Plate Tectonic and Regional Structural Geology in West Java

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Abstract

Although the geological structures of Java Island has been widely studied, but there were still many problems that cannot be explained, especially regarding to the genetic relationship between regional fault structures that developed in this region.

There are differences in the pattern of faults that developed within the pre-Tertiary basement rocks and Tertiary sedimentary rocks covers. The main structures which developed in the basement are generally having EW, NE-SW and NS directions; whereas in the Tertiary sedimentary rocks, the structure are generally trending to EW as a thrust folds structure. The exception of the Pelabuhanratu and Citanduy Faults, fault structures with the other directions are relatively localized as tear fault.

The fault structures of NE-SW trending are associated with subduction activity during Cretaceous period. This fault pattern has been reactivated during the Early Tertiary tectonic period which generate fault structures of NS trending. At that time, the position of the subduction track have been in position as it is now (modern subduct). Subduction activity of the last stage, in addition to activating the old structural pattern has also formed a new fault pattern with EW direction. This fault pattern was then controls the formation of fore arc basin, back arc basin and volcanic ranges. The three of fault patterns above, contribute to the formation of the Tertiary basins in the western part of Java Island (pre-rift).

Pre-rift fault patterns were still active until the Oligocene epoch (Syn-rift). This condition is reflected from the configuration of distribution the Paleogene rocks formation which are bounded by fault structures, and shows the difference in the thickness of rock layers. Therefore, the entire fault pattern that formed in Paleogene sedimentary rocks, were generally involving the basement rocks (thick skin tectonic).

At the end of the Tertiary, the entire of Tertiary age sedimentary rocks have been folded and faulted with generally EW direction (post-rift). This latter fault structures, generally were not directly related to the pattern of old faults but involves only to its rock covers which forms thrust fold structure pattern (thin skin tectonic).

Keywords: basin, fold, fault, subduction, tectonic, volcanic.
Introduction

The history of plate collision of Java Island have been concluded differently by a number of researcher. However, the pattern of faults as one of its secondary product were relatively similar although the formation age and mechanism have also been determined differently. Through this paper, we believe that there are only two subduction track during Cretaceous and Tertiary periods. Those are the Cretaceous Subduction track that cross through Ciletuh-Meratus and the Tertiary Subduction track as the latest pathways with the position as it is now. Each of subduction activity has formed with different structural pattern, depending on the position of subduction track at that time.

Method

It was difficult to determine the regional structures based on the basement rocks in the study area if its based only on the field data, because of limited bedrock outcrops. Therefore, most of the result were obtained from the subsurface geological studies that have been published (figure 1). Furthermore, primary data which related to the fault, were wholly obtained from field outcrops of sedimentary rocks that exposed in the field (figure 2-6). By combining all of data that related to the structures of whole Java Island which have been made by previous researchers, it can be concluded that there are four major fault patterns. These patterns are: the fault of NW-SE trending, NE-SW trending, EW trending and NS trending (figure 7 and 8).

The whole of structural patterns are the result of the plate collision activity that have occured on Java Island. Based on the history of its plate collision, it can be seen that there are two subduction track which have different age and position, namely the Cretaceous Subduction and the Tertiary Subduction track or also named as the Modern Subduct (Katili, 1973; Asikin, 1974; Hamilto, 1979; Martodjojo, 1984; and Davies 1984).

With reference to the relationship of structural patterns and subduction activities as mentioned above, there will be two major structural patterns in Java Island which contribute to the formation of the Tertiary sedimentary basins, they are the Fault pattern of EW trending which have relationship with the Tertiary
subduction and the Fault pattern of NE-SW trending which associated with the Cretaceous subduction. Although the Tertiary sedimentary basins in the study area are dominated by both patterns, but also found structural pattern of NS trending which also controls the formation of the Tertiary sedimentary basin, such as those in the basin of northern West Java.

There are genetical relationship between the development of major fault patterns and subduction activities. Regional structures in a particular area will have a pattern that parallel to its collision track. One such example as occured in Southeast Asia. In this region, around the mountains of Himalayas the development of structural patterns are dominated by EW direction that parallel to the position of plate collision track. Thus also in Sumatera and Java Island, each pattern is dominated by the SW-NE and EW trending and parallel to the position of subduction track. The next is between Sumatera and Java Island or in the region between the Sunda Strait and Ujungkulon, the structural pattern is dominated by WNW-ESE direction caused by the subduction path that began to turn-out around this region, which originally trending NE-SW on Sumatera Island and became trending EW in the Southern of Java.

Based on this explanation, it can be concluded that the major structure that developed in the basement rocks of Java Island, consists of two main patterns. Those are the NE-SW trending pattern that associated with the Cretaceous subduction and the pattern of EW trending which parallel to the Tertiary subduction (figure 9). The relationship to the Tertiary subduction, that pattern of EW trending is controlling position of basins (forearc and backarc basin) and highs (volcanic arc). Another direction of fault pattern were categorized as secondary fault and stated as a new formed fault structure or as a result of reactivation of old fault by younger tectonic.
Fault pattern of NE-SW Trending on Basement Rocks

The structural pattern of NE-SW trending is an old fault that have formed simultaneously with the Cretaceous paleo-subduct. In northern part of West Java, this structural pattern have formed a number of sub-basins and highs, among others are Karimun Jawa High, Vera Basin, Biliton Basin and Zaitun Basin. The NE-SW structural pattern is also develop in the Southern of West Java – Banten, such as in Ujungkulon Offshore, Pelabuhanratu – Ciletuh Offshore and in the Ciletuh Valley. The following are the explanations:

The NE-SW Fault Pattern in the Northern of West Java

In this region, there are many fault patterns of NE-SW trending were found. This fault is contribute to the development of Paleogene highs and basins (figure 10). Regionally, the fault pattern has grown to the northern region of Central and East Java and continuously up to southern Kalimantan. Pembuang Basin is one of the basin in Central Kalimantan which orientation controlled by the NE-SW fault pattern.

Currently in the northern of West Java, position of NE-SW structural patterns are inside the backarc basin which controlled by structural pattern of EW trending. Therefore, the Paleogene highs and basins of EW direction, can be stated as local highs/basins (secondary) that located inside the regional backarc (main). Based on this reason, the structural pattern of NE-SW is a result of reactivation old faults by the Tertiary Subduct System.

The NE-SW Fault Pattern in Western Part of Southern Java

In the offshore of Ujungkulon, fault structures were found in the basement rocks and having direction of NE-SW (Yulianto, et al., 2007). Based on analysis of the regional structures, it can be concluded that its formation was the result of reactivation of old faults that has formed and associated with the Cretaceous Subduction. In the subsequent tectonic periods, this fault was continued to be active and simultaneously with the Paleogene sedimentation process. There is similarity of the structural pattern within the basement rocks compared with the pattern in the Middle Eocene sedimentary rock that overlies on it, to prove this conclusion.
Fault Pattern of Pelabuhanratu-Ciletuh Offshore

Fault pattern of Pelabuhanratu-Ciletuh offshore is a regional fault pattern with NE-SW direction and developed intensely around the area of Pelabuhanratu-Ujung Genteng. One of these regional fault named as Pelabuhanratu Fault (Malod, J.A., et al., 1995).
Fault Patterns of NS and NNE-SSW directions

There were found structural patterns of NS and NNE-SSW directions which dominantly developed around the western part of West Java and Banten (figure 1). As mentioned previously, these structural patterns have resulted a number of Paleogene sub-highs and sub-basins, for example in the northern of West Java have formed the Tanggerang High, Ciputat Basin, Rengasengklok High, Pasir Putih Basin, Pamanukan High and Jatibarang Basin (figure 1); whereas in the southern part (South Banten) have formed the Ujungkulon High, Ujungkulon Basin, Honje High, and Malingping Basin. The entire sub-basins are located within back arc basin, fore arc basin and intra montane basin which the nature as the main basin in the Tertiary Collision System.

The NS fault pattern has begun to form in the Early Paleogene and controled the distribution of Eosen to Early Miocene sediment such as Jatibarang Formation, Talang Akar Formation and Baturaja Formation. The fault pattern was continued to be active until penetrate the Middle Miocene sedimentary rocks (Patmosukismo, S. and Yahya, I., 1974; figure 1). Entering the Upper Miocene age, sediment which accumulated in it has covered the entire sub-basin and consequently spreaded out and filling widely to back arc basin. One of the evidence is the spreading of Parigi Carbonate Formation (Middle Miocene) that covers the entire basin.

The explanation above shows that the sedimentation process during the Oligocene and late Middle Miocene has occurred simultaneously with a subsidence of the basin. For that reason, it can be concluded that the fault pattern of NS and
NNE-SSW directions were not categorized as major fault but as the pattern of local structures that contribute to the formation of the Paleogene sub-basin.

The mechanism of the NS and NNE-SSW fault patterns can be explained by using Riedel Shear Concept (figure 11). As it mentioned previously, the fault structures of NE-SW direction has occurred during the Cretaceous period. Fault pattern was then activated by a younger tectonic at the time when the position of subduction track has already in the southern of Java Island with EW direction. During that time, the compression forces of NS trending has caused NE-SW fault pattern reactivated and forming a fault pattern with NS direction as an extensional fault and fault pattern with NNE-SSW direction as Synthetic Riedel Shear. In this case, the Pelabuhanratu and Sunda Strait Faults which flanking the region of Banten, plays an important role in the development of fault pattern of NS trending in this region (figure 10).

**The Fault Patterns of EW direction**

Fault structure with the EW direction within the pre-Tertiary basement rocks, is a dominant and regional structural pattern. Similar with the structural pattern of NS and NNE-SSW directions, the pattern of EW is a newly formed fault structure during the Early Tertiary, and not as a result from reactivation of an old fault.

Based on seismic interpretation of back arc basin, fault structure within the basement rocks partially has penetrate into the sedimentary rock formation that lies over it. This fault pattern is always concluded as a result of reactivation of old faults that have been formed in the course of the Cretaceous subduction.
Essentially each of new plate collision, in addition to activating the old fault pattern is also forming a new pattern of structure. Therefore, not all the fault structures within the basement rocks in Java Island are the result of reactivation of an old fault. Considering the fault pattern of EW direction is parallel to the Tertiary Subduction track, therefore the inferred of its formation is associated with modern subduction (Cenozoic Subduction).

The fault pattern of EW direction in Java Island has controlled the formation of highs and lowlands, including forearc basin, accretional prism, volcanic arc, and back arc basin. Fore arc basin and deep ocean trenches are located in the southern Java Island, both are separated by an accretional prism. Inside the both basin, sediment accumulated in thick beds and has deformed to be folds and faults (figure 9).

Parallel to the fore arc basin, in the northern part have formed intra montane basin that located inside the volcanic ranges. Because of this position, the sedimentary rocks that accumulated inside the basin are containing volcanic material. In accordance with the Tertiary volcanic lines in Java Island that having EW direction, then the basins that formed inside are also have the same direction. It is also evidenced by the data of rock layers orientation and strike pattern reconstruction that shows the EW direction of distribution.

The EW fault pattern which believed to be related to subduction activity is Cimandiri Fault. The fault line or path is relatively coincides with the Cretaceous Subduction, thus concluded by Martodjojo (1984) as a result of reactivation of the paleo-subduction traces. Based on analysis of stratigraphic data, morphology and fault traces that were obtained from field surveys, it can be concluded that Cimandiri Fault was reactivated in the Late Tertiary as normal fault and reverse fault.
Conclusion

1. There are two major patterns of fault structures in Java Island, namely the fault of NE-SW and EW trending. The first one has formed and related to the Cretaceous subduction activity and the last one associated with the Tertiary subduction activity.

2. The fault pattern of NE-SW trending has caused the formation of highs and basins, including Biliton Basin, Bawean Basin, Karimun High, etc; whereas those of the EW fault pattern has caused the formation of fore arc basins, volcanic ridges and back arc basins.

3. The Tertiary Subduction has reactivated old fault patterns (Cretaceous) and produced fault pattern of NS direction. This formed a number of sub-basins and sub-highs, including Sunda Basin, northern West Java Basin, Tangerang High, Ujungkulon Basin, Ujungkulon High, Bayah High, etc.

References


