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Expert Discourse

## **Sidoarjo Mudflow Hypothesis in Geological Perspective**

[Photo caption. DR Ir. Agus Guntoro, M. Si.]

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So far, there are at least four hypotheses explaining the mud flow.

The Sidoarjo Mud (LUSI) which has occurred since 29 May 2006 until today is not subsiding, and it is in fact increasing. That mud flow is a difficult subject to explain both in technical or non-technical perspective. Thus, it becomes a long drawn out problem because there is lack of correct understanding of the event.

Explanations for the causes of the flow have been put forward by experts from various fields, and up to now there is no single and thorough conclusion. Technically, from various geological and geophysics data, there is still disagreement between the hypotheses and the existing data.

Besides that, the data are not well integrated, resulting in some difficulty in drawing conclusions about the causes of the mud flow.

Thus far, there are 4 (four) hypotheses that have been revealed to explain the mud flow; First, the flow occurs as a result of drilling activities. Second, the flow is caused by Earthquake. Third, the flow occurs as a result of *mud volcano* activity. And fourth, the flow is associated with or due to geothermal activity.

Each of the hypotheses above have different thought processes and are supported by different data. It would be a good idea if we look at the thought processes of those hypotheses and whether they fit the facts and data normatively, qualitatively, and quantitatively.

#### **Due to BJP-1 Well Drilling Activity**

This idea is the most dominant opinion and it has been socialized at every level of the community. Physically, the Sidoarjo Mud flow or LUSI occurs near the drilling location of the Banjar Panji Well-1 (BJP-1) which at the same time had a drilling problem. In this hypothesis, the allegation is that not running casing in the well between 3000 - 9000 feet was the main cause of the mud flow. Based on this

hypothesis, LUSI or the Sidoarjo Mud flow can be explained as follows.

The BJP-1 Well is an exploration well to test the geological and geophysical interpretation that hydrocarbon accumulation is present (also called as "Lead") in the Kujung Formation, a Carbonate formations at about 9,000 feet below the surface. The determination of this depth in the prognosis and interpretation was proven inaccurate which is common due to various factors. From the drilling report, when drilling activity reached about 9,200 feet, a *loss* occurred (the loss of drilling mud to a very *porous* formation). As a consequence, there is a *kick* (influx of fluid and gas, coming from the formation that has been penetrated by the drilling activity due to the decrease of the hydrostatic pressure in the well after the loss of the mud column because of the previous mud *loss*).

This kick or influx of fluid to the surface has been detected. The decrease in the hydrostatic pressure in the well resulted in a *kick*. In various drilling activities, this *kick* could lead to a flow in form of gas or oil from the reservoir to the surface. But, what has actually happened in the BJP-1 Well? This well clearly has no flow whatsoever. But around 150 m southwest of the well, the

flow occurred and it is now widely known as the Sidoarjo Mud Flow (LUSI). Then, does this hypothesis have correct arguments base on the existing facts?

**Due to Yogya Earthquake (occurred 2 days prior to LUSI)**

Earthquake is a natural event which occurs as a result of the release of the accumulated energy from rock masses that are pressured. These pressurized rock masses, in some specific critical point, crack (rupture) and releases elastic waves which are a fore shock in a series of earthquake vibration, and afterward, the rock will in turn break followed by the release of energy in form of elastic wave which is the main shock (Tarigan 2005).

Therefore, an earthquake has a close relationship with, what is known as a fault, so this earthquake line is also a fault line.

The process of energy release along a fault plane of rocks produces waves which will travel in rocks as media, and this will result in a number of deformation processes, one of which may cause liquefaction. This incident could make the rocks become squeezed and the fluids that are found among the particles are squeezed out, and, the rock layer becomes a slurry (liquid) that has no bearing

strength and it will lead up to tilt, submerge, sink or subsidence, failure of buildings and infrastructures whose foundation stands on such ground layer (Tarigan 2005).

It is thought that this earthquake could trigger the liquefaction that has occurred from the Kalibeng formation at the depth of approximately 2,000 feet - 6,000 feet which are over pressured. According to this hypothesis, the liquefaction process occurred. The Yogyakarta earthquake which occurred two days before this overflow may have triggered this liquefaction. Is that so?

**Due to Mud Volcano activity process.**

A mud volcano is a genetic geologic term. The term mud volcano is generally used in order to describe an appearance similar to an eruption or surface extrusion of mud, water or clay that sometimes occurs simultaneously with the outflow of methane gas (CH<sub>4</sub>).

Generally, a mud volcano tends to form solid mud or clay around the flow in the form a dome or any other form similar to a volcano. However, the shape of such mud volcano is not always like a dome; it may result in incompetent masses, and if it is squeezed, this will be go up along a weak zone such as fault or rupture.

Generally any seepage in form of gas, oil or salt water to the surface indicates the existence of mud volcano below. This is very common occurrence in East Java, especially around Porong, Sidoarjo. The appearance of Mud Volcanoes in the world varies from calm to explosive eruptions due to methane gas. Therefore, it is very reasonable to conclude that the existence of methane gas on the surface is also an indication of the existence of a mud volcano below. Observed data also indicates the existence of methane gas released together with this mud flow.

Judging from the size of the flow from this mud volcano, this hypothesis should be considered as the causes. But then, can we trust this hypothesis?

**Due to the presence of Geothermal activities.**

In addition, there is another hypothesis that attempted to show the role of geothermal process. This is because the existence of heat which is the source and water reservoir.

This reservoir is connected to a surface reservoir which continually recharges the heated reservoir. Geologically, the south of Banjar Panji Well is a volcanic complex area, and Mount Welirang is probably the source of

the active magma. It is assumed that this volcanic complex is a recharge area for the surface water. Again, is that so?

Then, the question to be raised is that "which of the four hypotheses is the true cause of the Sidoarjo Mud flow?"

In order to find the answer, it requires an investigation to synergize all data in a correct, accurate as well as honest manner. It seems that up to now, it has yet to succeed, and thus it needs verification, compilation as well as interpretation for all the available data and information that could satisfy all the stakeholders. Nevertheless, on the basis of the geological perspective, the available data tend to point toward the hypothesis associated with the existence of mud volcano processes. Based on the geological map of the Porong area - as it is seen in Banjar Panji, there is a well know surface structure, called as Watukosek Fault. The most interesting thing is that this Watukosek Fault is parallel and probably almost in line with the location or the point of hot mud overflow in the area around the Banjar Panji-1 Well.

With the similarity in terms of pattern and direction of the fault and mud flow, it is then interpreted that the mud flow is associated with the fault zone.

The result of seismic analysis that can be correlated to the paleo structure diapir in the Porong Well, it is felt that the source of the mud is on Ngimbang Zone or Kujung Zone from Eocene to Oligocene age.

One of the most interesting facts is that there is mud flow that occurred around 1000 years ago north of the Banjar Panji Well-1, namely in Kalang Anyar Village. At this location, it is found that there is mud volcano with the height of almost 20 m, and until this time this is still flowing.

Geographically, the location is in a direct line with another Mud Volcano in Pulungan Village, Mt. Anyar as well as Sidoarjo in the Northeast- Southwest direction.

Conclusions regarding the age of this flow is based on the existence of the Tawang Alun Temple with a Majapahit Kingdom Relic (personal communication Soffian Hadi 2006). In the location that is believed to have been built to commemorate the incident; very much like what is happening in Sidoarjo today.



### **Conclusions**

- a. A Mud Volcano is general phenomenon which is generally found starting from West Java to North Lombok in a west-east direction.
- b. Geological facts in the areas around East Java and Sidoarjo, shows that both active on inactive mud volcanoes are commonly found.
- c. It is very possible that the Sidoarjo Mud flow is not related to any drilling activities; but is a natural phenomenon in form of a mud volcano which comes out through the reactivated fault zone due to the earthquake that occurred in Yogyakarta two days before the flow.