Dynamic evolution of the Sagaing fault

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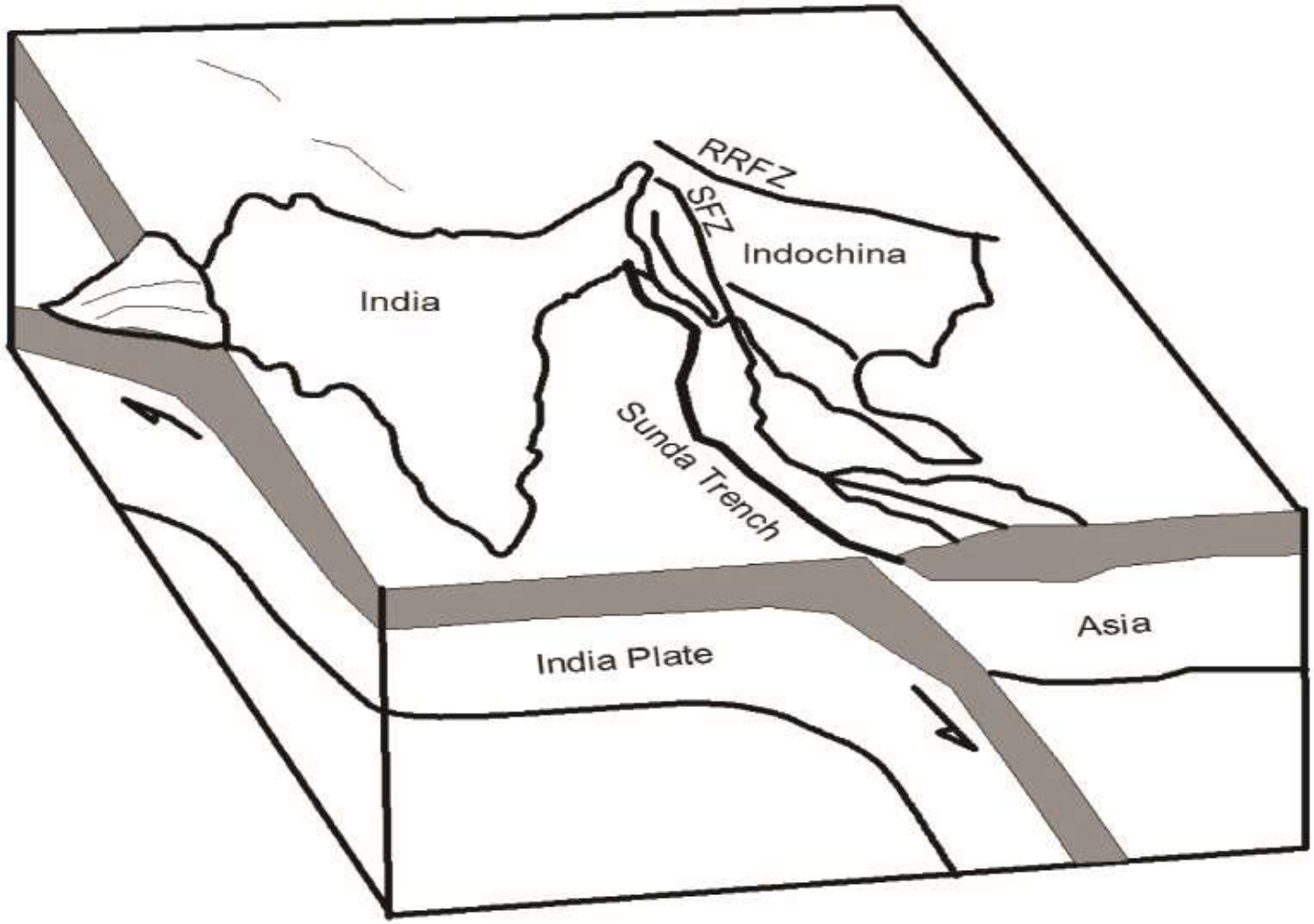
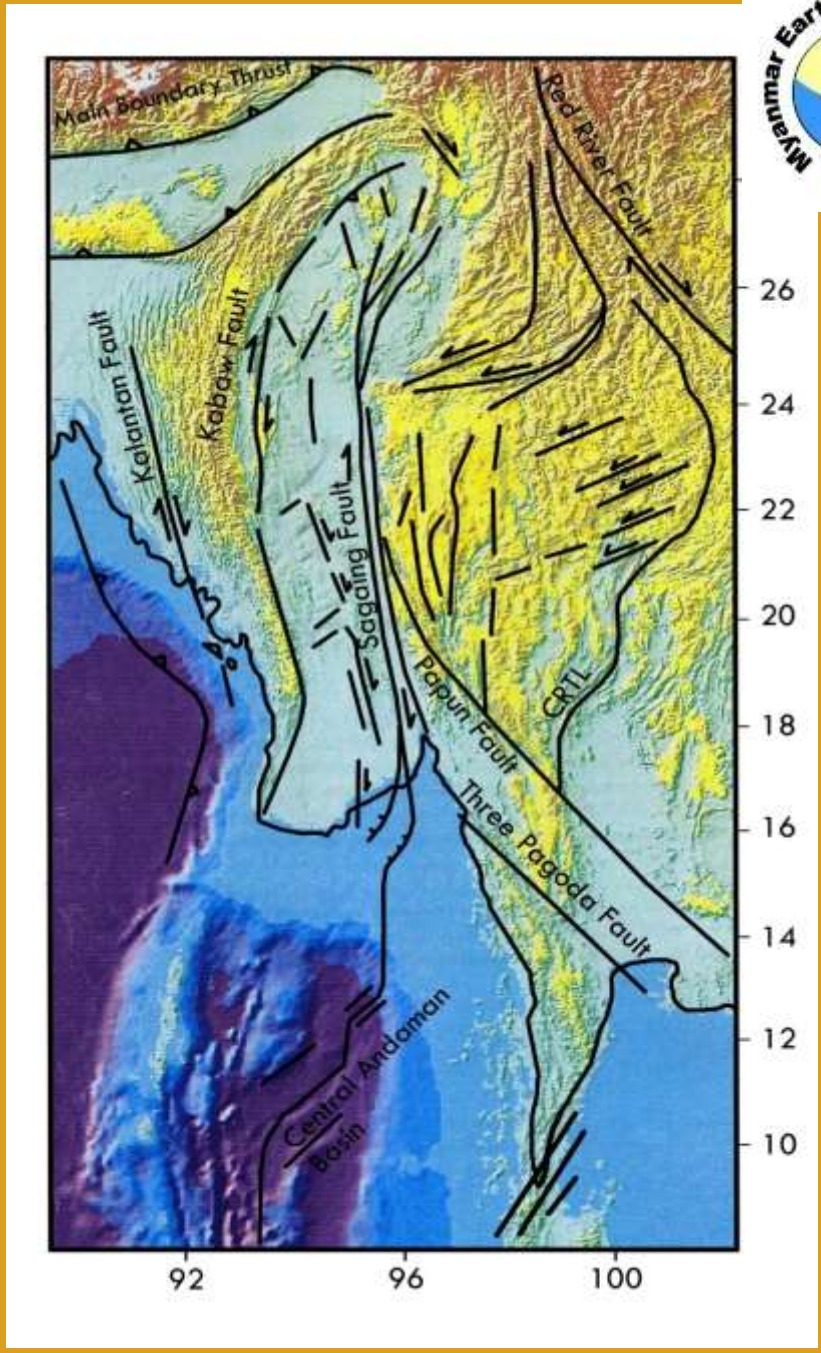
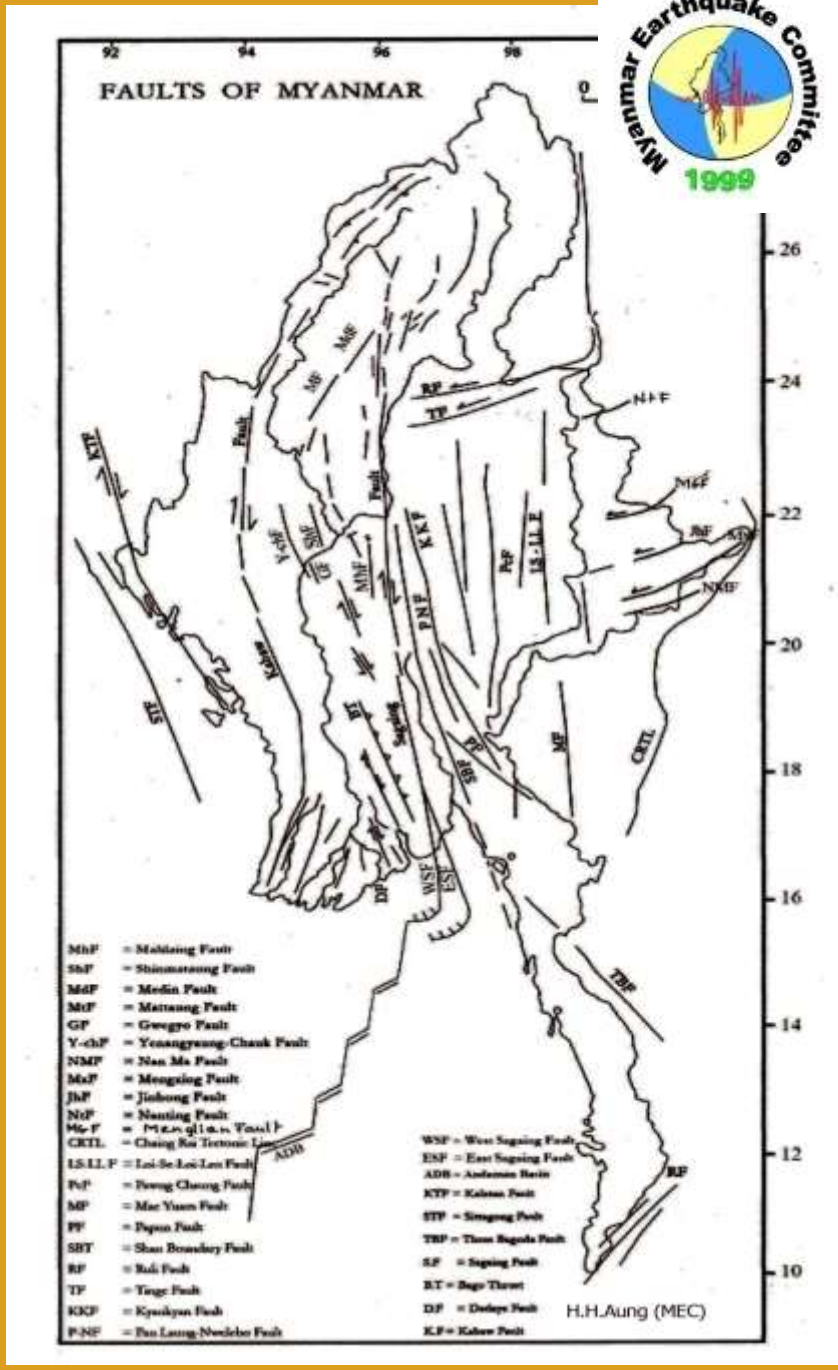
Tectonic setting of India and Burma plate (H.H.Aung, 2007)



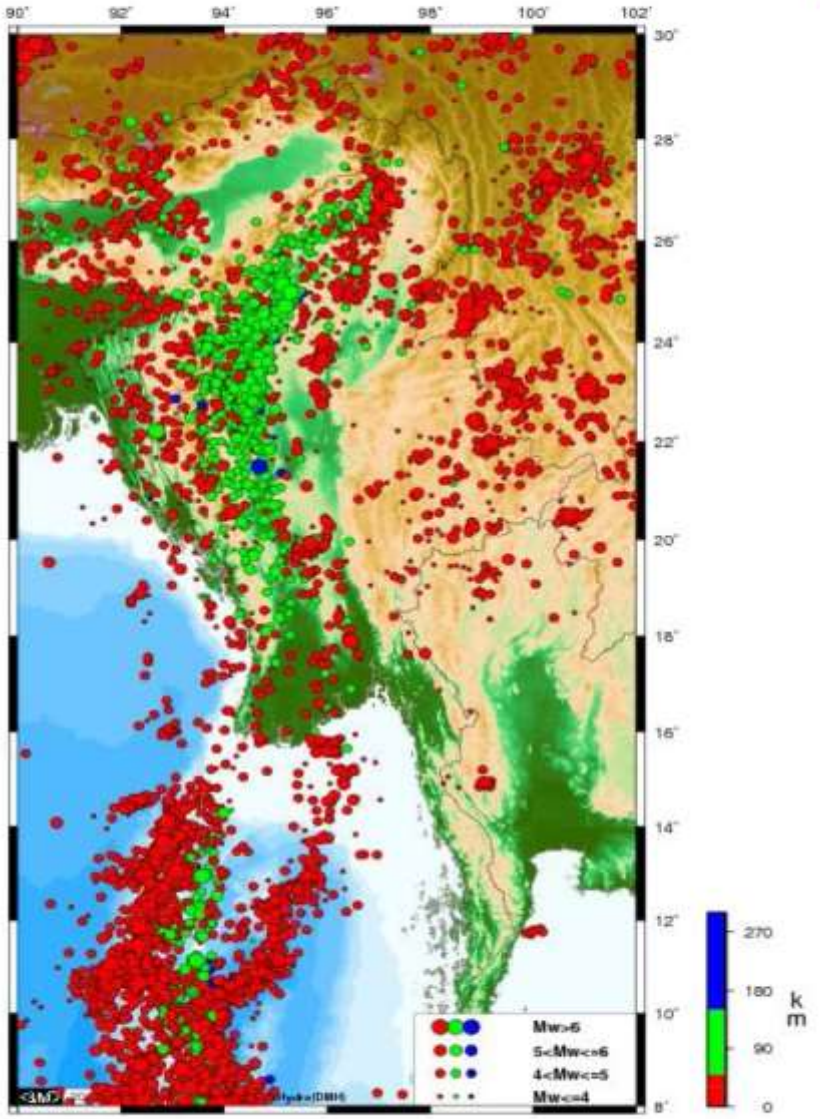
Major Faults(H.H.Aung)



FaultsofMyanmar(H.H.Aung)



USGS EQ.Catalog 1973-2010



Fault geometry of the Sagaing fault

- Fault longitude-96° 30E to 96° 08E to 96° 43E
- Relatively more westerly in the south-N-S in the central – then easterly in the north
- Average fault trend- N 9° W
- Depth-96km
- Velocity-18-25mm/yr
- Spreading in CAB- N29° W at a rate of 30mm/yr
- NW-SE oriented spreading and drifting of Burma plate along ridge segments in Gulf of Mottama
- Southern end of Sagaing Fault is northernmost of these oceanic transforms
- Offset-150km
- Length->1000km

Tectonic geomorphic features observed along the Sagain

Step-overs (from south to north)

- 17° N Kabauk In (1930 Bago Eq.)
- 17° 10N Zwedaik In
- 17° 27N Shwe dan In
- 21° 58N Yega In (1839 Eq., 1956 Eq.)
- 22° 30N a sag pond south of Singu plateau
- 23 N
- 23 45'N a sag pond west of Hti-chaing (1946, 1991 Tagaung Eq.)
- 24° N a sag pond north of Hti-chaing
- 25° N Indawgyi lake (1931 Kamaing Eq.)

Releasing/restraining bends

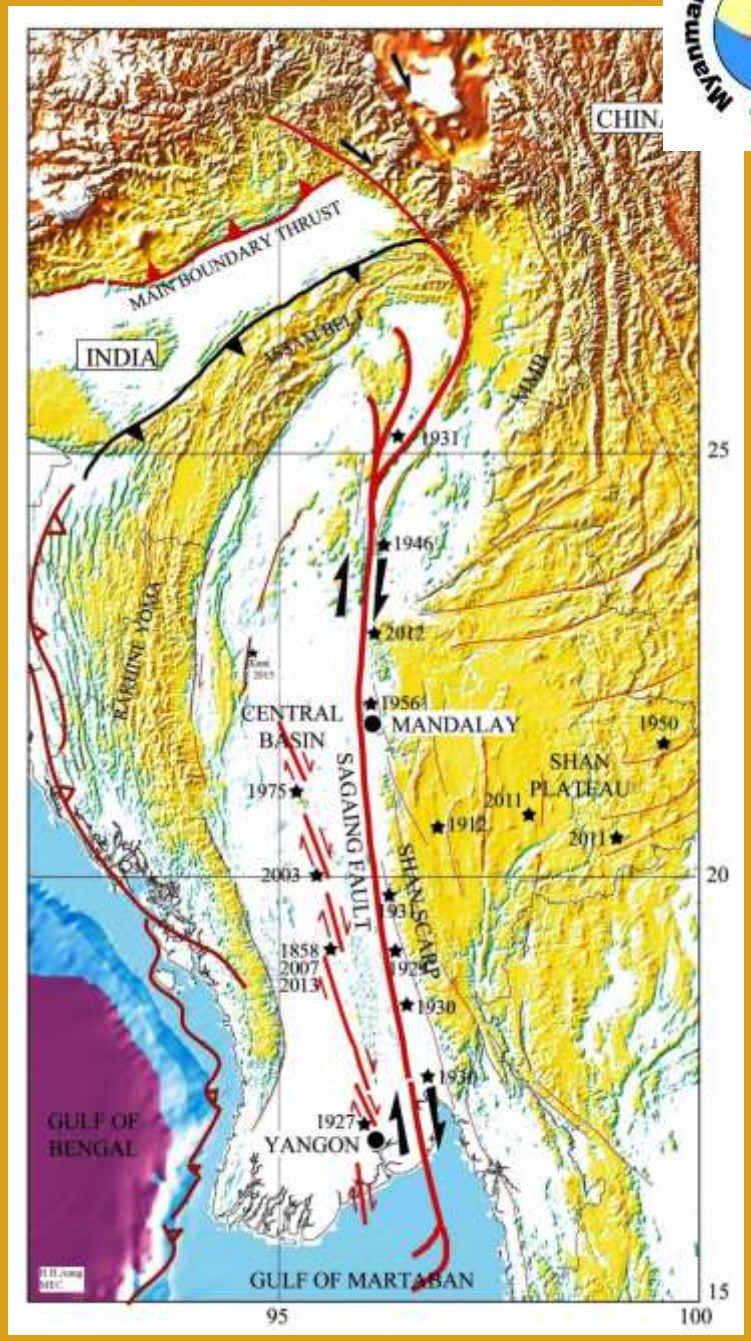
- 18° 30N to 19 ° 35N (1930 Phyu Eq. /1931 Pyinmana Eq.)
- 17° 05N to 17 ° 20N

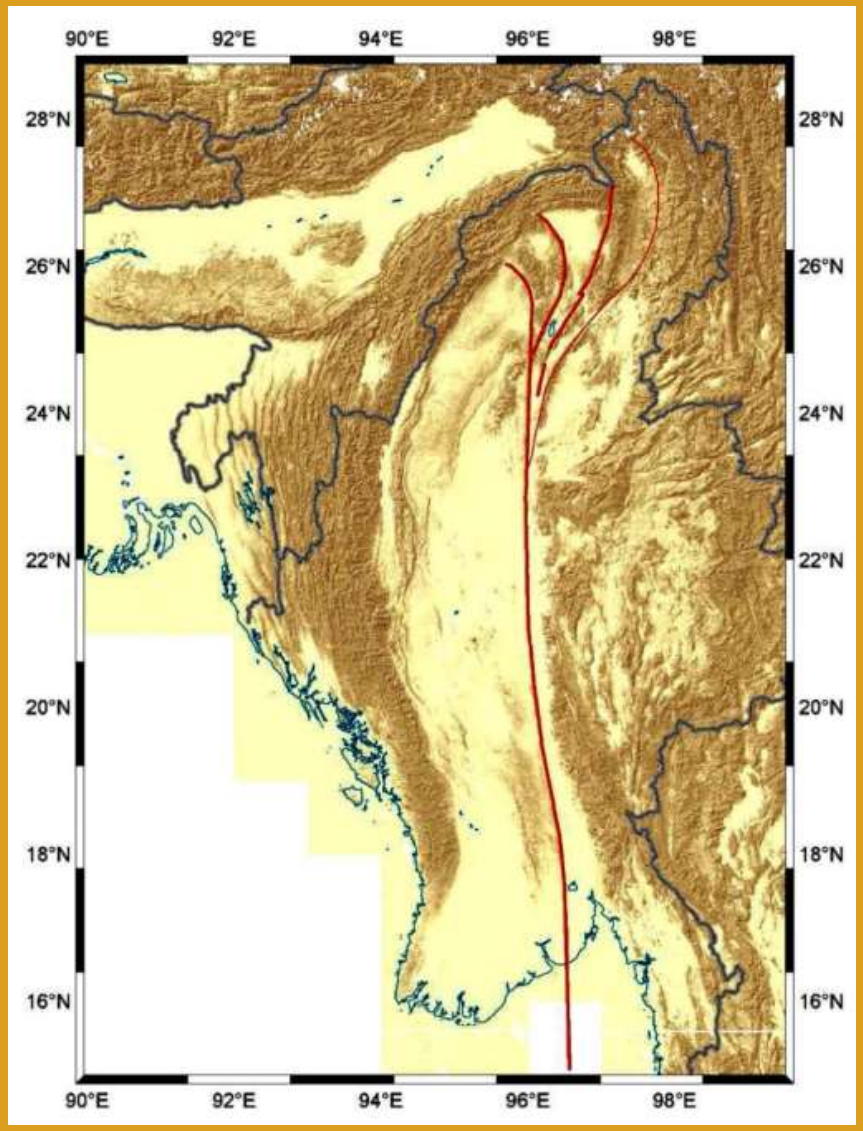
Linear fault Scarps Many places (1929 Swa Eq.)

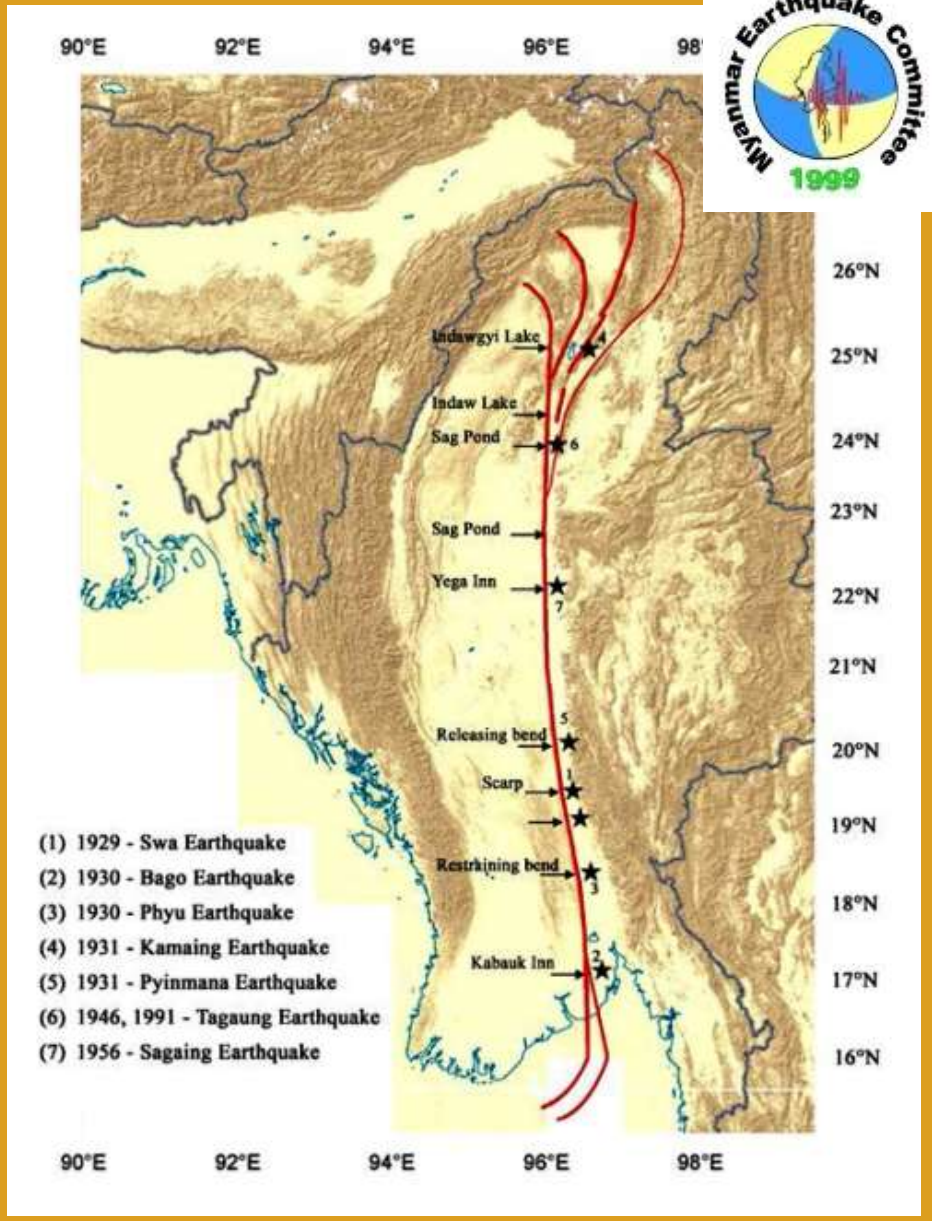
Pressure Ridges Desunpa, Magyigyin, Sagaing, Minwun, Tagaung

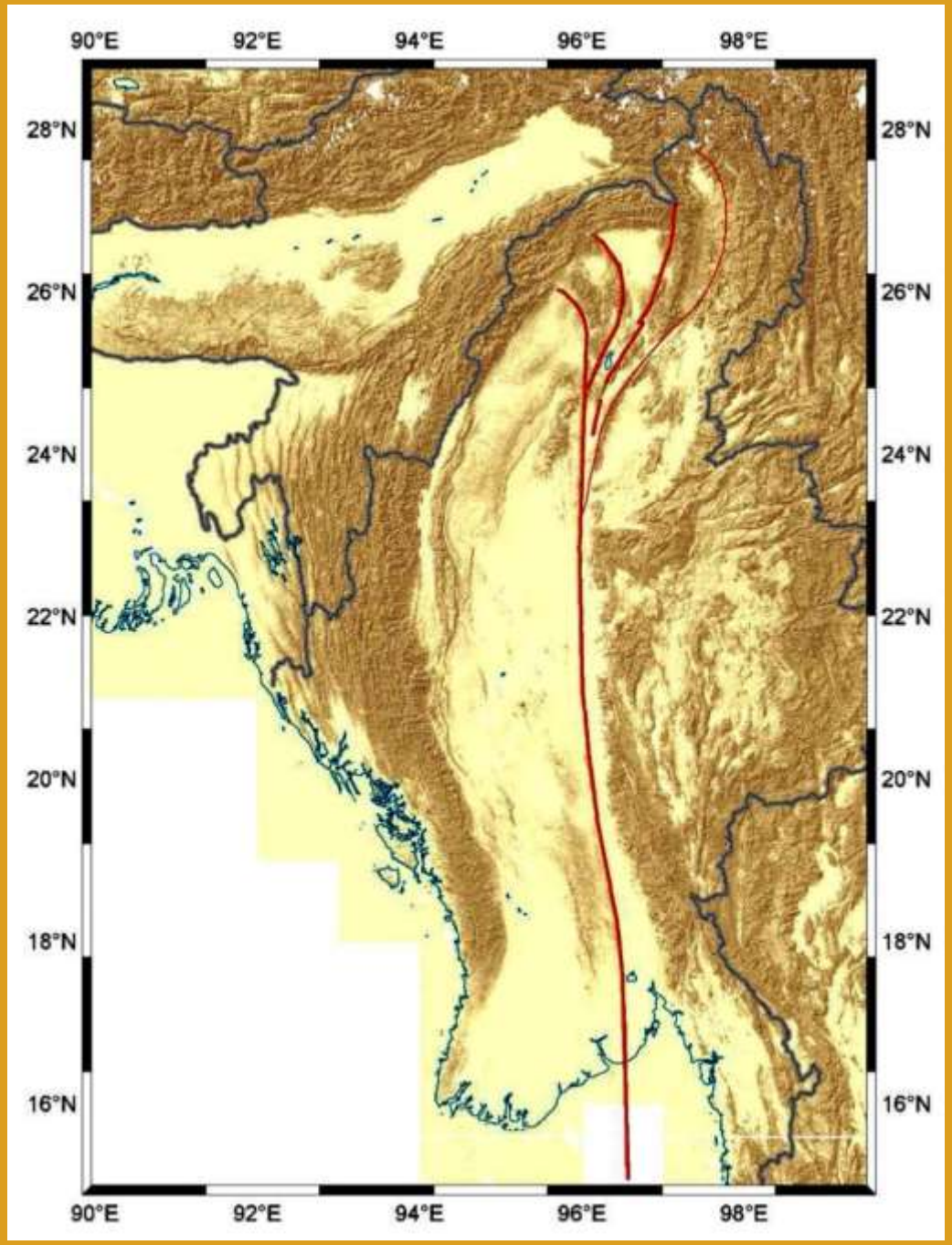
Seismicity of Myanmar

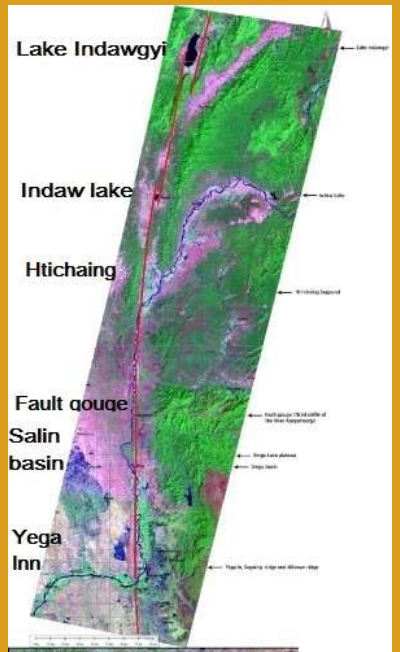
- 1839 Ava Earthquake
- 1929 Swa Earthquake
- 1930 Bago(Pegu) Earthquke
- !930 Phyu Earthquake
- 1931 Kamaing Earthquake
- 1931 Pyinmana Earthquake
- 1956 Sagaing Earthquake
- 1946 Tagaung Earthquake
- 1991 Tagaung Earthquake

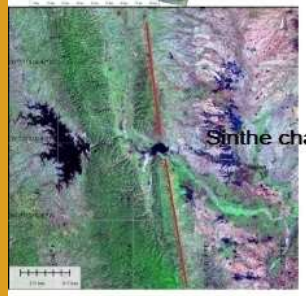


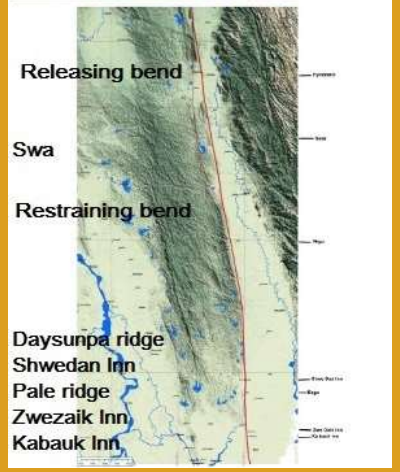

90°E
92°E
94°E
96°E
98°E
28°N
26°N
24°N
22°N
20°N
18°N
16°N


Myanmar Earthquake Committee
1999
Indawgyi Lake
Indaw Lake
Sag Pond
Sag Pond
Yega Inn
Releasing bend
Scarp
Restraining bend
Kabauk Inn
(1) 1929 - Swa Earthquake
(2) 1930 - Bago Earthquake
(3) 1930 - Phyu Earthquake
(4) 1931 - Kamaing Earthquake
(5) 1931 - Pyinmana Earthquake
(6) 1946, 1991 - Tagaung Earthquake
(7) 1956 - Sagaing Earthquake









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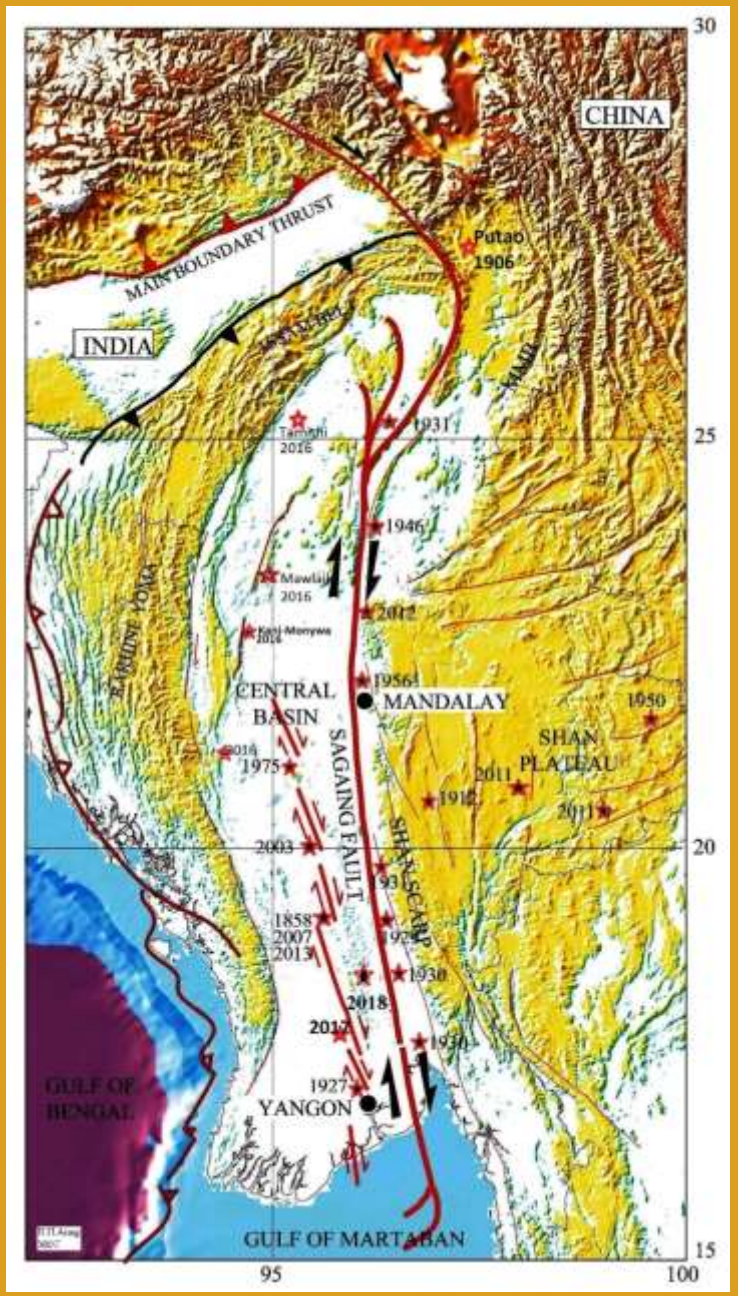

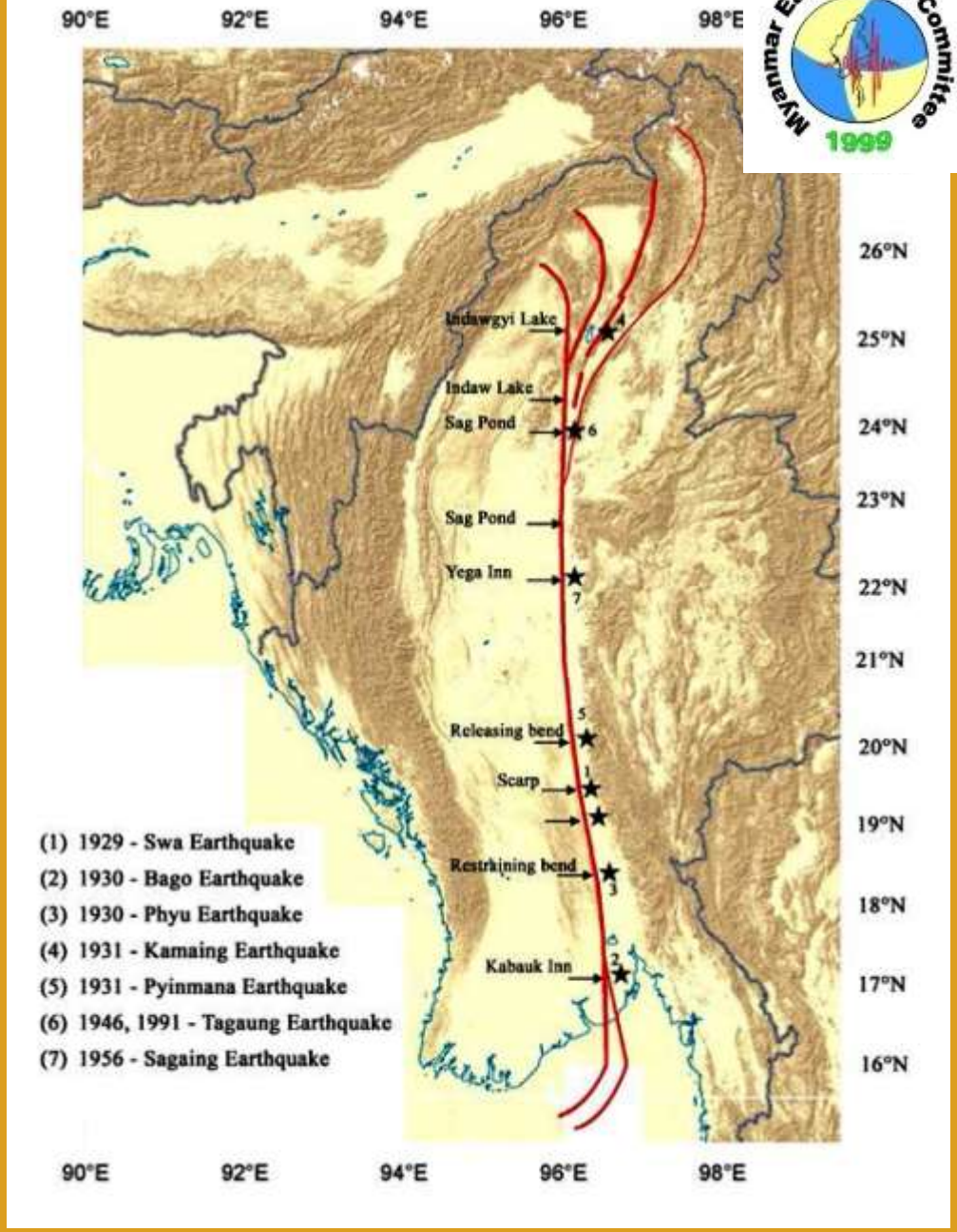

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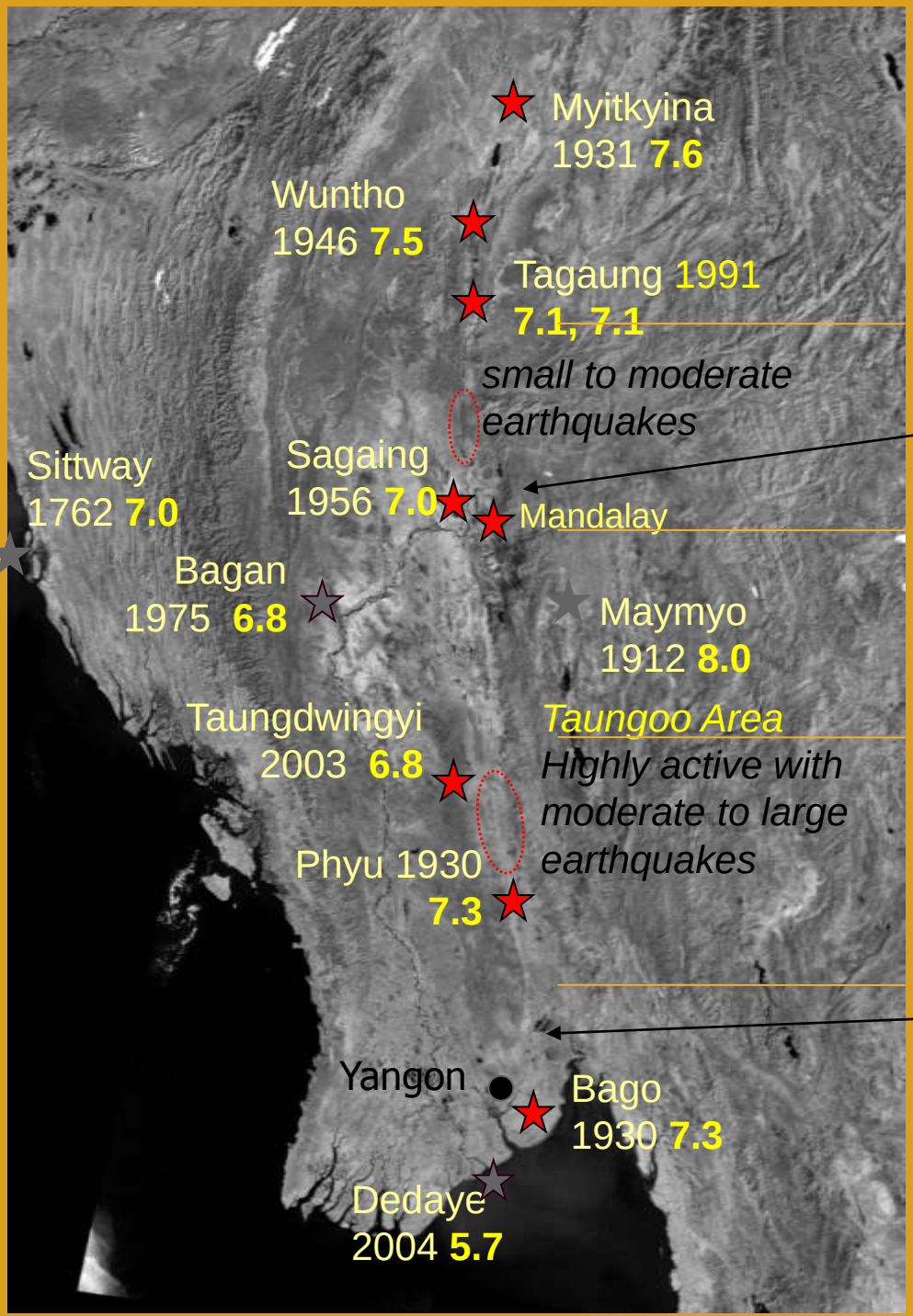
Significant Earthquakes



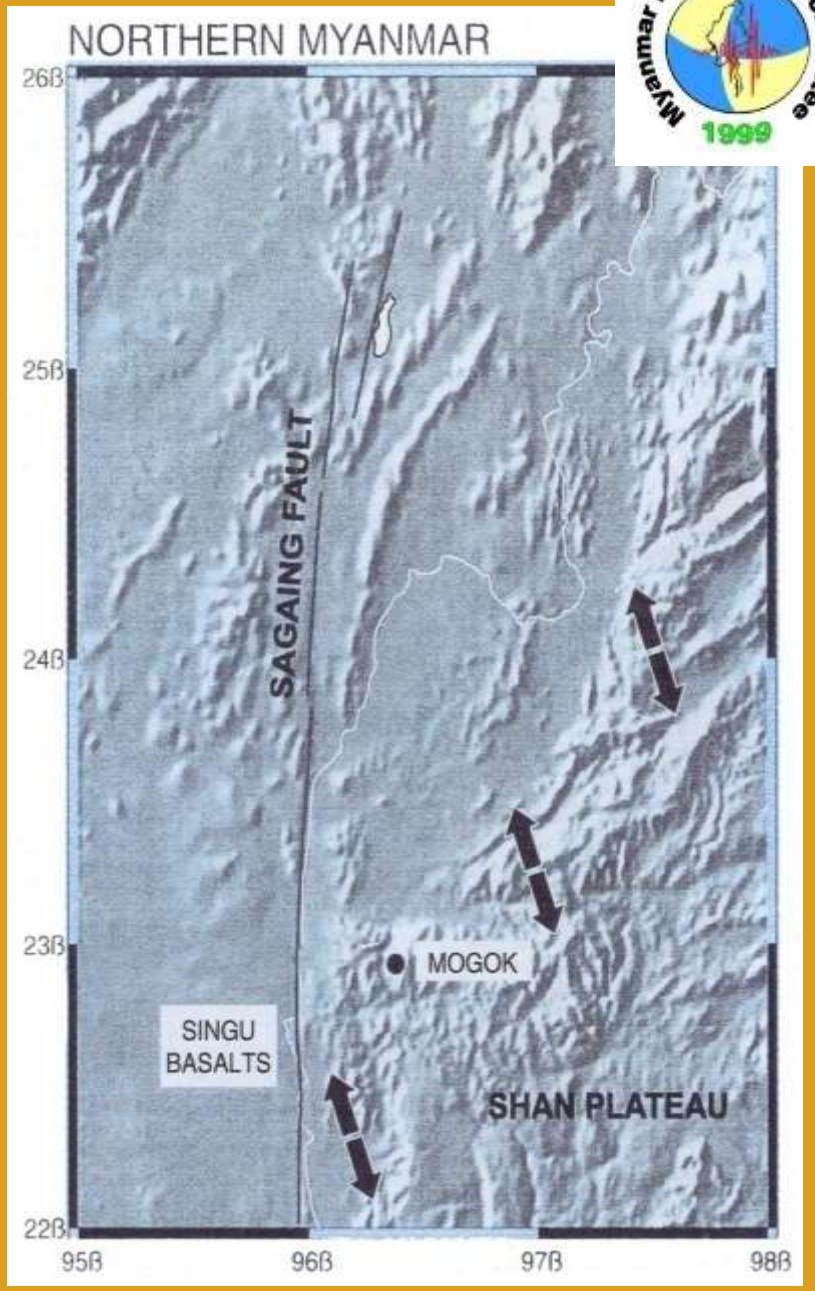
Historic earthquakes in AVA Era

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

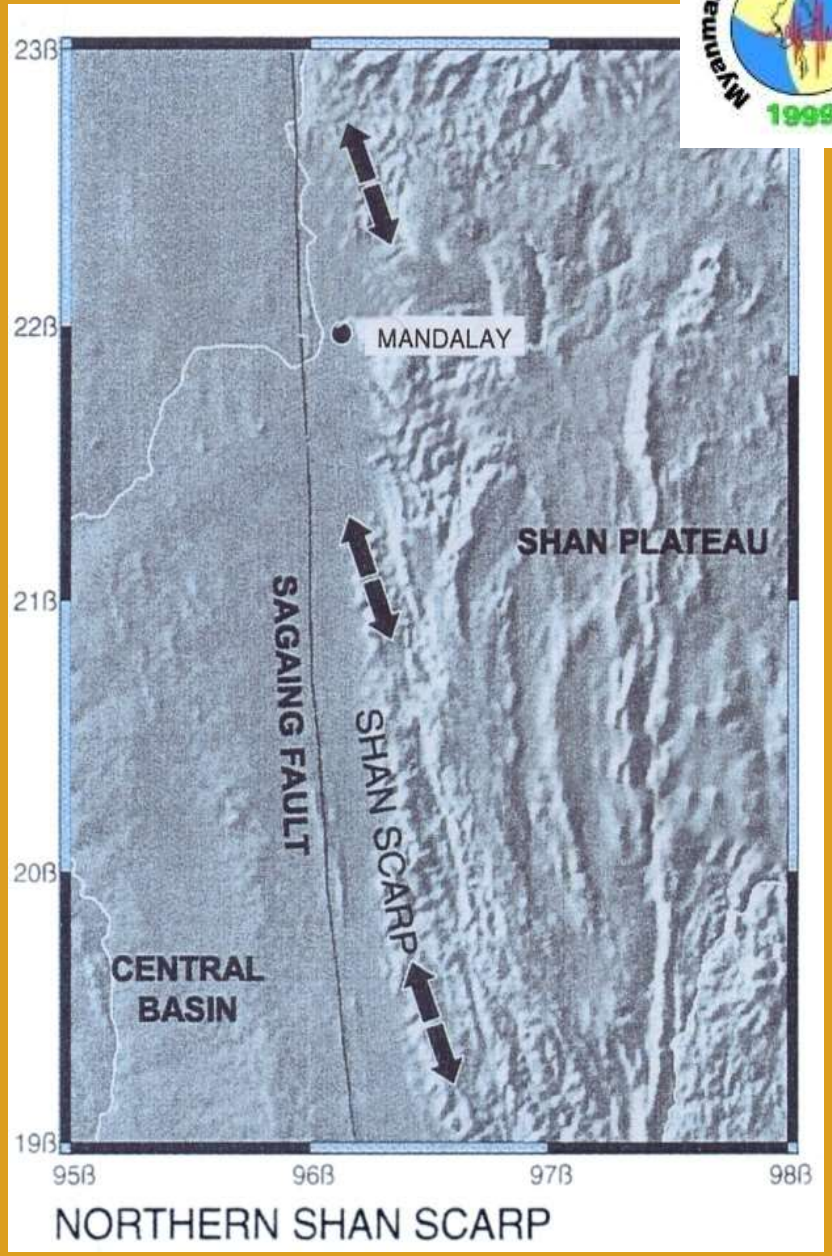
Historic Earthquakes in Bago

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

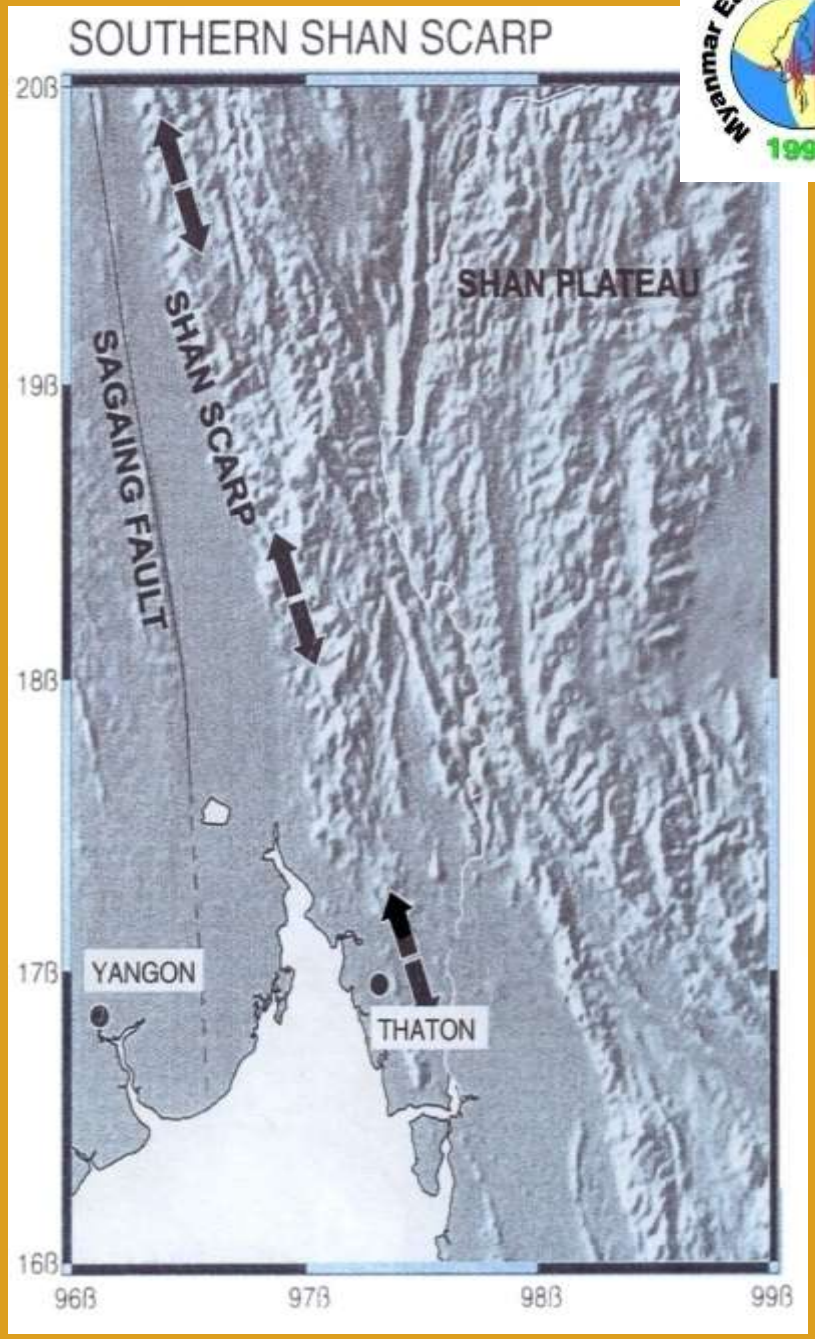
Northern part of Sagaing fault



Central part of Sagaing fault



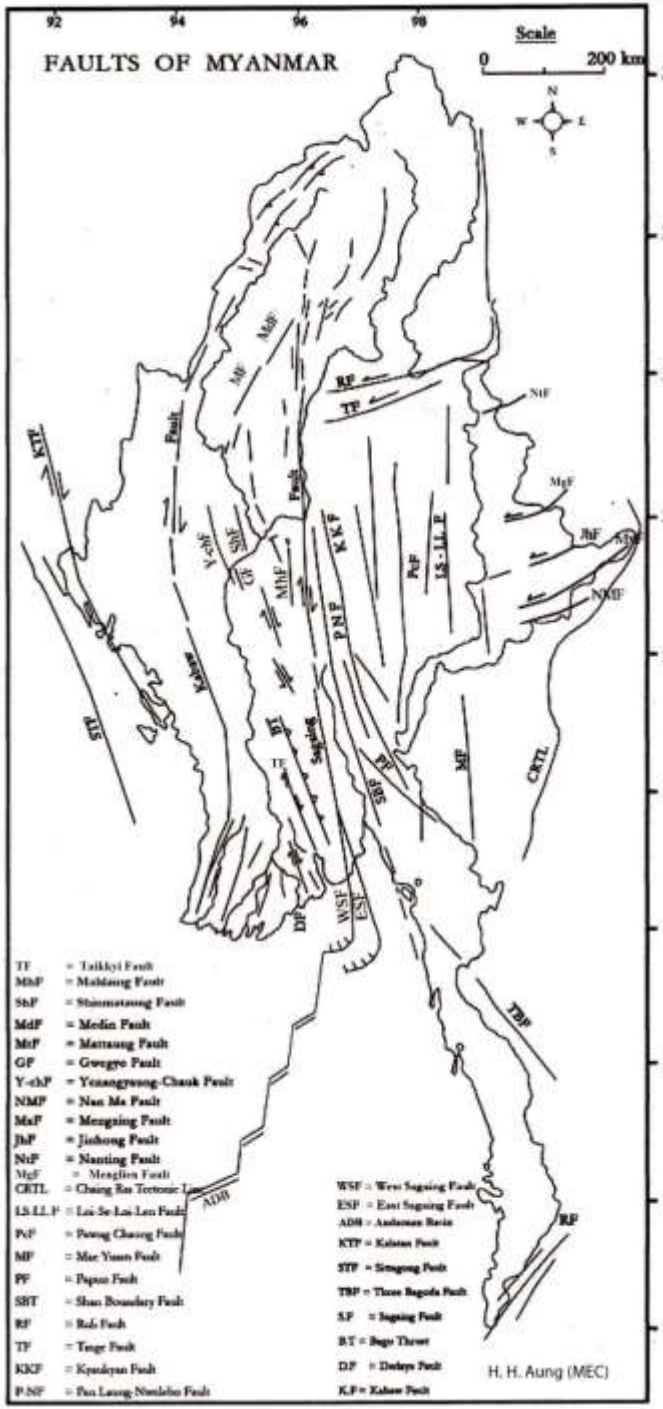
Southern part of Sagaing fault



မြန်မာ့ငလျင်သမိုင်း

(ပြုစုသူ) လှလှအောင် မြန်မာနိုင်ငံငလျင်ကော်မတီ

(၁)	၁၈၃၉ခုနှစ် မင်းကွန်းပုထိုးတော်ကြီး ပျက်စီးစေခဲ့သော အင်းဝငလျင်			
(၂)	၃၁. ၈. ၁၉၀၆	27° 00′ N 97° 00′E	7.0	ပူတာအိုငလျင်
(၃)	၁၂. ၈. ၁၉၀၈	27° 00′ N 97° 00′E	7.5	ပူတာအိုငလျင်
(၄)	၂၃. ၅. ၁၉၁၂	21° 00′ N 97° 00′E	8.0	မေမြို့ငလျင်
(၅)	၈. ၈. ၁၉၂၉	19° 25′ N 96° 25′E	7.0	ဆွာငလျင်
(၆)	၅. ၅. ၁၉၃၀	17° 00′ N 96° 55′E	7.3	ပဲခူးငလျင်
(၇)	၃. ၁၂. ၁၉၃၀	18° 00′ N 96° 50′E	7.3	ဖြူးငလျင်
(၈)	၂၇. ၁. ၁၉၃၁	25° 60′ N 96° 80′E	7.6	ကာမိုင်ငလျင်
(၉)	၁၂. ၉. ၁၉၄၆	23° 50′ N 96° 00′E	7.0	တကောင်းငလျင်
(၁၀)	၁၃. ၉. ၁၉၄၆	23° 50′ N 96° 00′E	7.0	တကောင်းငလျင်
(၁၁)	၁၆. ၇. ၁၉၅၆	22° 00′ N 96° 00′E	7.0	စစ်ကိုင်းငလျင်
(၁၂)	၈. ၇. ၁၉၇၅	21° 50′ N 94° 70′E	6.8	ပုဂံငလျင်
(၁၃)	၅. ၁. ၁၉၉၁	23° 48′ N 95° 98′E	7.1	တကောင်းငလျင်
(၁၄)	၂၂. ၉. ၂၀၀၃	19° 94′ N 95° 72′E	6.8	တောင်တွင်းကြီးငလျင်
(၁၅)	၁၇. ၁၂. ၁၉၂၇	16.950 N 96.127E	7.0	ရန်ကုန်ငလျင်
(၁၆)	၂၄. ၃. ၂၀၁၁	20° 705′ N 99° 949′E	6.8	တာလေးငလျင်
(၁၇)	၁၁. ၁၁. ၂၀၁၂	23° 009′ N 95° 884′E	6.8	သပိတ်ကျင်းငလျင်
(၁၈)	၂၇. ၁၂. ၂၀၁၅	22.614N-95.04E	5.4	မုံရွာ- ကနီ ငလျင်
(၁၉)	၁၃. ၄. ၂၀၁၆	23° 133′ N 94° 900′E	6.9	မော်လိုက်ငလျင်
(၂၀)	၂၄. ၈. ၂၀၁၆	20° 919′ N 94° 579′E	6.8	ချောက်ငလျင်
(၂၁)	၁၃.၃.၂၀၁၇	17 415N, 95.999E	5.1	တိုက်ကြီးငလျင်



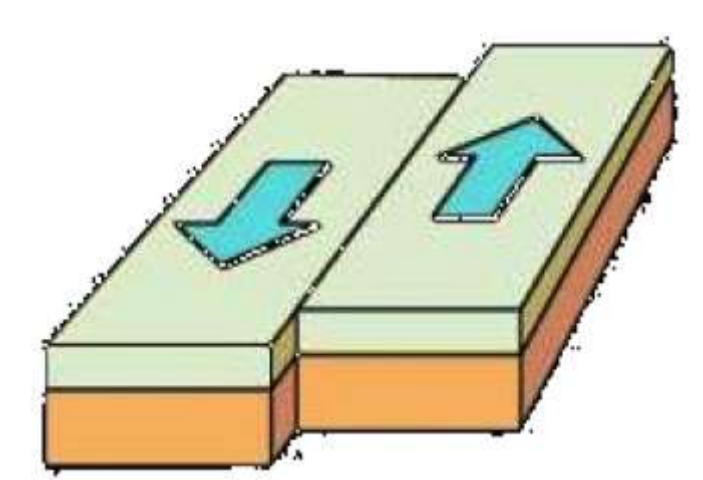
FAULTS OF MYANMAR

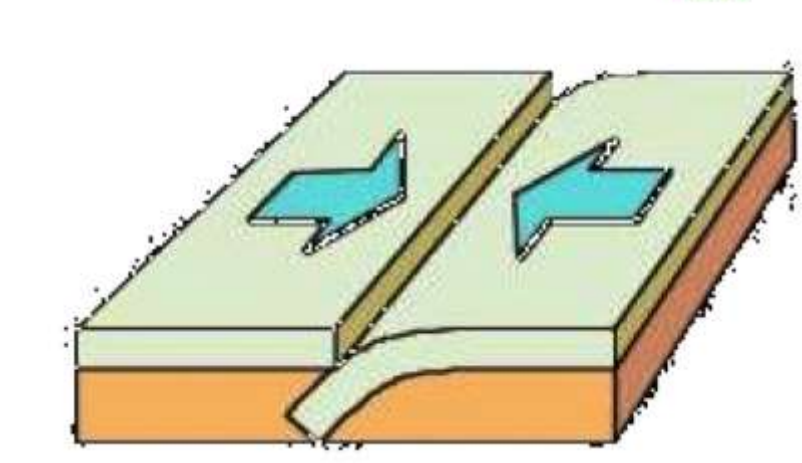
Compiled from Oil Map Of Myanmar (Bender, 1983)
by H.H.Aung

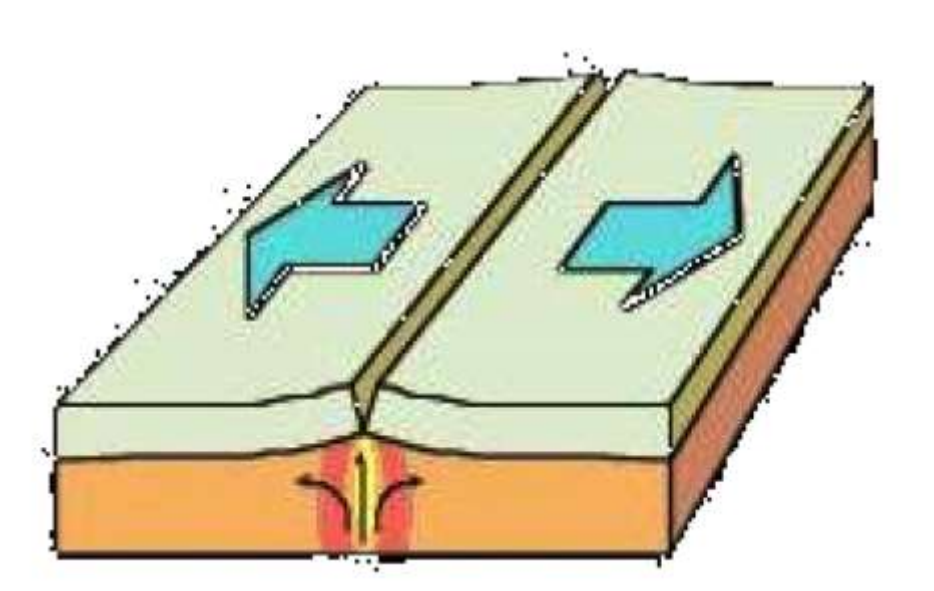
MhF = Mahlaing Fault
ShF = Shimmataung Fault
MdF = Medin Fault
MtF = Mattaung Fault
GF = Gwegyo Fault
Y-chF = Yenangyaung-Chauk Fault
NMF = Nan Ma Fault
MxF = Mengxing Fault
JhF = Jinhong Fault
NtF = Nanting Fault
MGF = Menglian Fault
CRTL = Chaing Rai Tectonic Line
LS-LL F = Loi-Se-Loi-Len Fault
PcF = Pawng Chaung Fault
MF = Mae Yuam Fault
PF = Papun Fault
SBT = Shan Boundary Fault
RF = Ruli Fault
TF = Tinge Fault
KKF = Kyaukyan Fault
P-NF = Pan Laung-Nwelebo Fault

WSF = West Sagaing Fault
ESF = East Sagaing Fault
ADB = Andaman Basin
KTF = Kalatan Fault
STF = Sittagoong Fault
TBF = Three Pagoda Fault
S.F = Sagaing Fault
B.T = Bago Thrust
D.F = Dedaye Fault
K.F = Kabaw Fault

3 types of plate boundary







Myanmar Earthquake Committee
1999

Seismicity Background & IMPACT

- Ava Earthquake 1839
- 1. Putao earthquake 31.8.1906 27° 00' N 97° 00'E 7.0
- 2. Putao earthquake 12.8.1908 27° 00' N 97° 00'E 7.5
- 3. May Myo earthquake 23.5.1912 21° 00' N 97° 00'E 8.0
- 4. Swar earthquake 8.8.1929 19° 25' N 96° 25'E 7.0
- 5.Bago(Pegu) earthquake 5.5.1930 17° 00' N 96° 55'E 7.3
- 6.Phyu earthquake 3.12.1930 18° 00' N 96° 50'E 7.3
- 7. Kamaing earthquake 27.1.1931 25° 60' N 96° 80'E 7.6
- 8. Tagaung earthquake 12.9.1946 23° 50' N 96° 00'E 7.0
- 9. Tagaung earthquake 13.9.1946 23° 50' N 96° 00'E 7.0
- 10. Sagaing earthquake 16.7.1956 22° 00' N 96° 00'E 7.0
- 11. Bagan earthquake 8.7.1975 21° 50' N 94° 70'E 6.8
- 12.Tagaung earthquake 5.1.1991 23° 48' N 95° 98'E 7.1
- 13.Taungdwingyi earthquake 22.9.2003 19° 94' N 95° 72'E 6.8
- 14. Yangon earthquake 17.12.1927 20° 705' N 99° 949'E 7.0
- 15.Tarlay earthquake 4.3.2011 20° 705' N 99° 949'E 6.8
- 16. Thabeikyin earthquake 11.11.2012 23° 009' N 95° 884'E 6.8
- 17. Thayet-Aunglan EQ. 3.4.2013 19.24N-95.66 E 5.4
- 18. Monywa-Kani earthquake 27.12.2015 22.614N-95.04E 5.4
- 19. Mawlaik earthquake 13.4.2016 22.614N-95.04E 6.9
- 20.. Chauk earthquake 24.8.2916 20° 919' N 94° 579'E 6.8
- 21. Taikkyi earthquake 13.3.2017 5.1
-

1839 and 1956 eq.

Thabeikkyin Earthquake in Myanmar (2012)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TOUR GUIDELINE FOR GEOLOGIC TOURISTS ALONG THE SAGAING FAULT

Hla Hla Aung

Abstract: This article is written for the tourists who are interested in seismicity of Myanmar. It addresses two areas, how large earthquakes Myanmar experienced in the past and where did such earthquakes occur. The Sagaing fault runs through Myanmar from north to south for more than 1000 km and has created a series of sag ponds and scarps along the fault. The Sagaing fault is clearly visible on the satellite image from the northern terminus in Kachin State to Mandalay in the south for about 650 km. From Bago to the south, the Sagaing fault enters terrain of alluvial deposits that becomes difficult to follow the fault trace on the satellite image until the coast line at latitude 16° 30' N. The Sagaing fault is composed of numerous fault segments creating a series of tectonic geomorphic features such as fault scarps, pressure ridges, sag ponds and pull-apart basins, where the fault segments can give rise to either zones of compression or extension. Right-stepping segments arranged in en echelon pattern are designated as Yegyi, Singu, Dabeikkyin, Hti-chaing, Indaw and Indawgyi segments along the northern part of the fault from Mandalay to the north. From Mandalay to the coast in the south for about 350 km long stretch, the fault has many right-stepping fault segments. Yenanthe, Pyinmana, Swa, Phyu, Shwedaung, Zwekapin, Kabaung, and coastal segments. Where the fault segment overlap, extensional forces have created the linear depression between them such as Lake Indawgyi, Indaw lake, a sag pond near Hti-chaing, another sag pond near Singu, Yega In, Shwedan In, Zwekapin In and Kabaung In, Bagan In, and more sag ponds are tectonic lakes that were created by extensional forces. The folded structures or pressure ridges such as Tagaung ridge near Tagaung, Sagaing ridge and Monwon ridge near Sagaing, Maggigyin ridge near Pyinmana, Khodaingyi ridge near Phyu, Desanpa ridge and Pale ridge near Bago area where the fault steps to the left. These tectonic features do not represent the fault itself but rather continued motion on the Sagaing fault and appearing across the fault zone by transpressional forces. These tectonic geomorphic features are critical area for seismic hazard in Myanmar.

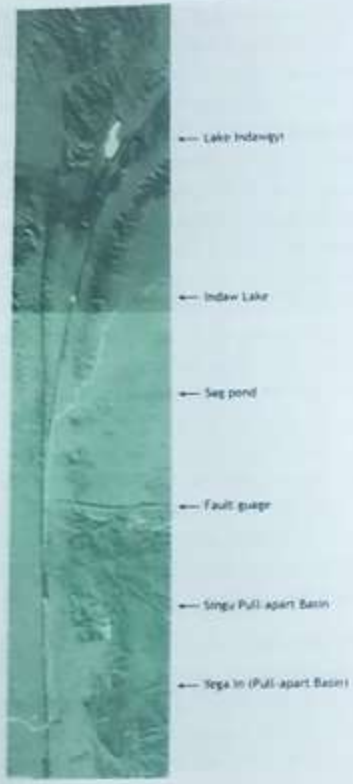
Keywords: step-over, segment, transtension, transpression, pull apart basin, sag pond, pressure ridge

Touring route along the fault

Approximately at latitude 23° N, there is Lake Indawgyi, a forest -fringed mountain lake popular with travelers from different parts of Myanmar for Yadanar Myenon Pagoda. The elongated shape Indawgyi follows the fault trace indicating continued fault motion on the Sagaing fault. Repeated earthquakes eventually split the hill apart creating vertical offset at points around the irregular normal fault formed by crustal extension forces even though the motion has been purely horizontal.

water filled the depression behind the ridge to form the lake (Bunge 2003). It is a typical fault bounded lake, it is long and its length oriented along the fault. The Ayeyarwady river rises in the hill ranges in the extreme north of Myanmar, at about latitude 26°N, and flows southward along the Sagaing fault trace from the vicinity of Tagaung at latitude 24°N. The fault is for the rest of the river above a quarter of a mile up to latitude 22°N. The Ayeyarwady river flows proudly and majestically through the third defile near Thabeikkyin following a somewhat straight course through a narrow, moderately deep gouge, the entire gouge zone with sheer fault planes. The recent fault scarp extends to the south passing through Singu where there is a sheer west-facing escarpment. At Singu, it has paused across the Sagaing fault trace and has been subsequently offset by the dextral motion, a maximum offset of 6.5 km on the northern border of Singu lava flows and minimum offset of 2.7 km on the southern border (Rangin et al, 1999). The Ayeyarwady river is winding its way along the base of Singu lava plateau, its surface being approximately 100 feet above the river level. To the south the fault once follows along the eastern side of Yega Inn, a large sag pond formed between its two fault scarps. The drainage of the Ayeyarwady river has been shaped by long-term motion on the Sagaing fault. From the north of Mandalay to Thabeikkyin, the Sagaing fault runs straight in N-S direction with a series of faults splays through metamorphic areas in northern Myanmar. Opposite Mandalay it swings around the southern end of the Sagaing ridge and now abruptly in an right-stepping sweep west. The Sagaing fault straightens out itself between Mamon range and Sagaing ridge and cuts through the heart of Sagaing city, southwest of Mandalay. The fault continues to the south through a chain of low hills of Tertiary rocks up to Yenanthin latitude and then it swerves along the eastern flank of NNW-SSE trending Bago Yoma to the Gulf of Mottama.

Other additional evidence of strike-slip faulting are streams offset like Sinthe chaung which is one of the best studied examples of an offset streams to be found in the area north of Pyinmana. Pyinmana-Lewe area itself is a large depression created by extensional forces at a releasing bend in the Sagaing fault system. The Sagaing fault creates a conspicuous fault scarp visible on satellite image to the near thwest of Swa. A remarkably straight and well-defined wall-like ridge of escarpment, Khodaingyi runs in the direction of WNW for many miles north and west of Phyu. It is another interesting fault feature formed by compressional force at the restraining bend in Sagaing fault zone. Our field tour has proceeded towards Bago along which has a number of interesting fault features are observed along the Sagaing fault. Continuing further south there is the Shwedan In, a small linear depression or sag pond that the Sagaing fault created with the height of 2.8 meters. Then the fault runs through the land of Bago area, creating a series of fault scarps, pressure ridges and sag ponds, where the fault segments can give rise to either zones of compression or extension. Such zones also exist at bends in the faults. One of the interesting fault features is in the West of Payagyi where Sagaing fault passes through the ancient fortress of Payagyi Myo Haung (old city of Payagyi) creating a fault scarp affecting the fortress about 7-8 meters destructly (Yu et al., 2009).



Bago itself is situated on a bedrock hill, the eastern margin of the hill is sharpely defined by the Sagaing fault. The hill is a pressure ridge that developed along the left-stepping straight fault branch. A restraining bend of the fault is also found in north of Mokaingyi where the anticline forms a linear ridge. Roughly parallel to and to the west of the Sagaing fault, there is the Pale fault in N-S direction with a total length of 17 km and to the south, it bends towards Sagaing fault with N 10° W (Tsutsumi et al.2009). To the south of Pale ridge, there is a linear depression called Zwekauk Inn developed at right stepover of the Sagaing fault. Epicentral location is the site of occurrence of Kabauk Inn (Inn is local name for a lake). It is a pull-apart basin marked by irregular depressions and oblique normal faults and formed in an extensional step-over between the fault segments. From Bago to the south,

a series of tectonic lakes can also develope along the Sagaing fault and then the fault enters terrain of alluvial deposits that becomes difficult to follow the fault trace on the satellite image until the coast line at latitude 16° 30'N. These tectonic features are formed by successive earthquakes over time.

Conclusion

Earthquake disasters are related to the local site specific characteristics and seismic stress field. Coseismic changes like migration of spring and stream, sinking of the ground are common styles of deformation and are dominated by right- lateral strike-slip faulting which in turn generate the NW-SE trending normal fault to down faulting. Most of major cities in Myanmar are sited very close to the localized pull-apart basin or localized linear scarp. The focal mechanism solution of earthquake (USGS) suggest a strike-slip faulting. Therefore, the deformation mode for these earthquakes is inferred basically to be a combination of normal and strike-slip faulting or a combination of thrust and strike-slip faulting.

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Thank you !