EARTHQUAKE MONITORING IN MALAYSIA

By

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Abstract

West Malaysia is occasionally affected by tremors originating from large earthquakes in the Sumatran plate margin. The maximum observed intensity so far was VI on the Modified Mercalli (MM) scale. East Malaysia has experienced earthquakes of local origin which some of them resulted in some damage on properties and even human injuries. Beside of the local earthquakes, East Malaysia also affected by large earthquakes located over Southern Philippines and in the Straits of Macassar, Sulu Sea and Celebes Sea. The maximum observed intensity so far was VII on MM scale.

The Malaysian Meteorological Service (MMS) is a Government institution, which is responsible for monitoring earthquake activities of the country. To do so, MMS is operating twelve seismic stations, while the MMS Head Quarter in Petaling Jaya, Selangor operates as a national seismic center.

1. Introduction

Malaysia is situated on the southern edge of the Eurasian Plate (Figure 1). It is close to the most two seismically active plate boundaries, the inter-plate boundary between the Indo-Australian and Eurasian Plates on the west and the inter-plate boundary between Eurasian and Philippine Plates on the east. Large earthquakes in and around these boundaries could extend and have extended to Malaysia. East Malaysia, beside of

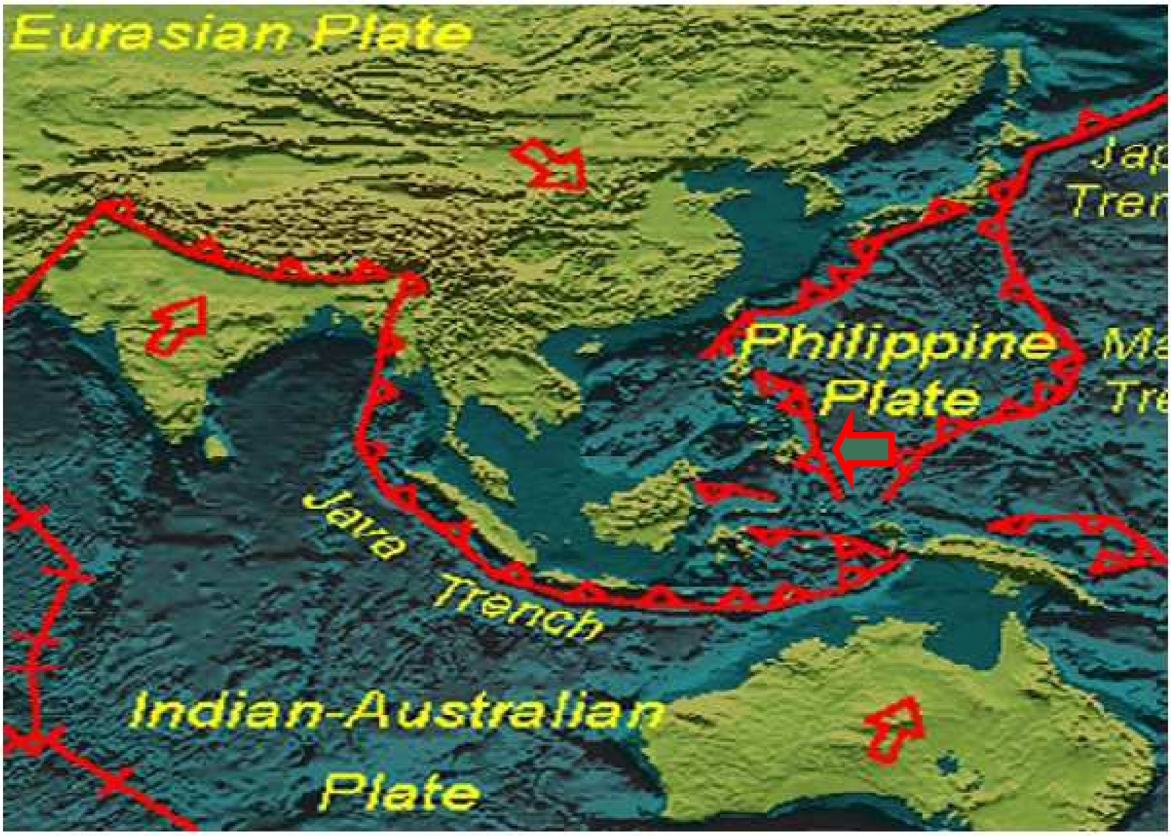


Figure 1. Major tectonic plates around Malaysia

affected by large earthquakes located over Southern Philippines and in the Straits of Macassar, Sulu Sea and Celebes Sea, these two states also have experienced earthquakes of local origin. Several possible active faults have been delineated and local earthquakes in East Malaysia appear to be related to some of them. The maximum intensities observed (MM scale) so far were VI for West Malaysia and VII for East Malaysia.

It is important to be note that earthquakes do not need to be of large magnitude to produce severe damage, because the degree of damage depends not only on the physical size of an earthquake but also on other factors such as where and when an earthquake occurred, the population density in the area concerned and secondary events such as fire.

2. Tectonic Setting Of Malaysia

Malaysia is close to the most two seismically active plate boundaries (Figure 2). In the west, Indian Ocean plate moves northeast ward and subducts under the Sumatra

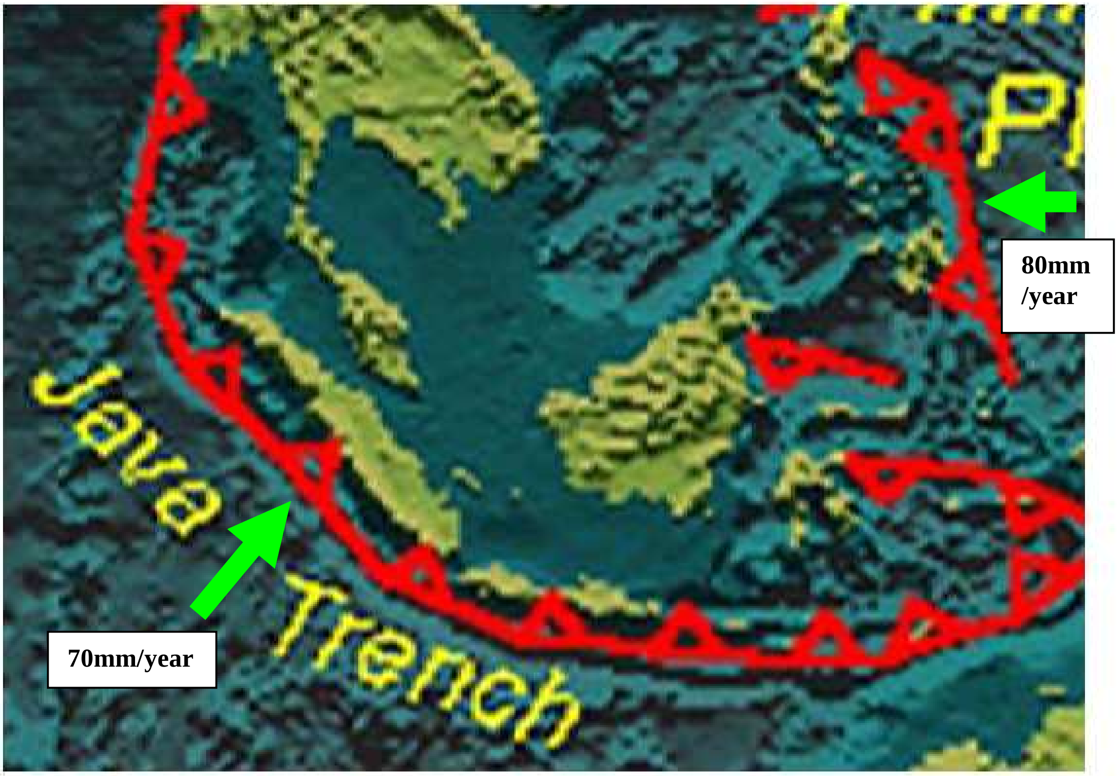


Figure 2. Plate boundaries around Malaysia

with an estimate velocity of the order of 7 cm/year. The direction of the plate movement under Sumatra Island makes the angle of almost right angle. The force generated by the movement of this Indian ocean plate has yielded a great Sumatran fault which divides Sumatra island into two blocks, west block and east block. These two blocks move relatively each other at which the west blocks moves northwest ward while east block move at the opposite direction i.e. Southeast ward. The Sumatran fault is segmented into 19 segments [*Natawidjaja, 2001*] from the most north Sumatra up to Lampung at almost the most south of Sumatra Island. From geodetic measurement it is found that each segment of the fault do not have same relatively velocity. It is observed that the northern segments have velocity higher than of the south. The average velocity of the relative movement of the block at northern side is at the other of 3.7 cm/year while at the southern out is only about 2 cm/year [*MGA, 1999*].

At the east of Malaysia, the Philippine plate moves westward with an estimate velocity of the order of 8 cm/year (Figure 2). Several micro faults in Sabah could be generated by the movement of this plate.

3. Seismic Activity

3.1 West Malaysia

In terms of seismic activity, West Malaysia is classified as a seismically stable area. No earthquake has originated from the area, although the flooding of the Kenyir Dam in Terengganu during 1984 - 1987 did create some seismic activity (maximum magnitude was 4.6 on the Richter scale). Although free from the threat of local earthquakes, West Malaysia is still considered vulnerable because it lies close to Sumatran fault and Sumatran Subduction zone. Large earthquakes that originated from these two active areas did create considerably ground motion over western part of West Malaysia.

Earthquakes from Sumtran Subduction Zone

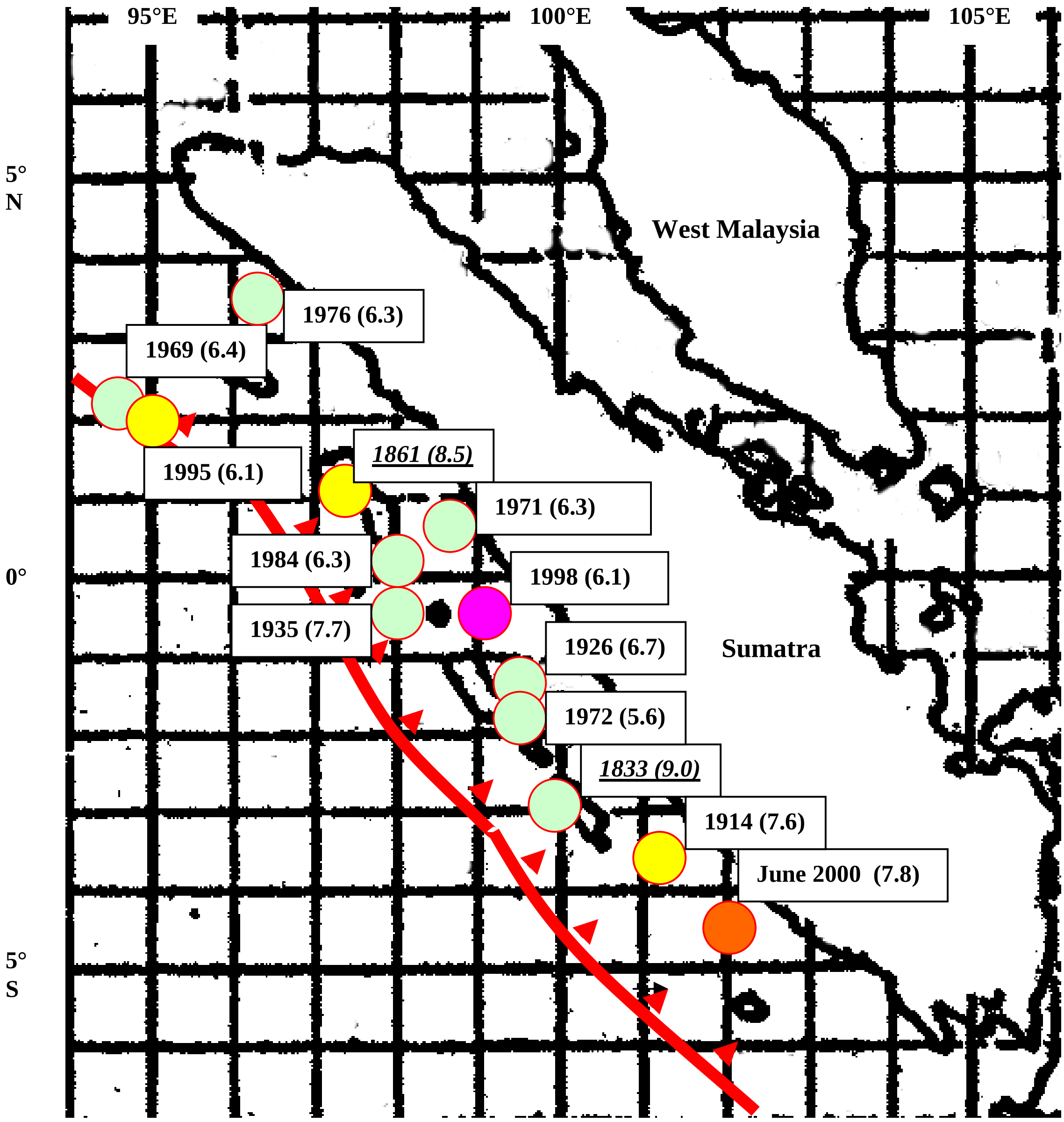
The Sumatran subduction zone accommodating the largest part of the plate convergence has produced two giant historical earthquake: 1833 event (Mw=9) and 1861 event (Mw=8.5). In the last 170 years, a total of 13 events of magnitudes between 5.6 and 9.0 originated from this subduction zone were felt in West Malaysia (Figure 3). The closest distance from earthquake source in this sunduction zone to the coast of West Malaysia is about 400km.

The recent Bengkulu Earthquake occurred in the Sumatran subduction zone on 4 June 2000 (Mw7.8) which epicentre was about 650km from Johore Baharu and about 800km from Kuala Lumpur had shook several buildings in Johore Baharu and Klang Valey. Hundreds people rushed out of their high-rise building down to the ground level. Minor crack in the building wall was reported in Johore Baharu. The maximum observed intensity in Johore Baharu and Kuala Lumpur was estimated of about VI on MM scale.

Earthquakes from Sumatran Fault

The Sumatran active fault consists of 19 geometrically defined segments separated mostly by stepover structures. These fault discontinuities have limited the magnitudes of large historical fault ruptures to between Mw 5.2 and 7.7. The closest distance from earthquake source in this fault to the coast of West Malaysia is about 260km (Figure 4).

The 1995 event with magnitude of about 7.0 on Richter Scale and about 450km from coach of Johore had shook many high-rise buildings in Johore. The maximum observed intensity in Johore Bahru was estimated of about VI on MM scale. The 1996 event with magnitude of about 5.4 on Richter Scale and about 300km from coast of



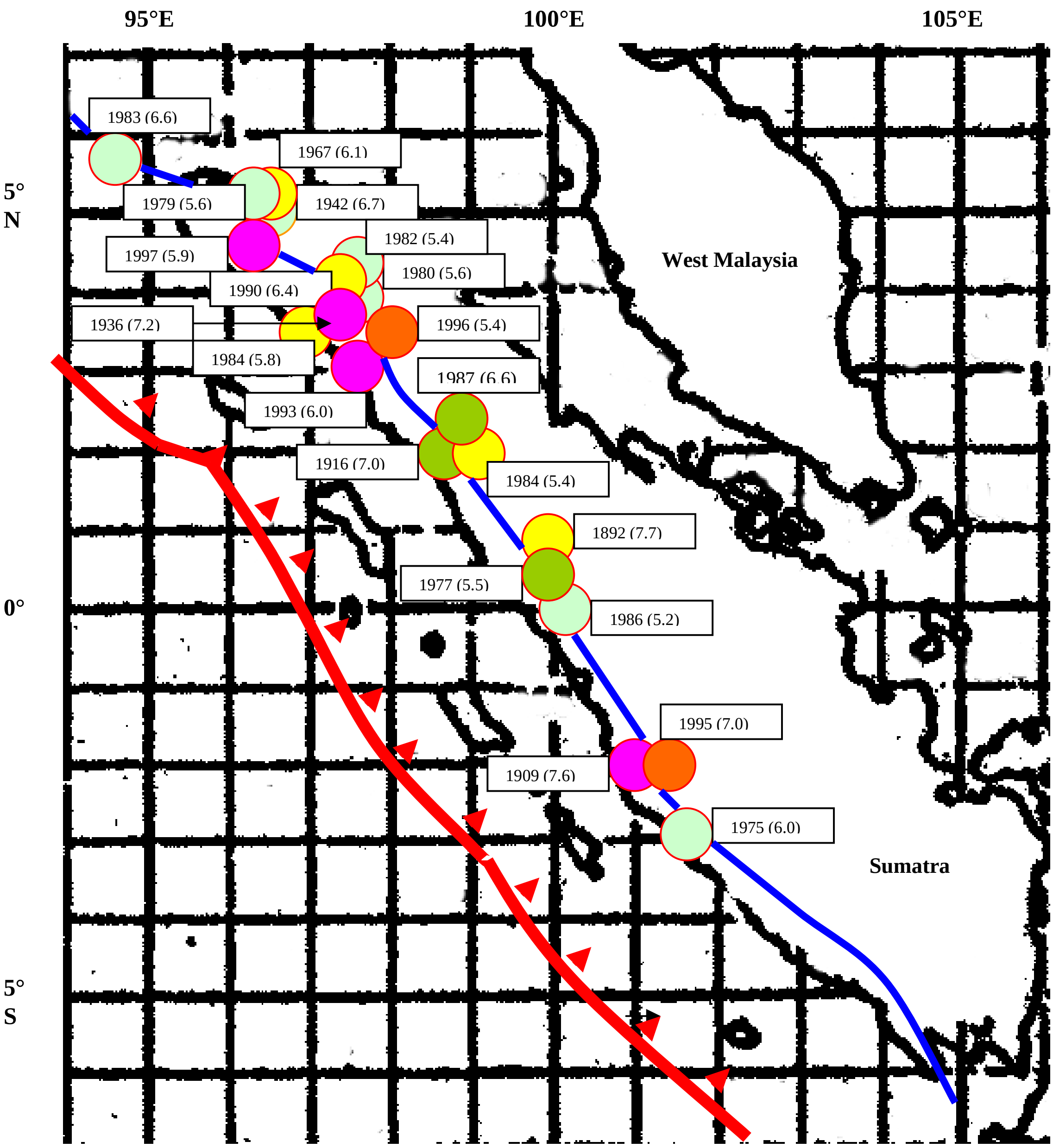
Lagend:

Maximum Observed Intensity (MM scale) experienced in western part of West Malaysia

II III IV V VI

Plate boundaries

Figure 3. Earthquake sources of the Sumatran subduction zone.



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Maximum Observed Intensity (MM scale) experienced in western part of West Malaysia

II III IV V VI

Sumatran Fault Plate boundaries

Figure 4. Earthquake sources of the Sumatran fault

Perak had shook many high-rise buildings in Penang, Perak, Kuala Lumpur and Selangor. The maximum observed intensity in Penang, Sitiawan, Tronoh, Lumut, Kuala Lumpur and Petaling Jaya was estimated of about VI on MM scale.

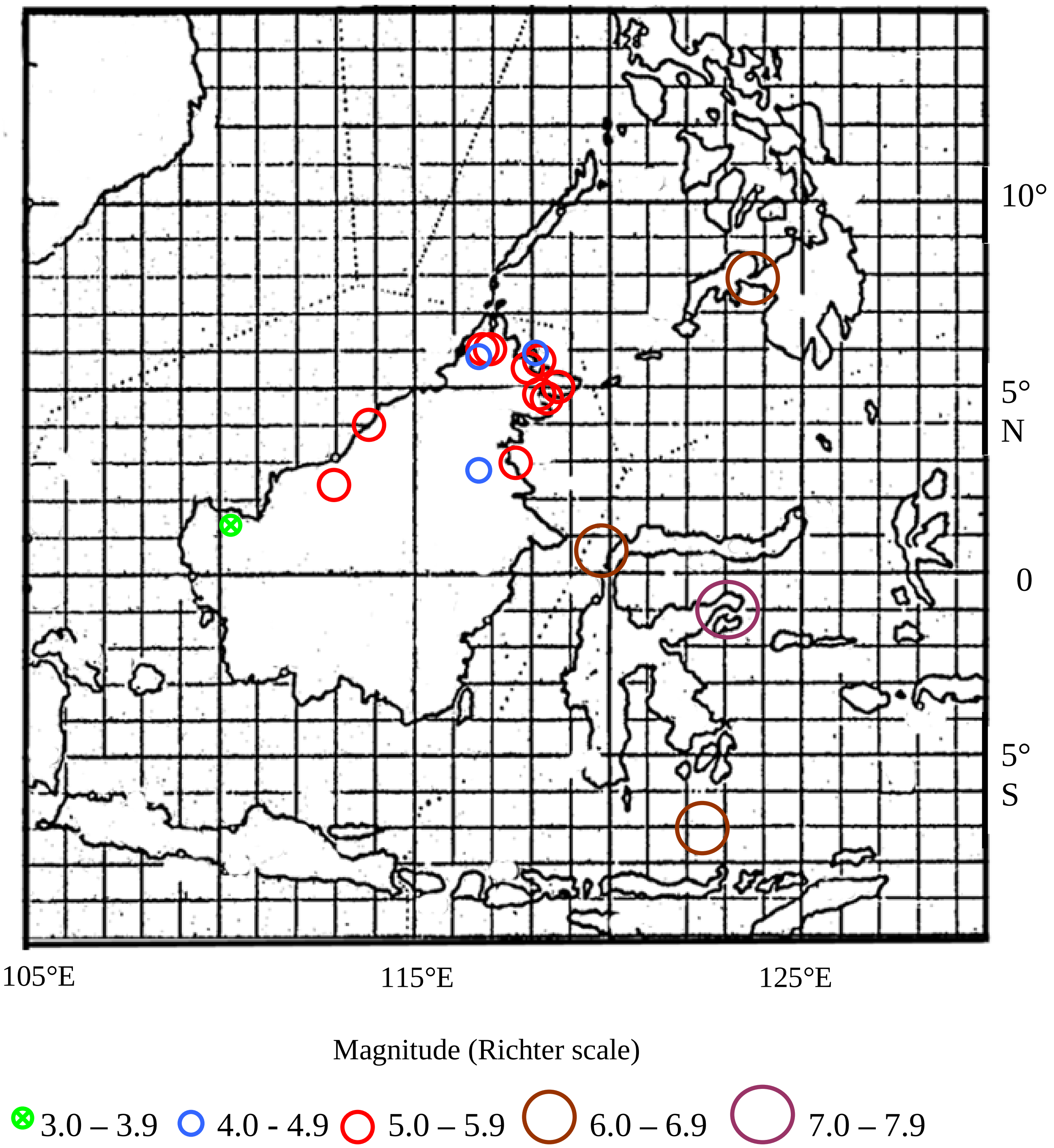

Figure 5. Epicentre of felt earthquakes in East Malaysia

3.2 East Malaysia

East Malaysia on the other hand, is classified as moderately active in seismicity. The area has experienced earthquakes of local origin with magnitudes of up to 5.8 on the Richter scale (Figure 5). Beside of the local earthquakes, East Malaysia also affected by large earthquakes located over Southern Philippine and the Straits of Macassar, Sulu Sea and Celebes Sea.

Sabah

Sabah is prone to earthquake activities if compared to other parts of Malaysia. Sabah has suffered several earthquakes of moderate magnitude. Some of these quakes have caused structural damage to buildings and other infrastructures and injuries to humans [*Leyu, C. H., 1980*]. One of the worsy earthquakes occurred in 1976 when a 5.8 magnitude on Richter scale temblor rocked Lahad Datu. The maximum observed intensity in Lahad Datu and Kunak was estimated of about VII on MM scale. In 1991, an earthquake of magnitude 4.5 on Richter scale shook Ranau, resulting in structural damage to a school. . The maximum observed intensity in Ranau was estimated of about VI on MM scale.

Eastern Sabah is also exposed to tremors caused by earthquakes in the southern Philippines and the Celebes (Figure 5). The maximum observed intensity produced by this long-distance earthquake was VI on MM scale.

Sarawak

Sarawak has experienced of several earthquakes of local origin. In the last 35 years, a total of three earthquake occurred in Sarawak with maximum observed intensity of IV on MM scale. Beside of having earthquakes of local origin, Sarawak was also affected by long-distance earthquake that originated from Southern Philippine and the Straits of Macassar, Sulu Sea and Celebes Sea. The maximum observed intensity in Sarawak produced by this distant earthquake was V on MM scale.

4. Seismograph Network In Malaysia

Seismic wave radiated by a sudden release energy in the earth will propagate to all direction and will arrive at a certain place depending to its velocity and the distance of the source to the place.

If several sensor at different places are operated and detect the seismic waves approaching them, then a set of data of arrival time will be obtained. Using this data someone can trace back where the waves come from.

The precision of tracing back the source will strongly depend to the quality of the data, which has several factor such as: timing system, pointing up the seismic phase, position of the source with respect to the stations, etc., beside the variety of the response

Figure 6. Seismological stations of Malaysia

of the earth passed by the waves. It is emphasized here the importance of the network configuration with respect to the seismic source. In case of Malaysia, it will not be easy to get a good epicenter determination for the earthquakes that take place in the west of Sumatra as well as at outside of Sarawak and Sabah.

To locate seismic epicenter and its magnitude, the seismologists require seismic data from the seismic stations. The quantity and quality of the data will determine the accuracy of the epicenter's location. The quantity of data means the number of time arrival of seismic phase used in the seismic determination, while the quality means the clock's precision used, the distribution of the station with respect to the epicenter and the exact pointing out of the seismic phase (this will depend to the signal to noise ratio of the signal).

Malaysian Meteorological Service (MMS) serves as national information centre for seismology. MMS provides information, advice and consultation related to earthquake to users such as engineers, architects and planners for socio-economic development of the country. The MMS started to operate seismic stations in 1979 by installing four Kinemetrics Short Period (vertical component) seismographs at Petaling Jaya (KLM), Kluang (KGM), Ipoh (IPM) and Kota Kinabalu (KKM).

As more and more high-rise buildings and large costly structures are being built urged MMS to continue with the seismological observation at different parts of the country. Three more stations, one at Kuala Terengganu (KTM), and the other two at Tawau (TSM) and Kuching (KSM) were installed during 1986 to 1988. To meet the increasing demand for seismological information in the country, five more stations were installed (Kuala Lumpur (FRM), Kudat (KDM), Sandakan (SDM), Bintulu (BTM) and Sibu (SDM)) during 1992 to 1998. Three of the total of twelve stations (Figure 6) are equipped with the Strong-motion accelerographs, i.e. Sibu, Bintulu and Sandakan.

Experience tells us that with this network, the MMS as already enough capability for the detecting and identifying earthquake in and around Malaysia with some degree of accuracy for the first hour after the event.

4. Conclusions And Recommendations

Sumatran subduction zone has potential to produce the future giant earthquake of magnitude up to about 9.0 (Mw) and Sumatran fault has pontential to produce the future large earthquake of magnitude up to 7.7 (Mw). The radiated seismic waves from the long-distance earthquake can be amplified on its path to the sites. The response of a building is dependent on the type of structural systems and the local geological conditions. The great Mexico City earthquake of 1985 testifies that major earthquake not only cause devastating losses locally, but can also be dangerous to tall buildings on soft soils several hundred kilometers away. For the case of the Mexico City earthquake, many tall modern buildings were destroyed at a distance of about 300km from the epicentre, while small older constructions were left unharmed. In other word, the incoming seismic waves that might have been attenuated to a harmless amplification were amplified locally by the surface layer of soft sediments. The high-rise and large engineering structures typically resonance with the predominant frequency of the incoming seismic waves thus will amplify the earthquake shaking.

Giant earthquake similar to the size of the 1833 (Mw9.0) event in the Sumatran subduction zone may produce ground motions that have a very long duration of about 300 s with a predominant period between 1.5 and 2.7 s, which is very close to the natural periods of the medium- and high-rise building widely found in Malaysia. Large earthquake similar to the size of the 1892 (Mw7.7) event in the Sumatran fault may produce same effect to the medium and high-rise buildings in Malaysia. Other than that, some active faults in Sabah has potential to produce the future moderate local earthquake of magnitude up to 5.8.

The recent Bengkulu Earthquake which epicentre was about 650km from Johore Baharu and about 800km from Kuala Lumpur had shook several buildings in Johore Baharu and Klang Valey. It gave valuable clues about what essential design elements must be incorporated into structures in Malaysia. Engineering work should be well planned, designed and built because they could be exposed during their life time to important seismic intensities due to earthquakes of certain magnitudes.

Presently anti-seismic regulations not applied in Malaysia. In order to ameliorate the seismic safeguard of the population and to cope with the economic development, Malaysia should dispose its own anti-seismic regulations adaptable to specific condition in the country, land management, disaster prevention and environment protection. The Malaysian Meteorological Service alone could not undertake such an enterprise. This seminar will answer this question.

Acknowledgment

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References

Leyu, C. H., 1980, Earthquake Swarm in Eastern Sabah, June-October, 1976.

MGA, 1999, Seismic Monitoring System in Malaysia.

Natawidjaja, D., 2001, Large Active Faults Along Sumatran Plate Margin and Their Seismic Threat to Indonesia, Malaysia and Singapore.