Seismic Events Detected with Department of Mineral Resources Observations at Major Fault Zones in Thailand

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ABSTRACT

Seismological observation networks were established at five major fault zones in Thailand to detect and to elucidate seismic activities associated with active fault systems. Each network has three seismological observation points equipped with short period seismometers. Observational results are recorded with data-loggers and are periodically collected at three networks, while wave data from two networks are continuously transmitted electronically to the Department of Mineral Resources. Wave data analyses show that no high level local seismicity has occurred at related fault zones. Only minor earthquakes have occurred and these are estimated to be within 40 kilometers of known fault zones.

KEYWORDS: earthquake, seismic activity, active fault, seismometer, observation network, epicenter.

INTRODUCTION

Thirteen major fault zones are present in Thailand, mainly in the north, west, and south of the country. Some of these are active faults that are the potential source of future large earthquakes of magnitude 6 to 7.5. Recurrence time of such earthquakes is intervals of 2,000 to 15,000 years (Fenton and others, 2003). Several of these fault zones are within 150 to 200 kilometers of densely populated areas, including Bangkok, Chiang Mai, and Phuket. Seismic activities larger than magnitude 4 to 4.5 in and around Thailand have been monitored by global seismological observation networks. Seismic events, both large and even smaller than magnitude 3, have been monitored by the Thai Meteorological Department and other organizations (Duerrast and others, 2007). However, precise seismic activities at those fault zones have not been adequately analyzed. Near the end of 2006, the Department of Mineral Resources began conducting investigations of seismic activities at major fault zones. This is being done at 15 seismological observation points in five networks at fault zones in the north, northwest, west, southwest, and south regions of Thailand. This has resulted in detecting infrequent occurrences of small and local seismic events, some being smaller than magnitude 3.

SEISMOLOGICAL OBSERVATIONS OF THE DEPARTMENT OF MINERAL RESOURCES

The Department of Mineral Resources' five networks are monitoring seismic activities in five fault zones. These fault zones are Thoen, Moei, Three Pagoda, Ranong, and Khlong Marui, from north to south. Each network, except the south network, is equipped with short-period type seismometers. The south network has broad band seismometers, though the frequency of these is adjusted to a short frequency range of 1 to 15 hertz. Each seismological observation point has a transducer, data-logger, battery, and geographic positioning system clock system. The electrical power for instruments is either a direct current solar cell system and/or an alternating current, depending on individual site conditions. Wave data are registered with data-loggers at all points and are periodically collected at the northwest, west, and southwest networks. These same data are continuously transmitted to the Department of Mineral Resources at the north and south networks. Readings of wave data, such as arrival times of phases for locations, are manually conducted. Major characteristics of seismometers are shown in Table 1. The distributions of the five observation networks, along with locations of three observation points, are shown in Figure 1.

Table 1. Summary of seismometer characteristics.

Transducer (Proper Frequency)	**CMG-6T-1 Short-period (1 Hz)**	**Trillium 40 Broad-band (0.025 - 40 Hz)**	**LE-3 Dlite MkII Short-period (1 Hz)**
Velocity Responsibility	2000 V/m/sec	1500 V/m/sec	400 V/m/sec
Component	3 (2H, 1V)	3 (2H, 1V)	3 (2H, 1V)
Frequency Responsibility	1 – 40 Hz	1 – 15 Hz (band pass filter)	1 – 40 Hz
Data Logger (Company)	Echo Seismic Recorder (Kelunji)	Taurus Portable Seismograph (Nanometrics)	Taurus Portable Seismograph (Nanometrics)
Power	DC 12 V	DC 15 V	DC 15 V
Data Format	SEED	SEED	SEED
Data Acquisition	Periodically collected	Real-time with IPstar	Real-time with ADSL
Observation Network	Northwest, West and Southwest	South	North

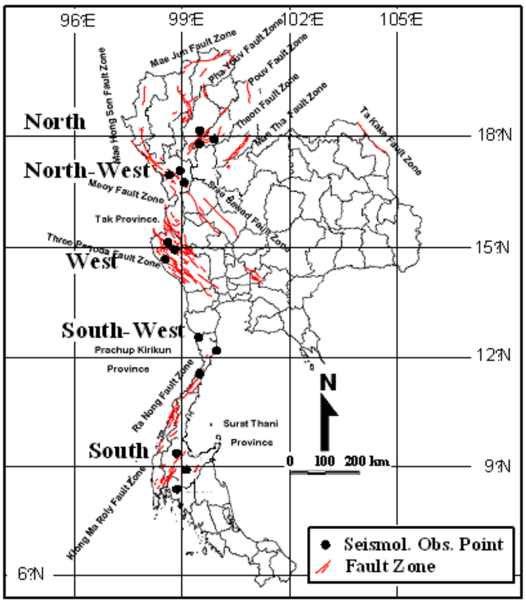

Figure 1. Five seismological observation networks at major fault zones in Thailand. Triangle-shaped networks are indicated with network names north, northwest, west, southwest, and south.

The networks are triangular-shaped, with sides ranging from 21 to 97 kilometers. They are expected to detect and locate small and local earthquakes that occur at, and near, fault zones. Within these networks, shallow events as small as magnitude 0.5 should be detectable. However, the smallest shallow events for which locations can be determined are magnitude 1.5 to 2.1 events, these depending on the narrowness of the triangular network shape. The narrower the shape is, the smaller the detected magnitude. Magnitudes are tentatively estimated with the formula proposed by Watanabe (1971) for wave data of velocity amplitudes of micro-earthquakes obtained with short-period type seismometers.

DETECTION OF LOCAL EARTHQUAKES NEAR FAULT ZONES

Seismic waves of earthquakes that occur at sites far from observation networks are readily detected by seismometers, even though their wave forms include long period components. These distant waves have shear wave, S, minus compressional wave, P, times of 30 to 50 seconds, or more, and indicate earthquake occurrences at sites 250 to 400 kilometers, or more, from the networks when Omori's coefficient is assumed to be 8 kilometers per second. Frequency of recordings of those earthquakes is greater at the north, northwest, and west networks than at the southwest and south networks. Most of these recordings are likely due to seismic activities within Myanmar, Laos, the Andaman Sea, Sumatra, and the southwest Pacific Ocean, according to hypocenter data determined by the Thai Meteorological Department and global hypocenter data determined by the U.S. Geological Survey.

Earthquakes having S wave minus P wave times shorter than 15 to 20 seconds are also recorded, the number of these recordings being 10 to 20 percent of the total events detected. All networks observe these events at different recording rates. These S wave minus P wave times indicate that the epicenters are within 100 to 150 kilometers of the observation points.

Very few earthquakes with S wave minus P wave times shorter than 10 seconds have been recorded. The epicenters of these earthquakes are just several tens of kilometers from the observation points. Even S wave minus P wave times of around 5 seconds have been recorded. Examples of wave forms of these short S wave minus P wave times are shown in Figure 2.

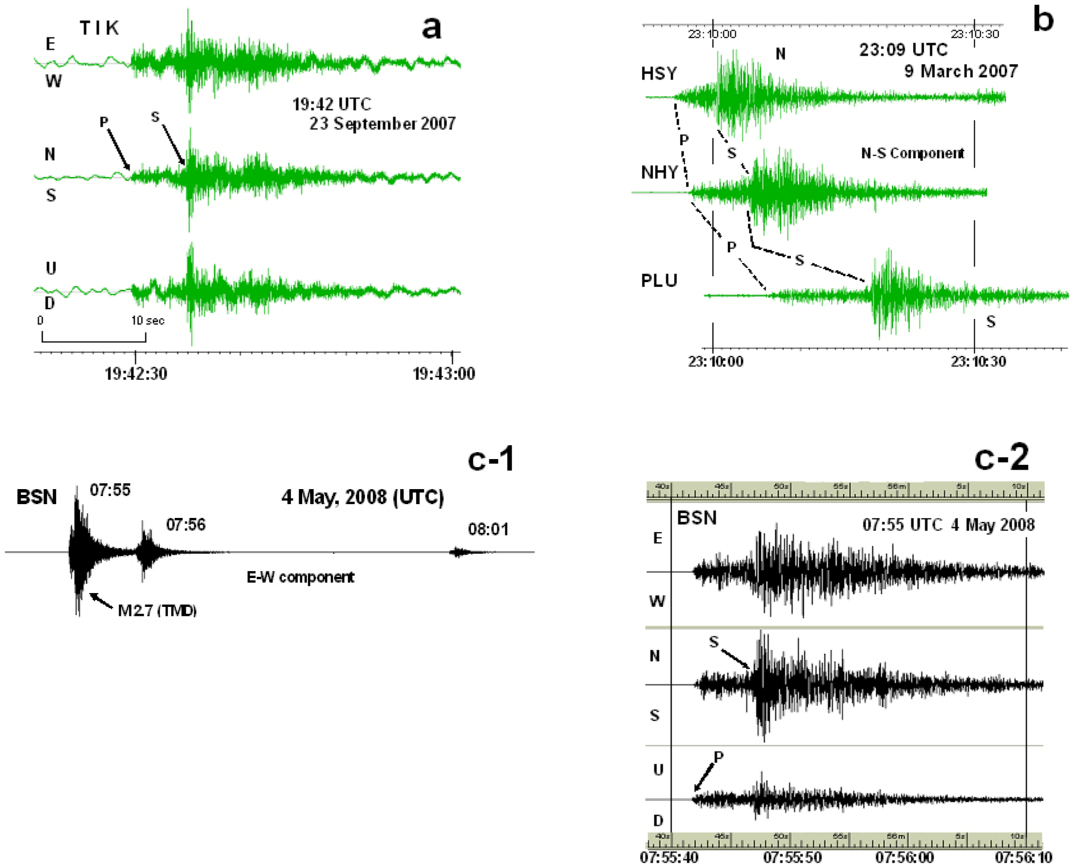

Figure 2. Wave forms of local earthquakes having short S wave minus P wave times of several seconds. In individual figure, point-name, date, component, time scale, and approximate point of arrival time of P and S waves are indicated. Each vertical axis scale for amplitude is fixed but not common among other wave records; a) observed at TIK, the east apex observation point of the west network; b) observed at three observation points of the southwest network. HSY, NHY, and PLU are the east, south, and north apex points of this network, respectively. The estimated location of this event is shown in Figure 3; c-1) Three local earthquakes monitored at the BSN observation point, the south apex point of the south network. The first event of these was located in the southwest region of Surat Thani Province; c-2) Wave forms of magnitude 2.7 event observed at the BSN point.

Figure 2-a shows wave forms obtained at TIK, which is the eastern apex point in the west network. The S wave minus P wave time is 5.1 seconds but the epicenter could not be estimated due to lack of other wave data. Figure 2-b represents the wave forms that were obtained at three observation points, HSY, NHY, and PLU, these being, respectively, the east, south, and north apex points of the southwest network. The S wave minus P wave times are 4.6, 7.1, and 11.9 seconds, respectively, at points HSY, NHY, and PLU. This is one of four events of which epicenters could be graphically estimated Figure 3). Figures 2-c-1 and 2-c-2 show the wave forms of earthquakes that occurred in the southwest region of Surat Thani province. The first event on Figure 2-c-1 had a magnitude of 2.7 and was accompanied by two smaller events. These have similar S wave minus P wave times of 5.2 seconds and are a group of the same seismic activity.

DISCUSSION

Occurrences of earthquakes inside Thailand that can be determined by global seismological observation networks are not at a high level compared to those in the world's plate boundary regions. According to a U.S. Geological Survey seismicity map, there is a steady occurrence of shallow magnitude 4 earthquakes in northern Thailand. These earthquakes are local earthquakes and are concentrated in the west region and in the northwest edge of the Gulf of Thailand (Sawada and others, 2008).

Many seismic events, including small magnitude events located mainly in the north, west, and south regions of Thailand, have been reported by Thai Meteorological Department. Increased occurrences of micro-earthquakes in Thailand's south region after the 26 December 2004 Sumatra-Andaman earthquake were precisely monitored (Duerrast and others, 2007). Concentrated occurrences of local earthquakes in the west region were interpreted as water reservoir-induced earthquakes (Charusiri and others, 2007). Many of these earthquakes are closely distributed in, and near, fault zones and some linear distributions of micro-seismic events are apparent.

Analyses of wave data of local earthquakes with short S wave minus P wave times have included reading wave phase arrival times, estimating hypocenters, and investigating seismicity at fault zones. However, the occurrence frequency is at a low level and the amplitudes are not large enough to be simultaneously detected at three network observation points. Also, there are some instrumental troubles for continuously recording wave data.

Twenty-seven local earthquakes with short S wave minus P wave times were detected in 2007 at the NHY point, the southern apex of the southwest network. Only four of these were simultaneously detected at three observation points and their locations were approximately estimated graphically using S wave minus P wave times and an assumed Omori coefficient (Sawada and others, 2008). These four earthquakes are located near shore in the northwest part of the Gulf of Thailand. Figure 3 shows their locations. Depths of these earthquakes were approximately 20 to 30 kilometers and their velocity amplitude magnitudes (Watanabe, 1971) were 2.2 to 3.9. The star mark in Figure 3 is the location of a magnitude 5.0 event that occurred in October 2006 as determined by the U.S. Geological Survey. The Prachuap Khiri Khan fault in the northern part of the Ranong fault zone is oriented northeast-southwest. If this fault extends offshore, the epicenters of the four March 2007 earthquakes would be near the fault's extension into the Gulf of Thailand (Figure 3). The distance between the location of the magnitude 5 event in 2006 and the small events in March 2007 is about 30 kilometers. However, through possible errors in estimating epicenters, both events may belong to the same group of seismic activity (Sawada and others, 2008). Local and small seismic activities are known to occur in this fault zone.

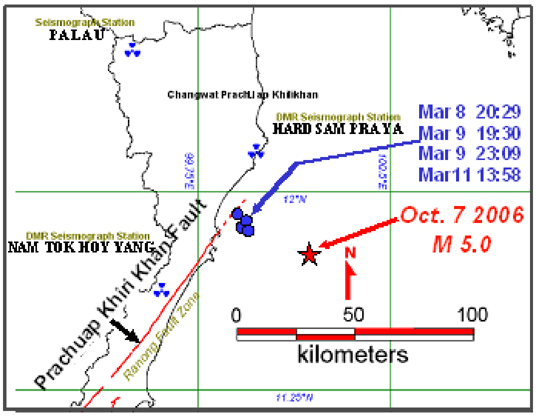

Figure 3. Epicenters of four local earthquakes and of one 2006 magnitude 5.0 event in the northwest edge of the Gulf of Thailand. Broken line in the Gulf of Thailand is a possible extension of a land fault.

The first event detected at the BSN observation point of the south network (Figures 2-c-1 and 2-c-2) was located about 50 kilometers to the northwest, near the border between southeast Surat Thani and northern Krabi Provinces. The magnitude of this event was 2.7. People in the northeast part of Phanom District, Surat Thani Province, reported shaking from the event (personal communication from Mr. S. Kosuwan). This area is about 60 kilometers northwest of the BSN observation point. Both areas are associated with many faults that make up the Khlong Marui fault zone.

Other seismic events with short S wave minus P wave times of several seconds were detected at seismological observation points, but their occurrence rates were infrequent. These earthquakes probably occurred in, or near, the Ranong and Khlong Marui fault zones.

The linear distributions of micro-earthquakes that reflect the distribution of fault lines should be determined. The present seismic activity is not at a high level but careful monitoring should be continued. Also, the efficiency of data processing of seismic waves and the accuracy of analyses of seismic activities should be increased.

CONCLUSIONS

The Department of Mineral Resources established seismological observation networks near the end of 2006 at five major fault zones in Thailand.

Local earthquakes with S wave minus P wave times shorter than 15 to 20 seconds make up 10 to 20 percent of total earthquakes detected at the networks.

Small and local earthquakes with short S wave minus P wave times of several seconds occur, but it is difficult to estimate their hypocenters because amplitudes are not clear enough to be simultaneously registered at network observation points.

Graphically located local earthquakes detected by the southwest network were close to the northern part of the Ranong fault zone. A local event detected at one observation point of the south network was the earthquake that occurred in the major portion of the Khlong Marui fault zone. Small and local seismic events occur infrequently at or near fault zones.

Local seismic activities are not at high level, but their occurrence has to be monitored to determine their relationship to active fault systems.

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