# Termination of a trench-linked strike-slip fault zone in the Sumatra–Java forearc basin and accretionary wedge complex

## *Batas akhir zona patahan mendatar yang terhubung dengan palung di cekungan busur muka dan komplek prisma akresi Sumatra–Jawa*

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**ABSTRACT** This paper presents a review of several published seismic reflection and seismicity data and analyzes of high-resolution bathymetry data to revise the exact location and reveal detail characteristics of a strike-slip fault zone that formed the southernmost segment of the Sumatran Fault (SF). Previous works interpreted this fault segment as a horst structure to the south of a pull-apart basin. We observe a clear linear trace of dissected seafloor parallels to SF in the high-resolution bathymetric map. This structure extends from the south of a pull-apart basin in the northwest to the Sunda accretionary wedge farther southeast. This lineament exhibits a narrow valley and a linear ridge that in the subsurface are interpreted as negative and positive flower structures, respectively. The structure exhibits a vertical fault plane and appears to have deformed the accretionary wedge sediments and basement at depth. A cluster of shallow seismicity is observed along this NW-trending fault zone, indicating the activity of this zone. Here, we proposed this strike-slip fault as the Ujung Kulon Fault that marks the southeasternmost segment of the SF zone. This segment deformed the area of the Sumatra-Java forearc basin and terminated in accretionary wedge near the trench. The accumulated strain within UKF may trigger large earthquake in the future, close to the highly populated areas in the coast of Sumatra and Java.

**Keywords:** Strike-slip fault, Sumatra Fault Zone, Ujung Kulon Fault, segmentation, Earthquake.

***ABSTRAK*** *Artikel ini menyajikan tinjauan terhadap beberapa data seismik refleksi dan kegempaan yang telah diterbitkan dalam beberapa makalah sebelumnya disertai analisis batimetri resolusi tinggi untuk memperbarui lokasinya dengan tepat dan mengungkap karakteristik detil zona patahan mendatar yang membentuk segmen paling tenggara dari Sesar Sumatra. Penelitian sebelumnya menafsirkan segmen sesar ini sebagai struktur horst di selatan cekungan pull-apart. Kami mengamati jejak linier yang jelas* *membelah dasar laut yang sejajar dengan SF dalam peta batimetri resolusi tinggi. Struktur ini membentang dari selatan Cekungan Semangko di bagian baratlaut ke arah prisma akresi Sunda di bagian tenggara. Kelurusan ini menunjukkan lembah sempit dan punggungan yang diintrepretasikan sebagai struktur bunga negatif dan positif. Struktur ini menunjukkan sesar vertikal yang juga telah mendeformasi sedimen prisma akresi dan basement. Klaster seismisitas dangkal teramati di sepanjang sesar yang menunjukkan aktivitas zona ini. Kami mengusulkan sesar mendatar ini sebagai Sesar Ujung Kulon sebagai segmen paling tenggara dari zona Sesar Sumatra. Segmen ini berkembang di daerah cekungan busur muka Sumatra-Jawa dan berakhir di prisma akresi di dekat palung. Strain yang terakumulasi di dalam UKF dapat memicu gempa bumi besar di masa mendatang, dekat dengan daerah padat penduduk di sepanjang pantai Sumatra dan Jawa.*

***Kata kunci:*** *Sesar geser, Sesar Sumatra, Sesar Ujung Kulon, Segmentasi, gempa bumi.*

## INTRODUCTION

Subduction-related active strike-slip faulting occurs in 50% of modern subduction zones (Jarrard, 1986) that include the Median Tectonic Line in Japan, Atacama Fault in Peru-Chile, and Sumatran Fault Zone (Fernandez-Blanco et al., 2016; Mann, 2007; Sato et al., 1998; Sieh and Natawidjaja, 2000). The 1995 Kobe earthquake, one of the most expensive natural disasters in history, is an example of an event that ruptured along the Median Tectonic Line fault zone, with aftershocks outline a rhomboidal pull-apart geometry (Mann, 2007; Sato et al., 1998). Furthermore, the area of initiation and termination of faults are of essential elements in the process of earthquake rupture (King and Nábělek, 1985). Hence, observation of detailed characteristics of fault segmentation is important for understanding the evolution of the fault zone and seismic hazard mitigation.

Sumatra Fault (SF) zone, a major subduction-related strike-slip fault in the Sunda arc stretches more than 1650 km along the axis of the island with 20 major defined segments (Natawidjaja et al., 2017a, 2017b; Natawidjaja, 2018a; Natawidjaja and Triyoso, 2007; Sieh and Natawidjaja, 2000). These segments, which range from 60 to 200 km long have limited the magnitude of historical earthquakes to between M6.5 and M7.7 (Natawidjaja and Triyoso, 2007).

In its southeasternmost segment, SF formed a transtensional pull-apart basin that had been interpreted due to the stepping-over between SF and Ujung Kulon Fault (UKF) (Malod et al., 1995; Malod and Kemal, 1996; Natawidjaja et al., 2017b; Natawidjaja, 2018a) (Figure 1). The UKF extends along ~200 km trench-parallel lineaments in the southern margin of Sunda Strait pull-apart basin (SPB) (Malod et al., 1995; Malod and Kemal, 1996). The geometry of UKF has been revealed by seismic reflection images as a set of NW-trending horst structures that bounded the (SPB) to the north and accretionary wedge complex farther south (Malod et al., 1995). The UKF has been interpreted to have formed due to the dextral movement of the southern part of the Mentawai sliver-plate (Malod and Kemal, 1996). However, recent observations of seismic reflection data (Susilohadi et al., 2009, 2005) suggest that the southernmost relay of the SFZ is located to the north of UKF of Malod et al. (1995) exhibiting a positive flower structure.

Furthermore, these authors proposed that the structures previously interpreted as UKF by Malod et al. (1995) were actually part of the Mentawai Fault Zone (MFZ).

In this paper, we analyze several published seismic reflection, local seismicity, and high-resolution bathymetry data to reveal the exact position, geometry, and structural setting of the southernmost segment of the SFZ and discuss its implication to the seismic hazards in this area.

## STRUCTURAL SETTING OF THE SUMATRA-JAVA FOREARC

In the Sunda subduction zone, a transition between two regimes of subduction occurs in the area between Sumatra and Java from oblique subduction to the west and frontal subduction farther east (Malod et al., 1995). The oblique subduction beneath Sumatra produces strain partitioning of convergent vectors. The SFZ accommodates a significant amount of the right-lateral component of the oblique convergence (Sieh and Natawidjaja, 2000) of the Indo-Australian plate beneath the Sunda plate (Fitch, 1972). A forearc sliver lies in between this strike-slip fault zone and trench (Jarrard, 1986; McCaffrey, 1991; McCaffrey et al., 2000). A vast accretionary wedge complex stretches in between the forearc basins and trench (Mosher et al., 2008; Schlüter et al., 2002; Susilohadi et al., 2005).

The SFZ stretches 1650 km along the backbone of Sumatra Island and had been divided into 19 segments of active faults (Natawidjaja et al., 2017a, 2017b; Natawidjaja, 2018a; Sieh and Natawidjaja, 2000). Another major fault observed offshore west Sumatra parallel to the SFZ, the Mentawai and West Andaman Fault Zone). Previously, this fault zone had been interpreted as a strike-slip fault in the boundary between deep forearc basin and outer arc high (Berglar et al., 2010; Diament et al., 1992). However, recent seismic reflection data imaged backthrusts in the margin of the accretionary wedge (Hananto et al., 2012; Mukti et al., 2012a, 2012b; Singh et al., 2010). Furthermore, similar characteristics of fault-thrust belt are also observed in the arcward margin of accretionary wedge in the northern Sumatra and Andaman forearc (Chauhan et al., 2009; Deighton et al., 2014; Hananto et al., 2012; Moeremans and Singh, 2015; Mukti, 2018a; Singh et al., 2013).

In its southern part, SF terminated into the Semangko pull-apart basin (Malod et al., 1995; Malod and Kemal, 1996; Sieh and Natawidjaja, 2000; Susilohadi et al., 2009). Detailed observation on the Semangko pull-apart basin revealed the occurrence of two north-trending grabens, the West Semangko, and East Semangko grabens (Mukti, 2018b; Susilohadi et al., 2009). To the south of the Semangko pull-apart basin, a trench parallel structure bounded the grabens here referred to as the Ujung Kulon Fault (UKF) (Malod et al., 1995; Malod and Kemal, 1996). This fault zone is described as a set of NW-trending horst and graben structures with a large thickness of Miocene-recent sediments of the seismic profile (Malod et al., 1995). However, based on seismic reflection data, the fault zone defined by Malod et al. (1995) has been suggested to have formed as part of the MFZ (Susilohadi et al., 2009). Furthermore, these authors determined an east-dipping normal fault in the eastern margin of Semangko basin as Ujung Kulon Fault, that formed in the early phase of the opening of Sunda Strait (Susilohadi et al., 2009).

Several strong and major earthquakes have been recorded along the SF system (Natawidjaja et al., 2017b; Natawidjaja and Triyoso, 2007). Since 1890, 21 major earthquakes have ruptured several segments of the SFZ with magnitudes ranges from 6.5 to 7.7 (Natawidjaja and Triyoso, 2007). They argued that on average, every 100 years of the accumulated strains in each segment of the SFZ are equivalent to an earthquake of magnitude 7.2 to 7.4, whereas for 200 years return period, each segment of the SFZ is capable of generating an earthquake with a magnitude range from *Mw* 7.4 to *Mw* 7.7. Hence, the SFZ is a fault zone prone to big earthquakes.

## DATA AND METHODS

The bathymetry data used in this study covers the area of offshore Sumatra–Java (Djajadihardja, 2010). The data were ping edited and provided as grid data in xyz-ASCII format. Gridding was performed with a grid spacing of 100 m and plotted in maps with the Generic Mapping Tool (GMT) software. We also use GEBCO one arc minute (British Oceanographic Data Center, 2003) for the background map. Several published seismic reflection data that acquired during Jabar cruise 1990 (Malod et al., 1995), SONNE-137 cruise (Reichert et al., 1999; Schlüter et al., 2002; Susilohadi et al., 2009, 2005), and SONNE-138 cruise (Flueh et al., 1999; Lelgemann et al., 2000) were re-analyzed. Determination of several key stratigraphic surface is referred to previous work (Susilohadi et al., 2009), with some modifications. However, the absence of well data that can be correlated to the seismic section led to the uncertainty of this age determination. We keep the stratigraphic units of each section as in the original article, because they were interpreted based on different data set acquired during different cruises. Relocated hypocenters (Pesicek et al., 2010) is used for background seismicity, compiled with seismicity from local network during KRAKMON project (Jaxybulatov et al., 2011).

We analyzed structural features on the compilation of high resolution bathymetry acquired during several cruises for detail surface expression of active faults on the seafloor. We also re-analyzed published seismic sections over the study area to better understand the structural configuration in the Sumatra-Java forearc system. Relocated hypocenters of global catalogue is used for background seismicity and compiled with seismicity from local network in the area between Sumatra and Java to trace the deeper continuation of structures observed in the bathymetry and seismic reflection data.

## RESULTS AND DISCUSSION

### Previous interpretations of the UKF

Based on the seismic reflection images acquired during Jabar Cruise (1990), the UKF of Malod et al. (1995) is depicted as a set of a trench-parallel horst in the northern boundary of the accretionary wedge between Sumatra and Java (Figure 2). This fault zone is characterized by a relatively thick Miocene and younger sediments in the grabens to north and south of UKF (Malod et al., 1995). On the structural map, the UKF dissected ridges and thrusts associated with the upper part of the accretionary wedge sediments at small angles (Malod et al., 1995). Based on the related stratigraphy in the fault zone, the UKF had been interpreted to have active during the Neogene. Interestingly, these horst and graben structures aligned parallel to the present-day subduction trench. However, because reflectors beneath the horst cannot be observed to correlate with the reflectors in the graben fills. Hence, the age of UKF cannot be ascertained by the Jabar-03 data set.

In 1999, GINCO2 expedition (SONNE Cruise SO-138) acquired seismic reflection and refraction in the Sunda Strait area to investigate the crustal structure and evolution of the Sunda Strait (Lelgemann et al., 2000). A nearly 110 km seismic reflection image revealed the stratigraphic and structural relationship in graben structures and basement blocks in the western part of the Sunda Strait (Figure 3). A nearly trench-parallel horst structure had been imaged in the southern margin of the Sunda Strait Grabens. This horst is an ~8-km-wide basement high structure that appears to have bounded the western graben to the north and the accretionary wedge complex farther south. Several Eocene-Oligocene to Recent sedimentary units had been interpreted for the graben fills both to the north and south of the horst structure (Lelgemann et al., 2000). These authors did not show the extent of UKF on map. However, the location of this horst coincides with the position of UKF proposed by Malod et al. (1995).

Susilohadi et al. (2009) have used seismic reflection data set of GINCO Cruise 1999 and they found that an east-dipping normal fault in the eastern flank of Panaitan ridge appears to have formed as the western margin of Krakatau Graben (Figure 4). This east-dipping faults referred to as UKF by Susilohadi et al. (2009). These authors interpreted deformation in the Krakatau Graben may have commenced in the early Late Miocene and is represented by the growth of narrow basement block faulting. Furthermore, the UKF and East Semangko Fault (ESF) were interpreted to have nucleated in the early opening of Sunda Strait, in the eastern and western margin of the Semangko Graben, respectively. The graben in Sunda Strait initiated in the early Late Miocene as a pull-apart basin due to the releasing step-over between the main strand of Sumatra Fault zone and its relay faults south of Ujung Kulon (Susilohadi et al., 2009, 2005). The southern relay of the Sumatra Fault is located to the north of that suggested by the previous works (Lelgemann et al., 2000; Malod et al., 1995; Malod and Kemal, 1996) exhibiting a positive flower structure rather than a horst structure.

### Bathymetric expression of UKF and seismicity

In the compiled bathymetric map, a clear linear trace of dissected seafloor is observed to the south of Semangko Graben that deformed seafloor of the forearc basin (Figure 5). This lineament exhibits a narrow valley that can be traced farther southeast to the south of Ujung Kulon Peninsula. Another trace of lineament is observed ~5 km to southeast of the end of the deep valley and appear to have form as a linear ridge. The clear straight lineament appears to have continued farther southeast and dissected the Sunda accretionary wedge. This ~260-km-long fault zone also appears to have crossed the Mentawai Fault (MF) segment in the Sunda Strait (Susilohadi et al., 2009) that previously have been interpreted as UKF (Lelgemann et al., 2000; Malod et al., 1995; Malod and Kemal, 1996) (Figure 6). Other lineaments of structural features are observed in the accretionary wedge complex.

The lineament to the south of Ujung Kulon Peninsula terminated in the area to the south of Palabuhanratu bay and formed typical horse-tail structures (Figure 6). This lineament appears to have dissected anticlinal ridges in the accretionary wedge complex. Overall, this lineament formed parallel to the East Semangko Fault (ESF) and Kota Agung Fault (KAF) that developed in the southeastern segment of SF on land. The ESF-KAF and the lineament to the south of Ujung Kulon Peninsula are separated by a ~70 km wide Semangko Graben.

Furthermore, a cluster of seismicity from local network seismogram is observed around the area of this lineament (Figure 6). The cluster of shallow seismicity observed along the NW-trending UKF is not parallel with the direction of the trench. Therefore, the cluster of seismicity around the UKF is unlikely to be related with the subduction megathrust, hence indicating the activity of the UKF itself.

## Seismic images of the UKF

In the sub-surface, nearly vertical faults are observed beneath the wall of the valley and interpreted to have developed farther at depth (Figure 7). These structures appear to have deformed the stratigraphic successions down to the basement of the forearc basin. Features of the deep valley and vertical faults at depth are interpreted as a negative flower structure that commonly observed in a strike-slip fault zone. This negative flower structure has been interpreted to have formed as part of the Sumatra Fault zone (Susilohadi et al., 2005). Farther southeast to the south of Palabuhanratu Bay, the lineament is characterized by a positive flower structure and formed a structural high in the bathymetry (Figure 8). The structure exhibits a vertical fault and at depth appears to have deformed the accretionary wedge sediments and basement. This positive flower structure has been interpreted to have formed as part of the Sumatra Fault zone (Susilohadi et al., 2005).

The location of this strike-slip fault to the south of Ujung Kulon peninsula is situated to the north of the previously proposed Ujung Kulon Fault (Lelgemann et al., 2000; Malod et al., 1995; Malod and Kemal, 1996) (Figure 1A). Whereas the location of Ujung Kulon Fault proposed by Susilohadi et al. (2009) is located farther north (Figure 1B). Here, we use the name of UKF for the lineament observed in the bathymetry and seismic reflection profiles to the south of Ujung Kulon Peninsula, with a revised location that validated by bathymetric data. The positive and negative flower structures are typical features observed in a strike-slip fault zone (Harding, 1990; Mann, 2007; Sylvester, 1988; Wilcox et al., 1973). Moreover, a horse-tail termination of this fault zone in its southeastern end strengthens the interpretation of the strike-slip fault, as have been observed in many field cases (Izart et al., 1994; Morley, 2002; Socquet and Pubellier, 2005).

## Age constraint of the UKF

To understand the temporal constraint on the development of the UKF, we need to analyze the depositional history of the Semangko pull-apart basin (SPB) that has been interpreted to have developed due to the stepping over between SF and UKF (Lelgemann et al., 2000; Malod et al., 1995; Malod and Kemal, 1996; Mukti, 2018b). Detail seismic characters and lithological interpretation of the basement and sedimentary rock units have been explained by Susilohadi et al. (2009) and reviewed in Mukti (2018).

Here, we briefly described the stratigraphic units in relation to the temporal constraint of the UKF. Unit 1, 2, and 3 represent the Upper Miocene, Pliocene, and Pliocene–Pleistocene sediments.

The lower sequence, Unit 1 is observed overlying the basement in the northern part of the SPB (Figure 9). Unit 1 appears to have a uniform thickness in the Semangko horst but thins near the Tabuan Ridge. Farther east, a thin package of Unit 1 is observed over the Tanggang Ridge. Unit 1 exhibits a similar thickness both in the hanging wall and footwall of the main basin. Unit 2 exhibits a similar pattern with Unit 1, showing relatively uniform thickness. However, Unit 2 thins near the Tanggang Ridge, as indicated by onlap reflectors within this unit to the tilted Unit 1 (Figure 9). The youngest sedimentary sequence, Unit 3 is deposited in the WSG and ESG where the thickness of this unit thickens in the eastern part of the SPB. Based on these observation, Unit 1 and Unit 2 may have been deposited as pre-kinematic strata in relation to the development of the pull-apart basin, whereas Unit 3 formed as the syn-kinematic basin fills. Based on the interpretation of syn-kinematic strata related to the stepping over between the SFZ and UKF, the initiation of the UKF and southern segment of the SFZ may have been commenced before the deposition of Unit 3, or at least since late Pliocene. The initiation of SF zone in the southeastern segment since at least Late Pliocene is similar to the suggestion that the formation of the active SF zone was initiated since 2 Ma based on field observation (Sieh and Natawidjaja, 2000).

## Relationship between UKF and SF

The UKF exhibit sharp linear characteristics, resemble to that of the strike-slip faults in the SF zone onshore (Natawidjaja, 2018a). Moreover, KAF is also formed parallel to the ESF and KAF. A comparable geometry of pull-apart basin have actually been observed in the central part of the Sumatran fault system that separated two segments of SF zone in the Barumun area (Sieh and Natawidjaja, 2000). This pull-apart feature exhibits a 23-km-wide releasing bend that bounded by the Sumpur and Angkola segments. Two historical earthquakes >M5 have been revealed along these segments, the M7,7 1892 and M6.1 1977 events (Natawidjaja, 2018b), suggesting the activity of this segment of the SF. Horse-tail structure in the southeastern end of UKF indicates the termination of the fault zone. The cluster of seismicity around the UKF is likely to be related with the activity of this southernmost segment of the SF. Therefore, based on those observations, it is likely that to include the UKF as the southeasternmost segment of the SF as have been suggested by Susilohadi et al. (2005) and Susilohadi et al. (2009) rather than as a single strike-slip fault zone (Malod et al., 1995).

Based on this study, the updates on the southeasternmost segments of SF is summarized as follows. Two strands of the SF in the Semangko Bay, the East Semangko Fault (ESF) and Kota Agung Fault (KAF) marked the southeastern part of SF onshore (Figure 6). These two faults extend seaward and act as basin side-wall faults in the boundary of a north trending graben. Northwest-trending lineaments in the center of the graben are observed in the bathymetry and seismic reflection data, suggesting the development of strike-slip fault (Figures 6, 9).

Farther south, the graben is bounded by a NW-trending UKF that extend farther southeast and dissected the Sunda accretionary wedge complex. Further south of UKF, a clear lineation of MFZ (*sensu* Susilohadi et al 2009) add more complexity because recently acquired seismic reflection data covered MFZ along the whole Sumatran forearc show this zone as backthrust (Deighton et al., 2014; Mukti et al., 2012a; Singh et al., 2010). Unfortunately, there was no seismic reflection crossing this lineament in the published works. One seismic line crossing the southern part of MFZ before it crossed the UKF (Figure 9), but we could not see detail beneath this structure.

Another option for the interpretation of the MF (*sensu* Susilohadi et al., 2009) is that this could be another strand of the SFZ in the Sunda Strait in similar configuration to the two strands of SF in the southern edge of Sumatra Island: the ESF and KAF. However, a better seismic reflection is needed to support this argument. The continuation of SF zone farther south of Java forearc added the complexity of geometry of the SF system that has been previously observed on land Sumatra (Natawidjaja, 2018a, 2018b; Sieh and Natawidjaja, 2000), Aceh and Weh islands (Fernandez-Blanco et al., 2016), north Sumatra offshore (Ghosal et al., 2012), and Sunda Strait area (Lelgemann et al., 2000; Malod et al., 1995; Mukti, 2018b; Susilohadi et al., 2009, 2005).

### Implication for seismic hazards

The SF zone is highly segmented that marked by more than a dozen discontinuities of 4–12 km wide (Sieh and Natawidjaja, 2000). These continuities are large enough to influence the seismic behavior of the fault as have been observed elsewhere (Harris et al., 1991; Harris and Day, 1993; King and Nábělek, 1985). The 200-km-long UKF is separated from the SF segments in the northwest by more than 90-km-wide discontinuity in the form of a pull-apart basin. This discontinuity is the largest as compared to the other stepovers in the SF zone that ranging from 4–12 km (Sieh and Natawidjaja, 2000). Furthermore, the length of the UKF segment is almost similar to the Renun Segment of the SFZ that had generated at least 3 large historical earthquakes (M 6.8–7.2) since the early 1900's (Natawidjaja and Triyoso, 2007). The termination of historical earthquake ruptures along the SF zone appears to have been related with large fault jogs (Natawidjaja et al., 1995). The 1995 Kobe earthquake that ruptured along a major strike-slip fault zone ended near the fault jog as indicated by a rhomboidal pull-apart pattern aftershocks (Mann, 2007; Sato et al., 1998).

A cluster of seismicity along this segment suggest that UKF is still active. The accumulated strain within this offshore segment may unleash large earthquake in the future, close to the highly populated areas in the coast of Sumatra and Java. Further investigation of the offshore segments of this trench-linked strike-slip fault zone is needed to anticipate potential future disasters associated with mature strain accumulation.

## CONCLUSIONS

Based on the interpretation of high-resolution bathymetry data, supported by published seismic reflection and seismicity data, we conclude that the southernmost segment of SF terminated at accretionary wedge complex close to the Sumatra-Java trench. This fault is situated to the north of the Ujung Kulon Fault

(UKF) of Malod et al. (1995) but to the south of UKF of Susilohadi et al. (2009). In the bathymetry, this fault exhibits a narrow valley and a linear ridge that can be traced from the south of Sunda Strait pull-apart basin and terminated at accretionary wedge near the trench. In the subsurface, the deep valley and linear ridge are interpreted as negative and positive flower structures, respectively. The structure exhibits a vertical fault and at depth appears to have deformed the sediments and basement of the forearc basin and accretionary wedge. Furthermore, a cluster of shallow seismicity is observed along this NW-trending fault zone, indicating the activity of this zone. We refer this strike-slip fault as the Ujung Kulon Fault that marked the southeasternmost segment of the SF zone and crossed the area of Sumatra-Java forearc basin and accretionary wedge near the trench.

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## Figures and captions

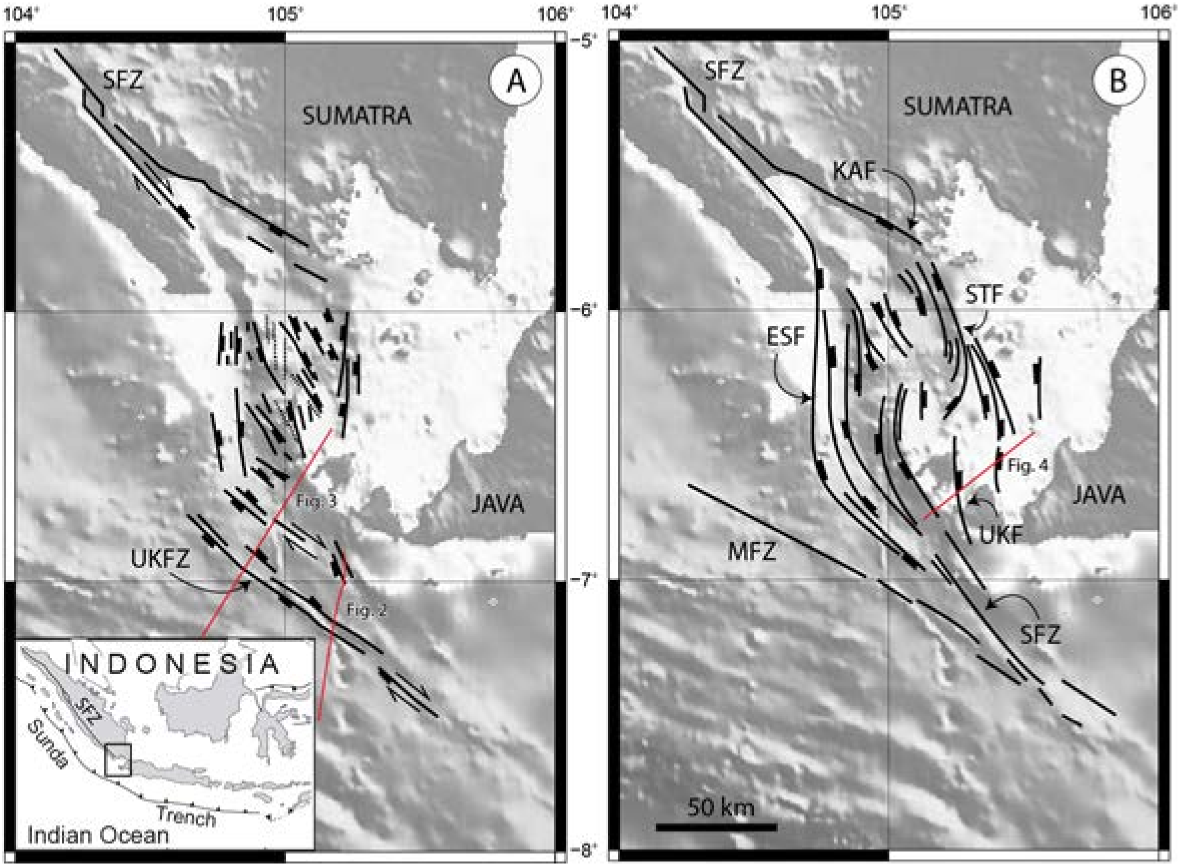

Figure 1. (A) Structural configuration of the south Sumatra–south Java forearc (Modified after Malod et al. (1995)). The SFZ stepped-over with the UKFZ and formed a pull-apart basin. (B) Structural interpretation of Susilohadi et al. (2009). The SFZ stepped over with its southern relay. The UKFZ of Malod et al., (1995) here was interpreted as MFZ. The Sunda Strait Segment is the southeastern part of the ~1800-km-long SFZ (index map) (Sieh and Natawidjaja, 2000). Red line is seismic profile shown in Figure 2-4.

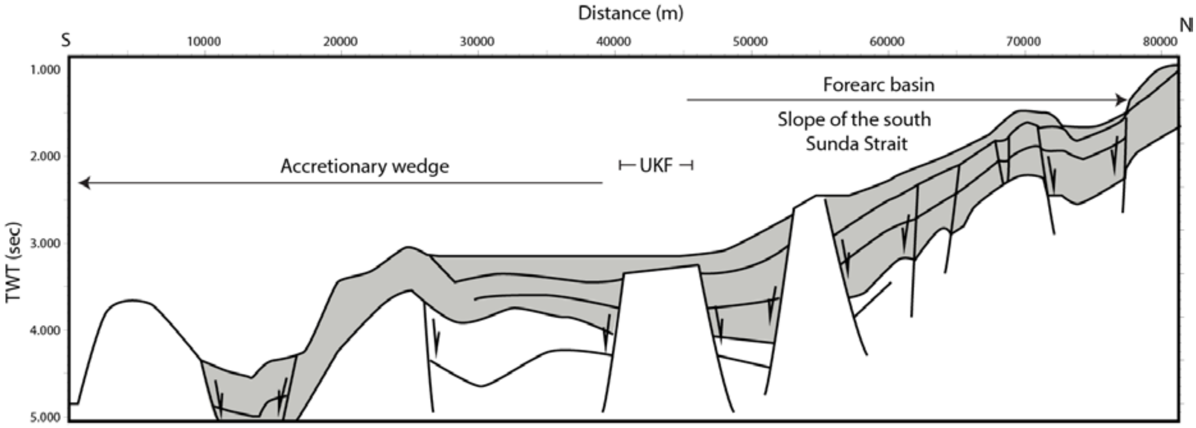

Figure 2. Feature of the UKF, horst and graben structures in between the Sumatra-Java forearc basin and accretionary wedge revealed from the seismic profile of Jabar-03. Modified after Malod et al. (1995). See Figure 1 for the location of the line.

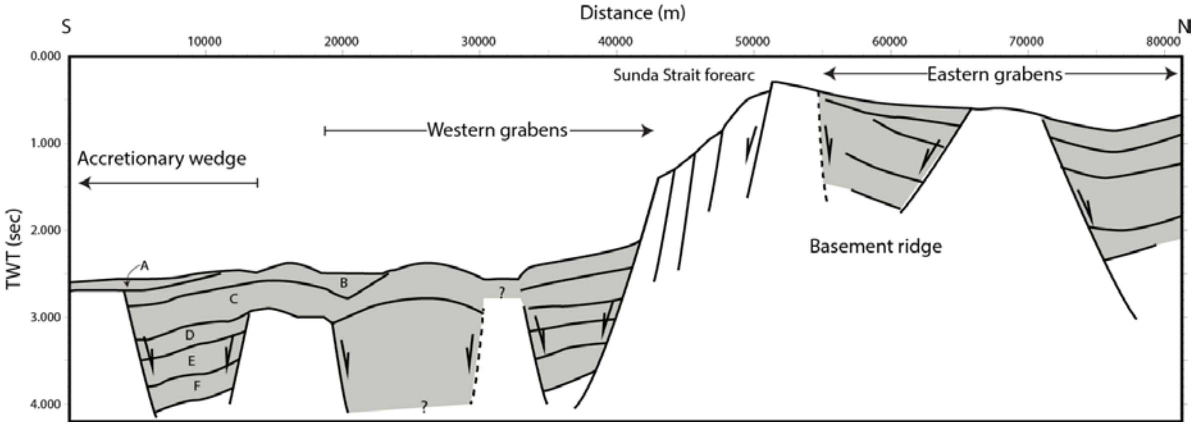

Figure 3. A horst structure in the boundary between grabens in the Sunda Strait and accretionary wedge depicted in the SO138-04 seismic section. Modified after Lelgemann et al. (2000). Young sedimentary units appear to have deposited above the horst structure.

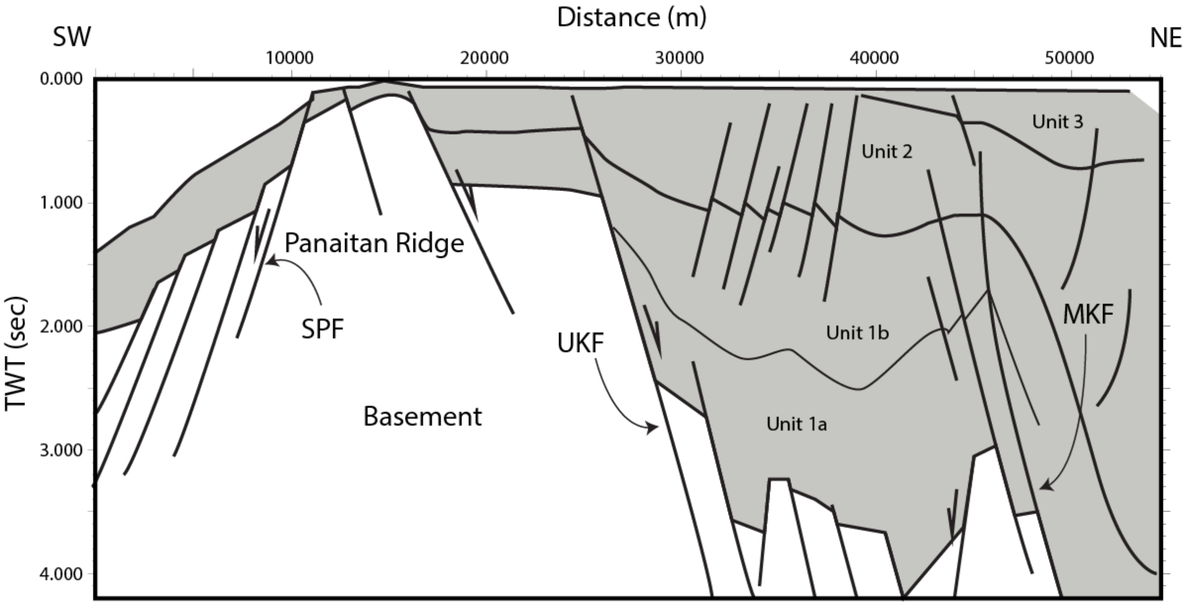

Figure 4. Interpretation of seismic profile crossing the UKF *sensu* Susilohadi et al. (2009) that exhibit as an east-dipping normal fault in the eastern flank of Panaitan Ridge. Redrawn after Susilohadi et al. (2009). UKF = Ujung Kulon Fault; MKF = Mid Krakatau Fault; SPF = South Panaitan Fault. See Figure 1 for the location of the line.

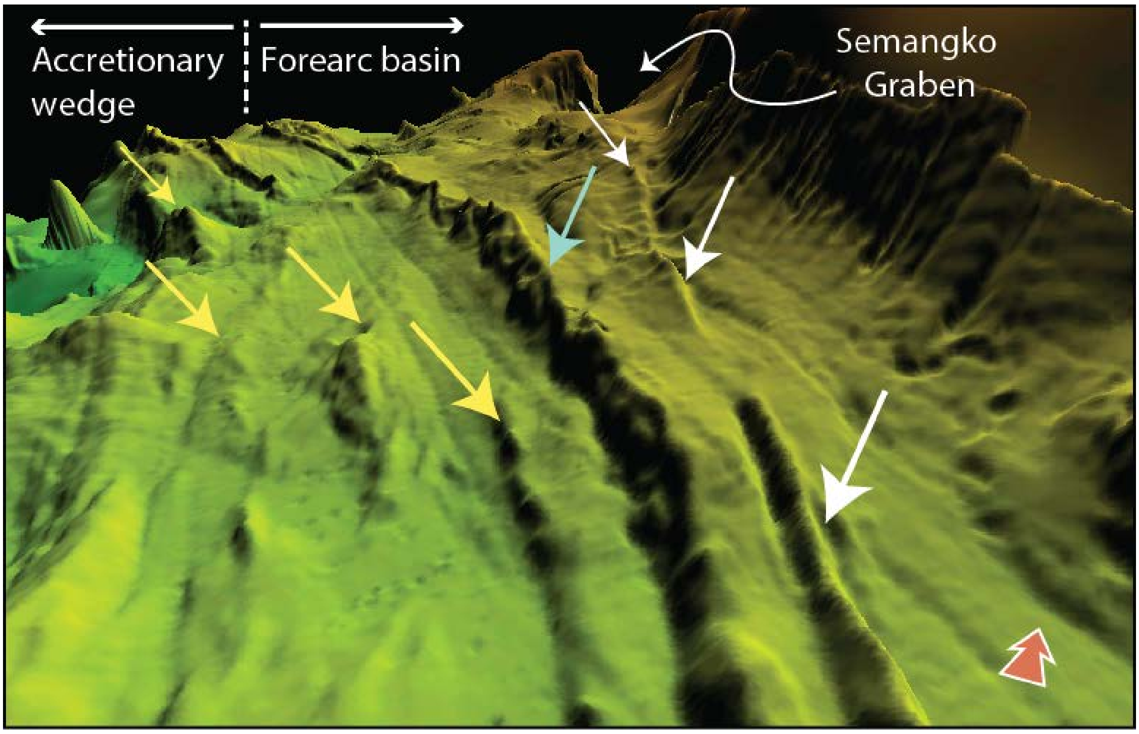

Figure 5. 3D perspective of bathymetry showing surface expression of structures in the south of western Java headed to the Semangko Graben. White arrows show the lineaments of UKF. The trace of Mentawai Fault is pointed by blue arrow. Yellow arrow marked lineaments of fold-thrust in the accretionary wedge complex. Red arrow for north direction.

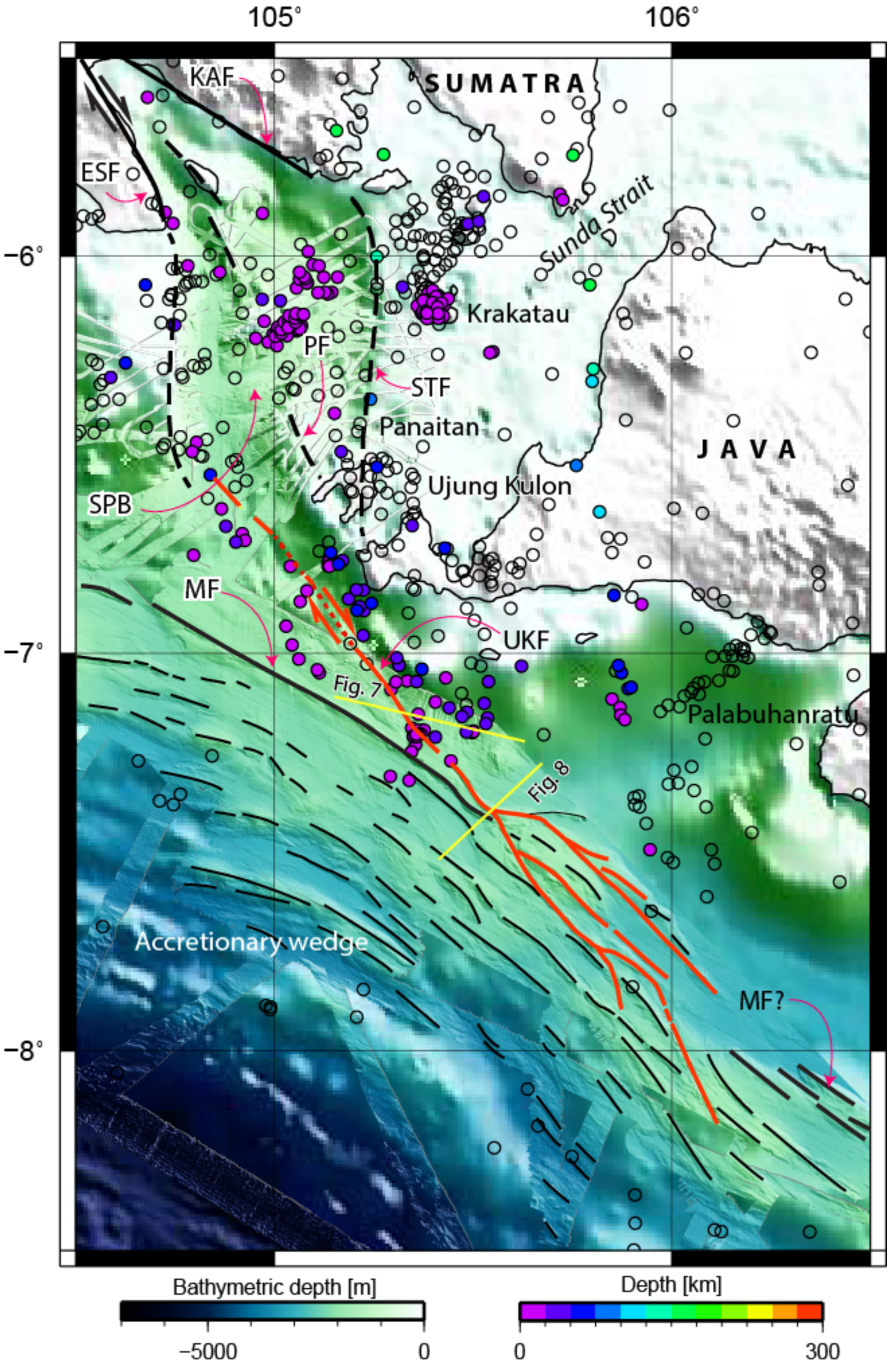

Figure 6. Bathymetry of the Sumatra-Java forearc showing expression of UKF on the sea floor. A straight lineament of UKF (solid red line) is observed to the south of Semangko Graben that can be traced farther southeast to the accretionary wedge complex south Java with a horse-tail structure termination. A cluster of seismicity (Jaxybulatov et al., 2011) is observed along the UKF (colored circles). Structures in the Semangko pull-apart basin (SPB) is simplified after Susilohadi et al. (2009) with some modifications. Black dashed lines in the center of the pull-apart basin represent lineaments observed in the bathymetry and seismic reflection data. Blank circles are seismicity data of Pesicek et al. (2010). UKF = Ujung Kulon Fault (this study); MF = Mentawai Fault; KAF = Kota Agung Fault; ESF = East Semangko Fault; STF = South Tanggang Fault; PF = Panaitan Fault. Fault name based on Susilohadi et al. (2009). Thin solid black lines are anticlines in the accretionary wedge.

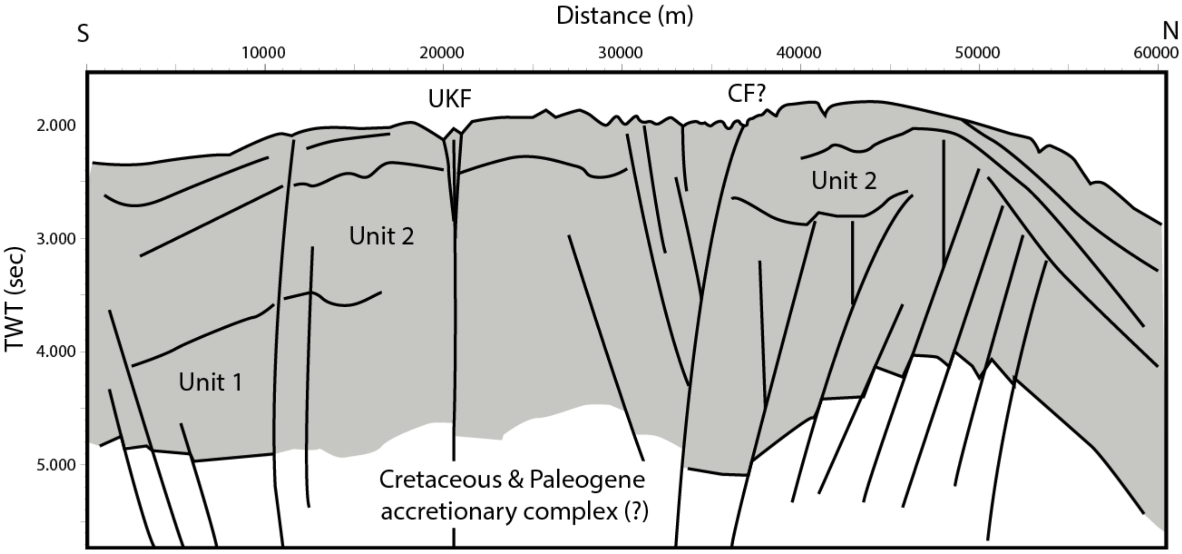

Figure 8. Interpretation of stratigraphy and structural styles in the area to the south of Ujung Kulon based on seismic reflection data, modified after Susilohadi et al. (2005). The UKF (this study) is marked by a negative flower structure. CF = Cimandiri Fault. Stratigraphic units are referred to Susilohadi et al. (2005).

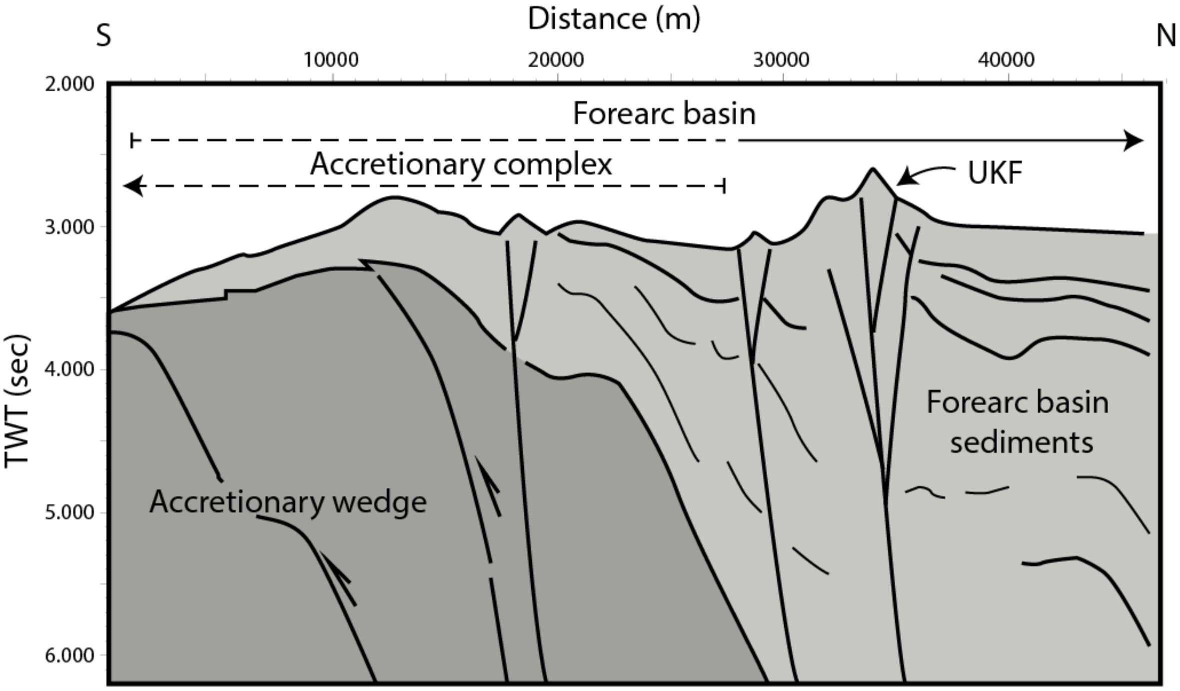

Figure 7. Re-interpretation of stratigraphy and structural styles in the area to the front of Palabuhanratu Bay based on seismic section in Susilohadi et al. (2005). The UKF (this study) is marked by a positive flower crossing the western flank of the south Java forearc basin. To the south of UKF, strike-slip faults deformed both forearc basin and accretionary wedge sediments. Note that the boundary between the accretionary wedge complex and forearc basin sediments is overlapped.

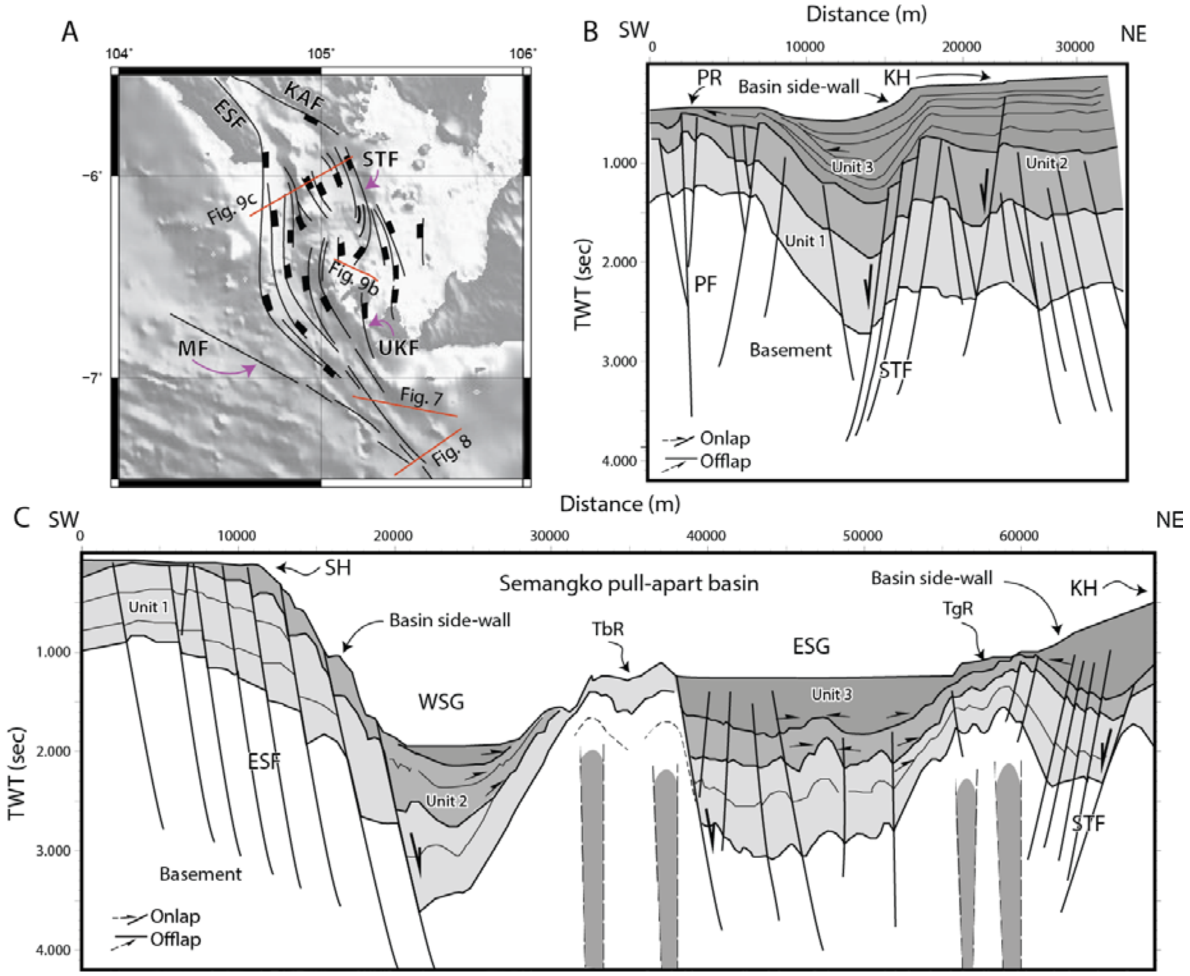

Figure 9. A. Simplified structural map of the Semangko pull-apart basin (SPB) showing seismic lines crossing the grabens. Modified after Susilohadi et al. (2009). B. Re-interpretation of stratigraphy and structures in the eastern part of SPB based on seismic section in Susilohadi et al. (2009). The previously unnamed fault zone beneath the basin side-wall may be coeval with the South Tanggang Fault (STF). Panaitan Fault (PF) is identified beneath Panaitan Ridge (PR) that previously unidentified in the seismic section. KH = Krakakatau Horst. C. Re-interpretation and structures and sedimentary units in the SPB based on seismic section in Susilohadi et al. (2009). West Semangko Graben (WSG) and East Semangko Graben (ESG) represent dual depocenters mode in the SPB. Tbr = Tabuan Ridge; TgR = Tanggang Ridge; SH = Semangko Horst; KH = Krakatau Horst