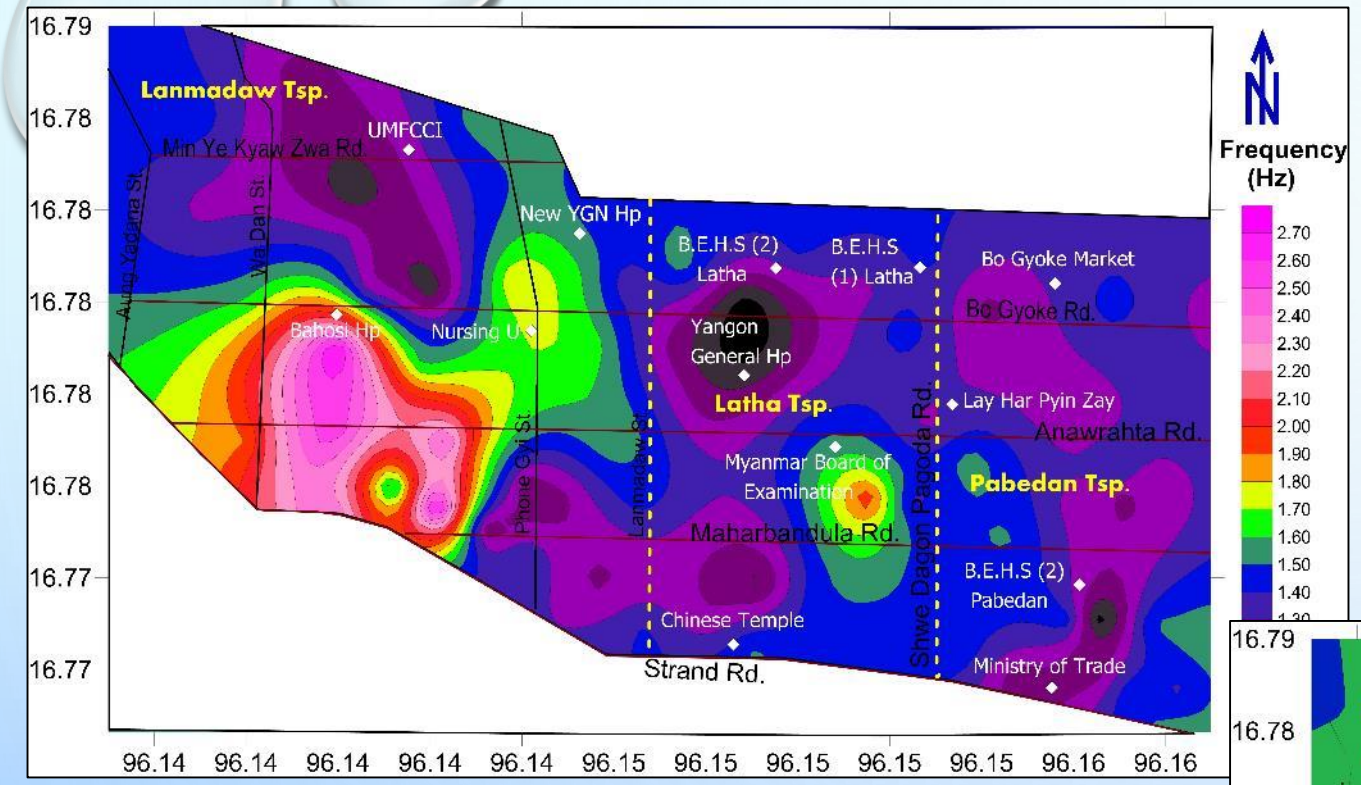
Latha Tsp.
Phone Gyi St.
Lanmadaw St.
Myanmar Board of
Examination
Shwe Dagon Pagoda Rd.
Pabedan Tsp.
Maharbandula Rd.
B.E.H.S (2)
Pabedan
Chinese Temple
Ministry of Trade
Strand Rd.
N
Thickness
(m)
170
160
150
140
130
120
110
100
90
80
70
60
50


Lanmadaw Tsp.
UMFCCI
Min Ye Kyaw Zwa Rd.
New YGN Hp
B.E.H.S (2) Latha
B.E.H.S (1) Latha
Bo Gyoke Market
Bo Gyoke Rd.
Bahosi Hp
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Yangon General Hp
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Anawrahta Rd.
Myanmar Board of Examination
Pabedan Tsp.
Maharbandula Rd.
B.E.H.S (2) Pabedan
Chinese Temple
Ministry of Trade
Strand Rd.
Aung Yadana St.
Wa Dan St.
Phone Gyi St.
Lanmadaw St.
Shwe Dagon Pagoda Rd.
Frequency (Hz)
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
1.90
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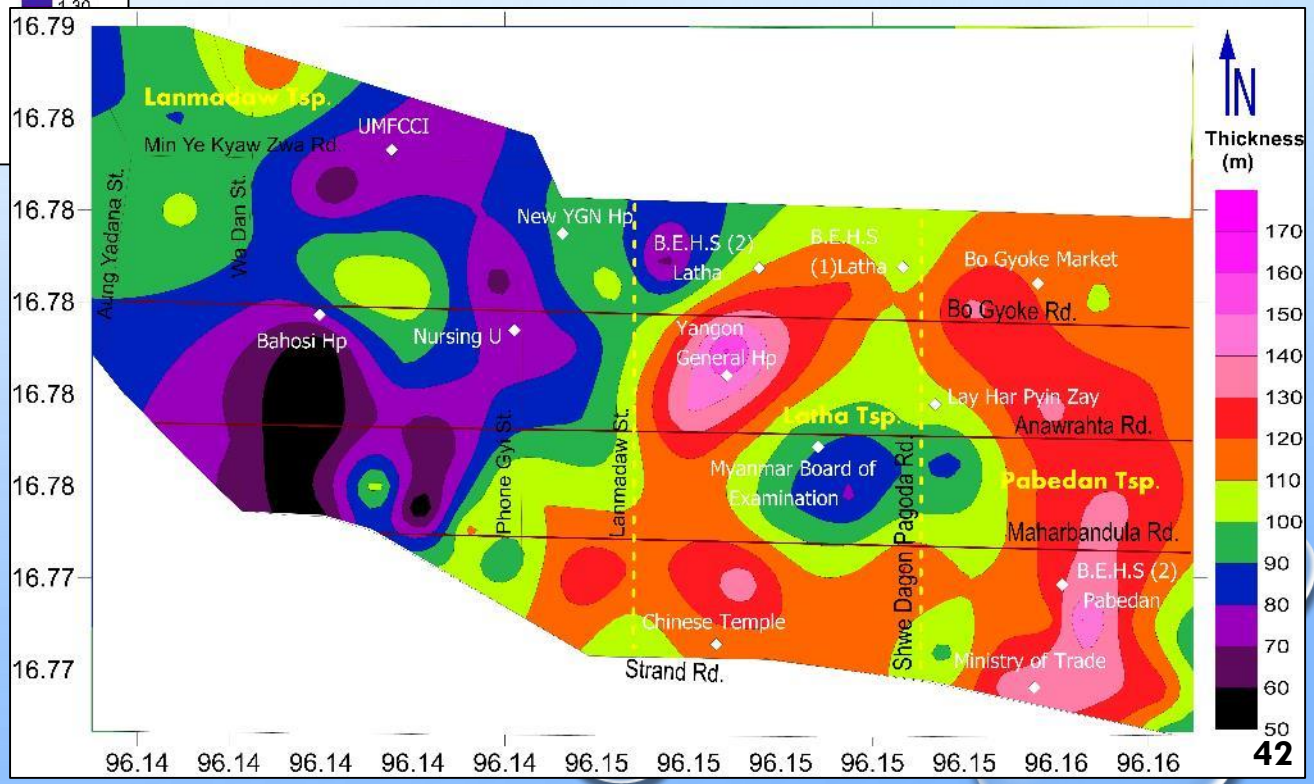
1.60
1.50
1.40
16.79
16.78
16.77
96.14
96.15
96.16


Lanmadaw Tsp.
UMFCCI
Min Ye Kyaw Zwa Rd.
New YGN Hp
B.E.H.S (2) Latha
B.E.H.S (1)Latha
Bo Gyoke Market
Bo Gyoke Rd.
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Chinese Temple
Ministry of Trade
Strand Rd.
Aung Yadana St.
Wa Dan St.
Phone Gyi St.
Lanmadaw St.
Shwe Dagon Pagoda Rd.
Thickness (m)
170
160
150
140
130
120
110
100
90
80
70
60
50
16.79
16.78
16.77
96.14
96.15
96.16

Build

Thicker Sediment:

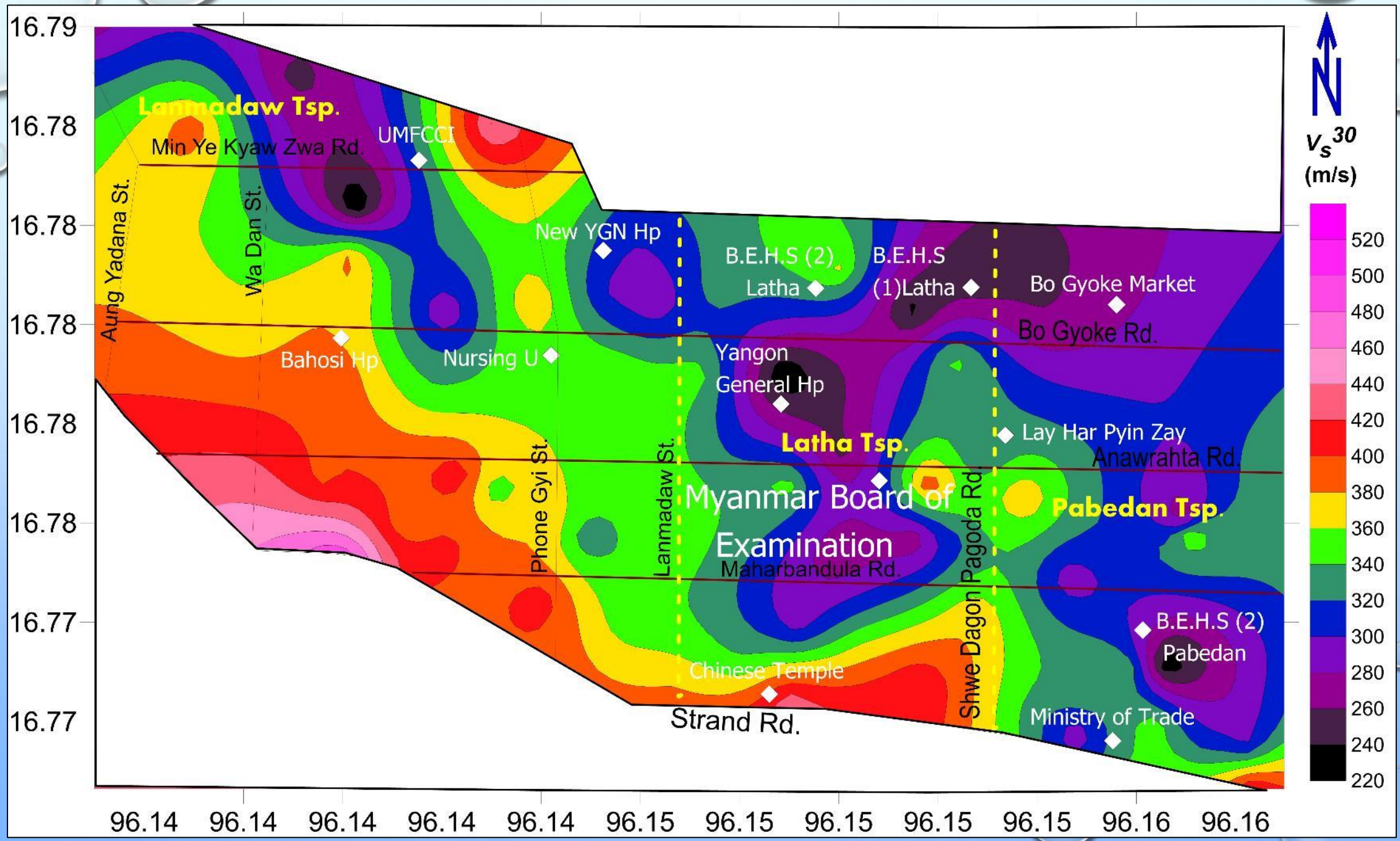
Higher Predominant Period
Dangerous place for High-rise Buildings

Thinner Sediment:

Lower Predominant Period
Dangerous place for Low-rise Buildings

4. *Vs30*

Average Shear Wave Velocity of upper 30m depth of underlying soil


16.79
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Lanmadaw Tsp.
Min Ye Kyaw Zwa Rd.
UMFCCI
Aung Yadana St.
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B.E.H.S (2) Latha
B.E.H.S (1)Latha
Bo Gyoke Market
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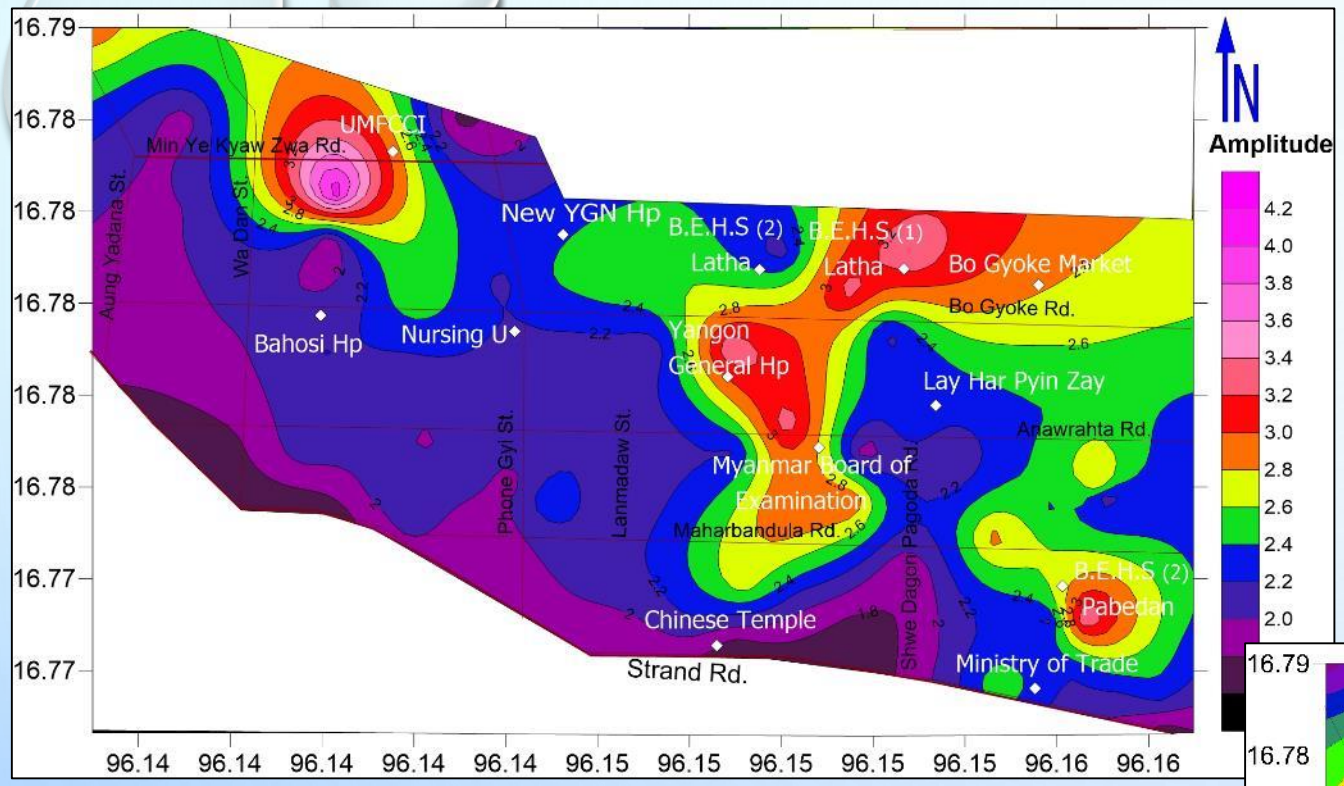
Myanmar Board of Examination
Maharbandula Rd.
Pabedan Tsp.
Shwe Dagon Pagoda Rd.
B.E.H.S (2) Pabedan
Chinese Temple
Strand Rd.
Ministry of Trade
96.14
96.14
96.14
96.14
96.14
96.15
96.15
96.15
96.15
96.15
96.16
96.16
N
$V_S{}^{30}$ (m/s)
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220


N
Amplitude
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
16.79
16.78
16.78
16.78
16.78
16.78
16.77
16.77
96.14
96.14
96.14
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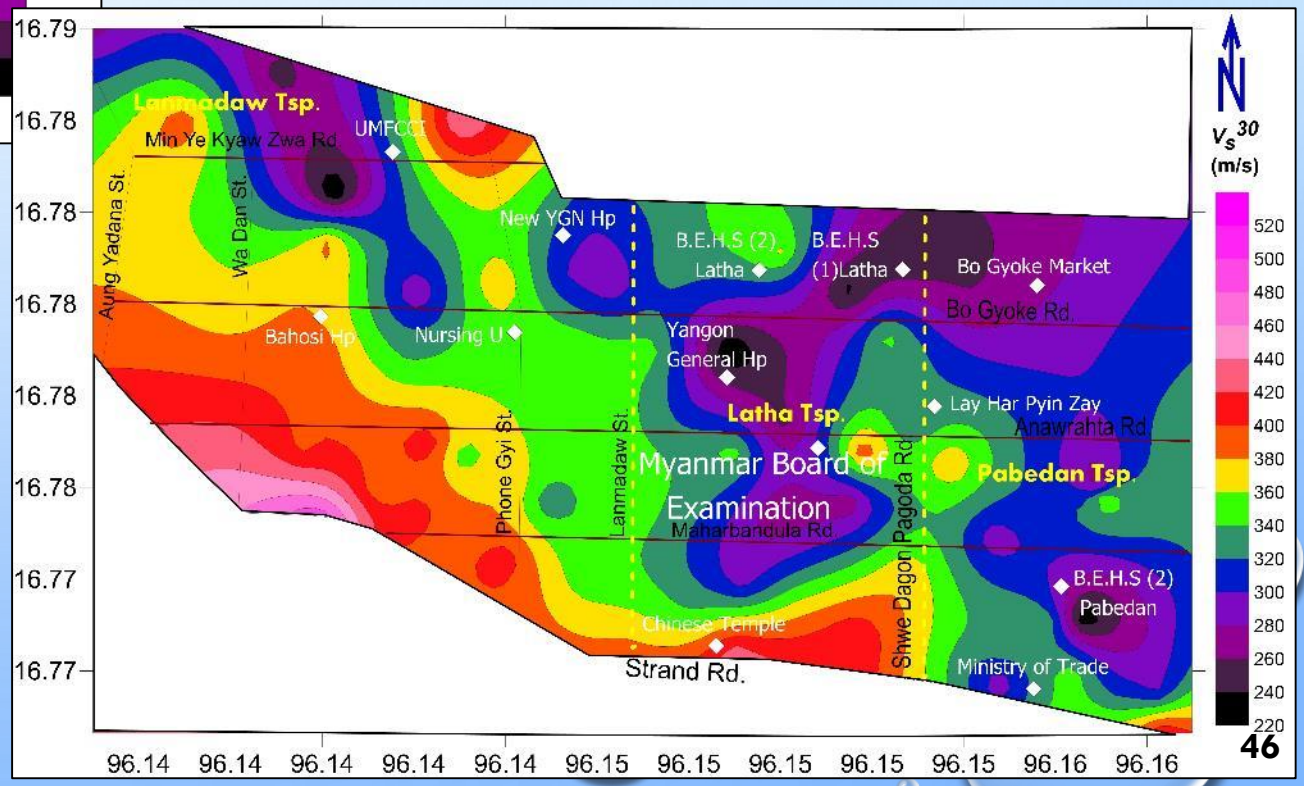
96.16
96.16
UMFCCI
Min Ye Kyaw Zwa Rd.
New YGN Hp
B.E.H.S (2)
B.E.H.S (1)
Latha
Latha
Bo Gyoke Market
Bo Gyoke Rd.
Bahosi Hp
Nursing U
Yangon General Hp
Lay Har Pyin Zay
Anawrahta Rd.
Myanmar Board of Examination
Maharbandula Rd.
B.E.H.S (2)
Pabedan
Chinese Temple
Ministry of Trade
Strand Rd.
Aung Yadana St.
Wa Dan St.
Phone Gyi St.
Lanmadaw St.
Shwe Dagon Pagoda Rd.


N
V_s30 (m/s)
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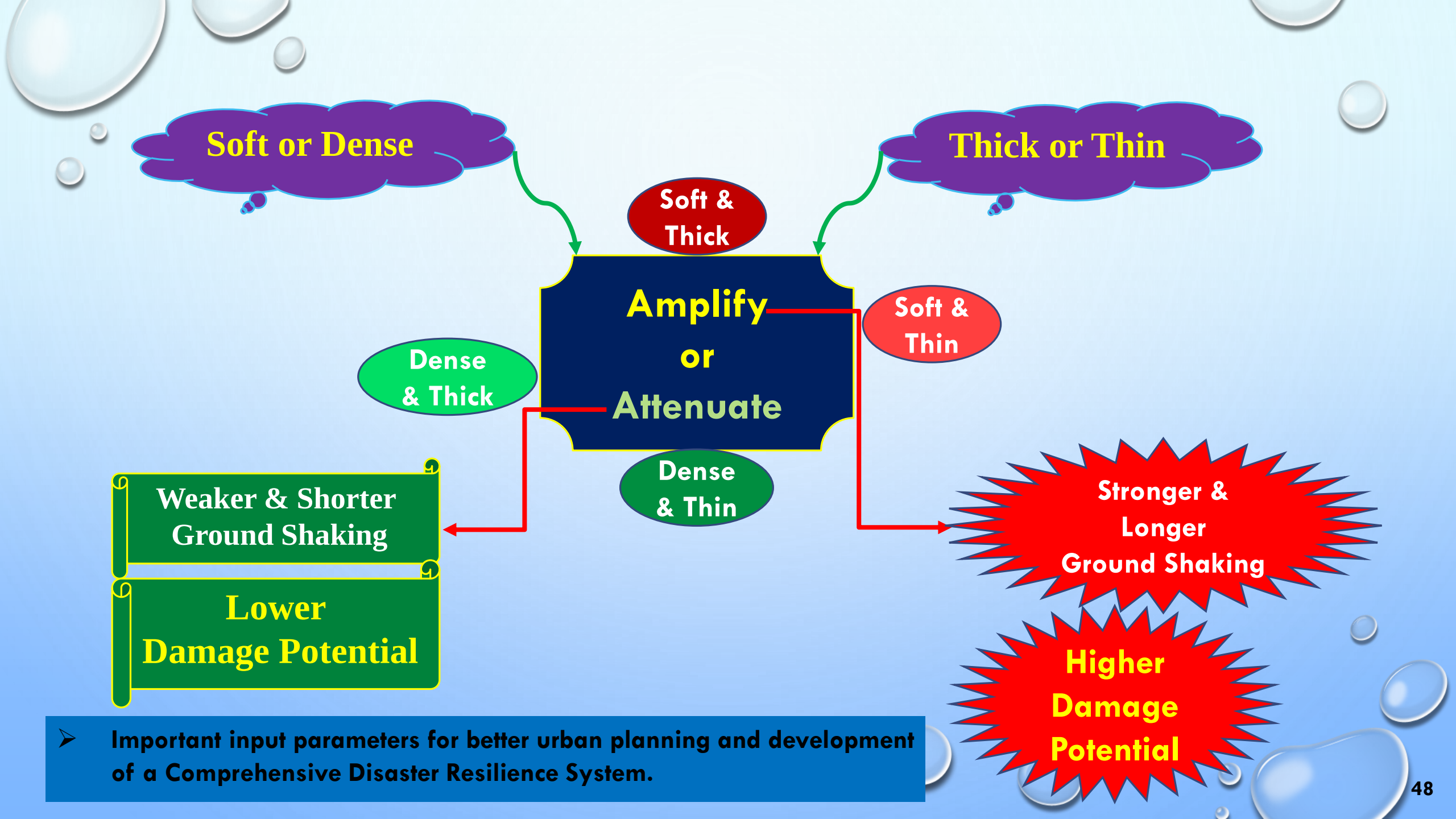
Lanmadaw Tsp.
Min Ye Kyaw Zwa Rd.
UMFCCI
New YGN Hp
B.E.H.S (2)
Latha
B.E.H.S (1)Latha
Bo Gyoke Market
Bo Gyoke Rd.
Bahosi Hp
Nursing U
Yangon General Hp
Latha Tsp.
Lay Har Pyin Zay
Anawrahta Rd.
Myanmar Board of Examination
Maharbandula Rd.
Pabedan Tsp.
B.E.H.S (2)
Pabedan
Chinese Temple
Ministry of Trade
Strand Rd.
Aung Yadana St.
Wa Dan St.
Phone Gyi St.
Lanmadaw St.
Shwe Dagon Pagoda Rd.

Conclusion



- Important input parameters for better urban planning and development of a Comprehensive Disaster Resilience System.

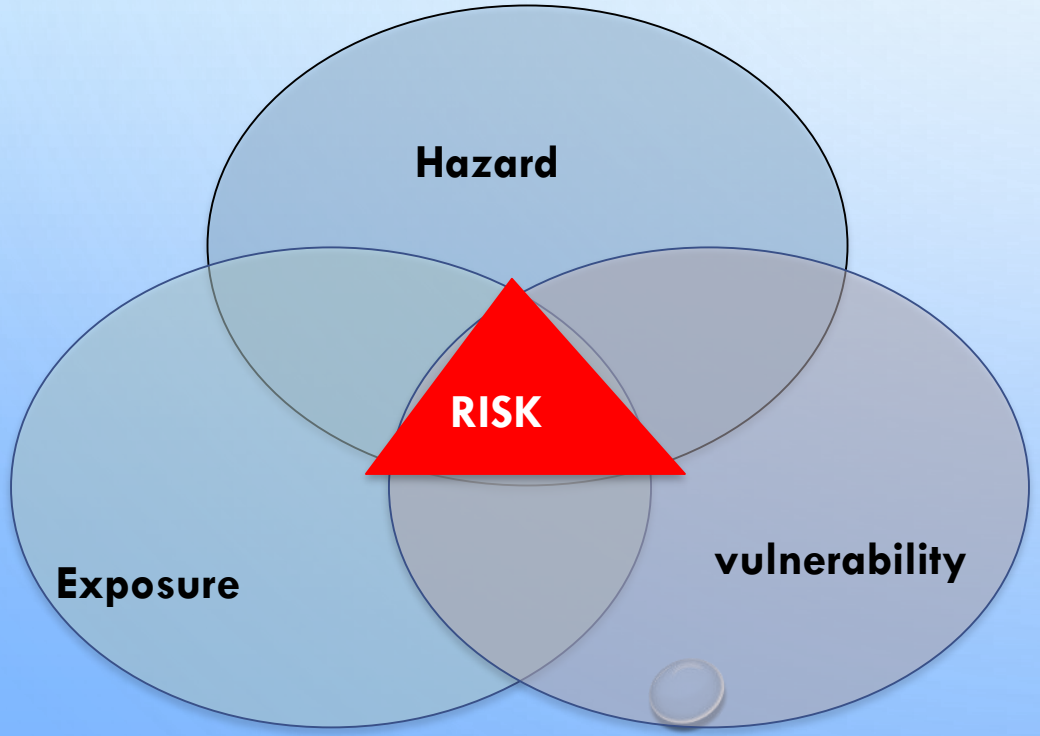
Applicability of Outcomes

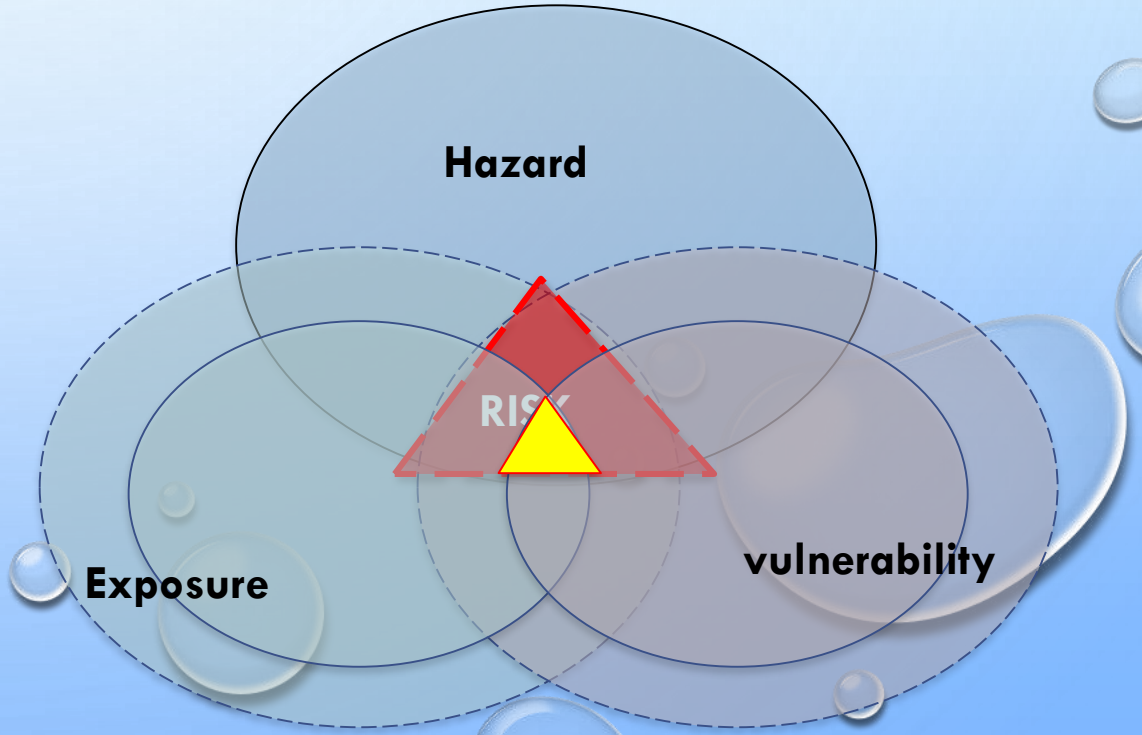
Main Input Data for Disaster Management System

Applicability of Outcomes

Risk Analysis and Mitigation

RISK = Hazard x Exposure x Vulnerability






Thank
you!!