

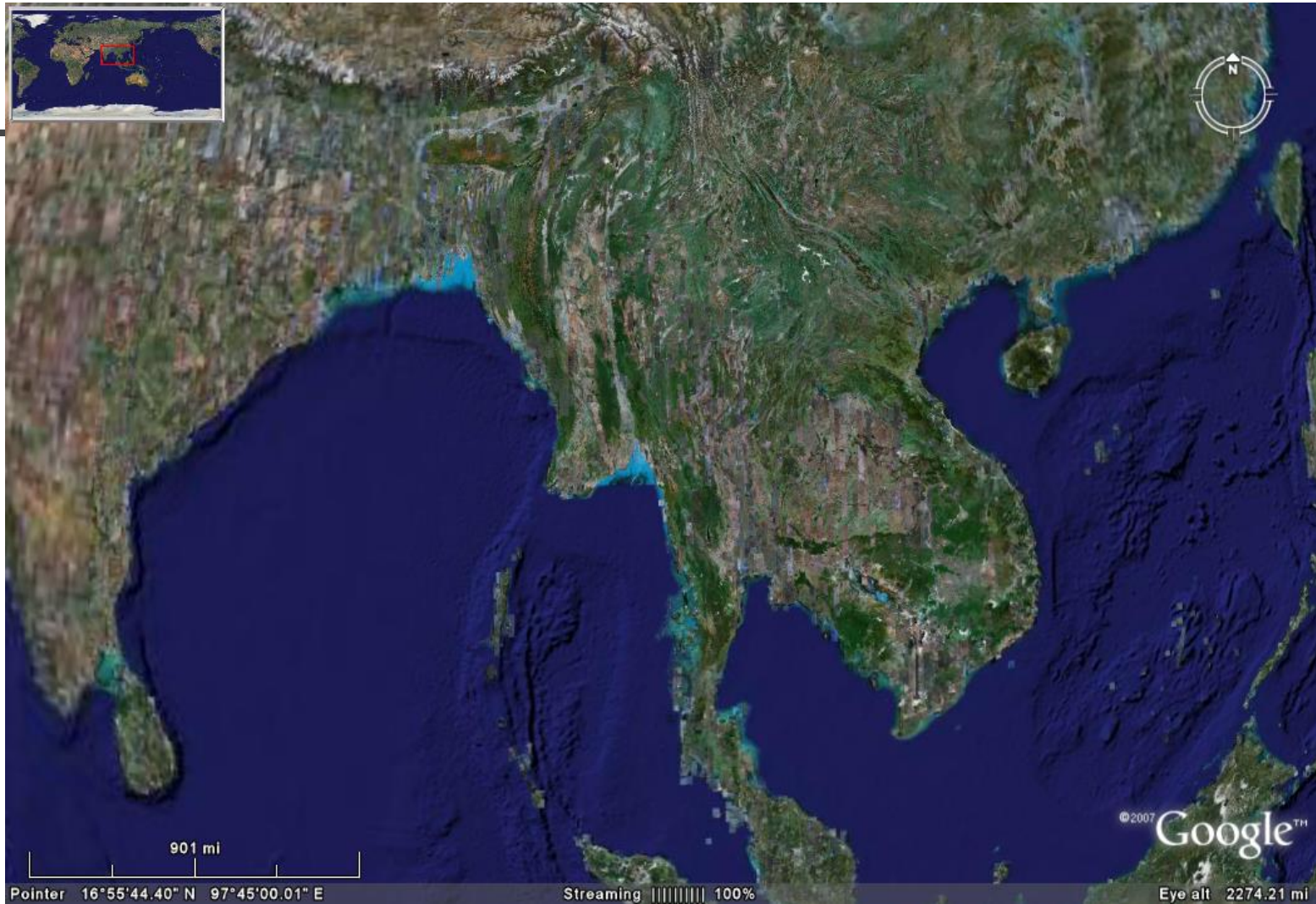
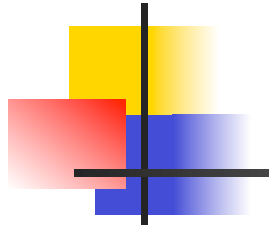


# Hazard Profile of Myanmar

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Hla Hla Aung  
Senior Researcher  
Myanmar Earthquake Committee  
Former Lecturer in Geology  
University of Yangon

# Google Map of SE Asia





# Myanmar

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Bordered by

- Bangladesh
- India
- China
- Laos
- Thailand

Bounded by

- Bay of Bengal
- Andaman sea

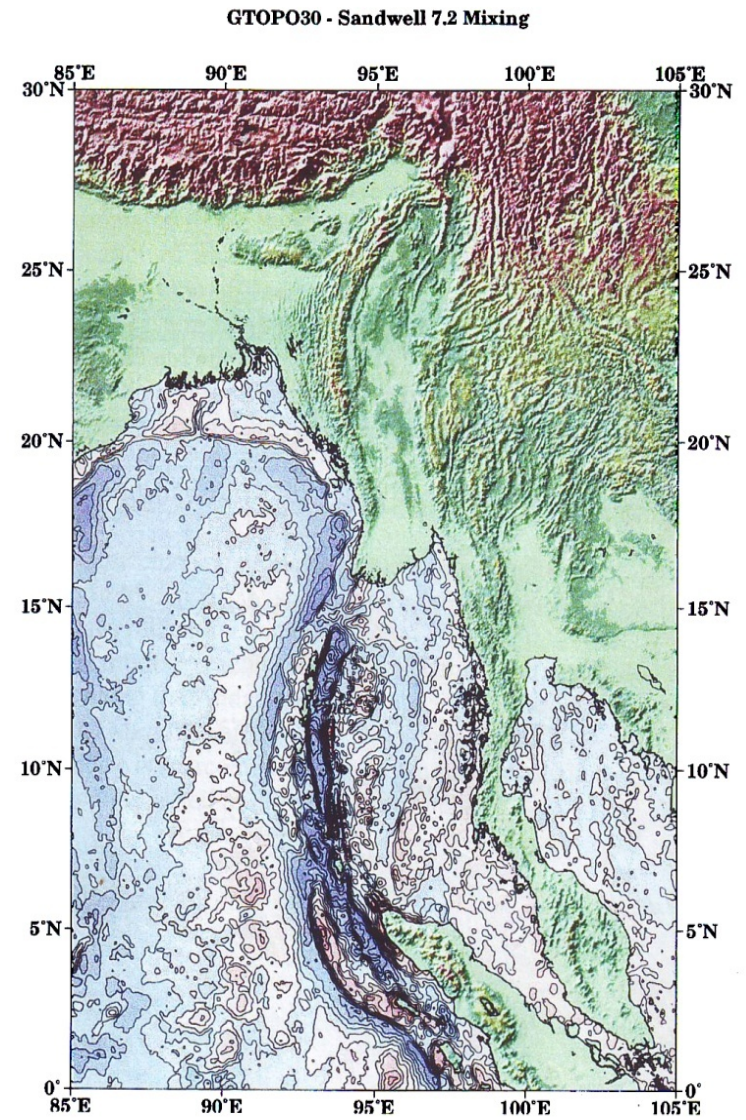


# Key indicators of Myanmar

---

- Total area 676,578 square-km  
(between 10N-28 30N/ 92 30E-101 30E )
- Coastline 2,400 km
- Number of district 67
- Number of township 330
- Estimated population 60 million
- Climate Tropical Monsoon
- Average precipitation 4000mm-5600mm  
dry zone >750mm
- Average temperature 25 C
  
- Disasters storm, storm surge, flood, earthquake/ tsunami,  
landslide, drought, forest fire, man-made fire

# Topographic Map of Myanmar







# Vulnerable areas in Myanmar and Disaster

---

- **Mountain area-**Yakhine, Kachin, Shan, Mon, Kayin

Landslide/rock fall, erosion, flash flood

- **Coastal zone-** Yakhine, Ayeyarwady, Tanintharyi

Storm, storm surge, flood, sea level rise, sea erosion, tsunami

- **River basin-** Kalatan, Ayeyarwady, Chindwin, Sittoung, Than Lwin-

flood/drought, erosion

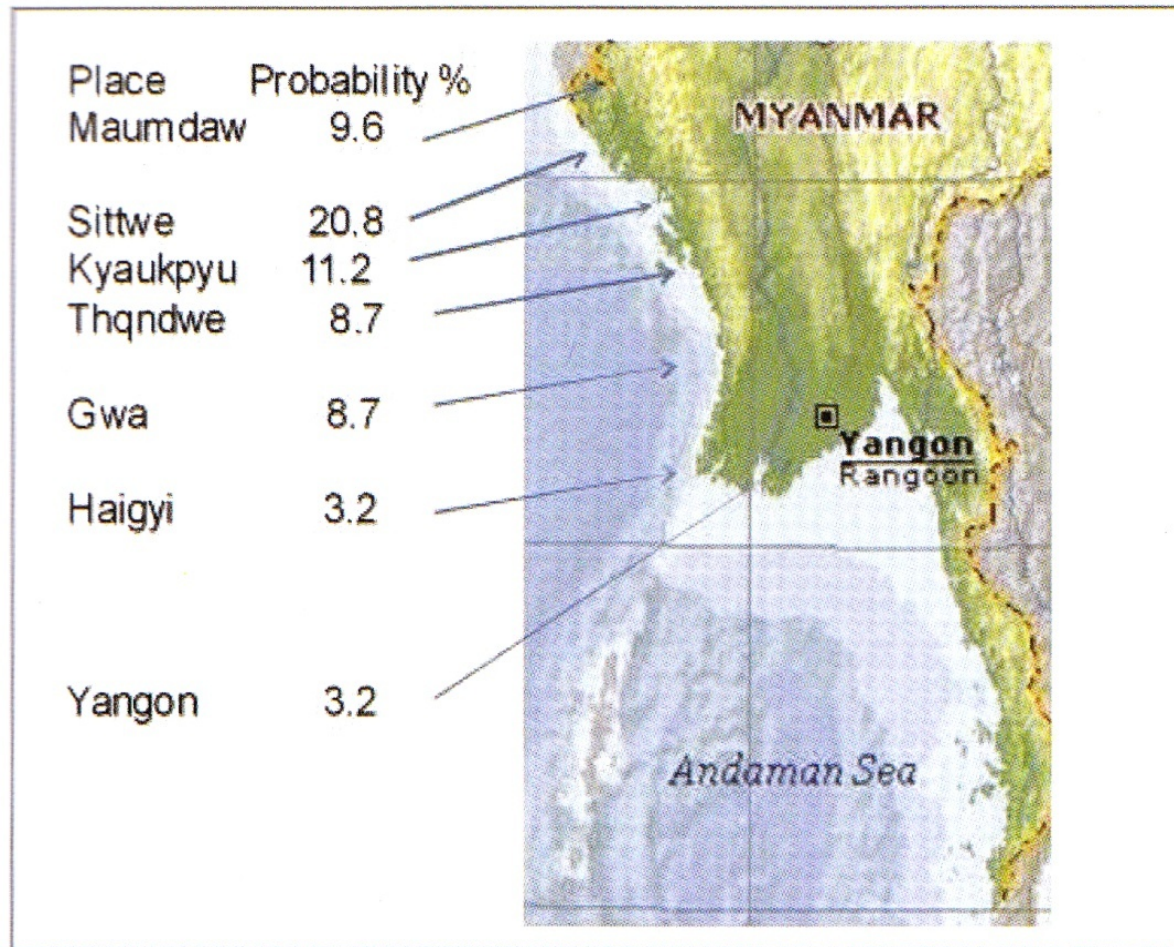
- **Near major faults-** earthquake, landslide

(Alpine-Himalayan-Indonesia seismic belt)

- **Housing**

# Cyclone Landfall

Figure 3 Cyclone landfall probability along Myanmar Coast (1947-2008)







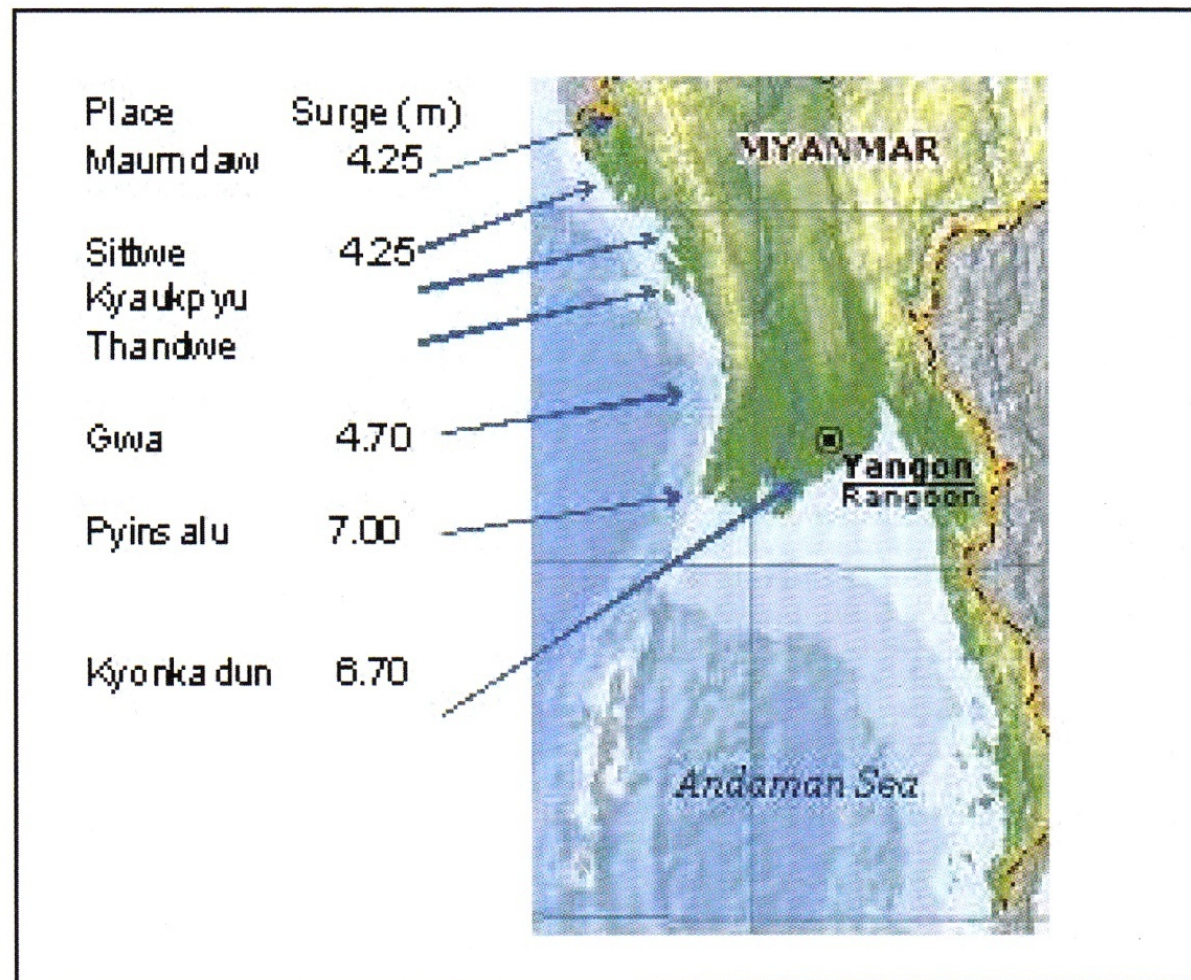
# Devastating Cyclones of Myanmar

---

- 1948 Sittwe A few people dead
- 1952 Sittwe 4 dead
- 1967 Kyaukpyu
- 1968 Sittwe 2 dead
- 1975 Pathein 303 dead
- 1978 Kyaukpyu
- 1982 Gwa 27 dead
- 1992 Thandwe 27 dead
- 1994 Maundaw
- 2006 Near Gwa 37 dead
- 2008 Ayeyarwady & Yangon 84,537 dead  
53,836 missing

# Storm surge

Figure 4 Storm surge observed along Myanmar Coast (1947-2008)



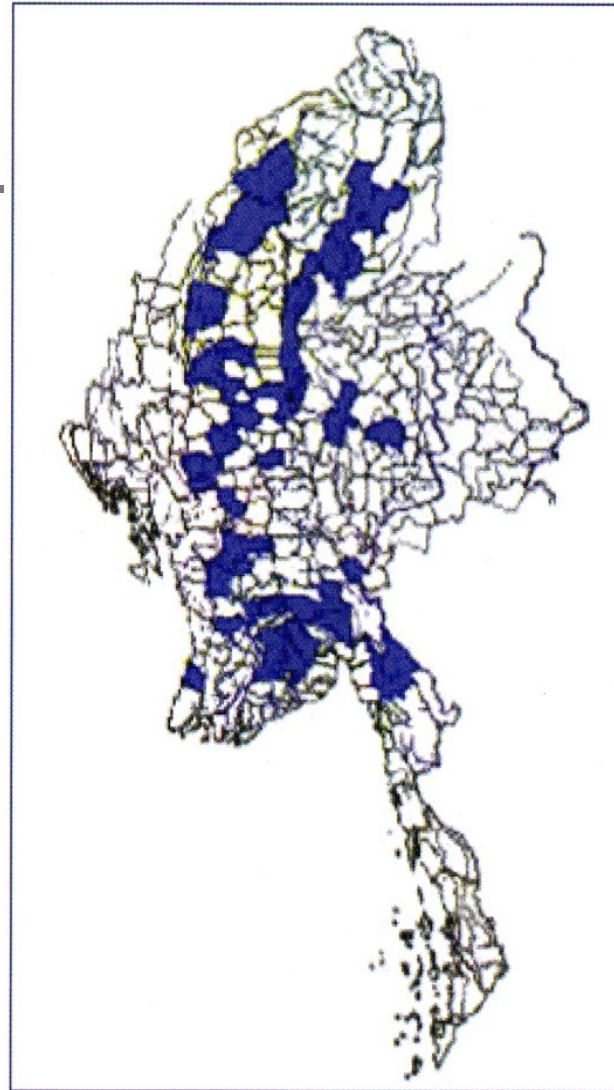
# Storm surge

Table 25 Distribution of Storm surge hazard potential (in percent) of Townships in Ayeyarwady and Yangon Divisions

Hazard Zones	Low	Moderate	High	Very High
<b>Ayeyarwady Division</b>				
Bogale	0	15	60	25
Einme	100			
Kangyidaung	100			
Kyaiklat	55	45		
Kyaunggon	100			
Laputta	15	20	40	25
Maubin	100			
Mawlamyinegyun	50	30	20	0
Myaungmya	95	5		
Ngaputaw	60	12	15	13
Pantanaw	100			
Pathein	90	10		
Pyapon	0	25	55	20
<b>Yangon Division</b>				
Dedaye	50	35	15	
Kawhmu	35	30	35	
Kayan	60	18	22	
Kungyangone	30	156	55	
Kyauktan	15	20	65	
Nyaungdon	100			
Tantabin	100			
Tanyin	80	20		
Thongwa	20	20	40	
Twante	45	35	15	
Yangon City	85	15		

# Flood-prone areas

Figure 18 : Flood prone areas in Myanmar



# Contd.

S/N	Location	Date	No. of Affected Village Tracts and Villages	No. of Affected Households	No. of Affected Families	Affected Population	Deaths	Loss (x100,000 kyat)
13.	Salingyi Township, Sagaing Division	18/8/02	-	1,647	1,702	10,216	-	-
14.	Kani Township, Sagaing Division	19/8/02	-	2,042	2,207	12,048	-	2,447 (222,454 USD)
15.	Kyaikmaraw Township, Mon Division	19/8/02	-	829	829	4,686	-	414 (37,636 USD)
16.	Hta/16 Ward, Shwepyithar Township, Yangon Division	8/9/02	-	886	886	4,541	-	-
17.	Hkamti Township, Sagaing Division	3/7/03	-	1,230	1,536	8,131	-	-
18.	Kyaukse District, Mandalay Division	9/10/06	All villages in 4 wards	1,443	1,763	7,045	-	351 (31,909 USD)
19.	Sagaing Division	11/9/06	6 villages near Yaymyetgyi Lake	770	791	5,372	-	-
20.	Kyaukpadaung Township, Mandalay Division	9/10/06	2 villages	14	18	97	16	-
21.	Bhamo, Shwegu, Myitkyina Townships, Kachin State	24/7/07	-	600	600	3,167	-	-

Note: Exchange rate - 1,100 kyat = 1 USD

# Dry zone/ Drought

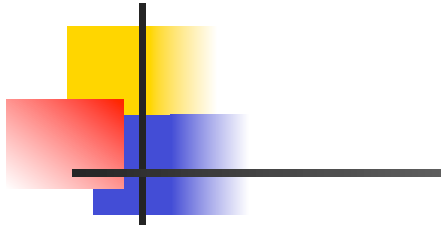


Table : 5 Dry zone Divisions, Districts and Townships

Sr. No.	Division	District	Township
1	Magway	Magway	Magway
2			Taungdwingyi
3			Natmauk
4			Myo Thit
5			Yaenanchaung
6			Chauk
7		Min Bu	Min Bu
8			Salin
9			Pwint Phyu
10			Nga Phe
11		Thayet	Thayet
12			Sinpaungwe
13			Mindon
14			Kan Ma
15			Aung Lan
16			Min Hla
17		Pakkoku	Pakkoku
18			Seik Phyu
19			Pauk
20			Yesagyo
21			Myaing
22	Mandalay	Nyaung Oo	Nyaung Oo
23		Myin Gyan	Taung Thar
24			Nga Zun
25			Kyauk Padaung
26			Nadoegyí
27		Myin Gyan	
28		Meikhtila	Meikhtila

# Dry zone Map

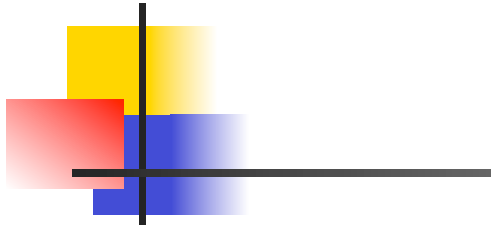
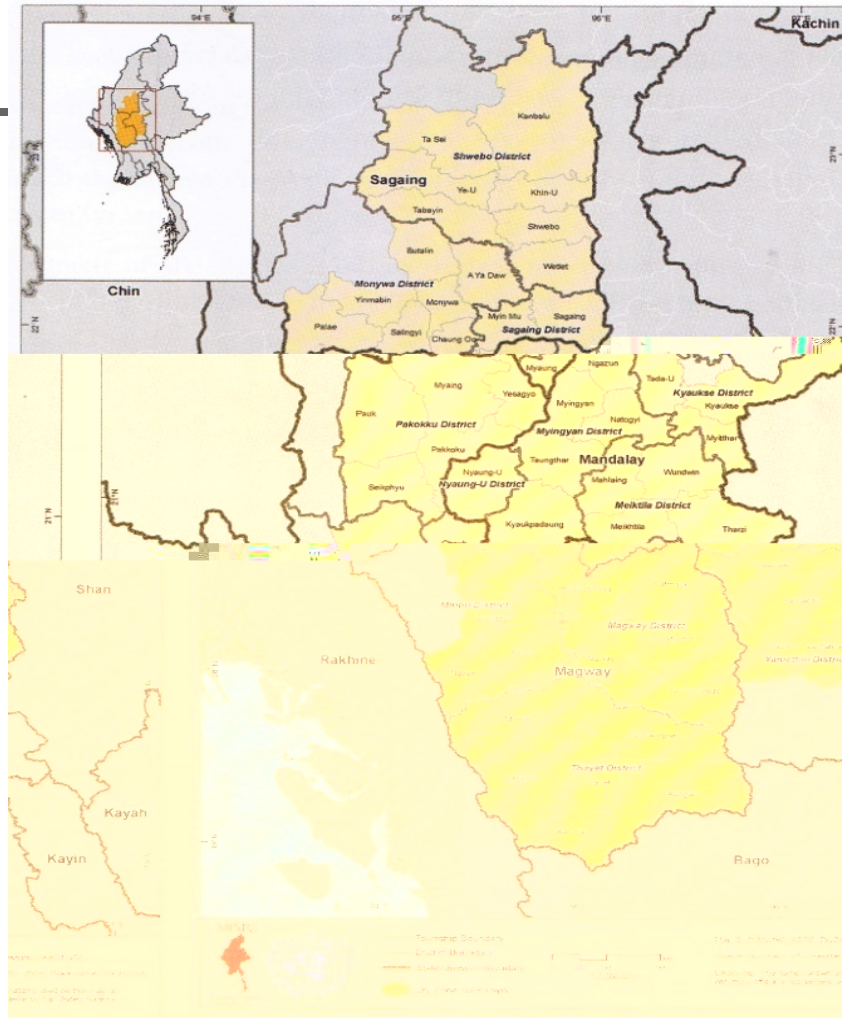


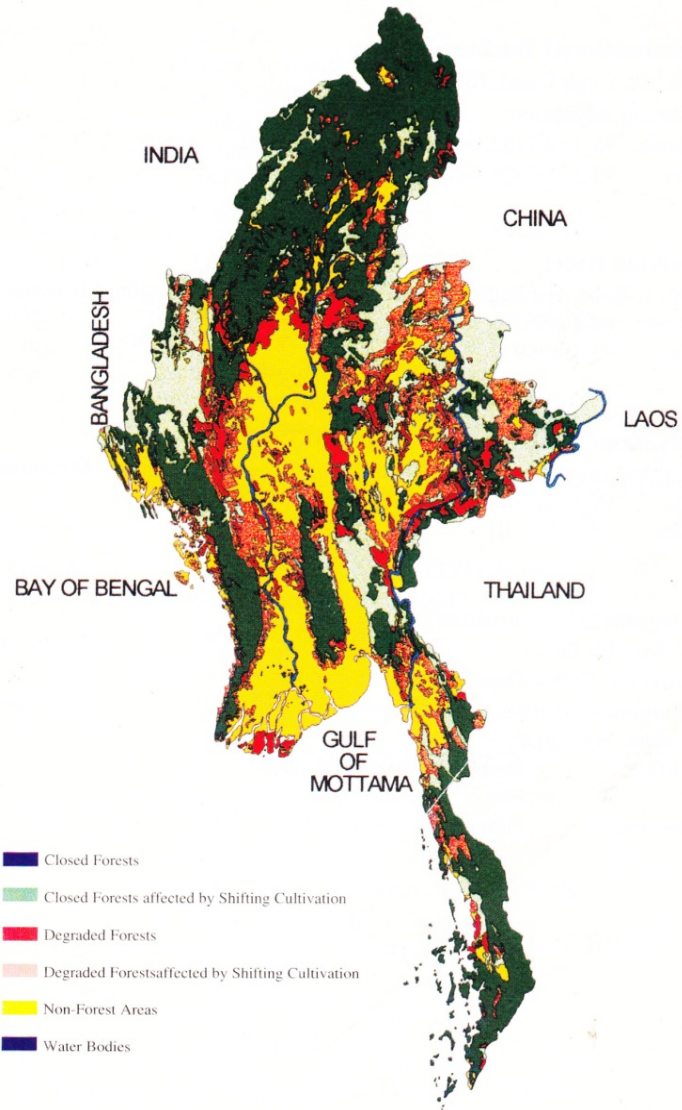
Figure 6 : Dry Zone Map of Myanmar



# Forest Map

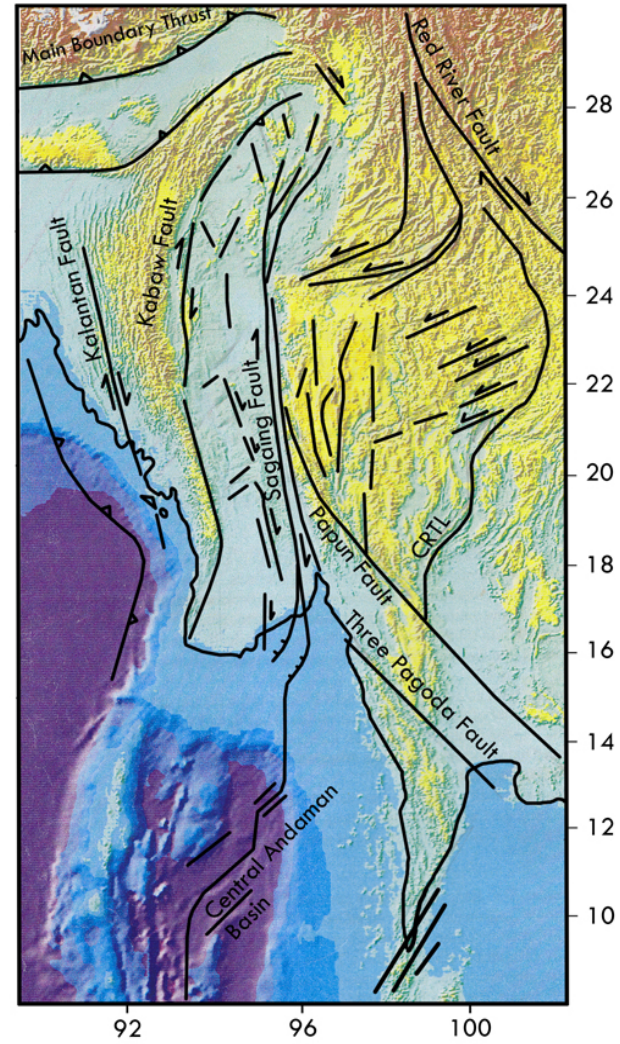


FOREST COVER STATUS MAP OF MYANMAR





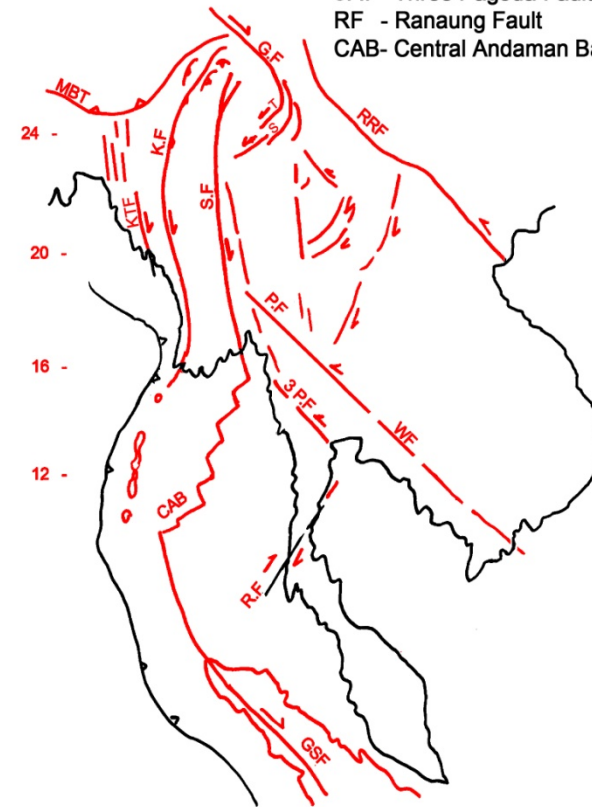
# Tectonic linearments & topography of Myanmar



# Major active faults in Myanmar



- KTF - Kyun Tharyar Fault
- PF - Kabaw Fault
- SF - Sagaing Fault
- ST - Shweli - Twinge Fault
- RRF- Red River Fault
- 3P.F- Three Pagoda Fault
- RF - Ranaung Fault
- CAB- Central Andaman Basin



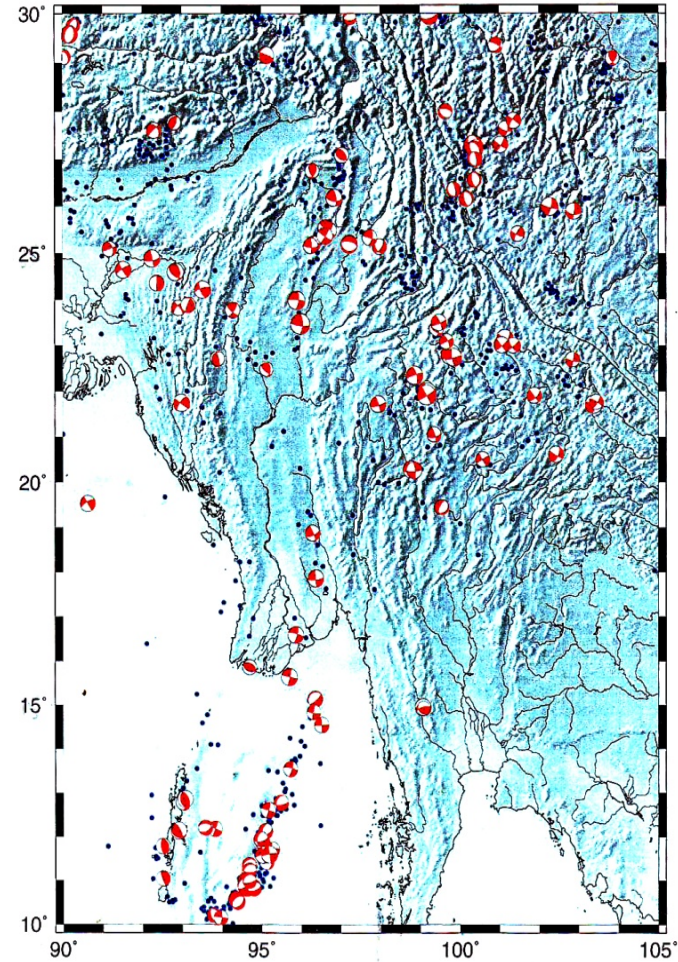
Tectonic Lineaments of Myanmar and its Surroundings

# Focal Mechanism Solution of earthquake

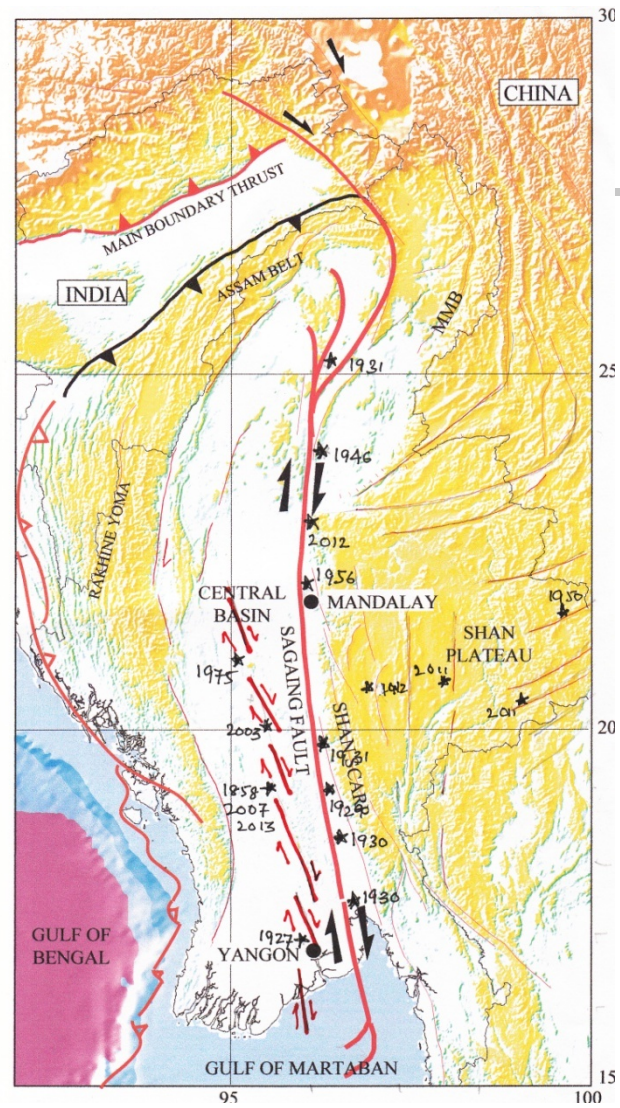
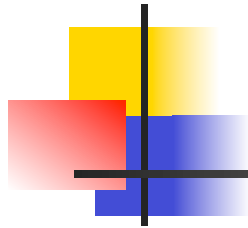


Shallow Seismicity ( 0-40 km) in the Burma Area

CMT from Harvard and Epicenter from ENGDFAL



# Seismicity of Myanmar

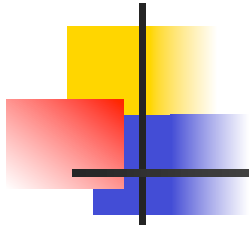


# List of historical earthquakes

Table 9 Summary of historical and recent earthquakes in Myanmar \*\*\*\*

Date	Location	Magnitude and/or brief description
868	Bago	Shwemawdaw Pagoda fell
875	Bago	Shwemawdaw Pagoda fell
1429	Innwa	Fire-stopping enclosure walls fell
1467	Innwa	Pagodas, solid and hollow, and brick monasteries destroyed
24 July 1485	Sagaing	3 well-known pagodas fell
1501	Innwa	Pagodas, etc. fell
13 Sept. 1564	Bago	Pagodas including Shwemawdaw and Mahazedi fell
1567	Bago	Kyaikko Pagoda fell
1582	Bago	Umbrella of Mahazedi Pagoda fell
9 Feb 1588	Bago	Pagodas, and other buildings fell
30 Mar 1591	Bago	The Great Incumbent Buddha destroyed
23 June 1620	Innwa	Ground surface broken, river fishes were killed after quake
18 Aug. 1637	Innwa	River water flush
10 Sept. 1646	Innwa	
11 June 1648	Innwa	
1 Sept. 1660	Innwa	
3 April 1690	Innwa	
15 Sept. 1696	Innwa	4 well-known pagodas destroyed
8 Aug. 1714	Innwa	Pagodas, etc. fell; the water from the river gushed into the city
4 June 1757	Bago	Shwemawdaw Pagoda damaged
2 April 1762	Sittwe	M=7 RS; very destructive violent earthquake felt over Bengal, Rakhine up to Calcutta.
27 Dec 1768	Bago	Ponnyayadana Pagoda fell
15 July 1771	Innwa	
9 June 1776	Innwa	A well-known pagoda fell
26 Apr 1830	Innwa	
21 Mar 1839	Innwa	Old palace and many buildings demolished;

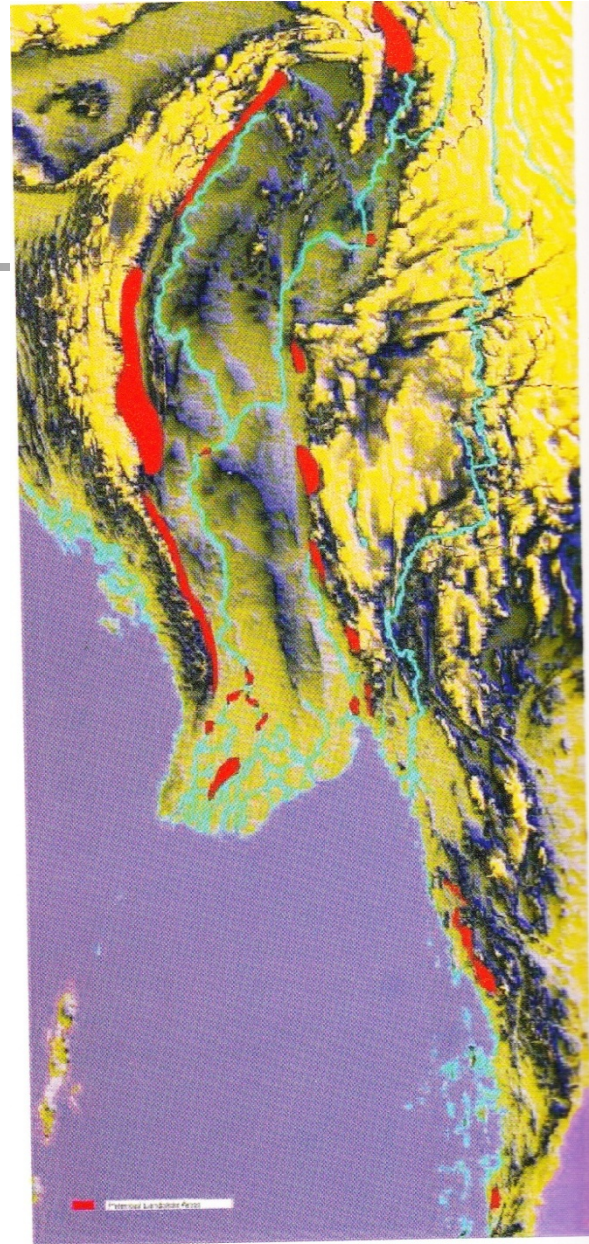
# contd



23 Mar 1839	Innwa	pagodas and city walls fell; ground surface broken; the river's flow was reversed for sometime; Mingun Pagoda shattered; about 300 to 400 persons killed
6 Feb 1843	Kyaukpyu	eruption of mud volcanoes at the Rambye (Ramree) Island
3 Jan 1848	Kyaukpyu	The civil line and other buildings were damaged
24 Aug 1858	Pyay	Collapsed houses and tops of pagodas at Pyay, Henzada, and Thayetmyo and felt with some damages in Innwa, Sittway, Kyaukpyu and Yangon
8 Oct 1888	Bago	Mahazedi Pagoda collapsed
6 Mar 1913	Bago	Shwemawdaw Pagoda lost its finial
5 July 1917	Bago	Shwemawdaw Pagoda fell
10 Sep 1927	Yangon	
17 Dec 1927	Yangon	M=7 RS; extended to Dedaye
8 Aug 1929	Near Taungoo	Bent railroad tracks, bridges and culverts collapsed, and loaded trucks overturned (Swa Earthquake)
5 May 1930	Near Khayan	M=7.3 RS, $I_{max}=IX$ ; in a zone trending north-south for 37 km south of Bago (on the Sagaing Fault line); about 500 persons in Bago and about 50 persons in Yangon killed
3 Dec 1930	Nyaunglebin	M=7.3 RS; railroad tracks twisted (Pyu Earthquake); about 30 persons killed
27 Jan 1931	East of Indawgyi	M=7.6 RS, $I_{max}=IX$ ; numerous fissures and cracks (Myitkyina Earthquake)
10 Aug 1931	Pyinmana	
27 Mar 1931	Yangon	
16 May 1931	Yangon	
21 May 1931	Yangon	
12 Sept. 1946	Tagaung	M=7.5 RS
12 Sept. 1946	Tagaung	M=7.75 RS
16 July 1956	Sagaing	M=7.0 RS; Several pagodas severely damaged (40 to 50 persons killed)
8 July 1976	Bagan	M=6.8 RS; Several pagodas in Bagan Ancient City were severely damaged (only 1 person killed)
22 Sept. 2003	Taungdwingyi	M=6.8; RS Severe damaged to rural houses and religious buildings (7 persons killed)

\*\*\*\*most of them along the Sagaing Fault

# Landslide Hazard Map



# Landslide

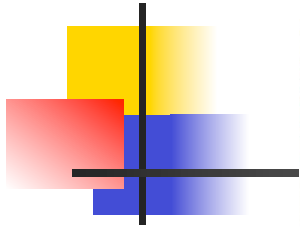



Table 22 List of Past Landslides in Myanmar

Year	Location	Name and Type	Triggering Process	Impact
1912	North of Taunggyi	Maymyo landslide	Earthquake	serious landslides and ground cracks
1946	Tagaung	Landslides	Earthquake	380 acres of crop damaged
1991	Tagaung	Landslides	Earthquake	some buildings destroyed
1999	Along the western slope of the Tanintharyi Ranges	Landslides	Torrential rain	Buried some villages
2001	Nansang	Subsidence	Heavy rain	about 50 feet diameter circular graven appeared
2003	Taungdwingyi	Landslides	Earthquake	some slopes and rail roads along the western embankment of Bago Yoma failure
2004	Kale Myo	Kale Landslides	Heavy rain	bridges and about 30 km of the main road destroyed
2008	Mogok	Mogok Landslides	Heavy rain and Excavation	about 11 people killed

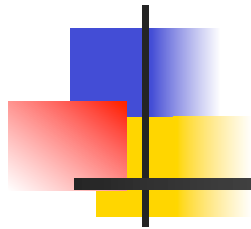


# Percentage of each disaster in Myanmar

- 
- Man-made fire-71 per cent
  - Storm- 11 percent
  - Flood- 10 percent
  - EQ/tsunami + landslide-8 percent
- 

The disaster incidences are distinctively increasing over recent decades due to the impact of climate change.

# Earthquake Potential in Myanmar



Hla Hla Aung  
Senior Researcher  
Myanmar Earthquake Committee



SHWEDAGON PAGODA  
YANGON, MYANMAR

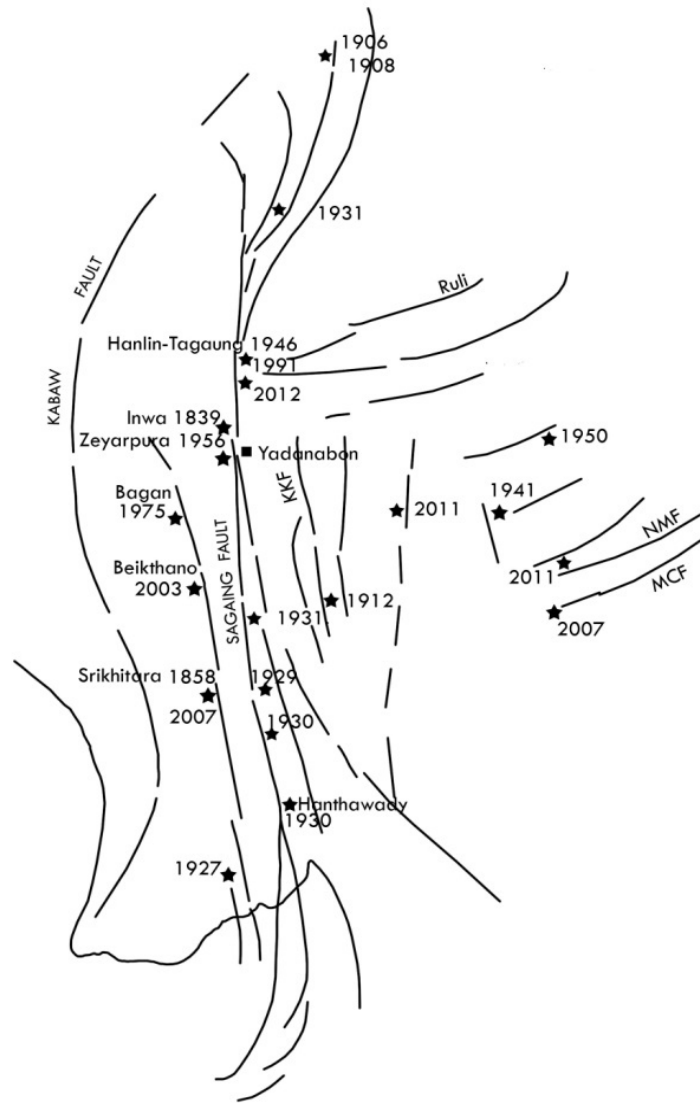


SHWEMADAW PAGODA  
BAGO, MYANMAR



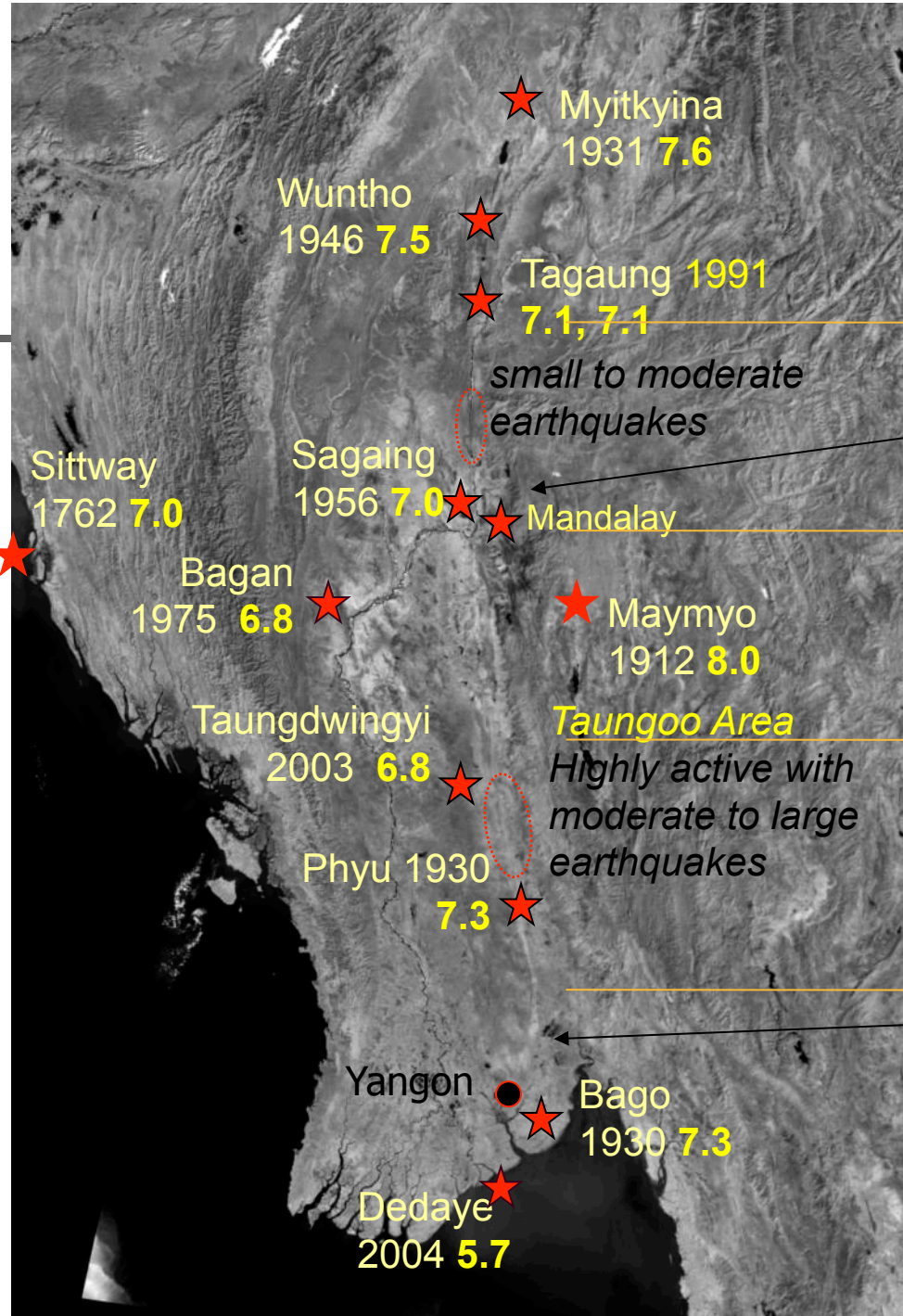
ANANDA PAGODA  
BAGAN, MYANMAR

# Ancient Capital Cities in Myanmar & Earthquakes





# Significant Earthquakes



*small to moderate earthquakes*

*Historic earthquakes in AVA Era*

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

*Taungoo Area Highly active with moderate to large earthquakes*

*Historic Earthquakes in Bago*

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



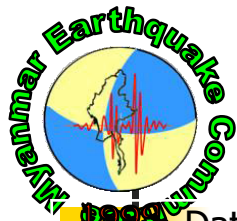
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11 June 1648	Innwa	
1 Sept. 1660	Innwa	
3 April 1690	Innwa	
15 Sept. 1696	Innwa	4 well known pagodas destroyed
8 Aug. 1714	Innwa	Pagodas, etc. fell; the water from the river gushed into the city
4 June 1757	Bago	Shwemawdaw Pagoda damaged





Date	Location	Magnitude and/or brief description
2 April 1762	Sittway	M=7; very destructive violent earthquake felt over Bengal, Rakhine up to Chittagong.
27 Dec. 1768	Bago	Ponnyayadana Pagoda fell
15 July 1771	Innwa	
9 June 1776	Innwa	A well known pagoda fell
26 April 1830	Innwa	
21 March 1839	Innwa	Old palace and many buildings demolished;
23 March 1839	Innwa	pagodas and city walls fell; ground surface broken; the river's flow was reversed for sometime; Mingun Pagoda shattered; about 300 to 400 persons killed
6 Feb. 1843	Kyaukpyu	eruption of mud volcanoes at the Rambye (Ramree) Island
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8 Oct. 1888	Bago	Mahazedi Pagoda collapsed
6 March 1913	Bago	Shwemawdaw Pagoda lost its finial
5 July 1917	Bago	Shwemawdaw Pagoda fell
10 Sept. 1927		
17 Dec. 1927		M=7; extended to Dedaye
8 Aug. 1929	Near Taungoo	Bent railroad tracks, bridges and culverts collapsed, and loaded trucks overturned (Swa Earthquake)



1999

Date

Location

Magnitude and/or brief description

5 May 1930

South of Bago

M=7.3,  $I_{max}$ =IX; in a zone trending north-south for 37 km south of Bago (on the Sagaing Fault line); about 500 persons in Bago and about 50 persons in Yangon killed

3 Dec. 1930

Nyaunglebin

M=7.3, railroad tracks twisted (Pyu Earthquake); about 30 persons killed

27 Jan. 1931

East of Indawgyi

M=7.6,  $I_{max}$ =IX; numerous fissures and cracks (Myitkyina Earthquake)

10 Aug. 1931

Pyinmana

27 March 1931

16 May 1931

21 May 1931

12 Sept. 1946

Tagaung

M=7.5

12 Sept. 1946

Tagaung

M=7.75

16 July 1956

Sagaing

M=7.0 Several pagodas severely damaged (40 to 50 persons killed)

8 July 1976

Bagan

M=6.8 Several pagodas in Bagan Ancient City were severely damaged (only 1 person killed)

5 Jan. 1991

Tagaung

M=7

22 Sept. 2003

Taungdwingyi

M=6.8 Severe damaged to rural houses and religious buildings (7 persons killed)

# BAGO EARTHQUAKES

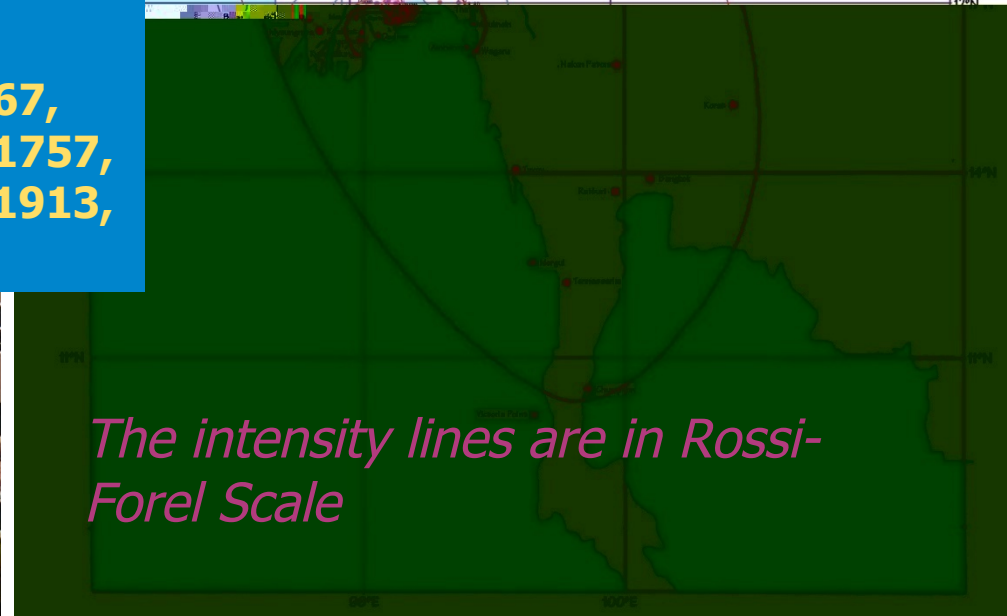
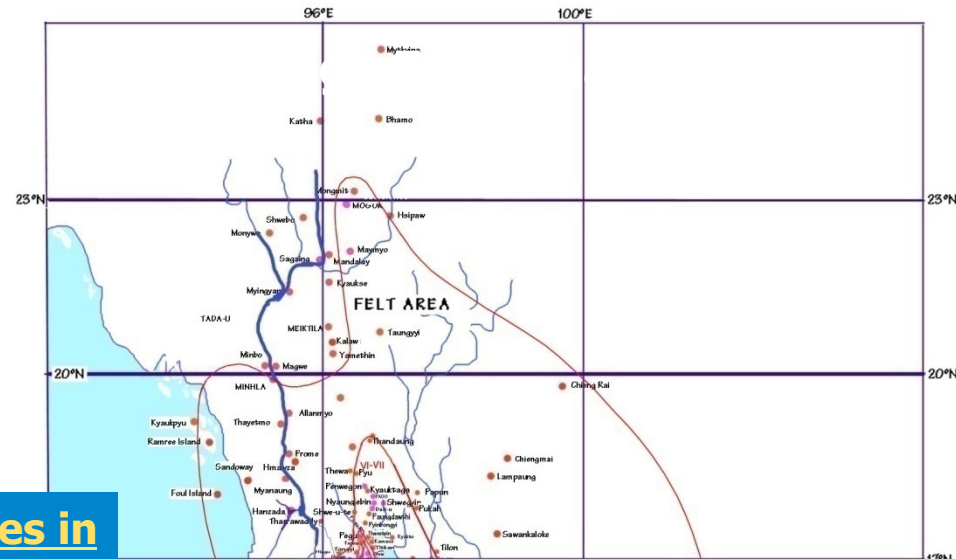


Present Day  
Bago City



## Historical Earthquakes in Bago (AD)

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



After J. C. Brown, 1934

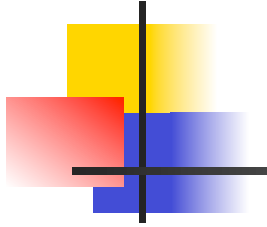


# BAGO EARTHQUAKE

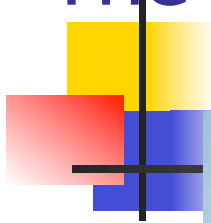


Top portion of the pagoda fallen down by 1917 Bago Earthquake

# The 1839 Inwa Earthquake & Mingun Pagoda



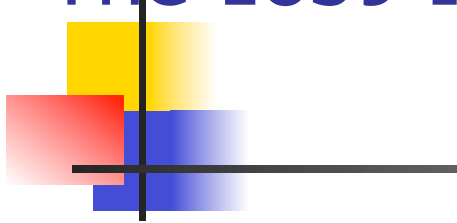
# The 1839 Inwa Earthquake & Mingun Pagoda



# The 1839 Inwa Earthquake

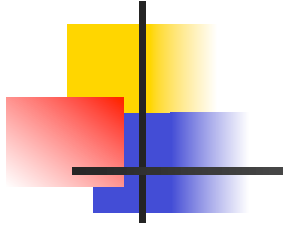


# The 1839 Inwa Earthquake





# The 1975 Pagan Earthquake



လုံးပတ်တော် အက်ကွဲ၍  
ထီးတော်မြေသွားရသော လောကနန္ဒာ ဘုရား



နှစ်မြစ်ကွဲအက်သွားပြီး ပန်းတင်နံ  
အမြေပြိုကျပျက်စီးသွားသော  
ငကျနားတောင်းစေတီ



ရွှေစည်းနံ့ စေတီ၏ ထီးတော်စောင်း၍  
အောက်မြေကြော့မှောက်ပျက်စီးခဲ့ရသည်  
၁၉၇၅ ခုနှစ်တွင် ဖြစ်ပျက်ခဲ့သော ငလျင်ကြောင့်ပျက်စီးသွားသော  
ပုဂံဘုရားများပုံဖြစ်သည်။



ရွှေဆံတော်ဘုရား ထီးတော်နှင့်တကွ ဖောင်းရစ်ပါမြေစသည်ကို တွေ့ရပုံ



ဧရာဝတီမြစ်အတွင်းသို့ ဘုရားလုံးပတ်တော်တစ်ခုလုံး  
ပြိုကျပျက်စီးသွားသော မူးဘုရား

လှလှအောင်  
မြန်မာနိုင်ငံငလျင်ကော်မတီ

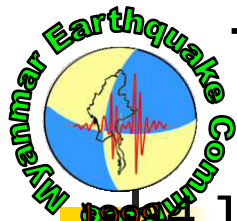


# TAUNGDWINGYI EARTHQUAKE

Magnitude 6.6 MYANMAR  
2003 September 21 18:16:13 UTC



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

1999/4 January 2006

Magnitude 4.4

Mainly affected in monumental buildings

People frightened





# TARLAY EARTHQUAKE

24 March 2010

Magnitude 6.8



# Damage



# Damage





# Liquefaction features (sand blow)









Liquefaction in the village  
photo: MRCS



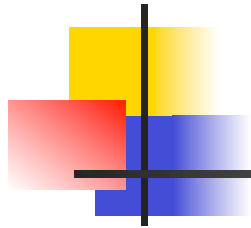
Bridge Offset  
(looking N)



East of  
Hospital







# South of Kone Hsar





South of  
Wan Ha



# South of Pha Kan





# Building Damages and Engineering Aspects





# RC Weakness, Detailings

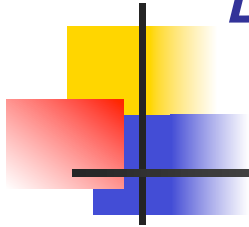




Columns

# Panpe

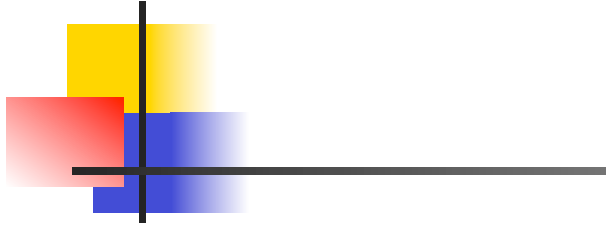
## *BASE ISOLATION*





Pha Kan House





Brickworks with Clay Mortar



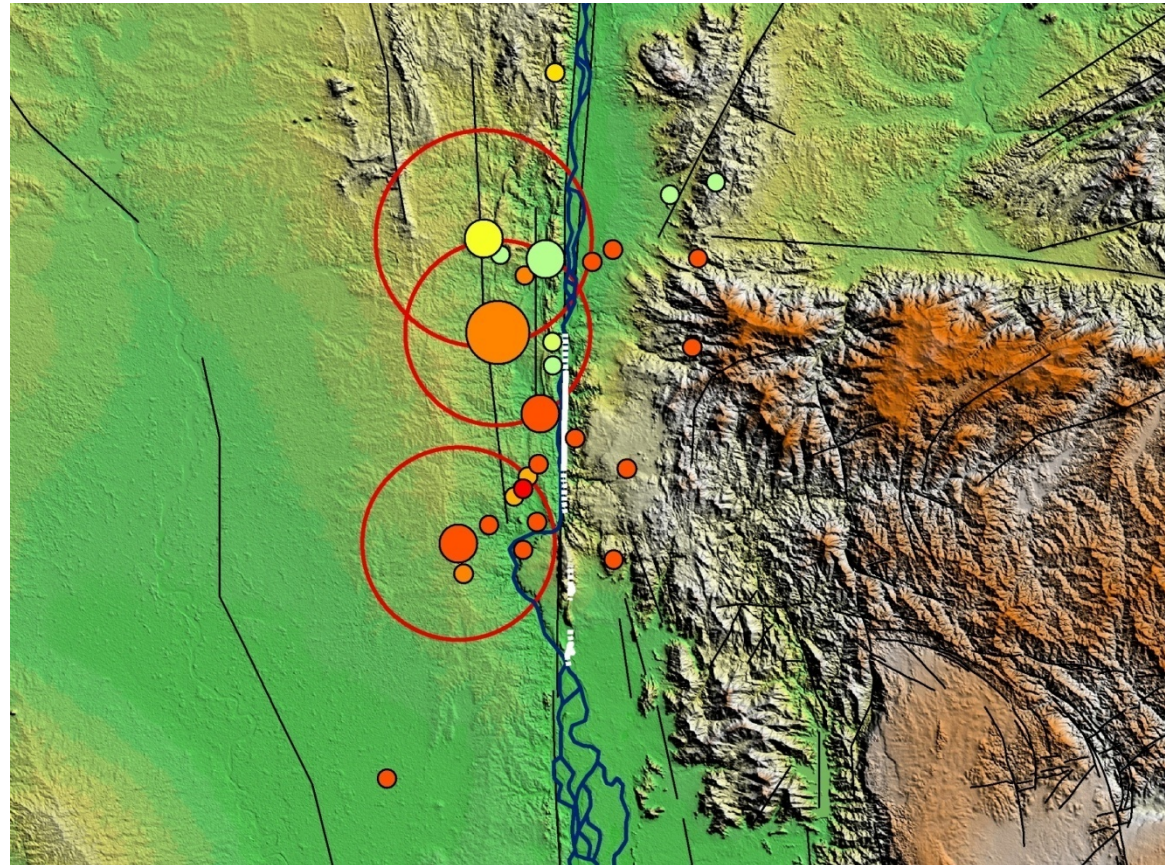
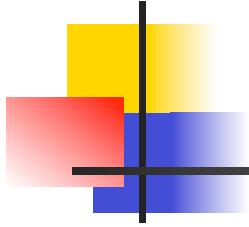


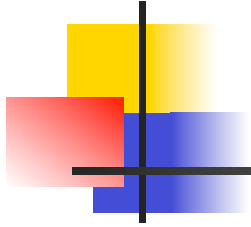


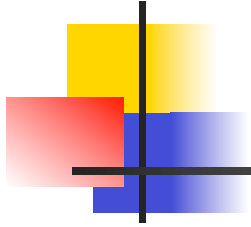
# Brick with Clay cement

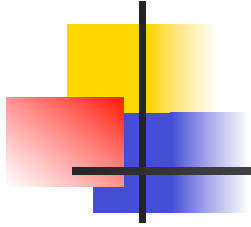


# The 2012 Thabeikkyin Earthquake

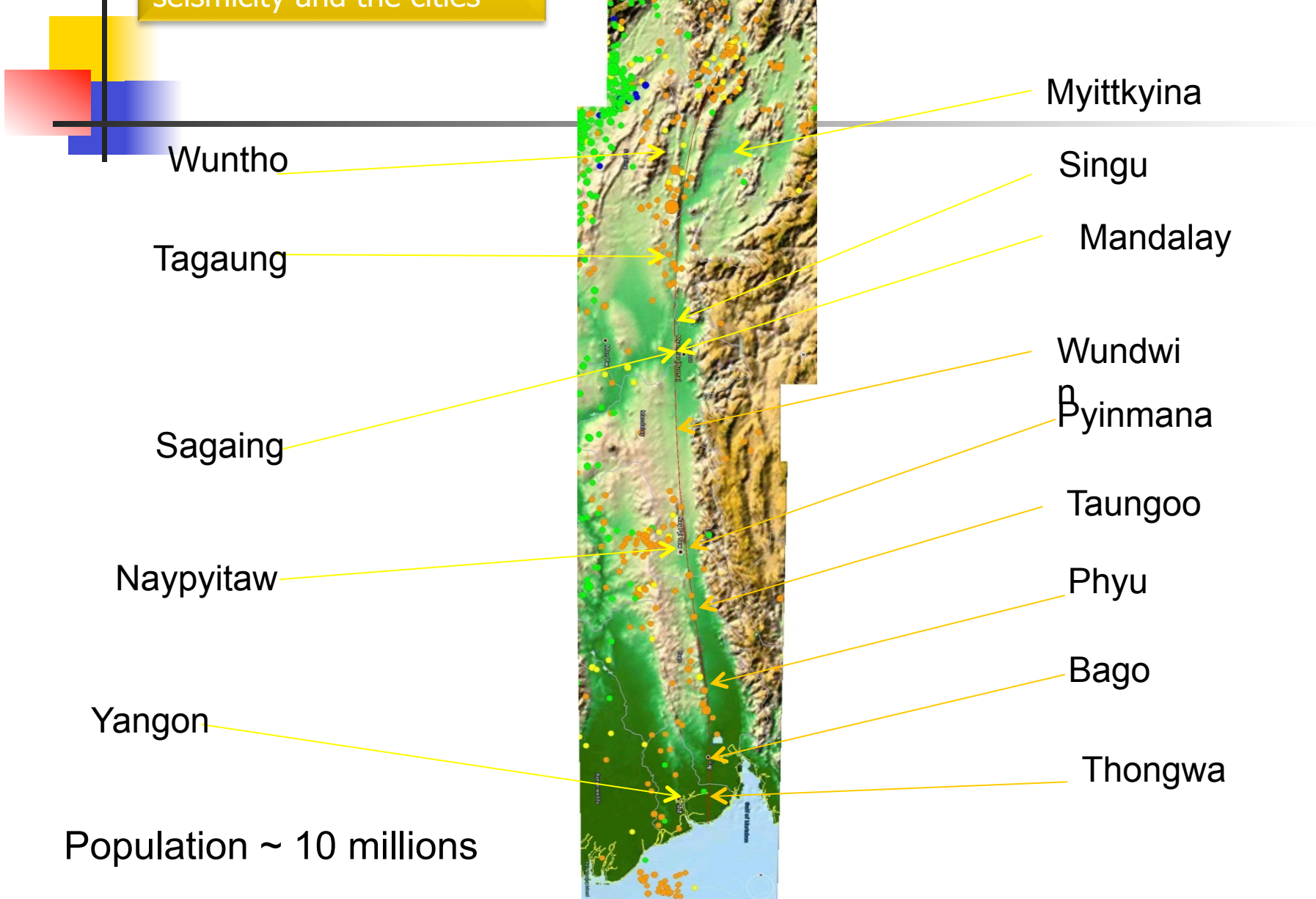








The Sagaing fault, seismicity and the cities



Wuntho

Tagaung

Sagaing

Naypyitaw

Yangon

Population ~ 10 millions

Myitkyina

Singu

Mandalay

Wundwi

Pyinmana

Taungoo

Phyu

Bago

Thongwa



# Earthquakes along the Sagaing Fault in 1930s

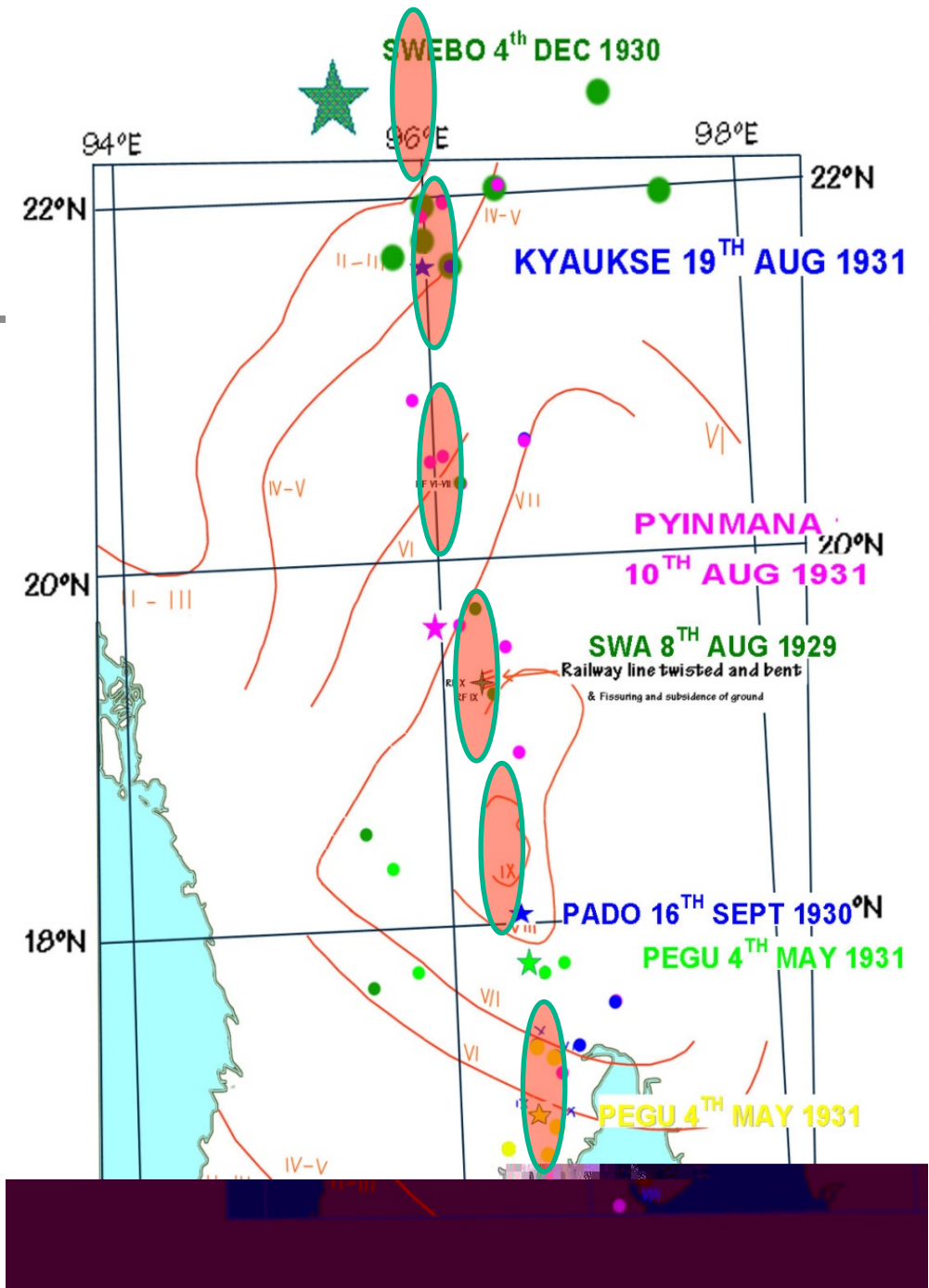


Figure: After J. C. Brown, 1934



- ◎ Myanmar Earthquake Committee
- ◎ California Institute of Technology
- ◎ Geological Survey of Japan
- ◎ Kyoto & Hiroshima Universities, Japan
- ◎ Earth Observatory of Singapore (NTU)
- ◎ Asia Disaster Preparedness Center (adpc)
- ◎ Asia Institute of Technology (AIT)
- ◎ USGS

