Seismicity and Potential Seismic Hazard of Thailand:

The need of high-quality research work along the mountain slopes in Thailand

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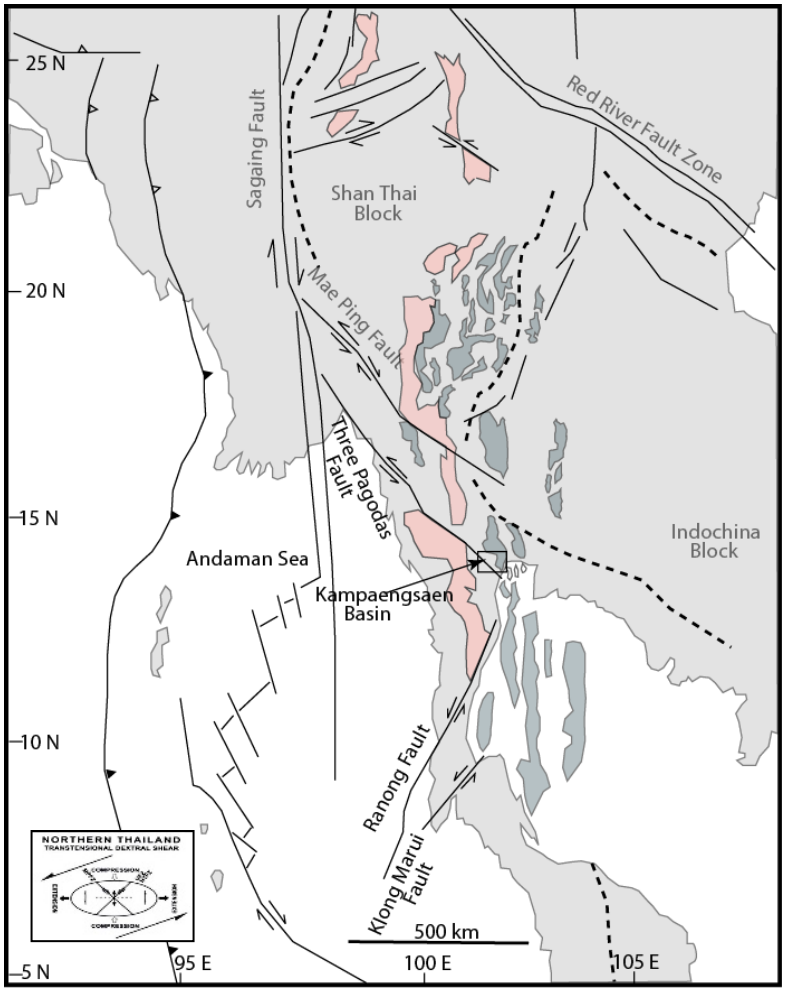
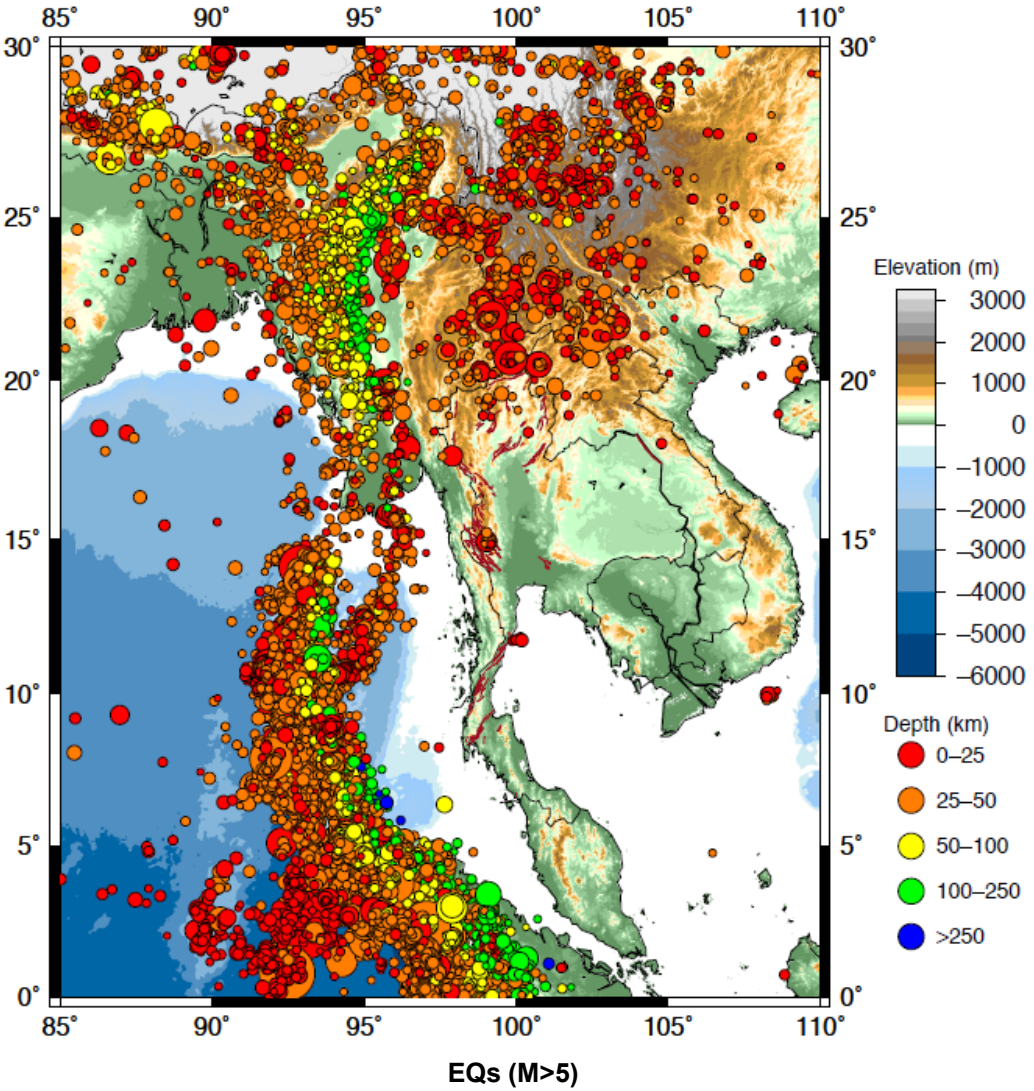
Thailand Tectonic Setting

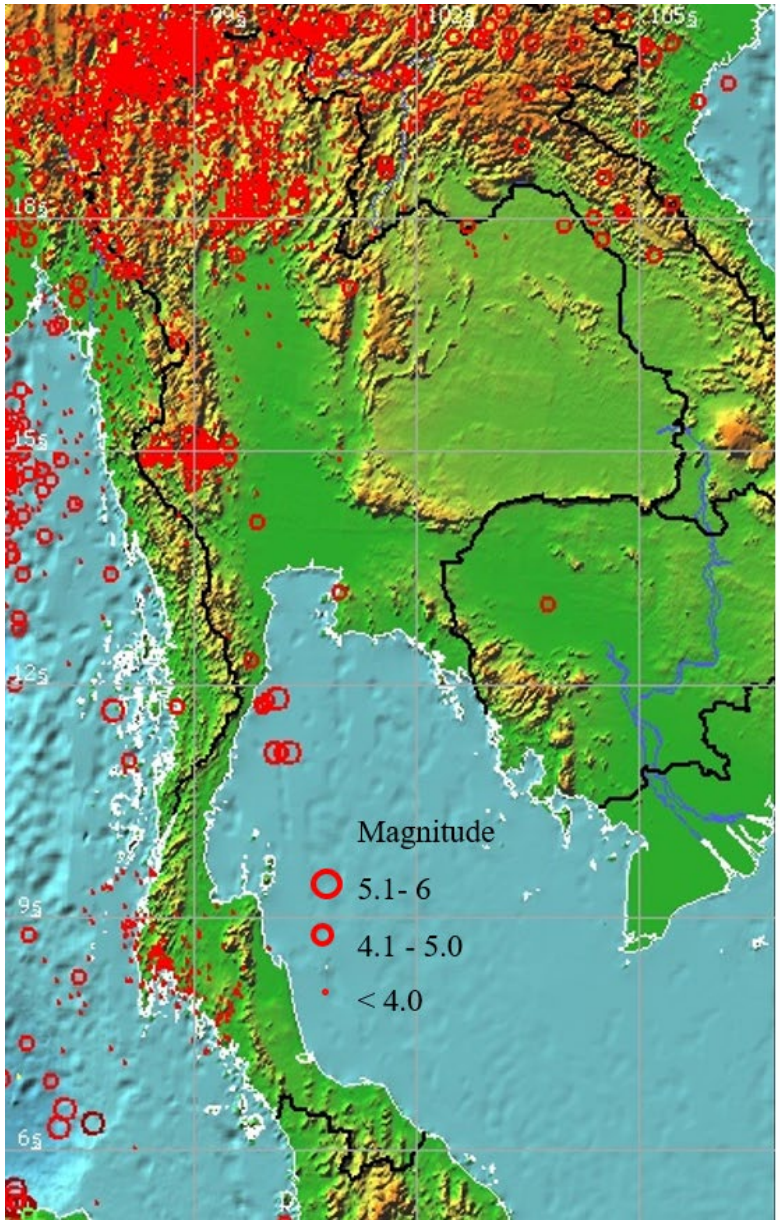


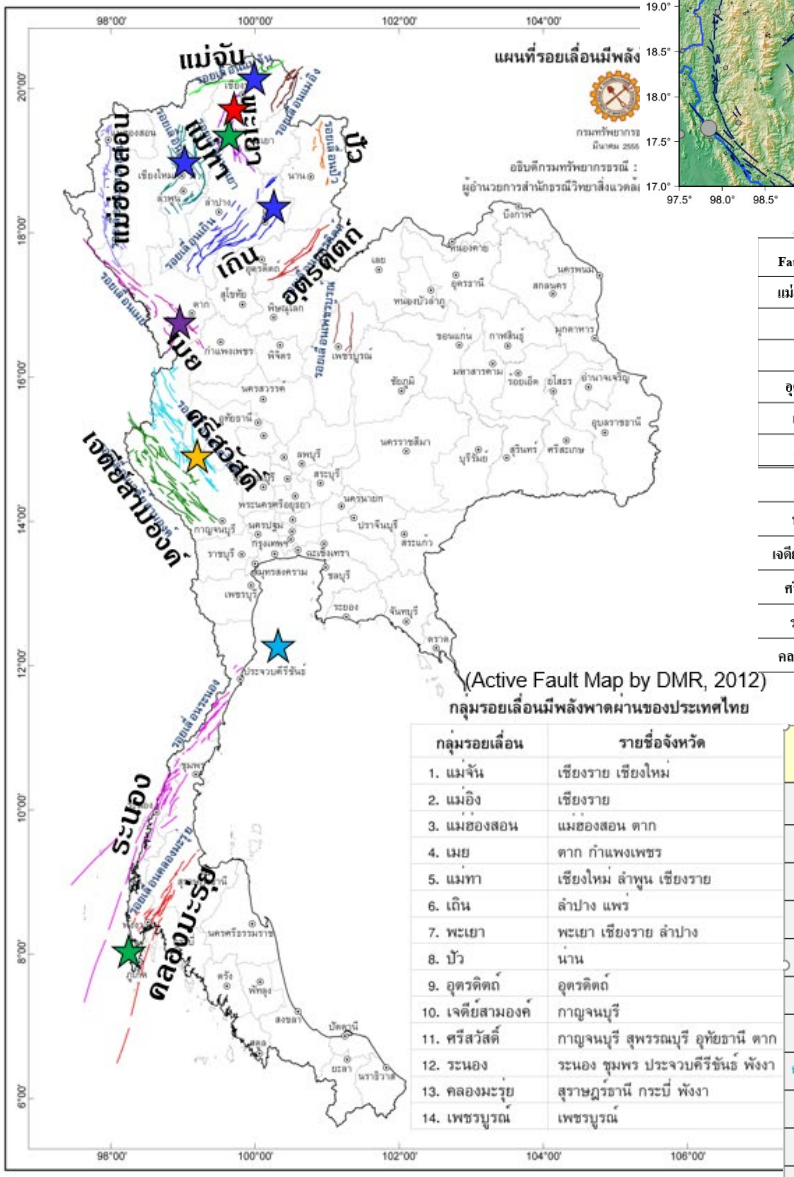
(Morley et al., 2001)



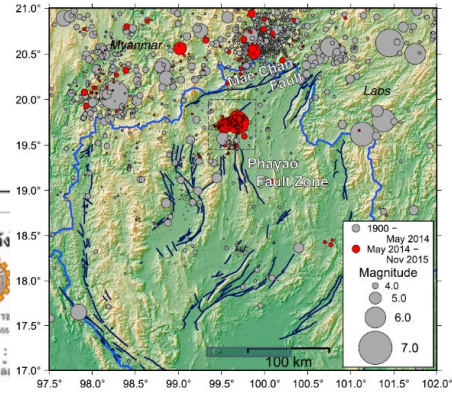
EQs (M>5)

Seismicity of Thailand





กลุ่มรอยเลื่อน	รายชื่อจังหวัด
1. แม่จัน	เชียงราย เชียงใหม่
2. แม่อิง	เชียงราย
3. แม่ฮ่องสอน	แม่ฮ่องสอน ตาก
4. เมย	ตาก กำแพงเพชร
5. แม่ทา	เชียงใหม่ ลำพูน เชียงราย
6. เถิน	ลำปาง แพร่
7. พะเยา	พะเยา เชียงราย ลำปาง
8. ปัว	น่าน
9. อุตรดิตถ์	อุตรดิตถ์
10. เจดีย์สามองค์	กาญจนบุรี
11. ศรีสวัสดิ์	กาญจนบุรี สุพรรณบุรี อุทัยธานี ตาก
12. ระนอง	ระนอง ชุมพร ประจวบคีรีขันธ์ พังงา
13. คลองมะรุ่ย	สุราษฎร์ธานี กระบี่ พังงา
14. เพชรบูรณ์	เพชรบูรณ์

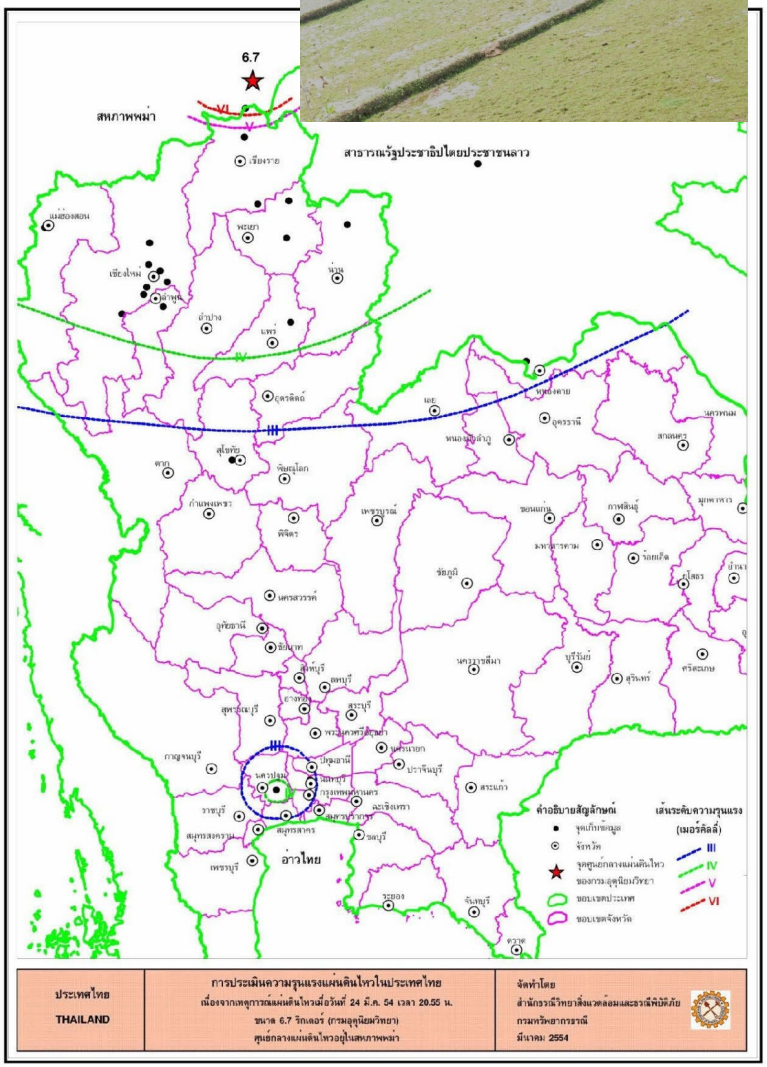


Fault Zone	Latest movement	Maximum Credible Earthquake
แม่ฮ่องสอน	2,000	6.7
เมย	2,000	6.5
ปัว	1,500	6.7
อุตรดิตถ์	2,000	6.3
แม่จัน	1,500	6.9
แม่ทา	2,000	6.7
เถิน	2,000	6.6
พะเยา	2,000	6.2
เจดีย์สามองค์	2,000	6.6
ศรีสวัสดิ์	1,400	6.8
ระนอง	2,000	6.5
คลองมะรุ่ย	2,000	6.8

วันเกิดเหตุการณ์	ศูนย์กลางแผ่นดินไหว	ขนาด (ริกเตอร์)
17 ก.พ. 2518	อ.ท่าสองยาง จ.ตาก	5.6
15 เม.ย. 2526	อ.ศรีสวัสดิ์ จ.กาญจนบุรี	5.5
22 เม.ย. 2526	อ.ศรีสวัสดิ์ จ.กาญจนบุรี	5.9
22 เม.ย. 2526	อ.ศรีสวัสดิ์ จ.กาญจนบุรี	5.2
11 ก.ย. 2537	อ.พาน จ.เชียงราย	5.1
9 ธ.ค. 2538	อ.ร้องกวาง จ.แพร่	5.0
21 ธ.ค. 2538	อ.พร้าว จ.เชียงใหม่	5.2
ก.ย. - ต.ค. 2549	อ่าวไทย	4.2-5.6
13 ธ.ค. 2549	อ.แม่ริม จ.เชียงใหม่	5.1
16 เม.ย 55 6 พค 58	จ. ภูเก็ต	4.3, 4.6
5 พ.ค. 2557	อ.แม่ลาว/พาน จ.เชียงราย	6.3

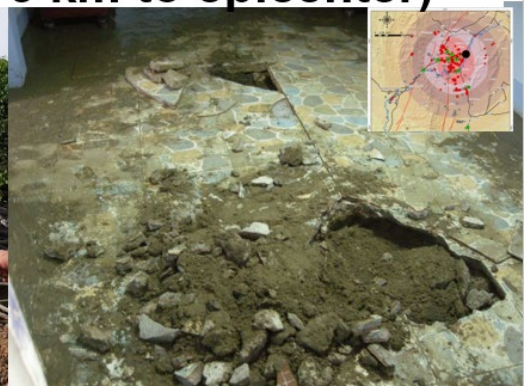
Major Historical and Recent Earthquakes That Affects Thailand

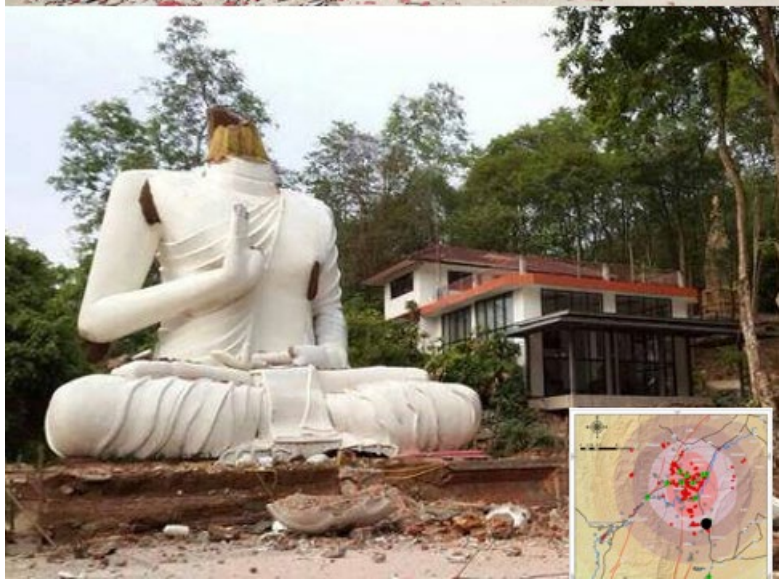
24 March 2011 M6.7 in Myanmar (100-150 Deaths in Myanmar)



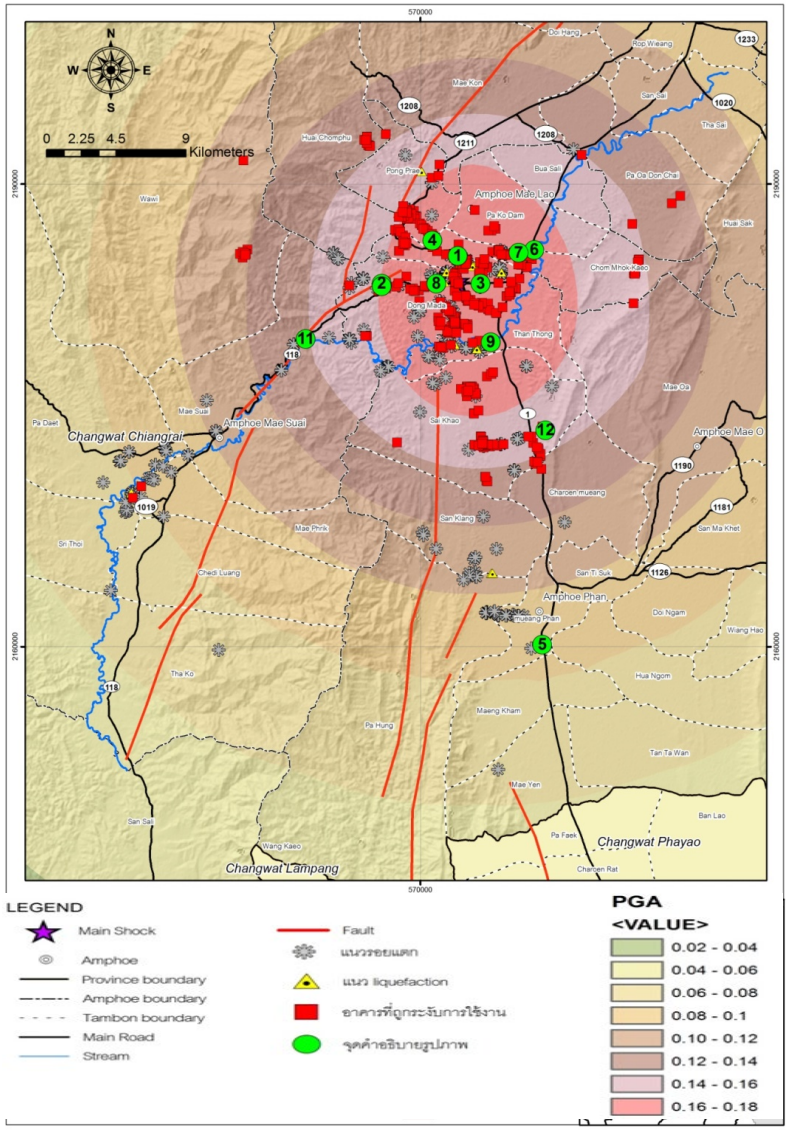
M6.2 Chiang Rai EQ (May 5th, 2014, 18:08 pm, 19.66◦N 99.67◦E 10km)

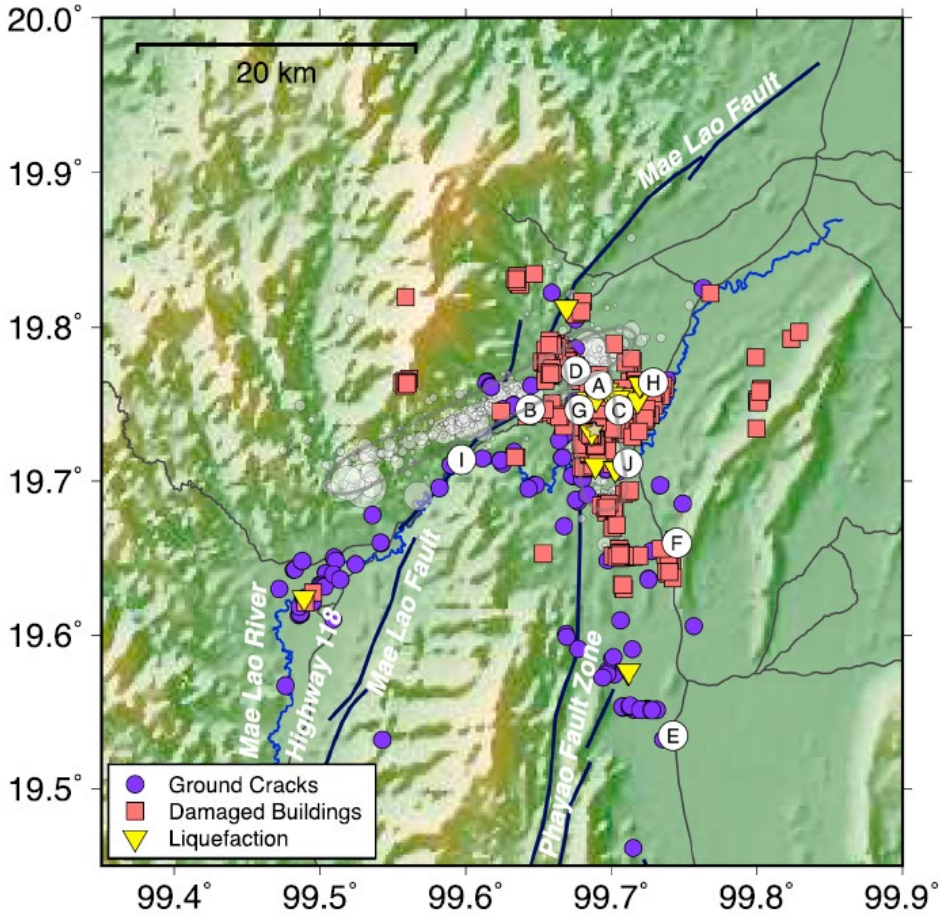
Near Field Effects (0-5 km to epicenter)





More than 15,000 building with degrees from minor damages to total collapse and yielded a total damage of US$300 million

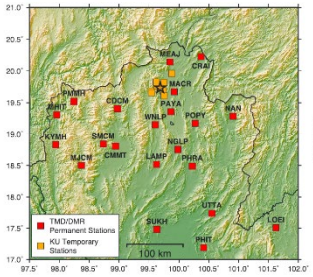


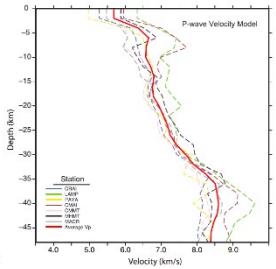


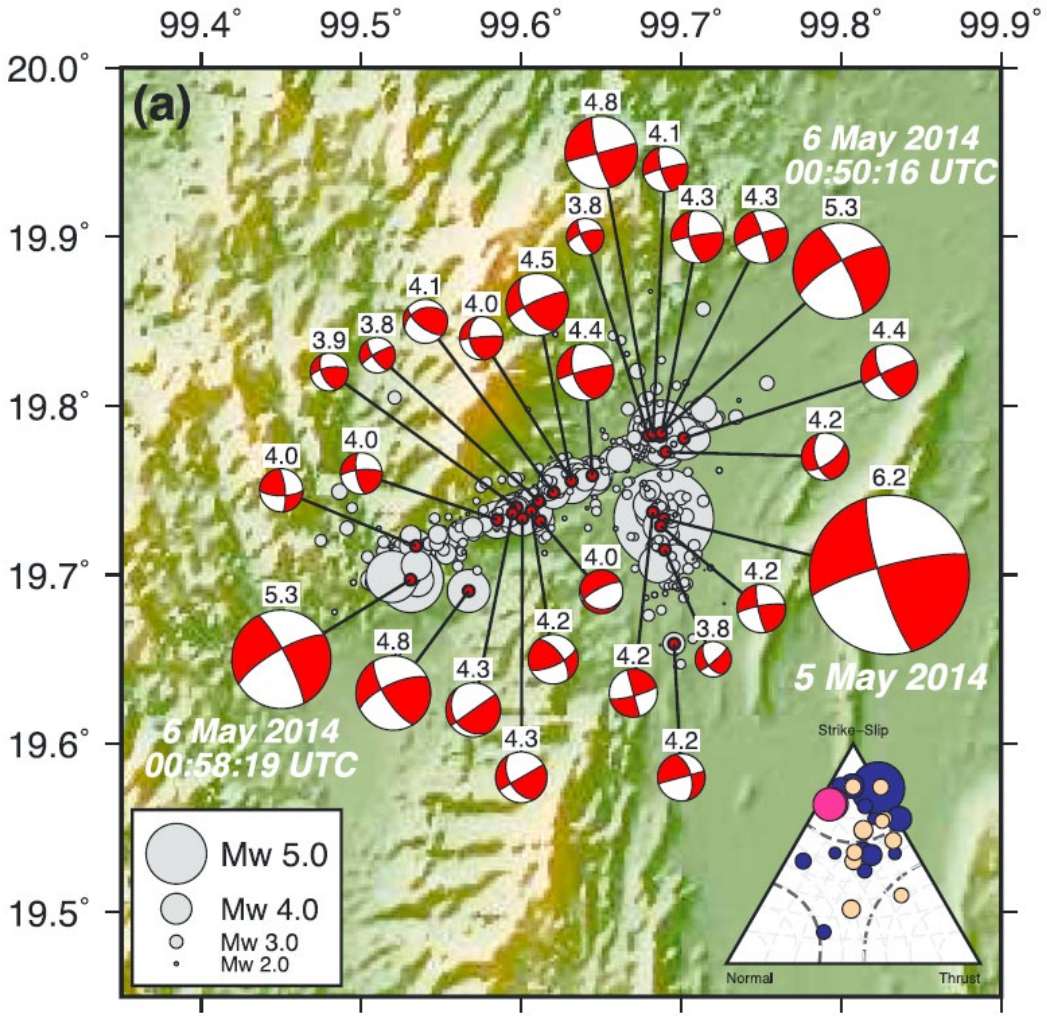
Damages Map vs Simulated PGA

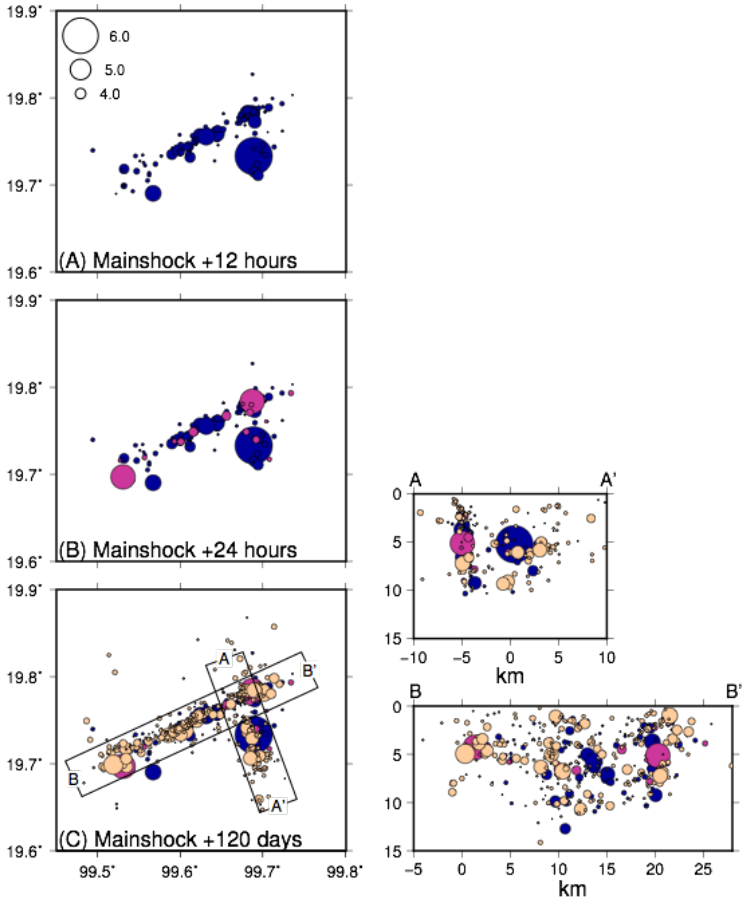
(M6.2 at 10km depth, Sadigh et al., 1997's attenuation model)

Aftershocks Monitoring and Relocation









Delineation of two 'conjugate' fault trends

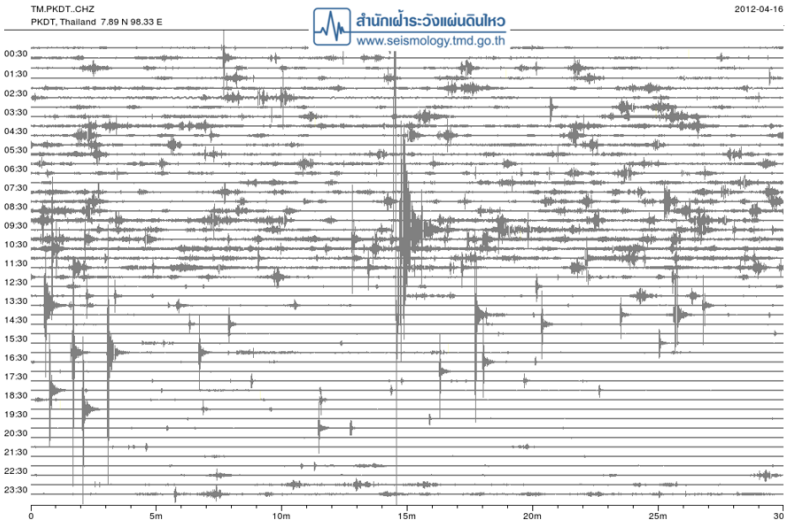
Phuket EQ

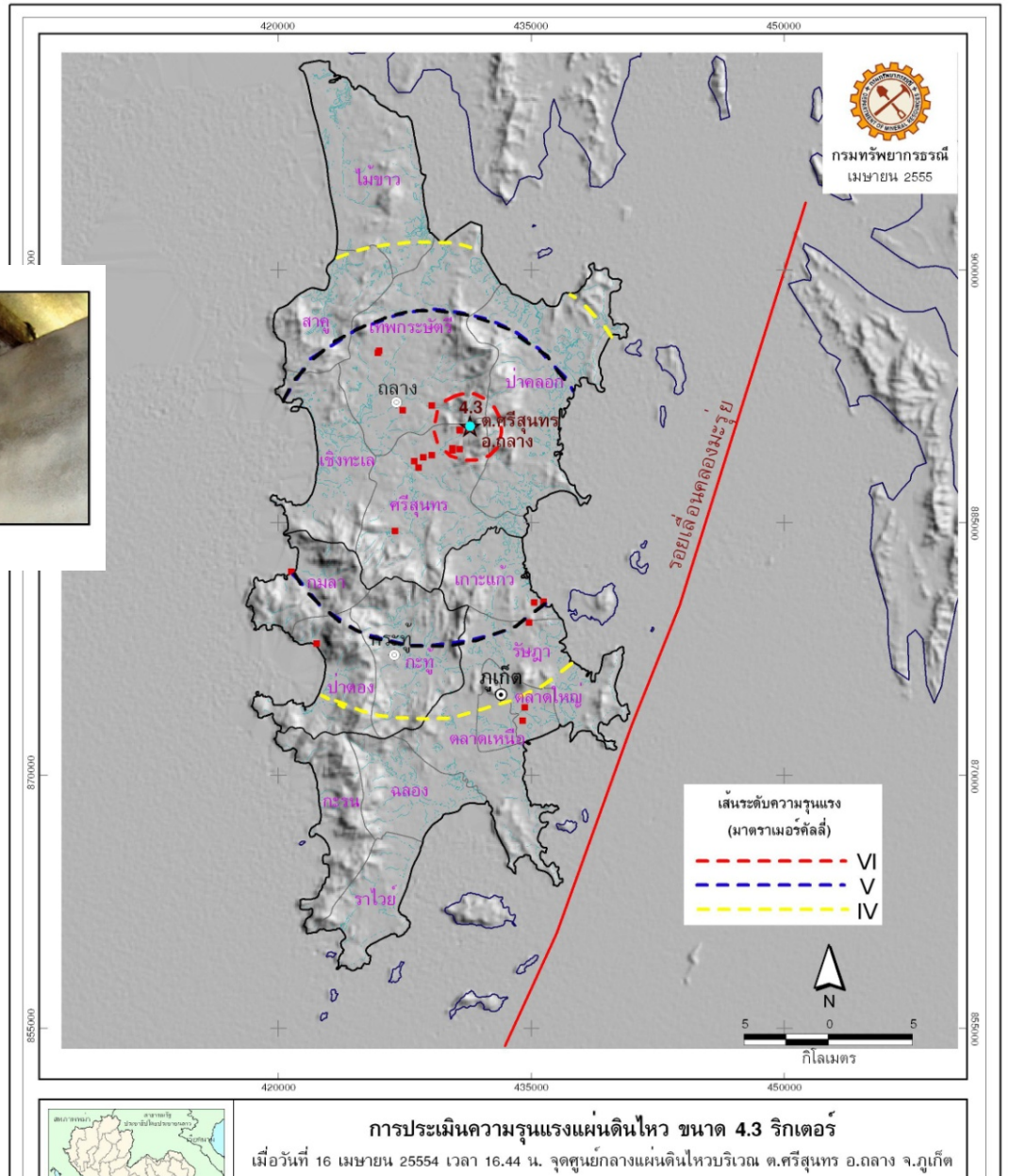
A rare earthquake (M_L 4.3) occurred at 09:44:25 hrs.(UTC) on 16 April 2012 in the Si Sunthon District, Thalang District, Phuket province, southern Thailand

This earthquake caused slight building damages and was felt throughout the Phuket island.

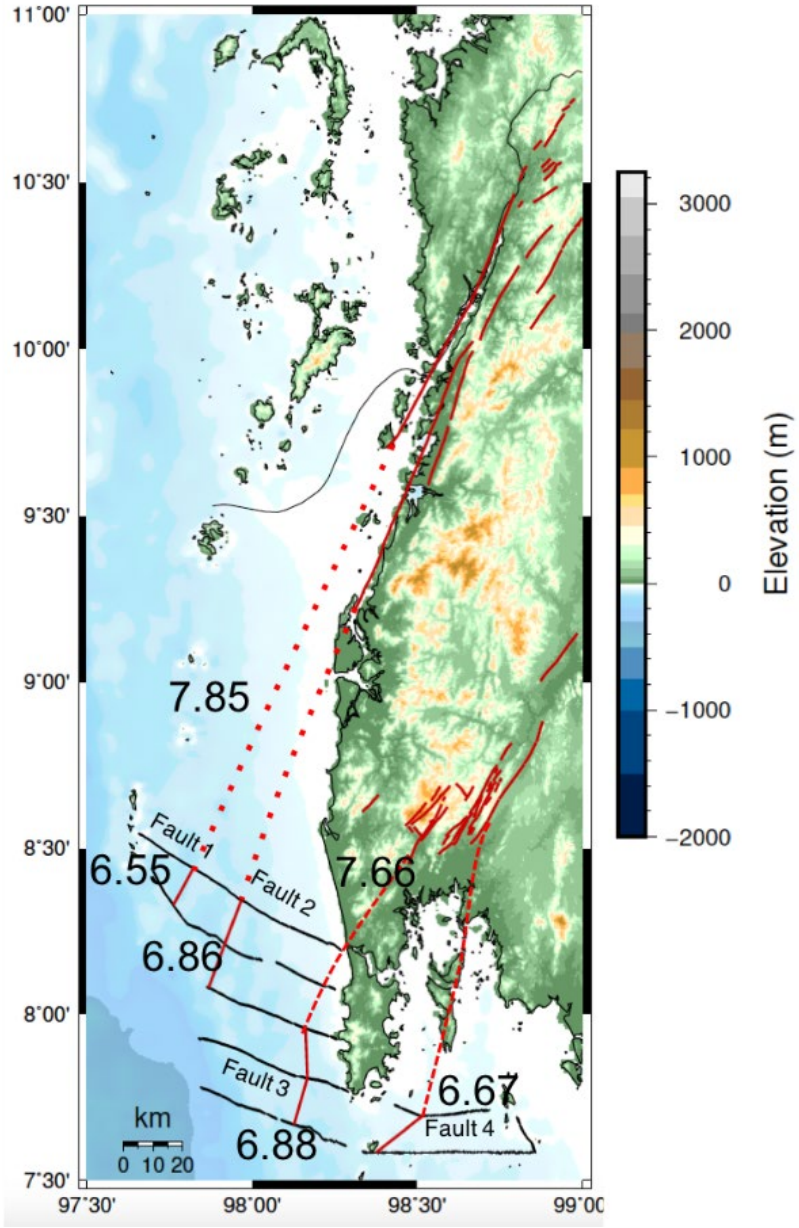
MMI 6 near the epicenter

29 aftershocks M>1.5ML occurred during 24hrs from the mainshock.





Seismic Hazard in the Southern Thailand

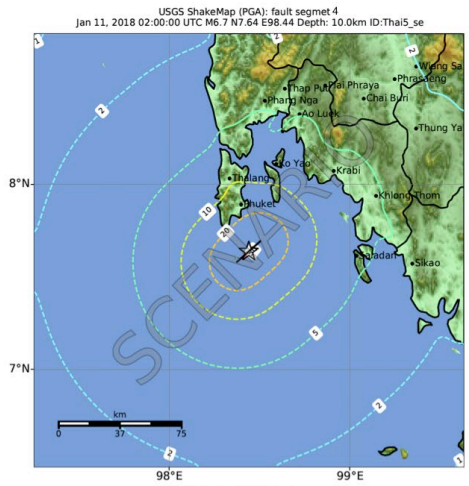


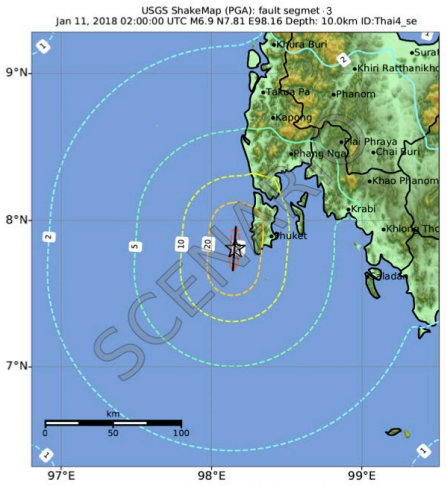
(After Ramirez 2019)

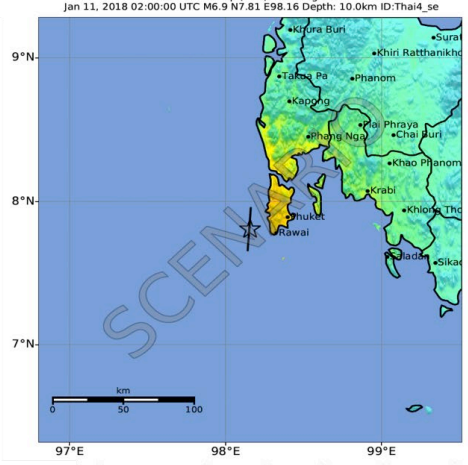
Segment	Length (km)	Magnitude (Mw)	Slip (m)
1	13.87	6.55	1.22
2	31.31	6.86	1.56
4	32.93	6.88	1.59
5	18.98	6.67	1.34
Full Khlong Marui	172.93	7.51	2.63
Full Ranong	430.00	7.85	3.48
Short Khlong Marui	47.234	7.02	1.77
Short Ranong	96.82	7.29	2.21

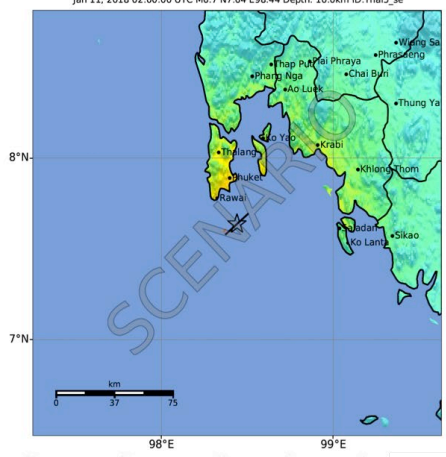
Offshore fault segments and the potential maximum earthquake magnitude (Wesnousky, 2008)

Scenario Shake Map: intensity up to VIII

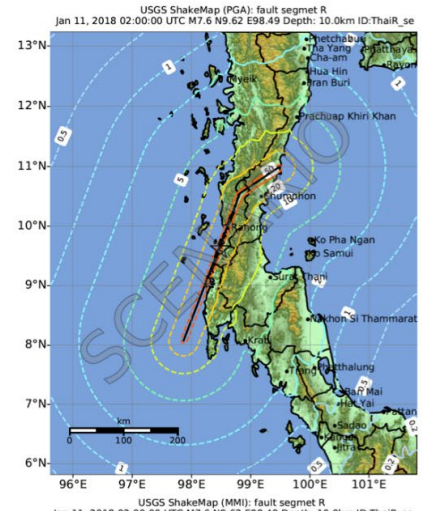


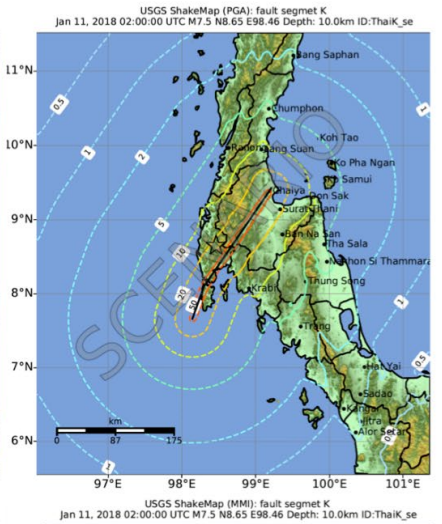


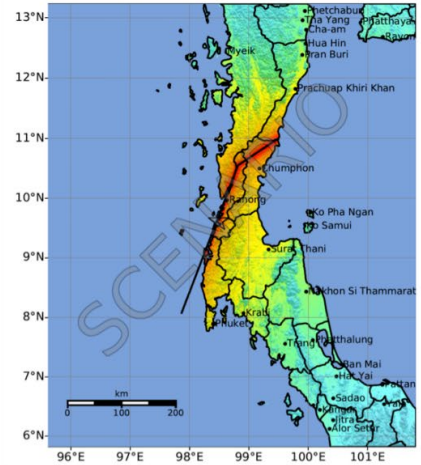


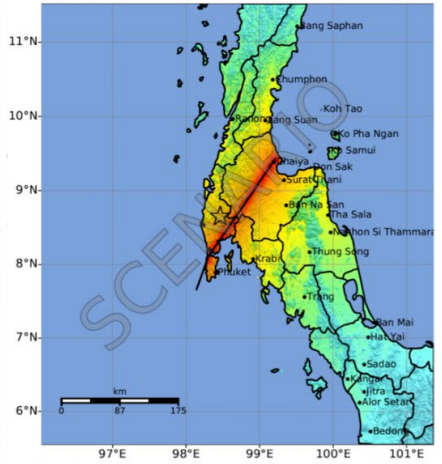


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+





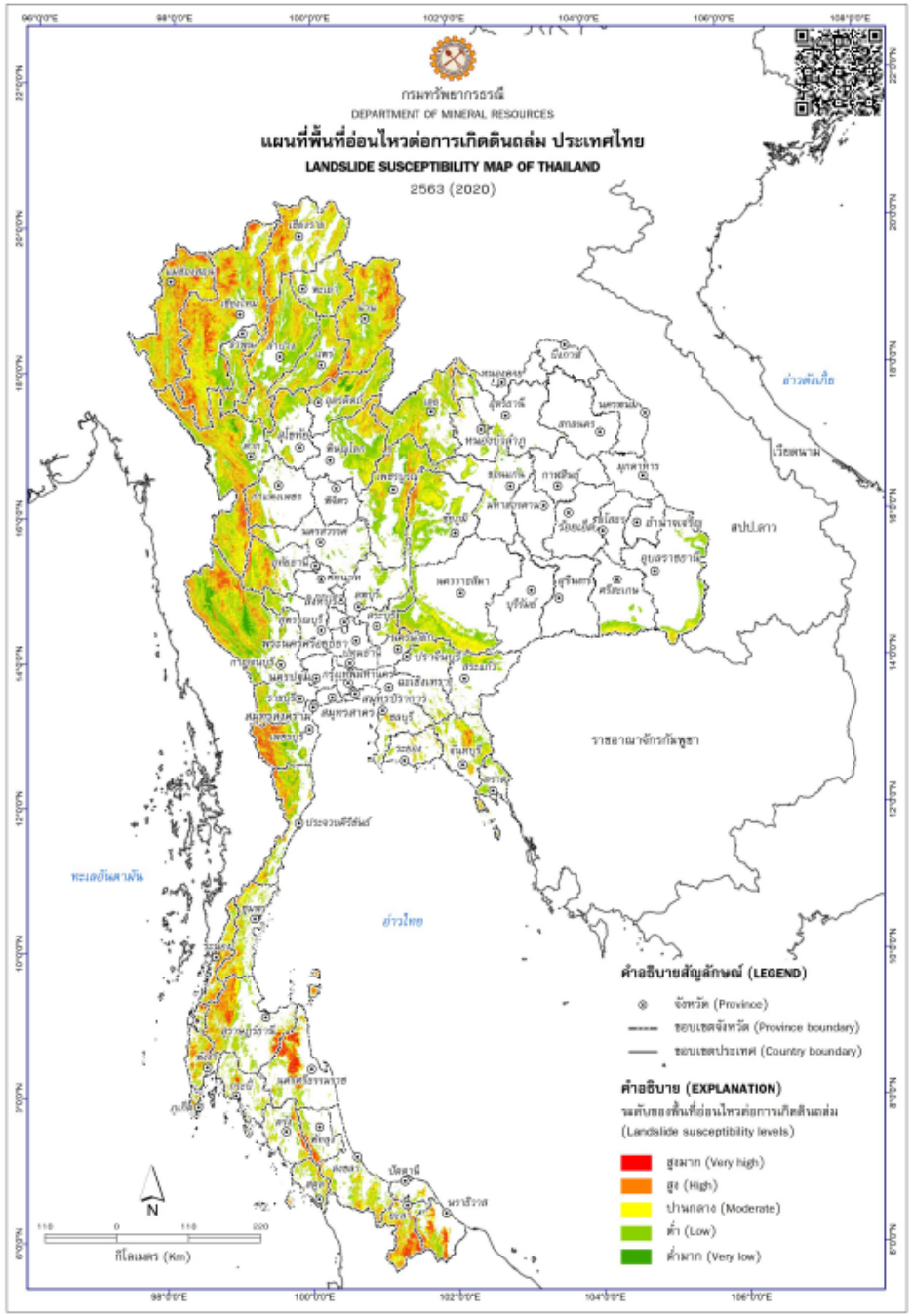


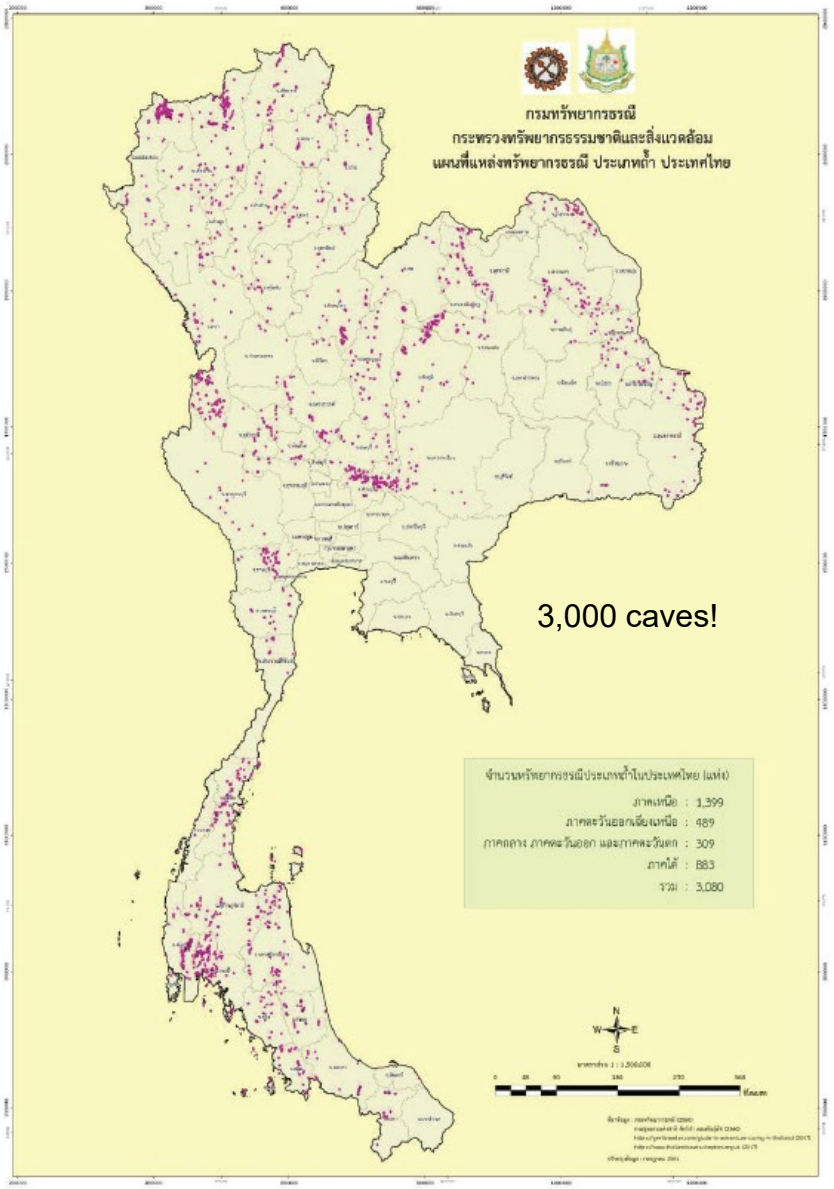


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

(After Ramirez 2019)

Landslide Hazard of Thailand

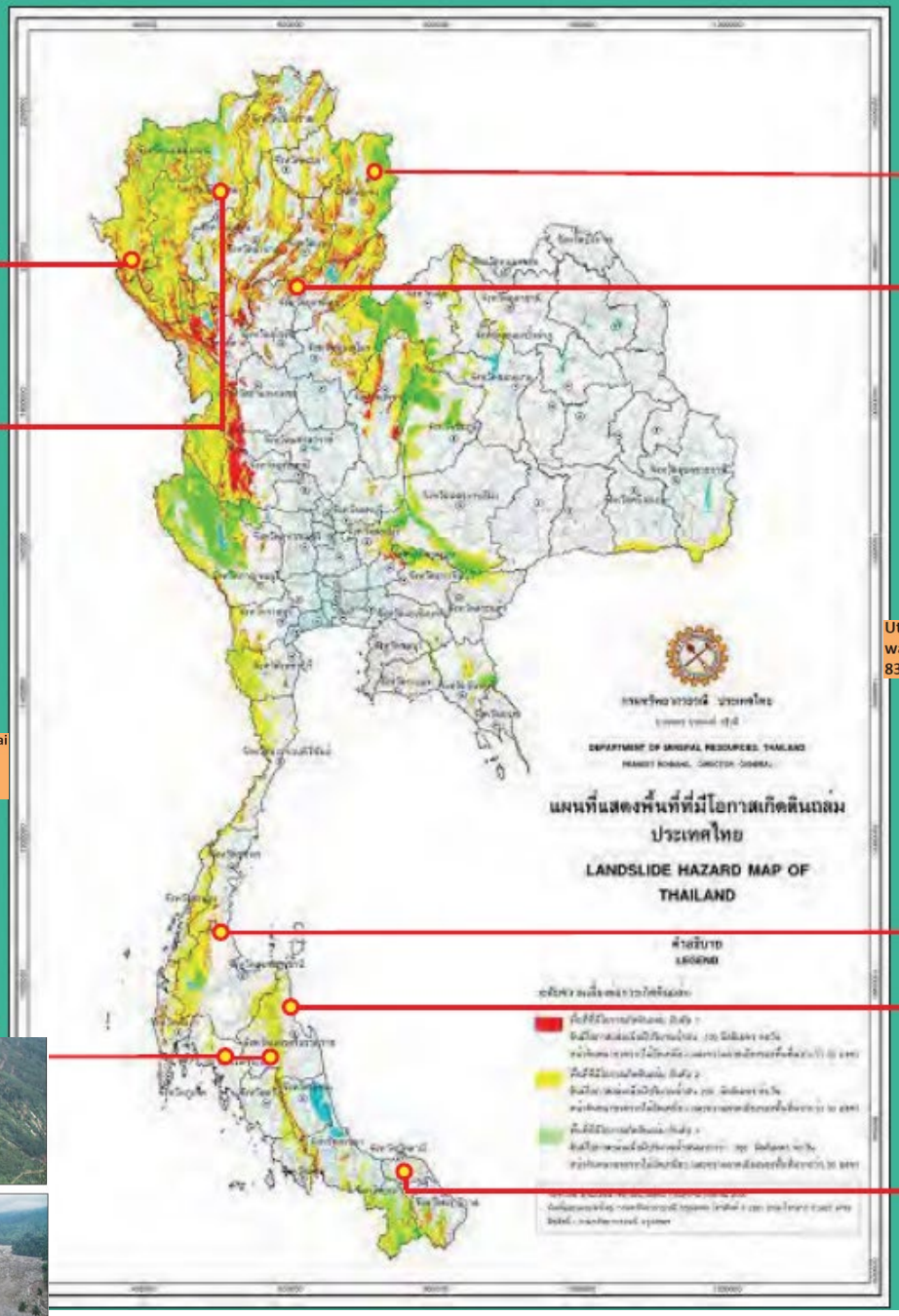




(Source: Department of Mineral Resources)

Landslide in Thailand

1 Introduction



Sob Moei, Mea Hong Son,
17 September 2018

1) Mae Rim , Chiang mai
1 July 2016

2) Prao/ Mae Rim/ Mae Cham/ Hod, Chiang mai
23 May 2017

11 districts of Chiang Mai was affected
213 people death,
111 people loss

Krabi/ Nakhon Sithamarat,
30 March 2011

Krabi / Nakhon sithamarat was affected
14 people death,
loss 10,000 millions bath

Bo Kluea, Nan, 28 July 2018

1) Laplea/ Thapla, Uttaradit,
22 May 2006

2) Nam Pad, Uttraradit
9 Sep 2011

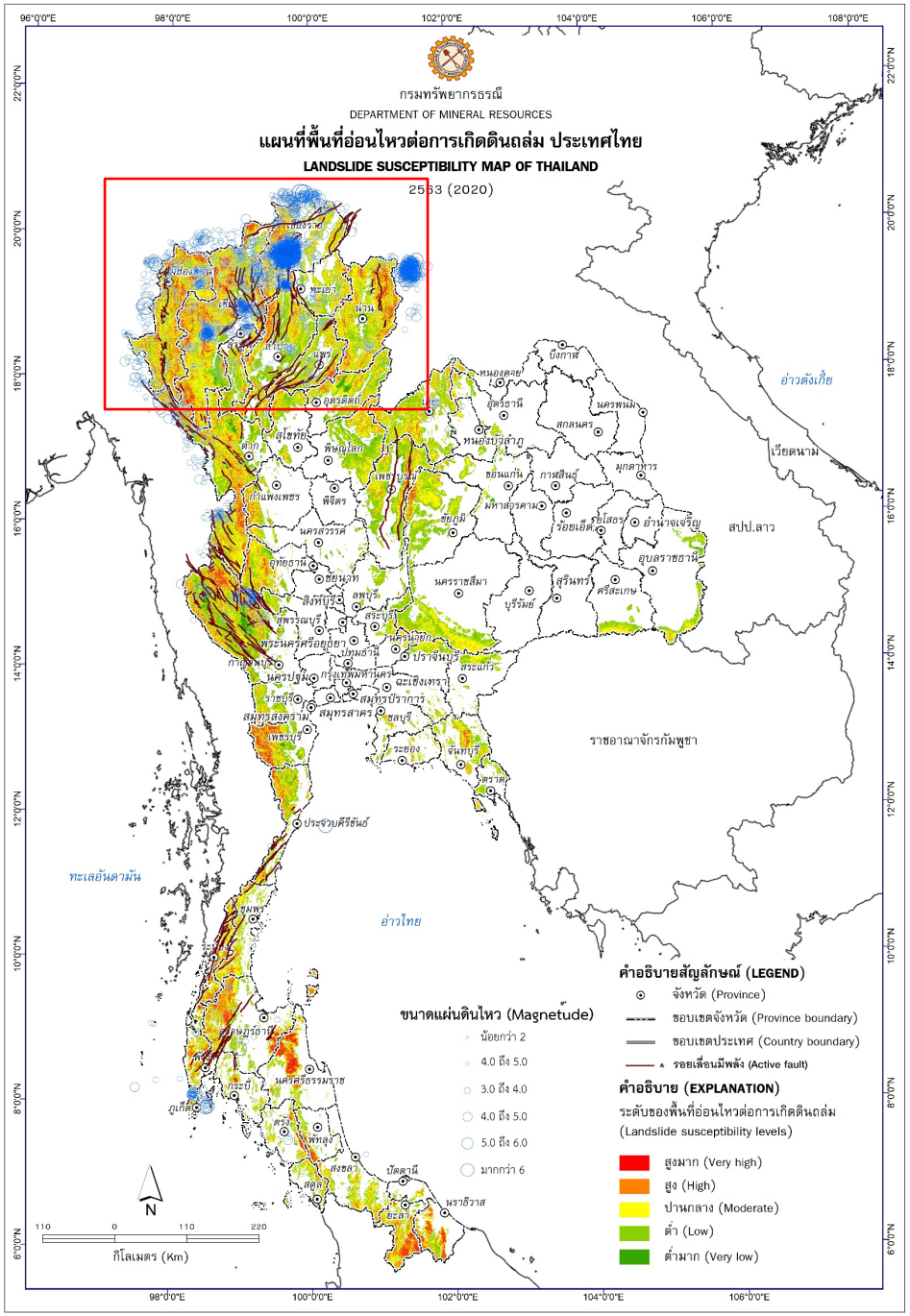
Uttradit/ phrea/ Shkhothai was affected,
83 people death,

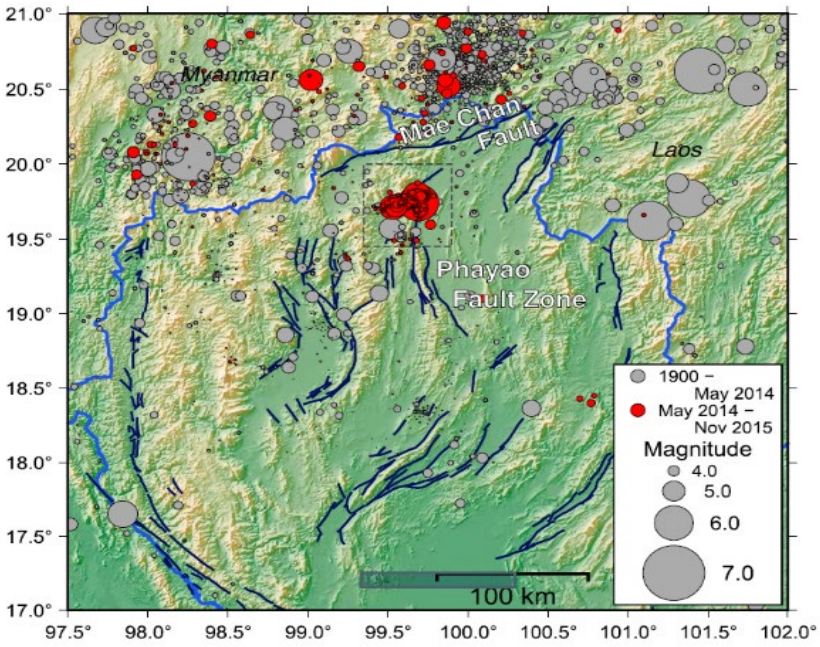
Klongmui, Viphawadee,
Suratthani, 11 Dec 2008

Khanom,
Nakonsrithammarat,
4 Nov 2010

Bunnagsatar, Srisakhon,
Pattahni, 6 Nov 2009

(After R. Teerarungsigul, 2019)



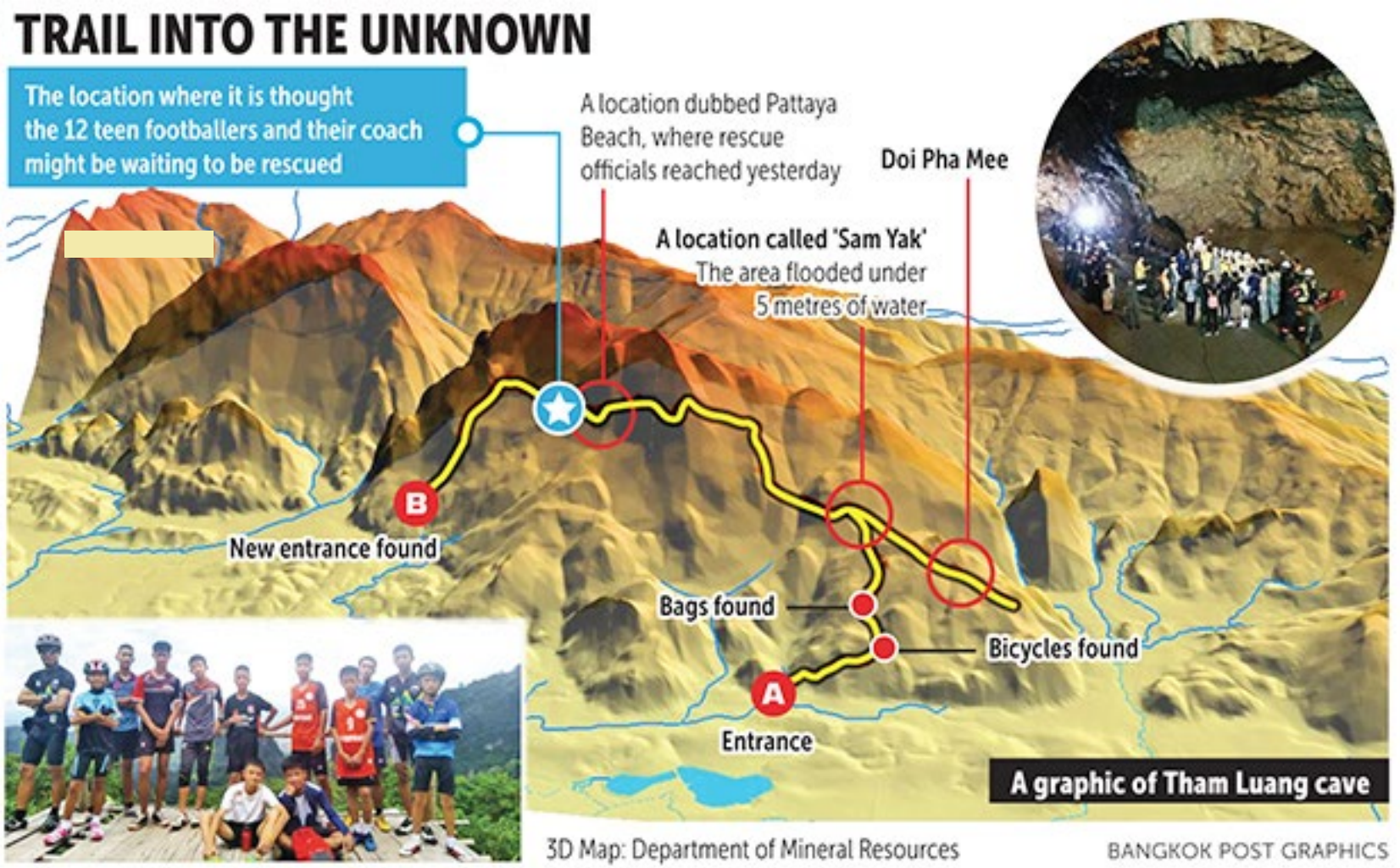


Earthquakes in High Landslide Susceptibility Areas

Future research needs:

- Sophisticated analytical method for landslide hazard (probabilistic, etc.)
- Real time simulation (debris flow model, extent of damage from the landslide events, etc.)
- Real time monitoring data (rainfalls, water flows, mass wasting, creeping etc.)
- Integrated data, especially high-resolution remote sensing and dynamic/field data such as ground shaking, wildfire, geology, geotechnical engineering data etc.
- To integrate landslide hazard analysis affected by ground shakings in case of moderate earthquake.

Mountainous Hazard in Thailand: Tham Luang Cave Rescue Operation



(Source: Bangkok Post)

What did earth scientists do during the rescue missions?

Before the boys were found

Geologists and cave explorers + GIS mappers

Geophysicists: ID cavity for cave entrance

Water management: water diversion

Meteorologists: Weather forecast

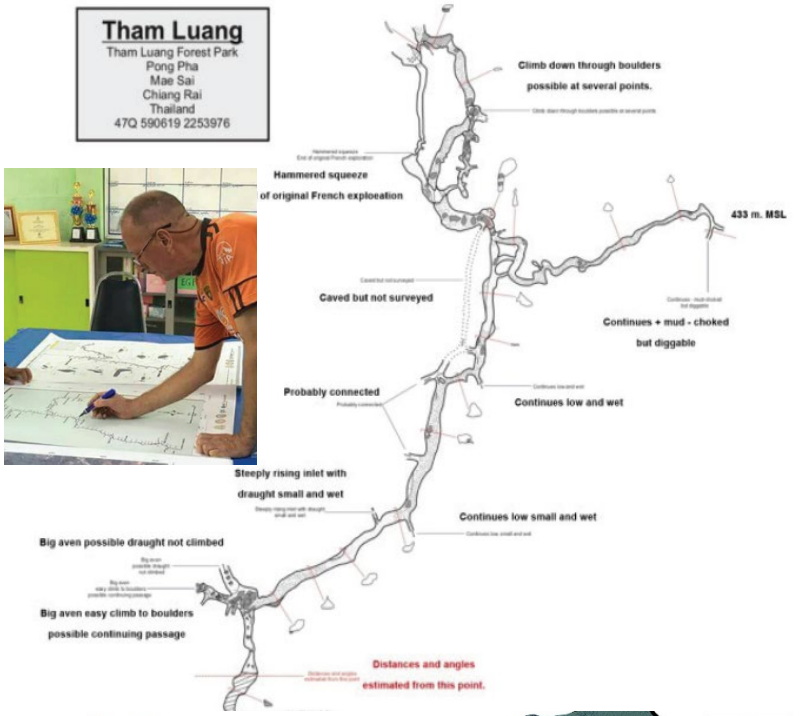
After the boys were found

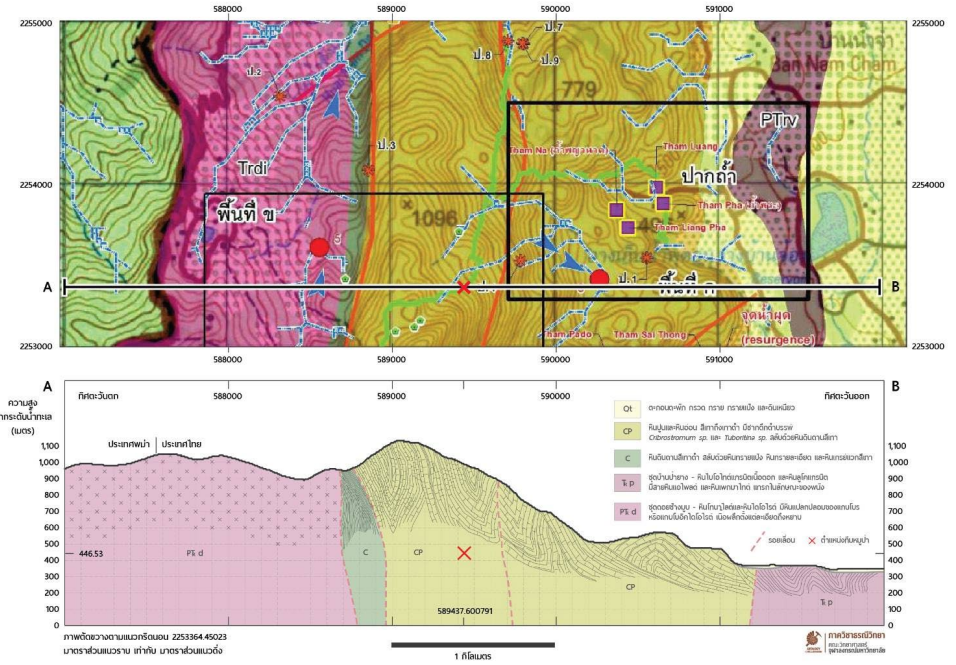
Water management: Pumping water: starting just before the boy were found

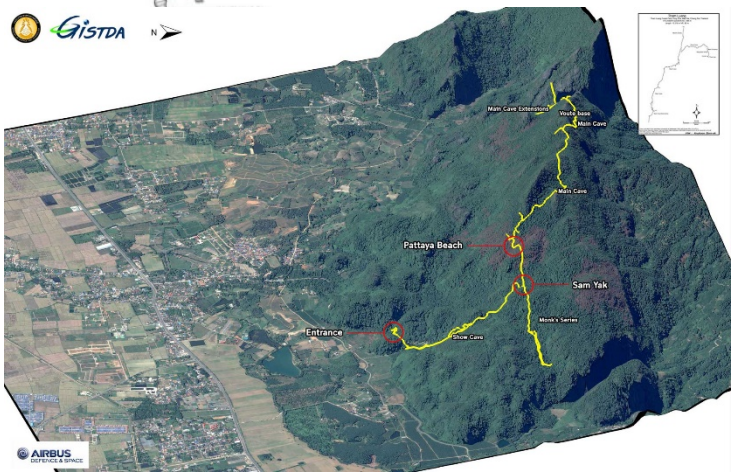
Meteorologists: Rain Fall monitoring/detailed weather forecast

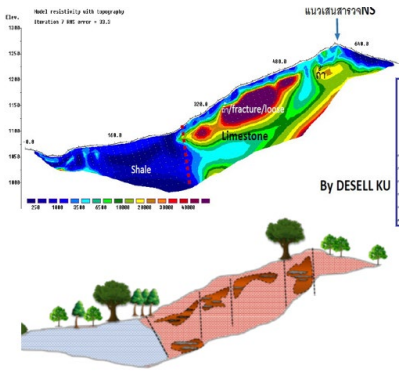
Seismologists (locating locations of the boys)

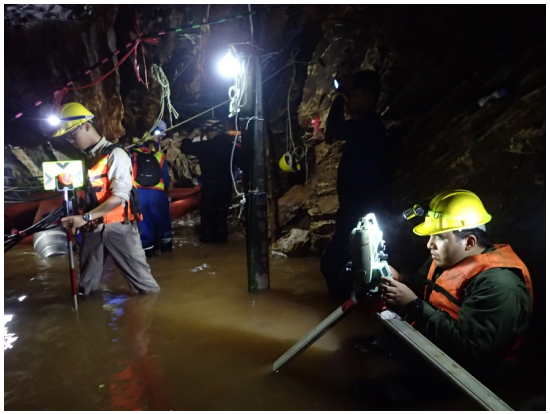
Geologists, cave explorers, Geophysicists and GIS mappers: Cave Route, Geology of the cave and surface water flow direction





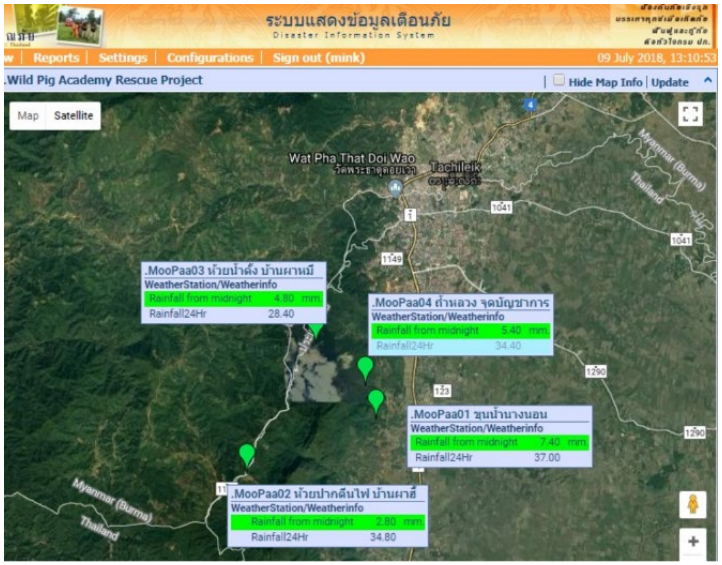


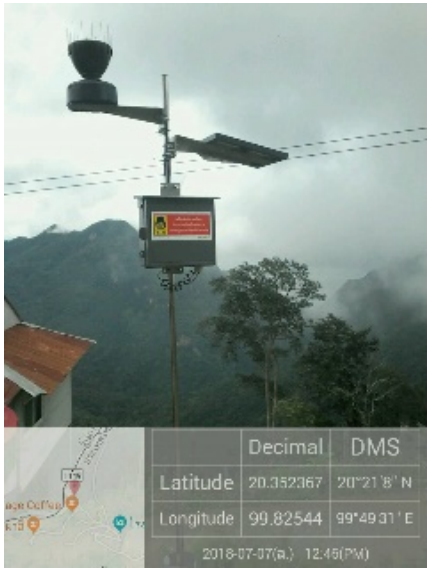




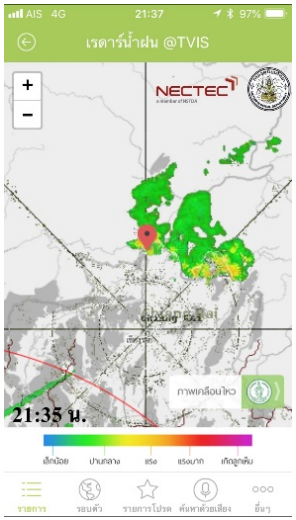
(Sources: KU, Martin Ellis, GISTDA, Department of Mineral Resources and Chulalongkorn University)

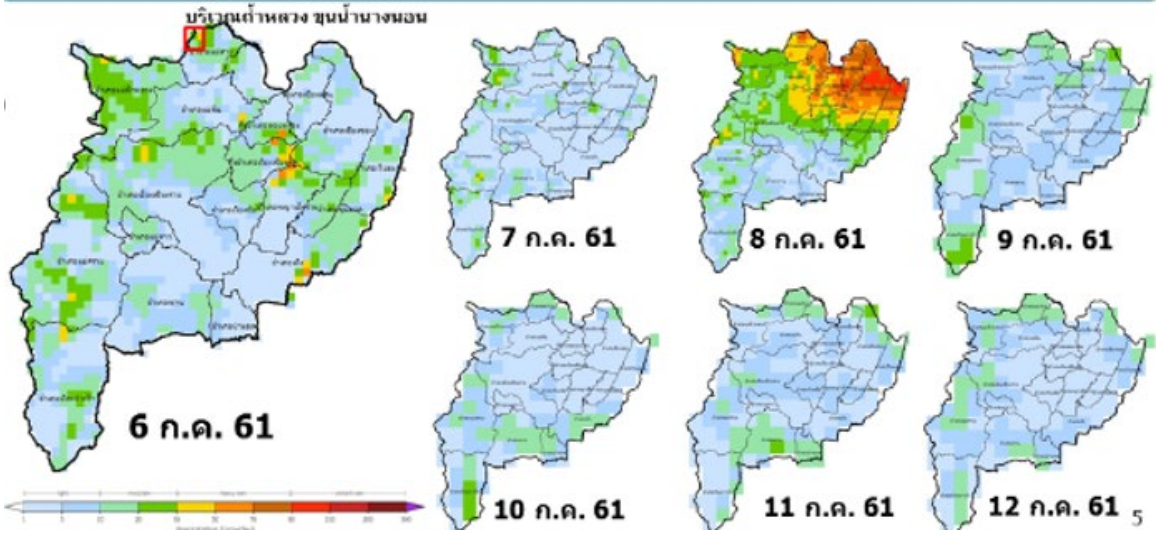
Rainfall Monitoring and Pumping Water out





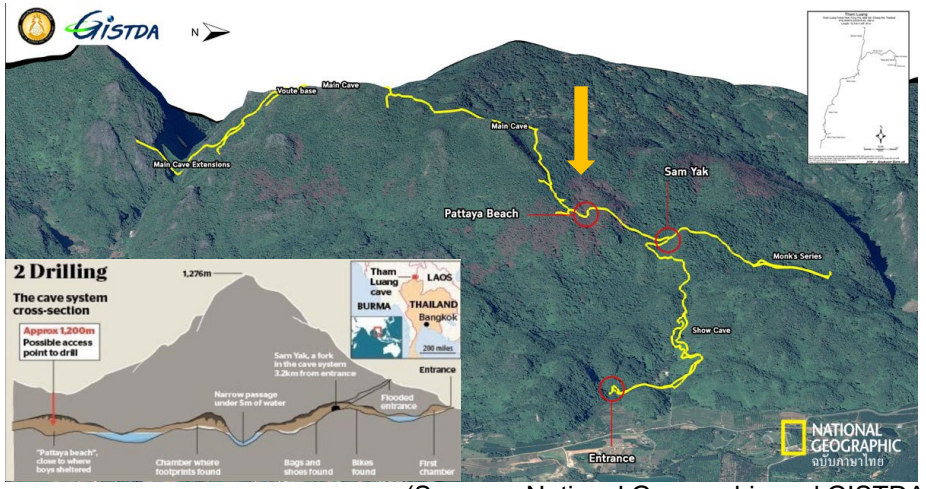
4 Stations around operation site installed since 7 July 2018





(Credits: National Electronics and Computer Technology Center, Department of Disaster Prevention and Mitigation, Thai Meteorological Department, Hydro Informatics Institute, CH. Karnchang PLC)

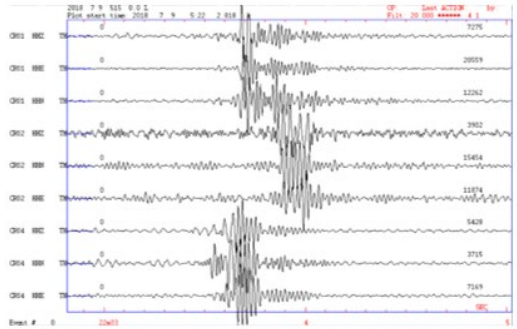
Locating the boys' location using earthquake location concept



(Sources: National Geographic and GISTDA)

Accuracy Test: 9 July 18

Location of the source from the calculation is only about 10 m from the real location!



(20 – 100 Hz BP filter) from 3 stations (3 components) The duration of data about 0.5 sec.

Conclusions

Thailand has moderate seismic hazard with many active fault capable of earthquake up to M7. The largest earthquake (M6.2) generated intensity level of 8 MMI).

Many of the high seismic hazard/active fault locations are located in the mountainous areas which have high landslide hazard.

There are very little landslide real time monitoring system in Thailand due to the high cost and low population density living in the high landslide hazard areas.

Thailand need further landslide hazard research with new technology especially simulation of flow model, probabilistic landslide hazard, INSAR, real time monitoring system, etc.