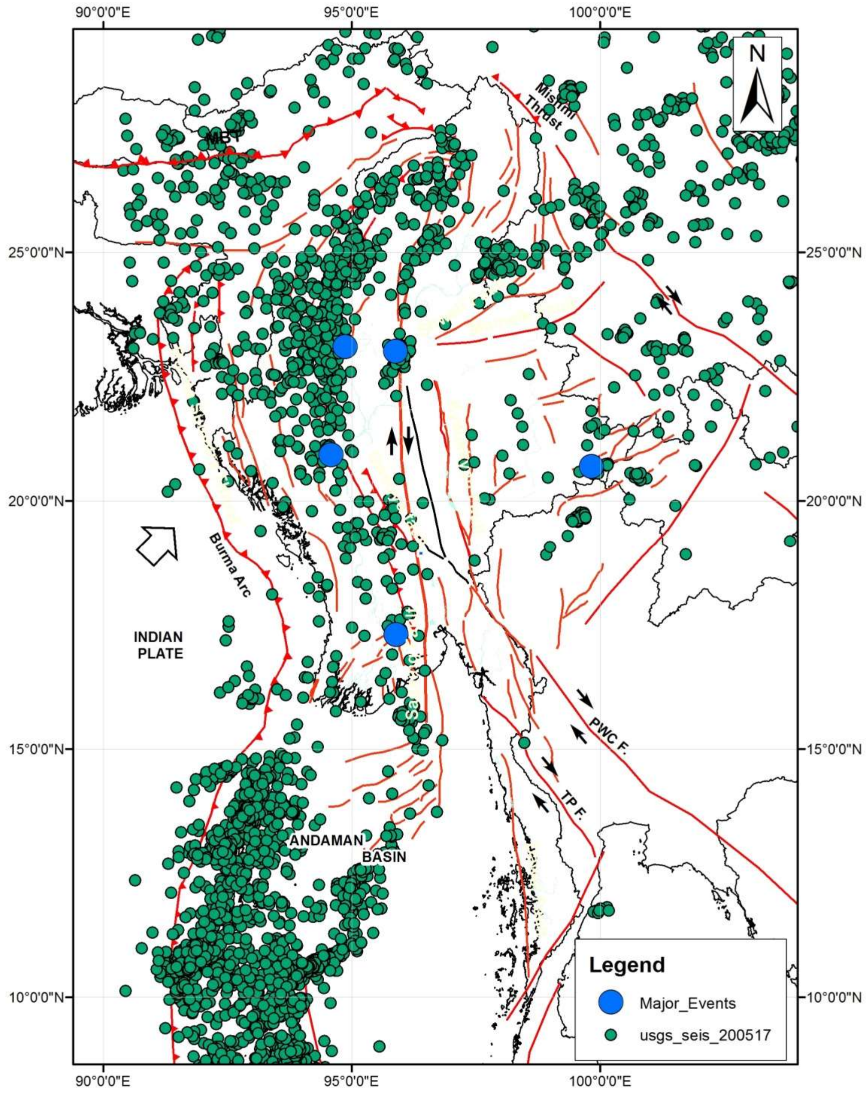
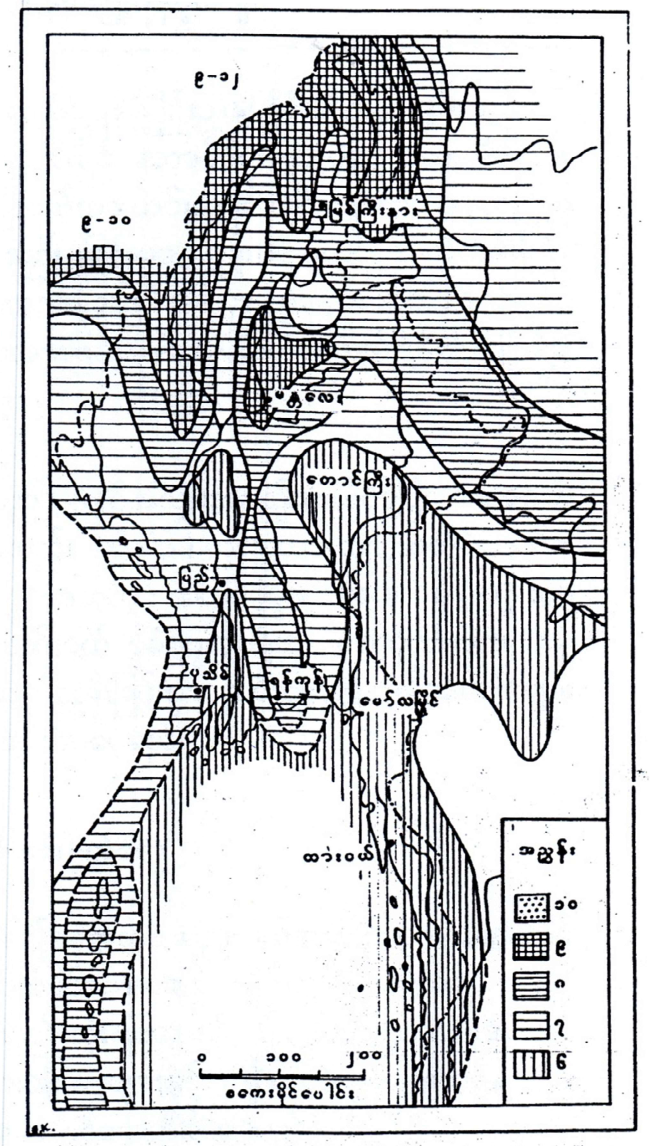
Evolution of Earthquake Maps in Myanmar (Deterministic and PSHA)



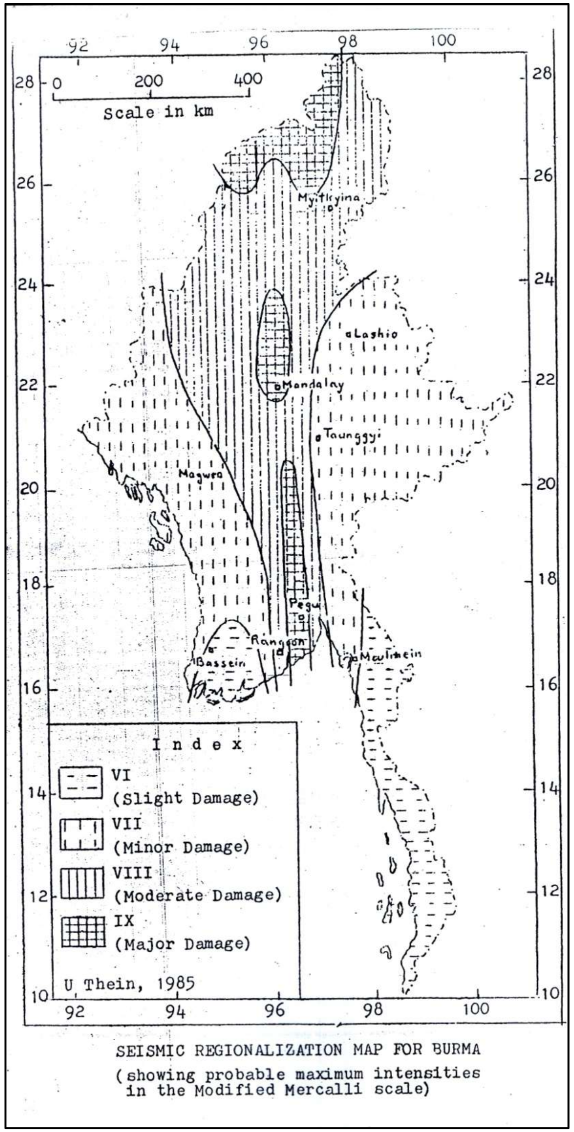
Outcomes of Presentation

- How hazard maps perform
- To understand hazard mapping used available data including the limitation of historical records in short span of time period
- PSHA addresses how strongly and how often the earthquake will shake
- PSHA combine earthquake size, location, pb of occurrence and the result in term of ground motion and Associated annual probability of occurrence (or exceedances)
- PSHA uses estimates of the probability of future earthquakes and the resulting shaking to predict the shaking expected with a probability over a given time period

Deterministic Seismic Hazard Analysis (DSHA)



Gorshkov 1959
(Prof. from Moscow Unv.)



Maung Thein (1985)
Map:Modified Mercalli Scale

Modified Mercalli Scale

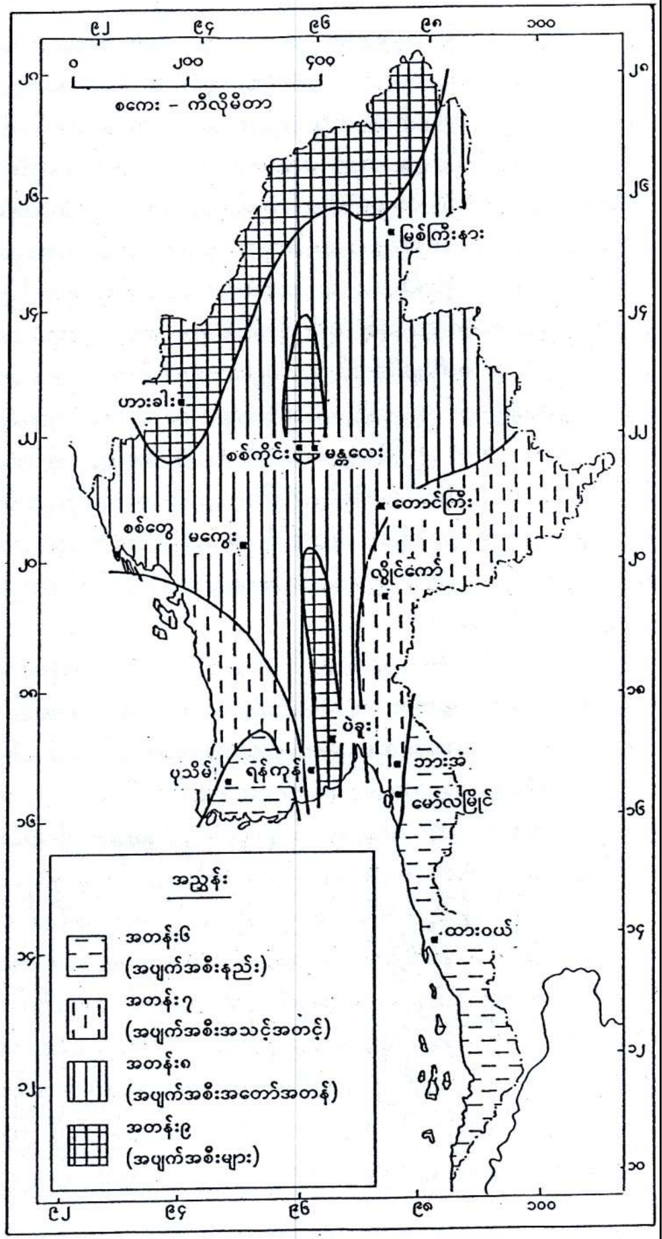
ivsifjyif;xeftm;(Intensity) ukdwkdif;wmjcif;

Modified Mercalli Scale	
I	Detected only by sensitive instruments
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibration like passing truck
IV	Felt indoors by many, outdoors by few, at night some may awaken; dishes, windows, doors disturbed; motor cars rock noticeably
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of automobiles
VIII	Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air

Richter Magnitude Scale

1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8

Deterministic Seismic Hazard Analysis (DSHA) Map



ပုံ-၂။ မြန်မာနိုင်ငံ၏ငလျင်အန္တရာယ်ပြမြေပုံ။
(ဒေသအလိုက် အမြင့်ဆုံးခံရဖွယ်ရှိသော ပြင်းထန်အားများကို
ပြင်ထားမာကယ်လီစကေး (MM) အတန်းများဖြင့်ပြထားသည်။)

- Intensity
- Active faults
- Earthquake scenario
- **Modified Mercalli Scale**

Maung Thein (2001)

Deterministic Seismic Hazard Analysis (DSHA)

Maung Thein (2003)

Map: PGA-MM scale

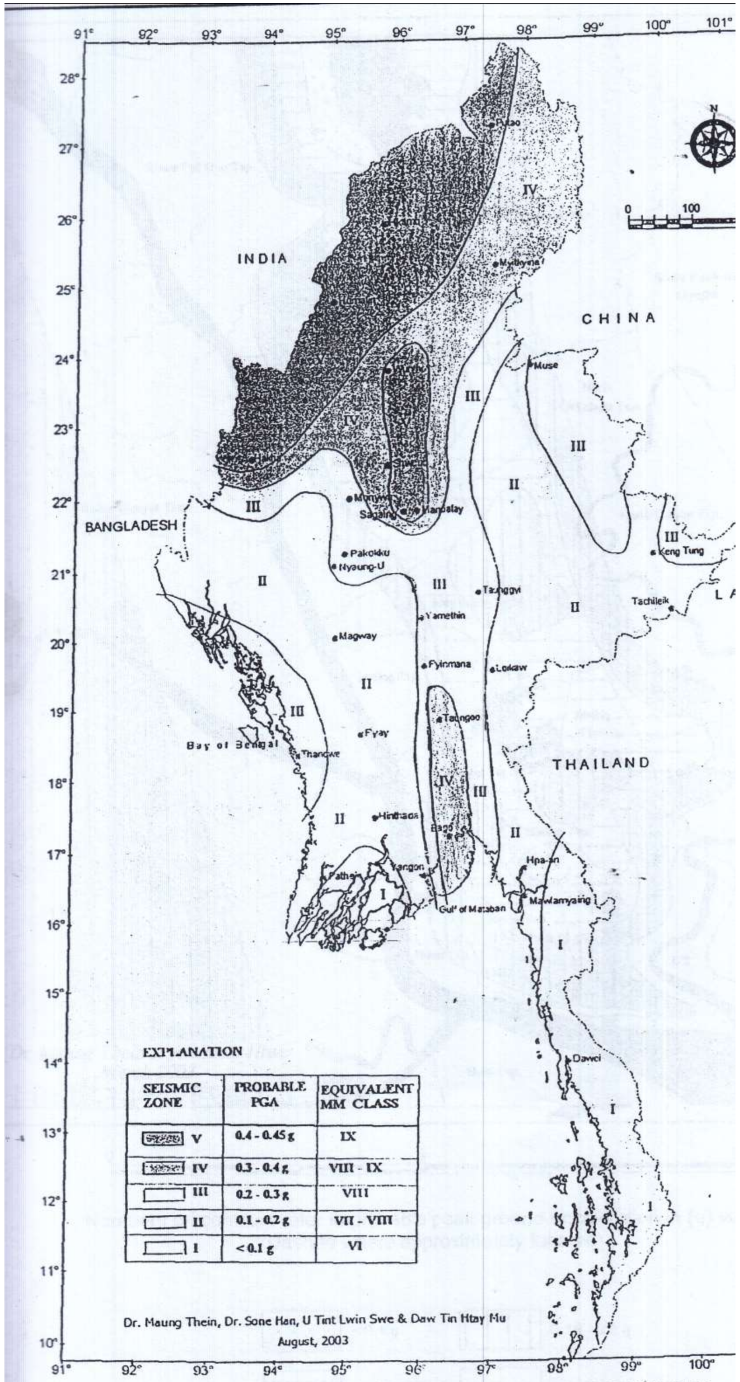
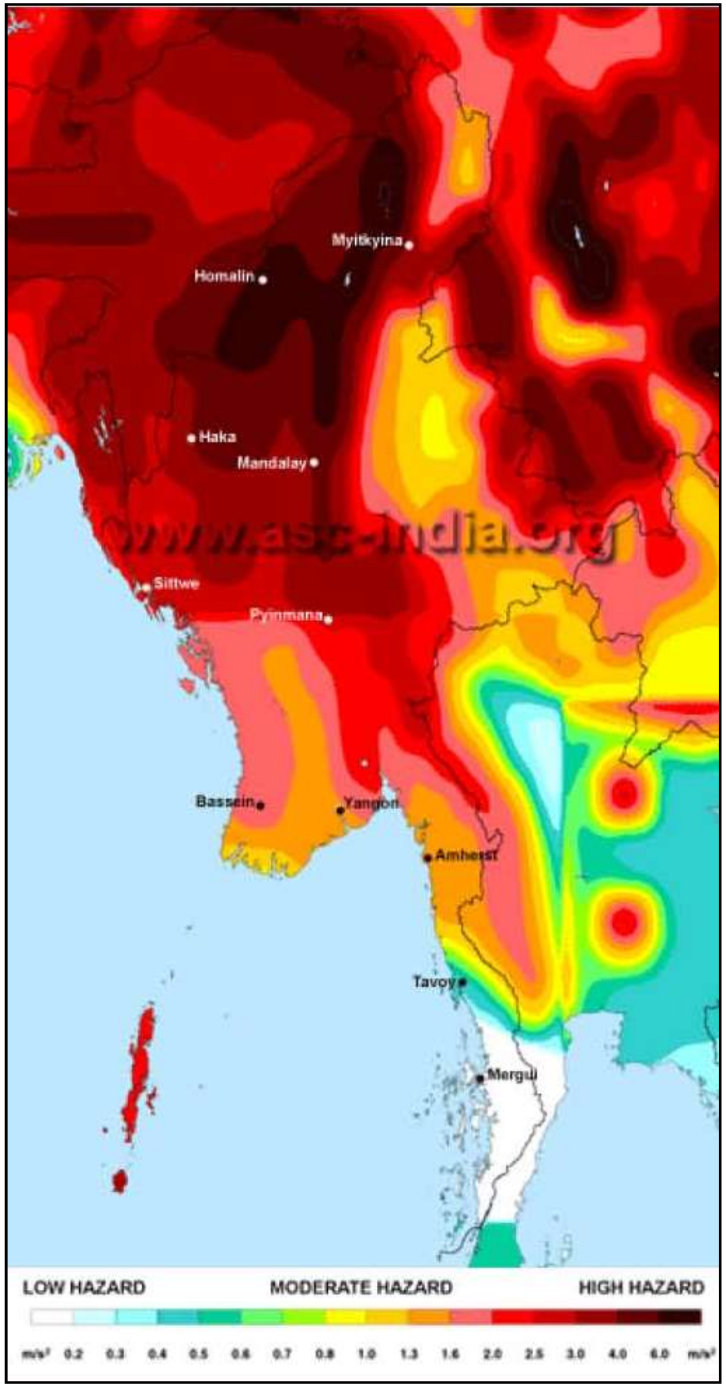


Figure 1. SEISMIC ZONE MAP OF MYANMAR
(Shown with probable maximum intensities in g values)

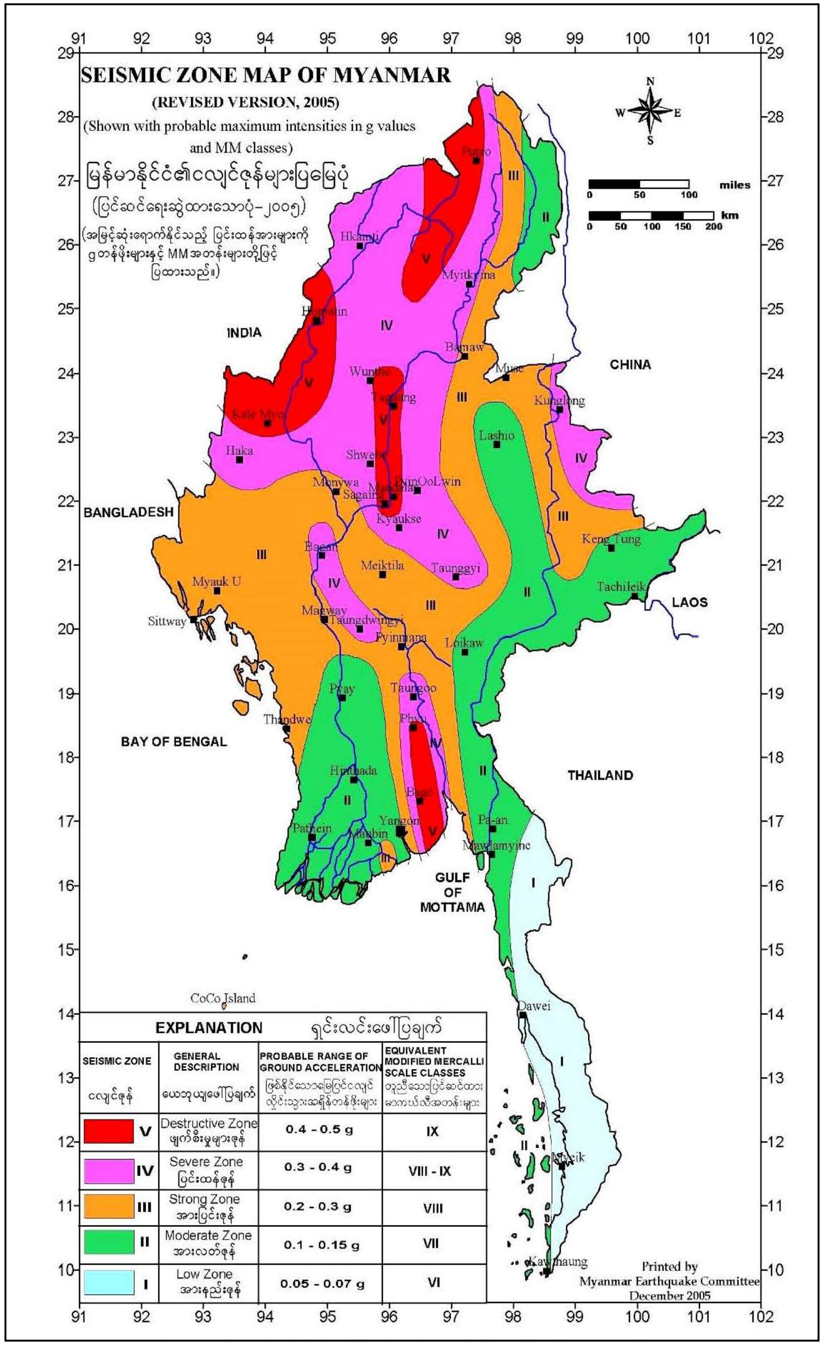
Probable PGA value

Equivalent MM class

Global Seismic Hazard Assessment Program (GSHAP)



The Asia seismic hazard map of Myanmar for 10% probability of exceedance in 50 years, compiled from the Global Seismic Hazard Assessment Program (GSHAP). Maung Thein and Tint Lwin Swe (2005)



Deterministic Seismic Hazard Analysis (DSHA) Map

- Seismotectonic conditions
- Epicenter
- Intensity, damage. Loss of lives
- Previous earthquakes
- Calculated PGA and MM class

Maung Thein et.al (2005)

Procedures of PSHA Based on the concepts of (Cornell, 1968, McGuire, 1976, Reiter, 1990 and Kramer, 1996)

***1.Identification and characterization of earthquake sources*:**

2.Calculation of the seismic occurrence parameters for each

***3.Developing the attenuation relation*:**

***4.Integration of variables to estimate the seismic hazard*:**

Calculation of the Event Rate

Probability of the Event Magnitude

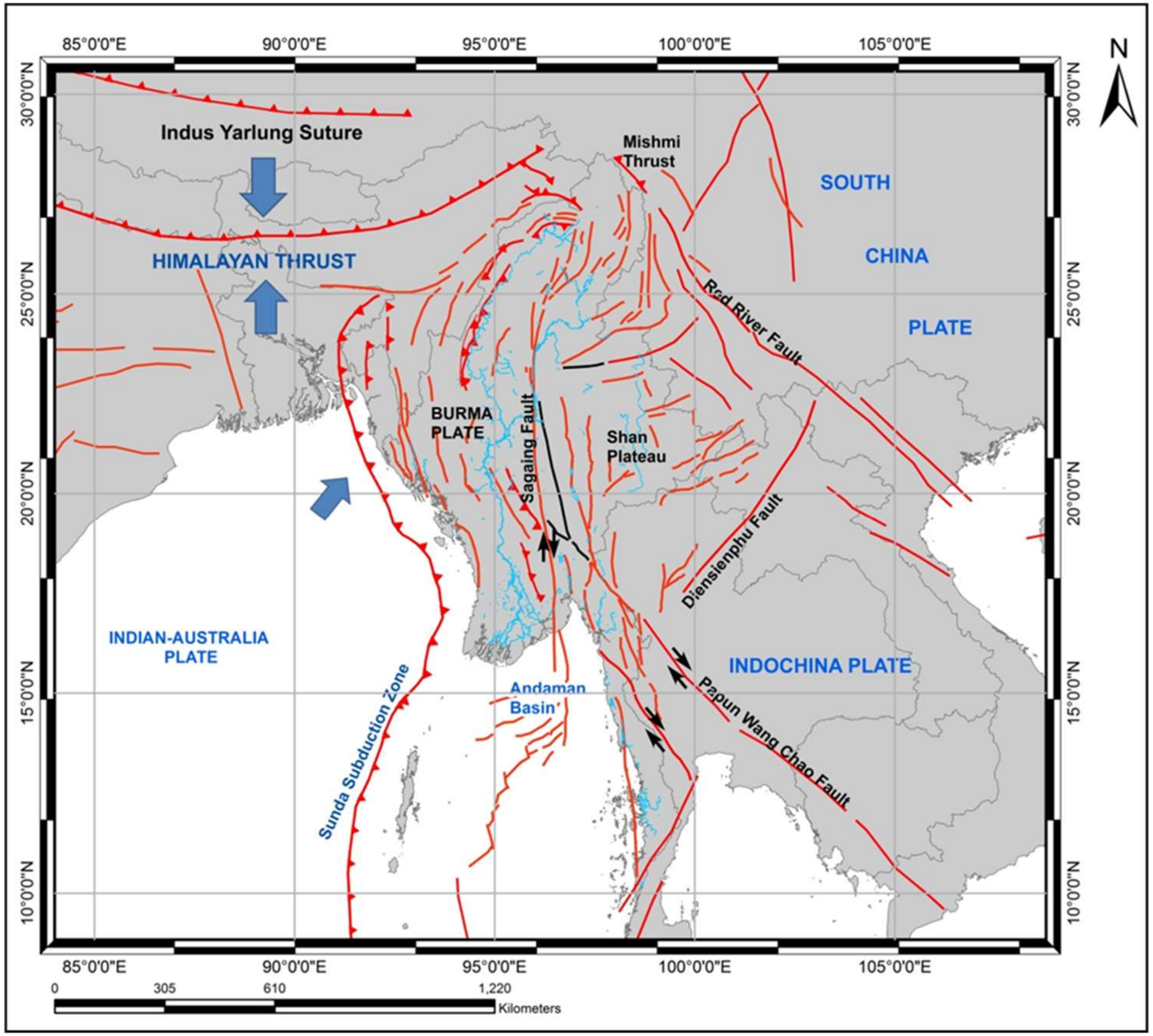
Probability for the Source-to-site Distance

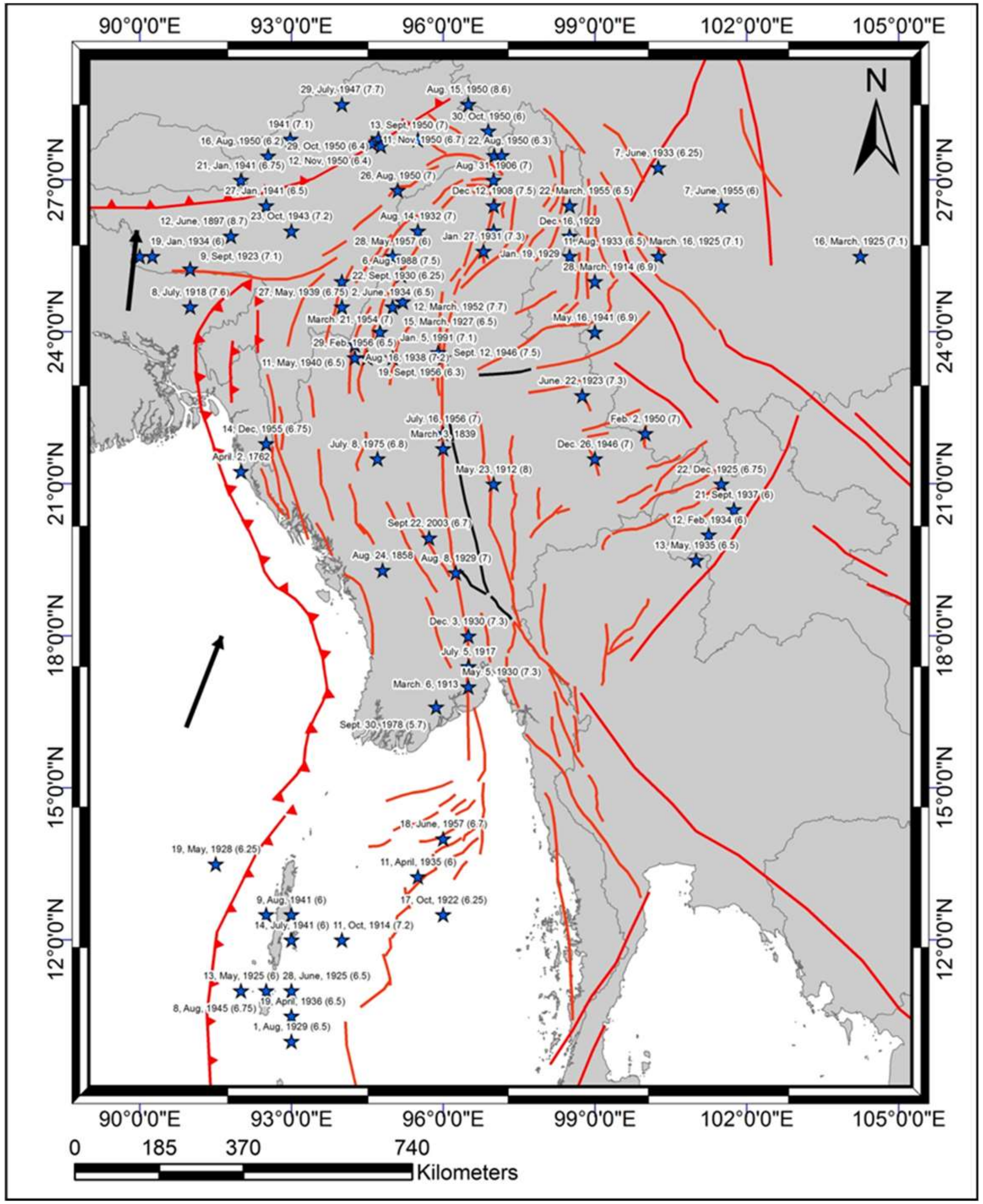
Probability for Ground Motion Parameter

Probability for Exceedance

Regional Tectonic Setting

- Subduction rate 36 mm/year





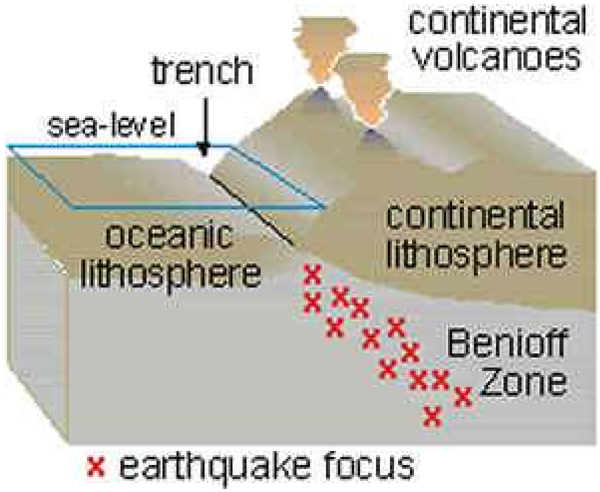
Map of the epicentral distribution of the most significant earthquakes

Accommodation of plate motion stress on the Sagaing fault and subduction, high level seismicity in Wadati-Benioff zone geometry.

60% of the motion is accommodated on the Sagaing fault based on (GPS) surveys

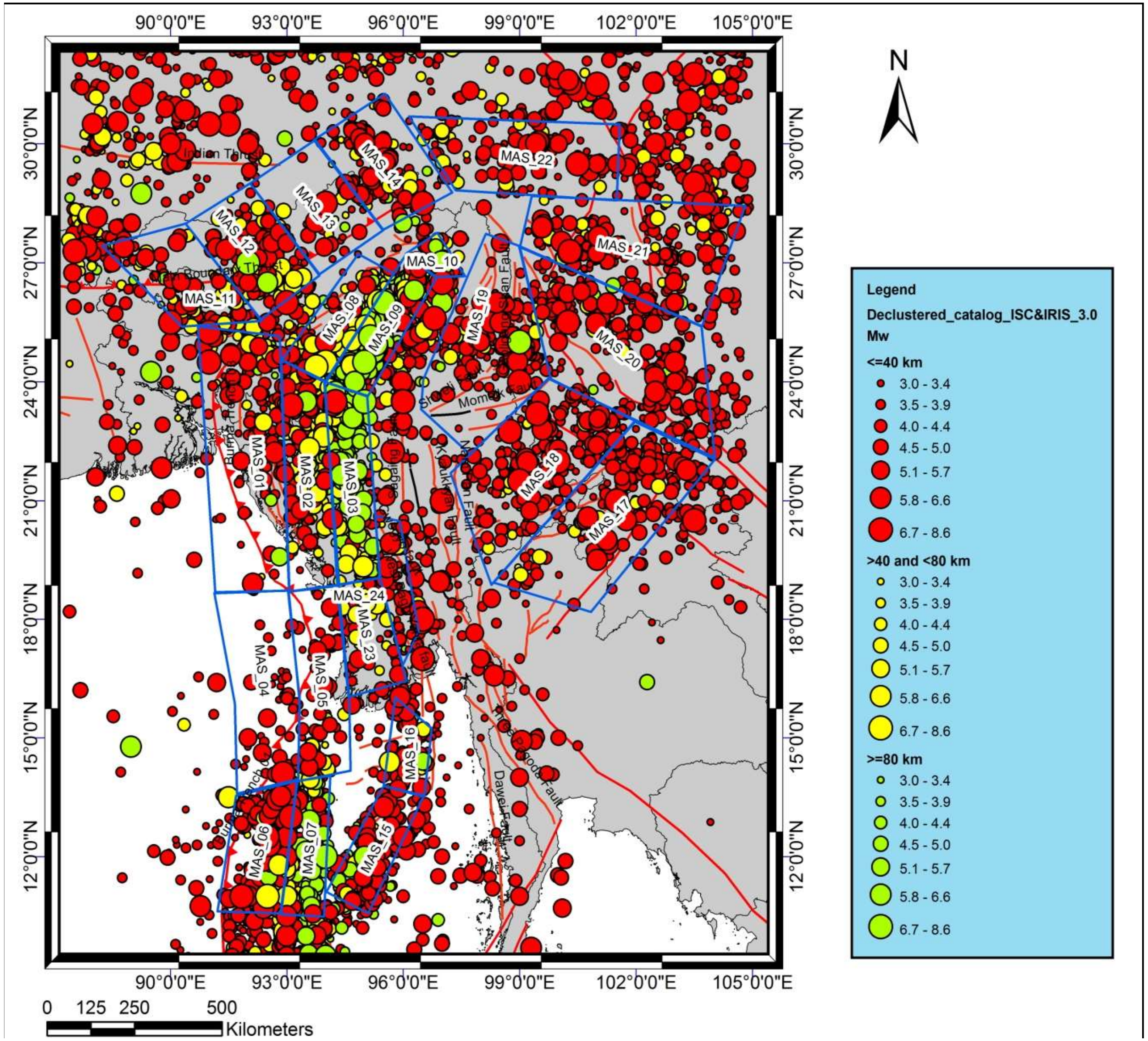
East dipping Benioff zone that extends to a depth of 180 km

crustal seismic zone continues 60 – 80 km east of the Benioff zone



Picture Source USGS

Identification of Seismic Sources

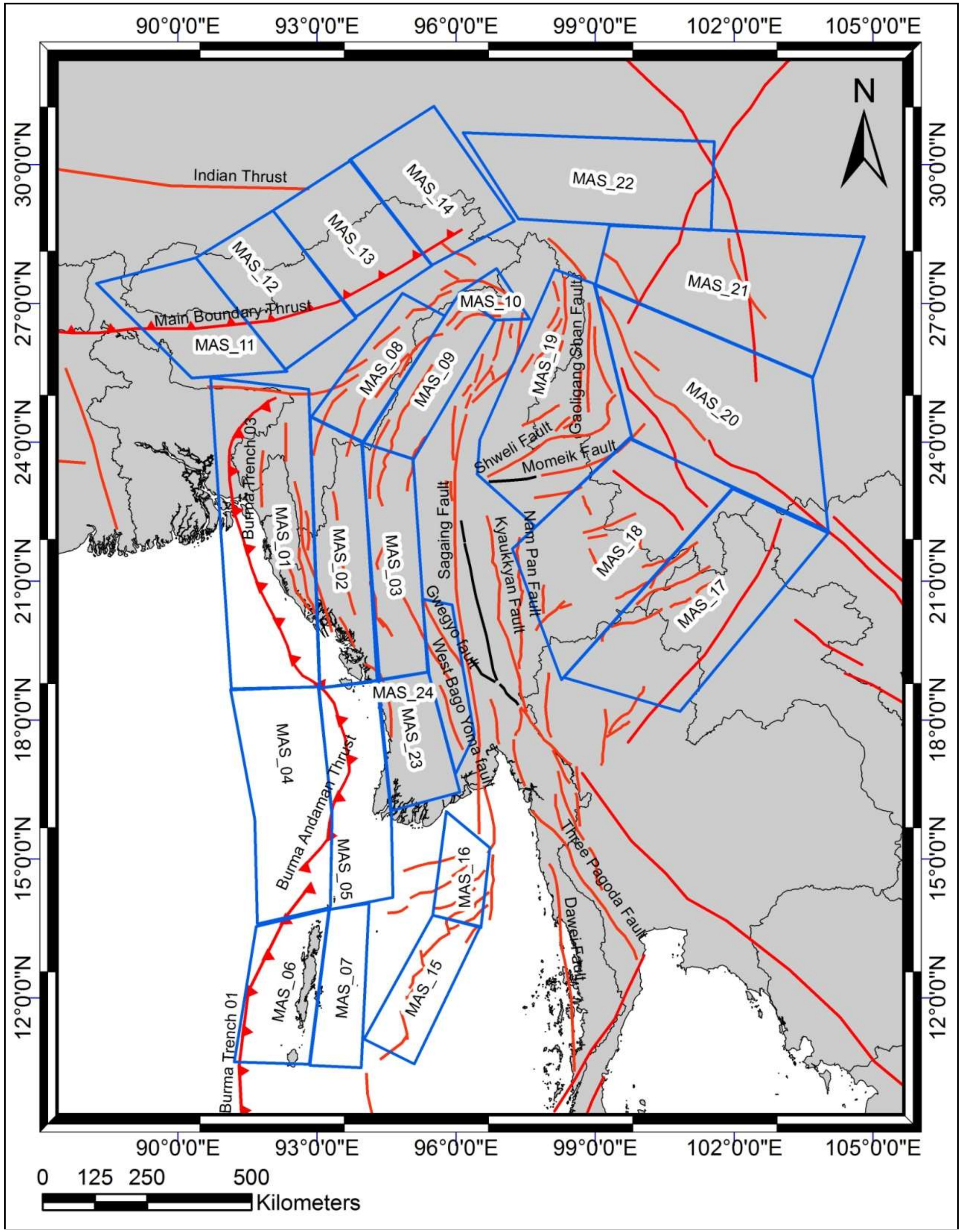


Earthquake data source Major equakes as 1762 event

United State Geological SurveyANSS, USGS earthquake catalogs

International Seismological Center, England (ISC earthquake database)

IRIS catalog.



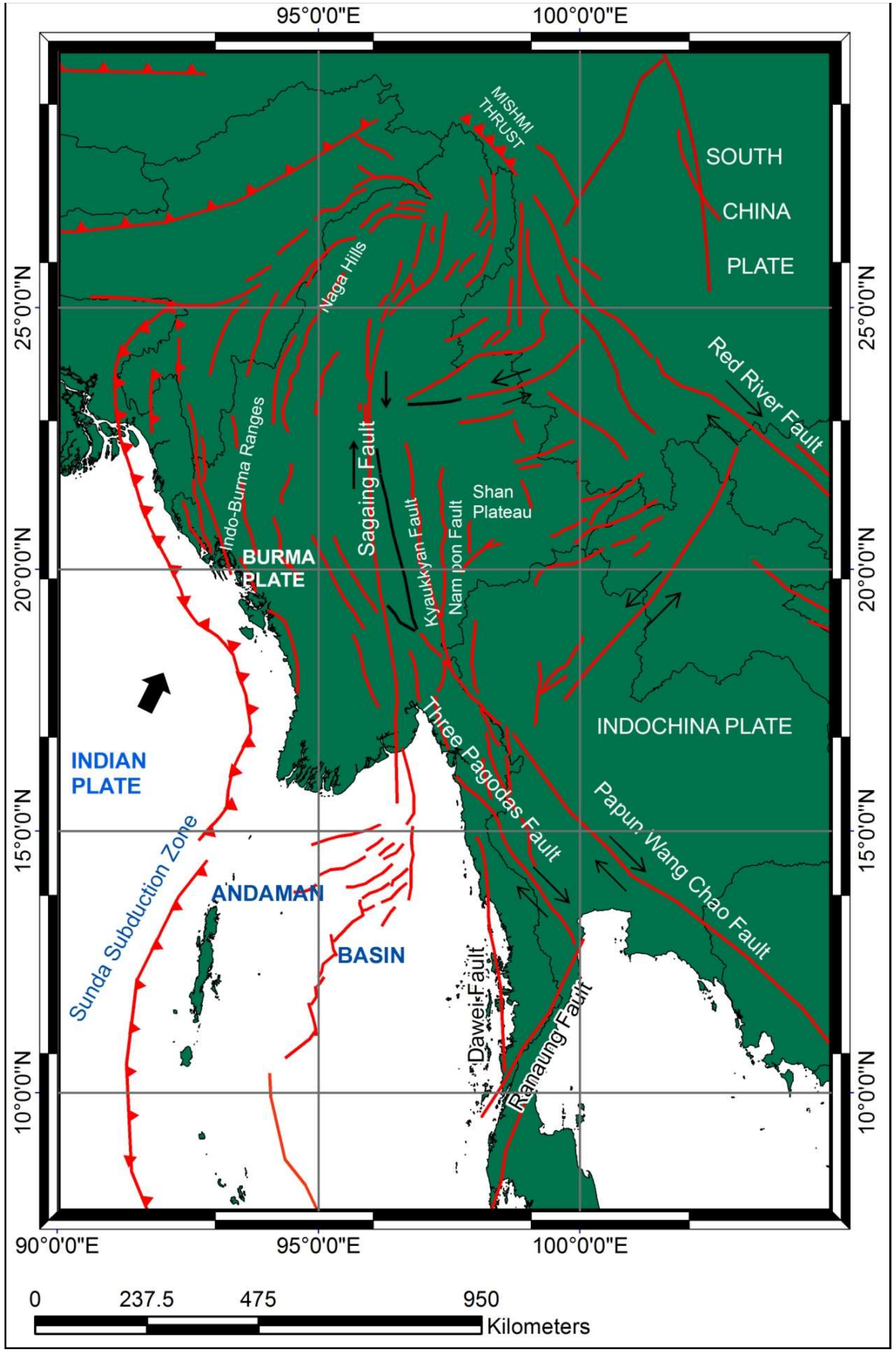
Area seismic sources of four tectonic domains

- subduction zone of Indian and Burma plates (11 nos.)
- Indian Asia collision zone(4nos.)
- Eastern Highland and southern part of South China plate &north – western part of Indochina plate (6 nos.)
- Andaman basin (2nos.)

Terminology Related to Recovery of Fault activity

Geologic Age			Years before Present	Fault Activity
Era	Period	Epoch		
Cenozoic	Quaternary	Historic Holocene	200 10,000	Active
		Pleistocene	1,650,000	Potentially active
	Tertiary	Pre-Pleistocene	65,000,000	Inactive
	Pre-Cenozoic time		4,500,000,000	
	Age of Earth			

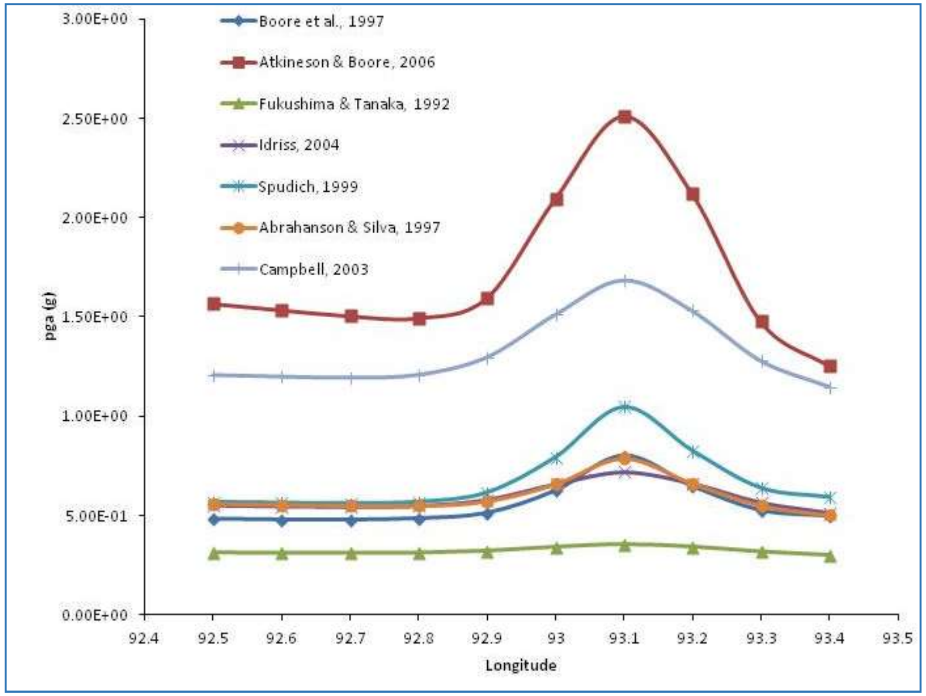
Source: *After California State Mining and Geology Board Classification, 1973.*

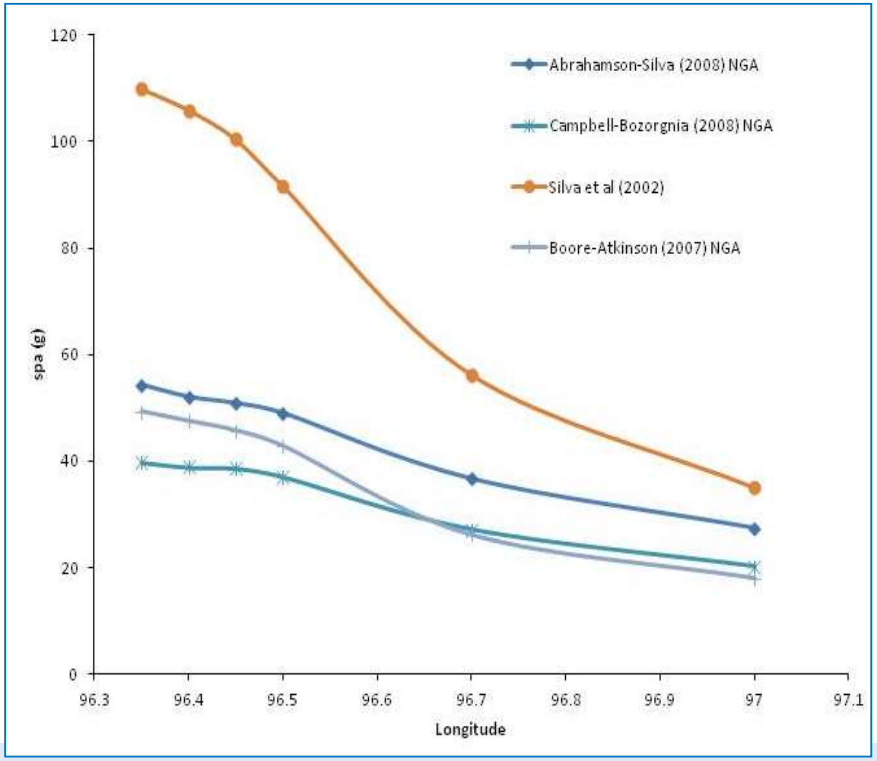


Fault specific seismic sources

- Sagaing fault,
- Kyaukkyan fault,
- Nam pon fault,
- Papun Wang Chao fault,
- Three Pagodas fault,
- Dawei fault, and
- Ranaung fault.

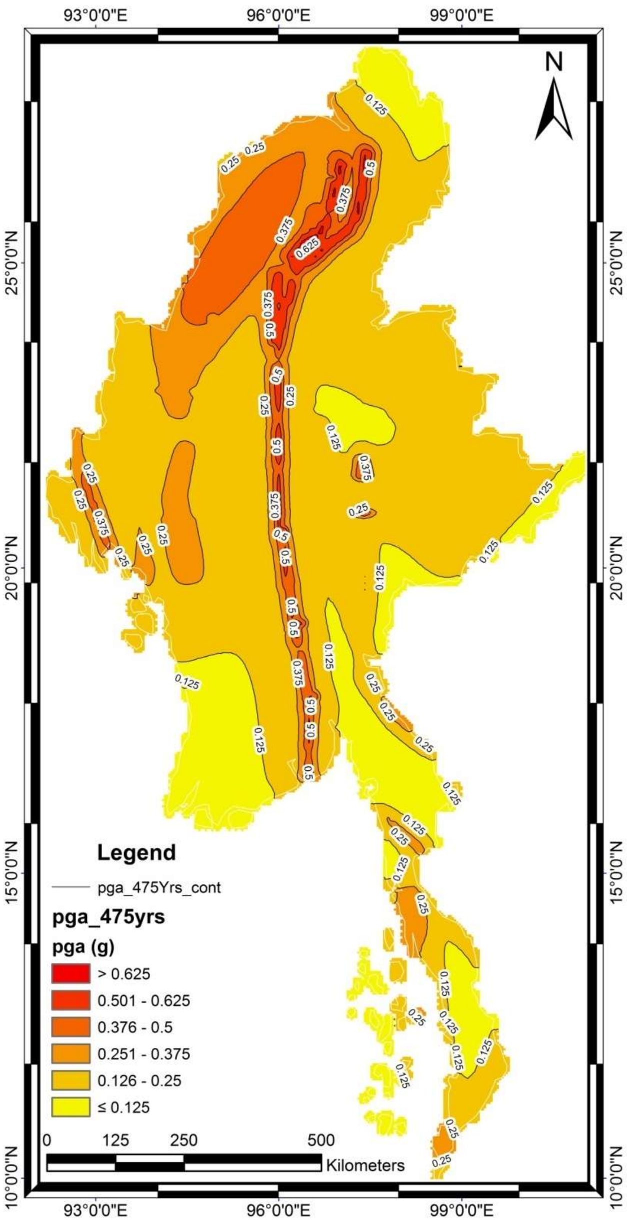
Seven attenuation relations for PGA & four relations for PGV values in validating the ground motion



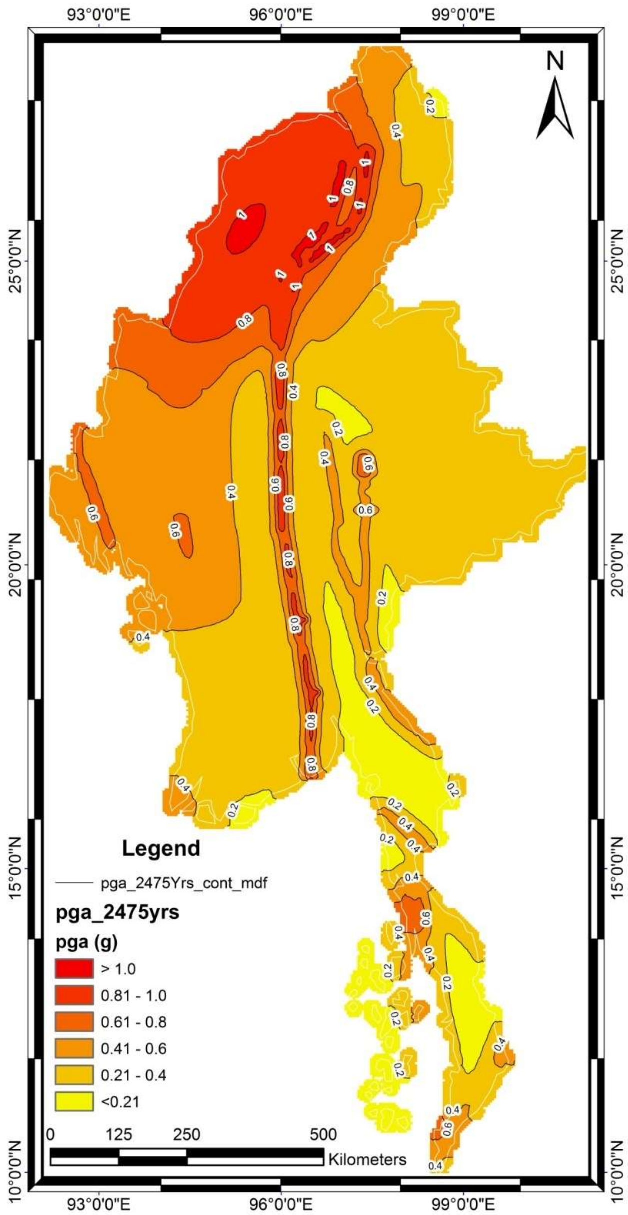


Boore et al. (1997) for PGA ,Boore and Atkinson (2007) for PGV are applied for developing PSHA Map

- the moment magnitude,
- the closest distance to the surface projection of the fault,
- the events with M <6, that equal to the epicentral distance,
- and V_{S30} is the average shear wave velocity from the surface to a depth of 30 m.



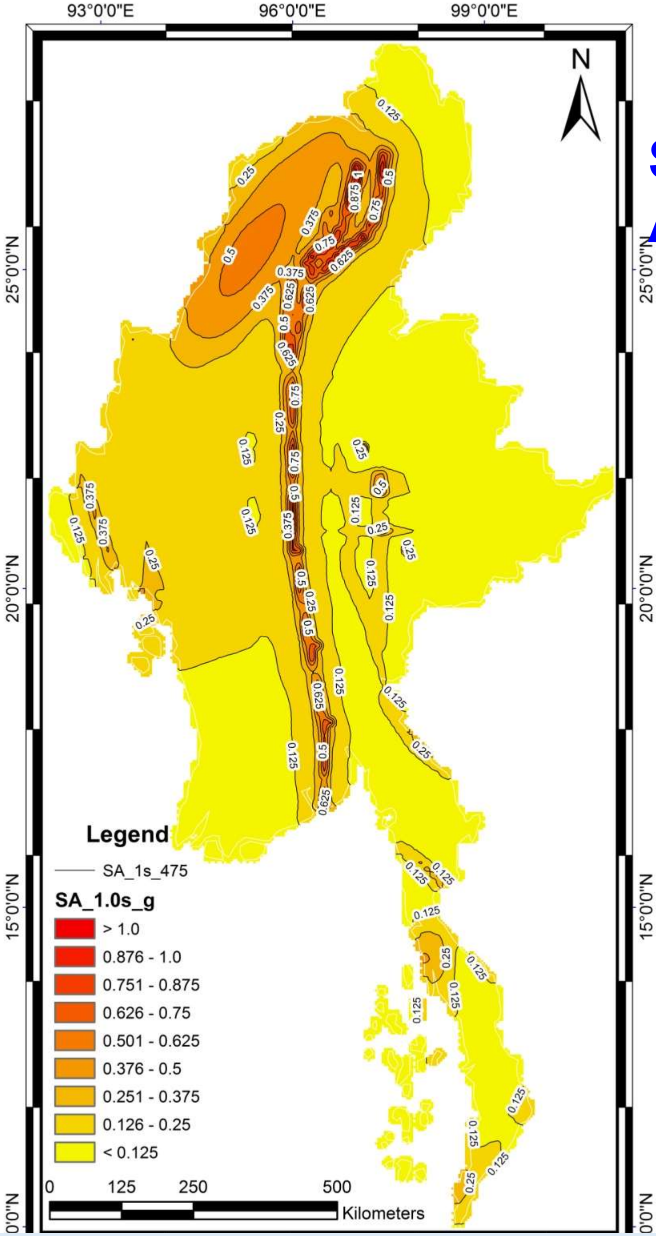
PGA (g) for 10 % probability of exceedance in 50 years in return period of 475 years



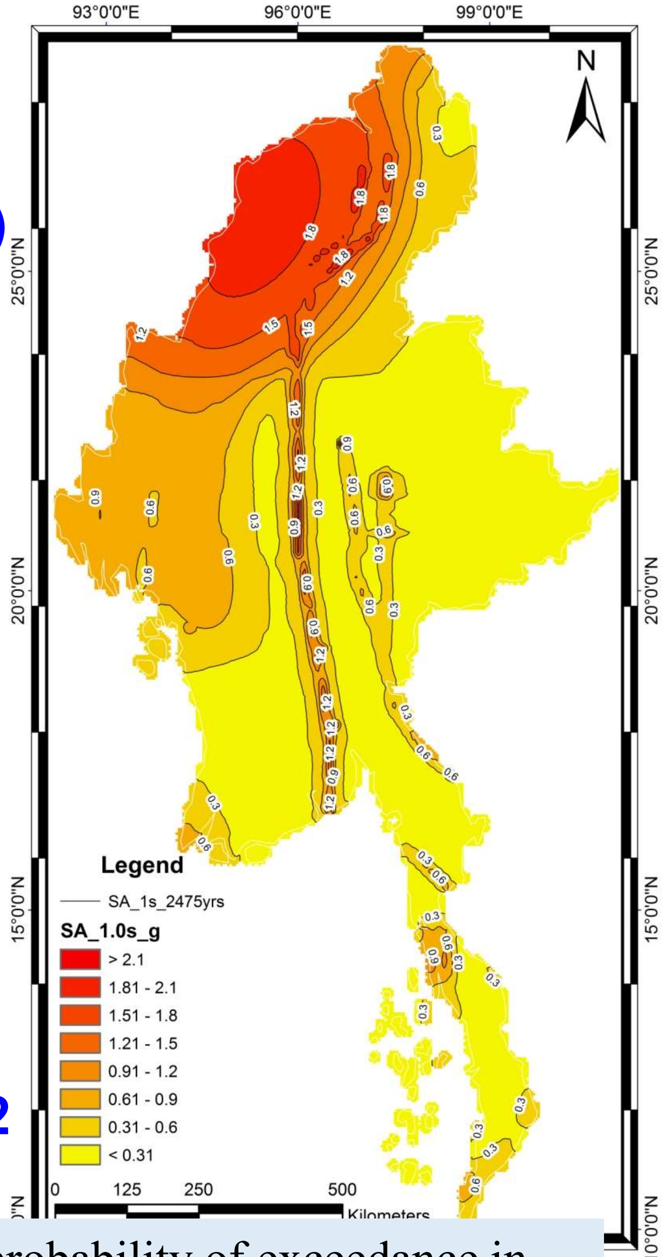
PGA (g) for 2 % probability of exceedance in 50 years in return period of 2475 years

Myothant et.al 2012

Spectral Response Acceleration (S_s:1s)



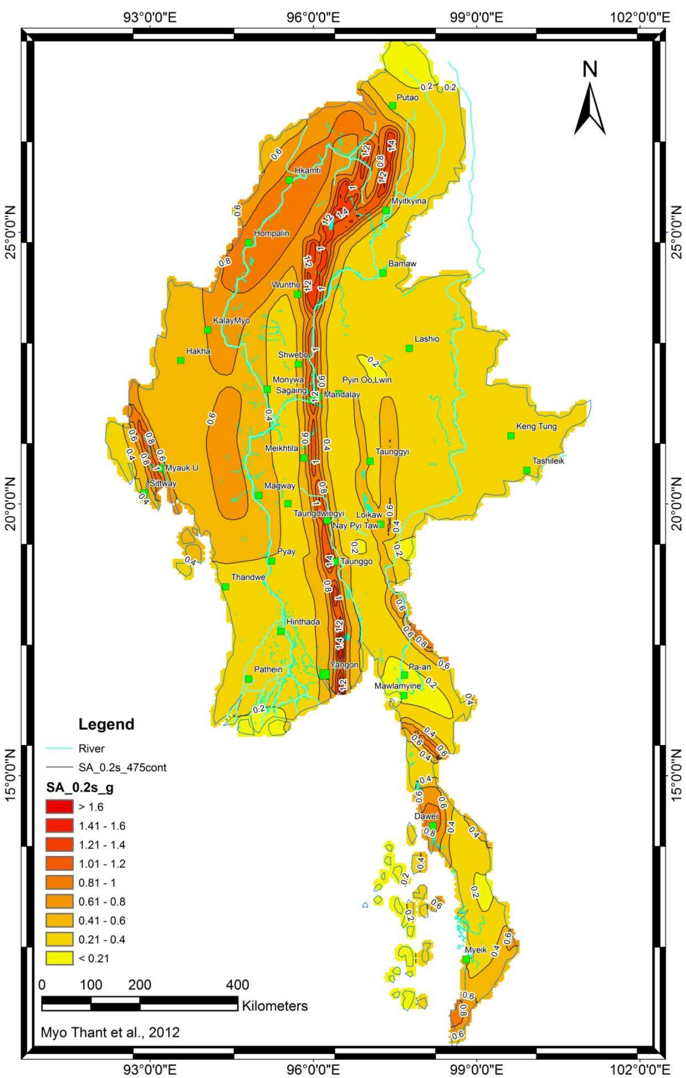
1s-10 % probability of exceedance in 50 years in return period of 475 years



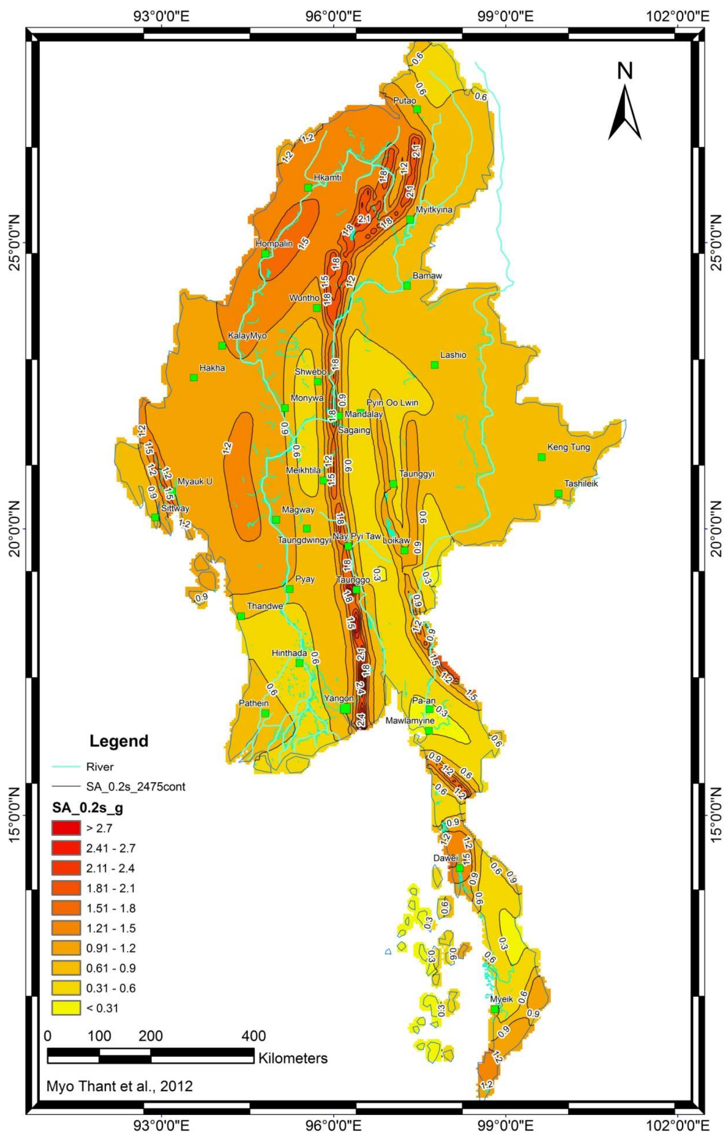
1s - 2 % probability of exceedance in 50 years in return period of 2475 years

Myothant et.al 2012

Spectral Responsee Acceleration (S_1:0.2s)



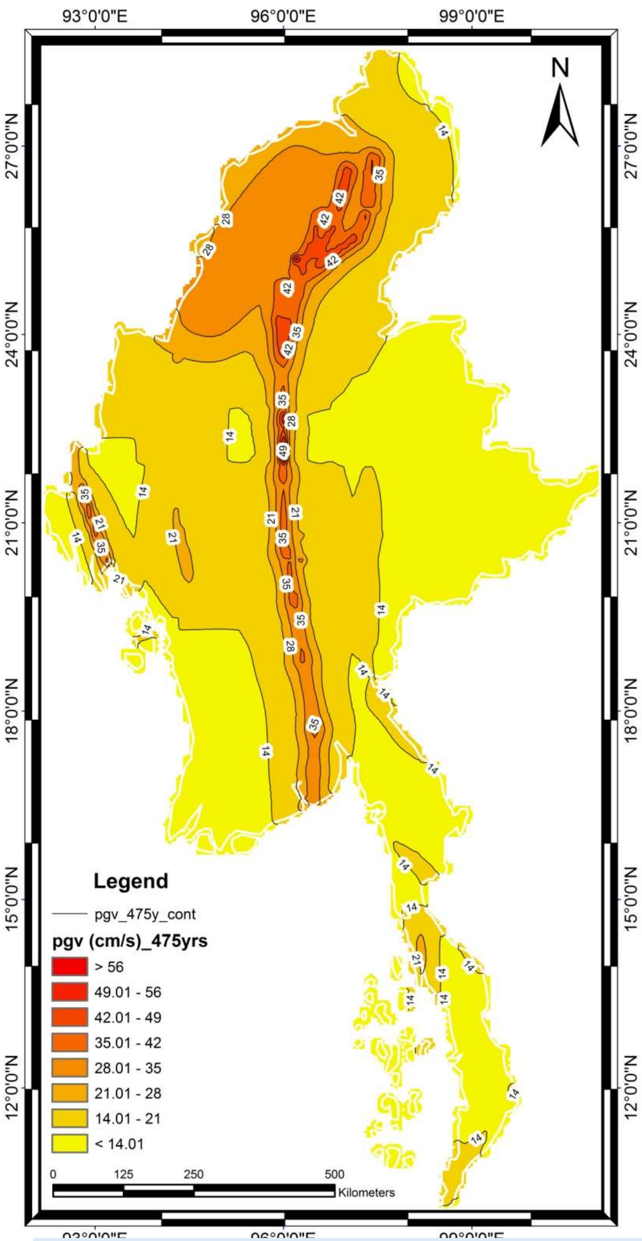
0.2s-10 % probability of exceedance in 50 years in return period of 475 years



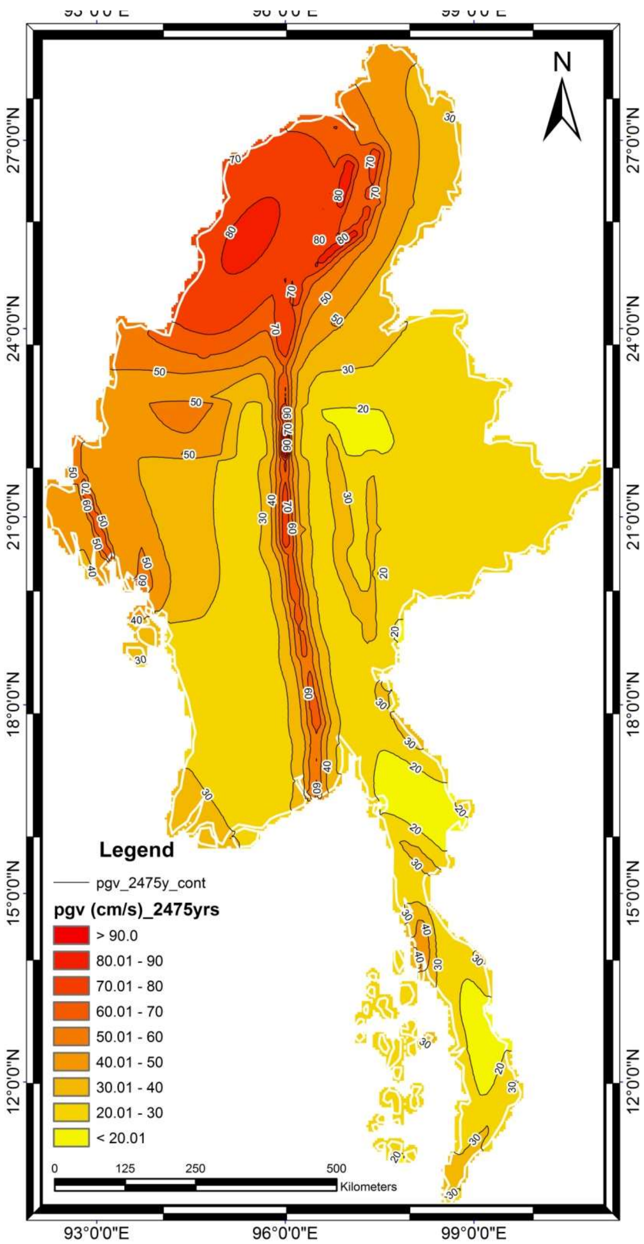
0.2s - 2 % probability of exceedance in 50 years in return period of 2475 years

Myothant et.al 2012

PGV

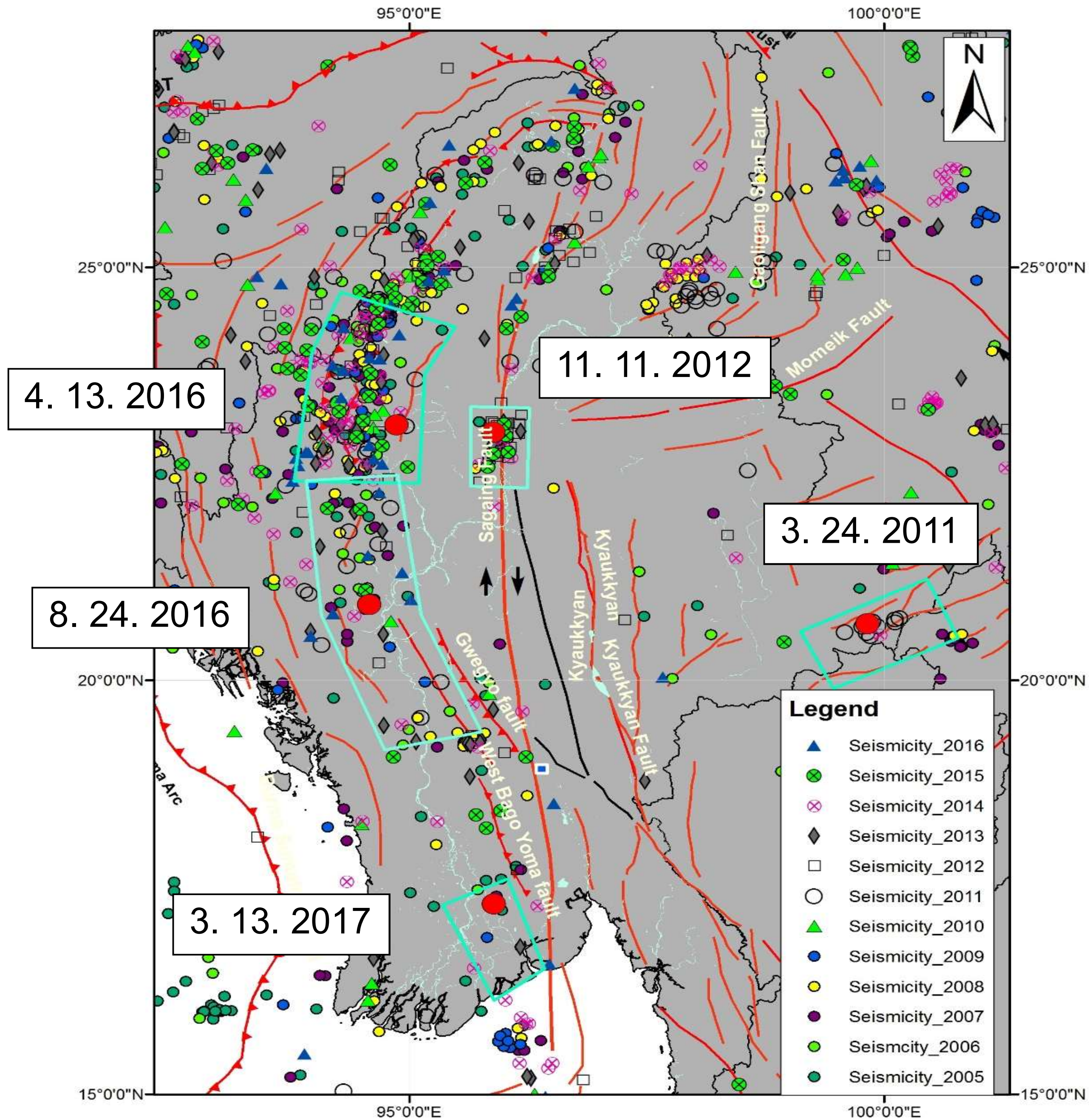


PGV (cm/s) for 10 % probability of exceedance in 50 years in return period of 475 years



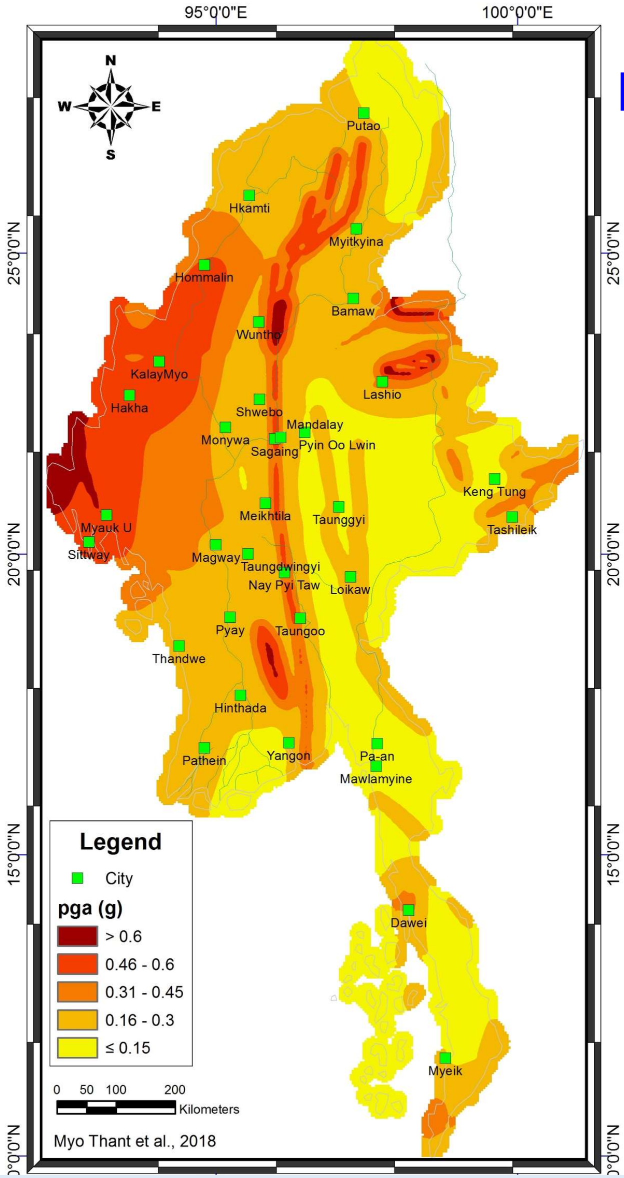
PGV (cm/s) for 2 % probability of exceedance in 50 years in return period of 2475 years

Myothant et.al 2012

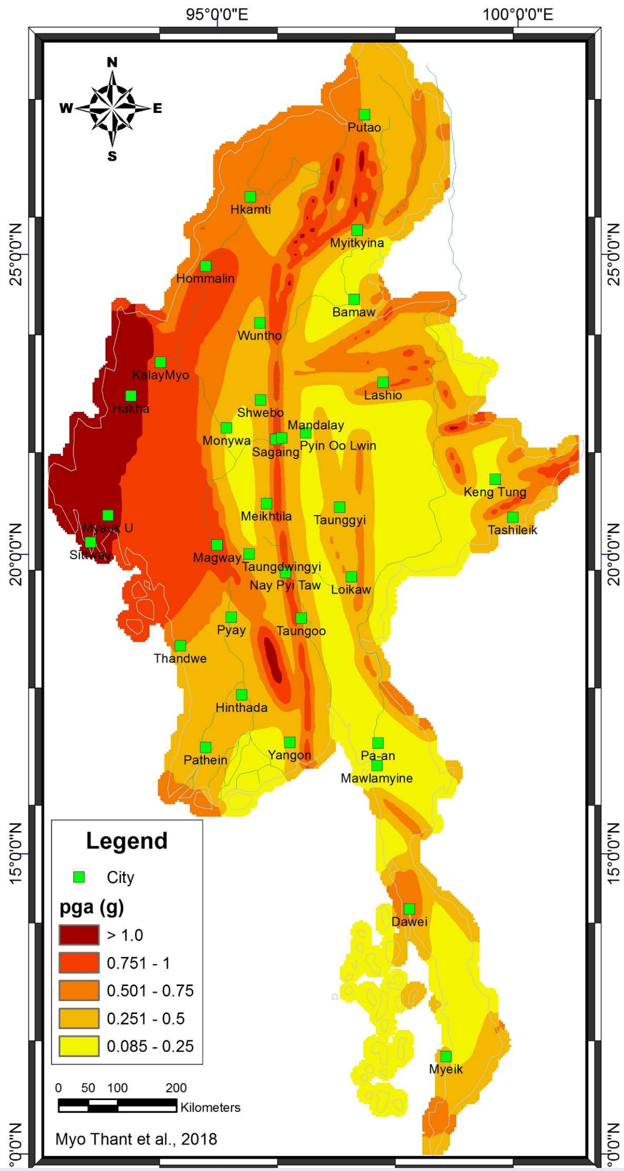


Department of Meteorology and Hydrology (DMH), Myanmar;
USGS
(2002 – 2016)

Myothant et.al 2018



PGA (g) for 10 % probability of exceedance in 50 years in return period of 475 years



PGA (g) for 2 % probability of exceedance in 50 years in return period of 2475 years

1.Let the design life of structure be 50 years, What will be the return period for the probabilities of exceedance 2% and 10%?

2. Let the design life of structure be 30 years, What will the probabilities of exceedance for return period of 475 years and 2475 years?

Probability Non Probability (X)

$P=1/E$ $X=1-P$

$P_{50}= 1-(1-P)^{50}$

$0.2= 1-(1-1/E)^{50}$

$0.01= 1-(1-(1/E))^{50}$

$P_{yf}= 1-X$

$P_{yr}= 1-(1-P)^{yr}$

$P_{yr}= 1-(1-1/E)^{yr}$ $P_{30}= 1-(1-P)^{30}$

$P_{30}= 1-(1-(1/475))^{30}$

$P_{30}= 1-(1-(1/2475))^{30}$

Critical structures(nuclear power plant, long time waste disposal) which is more reliable to use?

Attention to be paid on the following facts

- The hazard maps are calculated based on **hard rock condition(site class B)** with the average shear wave velocity of upper 30 m, **V_{s30} of 1500 m/s**.
- Historical earthquake records are limited and short time span.
- Site specific ground motion, spectral response analysis should be done for critical structures.

Thank you for you
Attention !!!