Seismic Hazards and Engineering Response: Lessons from Past Earthquakes

Dr Su Su Kyi, Professor

University of Yangon

Content

Asymmetric ground motion

- Strong Push
- One direction dominant
- Velocity pulse

Ground Motion component

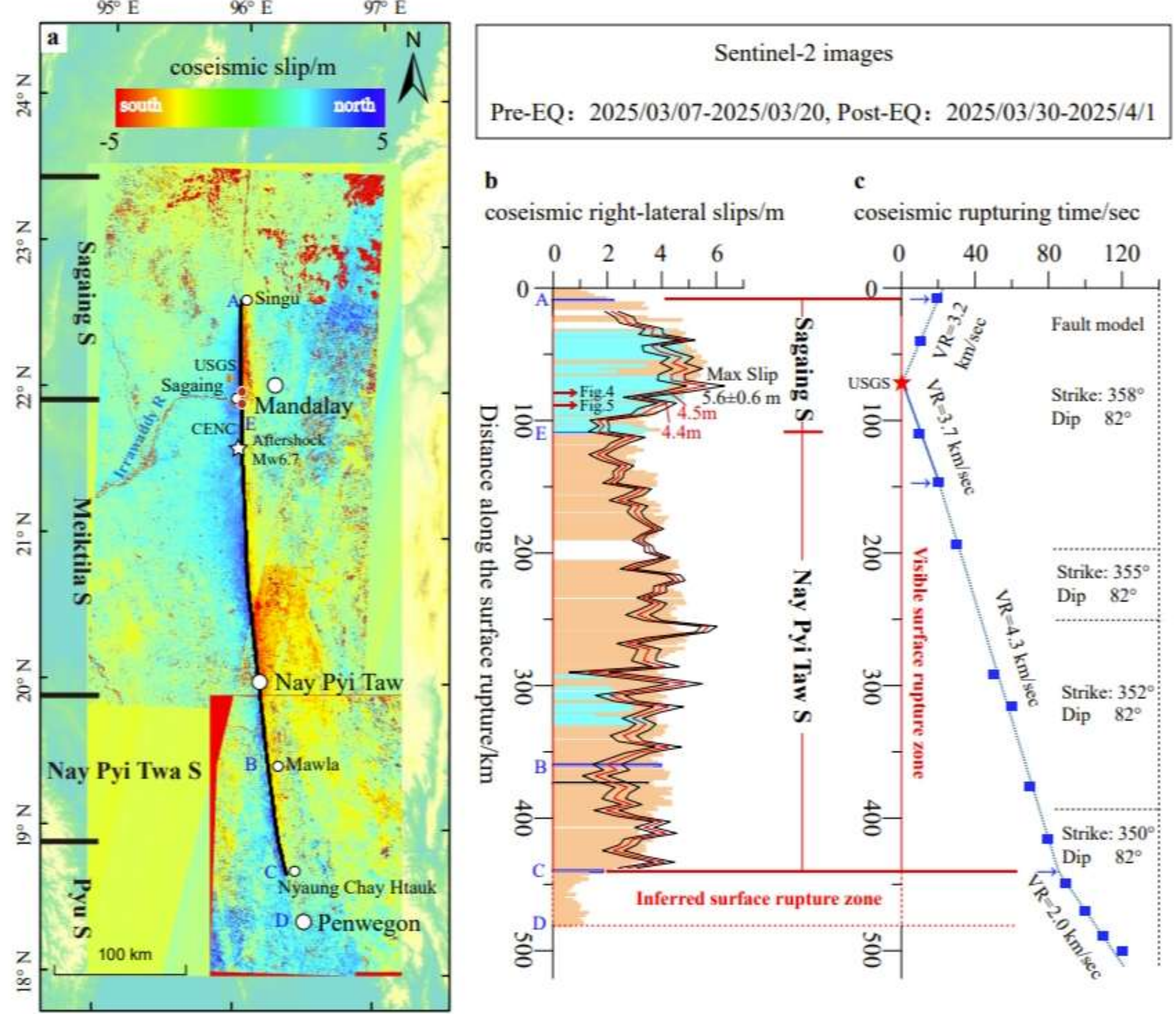
- Fault normal
- Fault parallel

Liquefaction Mechanism

- Strain Softening
- Map

Integrated Interpretation

Current Research Progress



China Earthquake Networks Center

A magnitude 7.7 earthquake occurred on March 28, 2025

starting from Singu City in the north, passing through Sagaing City and Nay Pya Taw City, and ending at Penwegon City in the south.

The total length of the surface rupture zone was approximately 465±25 km.

Twelve minutes after the main shock, the largest aftershock to date occurred about 31 km south of the main shock (21.60°N, 95.95°E, Depth: 30 km), with a magnitude of 6.7.

Asymmetric Ground motion

Sagaing Fault: One dominant movement in one direction

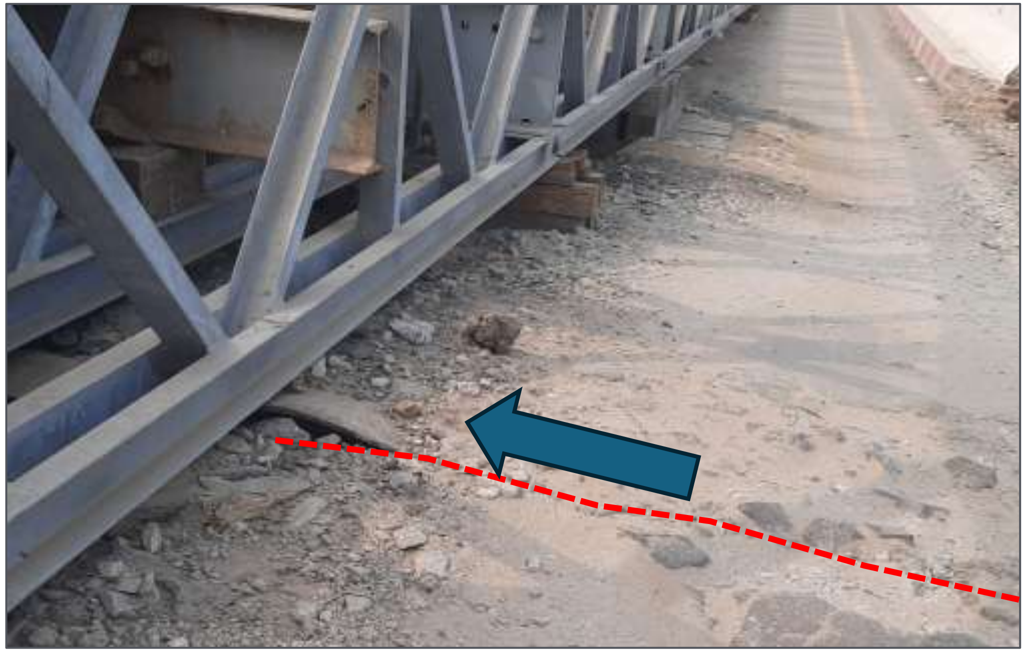
- Energy is **focused forward** (directivity)
- **Velocity pulse**-The ground moves **quickly in one direction** with **large displacement in short time**
- Velocity pulses are strongest in: **Fault-normal direction**
- Single movement causes major damage

Asymmetric motion causes:

- **Permanent displacement**
- Higher displacement demand on structures
- Cause structural yielding and foundation failure
- More damage in long period structure:
    - Bridges
    - Piles
    - Retaining structures

Structural response depends on **orientation relative to fault**

- Fault normal: High amplitude
- Velocity pulses
- Fault parallel: Lower amplitude

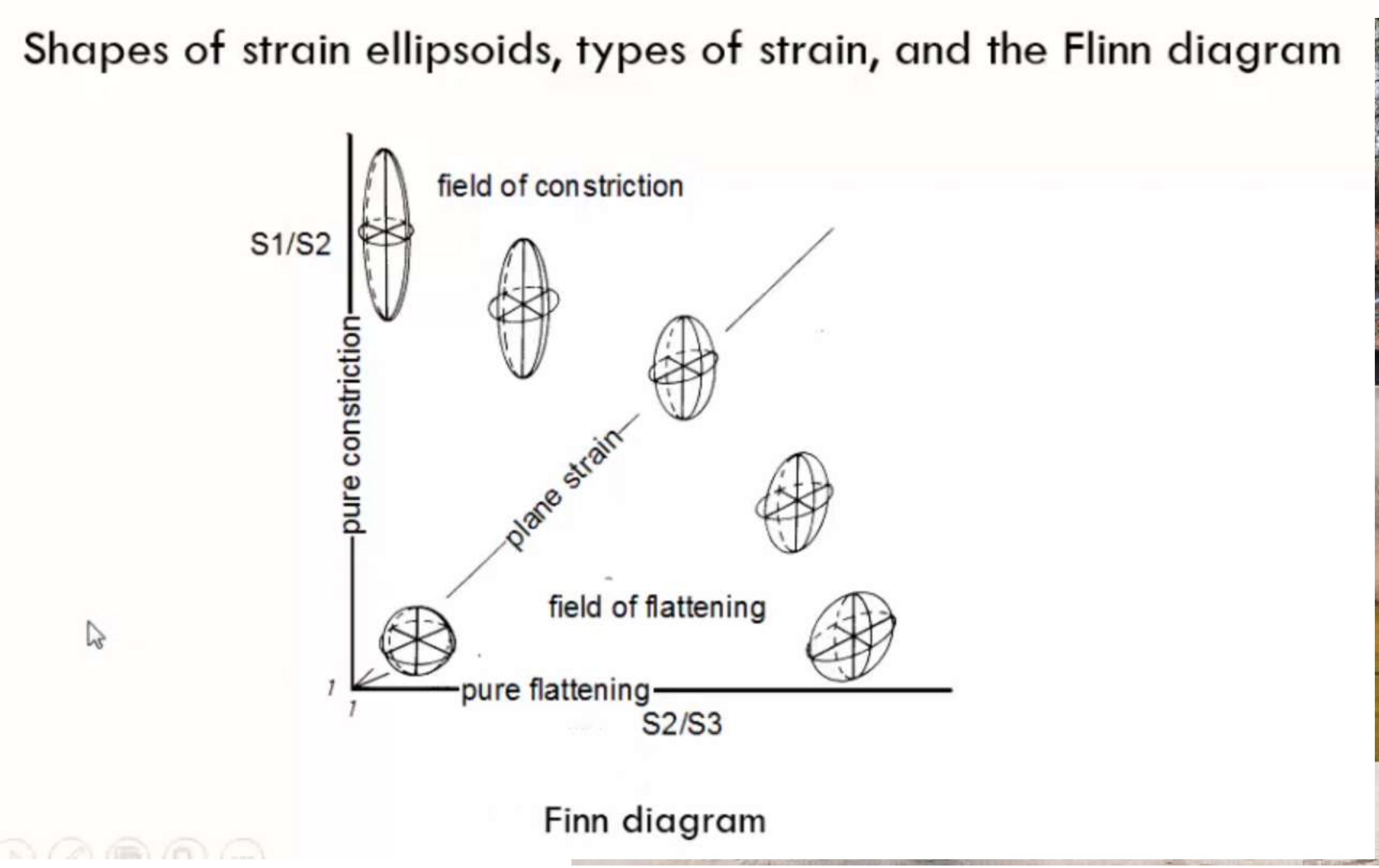


Swa Bridge

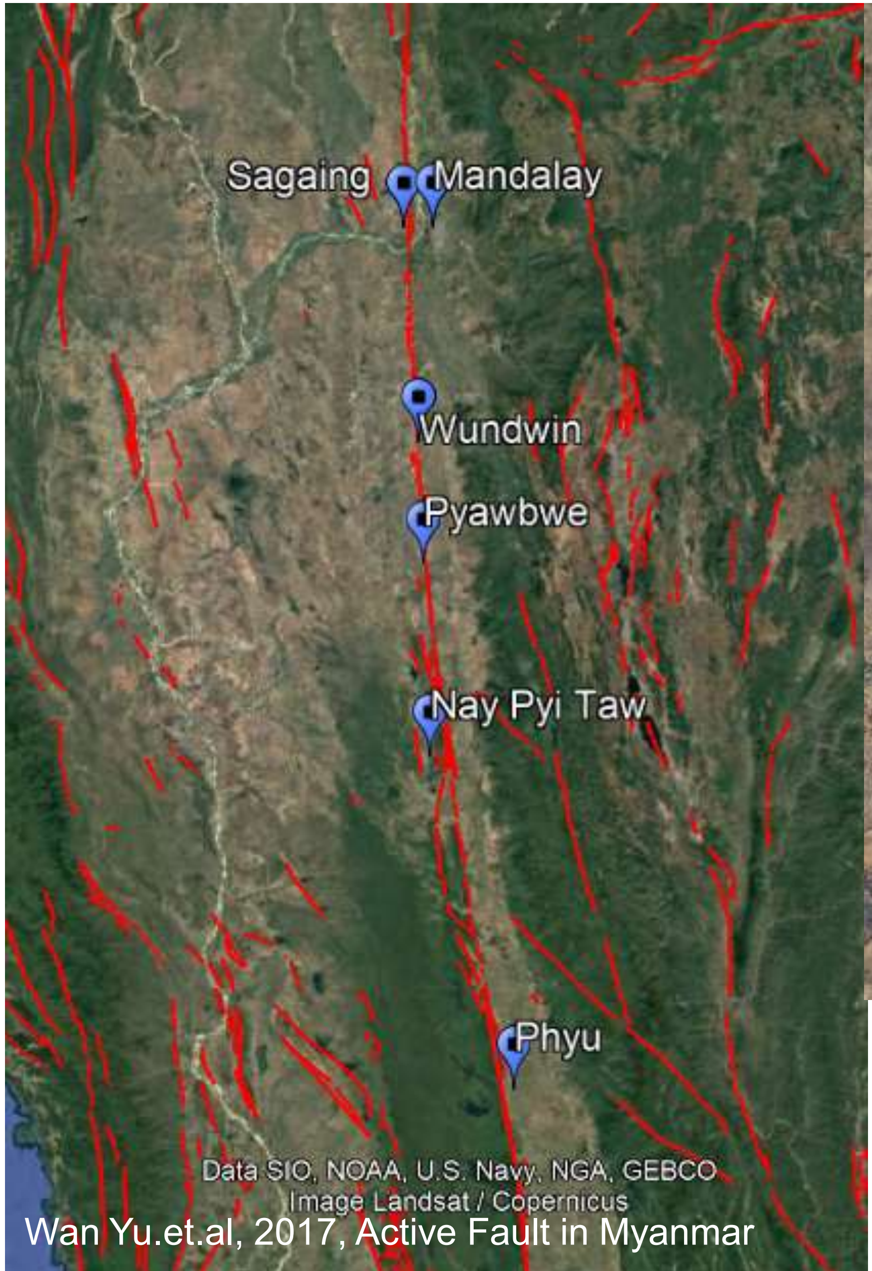


Structures-Fault Normal Directivity Effect

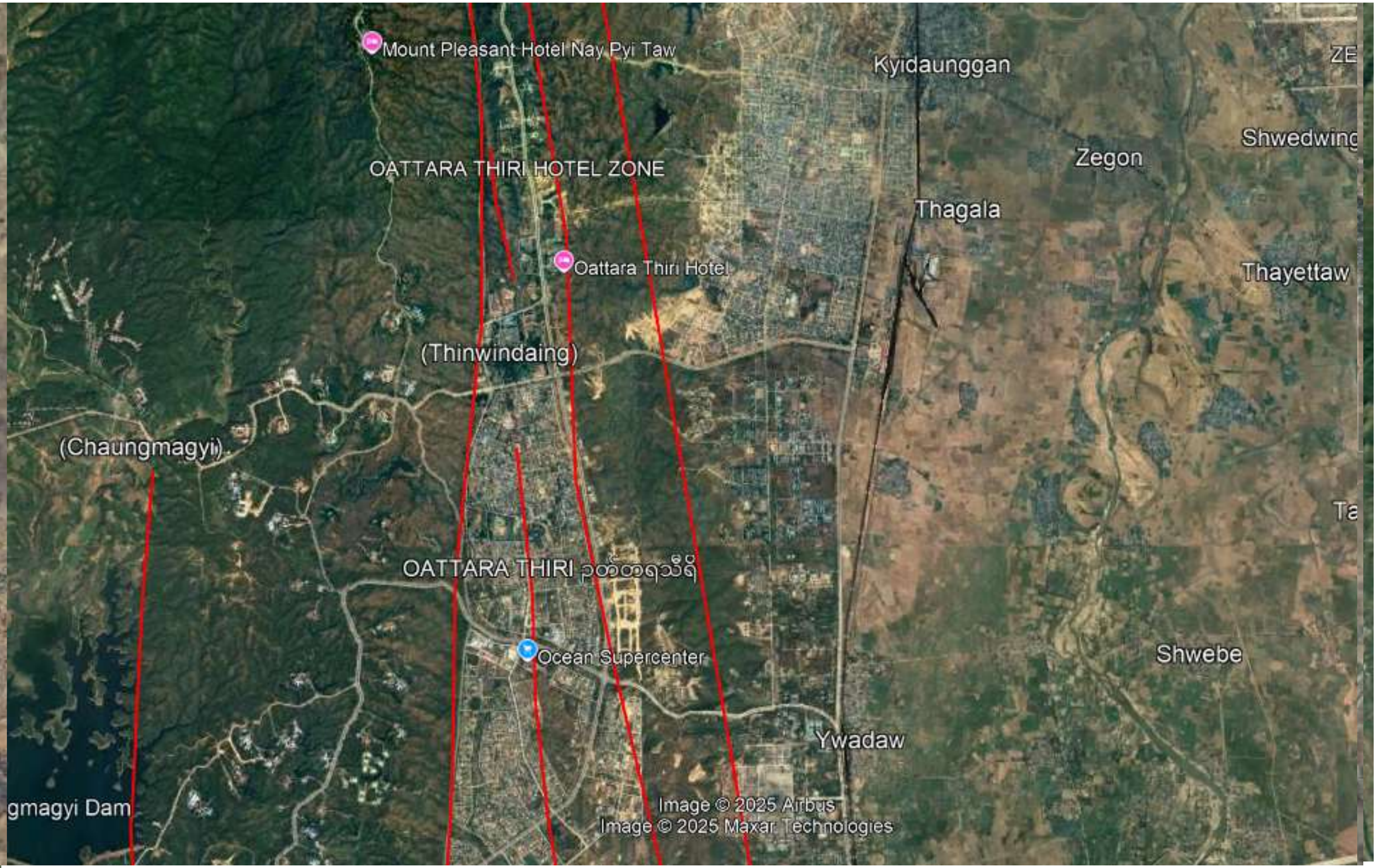
Elliptical Damage



Major Fault directivity affected Cities

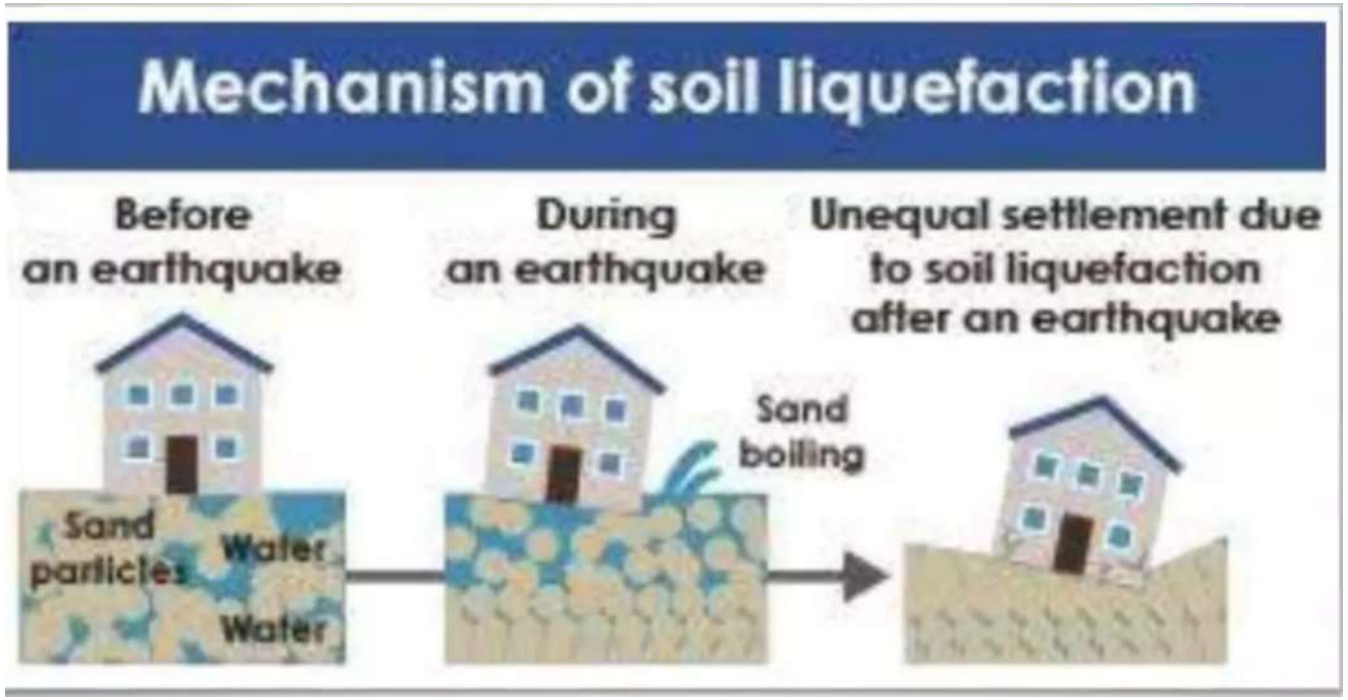


Wan Yu.et.al, 2017, Active Fault in Myanmar



ပြတ်ရွေ့ပေါ်တိုက်ရိုက်တည်ရှိနေခြင်းကြောင့်ပျက်စီးခြင်း

တုန်ခါမှု ကြောင့်သဲနုန်းအရည်ပျော်ဖြစ်စဉ်(Liquefaction)



www.cti.co.jp/en/solution/cae/cae2

1) Lower fine content of saturated soil (Fine content is meant the size less than 0.06 mm)
2) Lower Standard Penetration Test blow count (N) of saturated sandy soil
3) Shallow groundwater table
4) Bigger maximum peak acceleration

ရေပြည့်ဝ၊ရွယ်စေ့ညီ သဲ၊ အရွယ်သေး -နုန်း-ပါဝင်မှု၃၅%ထက်နည်း

•**Sand Boil** – Fine sand ejected to surface under pressure

•**Ground Oscillation** – Lateral soil movement without slope; fractures of rigid structures, pipes

•**Settlement** – Sinking of ground, especially under structures

•**Flow Failure** – Downhill movement of soil mass (e.g., riverbanks)

•**Floatation** – Light structures like tanks pushed upward/float

တုန်ခါမှု ကြောင့်သဲအရည်ပျော်ဖြစ်စဉ်(Liquefaction)
Lateral Soil Movement -Flow Like Water

Magnitude 7.5–7.6 earthquake, Palu, 2018, Indonesia

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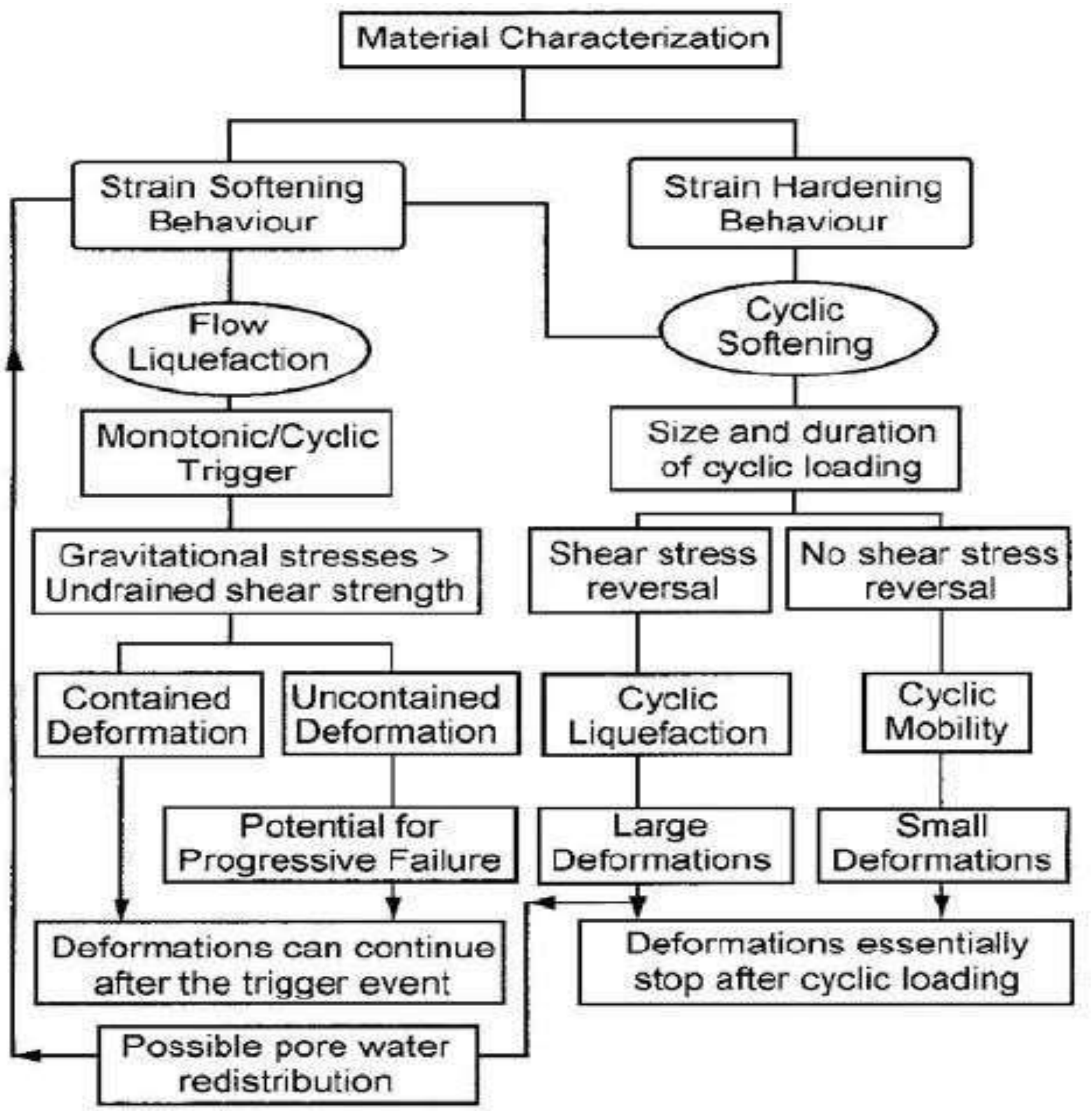
Lateral Soil Movement -Flow Like Water

Test Result of Samples from Liquefaction Areas

Sample Name	Sand (%)	Silt&Clay (%)	USGS Classification
Ngwe Shan Gon (North),Nay Pyi Taw	96.03	3.97	SP
Ngwe Shan Gon (South),Nay Pyi Taw	86.51	13.49	SP
Da Hat Gon Ywar (Ground Failure)	89.7	10.3	SP
Innwa (MDY) (1)	94.05	5.95	SP
Innwa (MDY) (2)	36.3	63.7	ML
Yin Taung Ward (MDY-SG Road)	91.27	8.73	SP
Yae Khar Inn, Nay Pyi Taw	84.16	15.84	SP

Evaluation of Liquefaction (After Robertson and Wride, 1998)



Strain hardening and large displacement behavior describe post-yield soil response, whereas the Robertson & Wride (1998) method evaluates liquefaction triggering.

In near-fault conditions, pulse-like loading with limited stress reversal may still induce liquefaction and significant ground deformation."

Liquefaction does **not always require full stress reversal**

Near-fault condition:

Few cycles

Large pulse

→ Still causes **ground failure**

Subsurface piping
Water flows through weak zones
Removes fine particles
Creates temporary voids
Surface collapses - holes

Mechanism (complete process)

1. Earthquake shaking close to the Sagaing Fault
2. Loose saturated soil - **liquefaction**
3. Effective stress drops (σ' ↓)
4. Soil -**strain softening**
5. Ground behaves like **flowing mass**
6. Surface collapses –localized holes

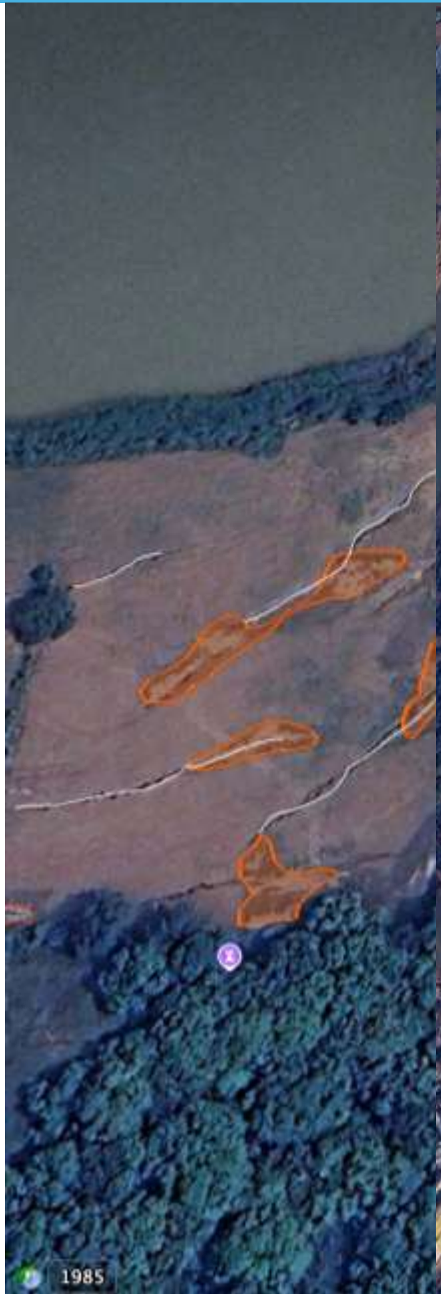
Lateral spreading occurs

- Toward: Slope or Free face -river

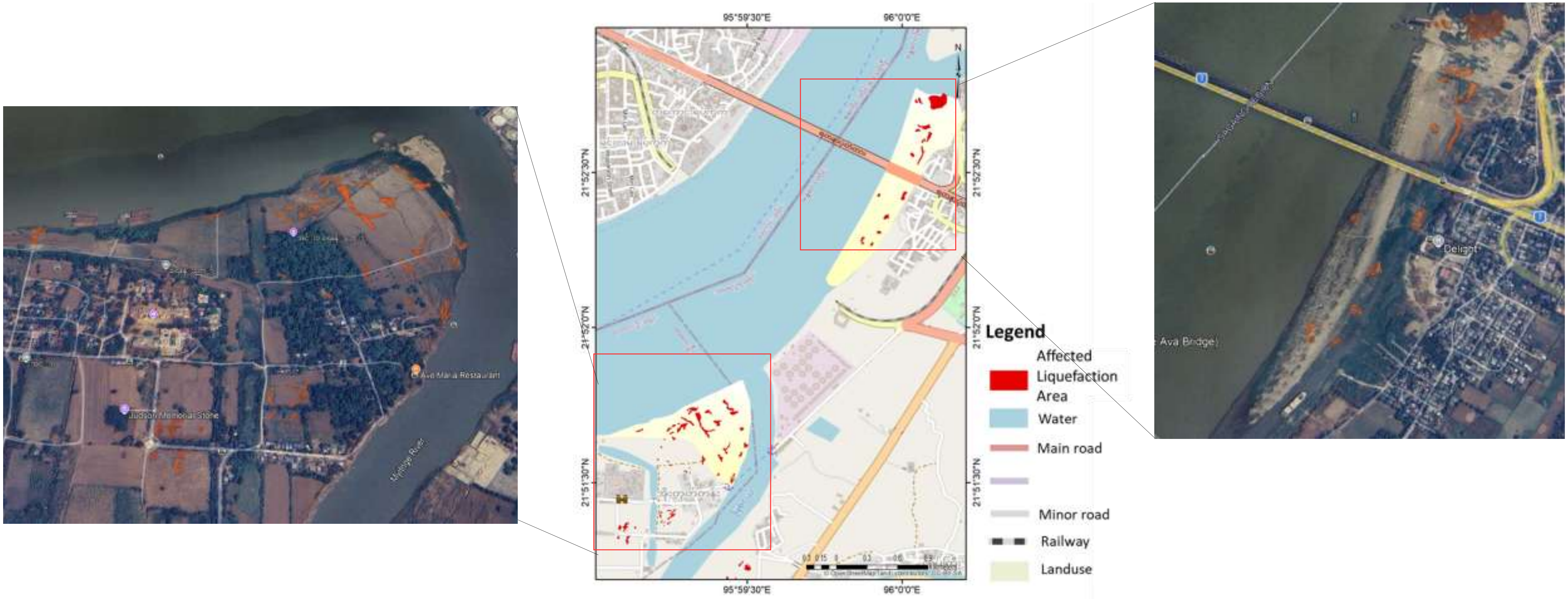
Surface effects

- Cracks
- Scarps
- Settlement
- Collapse

Liquefaction Areas – Innwa-Ye Lun Kyaw areas



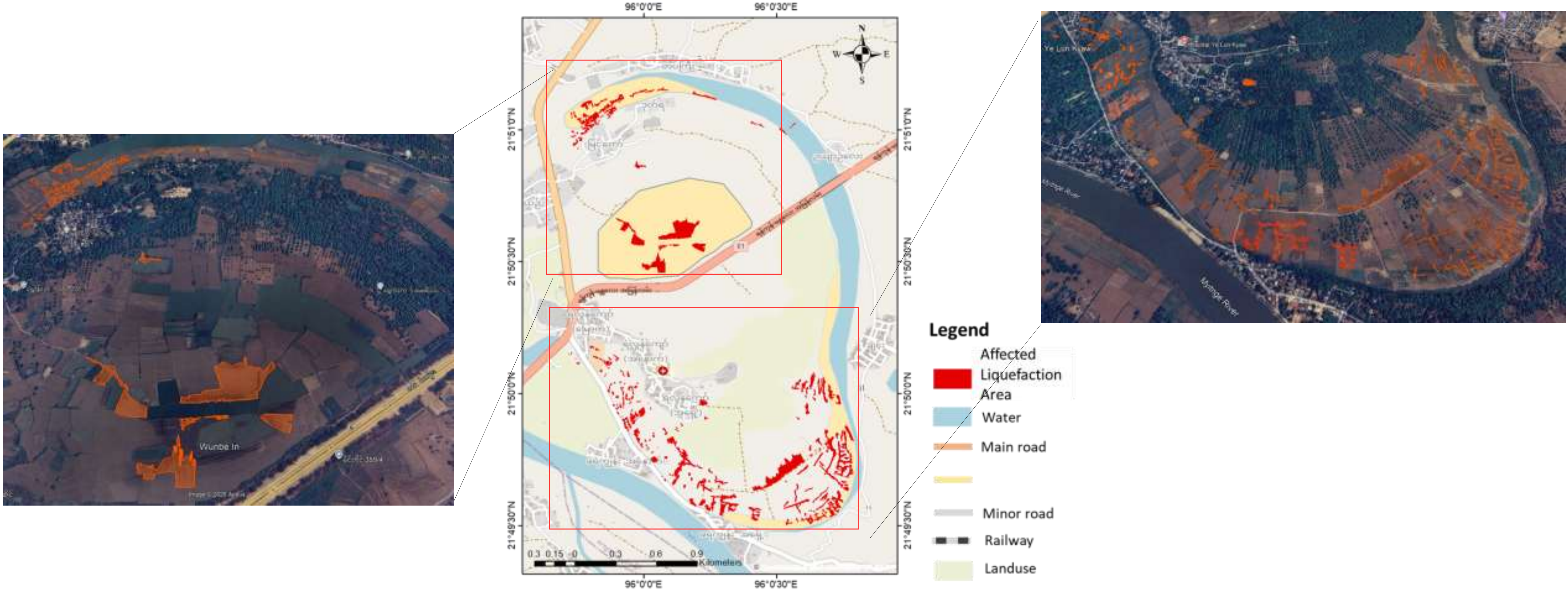
Liquefaction Hazard Mapping



Fig; Liquefied-Zone Map near INNWA after 7.7 Mw Mandalay Earthquake

Map Features; Liquefaction-zones primarily along the river bank and low-lying alluvial plains of INNWA.

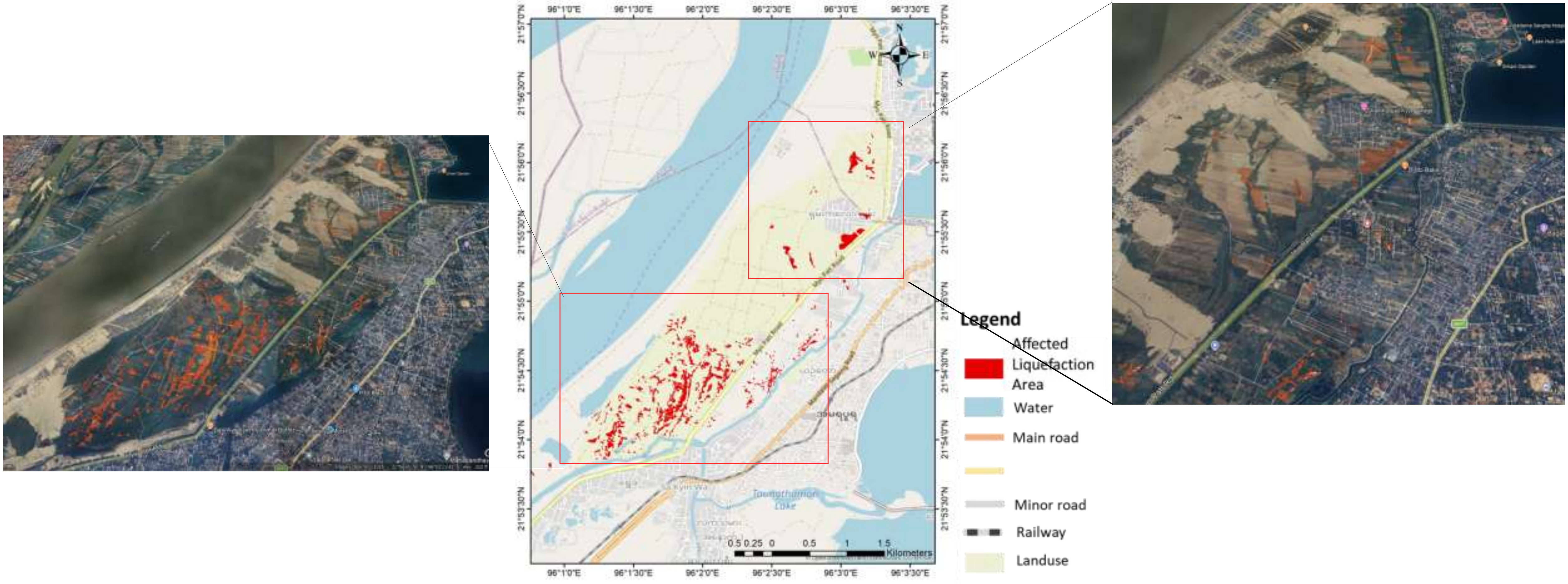
Liquefaction Hazard Mapping



Fig; Liquefied-Zone Map near Ye Lon Kyaw Area after 7.7 Mw Mandalay Earthquake

Map Features; Alluvial plains of Ye Lon Kyaw Area .

Liquefaction Hazard Mapping

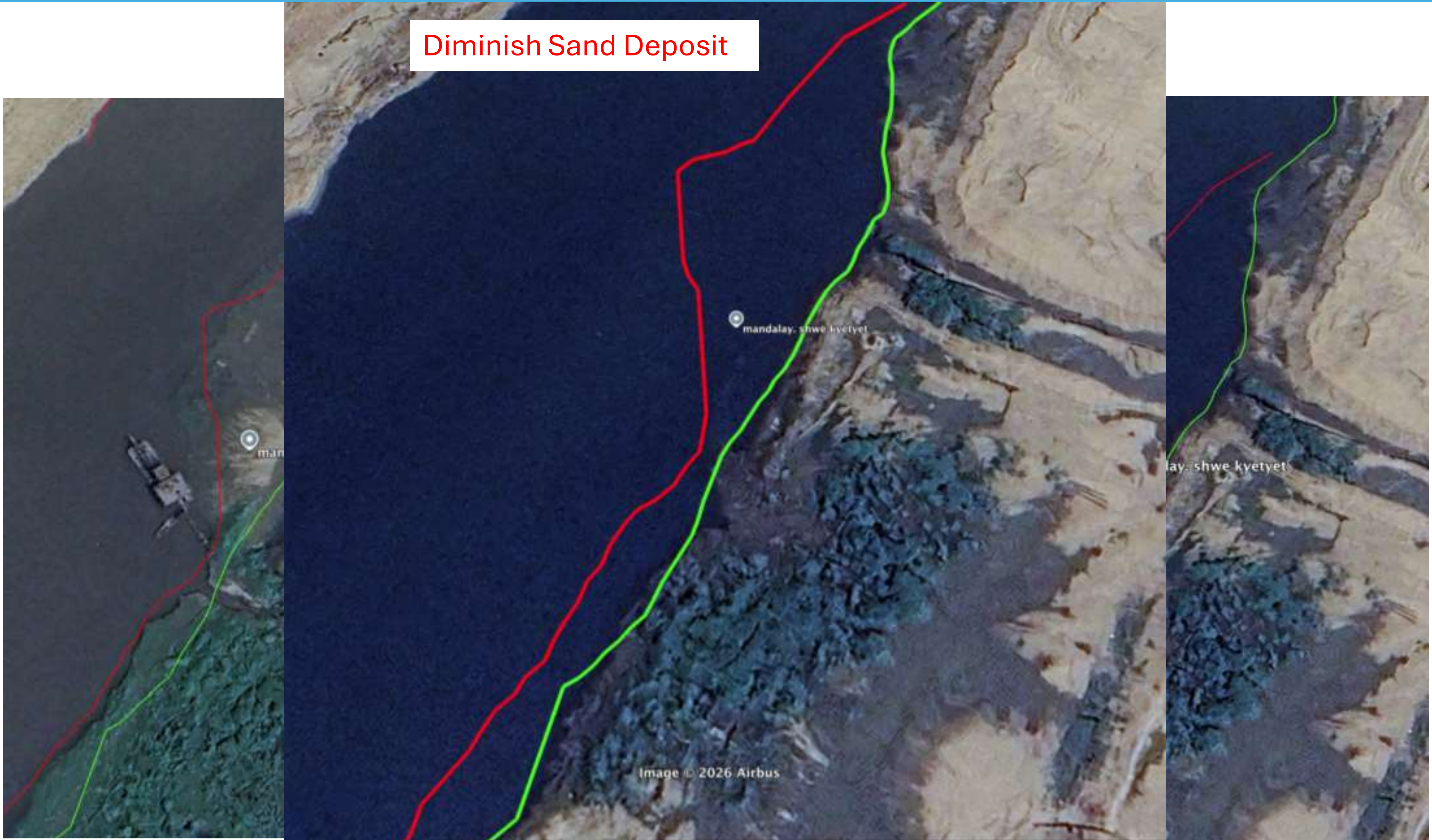


Fig; Liquefied-Zone Map near INNWA after 7.7 Mw Mandalay Earthquake

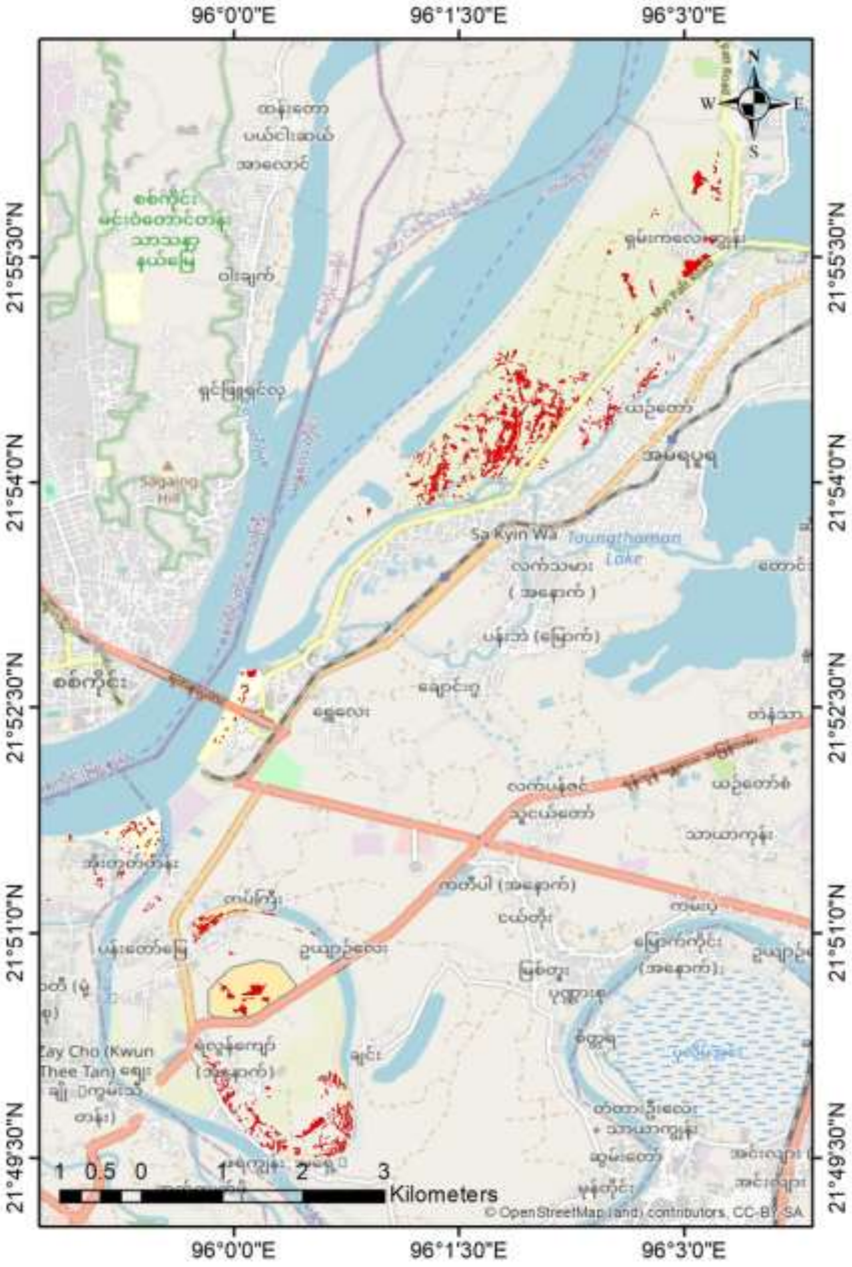
Map Features; Low-lying alluvial plains of Amrapura

Diminish of Sand Deposit

Diminish of Sand Deposit



LIQUEFACTION HAZARD MAP IN INNWA–AMARAPURA AREAS



This map show affected liquefaction area (after earthquake)

Legend

- Affected Liquefaction Area
- Water body
- Main road
- Secondary road
- Minor road
- Railway
- Landuse

In Innwa–Amarapura:

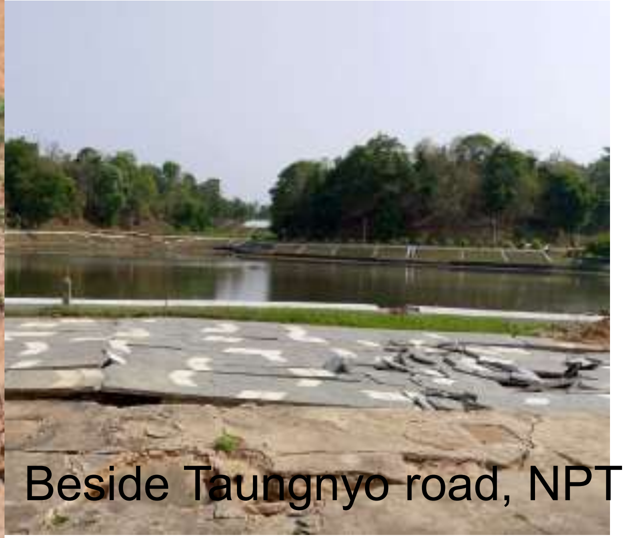
1. Soft thick unconsolidated alluvial soil
2. Seismic load exceed Soil resistance
3. Pore pressure increases, effective stress reduces
4. Loose saturated soil – strain softening
5. Cause large deformation and lateral spreading

After Su Su Kyi, Pyae Thiri Htet and Khin Mi Mi Tun 2026

Flow Movement

ငလျင်ကြောင့်မြေသား
အဆင့်လိုက်ပြိုကျပုံ

Earthquake Induced sliding



Conclusion

- Fault directivity effect especially avoid -fault normal

- Surface features (sand boils, subsidence, lateral spreading) indicate **significant coseismic deformation** along liquefiable zones.

- Liquefaction does **not always require full stress reversal**

- Observation shows the need for **integrated geotechnical and fault-proximity analysis** for hazard mitigation and resilient infrastructure planning.

CHINA UNIVERSITY OF GEOSCIENCES
北京 · BEIJING

UNIVERSITY OF YANGON

Collaborative Research Progress
Integrated Geophysical Research on the Sagaing Fault

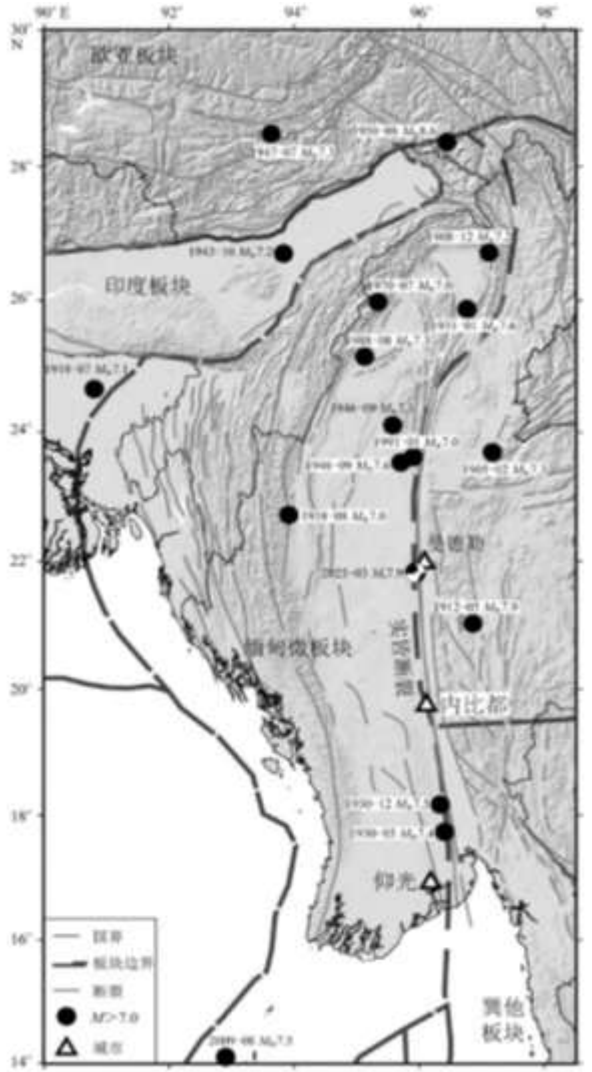
Presenter: Liu Zhen, PhD Candidate, CUGB

2026. April.4

Research Background

Research Background and Significance

- The Sagaing Fault is a major dextral strike-slip boundary between the Myanmar and Sunda plates. It accommodates the oblique convergence of the Indian-Sunda plates, making its kinematics crucial for assessing seismic potential.
- Research on this fault provides a critical scientific basis for seismic disaster mitigation in high-density urban centers such as **Mandalay, Naypyidaw and Yangon.**



[1]王宇凡,孟国杰,吴伟伟.利用GPS数据研究缅甸实皆断裂形变特征[J].地震,2025,45(03):1-12.

Collerborative Research

Multi-parameter Characterization of a Fault Zone: Integrating Active/Passive Seismic and Magnetotellurics for Comprehensive Subsurface Geophysical Field Research

SMARTSOLO IGU-16 1c

- Ambient Noise
- Reflection Seismology
- Guided Waves

SMARTSOLO IGU-16 3c

- 3D 3-Component Array

DEM-R07-C5

- **Magnetotellurics** -MT
- **Audio-magnetotellurics**-AMT

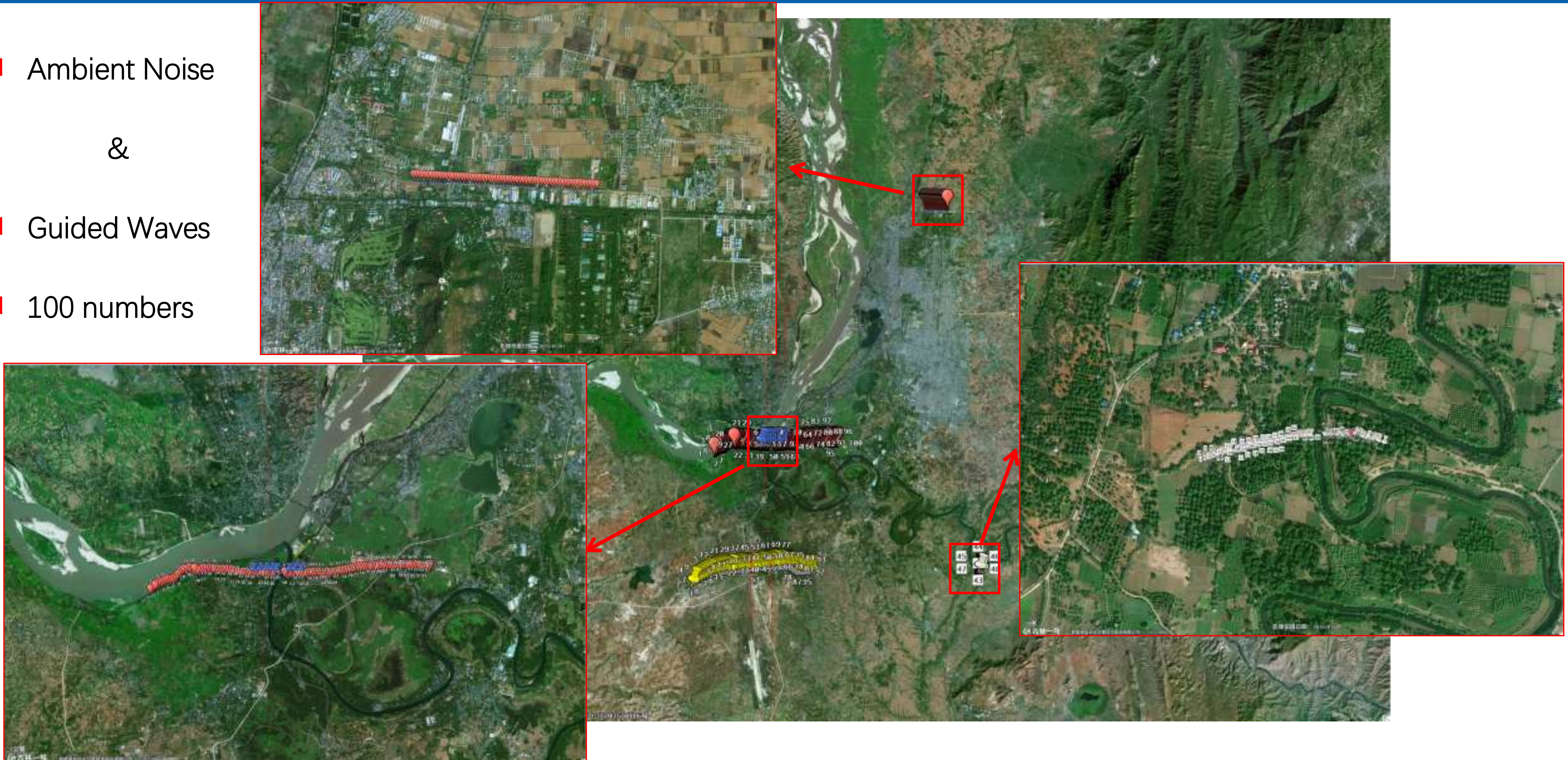
Current Progress

Current Progress

- Ambient Noise

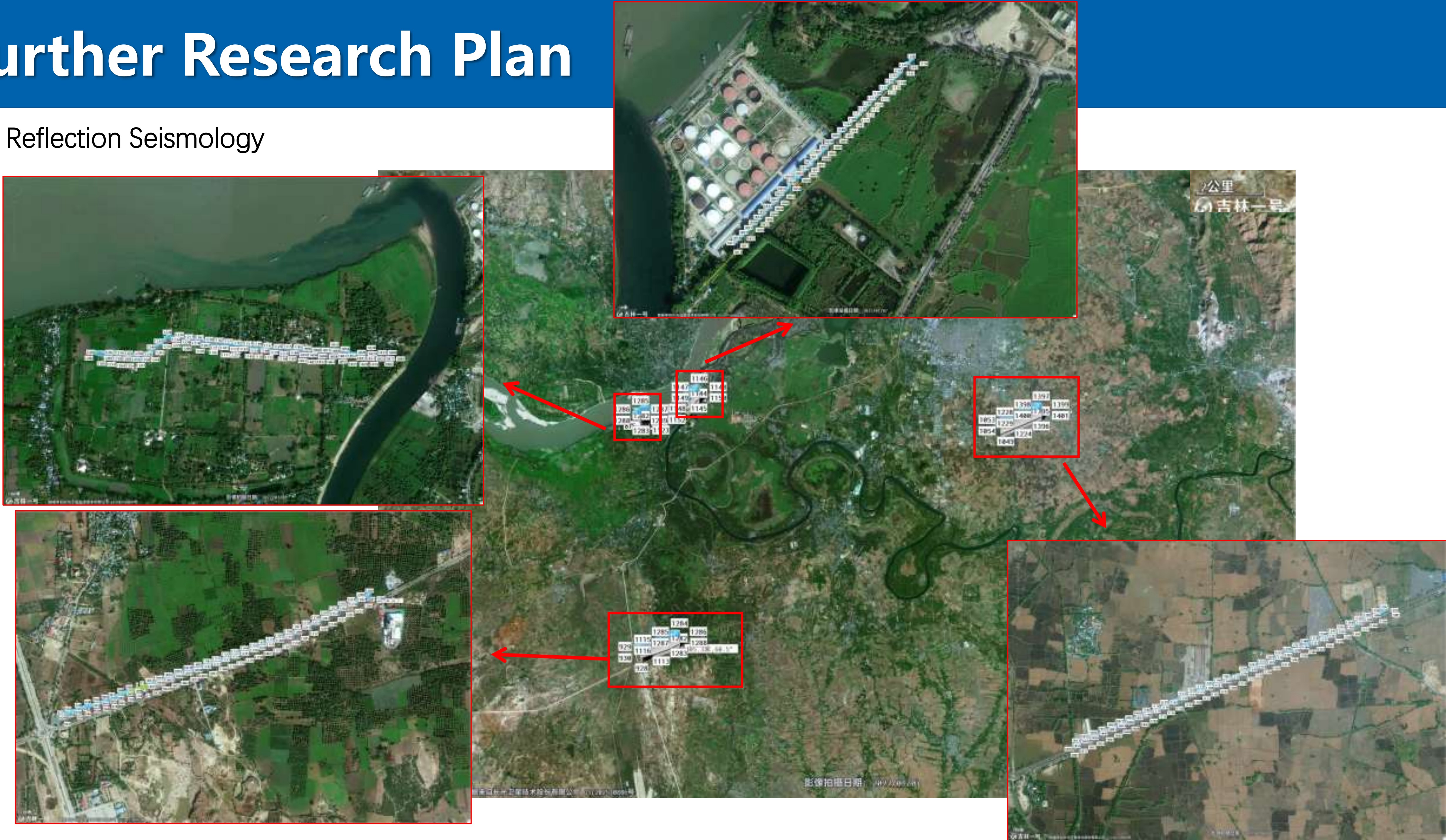
  &

- Guided Waves
- 100 numbers



Further Research Plan

- Reflection Seismology



Current Progress

- 3D 3-Component Array
- 50 numbers

Current Progress

- MT-Magnetotellurics

- Audio-frequency Magnetotellurics - AMT

Method	Point Spacing	Line Length
AMT	400m	9.6km
MT	2000m	20km

Further Research Plan

Integrated Data Processing & Multi-Physics Joint Imaging

- Multi-Source Seismic Data Integration
- Structural-Constrained MT Inversion
- Seismic Wavefield Synthesis & Guided Wave Modeling





Thank you!