After four years of Ground Displacement following LUSI Mud Volcano eruption: Sign of its ending eruption

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FIG Working Week 2011
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011
Main Vent of LUSI

Steam spraying out from the main vent of LUSI
FIG Working Week 2011
Bridging the Gap between Cultures
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Hasanuddin Z. Abidin, 2006

Flooded Factories

Hasanuddin Z. Abidin, 2006

Flooded Houses
The eruption of the LUSI mud volcano has triggered vertical (subsidence) and horizontal ground displacements.

In the early development of mud volcano, GPS surveys results show that ground displacement around the eruption area was occurring at rates up to

1 cm/day (horizontal displacements)
4 cm/day (vertical displacements)
Hasanuddin Z. Abidin, 2008

Ground displacements generated infrastructural damages in the area
Dextral Movement of Railway (km 39.2)

27 September 2006

Movement of Toll Bridge

KK Geodesi (2006)
Cracking of buildings and houses

INVESTIGATION OF GROUND DISPLACEMENT OF LUSI MUD VOLCANO

Documentation of GPS Survey around LUSI Mud Volcano
1st YEAR OF GROUND DISPLACEMENT AROUND LUSI

Vertical displacement on inner Caldera vary between -1.5 to -10 meter in year 1st (rate -1.5 to -10 m/yr)

Vertical displacements on rim of Caldera vary between -0.5 to -1.9 meter in year 1st (rate -0.5 to -1.9 m/yr)

Vertical displacements on outer Caldera vary between -0.05 to -0.25 meter in year 1st (rate -0.05 to -0.25 m/yr)

Figure Conceptual model on first year of ground displacement around LUSI Mud Volcano

1st YEAR OF GROUND DISPLACEMENT AROUND LUSI

Figure 3 Graphic trend after several month from eruption up to a year time, on the series of vertical displacement component (in meter) on several GPS points investigation in LUSI area.
A very much interesting to see from the first year of ground displacement observation result, the pattern of horizontal displacement showed concentrate outlook toward the center of subsidence, meanwhile the vertical displacement given the model of cone subsidence.

These GPS derived information together with field surface representation of displacement (cracks), and also occurred bubble plotting, micro seismic, etc has shown the good fact that caldera formation processes is being developed in LUSI mud volcano.
What happen after four years of the eruption turn out that the ground displacement has slowing at rates. Its not 2-4 cm/day anymore but only several centimeter up to desimeter in a years time. A linier trend were replaced by exponential decay instead.
AFTER 4th YEAR OF GROUND DISPLACEMENT AROUND LUSI

Rate of vertical displacement were unidentified at inner Caldera due to chaotic event of graben processes as part of Caldera formation processes (after first years since eruption)

Rate of vertical displacements on rim of Caldera vary between -4 to -10 centimeter in year 4th

Rate of vertical displacements on outer Caldera vary between 0.0 to -2 centimeter in year 4th

Figure Conceptual model after four year of ground displacement around LUSI Mud Volcano

AFTER 4th YEAR OF GROUND DISPLACEMENT AROUND LUSI

Figure 4 Graphic trend after around four year time from eruption, on the series of vertical displacement component on several GPS points investigation in LUSI Mud Volcano area.
SIGN OF LUSI ENDING ERUPTION ??

Exponential decay of displacement might be indicating or signing the ending of LUSI Mud volcano eruption. From the displacement projection result, after 10 year period we will see rate generally 1-2 cm/years surrounding the eruption area which we can simply conclude that eruption may be ignored, and within 20 years we will see the rates generally less then cm/year which can be state that the eruption generally ended.

Seeing other research (Davies et.al, 2010) which made prediction of 26 years probabilistic longevity estimate for the LUSI mud volcano eruption, a very much similarity in the eruption time prediction found with our result (~20 years).

CLOSING REMARKS (1)

The first 4 months of mud extrusion showed the rates of displacements (from data compilation and interpolation) are in the order of 0,4 to 2,5 cm/day and increasing on the next 8 to 12 month later into 0,6 to 3,8 cm/day for vertical component surrounding the eruption site.

After four years of the eruption turn out that the ground displacements have slowing down. The rates not 2-4 cm/day anymore but only several centimeter up to decimeter/year. A linear trend were replaced by exponential decay.
CLOSING REMARKS (2)

The clear analysis showed that ground displacement devide into two stage which is rapid ground displacement (that explained to be associate with Caldera formation processes) and normal ground displacement representing adjustment from the effects of mud loading, ground relaxation due to mud outflow, etc.

Since the displacement associate with the eruption, the exponential decay might be indicating or signing the ending of LUSI Mud volcano eruption. From the displacement projection result, after ten years period we can simply conclude that eruption may be ignored, and within twenty years from the first eruption we may state that the eruption is generally ended.

THANK YOU