PROCEEDINGS OF GEOSEA XIV AND 45th IAGI ANNUAL CONVENTION 2016

"ASEAN Earth Resources and Geoscientist Role in AEC Era".

10-13 October 2016, Bandung, Indonesia

IKATAN AHLI GEOLOGI INDONESIA (IAGI)
IndonesiaAssociation of Geologist

Ikatan Ahli Geologi Indonesia (IAGI)
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PREFACE

The 45th Annual Scientific Convention of the Indonesian Association of Geologists (IAGI) this year has been held in conjunction with the GEOSEA Congress XIV (abbreviated as GIC-2016). The GEOSEA is a communication forum for the geologists in Southeast Asia countries.

The main theme of the event which is the ASEAN Earth Resources and Geoscientist Role in AEC (ASEAN Economic Community) Era has made the papers submitted and presented in the event covering a wide range of variety. The main theme covering two main topics, i.e. earth resources and geoscientist development in ASEAN countries has also been represented by the papers presented in this event.

Although since several years ago, the earth resource industry situation has not been that bright, triggered by the declining of commodity prices, regulation uncertainty, and also other issues related to the local stakeholders; this GIC 2016 event has attracted significant numbers of participants including industry geologists, faculty staff from the universities, government agencies, contractor companies, and other experts. It is the IAGI's pride to present this GIC 2016 event for the benefit of geological society in both Indonesia and ASEAN countries.

The proceedings contain all papers presented in the GIC 2016, covering various topics including

1. Engineering Geology, Hydrogeology, Mitigation and Applied Geology
2. Geology and Geophysics Method and Application
3. Geotourism
4. Mineral And Energy Resources Management
5. Mineralogy, Petrology, Geochemistry
6. Sedimentology, Stratigraphy, and Petroleum Geology
7. Tectonic, Structural Geology and Geodynamic
8. Volcanology and Geothermal

They are written by experts from various geology background including industry, government institutions, and universities.

On behalf of IAGI, we would like to thank all authors, paper reviewers, editorial team, and also to all sponsors from industry and government for their contributions and involvements. Without all of them the GIC 2016 event and the publication of this proceeding will not happened.

Bandung, October 2016

Sukmandaru Prihatmoko
Chairman of IAGI (Indonesian Association of Geologists)

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Palinspastic Reconstruction Of Structural Evolution In The Semangko Pull Apart Basin, Sunda Strait: Timing And Kinematics

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Abstract

Structural evolution of the Semangko pull apart basin in the Sunda Strait is analyzed based on palinspastic reconstruction of re-interpreted seismic reflection data to understand the timing and kinematics of structures in such basin. We use more than seven multichannel seismic reflection data combined with swath bathymetry and seismicity data available in this area. A package of NW-SE trending planar- and listric-normal faults appear to have formed as graben and half graben system. These structure packages are defined as graben and half-graben structures which are developed in this zone. The main graben is West Semangko and East Semangko Grabens, whereas another graben system is recognized farther east, the Krakatau Graben. The Semangko Grabens were developed due to the overstepping of the Sumatra Fault in the northwestern area, and Ujung Kulon Fault in the southeast. Palinspastic reconstruction shows kinematic evolution of the Semangko Grabens commenced in Middle Miocene, marked by the initiation of basement faulting with 0% to 4.77% extension, deposition of stratigraphic Unit 1 and Unit 2 started at 4.77% to 10.90% extension contemporaneously with the initiation of uplift of NW-SE trending ridges due to the development of cross-basin fault in a transtensional system. The Plio-Pleistocene Unit 3 deposited during 10.90 to 11.62% extension, accompanied with the uplift of ridges and eroded all rock units. Based on those observations, Unit 3 was developed as a syn-transtensional deposit. The western graben appears to be more active and developed as compared to that in the eastern part, possibly due to the activity of Ujung Kulon Fault.

Keywords: *Semangko pull apart basin, transtensional, graben, Palinspastic, Kinematic, Cross-basin fault*

1. Introduction

Semangko pull apart basin is one of the active deformation zone on the southeastern part of Sundaland. This zone is part of the Sunda Strait that include into transition of two subduction system which are Normal subduction of Java and oblique subduction of Sumatra (Hamilton, 1979; Malod et al., 1995) (Figure 1). Deformation activeness in this zone is evidenced by the high intensity of seismicity along the north-south (Harjono et al., 1991). Generally, Semangko pull apart basin is an extensional opening zone caused by southeastern part of fault Sumatra segment movement (Natawidjaja and Sieh, 2000) with Ujungkulon fault movement in the southeastern part of the Sunda Strait and also accommodated by movement of the Sumatra Plate sliver that has similar trending (Huchon and Le Pichon, 1984). That mechanism resulted this zone called transtensional system (Lelgemann et al., 2000; Susilohadi et al., 2009). This zone has been deformed by the structure since Middle Miocene until Resent. Palinspastic study was conducted to determine the structure and kinematic evolution process of the graben system origin on Semangko pull apart basin Sunda Strait.

2. Data and Method

This study was used multichannel seismic reflection (MCS) data, which has been re-interpretation from publication of Susilohadi et al, (2009) combined with data swath bathymetry Sunda Strait which has resolution 30arc per second. Interpretation of sedimentary strata refers to the concept of seismic stratigraphy Vail et al, (1977) to determined horizon and structural geology. From that result, structural analysis with palinspastic methods was done to determined time evolution of deformation and kinematic formed characteristics of graben evolution. This palinspatic method is very concerned to layer thickness and geometry of the fault in order to balance the cross section. This step was done in order to make the cross section become balanced and actual with field conditions.

3. Stratigraphy of Semangko Pull Apart Basin

Based on interpretation of seismic reflection which NE-SW trending, we obtained three stratigraphic units deposited from the late Miocene-Resent. All stratigraphic units was divided into two sequences, Late Miocene-Early Pliocene sequence and Late Pliocene-Resent sequence.

3.1 Unit 1

Unit 1 was divided into two sub-units: lower and upper 1 unit. Lower Unit 1 is late Miocene Sediment (Susilohadi et al., 2009) which has onlap toward basement as lower boundary. That boundary indicates unconformity, lower unit 1 has characteristics with high-medium amplitudes, low frequency, pararrel and with lateral continuity in Semangko Horst and Tabuan Ridge (Figure 2). Upper Unit

1 deposited as conformity toward lower unit 1, characteristic of internal facies is low-medium amplitudes, medium frequency, parrarel-sub parrarel, lateral continuity along Semangko horst, Tabuan ridge and Krakatau ridge (Figure 2 & 3).

3.2 Unit 2

Unit 2 is deposited as conformity overlaid unit 1, unit 2 is a rocks unit deposited during Early Pliocene (Susilohadi et al., 2009), This unit covered all area of basin part, reflection characteristics of unit 2 has medium-low amplitudes, medium frequency, parrarel-sub parrarel, lateral continuity in Semangko horst. Unit 2 deposition period is also influenced by the increased of magmatism and dyke intrusion that penetrate this sedimentary layer (Figure 3).

3.3 Unit 3

Unit 3 is deposited unconformity to unit 2, this unit has downlap as lower boundary and sequence boundary of Late Miocene-Early Pliocene sediment, unit 3 was deposite at Late Pliocene -Pleistocene (Susilohadi et al., 2009) with the characteristics of onlap fill, medium-low amplitudes, medium frequency, sub-pararrel (Figure 2 & 3). The thickness of this unit is highly variable ranging from 0.1 TWT in West Semangko graben and thicken towards N-E where in the depocenter of Krakatau graben based exploration well C-1 SX owned Pertamina and AMINOIL 1973 found that at depth of 3005 meters still get Late Pliocene sediment with claystone lithology associated with volcanic clastic sediment that was defined as a sublitoral-upper bathyal deposited (Noujaim, 1976).

4. Structural Geology

The results of seismic interpretation SO137-21 and SO137-23 found that the pattern of main structure was formed with NW-SE and N-S trend, where the Semangko pull apart basin formed half graben in west and eastern part of the graben. Structural package of westerm half graben has normal fault with planar geometry, whereas in the eastern part of the graben has a more varied geometry that is planar-listric normal fault.

Major fault located on western flank basin (West Semangko fault) and east (East Semangko fault) is active untill top unit 2 and limited by ridge in every fault, the western part is limited by Semangko horst have planar normal faults package characteristics (NW-SE) and the western part bounded by Krakatau ridge characteristics have varies packages fault was planar-listric normal fault (NW-SE), on the central Semangko pull apart basin is an ridge that is in form by the process of intrusion. this led to the formation of tilted block after unit 2 was sedimented and bounded by East Tabuan fault sloped towards the NE (Figure 3).

5. Palinspastic Recontruction

Based on balanced cross section reconstruction of line SO137-23, it was found that 12.38% extension which occurs from the Middle Miocene-Resen and 1.12 contraction ratio (Figure 4). Initial deformation is Basement block faulting in the Early-Middle Miocene with 0% extension and 0 contraction ratio.

In Late Miocene-Early Pliocene deposited unit 1 and unit 2 with a value of 4.77 to 10.9% extension and 1.04 to 1.10% contraction ratio. Unit 1 and 2 was deposited laterally and with similar thickness of Semangko zone. Unit 3 was deposited 11.62% extension ratio with a 1.11 contraction. Unit 3 was not deposited in every zones of Semangko pull apart basin. It can be seen at 12.38% extension at West Semangko graben that is thinned. Depositional units ends at the graben boundary until Semangko horst.

6. Interpretation and Discussion

Based on interpretation of 2D seismic reflection, swath bathymetry data and seismicity which was combined with palinspastic reconstruction, we can found that structure evolution of Semangko pull apart basin is closely related to transtensional zone caused by the activity of Sumatra fault and Ujungkulon fault movement in southeast. Middle Miocene or 0% extension is initial phase of local deformation caused by "basement" block faulting. This phase has a local slope basement morphology in southwest, in the Late Miocene or 4.77 to 8.59% extension is a time when unit 1 deposited on basin and ridge with the similar thickness and was not influenced by transtensional structure in this area so this unit 1 is categorized as a sediment pre-transtensional.

Unit 2 was deposited on early Pliocene-late Pliocene or 10.9% extension with sediment covered Semangko pull apart basin, after unit 2 deposition, reactivation of old structure as evidenced by the difference of throw on hangging wall side, antithetic fault emergence and commencement of removal from Tabuan ridge caused by the activities of cross-basin fault SE-NW trending, beside of that, after last deposition of this unit, graben with trending SE-NW and N-S was formed as a result from transtensional system in this zone, based on this interpretation, unit 2 was pre-transtensional sediment.

Unit 3 was deposited at Late Pliocene -Pliestocene or 11.62 to 12.38% extension, this unit is not deposited in Semangko horst and eroded in Tabuan ridge-Panaitan ridge. Unit 3 is closely associated with the formation of pull apart basin in this zone because these units have varying thickness which is caused by a constant decline in the East Semangko Graben Krakatau graben. Because of that, this unit was classified as a syn-transtensional. Graben of west zone implies more active than eastern part, this implies with greater total subsidence and deformation was concentrated

in half-graben if we seen in regional seismicity, it was interpreted as a result from the movement of Ujungkulon Fault was more active in the southeast.

Structural evolution of Sunda Strait started from Middle Miocene (Figure 5) which was in this epoch as origin of Sumatra dextral fault zone with trending SE-NW, the evolution continues in the late Miocene- Early Pliocene was formed en-echelon fault along east-west wing and central basin zone, at the end of the Pliocene-Pliestocene, en-echelon fault was merged with PDZ (Principle Displacement Zone) forming west Semangko fault and east Semangko fault. Faults formed at the central basin is a right oblique strike slip fault where the results of fault activity makes this zone weak, that weak zone as accommodation emergence of intrusion activity and led to the appointment Tabuan and Panaitan island, this activity was look from unit 1 and unit 2 internal reflector where the reflector converge towards the ridge which was suggests a tilted block and the initiation of removal Tabuan ridge after deposition of unit 2 and continues after unit 3 deposition.

Conclusions

- Semangko pull apart basin formed by movement of the overstepping fault SFZ and UKFZ.
- 2 major structural pattern that is formed predominantly normal faults (N - S) and (NW - SE) trending.
- 3 units rocks Late Miocene-Pliestocene; unit 1 and unit 2 pre-transtensional , unit 3 syn-transtensional.
- Total strain formed of Middle Miocene-Resen of 0.123 total extension 12.38% and contraction ratio of 1.12.
- The western graben appears to be more active and developed as compared to that in the eastern part, possibly due to the activity of Ujung Kulon Fault

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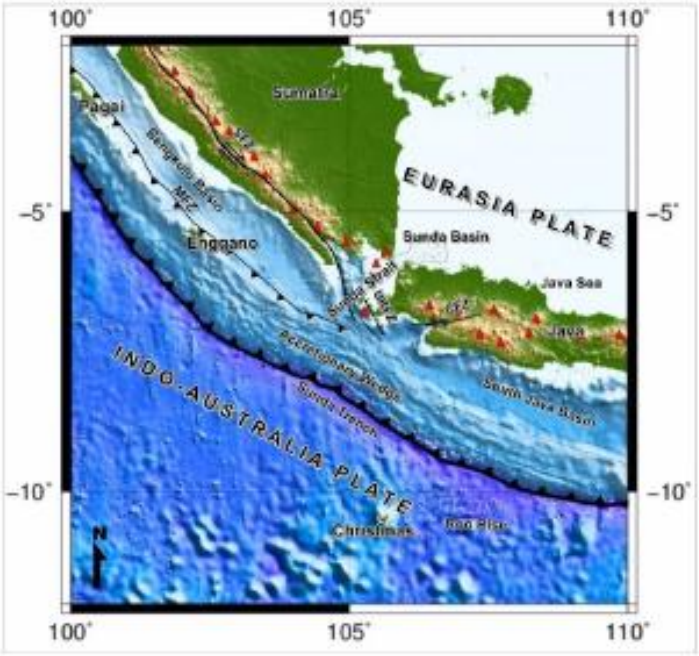

Figure 1 : Tectonic map of Western Sundaland SFZ based on Sieh and Natawidjaja (2000), MFZ Based on Susilohadi et al., (2005), CFZ Based on Malod et al., (1995), Sunda Trench basen on Hamilton (1979) and research location at Semangko pull apart basin, Sunda Strait

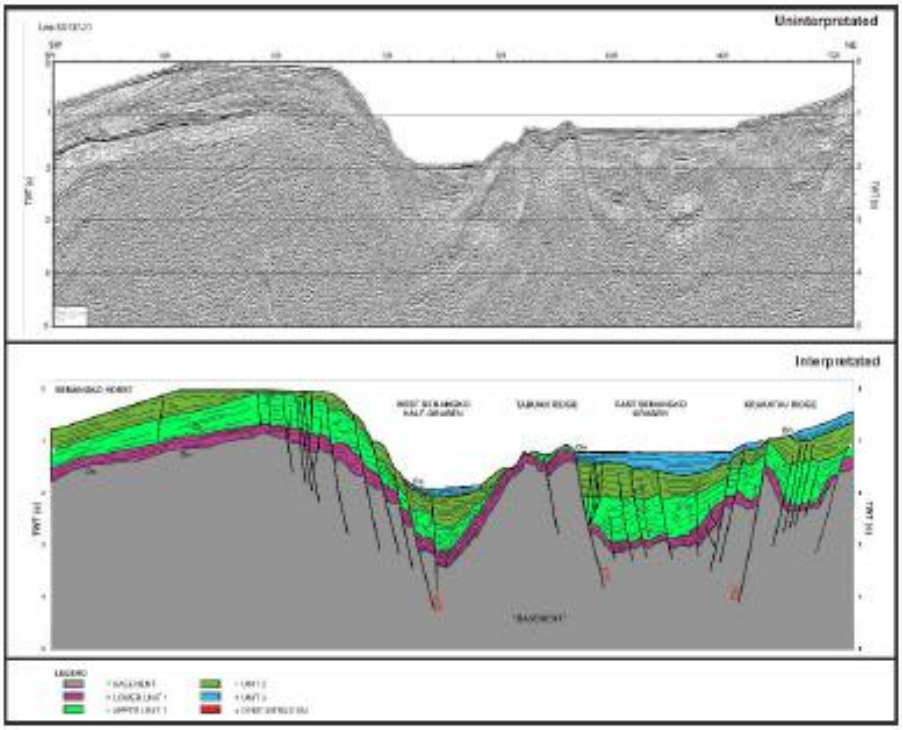

Figure 2 : Seismic section Line SO137-21 re-interpretated Susilohadi et al., (2009)

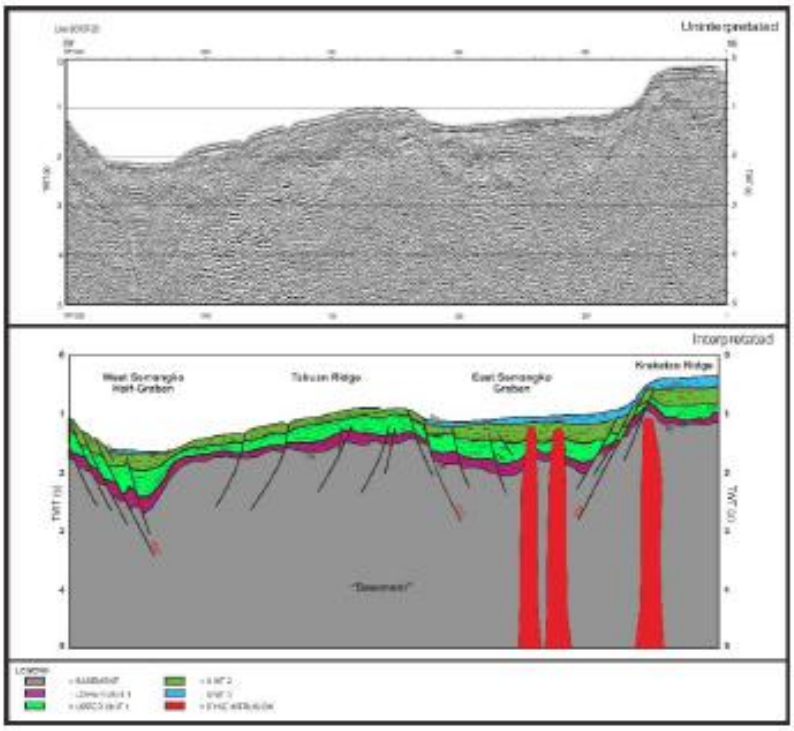

Figure 3 : Seismic section line SO137-21 re-interpretated Susilohadi et al., (2009)

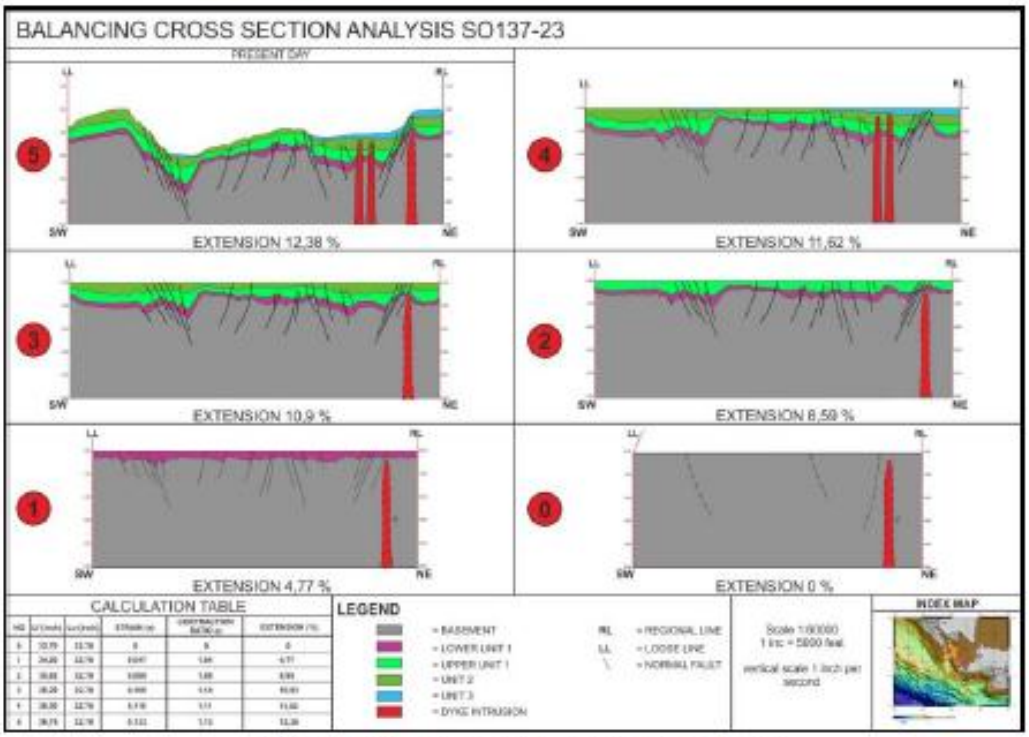

Figure 4 : Result of palinspastic reconstruction line SO137-21

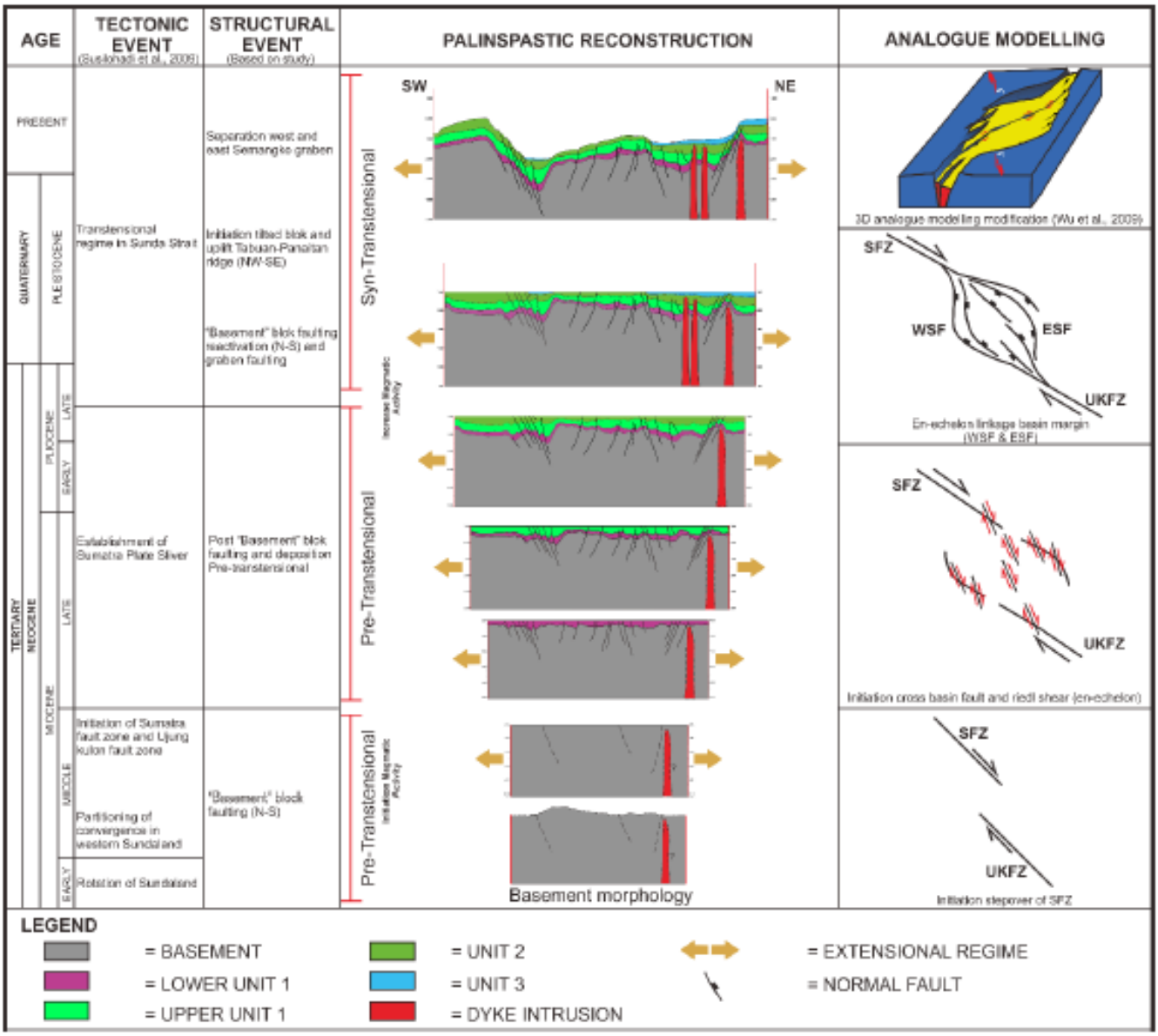

Figure 5 : Structural evolution diagram for the research area, tectonic event based on Susilohadi et al., (2009) and 3D analogue modelling based on Wu et al., (2009)