Seismic Expression of Some Geological Features of Andaman-Offshore West Sumatra Subduction zone

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A subduction zone developed in the south of Myanmar, continued to the Andaman Sea (India), west of Sumatra and south of Java (Indonesia). Two major fault system developed parallel to the subduction zone, so called the Mentawai Fault System and Sumatra Fault system. To the north, where the subduction zone changes its orientation from NNW-SSE to NS, a spreading zone developed towards the east of Andaman Sea (Figure 1). This zone is a complex and active geological system. The 2004 Aceh Tsunami was a major disaster which was triggered in this subduction zone.

The Andaman - Offshore West Sumatra subduction system is where part of the Indo-Australian oceanic plate moving northwards and going beneath the southern tip of Eurasian continental plate. Sumatra Island, which is part of Indonesian volcanic island arc, occurs parallel to and inland from the boundary between these two plates. An accretionary prism or wedge has formed from sediments that accreted onto the non-subducting plate. Most of the material in this wedge consists of marine sediments scraped off from the downgoing slab of Indian oceanic plate with some erosional products of Sumatra volcanics. Fore-arc ridge in this system is a chain of islands (e.g. Andaman, Simeulue, Nias, Mentawai, and Enggano), formed by the accretionary wedge. A series of fore-arc basins developed between the accretionary ridge and the volcanic arc (Figure 2).

This region is also an active petroleum exploration area. Recently, there are a number of companies (e.g. Spectrum, TGS and Geco) that provide new and reprocessed seismic lines to the market. These seismic lines show the geological features in this subduction system.

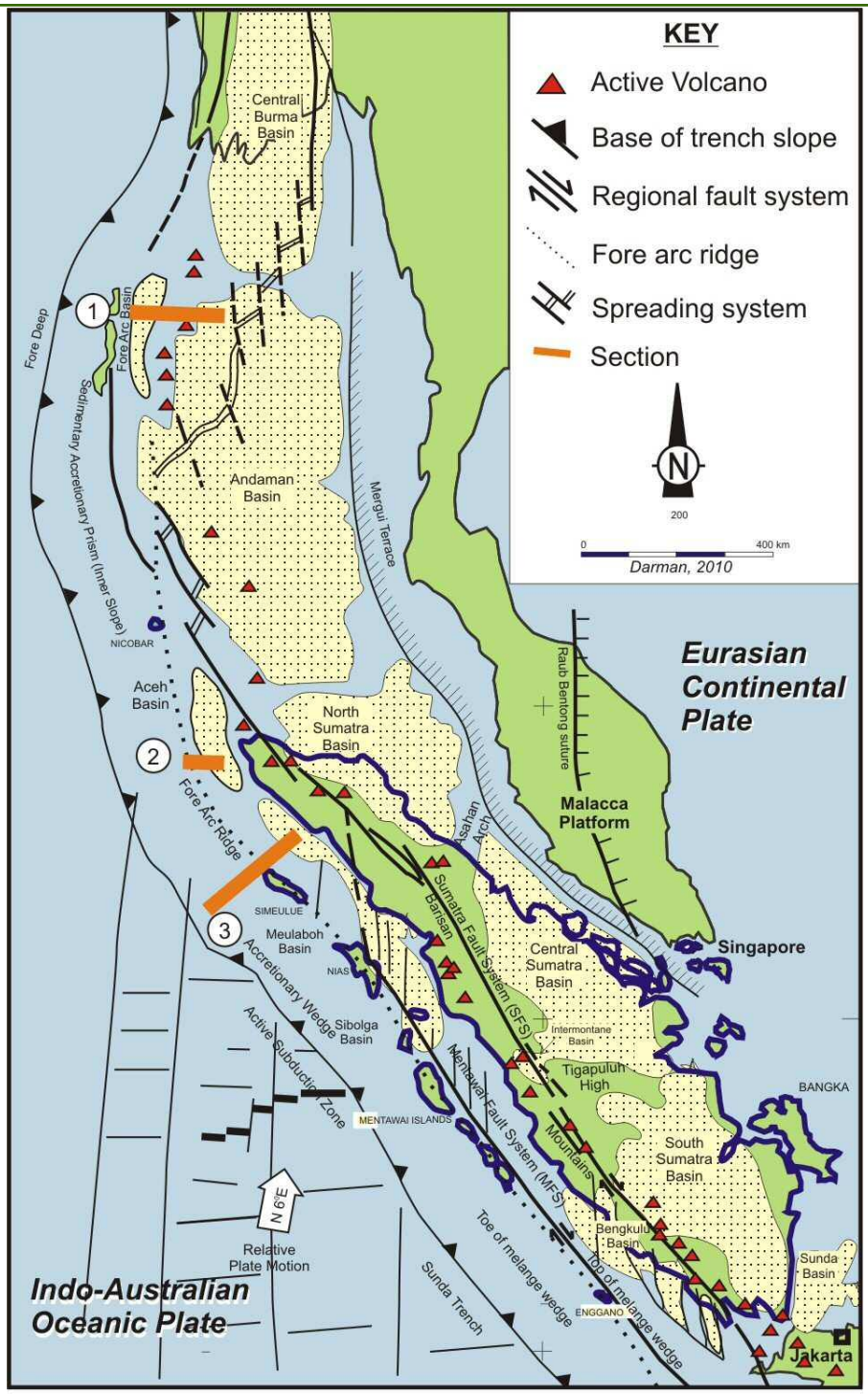


Figure 1: Regional tectonic setting of Andaman—Offshore West Sumatra subduction zone. Section 1: Andaman section; Section 2: West Aceh section; Section 3: Simeuleu Section, (modified from several different sources)

1. Andaman Section

The 2010 articles in Geo-ExPro and AAPG Explorer displayed seismic sections of Andaman Sea. These sections were recently reprocessed by Spectrum in 2010 to support exploration licenses by the Indian authority. The regional seismic section shows a submarine volcanic arc, which separates the back-arc basin from the fore-arc basin. East Andaman fault system developed bathymet-

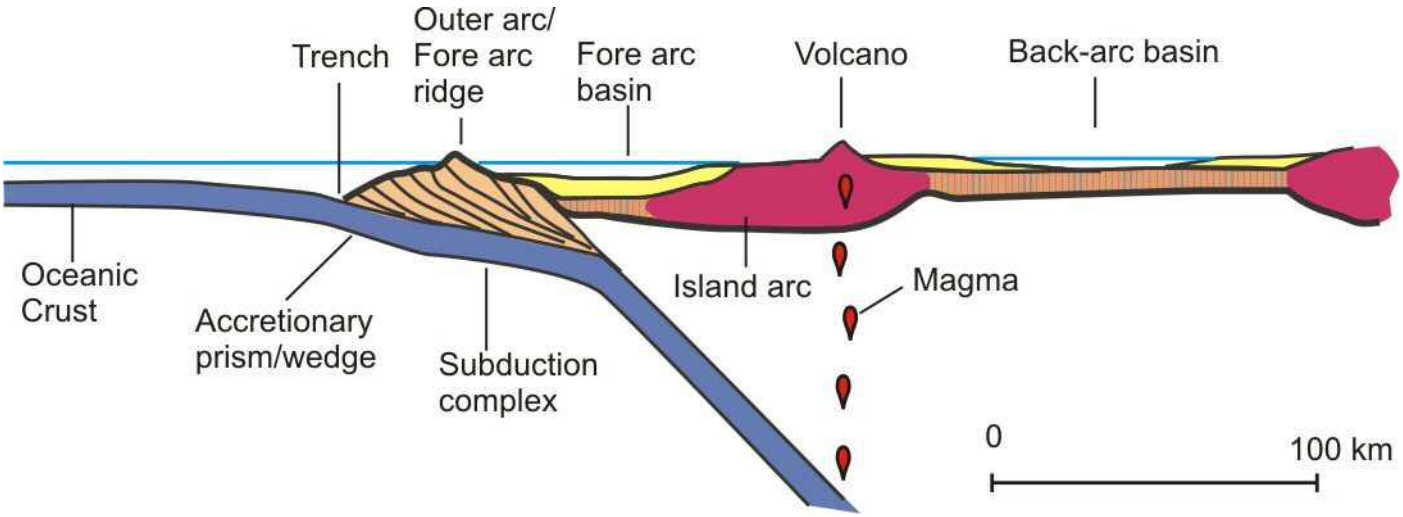


Figure 2. Schematic regional cross section of a subduction zone

ric high called 'invisible bank' in the middle of the fore arc basin. Part of the fore-arc is shown on the west of the section. Further west of this section the fore arc ridge appear to the sea surface as Andaman Island (Figure 3).

The interpretation suggests Pliocene-Recent stratigraphic interval at the shallowest section. This unit thins in parts due to volcanic activity and fault movement. Neogene units are thicker in the back arc basin compared to the fore-arc basin. The majority of the back-arc basin is deeper than 3000 MSec. TWT.

A seismic section published in AAPG Explorer show a Miocene Limestone unit which thins towards the deeper water. The interpretation also indicates a shelf deposit, shelf edge and an isolated shoal (Figure 4). The shelf unit is about 3-4 Msec. TWT deep.

The Neogene unit is underlain by Pre-Neogene sediments which is thins towards the volcanic arc. In parts the pre-Neogene sequence has been completely eroded away. This unit seems thicken to the west of the section in the fore-arc ridge zone. It is believed that the deeper stratigraphic unit has limited data control.

2. West Aceh Section (Profile Sumenta 32)

A seismic section published by Malod et al

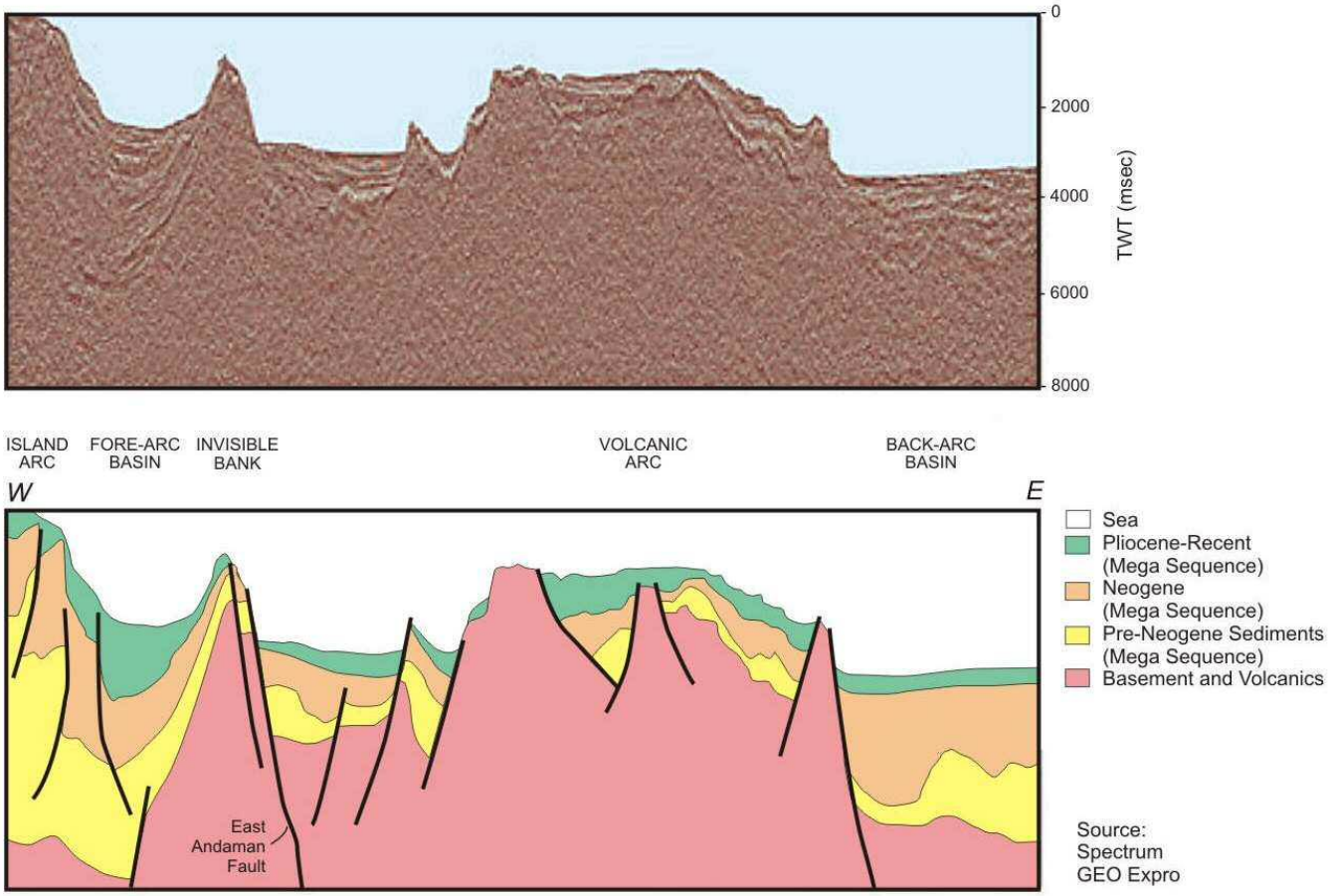


Figure 3. West to east geoseismic cross section through the northern part of the Andaman fore-arc basin area (after Scaife & Billings, 2010)

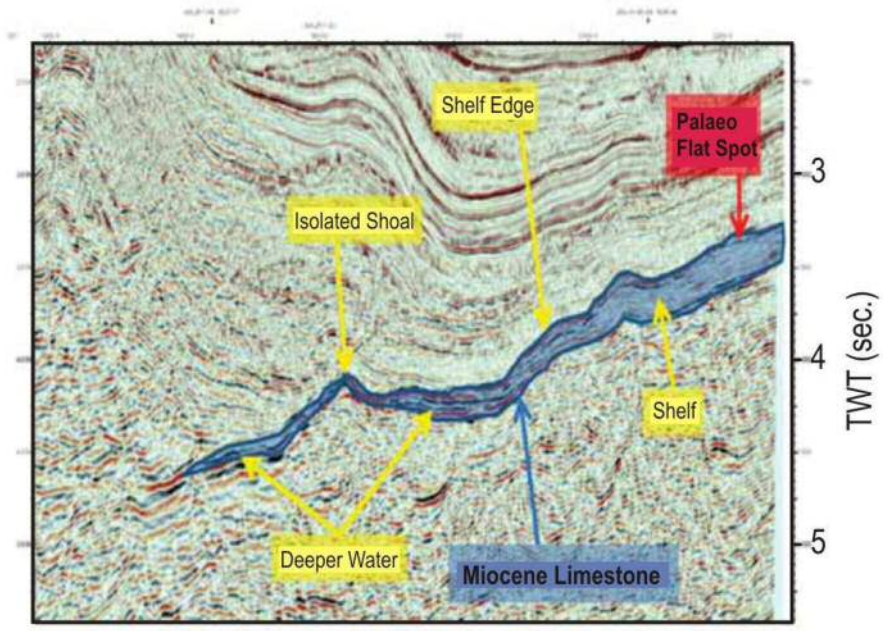


Figure 4. An example of limestone build-up—the basins's cap rock. The section length is 28 km. Data courtesy of Spectum ASA, published in AAPG Explorer—October 2010

(1993) is a result of Baruna Jaya shallow seismic survey in 1991. The survey is part of collaboration between Indonesian and France government.

This short section shows a reverse fault which bound the western part of the fore-arc basin (Figure 5). The fault goes all the way to the sea floor at about 3.5 sec. TWT, separating the accretionary prism from the fore-arc basin. The accretionary prism in the SW of this section is clearly shown as a bathymetric high and the fore-arc basin appear as a flat sea base.

The fore-arc basin was filled with Late Miocene and younger deposits. Flat reflectors shows that there were very little tectonic impact on this area despite the major earth quakes and tsunami developed in this region.

Unfortunately the seismic section is too short and too shallow to show the regional picture. The complex geology in the accretionary complex result in unclear seismic expression in this area.

3. Simeuleu Section

In July 2006, Geco acquired 3 deep seismic sections in offshore west Aceh (Bunting et al, 2007) to image active faults along the subduction zone, quantify the volume of water that penetrated along these faults and provide information to optimize the location of future borehole location for the Integrated Ocean Drilling Program (IODP).

The seismic section is more than 16 sec. TWT deep and shows the oceanic Moho on the SW of the section. An indication of continental Moho appears in the NE of the section. The section also shows the trench and the accretionary wedge of the West Sumatra subduction zone (Figure 6).

Slightly to the south of this line, TGS shot some seismic which was focused on the fore-arc basin. The seismic section clearly shows the fore-arc ridge and major regional NW trending fault zone in the SW of the section (Figure 7). In the NE, present day shelf deposit is well imaged. Meulaboh fore-arc basin has thick post late Miocene deposit adjacent to the NW trending fault zone as this fault generate an accommodation space for about 2 sec. TWT deep.

Conclusion

Recent seismic sections published by Spectrum, Geco and TGS, shows different element of the Andaman-Offshore West Sumatra. Indonesian BPPT Baruna Jaya shallow seismic, acquired in 1991, shows sea bottom profiles which are controlled by tectonic features. These seismic lines clearly show the subsea volcanic arc, accretionary wedge, fore-arc basin, the trench, and boundaries of each element.

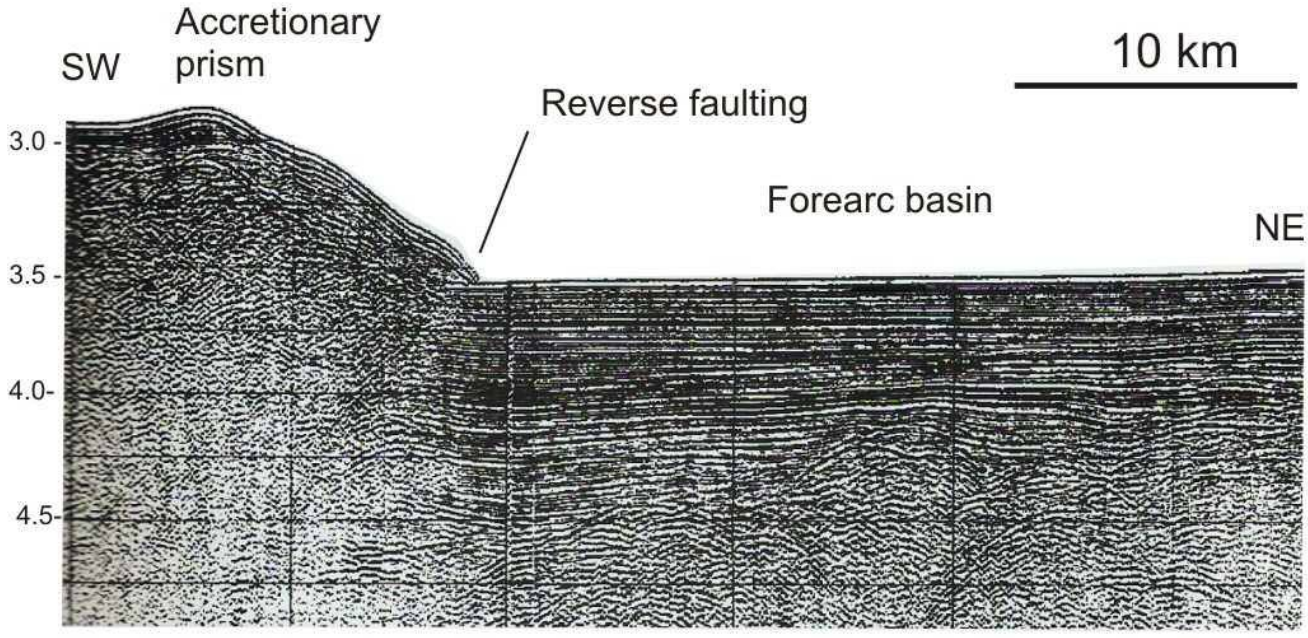


Figure 5. Profile SUMENTA 32, west Aceh section showing reverse fault bounding the Aceh Basin to the west and interpreted as possible strike-slip fault zone. Location of the profile is in Figure 1..

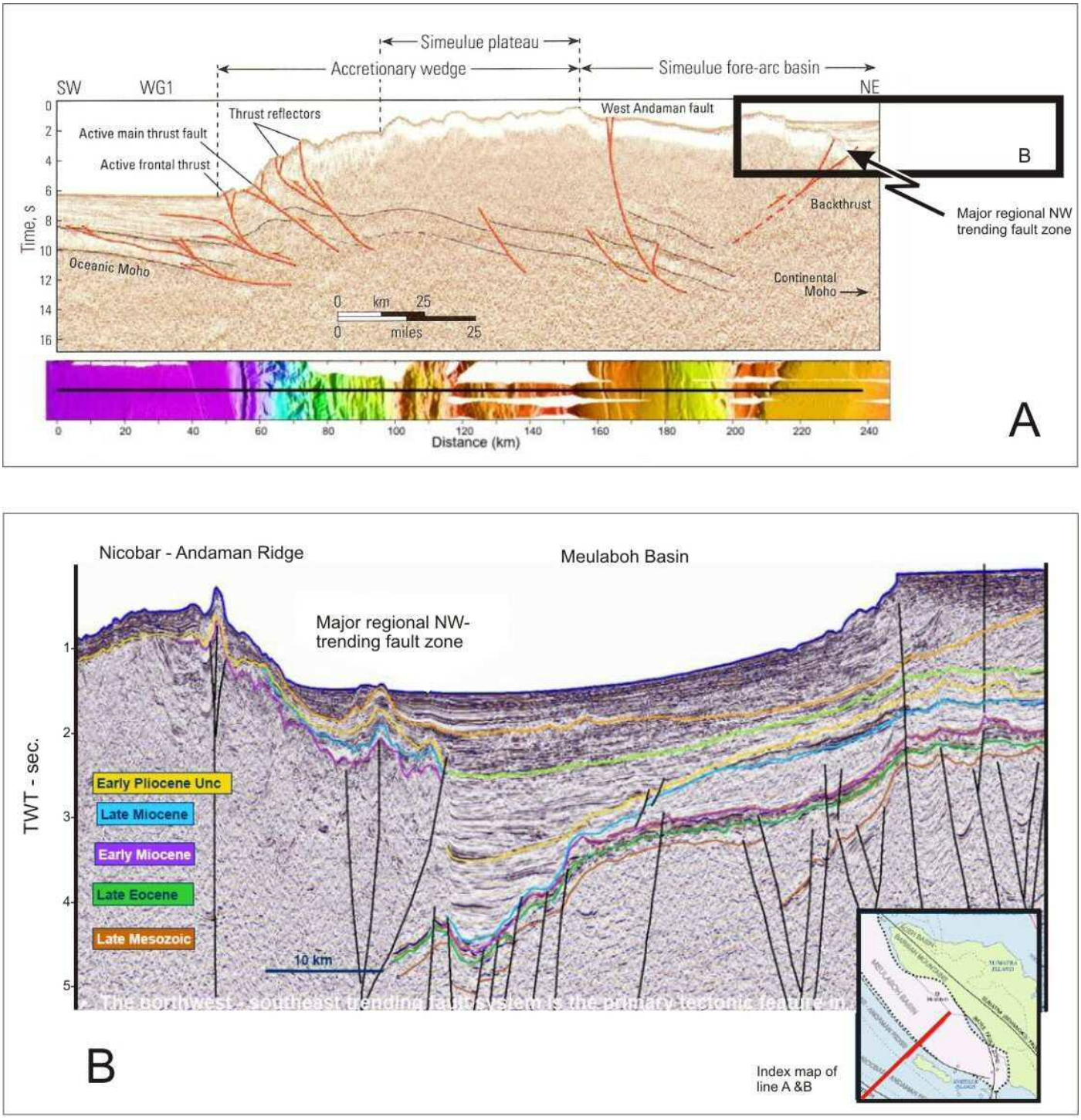


Figure 6. Simeulue Section. A) Preliminary results from the Geco WG1 seismic line with interpretation reveals faulting and deep boundaries. The main thrust fault can be seen on this image, as well as other reflectors. The Moho, short for the Mohorovicic discontinuity, is the boundary between the Earth's crust and the mantle, and can be identified here. B) A seismic section acquired by TGS showing the northwest-southeast trending fault system as the primary tectonic feature in the west of Meulaboh—Sibolga Basin

Both carbonate and clastic deposits are shown on the seismic sections with indication of potential hydrocarbon.

References

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