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Review of active faults and seismicity in Thailand

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Abstract: There was little awareness on earthquake hazards in Thailand until the country experienced the 1983 earthquake. Though Thailand has long been recognized as situated in the low seismicity region and there were not very much earthquake damaged events in her past history, there are more than 4,000 small to moderate quakes detected in Thailand and nearby since the installment of the worldwide seismograph network in 1902. After the establishment of National Earthquake Committee in 1984 and installment of 12 seismic network stations, more studies related to earthquakes have been generated. However, most of the qualified studies concern to some extent with the engineering properties related to the earth tremors.

At present it is recognized that many earthquake activities have a closely temporal and spatial relation to the fault movements. However, based on our study, the recent fault activities are more or less linked to the extrusion tectonics caused by the India-Asia collision during mid-Tertiary. There are at least three approaches to defining the active fault (AF) — general, engineering, and regulatory definitions, however, all of which use the age of the last past activity. The faults that do not meet general requirements are interpreted as either potentially active (PAF) or tentatively active (TAF). In the adoption of the active fault classification, the geological, geotectonic, geochronological, and seismological evidences allow us to group the faults in Thailand into 5 major fault zones (FZ), namely the northern, western-northwestern, central peninsular, southern peninsular, and eastern-northeastern FZs.

However, not all FZs are considered as the AF. Most faults of the central and southern peninsular and east-northeast FZs are inferred as PAF and TAF. Many faults belonging to the northern and western-northwestern FZs are regarded as the AF. Exception is the Mae Tha, Nam Pat and Pha Yao faults are inferred as TAF due to their subdued and deeply eroded morphology and scarps. Based upon the fault activity in conjunction with the seismic zoning maps, the seismic risk map of Thailand is proposed.

INTRODUCTION

Earthquake hazards in Thailand have been rather remote and hardly known until the country has experienced several quakes. More than 4,000 earthquakes have been detected after the installment of the world-wide seismograph network in 1902. Although these quakes are relatively minor to moderate in the global norm, they seem to be essential phenomena for the Thai people. Although strong destructive earthquakes have never occurred in Thailand, strong earthquakes frequently happened at the borders of the neighbouring countries (e.g., Myanmar and southern China). For example, the most destructive earthquake ever recorded in the recent time happened in northern Myanmar on 5 May 1980 with the magnitude of 7.3 and almost entirely destroyed Pegu township with hundreds injured and people killed. It was recognized that the largest tremor instrumentally recorded at magnitude 8.7 took place on 26 June 1941 in the Andaman Sea (Nutalaya *et al.*, 1985).

In the old days, some earthquakes with the maximum intensity VI MM were recognized in Thailand (Prachaub, 1996). After several major dams construction together with the appearance of a few quakes close to Bangkok, the awareness of such aspect have come to the mind. Consequently, efforts have arisen to gain more knowledge due to our lack of awareness in the past.

The aims of this paper are to make a critical review, to provide an up-to-date information on the earthquake activities in Thailand, and to propose, based upon several geological, geochronological, and seismological information, the active fault zones in Thailand.

PAST ACTIVITIES

It was not until 1963, when the first WWSSN (World Wide Standard Seismograph Network) station was set up in Chiang Mai, northern Thailand, by Geophysics Subdivision, Weathering Forecasting Division, Meteorological Department of Thailand (TMD) and the other (vertical component of short period and three component of long period seismograph) in Songkhla in 1965, both under the support of the US government (Prachaub and Wetchbunthung, 1992). In 1974, Thailand established 2 short-period vertical component seismographs that were installed in 1975 under the assistance of UNESCO in Tak and Nakhon Ratchasima (see Fig. 1 and Table 1) immediately after the unexpected large earth tremor in Mae Sot, Tak, western Thailand (17 February, 1975). In 1982, before the other serious quake took place (15–22 April, 1983), three other seismological stations (short and vertical signals) were established with the cooperative work between the Electricity Generating Authority of Thailand (EGAT) and TMD for detecting seismic activities in areas dominated by power plants (see Prachaub, 1990, 1996).

However, during those periods, not much research work has been done on the earthquake analyses of the country. Nevertheless, much of the work was contributed by TMD to the public for the awareness and relations in the forms of booklets, leaflets and the like to educate people in the easy-to-read Thai language.

RECENT ACTIVITIES

The National Earthquake Committee of Thailand (NECT) was established with the endorsement of the cabinet in September 1985. It was believed that the committee was set up after the major earthquake on 22 April 1983 (with the magnitude 5.9 on the Richter scale) which happened in northwest Thailand near Bangkok. This perhaps was critical enough to gain public concern and attention for the Thai society. The major tasks of the committee include to coordinate with domestic and/or international associations, organisations, and agencies dealing with earthquake activities for the exchange of knowledge, information and opinion, to promote research on earthquake-related subjects, to distribute knowledge on seismic risk mitigation to the public, and to propose measures and strategies for seismic risk mitigation.

The first comprehensive and pioneering systematic study on seismicity in Thailand was performed by a staff of the Asian Institute of Technology or AIT in 1983 (Nutalaya *et al.*, 1985). After the 1983 earthquake, public concern for building safety has increased due to the fact that no structures in Thailand have been designed for seismic effects (Lukkunaprasit, 1994). During that time the only research work was done by a DMR geologist on the seismogenic of Thailand (Siribhadi, 1988), but no further studies have been done afterwards.

The other seismic instrument with a short-period vertical component was equipped in Pak Chong, Nakhon Ratchasima, in 1985 by TMD as the telemetry station in order for the signal to be telemetried to Bangkok through telephone.

In 1986, the Earthquake Engineering and Vibration Research Laboratory of Chulalongkorn University (CU-EVR), in collaboration with Department of Public Works set up more than a dozen of accelerometers at two buildings in Bangkok with the prime goal to assess the equivalent seismic forces for use in designing building with economy and safety and to obtain improved seismic design code values to be promulgated in the building regulations (Lakkunaprasit, 1994). However, the seismic risk mitigation in Thailand cannot be worked out properly due to the paucity of appropriate data and relevant research studies regarding the seismicity of the country.

Klaipongpan *et al.* (1991) and Hetrakul *et al.* (1991) studied the seismicity of the Khao Lam Dam, Karnchanaburi, western Thailand. It is agreed that the 1983 earthquake at the dam was caused by the impoundment of water in the reservoir and that the release of stress is expressed as the movement along pre-existing planes of faults. However, with the awareness of the relationship between the earthquake activity and the tectonic regime in the other region of the country, the collaboration between Department of Mineral Resources and the EGAT embarked a study program on earthquake in the Nam Yuam River Basin, Mae Sariang, Mae Hong Son (see Hinthong *et al.*, 1992).

In 1992, with the assistance of the USGS, the TMD installed the computer linked seismograph of the IRIS II (Incorporated Research Institute for Seismology) station at the bottom of the borehole to a depth of approximately 100 m in Chiangmai with the high performance, continuous broadband digital seismic system. In this circumstance, seismic data can be retrieved from any IRIS station world wide by dialing up two station code numbers. To extend the ability of seismic network for monitoring earthquakes in northeastern and southern parts of the country, two other stations were installed in

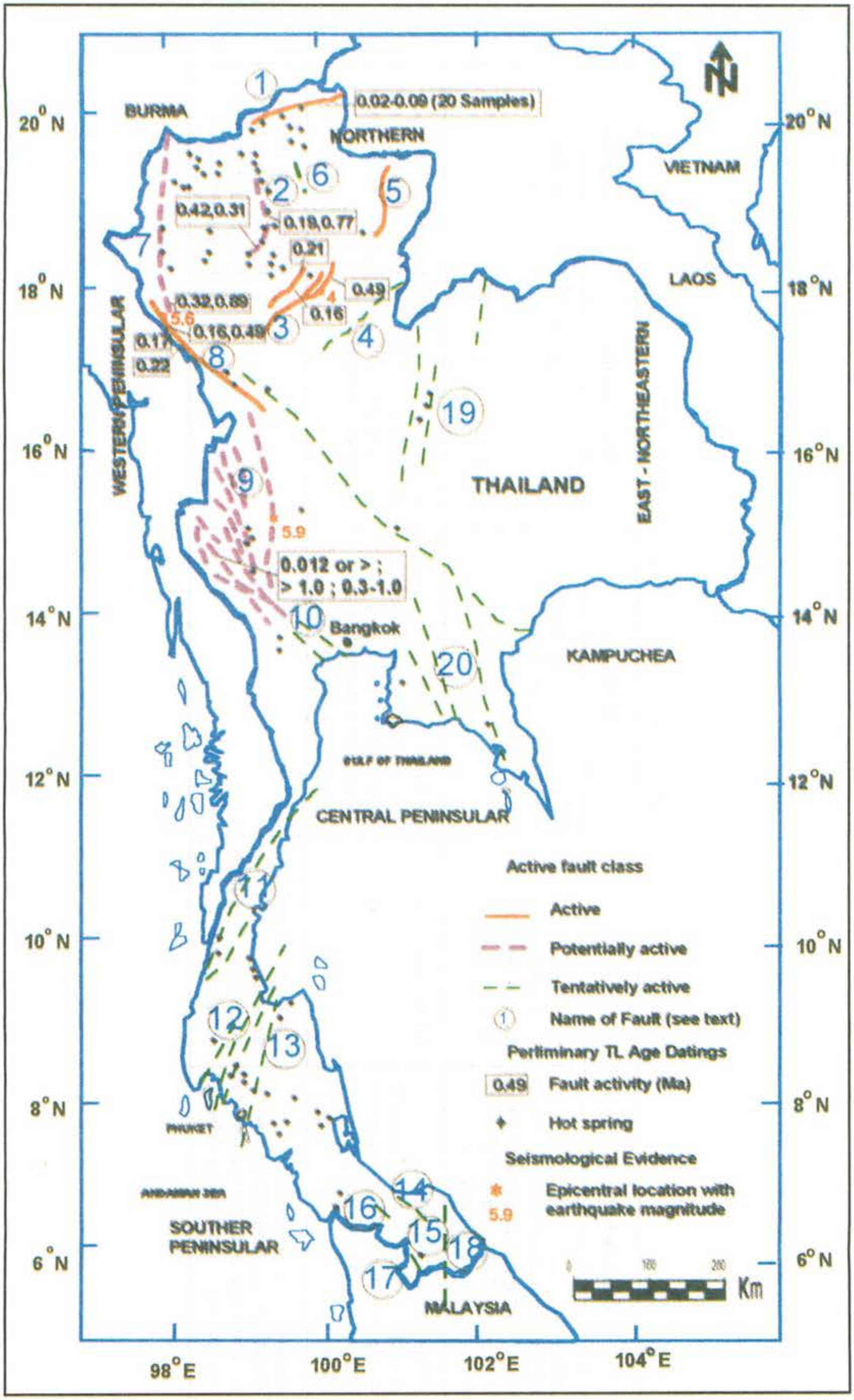

Figure 1. Active fault map of Thailand showing major fault zones, their orientations, magnitudes of past movement, TL-dating data, and associated hot springs. Numbers in circle indicate individual faults mentioned in text.

Table 1. Active fault classification, criteria and examples in Thailand.

Class/Definition	Historic	Geologic	Seismologic	Examples
Active (AF): tectonic fault which has a history of strong earthquake or surface faulting in the past 35,000 years or a series of quakes during 500,000 years.	Surface faulting and associated strong quakes, geodetic evidence.	Young Quaternary deposits cut by fault. Distinct youthful geomorphic features.	Epicenters along that fault.	Mae Chan, Phrae, Thoen, Pua
Potentially Active (PAF): A tectonic fault without historic surface offset, but with a recurrence interval sufficient to the particular project.	No reliable report.	Subdued and eroded geomorphic features, faults not known to cut young alluviums, but offset older Quaternary deposits.	Alignment of epicenters but with low confidence of assigned locations.	Mae Tha, Mae Hong Son, Srisawat, Three-Pagoda, Klong Marui
Tentatively Active (TAF): A fault with insufficient data to define past activity and its recurrence interval is very long or poorly defined.	Data indicate fault evidences, but evidences may not be not definitive.			Payao, Nam Pat, Ranong, Klong Marui, Klong Thom Southern Peninsular

Ubonratchathani and Phuket, respectively. At present, there are 12 seismic network stations authorised by TMD (see Table 1) and about a dozen of strong motion accelerographs (SMA) at the major dam sites and more than 40 portable SMA all over the country. Recently, Warnitchai and Lisantono (1996) presented the seismic risk map for Thailand using probabilistic acceleration analysis.

It seems likely that Thailand had managed herself to the point for performing more detailed research works on seismicity. However, it was not until 1994 when DMR received more tectonic data to unravel that most of the earthquakes in Thailand and nearby are caused by the reactivation of the active faults (see Hinthong, 1995). As a result the project on study of active fault in Thailand was initiated and substantially evolved from the attempt to appoint the sub-committee on Work Plan no. 6 in the National Earthquake Committee. In 1995, the Kaeng Sua Ten earthquake project in northern Thailand was granted to Woodward Clyde company. The result indicated that the faults within the area proposed for dam site construction are not considered active (see Fenton *et al.*, 1997; Bott *et al.*, 1977). Very recently, DMR conducted two projects regarding the determination and delineation of active faults by detailed survey and trenching method in areas of Mae Hong Son and Chiang Rai provinces.

TECTONIC SETTING AND CLASSIFICATION OF ACTIVE FAULTS

The tectonic framework of Thailand and adjoining regions is designated by the amalgamation of diversified tectonostratigraphic terranes, namely Shan-Thai, Lampang-Chiang Rai, Nakhon Thai, and Indochina (Charusiri *et al.*, 1997). The terranes evolved from pre-Mesozoic blocks with various Meso-Cenozoic reactivated structures. Neotectonic features are characterized by the strike slip movements with several degrees of intensities. The collision of India with Asia during mid-Tertiary and the subsequent extrusion tectonics may have caused the strike-slip motion of Indochina terrane with respective to the Cathasian block. This gave rise to the development of extension tectonics, and resulted in the opening of Gulf of Thailand (Bunopas, 1992), South China Sea (Hutchison, 1989), Andaman Sea (Polachan, 1988), East Vietnam Sea (Le Van De, 1997). This perhaps account for the earthquakes, active faulting, volcanism, and geothermal activities.

It has generally been accepted in Thailand that there are several sets of faults which have contrasting ages (Charusiri, 1989) and directions (Chuaviroj, 1995). At present we all agree in principle that the faults can be classified into 2 categories, based upon their activities (Cluff and Bolt, 1969; Slemmon, 1982), i.e., active (or alive) and inactive (or dead) faults. However, we do not know much whether the faults in Thailand are categorised as active or not. Further more, there is no definite consensus regarding the ages of the faults that indicate the active or inactive phenomenon. Common criteria used for the term active fault as stated by Slemmon and Depolo (1988) include the features that the fault is always associated with earthquakes, exhibit physiographic evidences of recent activity, shows its offset during the present seismotectonic regime, and have the potential for future recurrence of offset. Several geoscientists defined active faults in many ways, Slemmon (1982) listed over 30 definitions made before 1950, the other nine definitions were made as quoted by Shrestha (1987). In Japan as quoted by Masuda and Kinugasa (1991) the active fault is the one which displays evidence of repeated movement in recent geologic time. On the other hand, Wesson *et al.* (1975) considered that the fault has been active over a considerable length of time (millions of years) and has been historically active or show evidence of movement in recent time and is likely to sustain its movement in the future. Hinthong (1995) shows that there are three different basic concepts regarding the definition of the active fault, i.e., common definition, engineering definition and regulatory definition. In the engineering sense (see Wang and Li, 1988; Ziony *et al.*, 1973), the fault is inferred to be active if the age of its activity is between 40,000 and 11,000 years, or the fault along with the earthquakes ($1 \leq M \leq 3$) frequently in a line or appeared on the surface, or the fault along with the earthquakes ($M \geq 5$) occurred may display its activity during the operation of the project. Active faults can also be defined under some special purposes. In the United States, Hart (1972) emphasized that the fault which is defined as active must have its surface displacement within Holocene time and if considered to be potentially active it must show evidence of surface displacement within the Quaternary time (see also Table 1). Ziony and Yerkes (1985) mentioned that for the location of large dams, a fault is regarded active if it has experienced slip during the past 100,000 years, and for nuclear power sites the fault which slipped several times during the last 500,000 years is considered as active. Costa and Baker (1981) and Shrestha (1987) categorized the fault as active if one movement took place during 35,000 years or more than one movement in 500,000 years.

It seems likely that the age of the last fault movement becomes essential in identifying whether or not the fault maintains its activity.

Table 2. Activity of faults in Thailand based on ages.

Era	Period	Epoch	Yrs. before	Fault activity
CENOZOIC	Quaternary	Holocene		
			11,000	*Fault Active during this range*
			→	35,000 yrs for nuclear site
			→	one quake with in 100,000 yrs for large dams
			→	500,000 yrs for nuclear sites (many quakes)
		Pleistocene	1,600,000	
	Tertiary	Pliocene	5,300,000	
		Pre-Pliocene	→	Neotectonics commenced
Pre - Cenozoic				

For Thailand, we herein classify the faults, based upon their activities first proposed by Cluff *et al.* (1969), as active (AF), potentially active (PAF), and tentatively active (TAF or activity uncertain) (see also Table 2). Since Thailand is not the principle site for earthquake foci, so the best definition used herein is from the combination of those above mentioned. Since the age of the active fault is also essential in our justification, we, therefore, propose that the fault which shows a slip movement in the ground at least once in the past 35,000 years, or more than once in the past 500,000 years is defined as an active fault (AF).

DATINGS OF ACTIVE FAULTS

Generally the recognition of active faults in Thailand adopted herein requires geologic, historic and seismologic criteria which are almost similar to those of Slemmon (1982). The practical, commonly and widely used methods for identifying the active faults as quoted by Slemmons and Depolo (1988) include geologic, remote-sensing, geophysical, and exploratory methods. Age dating method appears to be quite practical at present in accessing and recording the past movement activity (see McCalpin, 1995, 1996). Only the TL-dating method was applied for measuring the past activity of faults in Thailand. All the dates were analyzed at the TL-dating Laboratory Center at the Akita University (Hinthong, 1995). The first unpublished TL-dates were reported by Maneenai and Takashima (1994) from fault samples from northern and western Thailand. The subsequent result was recorded by Takashima and Maneenai (1995) for fault samples collected from the fault from the south. However, one dating information on Mae Chan fault, northernmost Thailand, was done by C-14 method (Kosuwan *et al.*, 1998). With such TL geochronological data along with the geomorphological and seismological evidences earlier mentioned, active fault classification can be categorized. Figure 1 displays location and orientation of the active faults and their TL-dates.

ACTIVE FAULT ZONES AND THEIR ACTIVITY CLASSIFICATION

The active fault zones in Thailand was first introduced as seismic source zones or seimotectonic source zones by Nutalaya *et al.* (1985) based upon both seismological and geological evidences. Subsequently, Shrestha (1987) identified 9 active faults of the country on the basis of only seismological data analysis. Based upon all the relevant geological, geotectonic, historical, and seismological data along with the earlier published works (e.g., Hinthong, 1995; Nutalaya *et al.*, 1985), and unpublished age data (e.g., Maneenai and Takashima, 1994; Takashima and Maneenai, 1995), we can delineate 5 major active fault zones (AFZ) in Thailand, including northern, western-northwestern, central peninsular, southern peninsular, and eastern-northeastern AFZ. Detailed description is shown below, and the locations and orientations of the faults with their TL-dating data and major past activities are illustrated in Figure 1.

The *Northern AFZ* includes 6 main fault zones (FZ)

The 185 km-long, E-trending *Mae Chan* FZ (1) indicates the latest movement of ca. 0.019 Ma (Kosuwan *et al.*, 1998). Recent activity is also marked by the presence of hot springs mostly located at the southern lineament of the fault. The largest recorded tremor of magnitude 4.0 Mb took place on 1 September, 1978, and the maximum focal depth is ca. 10 km. Hinthong (1995) categorized this fault as PAF whereas Shrestha (1987) and this paper identify it as AF.

The 110 km-long, roughly N-trending, S-shaped *Mae Tha* FZ (2) is signified by the movement ages of ca. 0.19 and 0.77 Ma. The fault plane has a moderate dipping angle to northwest. Small earthquakes with mostly less than 3 Mb and shallow depth occurred in the northwestern part of the fault. However, our geomorphological investigations show no fault activity during Quaternary. Hot spring locations are mainly in the southern part of the fault. The fault is regarded herein as the TAF due to its subdued and eroded features.

The approximately 120 km-long, arcuate, NE-trending *Thoen-Long-Phrae* FZ (3) recorded the movement ages of ca. 0.16, 0.21 and 0.49 Ma. During the past two decades, more than two dozen of earthquakes with the magnitudes of 3 to 4 Mb were detected along this fault. The latest maximum tremor was recorded on 23 December 1980 with the magnitude of 3.7 Mb. Most hot springs are discovered in the southern part of the Thoen Fault. Geomorphological evidence advocates the left lateral movement. The Thoen-Long-Phrae FZ is assigned by Hintong (1995) as the PAF, but we infer it as the AF.

The 60 km-long, NE-trending *Nam Pat* FZ (4) shows distinct and straight scarps along the Nam Nan River near Nam Pat District, however mostly the geomorphology indicates the pre-Quaternary feature. No major present-day earth quakes are seismologically detected. We consider this fault as the TAF.

The 68 km-long, N-trending *Pua* FZ (5) indicates west dipping and normal fault movement characteristics. The northern segment of the fault is marked by a linear escarpment. The middle part of the fault is characterized by the best developed wine glass canyon in northern Thailand (Fenton *et al.*, 1997). No TL-dating data have ever done yet. The earthquakes with the magnitude of 7 Mb occurred very close to the fault during 1934 and 1935 in Laos and Thailand, respectively (Bott *et al.*, 1997). We therefore regard this fault as the AF.

The 35 km-long, NW-trending *Phayao* FZ (6) exhibits a sharp scarp and late Quaternary movement with eastward downthrown side. The 1994 earthquake with the magnitude about 6 Mb at the northern extension of the fault may be very dominant. No age data have been done so far for its past activity. The Phayao FZ is inferred to be the TAF.

The TL-dating data indicates that the Thoen-Long-Phrae FZ yields the latest seismic movement in this zone at about 0.16 Ma (Maneenai and Takashima, 1994). Anyhow, it is quite interesting to note that all the TL-dating data do not show significantly different numbers among each other (see Fig. 1).

The *Western-Northwest AFZ* consists of 4 main FZs

The almost 200 km-long, straight and N-trending Mae Hong Son FZ (7) gave the TL ages of fault movements ca. 0.32 and 0.89 Ma. Our geological and Landsat image investigations clearly indicate that the fault is a sharp lineament with both thrusting and normal movements. Although no large earthquakes are recorded in Thailand, further to the north in Myanmar, an earth tremor with a magnitude of 5.1 Mb occurred on 1 March 1989. With these available information, we interpret the Mae Hong Son FZ as PAF.

The 450 km-long, NW-trending *Mae Ping* (or the Moei-Uthai Thani, Shrestha, 1987) FZ (8) has its several spray faults, passing upper Chao Phraya basin. The major, W-WNW branch is observed cross-cutting Holocene sediments in Tak. TL dates indicate several fault movements ca. 0.16, 0.17, 0.22, and 0.49 Ma. An earthquake of magnitude 5.6 Mb happened on 17 February 1975. A fault plane solution indicates a principal component of dextral movement (Shrestha, 1987). The Mae Ping FZ can be reliably assigned as the AF.

The 200 km-long, arcuate N-NNW–trending *Sri Sawat* FZ (9) hosts several spray faults. Though several hundred shallow-depth quakes were reported along these faults, they are regarded as the reservoir-induced earthquake (RIS) by Klaipongpan *et al.* (1991) and Chang and Chen (1992). The largest tremor took place on 22 April 1983, with the magnitude of 5.9 Mb and exhibited dextral movement along the Srisawat fault

(Shrestha, 1987), but Klaipongpan *et al.* (1991) emphasized, based on the seismicity, that the east-trending reverse fault at the southern end of the fault is considered to account for the surface rupture. Base upon these data we infer the Sri Sawat FZ as the PAF.

The 280 km-long, NW-trending *Three Pagoda* FZ (10) has its southeastward extension passing very close Bangkok (Tulyatid, 1997). Two large earthquakes of magnitude 7.6 and 5.8 Mb were reported along this FZ during 7 January 1937 and 11 January 1960, respectively. The other two tremors occurred on 22 January and 11 July 1985 with magnitudes of 4.5 and 3.9, respectively. However, these quakes are regarded to have occurred as a result of RIS. Later minor quakes, as evidenced by the swamp-type epicentral and hypocentral distribution, show mostly the sinistral motion along the NE-trending conjugate fault (Klaipongpan *et al.*, 1991). TL-dating data yield the movement ages of 0.012, 0.3, and 1.0 Ma along this FZ. However, at present we consider the Three-Pagoda FZ as the PAF, whereas its conjugate set and its associated branch may represent the AF *"sensu stricto"*.

Further to the south, the *Central Peninsular AFZ* includes three major NE-trending Ranong, Klong Marui and Klong Thom FZs.

The 290 km-long *Ranong* FZ (11) which lies following the channel of Kraburi River, has its subsidiary faults cutting granites and Cenozoic sediments. No dating data are available for its past activity. However, a few hot springs are located along the southern end of the fault. Even though, Shrestha (1987) noted that an earthquake with the magnitude of 5.6 happened along this fault during 30 September 1978, we regard it as the TAF.

The 150 km-long, *Klong Marui* FZ (12) which cuts across the Phang Nga Bay and Ban Don Bay, follows the Klong Marui channel and mainly pass granites and Cenozoic sediments. Although no recent earthquakes were recorded, the TL geochronological data indicate that the fault had a long and complex historical movements during 0.18, 0.29, 0.40, 0.44, 0.70, 0.85, >1.01, 6.9 and 8.29 Ma. Hot springs are mostly concentrated at the southern portion of the fault. At present the fault is inferred as the PAF, Shrestha (1987), however, advocated it as the AF.

The 150 km-long *Klong Thom* FZ (13) has a few hot springs situated at the southern end. TL-dating data from its western branch indicate that the FZ may have its past activities during 0.76, >0.86, and 1.24 Ma. We herein regard this fault as the TAF.

The *Southern Peninsular FZ* consists of several sets of relatively short (10–30 km-long) faults with sparsely distributed hot springs. Hinthong (1995) named them as Khok Po (14), Saba Yoi (15), Yala (16) and Betong (17) faults, of which their trends are mostly in the northwest direction. We redefine these faults and group them as parts of the N to NNE-trending Pattani FZ (18), as previously proposed by Chuaviroj (1995). The FZ also extends southwards to northern Malaysia. Since no dating data have been performed yet, and no large tremors have ever occurred in this region, the Pattani FZ is, therefore, assigned as the TAF.

The *Eastern-Northeastern AFZ* comprises two major faults, i.e., Loei-Petchabun and Rayong-Klang faults.

The almost 300 km-long, N-trending *Loei-Petchabun* FZ is characterized by a long basin-bounding fault in Phetchabun area. A few of small to intermediate earthquakes (≥ 4 Ml) were detected along the FZ. Hot springs are mostly located at the northern end of the FZ. Although Hinthong (1995) and Shrestha (1987) did not recognized this FZ, we categorize it as the TAF.

The 100 km-long, NW-trending *Rayong-Klaeng* FZ (20) is considered as the major spray of the Mae Ping FZ. Many of the fault traces are more developed in pre-Cenozoic sediments/rocks. Few hot springs are found scattering nearby the fault zone. No earthquake epicenters with magnitude over 3 Mb have been ever recorded. We therefore assign this FZ as TAF.

SEISMIC ZONING AND RISK MAPS

The seismic zoning map (Fig. 2) was first introduced by Chandragsu (1986) for applying in connection with the first seismic code of Thailand and is different from the intensity map proposed by Nutalaya *et al.* (1985). The seismic zoning map which was subsequently modified by Prachaub (1990), consists of three major seismic zones, namely zone 0 which corresponds to no seismicity, and zones 1 to 3 corresponding to mild, intermediate and strong quake intensities, respectively. Lukkunaprasit and Kuhatasadeekul (1993) proposed the other seismic zoning map based upon seismic coefficient, and Warnitchai and Lisantono (1996) made a new map using probabilistic analysis of epicenter distributions and peak ground acceleration. We found that the distributions and alignments of the major FZs in Thailand, epicentral distribution, hot spring locations, locations of large earthquakes, TL geochronological results, historical records, seismicity data and geotectonic context can lead us to propose the seismic risk map of the country. The map proposed is rather similar to that proposed earlier on the basis of probabilistic analysis of seismic hazard by Warnitchai and

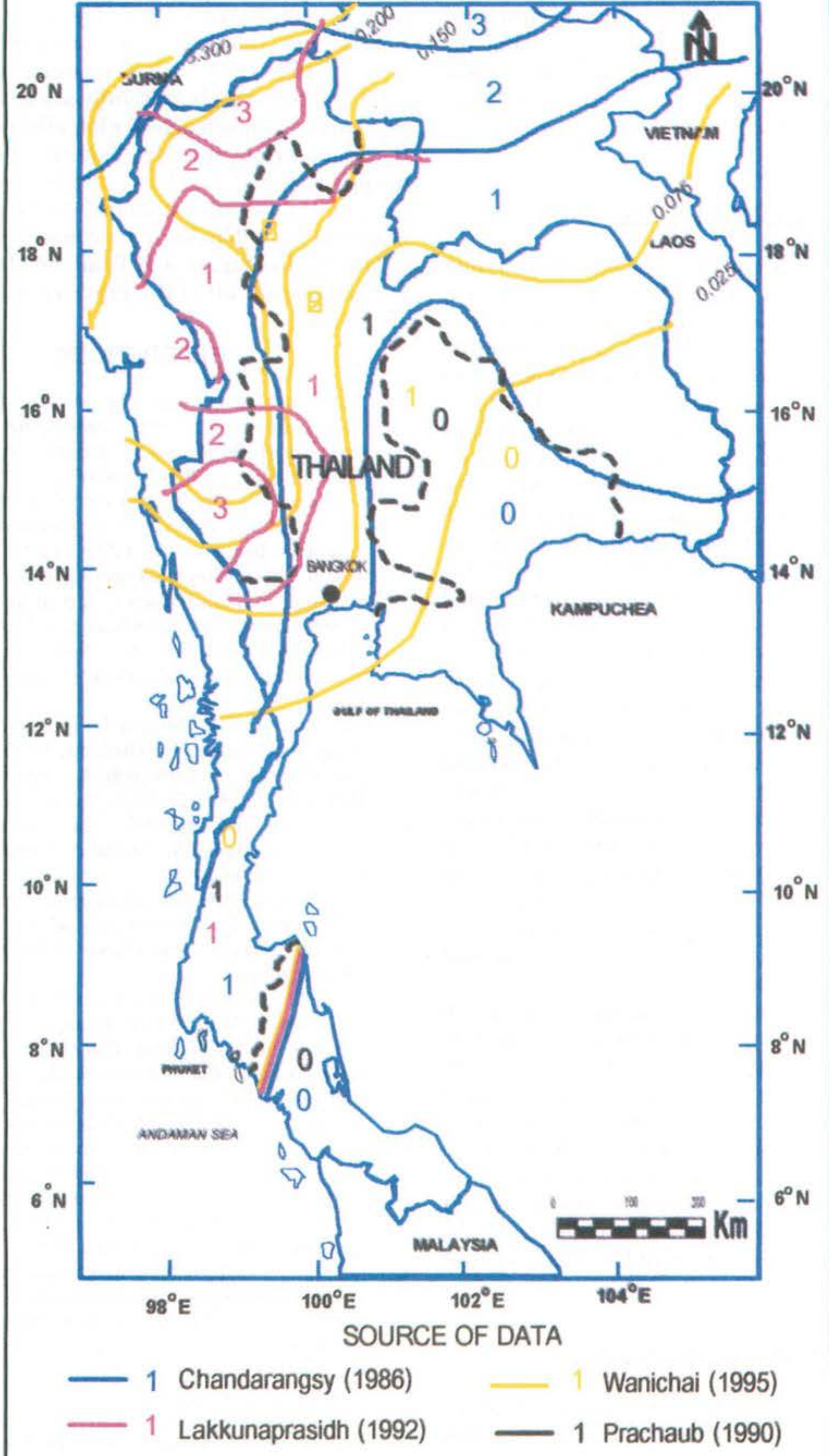

Figure 2. Seismic zoning map of Thailand showing zone boundaries of previous works and this work.

Lisantono (1996) (Fig. 2).

With the results obtained from the proposed seismic zoning maps together with the earthquake intensities, the seismic risk map of Thailand was herein proposed. The risk zone boundaries are delineated to fit fairly well with the provincial boundaries (Fig. 3).

CONCLUSION

The largest instrumentally recorded tremor with the magnitude of >7 Mb never occurred in Thailand, and the maximum one ever recorded took place in Andaman sea during 1941 with the magnitude of 8.4 Mb. Thailand have experienced several small to intermediate earthquakes for a long period of time dating back to 624 B.C. (Nutalaya *et al.*, 1985). Most of the quakes in Thailand are inferred to have been associated with active faults. However, attention of the detailed study on such faults has been considered after the establishment of the National Earthquake Committee in 1984.

Based on available geological, historical and seismological data, we subdivide major faults in Thailand into 6 zones (FZ), namely the northern, western-northwestern, central peninsular, southern peninsular, and eastern-northeastern FZ. Not all FZ are considered to be active, especially those associated with extrusion tectonics and generated as a result of the India-Asia continental collision during middle Tertiary. Generally, the faults belonging to the southern and central peninsular FZs as well as those of the eastern-northeastern FZs are inferred to be potentially to tentatively active (PAF to TAF). Those faults of the northern and western-northwestern FZs are mostly regarded as active faults (AF).

Since Thailand has just gained her research ability on defining the active faults in order to unravel their present and historical activities, more detailed studies are required, particularly those relevant to systematic planning on sampling patterns and dating methods applied. Our proposed seismic risk map, which is based upon new geotectonic and geochronological information, is rather preliminary and needs to be redefined in the very near future when more reliable data are better analysed.

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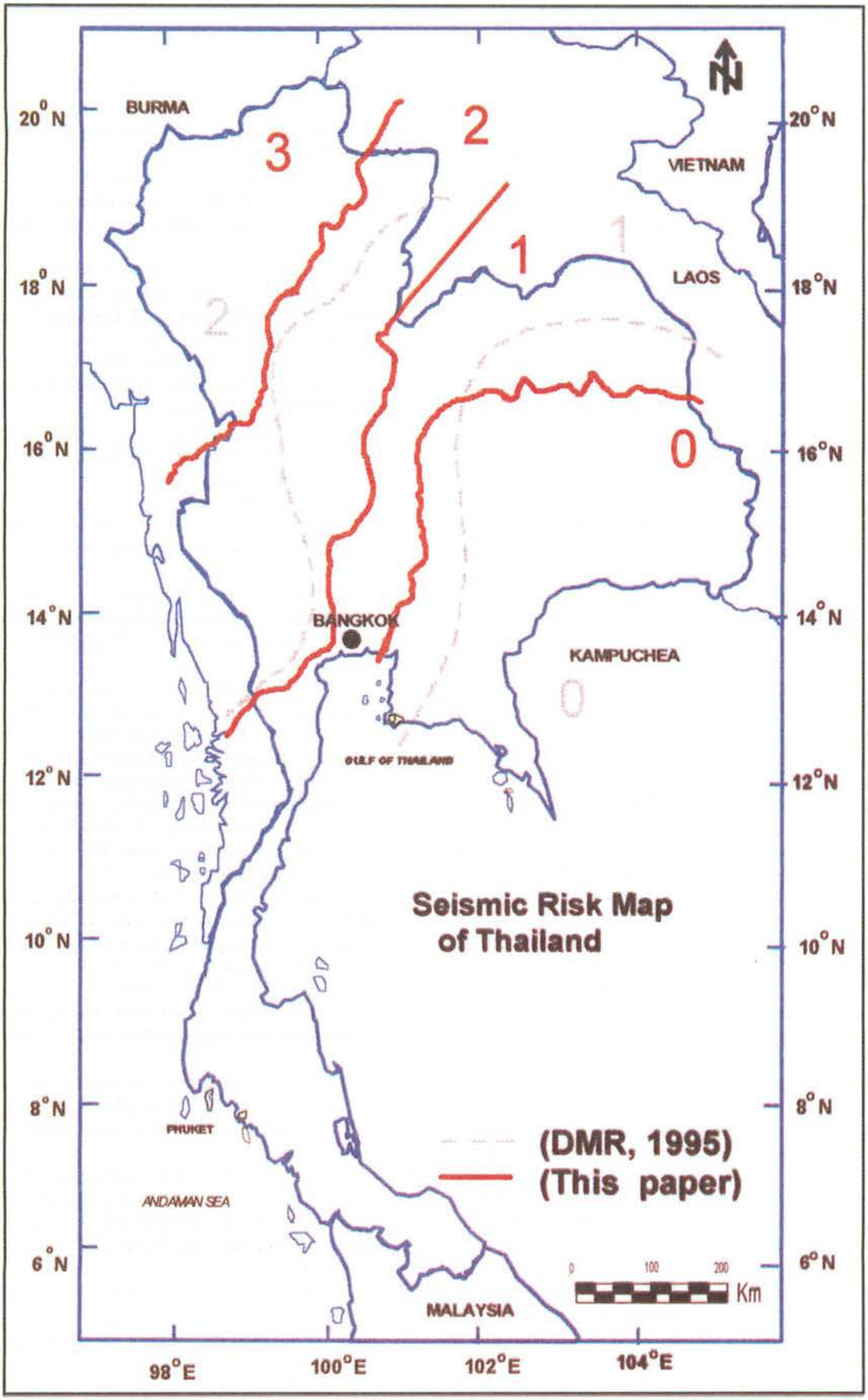

Figure 3. Seismic risk map of Thailand showing zone boundaries defined by DMR (1995) and this paper.

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