

Chapter 3

Geology & Tectonics

3.1 Geology

The general geological features of Indonesia are shown in Figure 3.1. The basement formation is metamorphic and it is intruded with plutonic formations. They are overlain with Mesozoic, Cenozoic, recent volcanic formations and quaternary deposits.

The oldest rocks of Sumatra Island are gneiss, schist and quartzite and the schists often contain gold. They probably belong to several geological periods, but all were folded and denuded before the Carboniferous beds were deposited. They form the backbone of the island, and crop out on the surface at intervals along the mountain chain which runs parallel to the west coast. They are penetrated by granitic rock at several locations, which are also Pre-Carboniferous.

The next series of rocks consist of slates below and limestone above. It lies unconformably upon the older rocks; and the limestone contains *Fusulina*, *Phihipsia* and *Productus*, indicating that it belongs to the Upper Carboniferous. These beds are found only

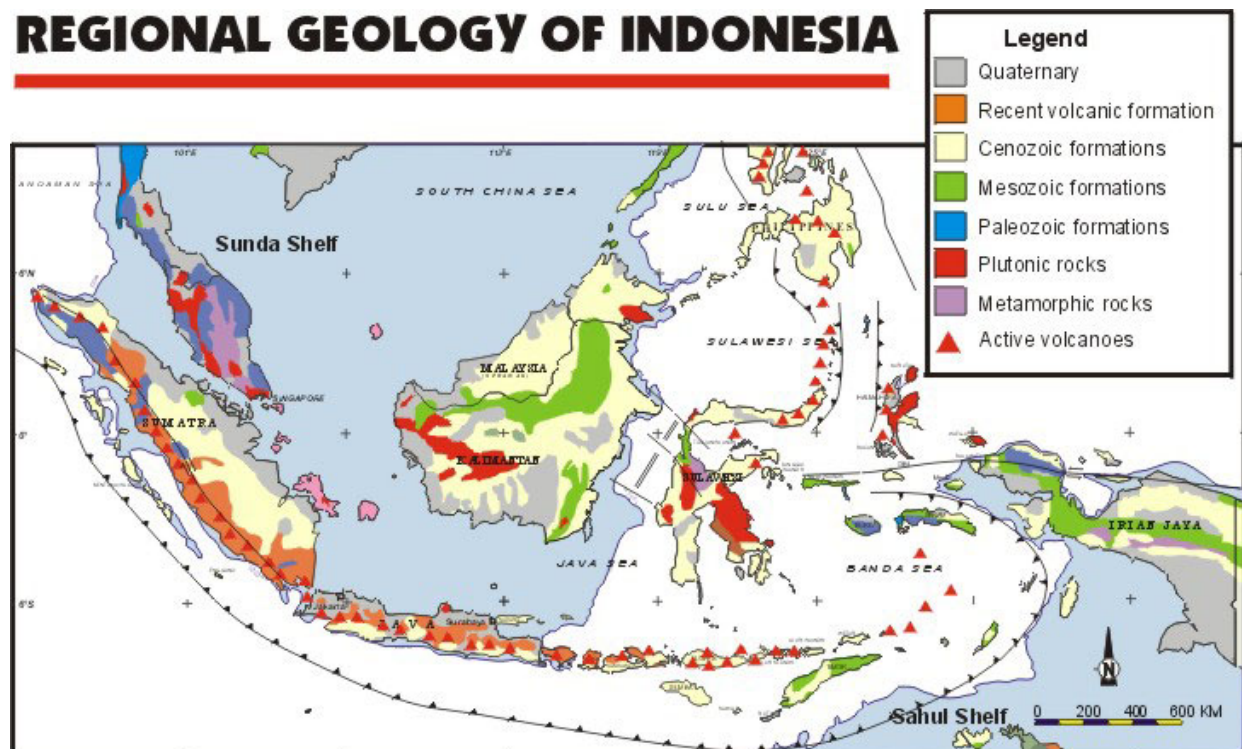


Figure 3.1 Regional geology of Indonesia (Indonesian Government)

in northern Sumatra. They are accompanied by intrusions of diabase and gabbro, and they are sometimes folded, but they are little disturbed. No Permian beds are known, and Mesozoic deposits such as Triassic clays and sandstones with *Daonella* have been found in the upper part of the basin of the Kwalu (East Sumatra). They rest unconformably upon the Carboniferous beds, and have been steeply tilted. Cretaceous beds also have been buckled. Tertiary deposits are very widely spread over the plains and low-lying regions. They consist of breccias, conglomerates, sandstones, marls, and limestones, with seams of coal and lignite.

The most valuable coal occurs in the Eocene beds. At the close of the Eocene period great eruptions of augite-andesite took place from two fissures which ran along the west coast. The Miocene consists chiefly of marls, with occasional beds of lignite and limestone. On the east coast it sometimes yields petroleum. The Pliocene formations occur mainly in the low-lying land and they are generally covered by alluvium. Sometimes they contain thick seams of lignite or brown coal.

Oil and gas deposits are found in Sumatra island and its continental shelf and they are located in the eastern side of the island in Aceh province. The Arun gas field was discovered in 1971 in the Province of Aceh. The field straddles the coastal plain between the Barisan Mts. and the Strait of Malacca. Condensate-rich gas is found in reef and associated carbonate facies of Lower and Middle Miocene Age that in places exceed 300m in thickness. These carbonates occur near the base of a Tertiary Age sedimentary section having a thickness of more than 3,000m. The carbonate rocks are underlain by a clastic sequence of variable thickness that rests on economic basement of pre-Tertiary Age. The reef carbonates occur on a large paleo-topographic high trending in a general north-south direction. The gas accumulation is mainly stratigraphic, having been trapped in a porous reefoid facies that is overlapped by Lower Baong (Middle and Upper Miocene) shale. Geochemical studies indicate that the Arun gas is derived directly from the Baong shale.

3.2 Volcanoes

The Indonesian region is one of the most seismically active zones of the earth; at the same time it has many active and potentially active volcanoes. It is a typical island-arc structure with its characteristic physiographic features, such as a deep oceanic trench, a geo-anticline belt, a volcanic inner arc and a marginal basin. Indonesia has some 400 volcanoes, of which approximately 100 are active.

The present volcanoes of Sumatra island lie along a line (with offshoots) which runs parallel to the west coast, but some distance to the east of the fissures, from which the early Tertiary lavas were erupted. Lava streams are seldom emitted from these volcanoes, the

material erupted consisting ash and scoriae, which are spread over a very wide extent of the island. Augite-andesite predominates, but basaltic and rhyolitic volcanics are also observed. Peuet-Sague and Bur Ni-Telong active volcanoes are located in the province of Aceh.

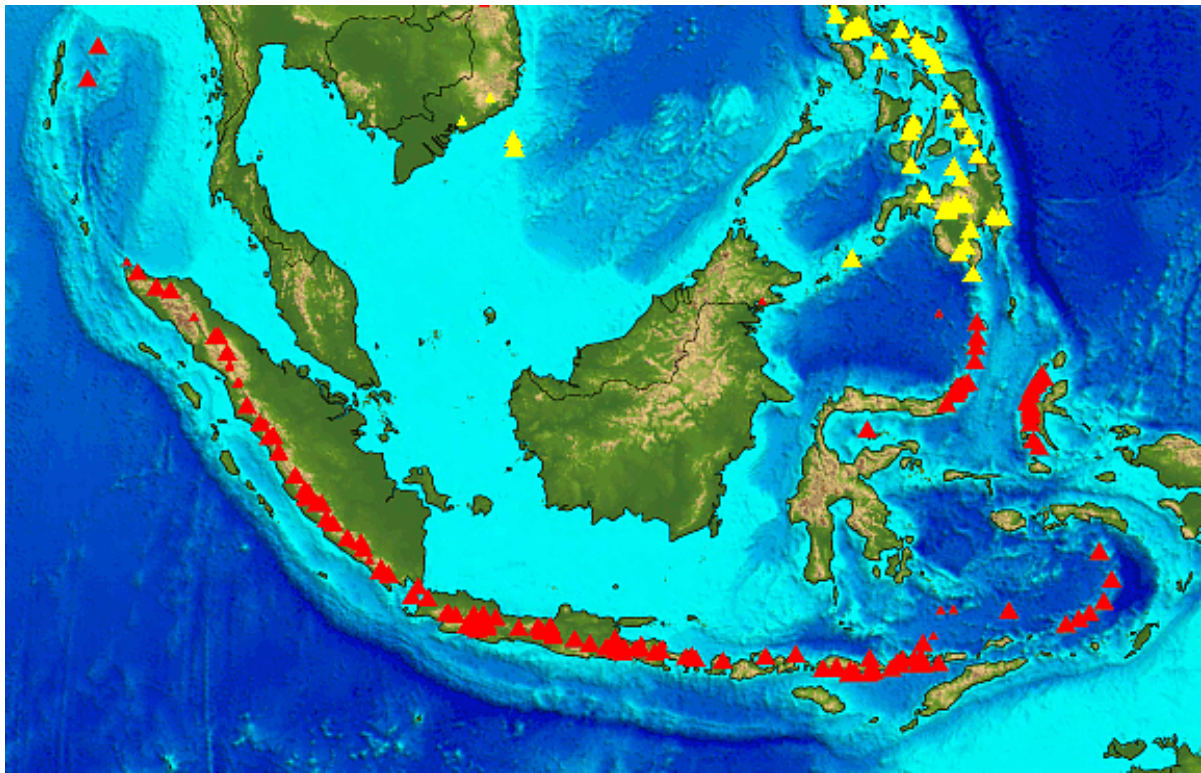


Figure 3.2 Volcanoes of Indonesia (Smithsonian Natural History of Museum)

3.3 Tectonics

Indonesia forms the southeastern extremity of the Euro-Asian lithospheric plate. It is bounded by the northward-moving Indo-Australian and the westward-moving Pacific (Philippine) plates and it is certainly one of the most complex active tectonic zone on earth. The rate of subduction is some centimeters per year; for example, it is 6.0 cm per year in the West Java Trench at 0°S 97°E (azimuth 23°); 4.9 cm per year in the East Java Trench at 12°S 120°E (azimuth 19°); and 10.7 cm per year in New Guinea at 3°S 142°E (azimuth 75°).

The subduction zone around the Euro-Asian plate is called the Sunda trench. Most of Indonesia's volcanoes are part of the Sunda arc, a 3,000-km-long line of volcanoes extending from northern Sumatra to the Banda Sea. These volcanoes are generally the result of subduction of the Australia Plate beneath the Eurasia Plate. Volcanoes in the Banda Sea result from subduction of the Pacific Plate under the Eurasia Plate.

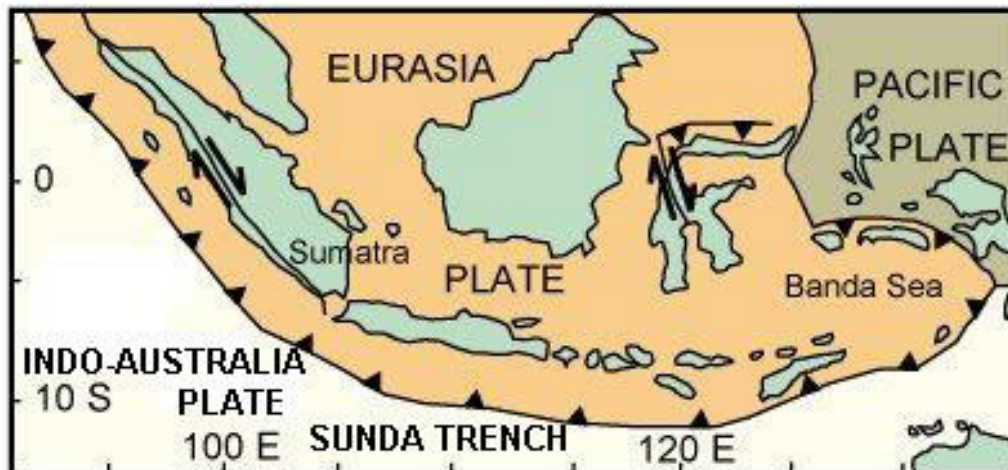


Figure 3.3 Plate tectonic model of Indonesia (Tectonics of Indonesia)

In the region of the earthquake, the Indo-Australia plate moves toward the northeast at a rate of about 6 cm/year relative to the Euro-Asian plate (Figure 3.4). This results in oblique convergence at the Sunda trench. The oblique motion is partitioned into thrust-faulting, which occurs on the plate-interface and which involves slip directed perpendicular to the trench, and strike-slip faulting, which occurs several hundred kilometers to the east of the trench and involves slip directed parallel to the trench.

This fault is named Sumatran fault, which passes through the entire island. The fault is divided into three segments, namely, southern, central and northern segments. The fault is thrust type with a dextral sense. Sumatran Fault System (SFS) probably dates from the Middle Miocene and the opening of the Andaman Sea, although the relative motions of the major plates have changed little since the Middle Eocene. The SFS runs the length of the Barisan Mountains, a range of uplifted basement blocks, granitic intrusions, and Tertiary sediments, topped by Tertiary-Recent volcanics. Studies of Mesozoic outcrops in central Sumatra suggest that the SFS has a displacement of approximately 150km in this area. It is however noted that strike slip deformation is distributed over a geographically wide area outside the present active trace of the SFS.

Figure 3.5 shows a view of Sumatran Fault in the western side of Banda Aceh city. The hills are made of heavily folded limestone and shale. The strike of folds has the trend of NW-SE. Figure 3.6 shows a view of bedding plane in limestone nearby Lhonga port, on which striations for two different episodes of relative motion are identified. The earlier event has a sense of dextral slip with a thrust component while the most recent one has a sense of dextral slip with a normal component, implying the trans-tensional deformation of Banda Aceh basin.

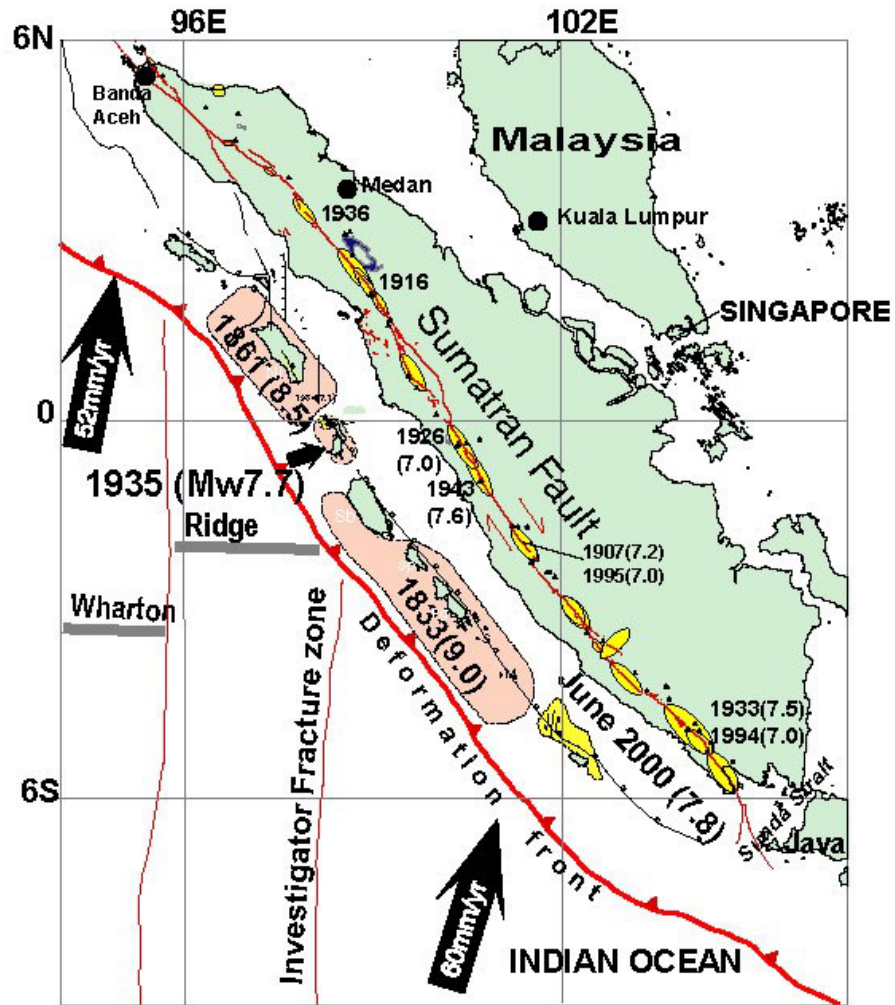


Figure 3.4 Seismo-tectonics of Sumatra Island (Natawidjaja(2005))



Figure 3.5 A view of Sumatran fault nearby Banda Aceh city(from NW to SE)



Figure 3.6 Striations on bedding plane in Lhonga
(Old and new striations associated with the motion of Sumatra fault)

References

- Indonesian Government: http://www.iagi.or.id/indonesia_geology/
- Natawidjaja, D. (2005): Research on active tectonics of the Sumatran plate margin.
<http://www.gps.caltech.edu/~danny/research/research.htm>
- Tectonics of Indonesia (2004):
http://volcano.und.nodak.edu/vwdocs/volc_images/southeast_asia/indonesia/tectonics.html
- Smithsonian Natural museum of History: Volcanoes of Indonesia:
<http://www.volcano.si.edu/world/region.cfm?rnum=06>

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