ပုဂံစေတီပုထိုးများနှင့်ငလျင်

နာယက
မြန်မာနိုင်ငံငလျင်ကော်မတီ
မြန်မာနိုင်ငံအင်ဂျင်နီယာအသင်းချုပ်

References

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- Maria Letizia Amadori et al. (2018)
- Tettoni: *Burmese Design & Architecture*, 2000
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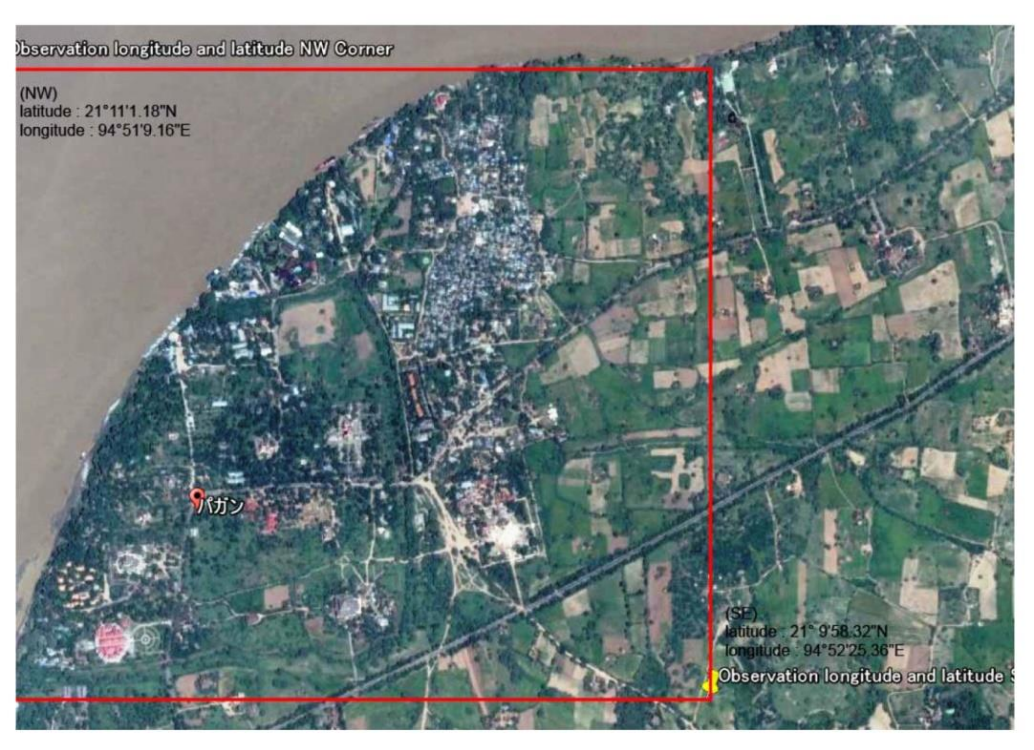
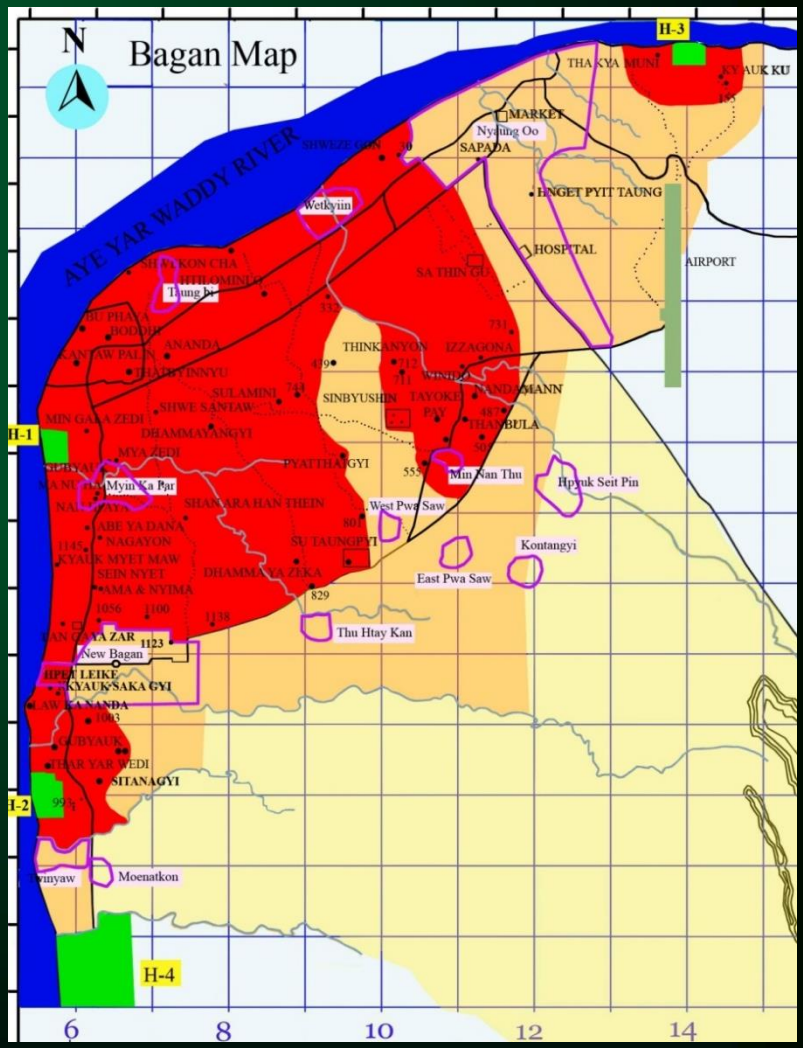
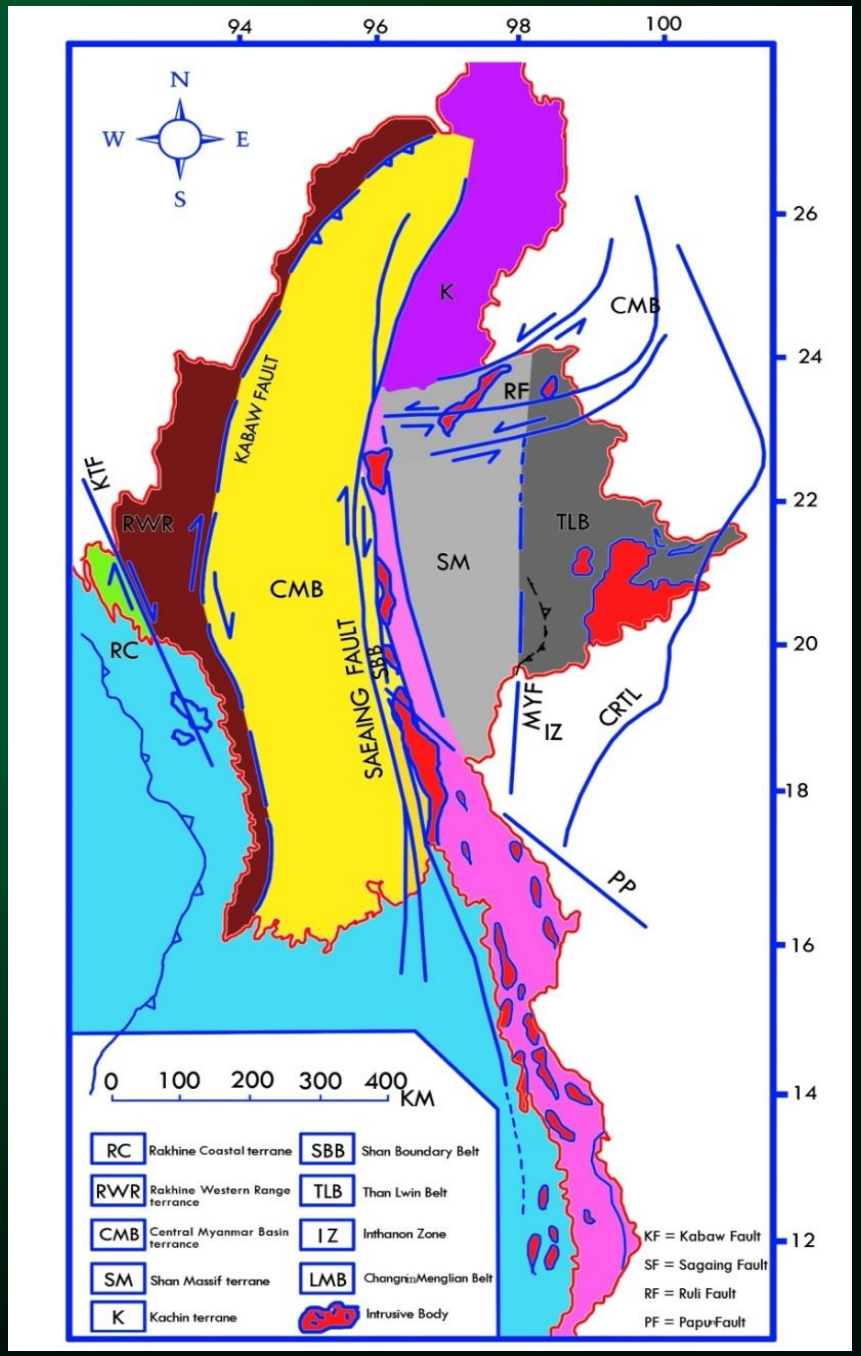
Location map of Bagan City Lat.21 10 N / Long.94 51 E






N
India
China
Myitkyina
Bamaw
Lasho
Hakha
Mandalay
Kyaington
Bagan
Sittwe
Magwe
Taunggyi
Naypyitaw
Thailand
Patthein
Yangon
Bay of Bengal
Dawei
Myeik


94
96
98
100
N
W
E
S
26
24
22
20
18
16
14
12
K
CMB
KABAW FAULT
RF
KTF
RWR
CMB
SM
TLB
RC
SAEAING FAULT
SBB
MYF
IZ
CRTL
PP
0 100 200 300 400 KM
RC Rakhine Coastal terrane
RWR Rakhine Western Range terrance
CMB Central Myanmar Basin terrance
SM Shan Massif terrane
K Kachin terrane
SBB Shan Boundary Belt
TLB Than Lwin Belt
IZ Inthanon Zone
LMB Changning-Menglian Belt
Intrusive Body
KF = Kabaw Fault
SF = Sagaing Fault
RF = Ruli Fault
PF = Papu Fault

Location of the Bagan City

- Bagan City, capital city of the Burmese Empire,
- The land of temples and stupas located in the heart of desert-like plain, the very center of the Dry Zone of Myanmar.
- Mandalay Region, Nyaung-Oo District,
- It is on the right bank of Aye-ya-wady River, covering an area of a little over 42-square kilometers in the west of Mt.Popa,
- At latitude 21°10’N and longitude 94°51’E

Bagan Dynasty

- 55 Kings ruled over a long period of 12 centuries.
- Bagan Dynasty from AD 107 with King Thamu-dayit.
- 42nd King is Anaw-rata (1044-1077)
- Construction of Stupas and Temples of 4446733 (more than 4 million) (U Than Swe) from AD 11 to AD 13, within 1260 years (hle-win-yo-than-ta-nyan-nyan)
- Now only 3122 left at present.

Geology in surrounding area of Bagan

The geology of Bagan area consists of Holocene surficial deposits of gravel, sand, silt and clay. The underlying rock formations that crop out around the Bagan area are mostly sandstone, siltstone and shale of the Pegu Group of Oligocene-Miocene and the Irrawaddy Group of Pliocene-Pleistocene.

Beyond the confluence point, at the places of Naung-oo, Pagan, Sale and Chauk area, the river formed a terrace system consists of 5 terraces.

This terrace system shows up clearly, particularly in the area between Sale and Chauk. It consists of sand and fine sand, silt,red gravels and red sand, aeolian sand, the loess-like “Pagan Silt”. The aeolian sediment are formed by the accumulation of wind-blown silt, sand and less clay.

Radio carbon dating by Pamela Gutman & Bob Hudson

Radio Carbon Dates for Bagan

	Materials	Date Ranges
Kyansittha Palace	Teak Fragments in Postholes (Sockets of Timber Columns)	AD 980-1250
	Fire Damage	AD 1220-1300 AD 1320-1440
City Wall	Latrine outside wall	AD 990-1210
	Below east wall	AD 1030-1330 AD 1020-1220
Otein Taung Pottery Mounds	Eastern Mound	AD 1290-1410 AD 880-1030
	Ash layer in fields between mounds	AD 760-980
	Western Mound	AD 1020-1220 AD 1010-1190

MONUMENTS IN BAGAN HERITAGE REGION

- (1) TEMPLES AND STUPAS 1745
- (2) MONASTERIES 431
- (3) OTHERS 54
  - (4) BURIED MOUNDS 298

- TOTAL 3122

Bagan Cultural Heritage Zone

Total Area 42 sq. kilometres

Residential Nyaung Oo Township
New Bagan Township and
13 villages

Total monuments 3122 in different types, sizes

Historical Background

Traditional chronicles 2nd CE
Documented History 849_ 1368 CE

Bagan socio-cultural traits inherited from its predecessor Pyu period (2nd BC_ 9th CE)

Historic City of Bagan

- YON HLUT KYONE PALACE SITE
- KYAUK SAKA GYI PALACE SITE
- THIRI PYIT SAYA PALACE SITE
- TAN PA WADDY PALACE SITE
- PYIN PYAR MIN PALACE SITE

Construction Technology of Pagodas

- very advanced technology
- Large solid core
- Load bearing system
- Use of vaults and arches
- Bricks (baked), natural stone (sst.)
- Foundation geometry has all essentials with deep foundation with proportionate between height and depth of structures.

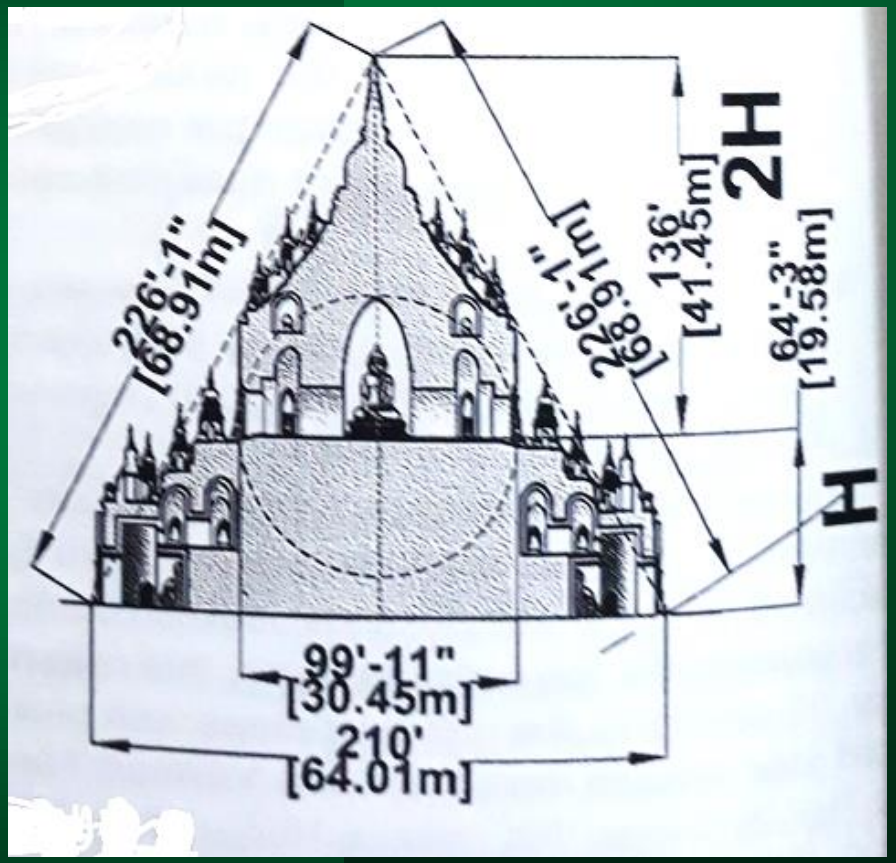
ပုဂံ အဂ်ံတေ ပြုလုပ်နည်း

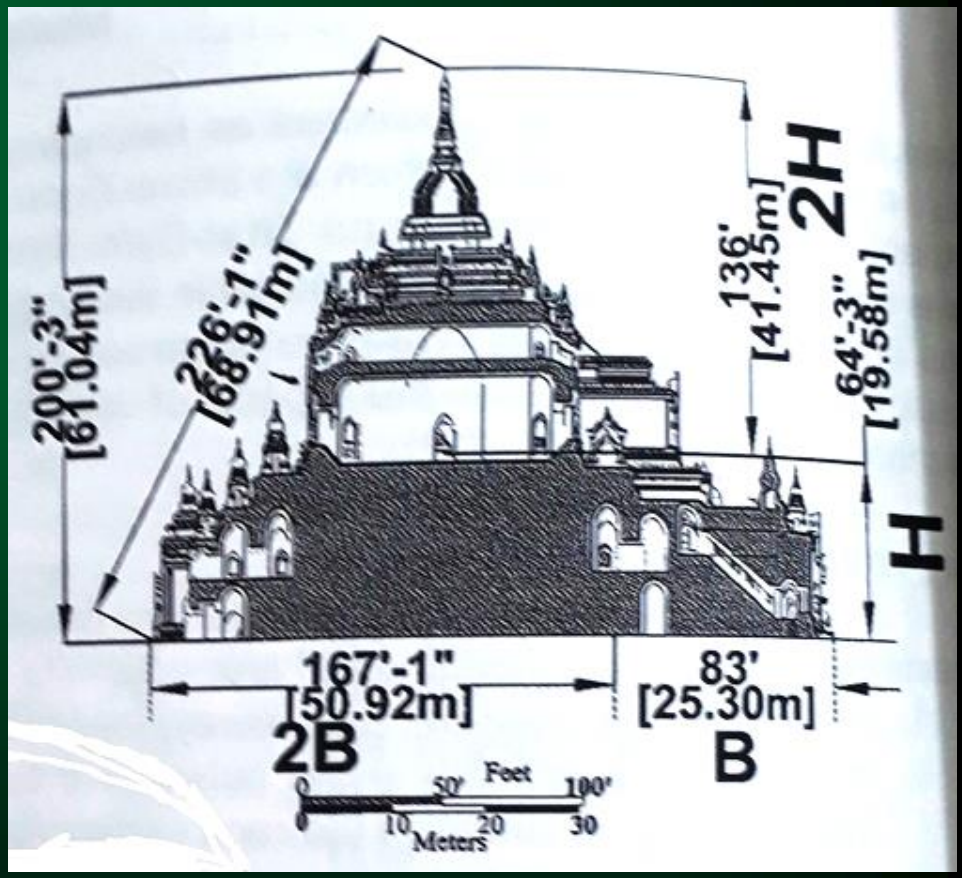
- အုံတုံသတ္တ နဝကျွဲကော်
- ဒွေးနော်တင်လဲ အုတ်သျစ်ခွဲနှင့်
- လဲဝါတဆုတ် ဆီတမူတ်ကို
- မယုတ်စုပေါင်း ညက်စွာထောင်းတော
- ဥသျစ်စကေး တင်လဲဒွေးနှင့်
- အုံတုံပဥ္စ ကျွဲကော်ဆ
- မှတ်ကြအဂ်ံတေ

Construction Technology

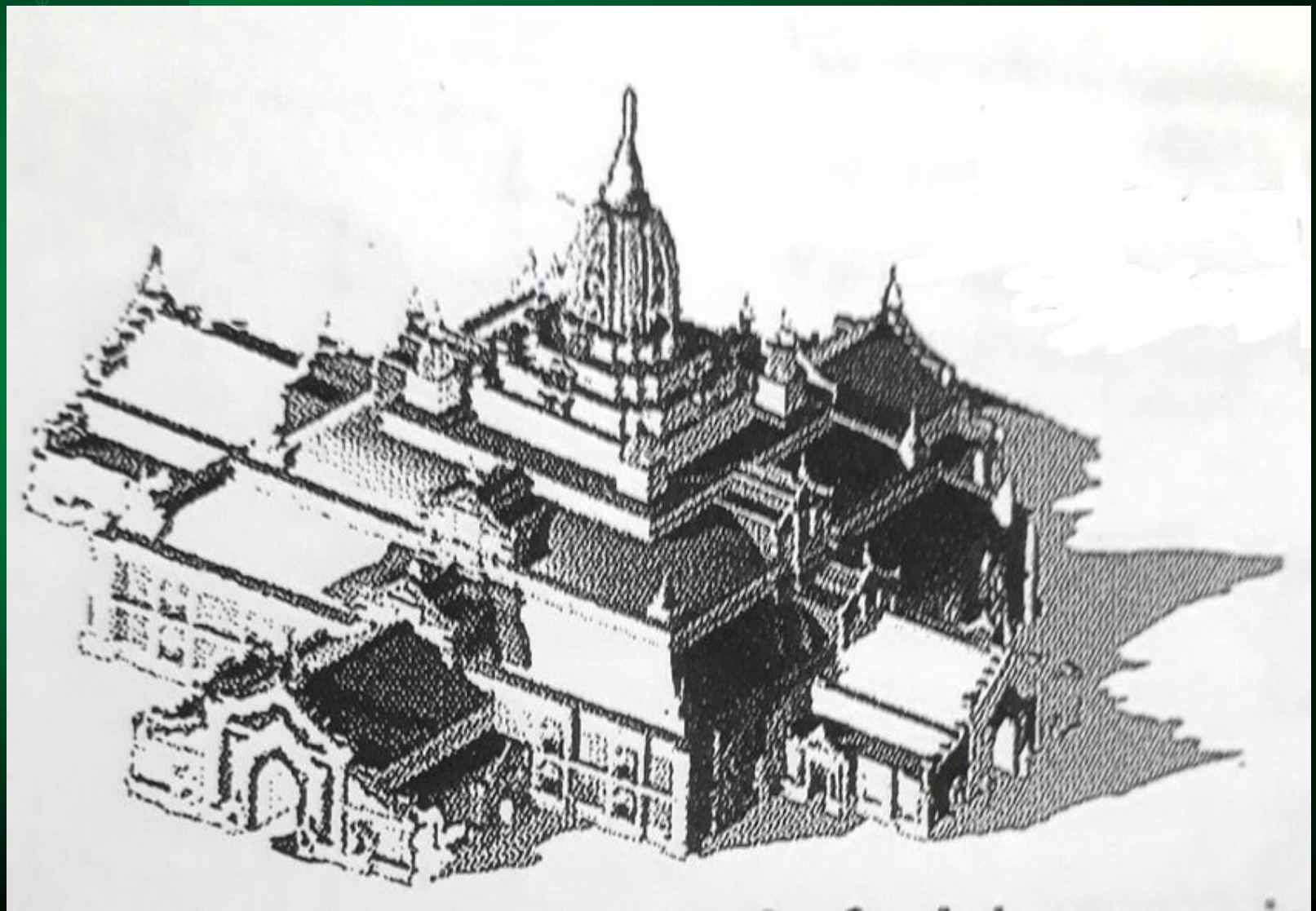
- Temples are square shape with large, solid core in the center as piller
- Surrounded by the four-corridors around the main temple (pagoda)
- Very thick wall with holes to get natural light
- Windows are constructed in the shape of arch
- Thin, Baked bricks or natural sandstone slabs with large square shape are used, one side is concave for more cement

Propotion is designed as an equilateral triangle.





Propotion is designed between height and width= the golden ratio



Previous earthquakes in Bagan (recorded)

- 25 November 1372
- 14 July 1485
- 1501
- 1588
- 1550
- 24 August 1714
- 1838, March 22nd
- 15 October 1856
- 1965
- 8 July 1975 M 6.8 (the largest in 900 years)
- 13 April 2016
- 27 July 2016
- 1 August 2016
- 24 August 2016 M 6.8

Previous EQ.s (Min Bu Aung Kyaing)

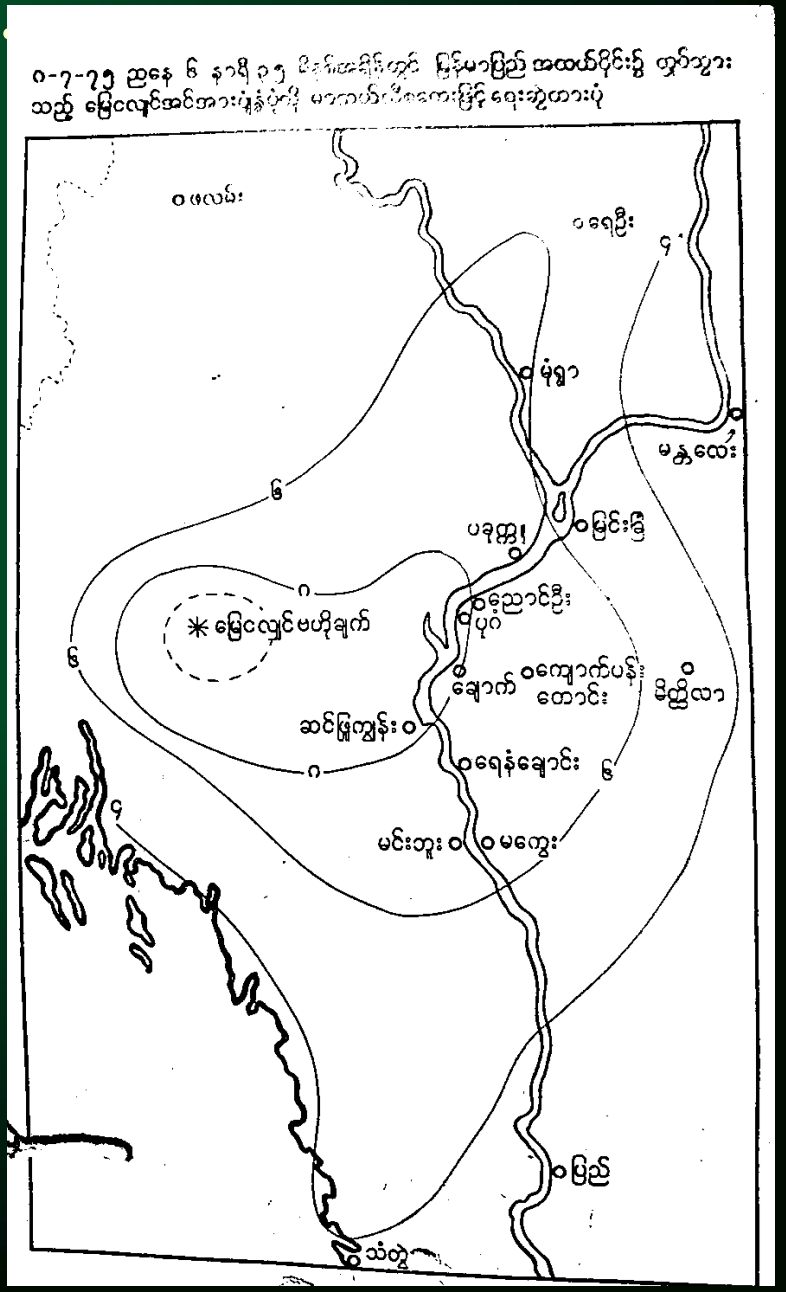
- AD 324
- AD 986
- AD 1286(Ta-yot-pyay-min)
- AD 1290
- AD 1380
- AD 1429A
- AD 1469
- AD 1485
- AD 1501
- AD 1777
- AD 1838
- AD 1965
- AD 1975
- AD 2016

List of intermediate-depth EQ.S

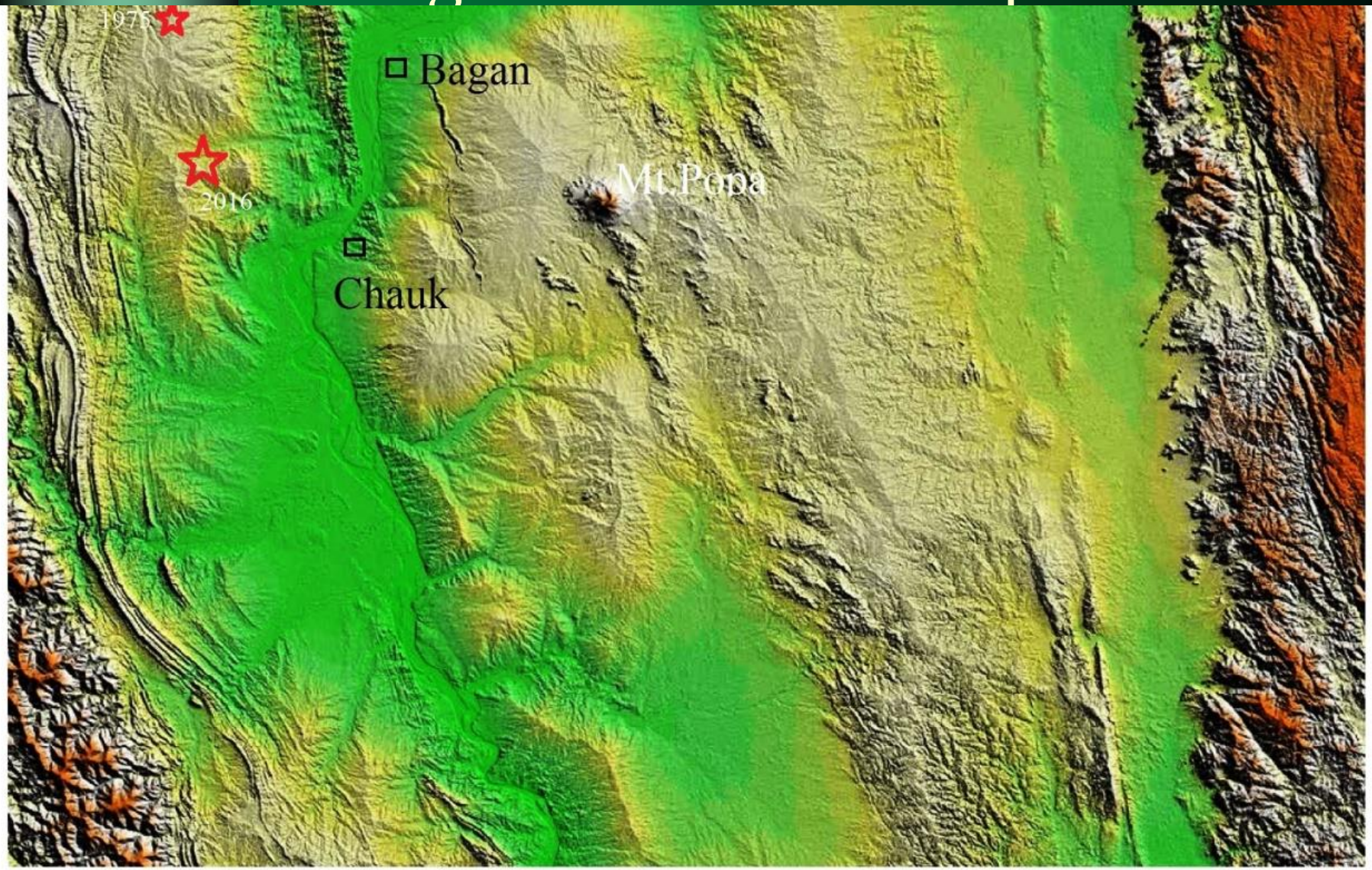
Serial	Name	Date	Time (UTC)	Epicenter	Tensor	M	Depth
1#	Myanaung	9.2.2018	4:41:43 UTC	18.213°N 94.288°E		4.2	28.7km
2#	Thandwe	18.8.2019	3:24:23 UTC	18.486°N 94.609°E		4.7	54.7km
3#	Mawlaik					4.7	22km
4#	Falam					4.8	42km
5#	Mawlaik-2	26.5.2018	11:42:23 UTC	23.004°N 94.608°E		4.5	95.3km
6#	Mawlaik-3	24.4.2018	4:08:35 UTC	22.923°N 94.804°°E	thrusting	5.2	105.9km
7#	Mawlaik-4	20.1.2018	10:00:06 UTC	23.89°N 94.702°E		4.2	85.5km
8#	Thandwe2	20.1.2018	4:00:05 UTC	18.24°N 94.06°E		4.0	
9#	Monywa	3.12.2018	9:47:14 UTC	22.361°N 94.504°E		4.7	96.8km
10#	Pyay	14.2.2018	7:14:01 UTC	18.724°N 95.251°E		4.7	81.4km
11#	Chauk	29.4.2018	5:58:57 UTC	21.124°N 94.435°E		4.5	89.6km
12#	Monywa-2	26.6.2016	12:00	22.209°N 95.034°E		4.6	21.8km
13#	Taunggup	27.3.2019	11:00:18 (MST)	18.88°N 94.14°E		4.5	10km
14#	Haka	25.1.2019	4:06:03 (MST)	23.12°N 94.08°E		4.2	
15#	Paung Pyin	17.3.2019	1:53:40 (MST)	24.02°N 94.59°E		4.8	84km
16#	Chauk-2	24.8.2016		20.919°N 94.579°E	thrusting	6.8	84.1km
17#	Mawlaik-5	13.4.2016	8:25 (MST)	23.133°N 94.900°E	thrusting	6.9	134km
18#	Kyauk-tu	19.11.2018			normal fault	4.9	76.1km
19#	Thandwe-2	18.8.2019		18.486°N 94.609°E	normal fault	4.7	54.7km
20#	Thandwe-3	18.8.2019		18.487°N 94.511°E		5.3	40.3km
21#	Shibweyan	26.8.2019	2:49:15 UTC	26.523°N 96.090°E		4.7	93.5km
22#	Chauk-3	6.9.2019	10:09:49 UTC	21.189°N 94.650°E		4.8	98.9km
23#	Bagan(Pagan)	8.7.1975	12:04:38 UTC	21.48N 94.04E		ISC-7	157km

Bagan & Chauk EQ

- The 1975 8-7-1975, 6:35 pm, Bagan earthquake M6.8 Depth157km,epicenter=Lat.21.48 °N-Long.94.04 E
- The 6.8 magnitude strong earthquake occurred on 24th August 2016 at intermediate depth of 84.1km with epicenter 20° 919' N 94° 579'E, 25 km west of Chauk. Focal mechanism solution of this event is given as compressional faulting (USGS) in subducting slab of India plate.



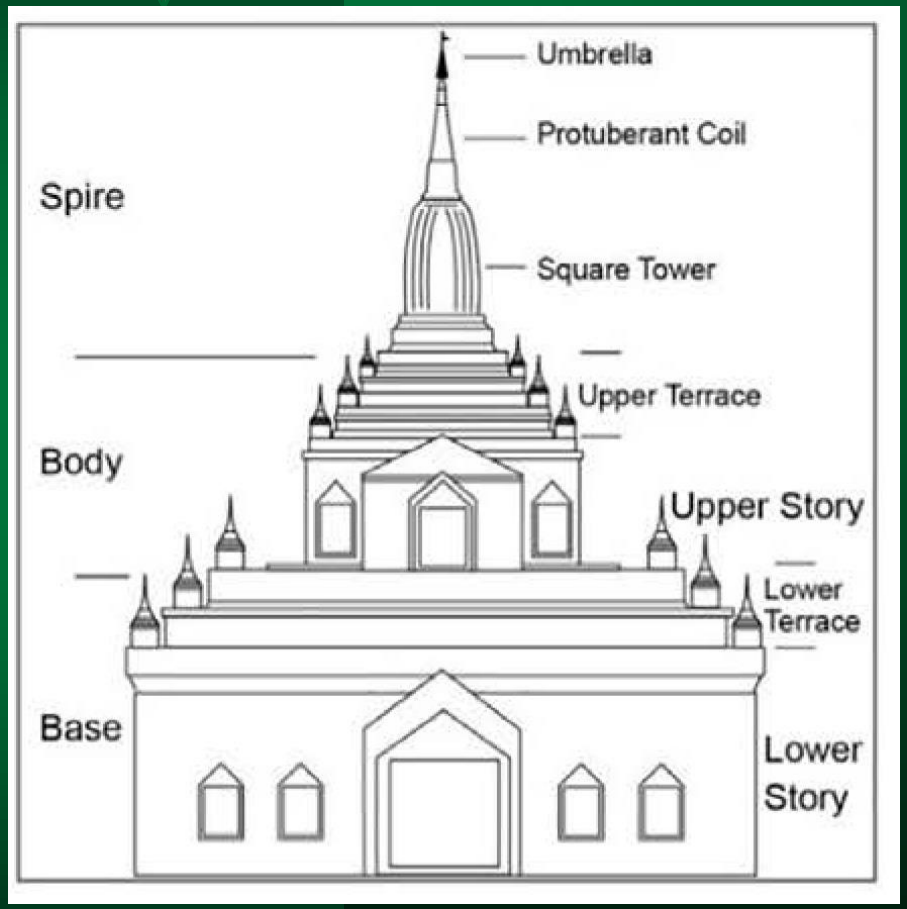
Satellite image of epicentral location of Bagan & Chauk earthquake

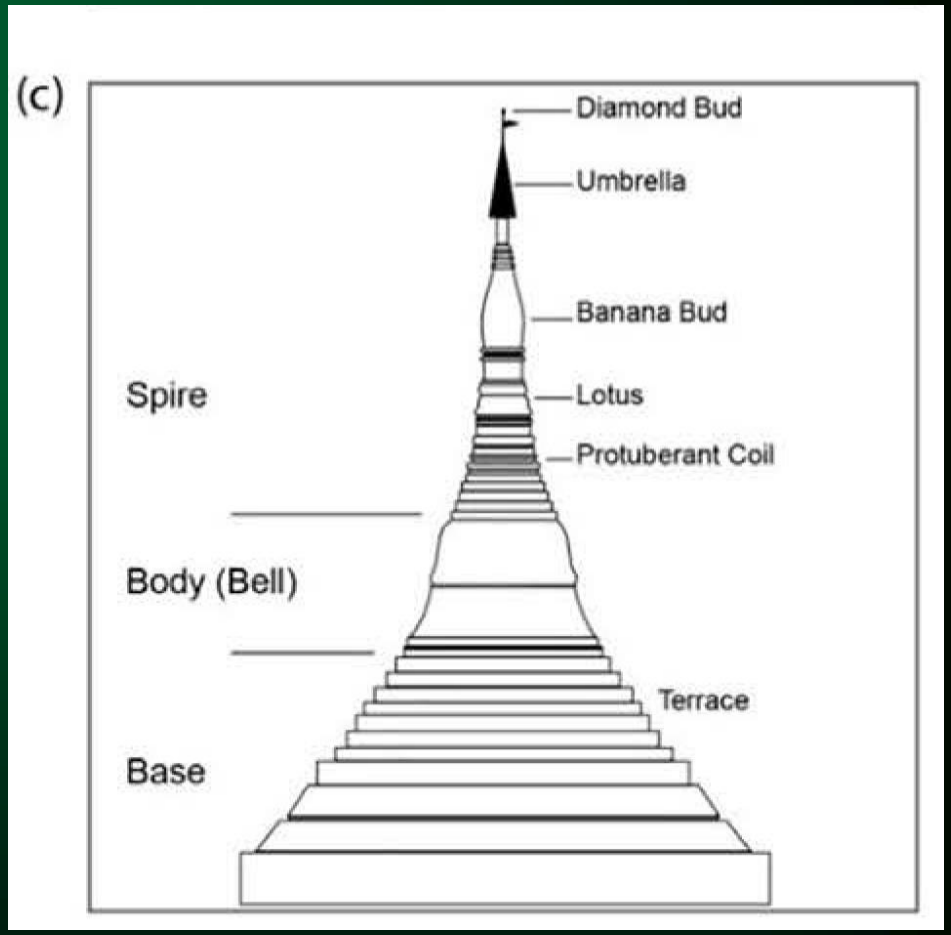


Epicentral Location of Bagan and Chauk eartquake

- Bagan earthquake-latitude 21° 50’N longitude 94° 70’ E/ D-157km/at 6:35pm
- Reverse faulting at intermediate depth in subduction slab of India-Burma plate
- Chauk earthquake- latitude 20° 919’ N
- longitude 94° 579’ E/
- D-41.0 km/ at 5:05 pm/

Combination of elements that composed a stupa or a temple





Shwe-san-daw stupa

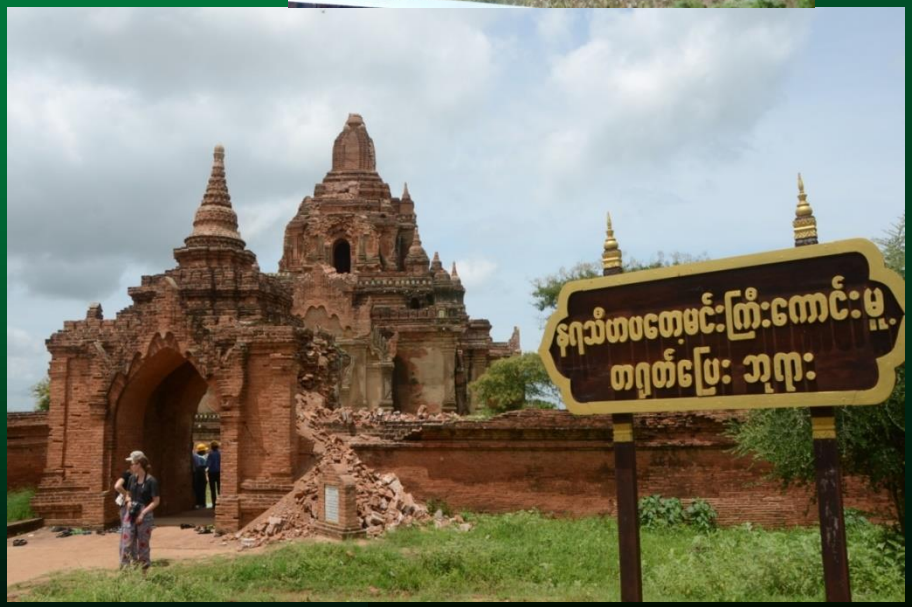
ရွှေဆံတော်ဘုရား ထီးတော်နှင့်တကွ ဖောင်းရစ်ပါမြေသည်ကို တွေ့ရပုံ

Sulamani Temple two-storeyed temple

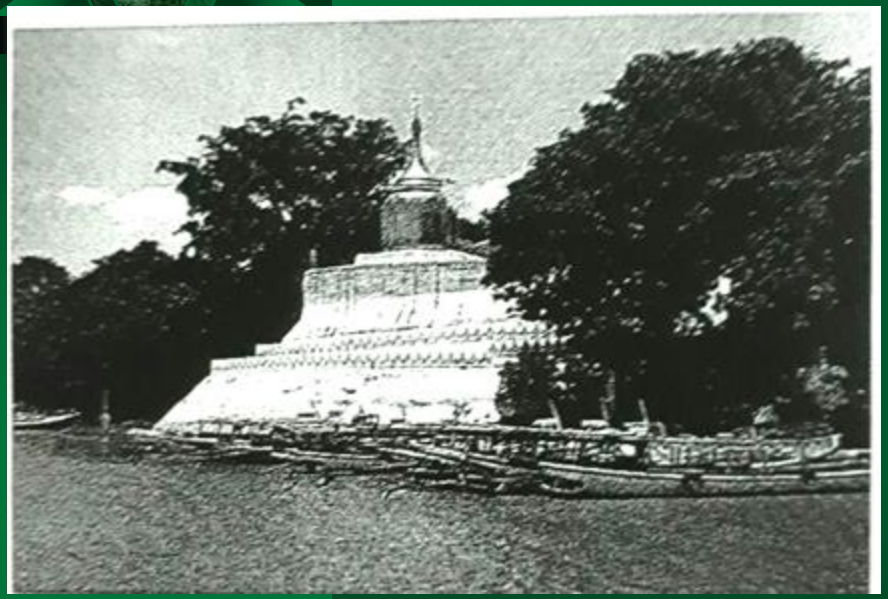
Shwe-si-gon Pagoda

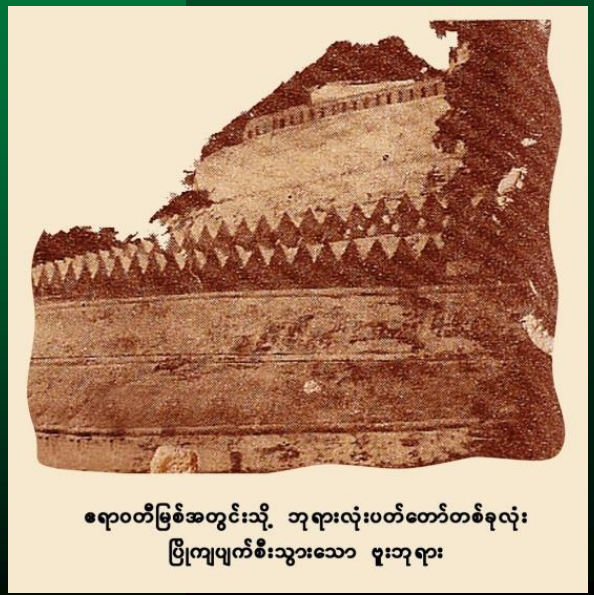
Su-lar-ma-ni Pagoda 2016

Nara-thiha-pa-te Pagoda 2016-two-storeyed temple



Bu pagoda





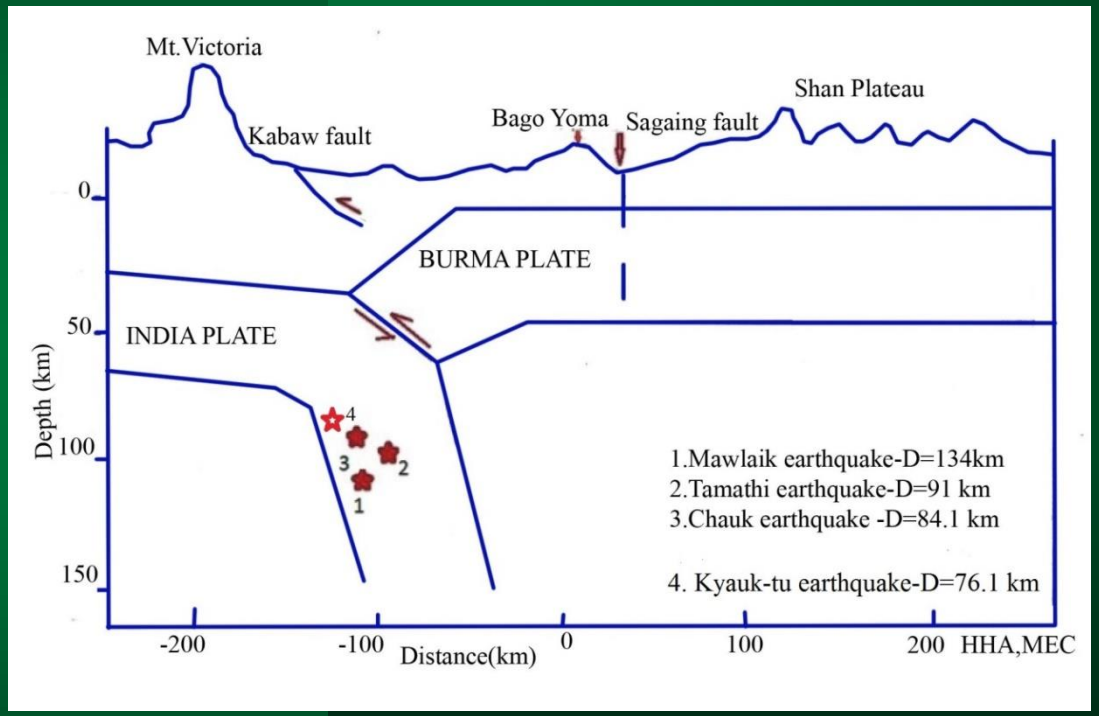
ရောဝတီမြစ်အတွင်းသို့ ဘုရားလုံးပတ်တော်တစ်ခုလုံး
ပြိုကျပျက်စီးသွားသော ဗူးဘုရား

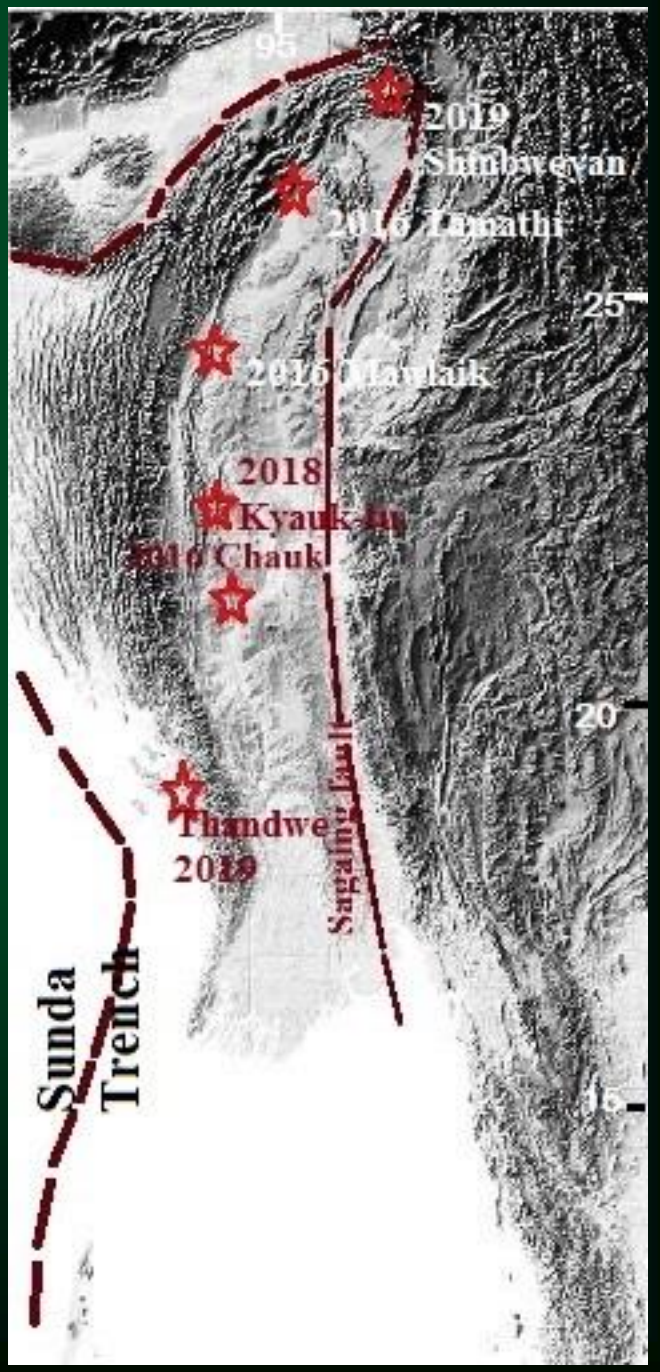
Large semi-underground monastery 20’-26’

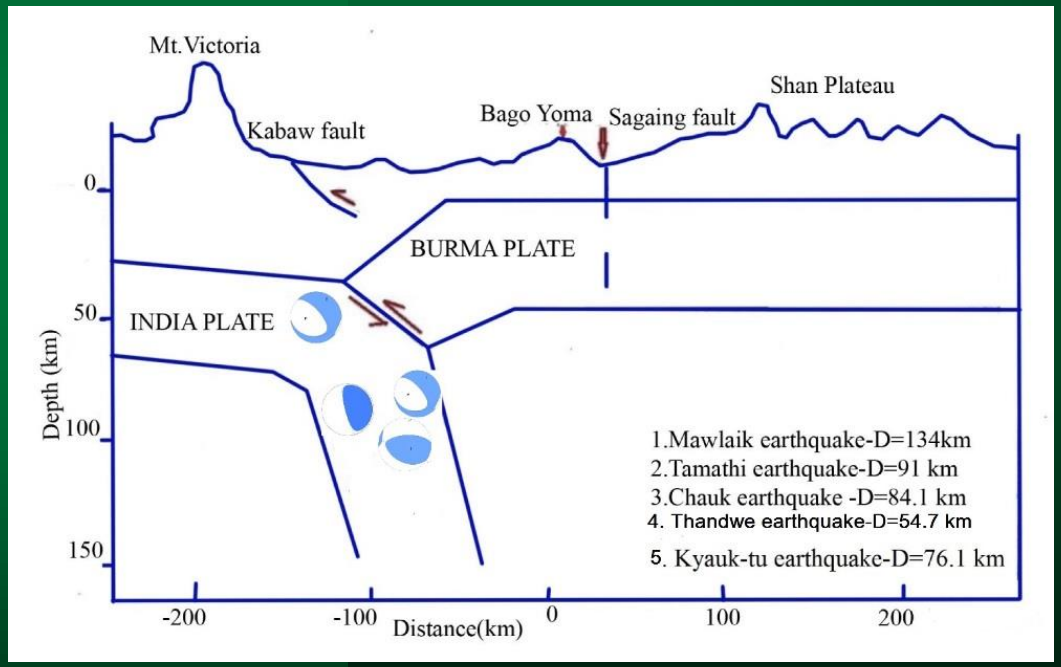
Me-taw ya pagoda

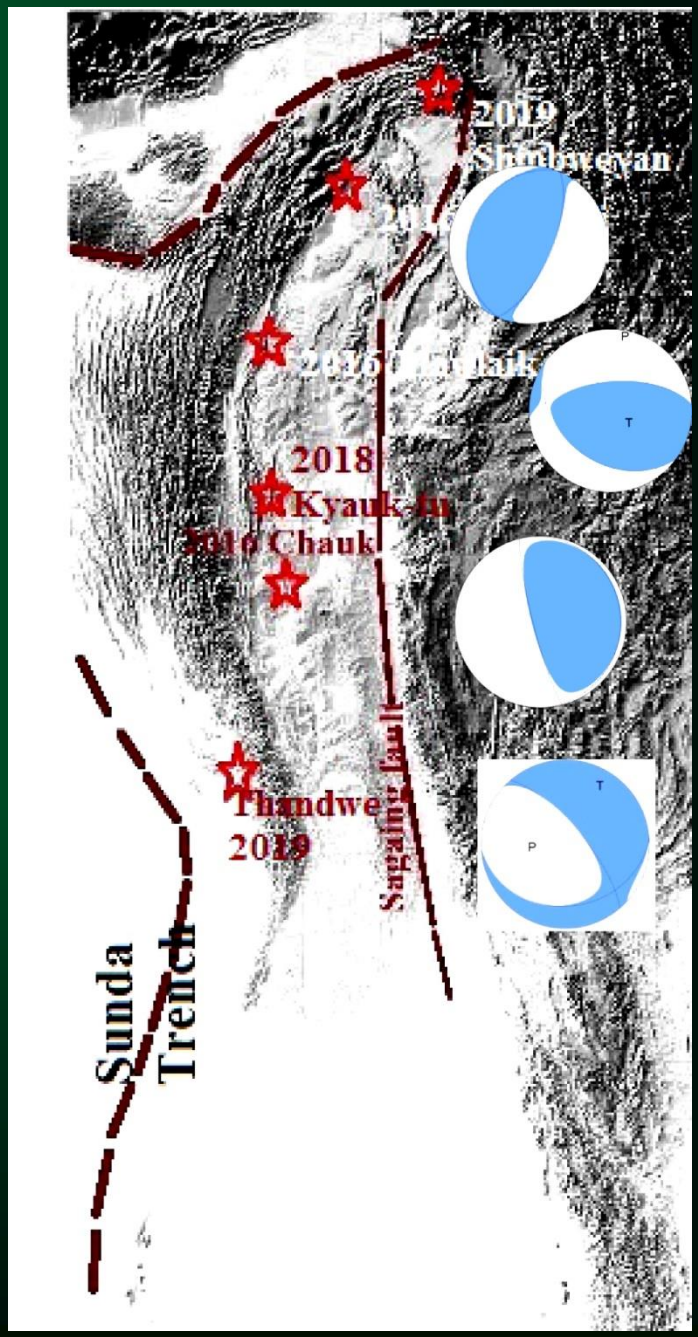
- Foundation geometry is 3-5 meter deep.

Significant EQ.s





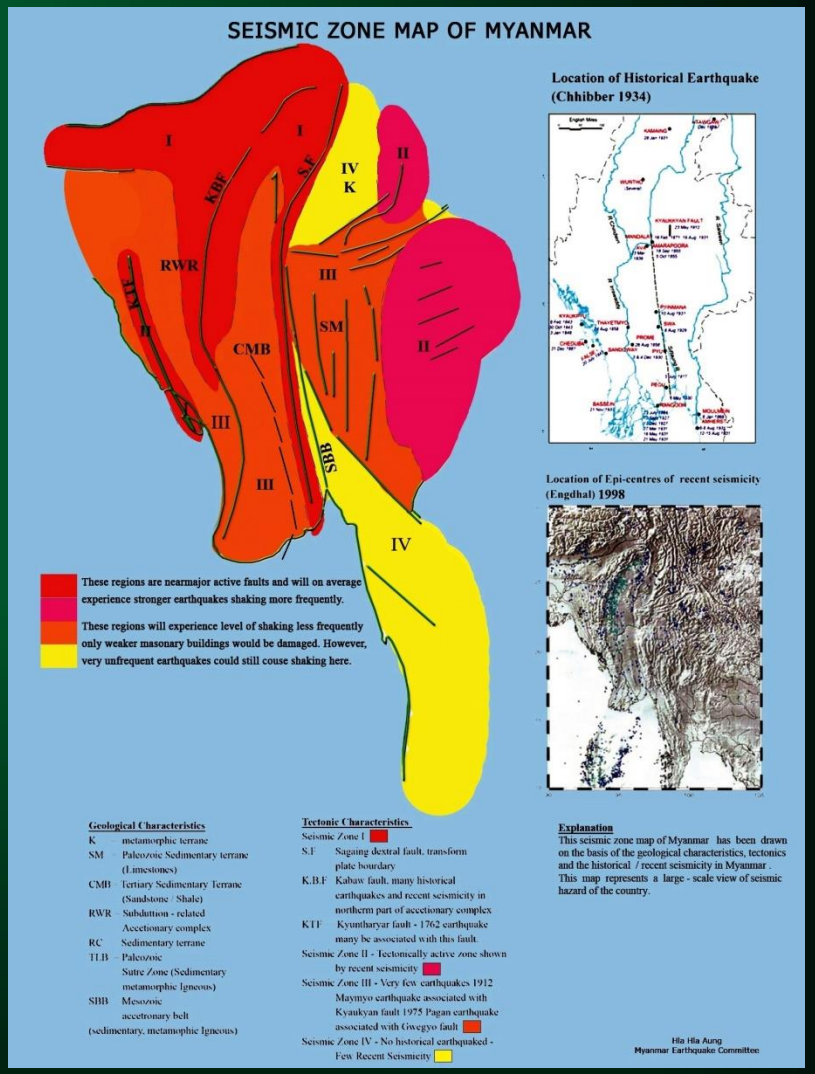

Mt.Victoria
Kabaw fault
Bago Yoma
Sagaing fault
Shan Plateau
BURMA PLATE
INDIA PLATE
Depth (km)
0
50
100
150
-200
-100
0
100
200
Distance(km)
1.Mawlaik earthquake-D=134km
2.Tamathi earthquake-D=91 km
3.Chauk earthquake -D=84.1 km
4. Thandwe earthquake-D=54.7 km
5. Kyauk-tu earthquake-D=76.1 km


2019
Shwebo-yan
2018
Kyauk-tu
2016 Chauk
Thandwe
2019
Sagaing fault
Sunda
Trench

မြန်မာ့လျှင်သမိုင်း

(ပြုစုသူ) လှလှအောင် မြန်မာနိုင်ငံလျှင်ကော်မတီ

(၁)	၁၈၃၉ခုနှစ် မင်းကွန်းပုထိုးတော်ကြီး ပျက်စီးစေခဲ့သော အင်းဝလျှင်			
(၂)	၃၁. ၈. ၁၉၀၆	27° 00' N 97° 00'E	7.0	ပူတာအိုလျှင်
(၃)	၁၂. ၈. ၁၉၀၈	27° 00' N 97° 00'E	7.5	ပူတာအိုလျှင်
(၄)	၂၃. ၅. ၁၉၁၂	21° 00' N 97° 00'E	8.0	မေမြို့လျှင်
(၅)	၈. ၈. ၁၉၂၉	19° 25' N 96° 25'E	7.0	ဆွာလျှင်
(၆)	၅. ၅. ၁၉၃၀	17° 00' N 96° 55'E	7.3	ပဲခူးလျှင်
(၇)	၃. ၁၂. ၁၉၃၀	18° 00' N 96° 50'E	7.3	ဖြူးလျှင်
(၈)	၂၇. ၁. ၁၉၃၁	25° 60' N 96° 80'E	7.6	ကာမိုင်လျှင်
(၉)	၁၂. ၉. ၁၉၄၆	23° 50' N 96° 00'E	7.0	တကောင်းလျှင်
(၁၀)	၁၃. ၉. ၁၉၄၆	23° 50' N 96° 00'E	7.0	တကောင်းလျှင်
(၁၁)	၁၆. ၇. ၁၉၅၆	22° 00' N 96° 00'E	7.0	စစ်ကိုင်းလျှင်
(၁၂)	၈. ၇. ၁၉၇၅	21° 50' N 94° 70'E	6.8	ပုဂံလျှင်
(၁၃)	၅. ၁. ၁၉၉၁	23° 48' N 95° 98'E	7.1	တကောင်းလျှင်
(၁၄)	၂၂. ၉. ၂၀၀၃	19° 94' N 95° 72'E	6.8	တောင်တွင်းကြီးလျှင်
(၁၅)	၁၇. ၁၂. ၁၉၂၇	16.950 N 96.127E	7.0	ရန်ကုန်လျှင်
(၁၆)	၂၄. ၃. ၂၀၁၁	20° 705' N 99° 949'E	6.8	တာလေလျှင်
(၁၇)	၁၁. ၁၁. ၂၀၁၂	23° 009' N 95° 884'E	6.8	သပိတ်ကျင်းလျှင်
(၁၈)	၂၇. ၁၂. ၂၀၁၅	22.614N-95.04E	5.4	မုံရွာ- ကနီ လျှင်
(၁၉)	၁၃. ၄. ၂၀၁၆	23° 133' N 94° 900'E	6.9	မော်လိုက်လျှင်
(၂၀)	၂၄. ၈. ၂၀၁၆	20° 919' N 94° 579'E	6.8	ချောက်လျှင်
(၂၁)	၁၃.၃.၂၀၁၇	17 415N, 95.999E	5.1	တိုက်ကြီးလျှင်



Effective Preparedness by R/S & GIS

- One of the most effective technological breakthroughs for archaeology is LiDAR or Laser scanning for heritage conservation.
- Planning and execution of reconstruction, restoration, conservation intervention is greatly needed.
- Point cloud are useful for building dimension measurements.
- Geospatial R/S tools for monitoring cultural heritage.
- To be able to withstand the future threatening earthquake, the Bagan archaeological sites should be maintained and preserved with post-earthquake reconstruction guidelines.

Thank you

Arch, core, pillar