Storms and Volcanoes : Preservation of Catastrophic Events in the Tanjung Layar Outcrop, Bayah, Banten, Indonesia

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Abstract

A detailed analysis of sedimentology, stratigraphy, and general biostratigraphy of the early Miocene Bayah area in Tanjung Layar outcrop indicates that the depositional environment of the area is shoreface. Three principal facies associations were defined within the sedimentary record of the Tanjung Layar outcrop based on petrography and observed sedimentary structures : i) storm beds, ii) lithic conglomerates, and iii) volcaniclastic deposits. Lithic conglomerates and volcaniclastic deposits are interpreted as debris flows derived from subaerial and subaqueous material. From thin sections, the immature volcanic material consists of feldspar, quartz, plagioclase, some opaques, and lithic fragments. Locally, bioturbated storm beds can have good reservoir potential in the Tanjung Layar area.

Keywords: Miocene, shoreface, subaqueous debris flows, petrography

1. Introduction

The sedimentology and stratigraphy of Tertiary outcrops in the Bayah of western Java have been described in general terms by previous authors (Clements and Hall, 2007; Keetley et al, 1997), but not in detail. The present study investigated the early Miocene Tanjung Layar outcrop in which several hundred meters of clastic sediments are exposed along the shoreline. The objective was to determine the paleodepositional environment and stratigraphic architecture.

The Bayah and Honje Highs are Tertiary structural highs located on the south coast of West Java, Indonesia, situated at the margin of the Malingping Low, the western extension of the Bogor Trough. Tanjung Layar outcrop as the study focus is part of the Bayah High comprises large E-W trending anticlines.

Based on the age (early Miocene), the Tanjung Layar sediments belong to the Honje Formation which includes volcanic deposits and shallow marine sediments (Keetley et al, 1997). The Tanjung Layar outcrop is located in Sawarna, Bayah sub-District, Banten Province, Indonesia (Figure 1). The approximate location is Latitude $06^0 59'41.9''$ South and Longitude $106^0 18'20.7''$ East.

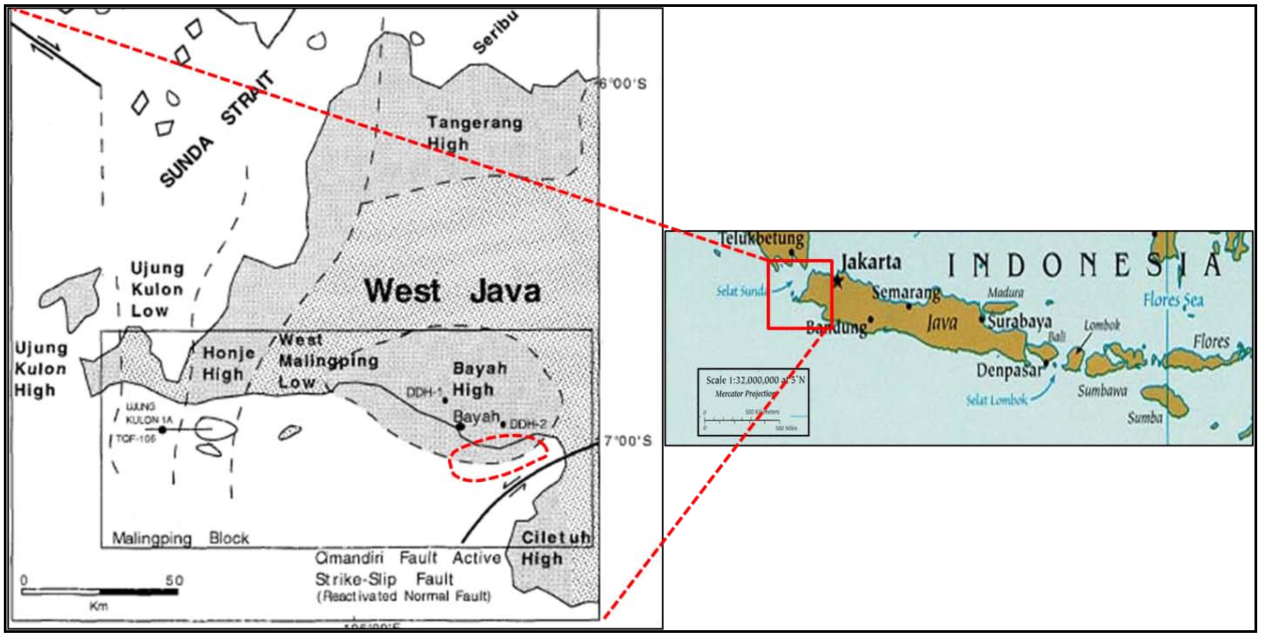

Figure 1. The Tanjung Layar outcrop, marked by the red dashed line, is part of the Bayah High, West Java region and Banten province, Indonesia.

Figure 2. The Tanjung Layar outcrop.

2. Sedimentary Facies and Depositional Environments

Based on measured sections, there are three facies in the Tanjung Layar outcrop. As defined based on lithology, sedimentary structures, and biostratigraphy.

Storm Beds

This facies association includes three lithofacies: i) *storm beds with mudstone interbeds*, ii) *bioturbated storm beds with mudstone interbeds*, iii) *hummocky cross stratified sandstones*.

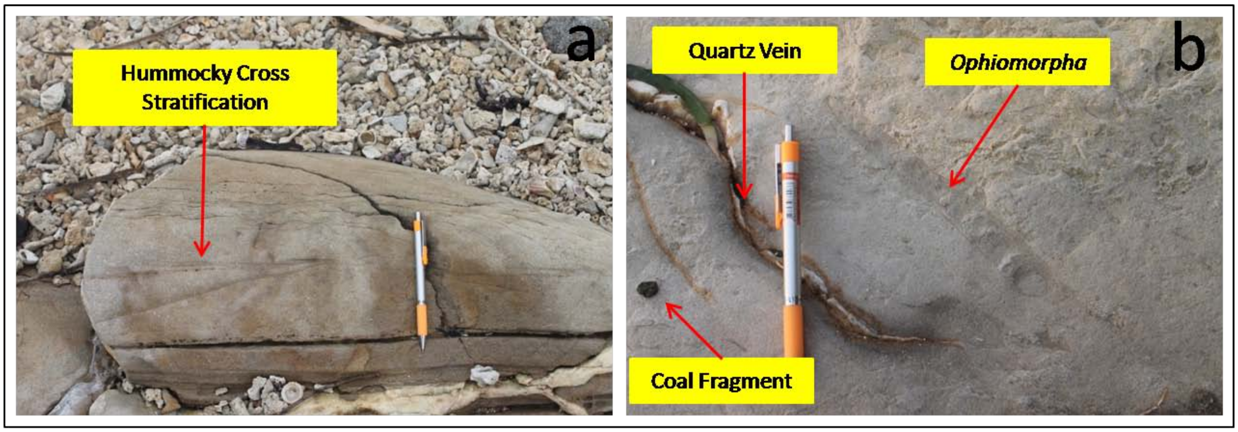

Figure 3. A- hummocky cross stratification found in the beds, B- *Ophiomorpha* is one of bioturbation record was found in the beds, there are coal fragments also which derived from terrestrial and quartz veins that dominant cut through of beds.

Sandstone beds form showed characteristic of storm beds. The beds are relative thin, continuing and dominant alternating with mudstones. Storm beds are product of shoreface environment. Erosive contact into mudstones suggest that the beds deposited with high energy which derived from storm or hurricane. there are abundant of parallel bedding in the beds. Cross bedding and asymmetrical ripple are common in the sandstone beds. Hummocky cross stratifications (HCS) are the most important sedimentary structure to identify storm beds. Not easy to find HCS on beds, therefore limited distribution. Moreover, presence of bioturbation in the facies also give evidence that the lithologies deposited in shoreface environment. Quartz veins which appear in the facies suggest that there were tectonic activities after deposition of the sediments.

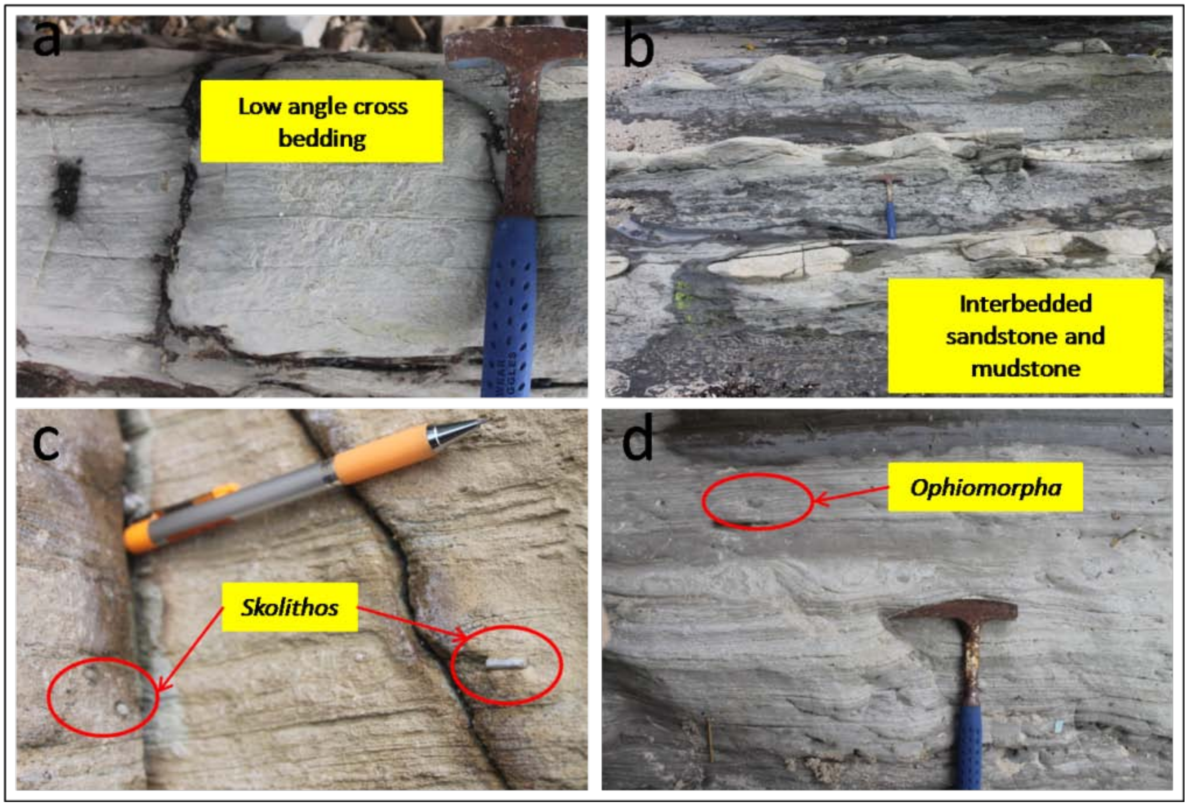

Figure 4. Sedimentary structures and bioturbation that found in the beds, A- low angle cross bedding, B- interbedded sandstone and mudstone is characterized of shoreface deposits, C- *skolithos*, D- *ophiomorpha*.

<u>Lithic Conglomerates</u>

This facies association is represented by two lithofacies: i) *Matrix supported lithic fragment conglomerate*, and ii) *Conglomeratic lithic sandstones*.

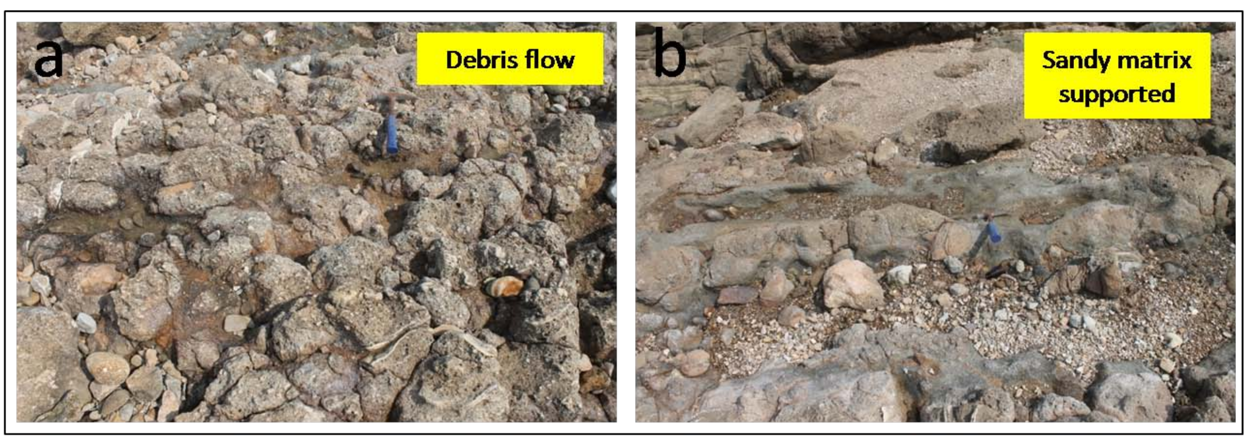

Figure 6. A- debris flows produced matrix supported conglomerate with no sedimentary structures, B- in the upper part, the conglomerate is dominant of sandy matrix supported.

Matrix supported conglomerate with no sedimentary structures indicates that the material was deposited from debris flows (Figure 12A). Hummocky cross stratification (HCS) in some lithic conglomeratic sandstone beds suggests that the facies was reworked by waves or storms. Moreover, its association with shoreface suggests that this facies developed in a subaqueous environment. Very high energy is needed to deposit conglomeratic debris flows, suggesting the depositional environment was on the slope.

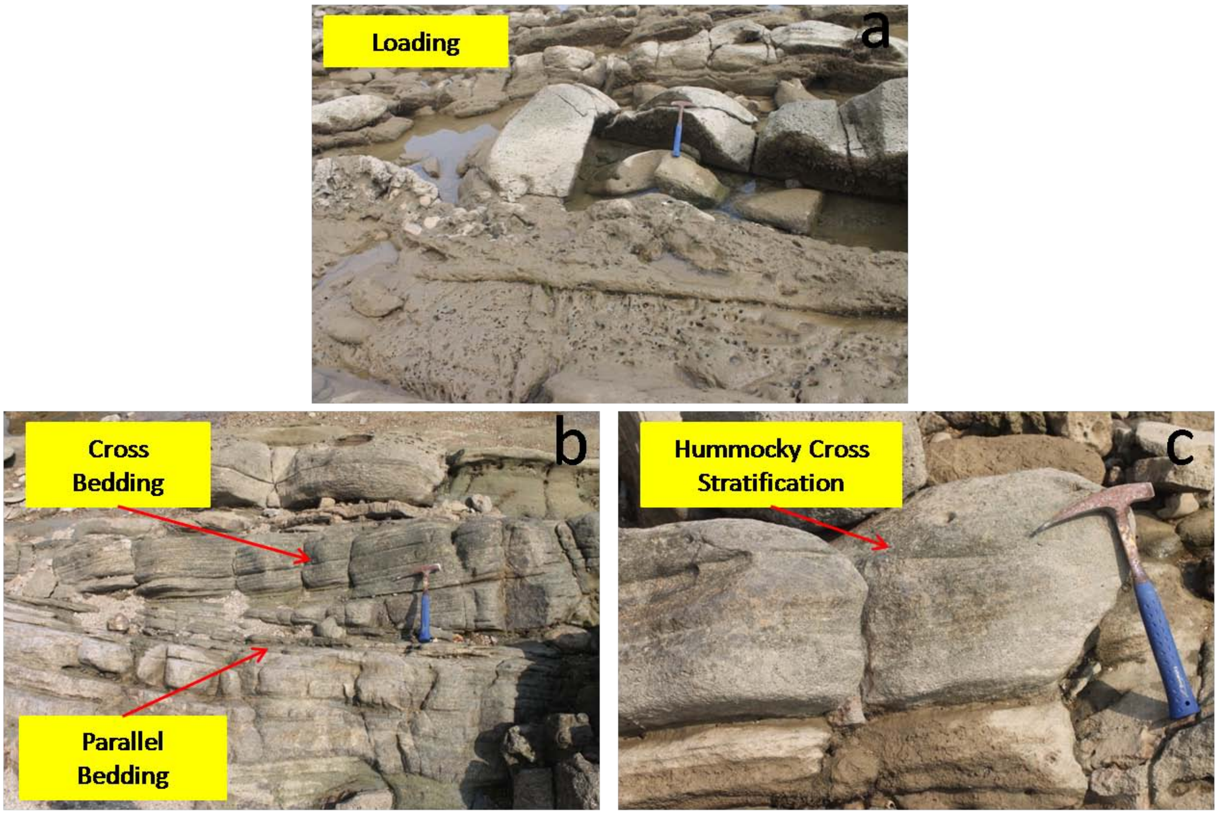

Figure 7. A- loading, B- sedimentary structures; cross bedding are rare in the beds,and parallel bedding are abundant in the sandstone beds, C- hummocky cross stratification found in the beds.

Volcaniclastic Deposits

This association is represented by three facies: i) *volcaniclastic gravelly sandstones*, ii) *volcaniclastic conglomeratic sandstones*, iii) *volcaniclastic conglomerates*.

Matrix support indicates that the material was deposited from cohesive debris flows. Volcanic material suggests that the sediments were derived from a subaerial source and transported into a subaqueous environment. The presence of coal fragments suggests that the material was transported from land into the sea. Subangular to subrounded grains indicates immature volcaniclastic material that was transported not far from its source.

Fining upward succession also suggest that gravity flows play a important role in this deposit because the big material will deposited in the bottom part of conglomerate bodies.

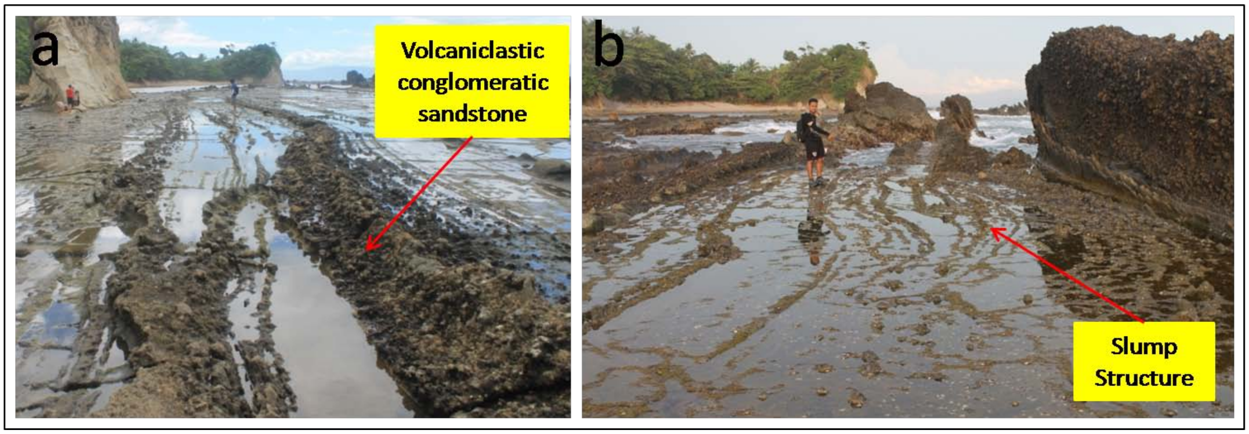

Figure 8. A- volcaniclastic conglomeratic sandstones with have both matrix supported dominantly and clast supported, B- Slump structure which occurred after deformation of rocks.

Slump structures in the outcrop were formed after deposition because they occur in multiple beds, not only in individual beds. This could be caused by tectonic as the outcrop location is in a subduction zone. Joints and minor faults are visible in the outcrop.

3. Stratigraphic Development

The vertical succession of the Tanjung Layar outcrop has a total thickness of 371.5 meters with 101 meters of unexposed section that is possibly mud. Generally, the shoreface depositional system has both progradational and retrogradational parasequences while the subaqueous debris flows are retrogradational. An erosive surface between the shoreface sands and the subaqueous debris flows is a possible sequence boundary.

4. Origin of volcaniclastic material

Sand in the conglomerates and conglomeratic sandstones was derived from volcanic material. Overall, angular shape dominates among the glass fragments, suggesting autoclastic, or hydroclastic fragmentation. Poor rounding of glass fragments argues for short transport.

In thin section, there is a lot of immature volcanic material such as elongate feldspar, lithic fragments, quartz prisms, and some opaques.

5. Depositional Setting

The depositional setting of the Bayah area was characterized as volcanic breccias, ignimbrites and epiclastic sediments from previous studies (Clements and Hall, 2007).

The present study suggests that the depositional environment of the Tanjung Layar outcrop are integrated to the previous studies and adding new interpretation about subaqueous debris flows. Recent study discuss more detail about lithologies which dominant of sandstones and mudstones in the shoreface area.

Recent research reveals that detail sedimentation processes in the study area by explaining the deposition setting in the shoreface environment which had facies changed from thin sandstones interbedded with mudstones to thick storm beds deposits. Depositional process in detail of subaqueous debris flows can be a new regional geology benchmark of surrounding area that not discussed before.

Regional geology of Bayah area which belong to Honje Formation is not mention about storm beds and subaqueous debris flows. The literatures mention about lihologies (litharenites, arenites, limestones, and volcanic deposits) and depositional environment in shallow marine (Keetley et al, 1997).

Association between storm beds and debris flows deposits is a continuation of previous studies and then improved to be used as a reference to determine the depositional setting of early Miocene deposits in the Bayah area.

6. Reservoir Implications

Locally, bioturbated sandstones can have good reservoir potential in the Tanjung Layar area. Bed thickness is around 12.5 m, and they extend more than five hundred meters.

Although volcaniclastic gravel sandstones have thick beds (more than 10 m), the lithofacies is not a good reservoir because of its matrix components. Volcaniclastic gravel sandstones typically have very low preserved porosity due to their abundance of mechanically and chemically unstable grains (Surdam and Boles, 1979).

Generally, reservoir potential of the whole Bayah area is poor. The lithologies are dominant of Miocene deposits which included volcanic material.

7. Conclusions

The sedimentology and sequence stratigraphy of Tanjung Layar outcrop indicates that :

a) The Tanjung Layar outcrop was deposited in a shoreface environment and includes subaqueous debris flows.
b) There are three facies that can be identified bases on the lithology, sedimentary structures, and biostratigraphy.
c) Shoreface strata are laterally extensive for at least 138 meter. However, the lateral extent of subaqueous debris flows of volcanic and lithic material is 132.5 meter.
d) In summary, the volcanic material most likely comes from a subaerial rhyolitic in clast source area. from thin section, in those lithologies there are a lot of volcanic material such as elongate Feldspar, lithic fragments, quartz prism, and some opacities.
e) Generally, reservoir potential of the whole Bayah High is poor because dominant of subaqueous debris flows of volcanic material.

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