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Stratigraphy and Structural Geology of Ciuyah Mud Volcanoes in Ciniru Area,West Java

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Abstract: ***Studio work, field observation and laboratory analysis has been done to confirm stratigraphic framework and structural geology in Ciniru Area. It is expected to confirm geological influence on the Ciuyah mud volcano complex in this area. The lithostratigraphic succession of Tertiary sediment was compiled by calcareous mudstone and sandstone, tuffaceous mudstone and sandstone, limestone, conglomerate as well as breccia of varying thickness. Those sediments ranging in age from Middle to Late Miocene was accumulated in deep open marine by turbidity current system. Igneous rock and Quaternary lava, lahar and piroclastic deposits were exposed locally. On the basis of imagery interpretation and field data, structural geology lineaments recorded dominantly in WSW – ENE and NW-SE directions, with minor in NE-SW-wards. Fluid and gas ejected through Tertiary sediments rock layers to surface when they find a structural geology fracture that associated with tectonic activity. It shown by similarity of mud fow orientation and structural lineaments.***

Keywords: lithostratigraphy, structural geology, Ciuyah, mud volcanoes, foraminifera

1. Introduction

Mud volcanoes are known as topographical expressions of naturally occurring cone formations created by geological erupted liquefied sediments and very fine grain size fragments, liquids and gases. It may be formed by a pressurized mud diapir which breaches the Earth’s surface. Mud volcanoes are mainly related to rapid sedimentation rates of thick deposits, occurrence of abnormally high formation pressure or overpressures fluids, under-compacted sediments, active compressional tectonics, high seismicity, occurrence of fault and the generation of hydrocarbons at depth. Typically they also related to tectonic subduction, accretionary system, passive margins within deltaic systems and active hydrothermal, collisional tectonic, convergent orogenic and active fault, fault-related fold and anticline. Structural geology acted as preferential pathways for deep formation fluids to reach the surface (Istadi, et al., 2012) [3]. The research on sedimentary successions and structural geology in Ciniru and surrounding areas was expected to confirm geological influence on the mud excretion phenomena in this area. The 22.5 ha square Ciuyah mud volcanoes are situated in Ciniru District.

2. Regional Geology

On the basis of landsat imagery and field observations on Ciniru and its surrounding, from the area between coordinates 7^{0}00’00”S to 7^{0}20’00” S and 108^{0}25’00” to 108^{0}35’00” E (Figure 1), the geomorphological units formed alluvial plain to high relief hill landform (Muhammadsyah, et al., 2012) [6].

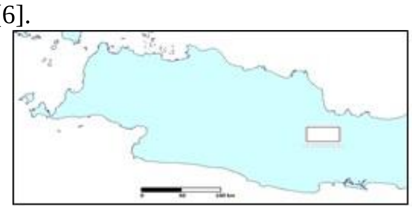

Figure 1: Ciniru area located approximately 25 km southeast of Kuningan Regency, West Java

Tectonics

Due to its position at the front of the subducting Australian plate under the Indo-Asia plate to the south, Java has been tectonically active. The study area are influenced by two tectonic phase. The first periods, taking place in the Middle Miocene resulted in uplift and was followed by andesitic and basaltic intrusions. The Pemali, Rambatan, Lawak and Halang Formations were folded and faulted. The NW-SE and NE-SW trending normal faults came into being. The second period, during the Plio-Pleistocene time, resulting in the formation of NW-SE to NE-SW trending strike-slip and thrust faults. The Plio-Pleistocene tectonism is characteristized by the formation of block-faulting. Moreover, the recent geophysical data tend to explain that the last tectonism reactived the previous normal faulting (Simanjuntak, 1979 and Wiriosudarmo, 1979 in Kastowo and Suwarna, 1996) [4].

According to Kastowo and Suwarna (1996) [4] and Budhitrisna (1987) [1]., this area is occupied by Tertiary sedimentary rock (Pemali, Rambatan, Lawak and Halang Formations), igneous rock, and Quaternary poorly consolidated deposits.

Pemali Formation (Tmp), consist of marls, tuffaceous sandstone and sandy limestone. Rambatan Formation (Tmr), is composed by sandstone and conglomerate. It is underlain conformably by the Pemali Formation. The Lawak Formation (Tml) that formed by limestone, calcareous sandstone and marl overlies conformably the Rambatan Formation. The lower part of Halang Formation is compiled by tuffaceous sandstone, conglomerate, marl, claystone and andesitic lava, whereas the upper part by reef limestone. Andesitic and basaltic lava, flow breccias and volcanic plugs are found locally. Lahar deposits (Qlc) and volcanic product of Careme (Qvyu) as well as river terrace (Qt) and alluvium (Qa) are partly covered the older sediment.

3. Methods

The research was begun by collecting secondary geological data. Landsat imagery interpretation has been done to find out lineaments and geological features of Ciniru and surrounding areas.

Geological mapping was taken mainly to identify lithology (type, texture, and typical characteristics) and structural indication in this area. The measuring sections were carried out to acquire stratigraphic relations between the widely spaced outcrop sections in the studied area. Samples were collected samples for laboratory analysis. The mud eruption was observed to find out the orientation of Ciuyah conduit system.

Twenty two rock samples have been selected on the basis of key stratigraphic levels. Sediment samples were analyzed in order to determine microfossils content. It will be used for age dating and depositional environment interpretation. Three muds have been analyzed in laboratory to confirm fragment composition and microfossils content.

4. Result

4.1. Stratigraphy

The lithostratigraphic succession was started by thick beds of calcareous mudstone with intercalations of calcareous sandstone and medium limestone (Figure 2). Calcareous mudstone are greyish blue, partly brittle. Calcareous sandstone are grey, fine grain sized, well sorted, subrounded, composed of feldspar, quartz, biotit and calcite. Clastical limestone are light grey, fine grain-sized, well sorted, subangular, contains microfossils. The appearance of *Globorotalia mayeri* and *Globorotalia praemenardii* - planktic foraminifera in samples which collected from Cipedak, Ciawi, Citapen, Cijamaka and Cibongkot Rivers confirmed that the unit was deposited in Middle Miocene or not younger than N.12 (more than 12.5 million years ago) (Isnaniawardhani, et al. 2015; Melty, et al., 2015) [2], [5]. Sedimentary structures (parallel lamination, cross bedding, convolute lamination and ripple marks) that supported by benthic form assemblages which shows sedimentation occured in upper bathyal bathymetric zones. Kastowo and Suwarna (1996) [4] and Budhitrisna (1987) [1] has named this unit as Pemali Formation (Tmp).

Figure 2. Calcareous mudstone with intercalations of calcareous sandstone and limestone outcroped on Sungai Cipedak.

The younger succession was composed by alternating of calcareous sandstone, conglomerate and mudstone (Figure 3). Sandstone are light grey, fine to coarse grain-size, sub angular, poorly sorted, composed by quartz, feldspar and calcite. Conglomerate is grey with poorly sorted rounded andesitic to basaltic fragments and calcareous sandstone matrix. It is overlain by thin beds greenish grey mudstone with thin sandstone intercalation. Tuffaceous sandstone with intercalations of poorly sorted conglomerate, breccia and mudstone overlies conformably the lower interval. Tuffaceous sandstone are light grey, fine to coarse grain size. poorly sorted, subrounded. Conglomerate is grey with poorly sorted rounded andesitic to basaltic fragments and tuff matrix. Breccia is grey with poorly sorted, angular andesitic to basaltic fragments and tuff matrix. Well bedded light grey limestone are outcroped locally. Mudstone is greyish blue. Commonly the sedimentary structures that recognized in the unit are gradded bedding, parallel lamination, convolute lamination, and flute-cast, it suggest the deposition in an open marine by turbidity currents. The appearance of *Sphaeropdinellopsis subdehiscens* and *Globorotalia siakensis* associated with *Globigerinoides subquadratus*, *Hastigerina siphonifera* and *Globorotalia menardii* in the lower part of this sections show the accumulated of sediments occurred in Middle Miocene or N.13 to N.14 (about more than 11.3 my before present). The appearance of *Globigerina nepenthes*, *G. praebulloides Globorotalia continuosa*, *G. menardii*, *G. pseudomiocenica Globigerinoides subquadratus*, and *Hastigerina aequilateralis* in the middle part of this sections suggested a Late Miocene age or N.15 (about 11.3 to 7.1 my BP.). The age of upper part of section was formed in Late in Late Miocene or in N.16 to N.17 (about 7.1 to not younger than 5.3 my BP) on the basis of *Globorotalia acostaensis*, *G. merotumida*, *G. dutertrei*, *G. humerosa*, *G. ruber*, *Candeina nitida*, *Globigerinoides extremus* and *Hastigerina aequilateralis* recorded in samples. Regression and transgression phase characterized by appearance of typical deep and shallow benthic foram. Neritic zone assembages is predominantly by Bolivina, Heterolepa, Pyrgo and Quinqueloculina; whereas bathyal zone by Brizalina, Globocasidulina and Melonis (Isnaniawardhani, et al. 2015) [2]. Previous study have named the last four units as Rambatan (Tmr), Lawak (Tml), and Halang Formations (Tmph/Tmphl) respectively.

Figure 3. Alternating of calcareous sandstone and mudstone on Sungai Cipedak

Basaltic lava breccia, lahar and volcanic deposits marked the volcanic activity in Plio-Peistocene. There is no fossils in these units. River terace and alluvial fan deposits are exposed along river-side.

4.2. Structural Geology

Structural geology imprinted out in the Miocene to Holocene rocks. On Landsat imagery, those are three lineament trends can be clearly recognized as lineaments, bedding slope and morphological or topographical geometry. In places the image interpretation is supported by field data, such as position, bedding and joint dips. Some of them are presumed to be a fault (Figure 4 and 5).

Detail surface mapping concern on structural geology recorded fold axials extending in Ciniru Area with WSW-ENE major direction. Faults pattern, comprising thrust and strike-slip types, present in the WSW – ENE and NW-SE trends as shown in Figure 4 and 5. These fault are affected the Tertiary clastic sediments that covered by alluvial sediments. Lineaments are interpreted as faults and joints which exist in the NE-SW direction trend.

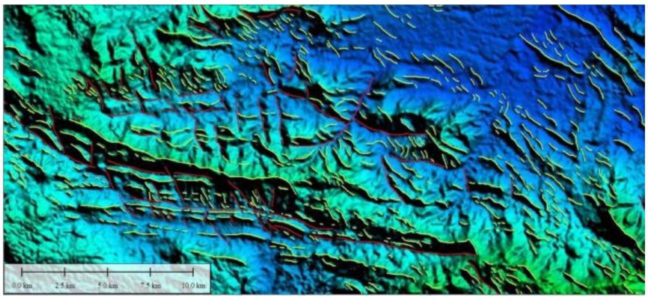

Figure 4. The lineament of fault, joint and fracture on the basis of the Landsat imaginery interpretation

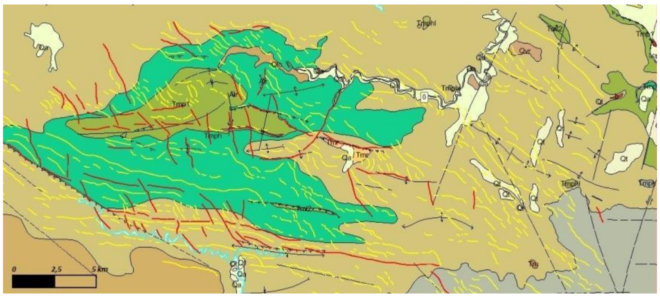

Figure 5. Stratigraphic framework and structural lineaments on Ciniru area

4.3. Eruption Materials

The materials ejected by the mud volcano are: (a) grey fine grain sized well sorted subrounded calcareous sandstone; (b) greyish blue mudstone; (c) light grey, fine to coarse grain-size, sub angular, poorly sorted sandstone; (d) light brown limestone (e) light grey fine to coarse grain size poorly sorted subrounded tuffaceous sandstone; and andesitic and basaltic fragments

Mud samples contains both planktic foraminifera (among all: *Candeina nitida*, *Globigerina nepenthes*, *G. praebulloides G. venezuelana*, *Globigerinoides extremus*, *G. immaturus G. obliquus*, *G. ruber*, *G. sacculiferus*, *G. trilobus*, *Globoquadrina altispira*, *G. dehiscens*, *Globorotalia acostaensis*, *G. dutertrei*, *G. humerosa*, *G. mayeri*, *G. menardii*, *G. merotumida*, *G. obesa*, *G. praemenardii G. pseudomiocenica*, *G. ruber*, *Hastigerina aequilateralis*, *H. siphonifera*, *Orbulina bilobata*, *O. suturalis*, *O. universa*, *Sphaeroidinellopsis seminulina*, and *S. subdehiscens*) and benthic foraminifera (among all: Bolivina, Bulimina, Brizalina, Casidulina, Cibicides, Dentalina, Elphidium, Eponides, Gyroidina, Globocasidulina, Hyalinea, Lenticulina, Martinotiella, Melonis, Nonion, Nodosaria, Nummulites, Planulina, Pyrgo, Quinqueloculina, Robulus, Rotalia, Sigmoilina, Stilostomella, Textularia and Uvigerina genera).

Laboratory analysis on mud samples shows the similarity of fragments composition and foraminifera content between mud and rock samples. It is assumed that fluid and gas ejected in mud volcanoes in Ciuyah have passed through Middle Miocene intercalations of calcareous mudstone and sandstone layers (lower succession) and Middle to Late Miocene intercalation of calcareous sandstone, mudstone and breccia layers (upper succession). It was supported by field data interpretation on the basis of rock layers dip (Figure 6).

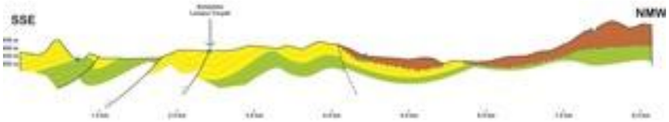

Figure 6: Profile of conduit system in escaping natural gas that rises to the surface (modification from Muhammadsyah, et al., 2012) [6].

4.4. Vent Orientation

The mud ejected to surface through vents which developed in generally vary from NW – SE ward, with minor WSW-ENE and SE-wards. The distribution of vent appeared to be in line with the direction of structural lineament (Figures 7 and 8). It is assumed that mud eruptions are associated with both major and secondary structural lineaments within the regional stress field.

Figure 7: The distribution of vent in Ciuyah Mud Volcanoes

Figure 8: The orientation of mud speading in Ciuyah

5. Conclusions

The lower lithostratigraphic succession is compiled by mudstone with intercalations of calcareous and tuffaceous sandstone. This interval was deposited in Middle Miocene or N.12 (more than 12.5 my BP). Sedimentary structures features and benthic form assemblages indicated the sedimentation occured in upper bathyal bathymetric zones.

The upper section consisting mainly by calcareous and tuffaceous sandstone, conglomerate, breccia, and mudstone deposited during Middle to Late Miocene age or N.13 to N.17 (more than 11.3 to 5.3 my BP) . Those sediments was accumulated in neritic to bathyal open marine in a turbidity currents system. It is reflected by sedimentary structures and benthic assemblages recorded in rocks.

Basaltic lava breccia, lahar and volcanic deposits marked the volcanic activity in Plio-Peistocene. The sediments covered partly by river and alluvial fan deposits.

The succession of Tertiary layers beds have been passed through fluid and gas during eruption. Lineament which occurs dominantly in WSW – ENE and NW-SE directions with the minor NE-SW-wards controlled the distribution and direction of conduit system.

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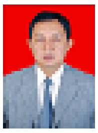

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