**PUSAT VULKANOLOGI DAN MITIGASI BENCANA GEOLOGI**
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# LESSON LEARNED FROM SOME VOLCANOES ERUPTIONS IN JAVA : INFERRED FROM MONITORING DATA

WORKSHOP SATREPS

10 NOVEMBER 2015

Integrated Study on Mitigation of Multimodal disasters caused by Ejection of Volcanic Products

# Outline

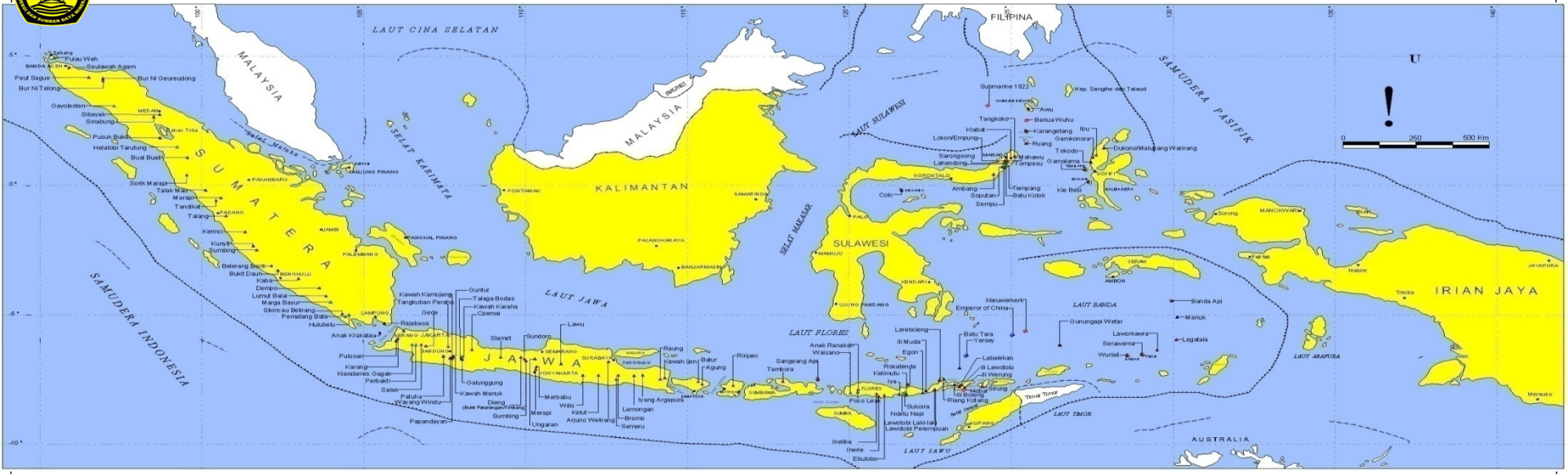
- COLLECTTING DATA : DATABASE ARCHIVES
  - VOLCANO MONITORING STRATEGY IN INDONESIA
  - RESEARCHE PROGRAM HAVE BEEN DONE :2014 – 2015
    1. SINABUNG (Data collecting and research, modelling)
    2. KELUD (Data collecting and research, modelling)
    3. GALUNGGUNG (HAZARD MODELLING)
    4. SEMERU (HAZARD MODELLING)
    5. GUNTUR (DATA COLLECTING)
- LESSON LEARNED :
  - WHAT IS A VOLCANO ERUPTION AND ITS IMPACT?
    1. MERAPI
    2. KELUD
    3. SEMERU
    4. SINABUNG
    5. GALUNGGUNG
- NEXT PROGRAM : NEED TO DISCUSS

| Outputs | Activities | Group | Leader/Members |
|---|---|---|---|
| | | | |
| | | | **<Leader of Group >.....: Agus Budianto (CVGHM)** |
| | 2-1 | 2-1 | <Leader of Sub Group 2-1> **Subandriyo**<br>**Agus** Budianto, Dewi Sri Sayudi, Kushendratno, Hetty<br>**Triastuti,** Sofyan Primulyana, Novi (CVGHM)<br>Agung Harijoko (UGM), Wayan Wan-nada (UGM) |
| | 2-2 | 2-2 | <Leader of Sub Group 2-2> **M. Nugraha Kartadinata**<br>Nia Haerani, Anjar Hariwaseso, Oktory Prainbada, Sri Sumarti, Nur Naning Aisyah (CVGHM), Rokhmat (STC), Andi Subiyanto (STC), Lucas Donny (UGM) |

# DATABASE

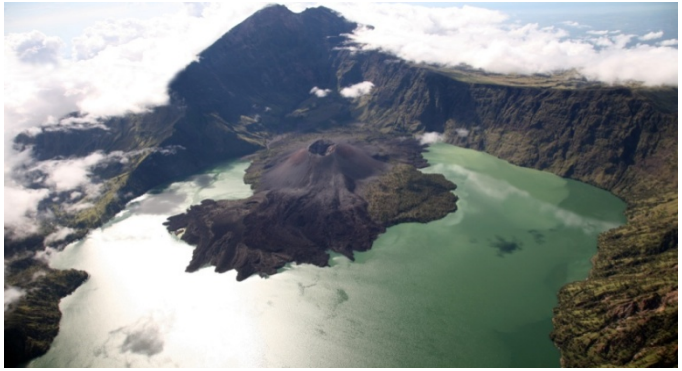
- Volcanism is the **phenomenon** of **eruption** of molten rock (magma) onto the surface of the Earth, where lava, pyroclastics and volcanic gases **erupt** through a break in the surface called a vent.
- Volcanic eruptions have the potential to cause loss of life, disrupt air traffic, impact climate, and significantly alter the surrounding landscape. Knowledge of the past behaviours of volcanoes is key to producing risk assessments of the hazards of modern explosive events.
- Currently, a collective record of volcano monitoring include: magnitude, Volcanic Explosivity Index (VEI), deposit volumes, eruption dates, and rock type; such parameters constituting the mainstay for description of eruptive activity.

# SEBARAN DAN KLASIFIKASI GUNUNG API - INDONESIA

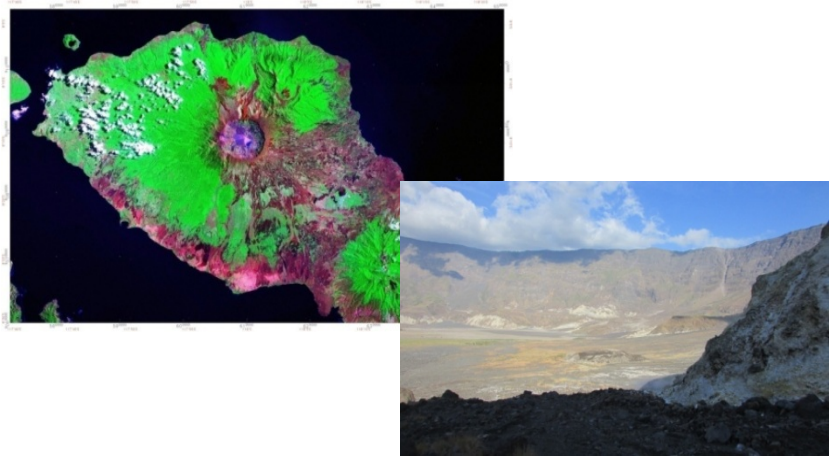



| No | Nama Gunungapi<br>*Name of volcano* | No | Nama Gunungapi<br>*Name of volcano* | No | Nama Gunungapi<br>*Name of volcano* | No | Nama Gunungapi<br>*Name of volcano* | No | Nama Gunungapi<br>*Name of volcano* | No | Nama Gunungapi<br>*Name of volcano* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **SUMATERA** | | | | | | **NTT** | | **SULAWESI TENGAH** | | **KEPULAUAN BANDA** |
| | **Tipe-A** | | **Tipe-C** | | **Tipe-B** | | **Tipe-A** | | **Tipe-A** | | **Tipe-A** |
| 1 | Peut Sagoe | 25 | Pulau Weh | 50 | Pulosari | 70 | Anak Ranakah | 95 | Colo | 113 | Nieuwerkerk |
| 2 | Bur Ni Telong | 26 | Gayo lesten | 51 | Karang | 71 | Inelika | | | 114 | Gunungapi Wetar |
| 3 | Seulawah Agam | 27 | Helatobi Tarutung | 52 | Patuha | 72 | Inerie | | **SULAWESI UTARA** | 115 | Wurlali, P. Damar |
| 4 | Sinabung | 28 | Marga Bayur | 53 | Wayang Windu | 73 | Ebulobo | | **Tipe-A** | 116 | Serawerna, P. Teon |
| 5 | Sorik Marapi | 29 | Pematang Bata | 54 | Talaga Bodas | 74 | Iya | 96 | Ambang | 117 | Laworkawra, P. Nila |
| 6 | Marapi | 30 | Hululobeh | 55 | Ungaran | 75 | Kelimutu | 97 | Soputan | 118 | Legatala, P. Serua |
| 7 | Tandikat | | | 56 | Merbabu | 76 | Rokatenda | 98 | Lokon/Empung | 119 | Banda Api |
| 8 | Talang | | **JAWA** | 57 | Lawu | 77 | Egon | 99 | Mahawu | | |
| 9 | Kerinci | | **Tipe-A** | 58 | Wilis | 78 | Lewotobi Laki-laki | 100 | Tangkoko | | **Tipe-B** |
| 10 | Sumbing | 31 | Salak | 59 | Iyang Argapura | 79 | Lewotobi Perempuan | | | 120 | Emperor of China |
| 11 | Kaba | 32 | Gede | | | 80 | Lerobolang | | **Tipe-B** | 121 | Manuk |
| 12 | Dempo | 33 | Tangkuban Parahu | | **Tipe-C** | 81 | Ili Boleng | | | | |
| 13 | Anak Krakatau | 34 | Ciremai | | | 82 | Batutara | 101 | Sempu | | **MALUKU UTARA** |
| | | 35 | Papandayan | 60 | Kiaraberes Gagak | 83 | Ili Lewotolo | 102 | Klabat | | **Tipe-A** |
| | **Tipe-B** | 36 | Guntur | 61 | Perbakti | 84 | Ili Werung | | | | |
| 14 | Bur Ni Geureudong | 37 | Gabanggung | 62 | Kawah Manuk | 85 | Hobal | | **Tipe-C** | 122 | Kie Besi |
| 15 | Sibayak | 38 | Slamet | 63 | Kawah Kamojang | 86 | Sirung | 103 | Batu Kolok | 123 | Gamalama |
| 16 | Pusuk Bukit | 39 | Dieng (Bukit Petarangan /Timbang) | 64 | Kawah Karaha | | | 104 | Sarongsong | 124 | Gamkonora |
| 17 | Bual Buali | | | | | | | 105 | Lahendong | 125 | Ibu |
| 18 | Talak Mau | 40 | Sundoro | | **BALI & NTB** | | **Tipe-B** | 106 | Tampang | 126 | Dukono/Mahupang Wairang |
| 19 | Kaunit | 41 | Sumbing | | | 87 | Ili Muda | 107 | Tompasu | | |
| 20 | Belerang Benti | 42 | Merapi | | **Tipe-A** | 88 | Labalekan | | | | **Tipe-B** |
| 21 | Bukit Daun | 43 | Kelut | 65 | Batur | 89 | Yersey | | **KEPULAUAN SANGIR** | 127 | Tokodo |
| 22 | Lumut Balai | 44 | Arjuno Welirang | 66 | Agung | | | | **Tipe-A** | | |
| 23 | Sekincau Belirang | 45 | Semeru | 67 | Rinjani | | **Tipe-C** | 108 | Ruang | | |
| 24 | Rajabasa | 46 | Bromo | 68 | Tambora | 90 | Waisano | 109 | Karangetang, Api Siau | | |
| | | 47 | Lamongan | 69 | Sangeang Api | 91 | Poco Leak | 110 | Banua Wuhu | | |
| | | 48 | Raung | | | 92 | Sukoria | 111 | Awu | | |
| | | 49 | Kawah Ijen | | | 93 | Ndetu Napi | 112 | Submarine 1922 | | |
| | | | | | | 94 | Riang Kotang | | | | |

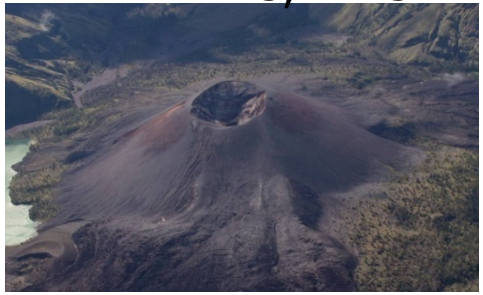
# CRATER AND CALDERA



KALDERA G, RINJANI



KALDERA G. TAMBORA



KAWAH ANAK RINJANI

KAWAH DORO API TOI

# Volcano Classification in Indonesia (based on historical eruption)

**Type-A:** Volcano which is recorded have experienced magmatic eruption at least one time after 1600. (77 volcanoes )

**Type-B:** After 1600 has not been recorded again a magmatic eruption, but still show signs of volcanic activity such as solfatara. (29 volcanoes )

**Type-C:** Unknown eruption history in human record, but there are still signs of past activity in the form of solfatara / fumarola field at weak levels. (21 volcanoes)

| CRATER | CRATER LAKE | CRATER LAKE WITH LAVA DOME | CRATER AND LAVA DOME | LAVA DOME AND LAVA |
|---|---|---|---|---|
|  Guntur |  Kelud |  Galunggung  Kelud |  MERAPI 2010 |  Sinabung |

# Volcanic Hazard Assessment

(There is no method to prevent Volcanic Eruption)

Volcanic Hazard Assessment is based on the principle that the past is the key to the future

Evaluation of Volcanic Hazard :

Two main complementary approaches, which may lead to their prediction

1. Study of eruption history, Mapping Volcanic Geology , volcanic hazard mapping
2. Monitoring Volcanic activity (We focus on Telemetry Data) and forecasting (Precursory Phenomena)

- QUICK RESPONSE TEAM

# VOLCANIC HAZARD MITIGATION

SOCIALIZATION

Early Warning System for Volcanoes

Volcanoes Monitoring

Volcanic Hazard Mapping

**Research :**

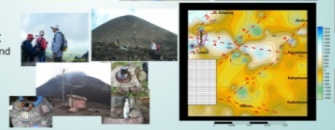
Geological Mapping

Deformation Research ;

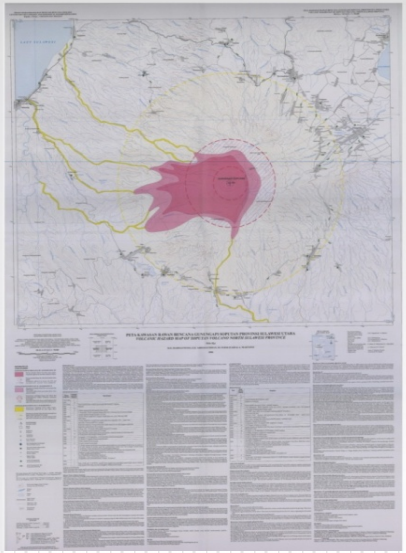
EDM, Leveling, GPS, Tiltmeter

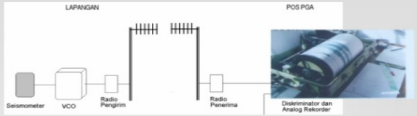
Geophysic Research:

Seismik, Gravity, Geomagnet, and Geolistrik

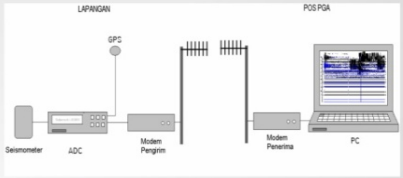


Geochemist Research





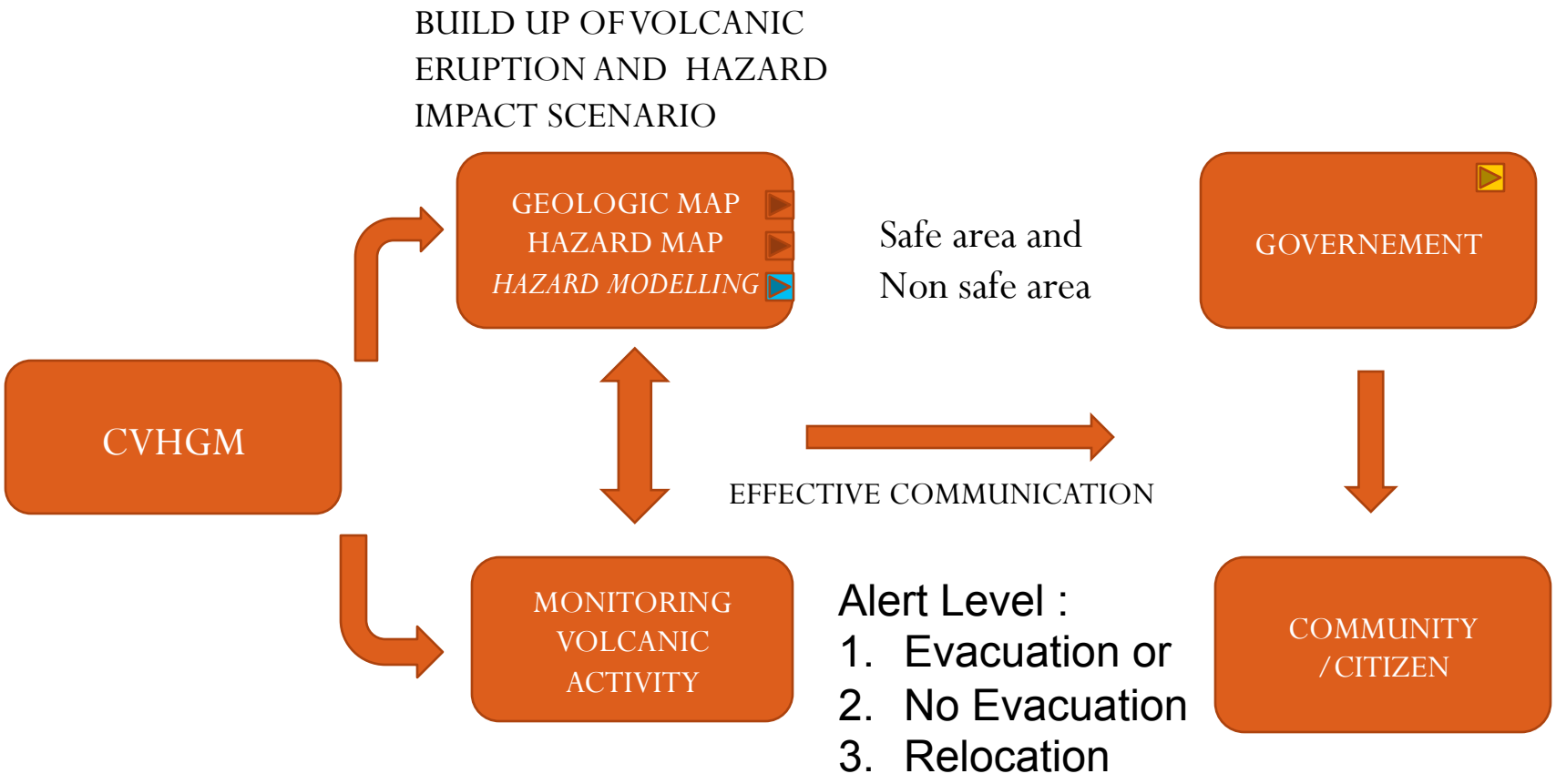

Volcano Seismicity Monitoring using analog Tecnology, receiving data fromVolcano Observatory with RTS (Radio Telemetry System)




Volcano Seismicity Monitoring using digital Tecnology, receiving data from Volcano observatory with Modem

GPS Measurement

# CVHGM ROLE : FORCASTING VOLCANIC ERUPTION



# Monitoring Strategy and Volcanic Hazard Assesment

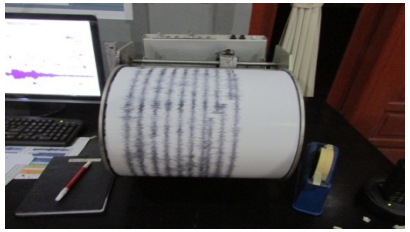
Seismic methode as a main tool in Indonesia

Deformation


Thermal Camera

Gas monitoring

- Seismic event classifcation
- Energy of seismic event
- Hypocenter and epicenter etc



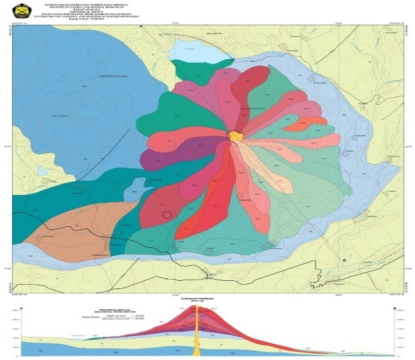
FORCASTING : Alert level

Level 1 : Normal

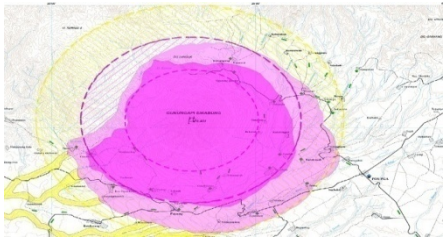
Level 2 : Waspada

Level 3 : Siaga

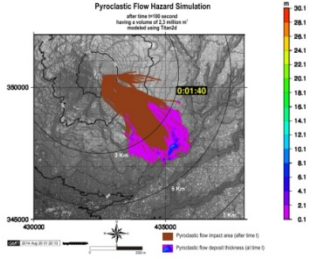
Level 4 : Awas



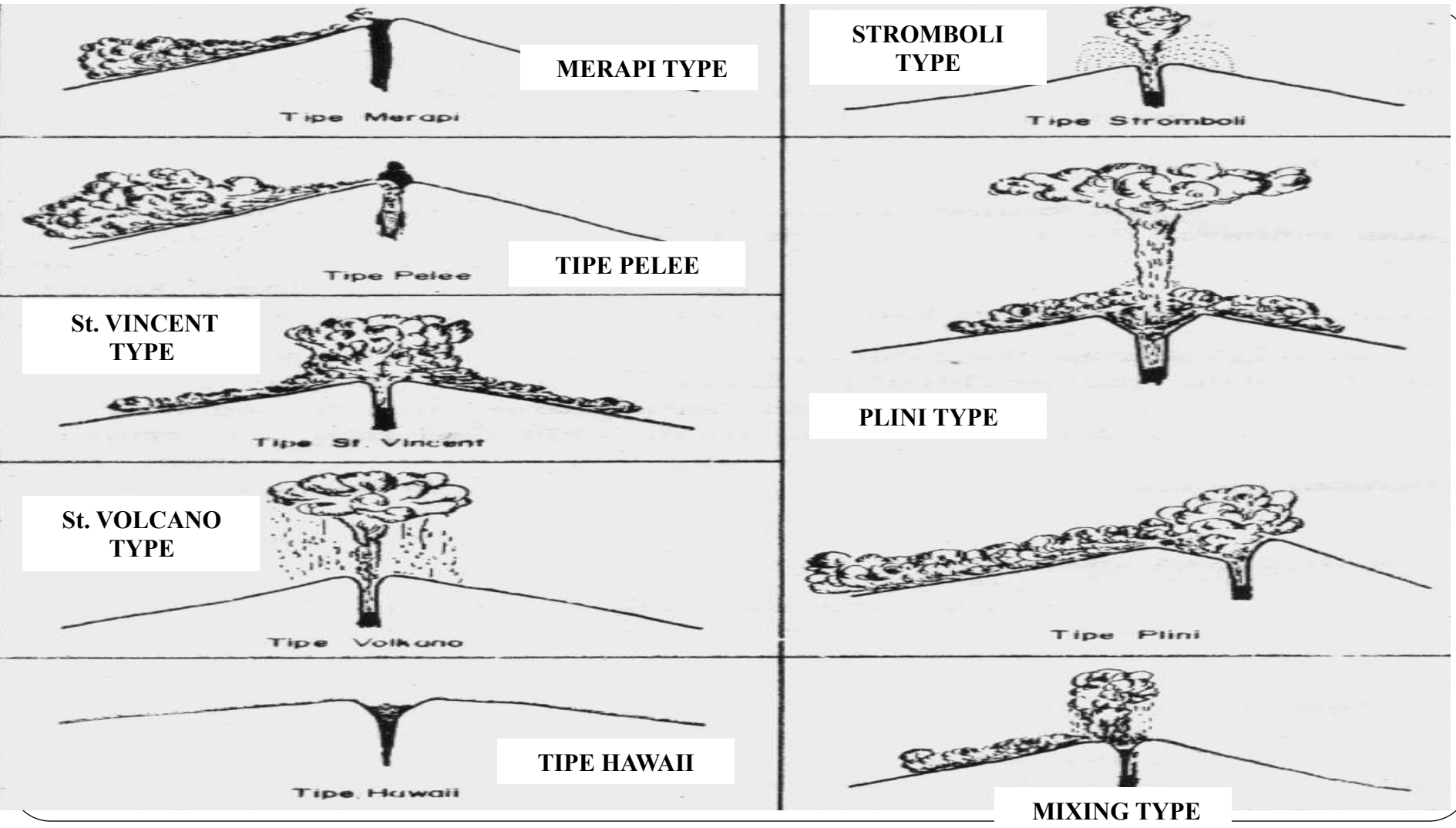
Geologic map



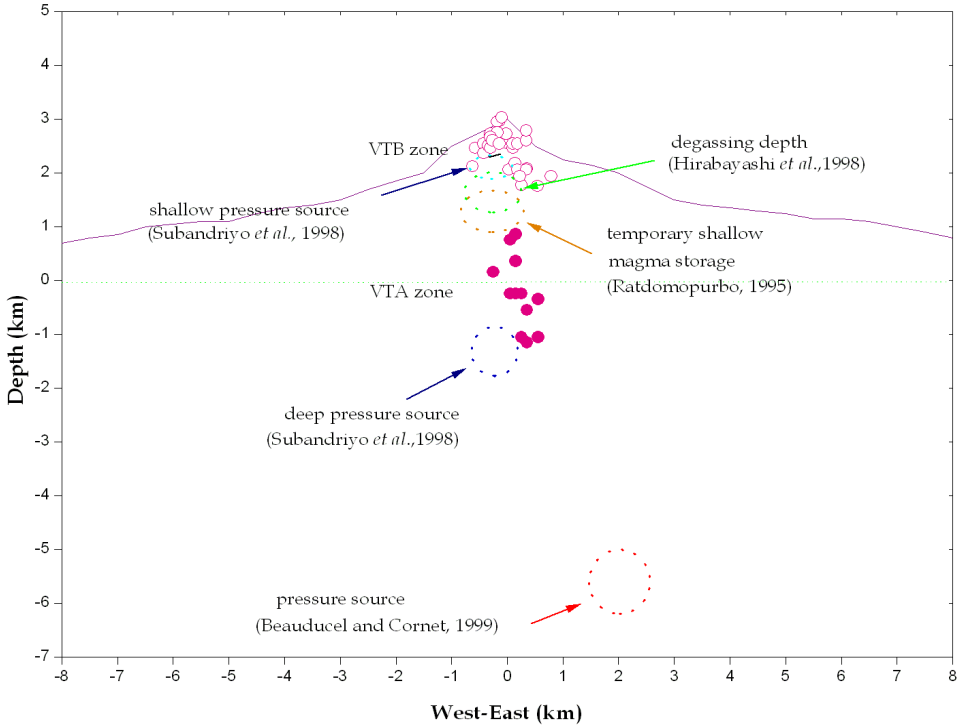
Hazard map

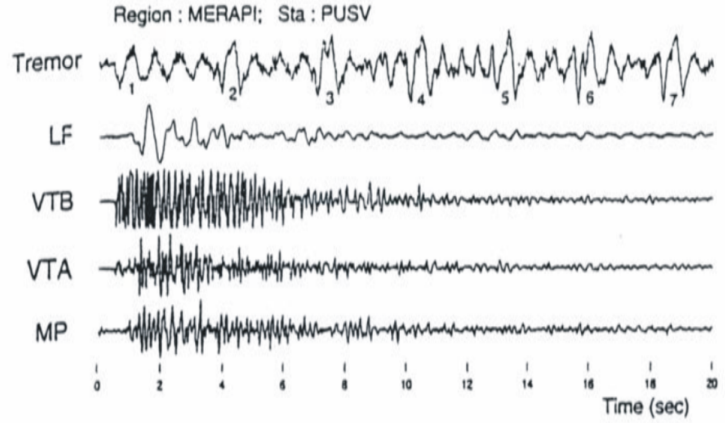


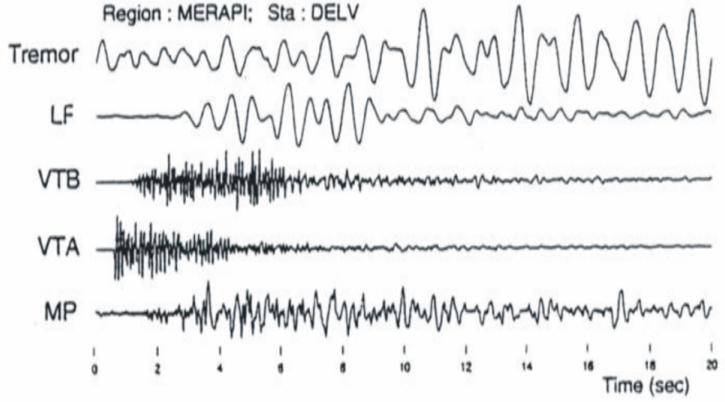

Hazard modeling


MERAPI TYPE
Tipe Merapi
STROMBOLI TYPE
Tipe Stromboli
TIPE PELEE
Tipe Pelee
St. VINCENT TYPE
Tipe St. Vincent
PLINI TYPE
St. VOLCANO TYPE
Tipe Volkano
Tipe Plini
TIPE HAWAII
Tipe Hawaii
MIXING TYPE

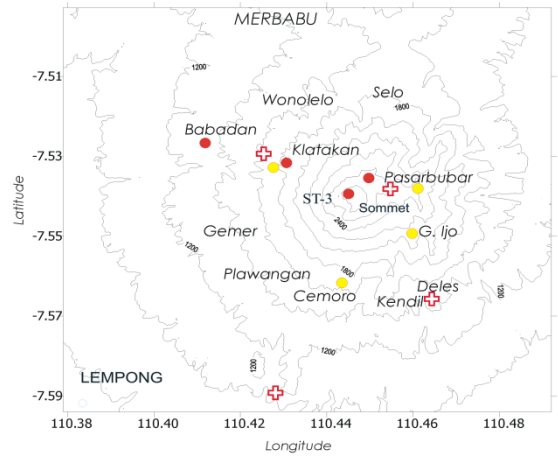
# MERAPI

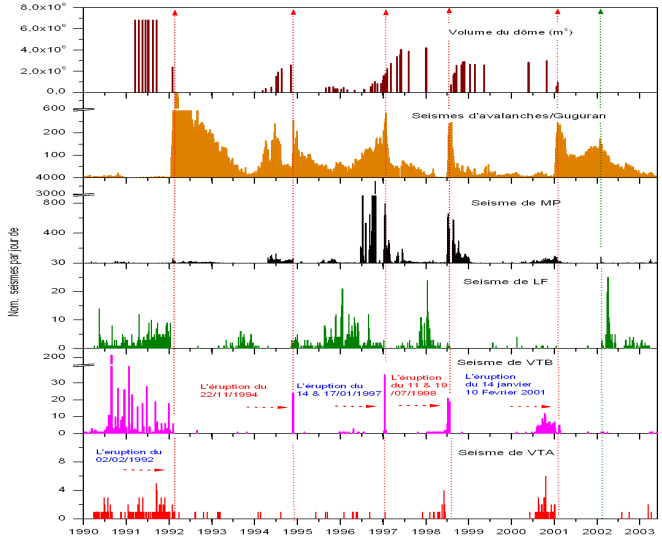


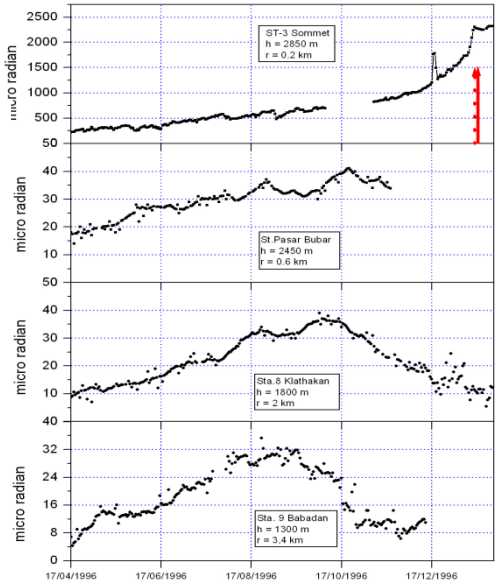



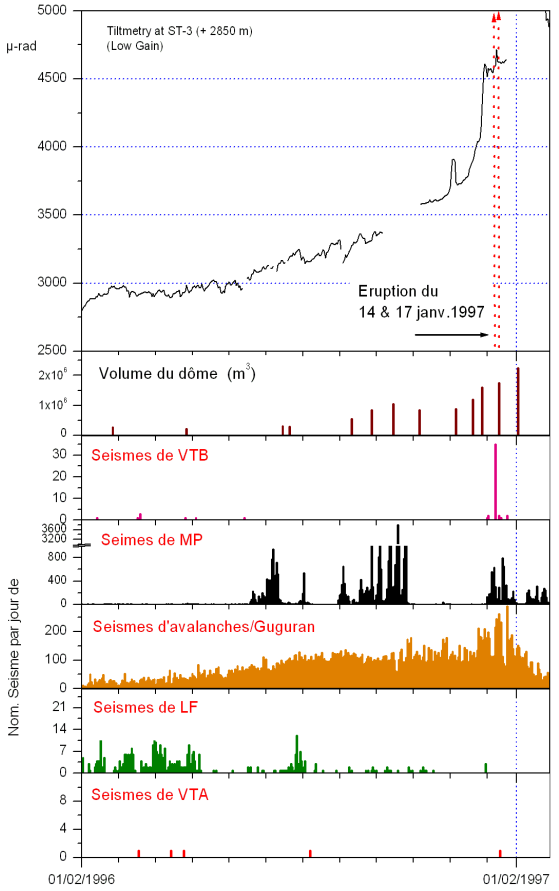




Compiled by Sri Hidayati, 2000


MERBABU
Wonolelo
Selo
Babadan
Klatakan
Pasarbubar
ST-3
Sommet
Gemer
G. Ijo
Plawangan
Cemoro
Kendil
Deles
LEMPONG
-7.51
-7.53
-7.55
-7.57
-7.59
Latitude
110.38
110.40
110.42
110.44
110.46
110.48
Longitude


Volume du dôme (m³)
Seismes d'avalanches/Guguran
Seisme de MP
Seisme de LF
Seisme de VTB
Seisme de VTA
Nom. seismes par jour de
L'eruption du 22/1/1994
L'eruption du 14 & 17/01/1997
L'eruption du 11 & 19 /07/1998
L'eruption du 14 janvier 10 Fevrier 2001
L'eruption du 02/02/1992
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

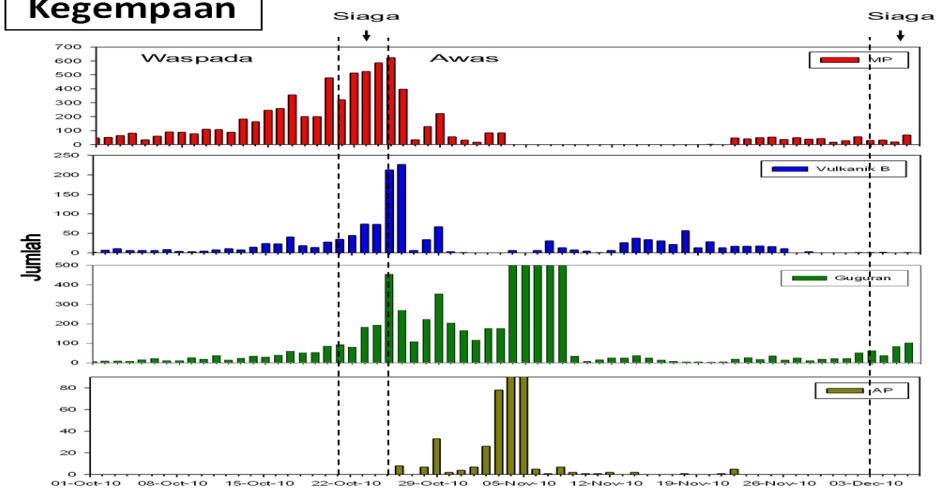

micro radian
ST-3 Sommet
h = 2850 m
r = 0.2 km
St.Pasar Bubar
h = 2450 m
r = 0.6 km
Sta.8 Klathakan
h = 1800 m
r = 2 km
Sta. 9 Babadan
h = 1300 m
r = 3.4 km
17/04/1996
17/06/1996
17/08/1996
17/10/1996
17/12/1996


Tiltmetry at ST-3 (+ 2850 m)
(Low Gain)
µ-rad
Eruption du
14 & 17 janv.1997
Volume du dôme (m³)
Seismes de VTB
Seimes de MP
Seismes d'avalanches/Guguran
Seismes de LF
Seismes de VTA
Nom. Seisme par jour de
01/02/1996
01/02/1997

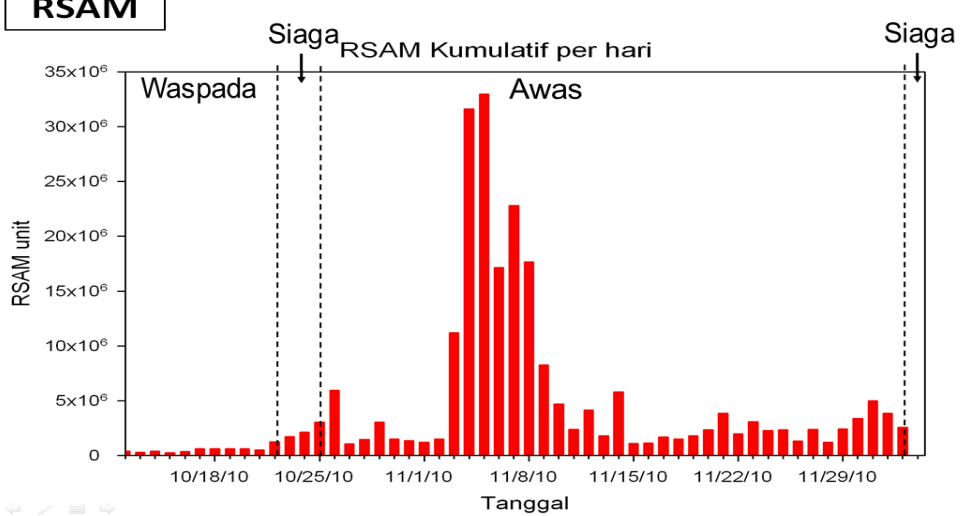
# MERAPI

# MERAPI 2010

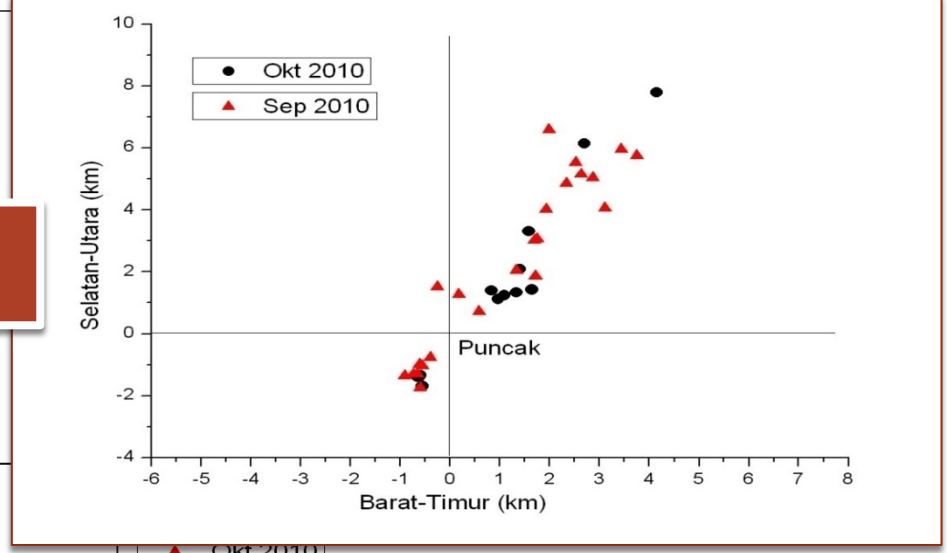
**Kegempaan**

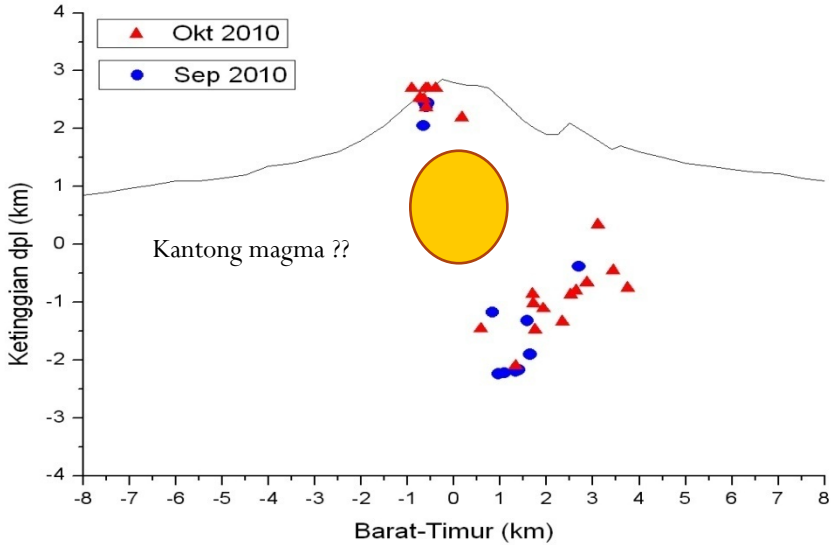


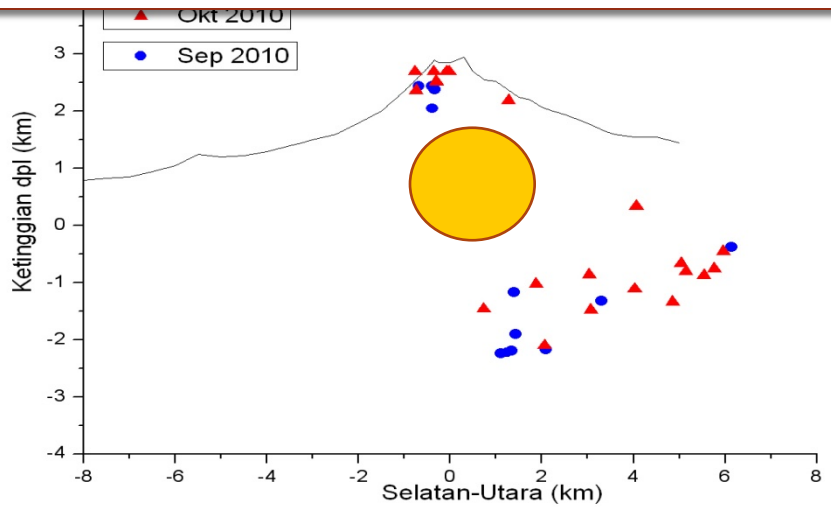

**RSAM**



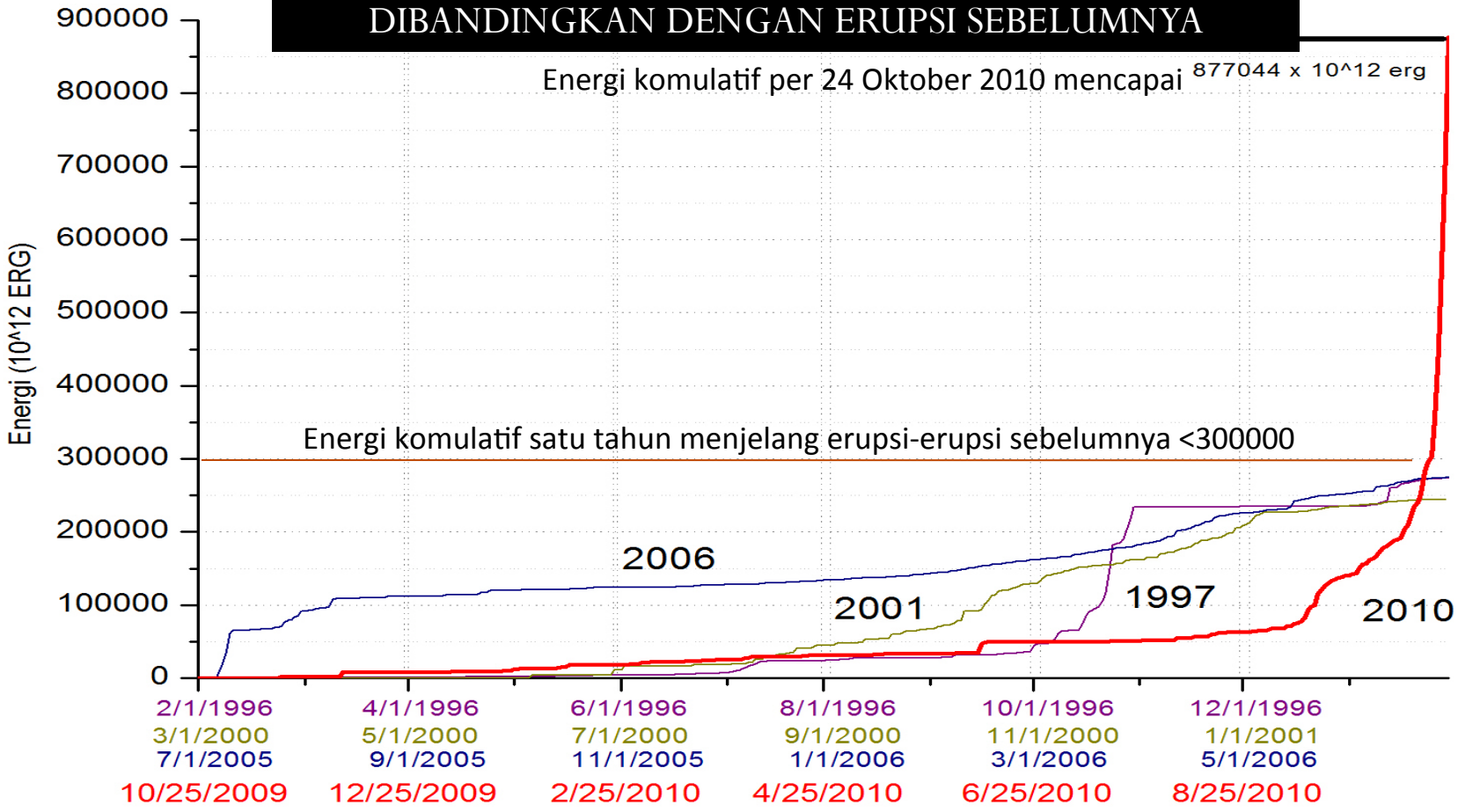
# Hiposenter Gempa VT



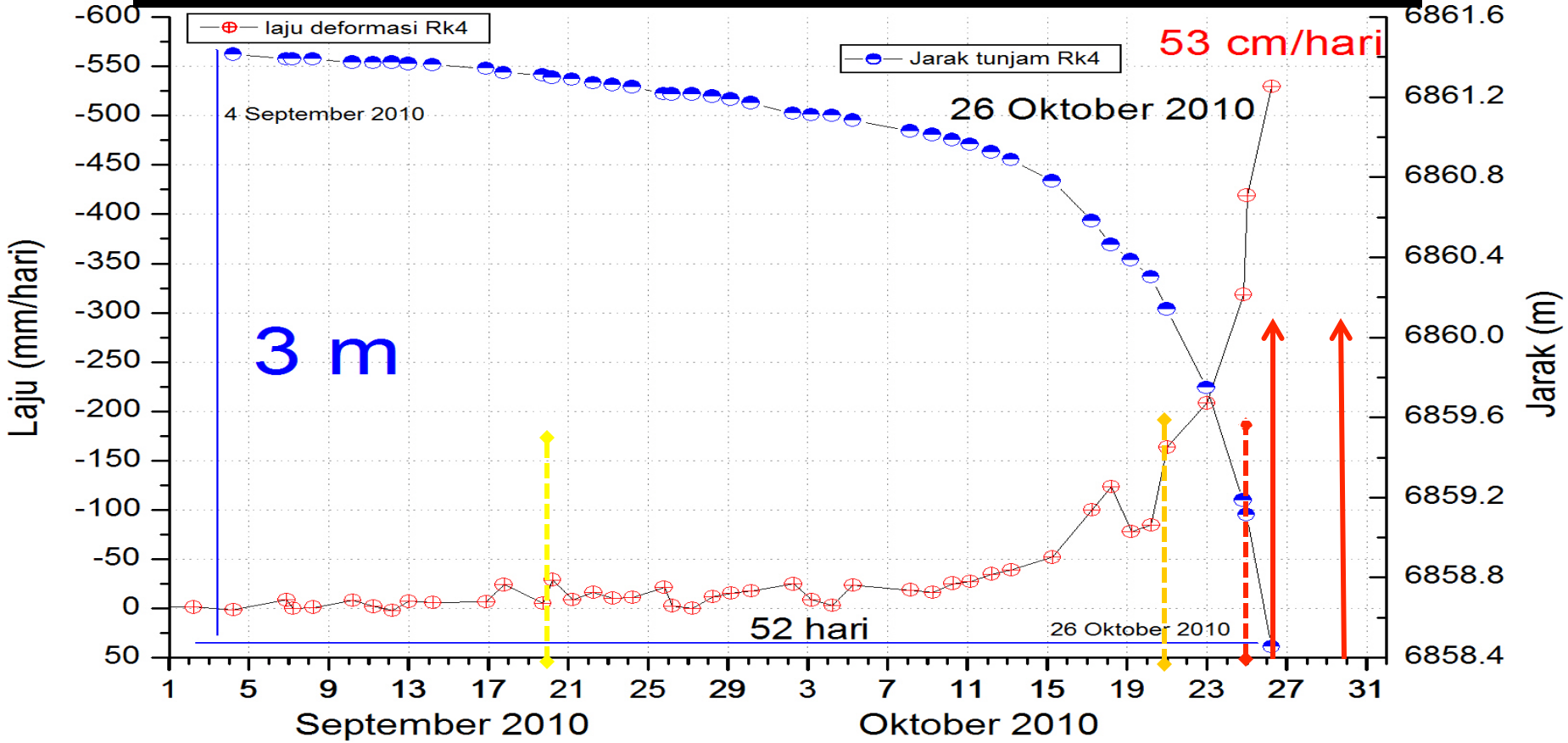



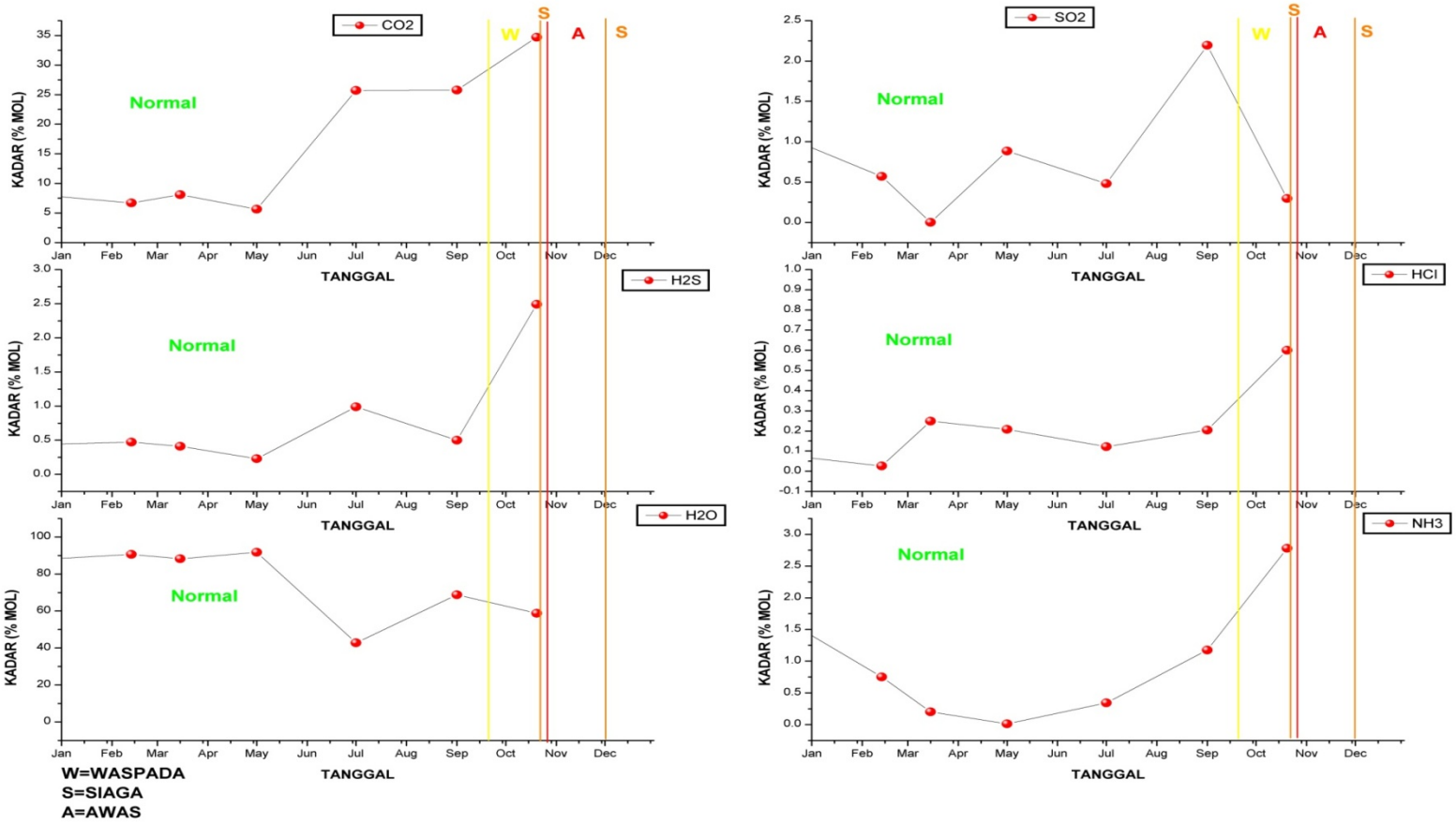
# ENERGI GEMPA KOMULATIF GEMPA 2010 DIBANDINGKAN DENGAN ERUPSI SEBELUMNYA



# DEFORMASI LERENG SELATAN




Inflasi (pembengkakkan) puncak hanya terukur di sektor Selatan (>3m).
Adapun sektor yang lain stabil



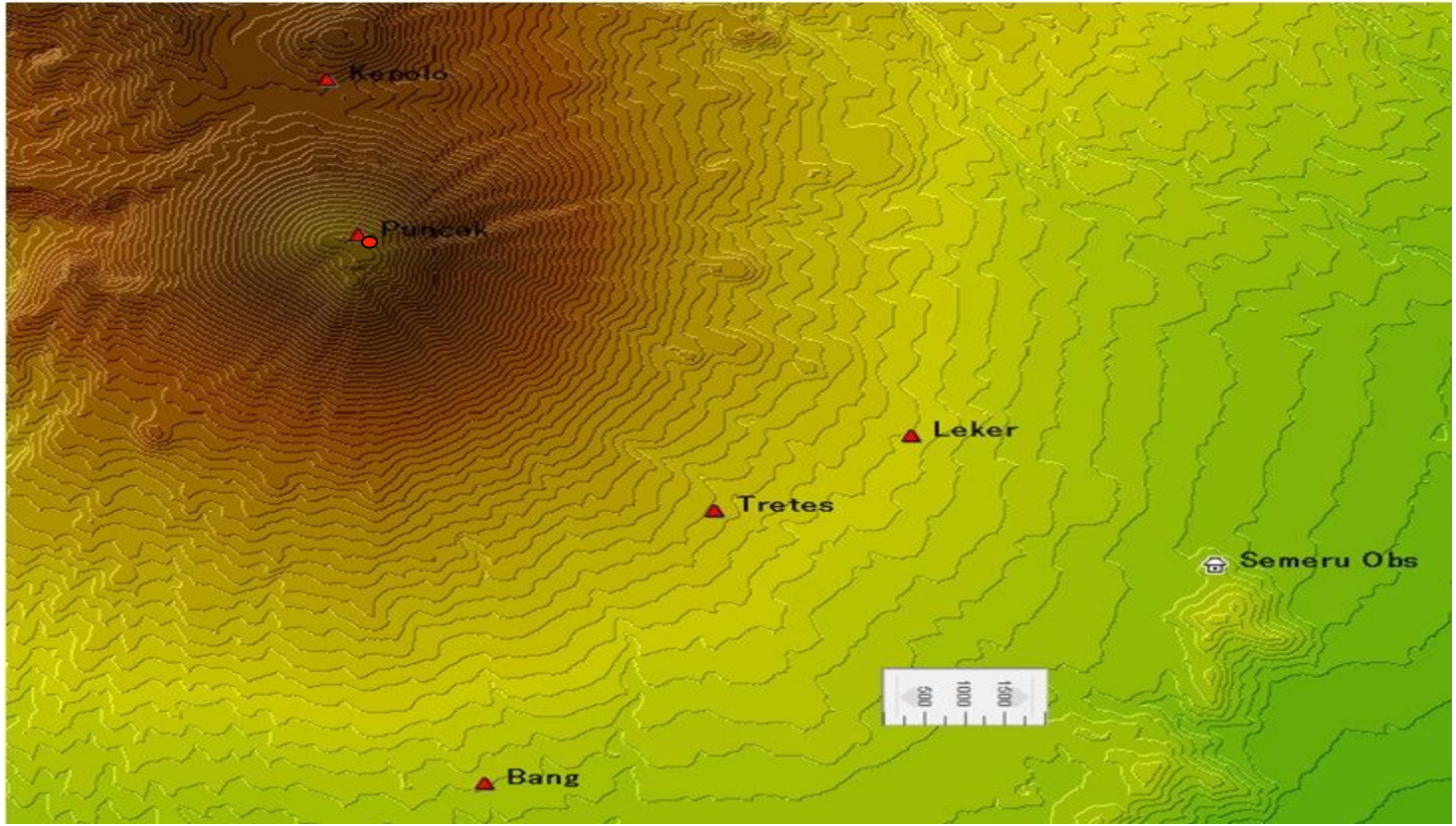

Grafik kadar unsur gas vulkanik G. Merapi 2010

# VEI : Volcano Explosivity Index

| VEI | PLUME HEIGHT | VOLUME | CLASSIFICATION (See Eruption Types) | EXAMPLE |
|---|---|---|---|---|
| 0 | <100 m | 1000s m3 | Hawaiian | Kilauea |
| 1 | 100-1000 m | 10,000s m3 | Hawaiian/Strombolian | Stromboli |
| 2 | 1-5 km | 1,000,000s m3 | Strombolian/Vulcanian | Galeras (1992) |
| 3 | 3-15 km | 10,000,000 m3 | Vulcanian | Ruiz (1985) |
| 4 | 10-25 km | 100,000,000s m3 | Vulcanian/Plinian | Galunggung (1982) |
| 5 | >25 km | 1 km3 | Plinian | St. Helens (1980) |
| 6 | >25 km | 10s km3 | Plinian/Ultra-Plinian | Krakatau (1883) |
| 7 | >25 km | 100s km3 | Ultra-Plinian | Tambora (1815) |
| 8 | >25 km | 1000s km3 | Ultra-Plinian | Toba (74 ka) |

Merapi Eruption on 2010 ( VEI 4, 140 Mm3

| SIZE (cubic km) | EXAMPLE | FREQUENCY (every . .) |
|---|---|---|
| .001-.01 | Kilauea, Unzen | several months |
| .01-.1 | Etna | 5 years |
| .1-1.0 | St. Helens (1980) | 10 years |
| 1-10 | Pinatubo, Katmai | 100 years |
| 10-100 | Krakatau (1883) | 1000 years |
| 100-1000 | Tambora (1815) | 10,000 years |
| >1000 | Yellowstone, Toba | 100,000 years |




*Seismic station*

*Tiltmeter*

# Typical of seismic earthquake

*A-type (deep volcanic type)*

*B-type (shallow volcanic type)*

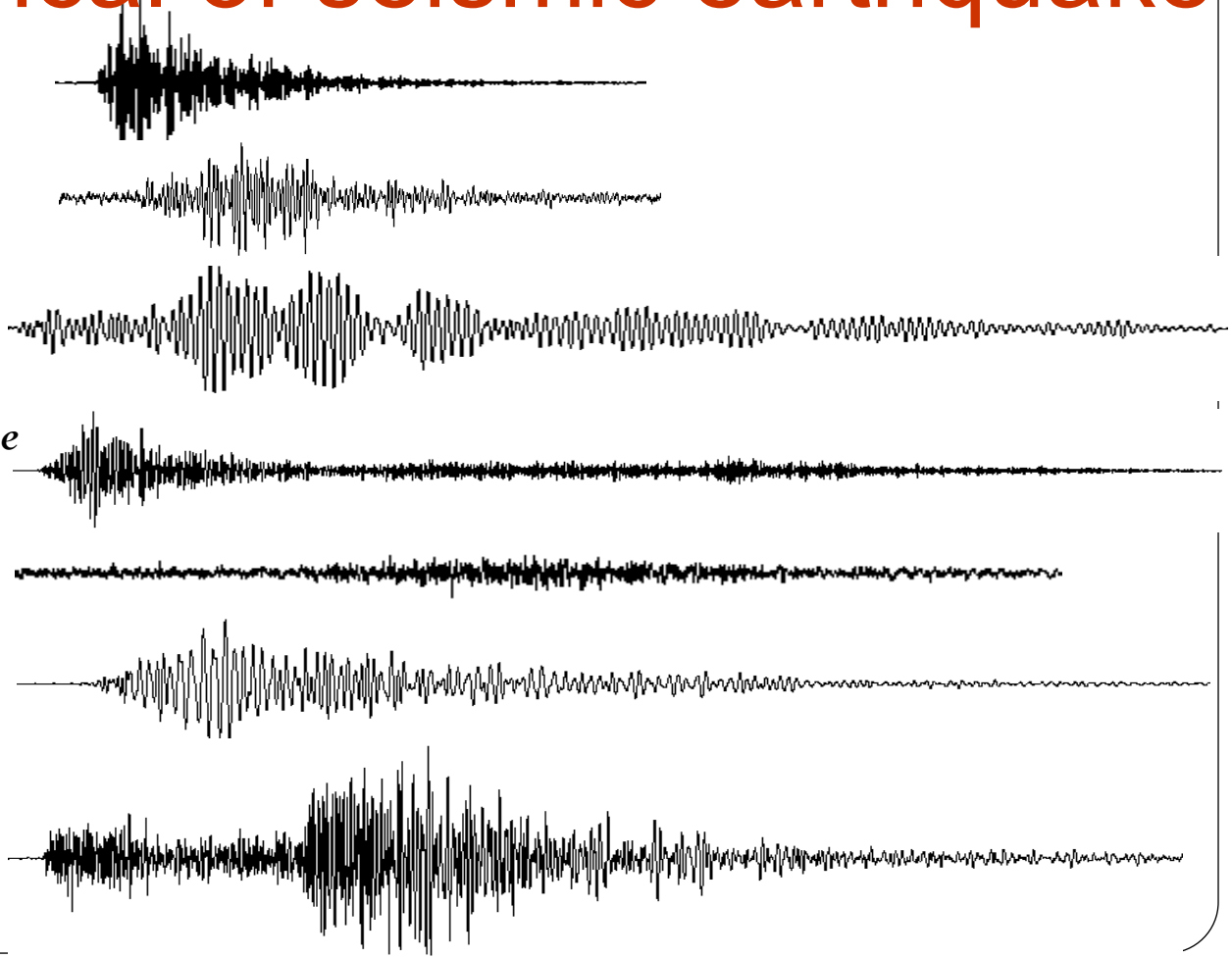
*Volcanic tremor*

*Pyroclastic flow/glowing avalanche*

*Avalanche*

*Explosion*

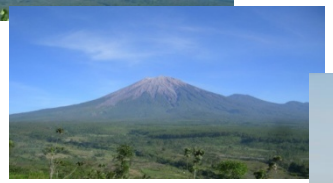
*Tectonic*

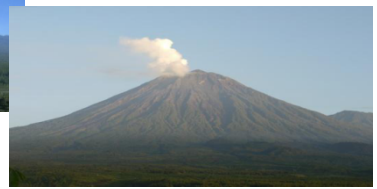


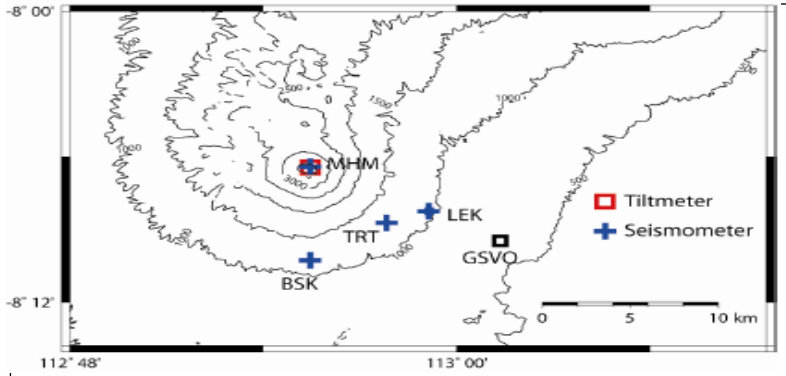
# Seismicity

*Level of activity*

- *1 (Normal)*
- *2 (Waspada)*
- *3 (Siaga)*
- *4 (Awas)*

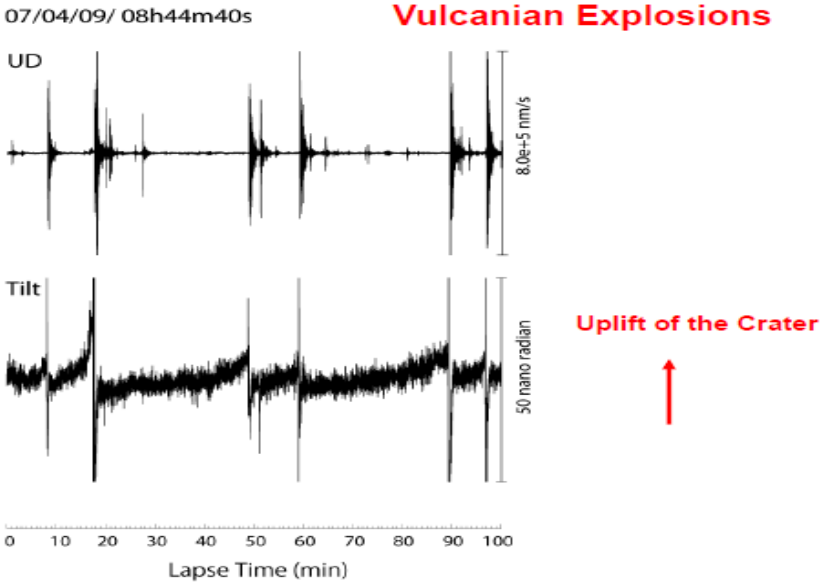


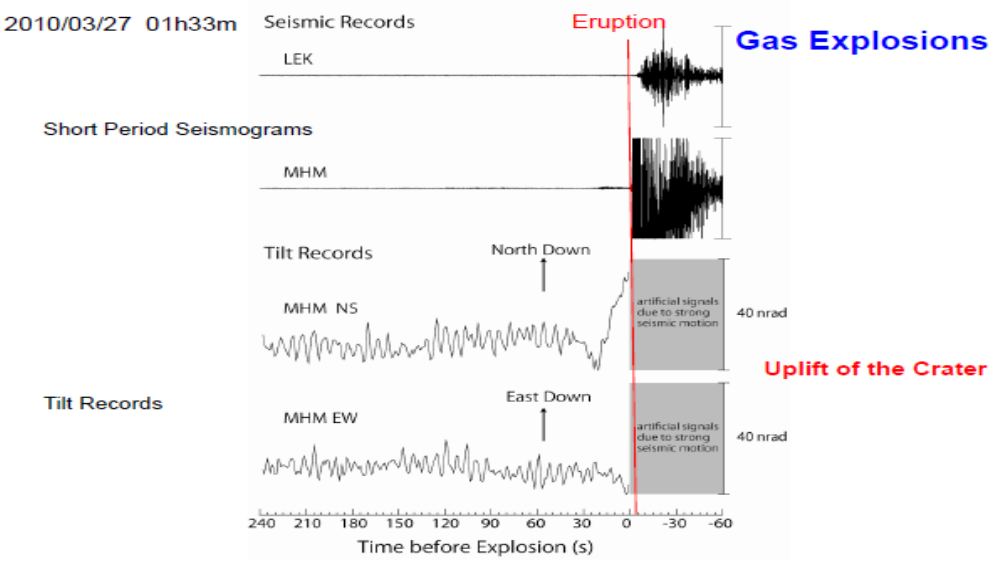





Seismograms

Tilt Records

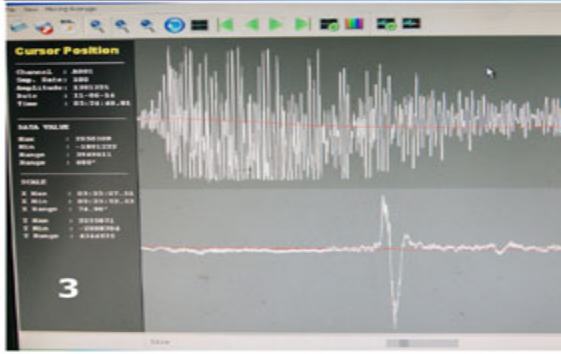



Volcano starts to inflate:
About 20 s before gas explosions with a constant rate 200-300 s before vulcanian explosions with accelerated rate

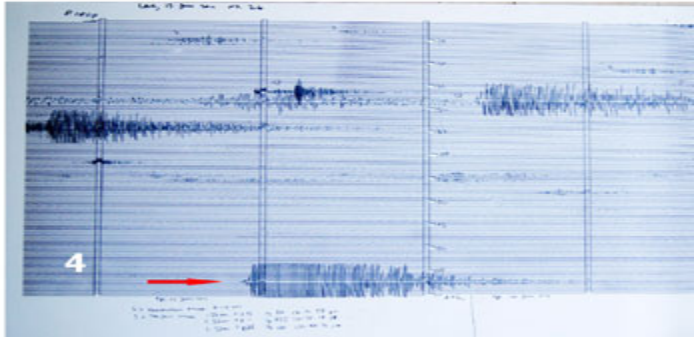
*Nishimura et al.,2010*



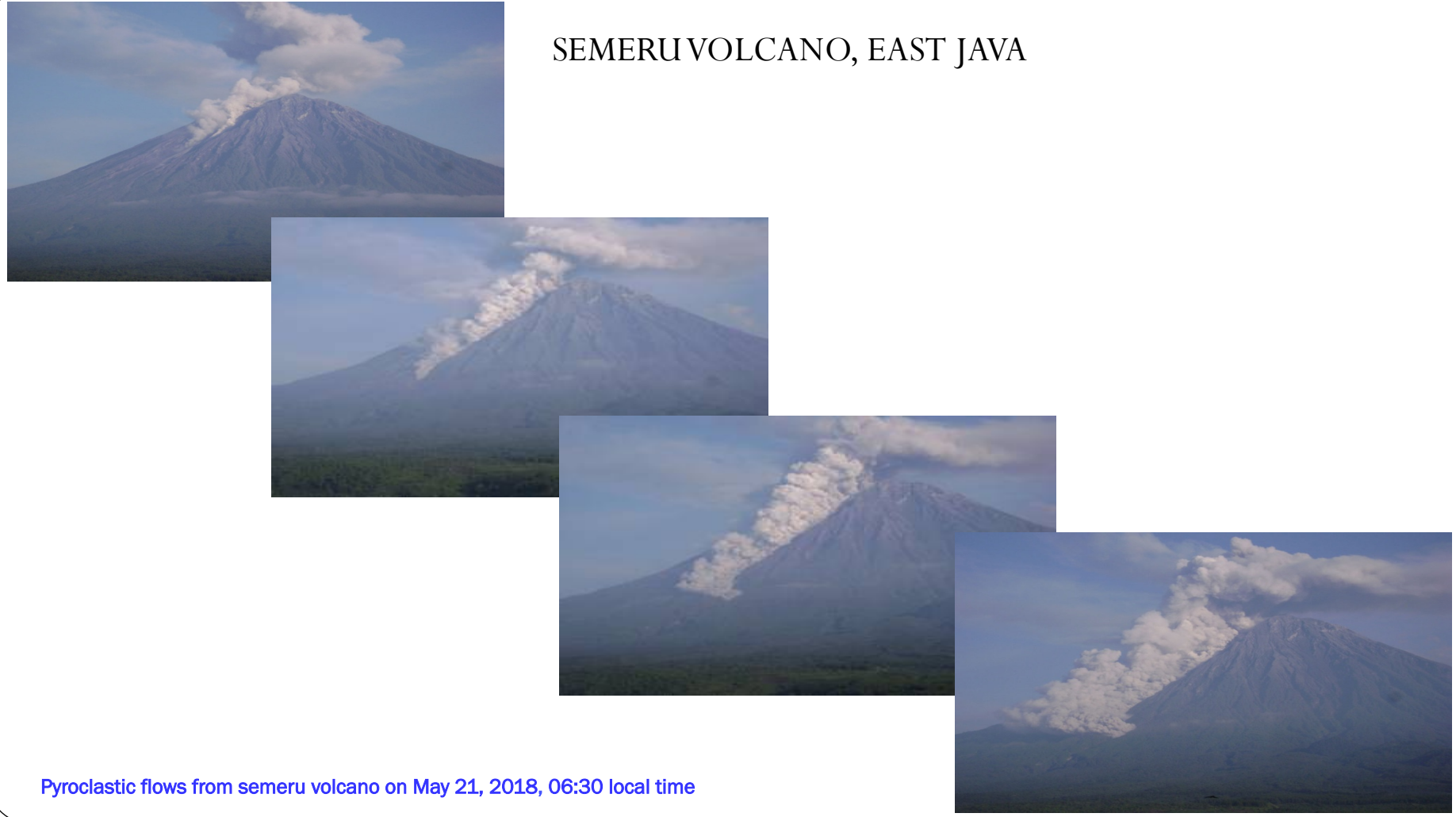



keterangan gambar :

1. Letusan G. Semeru tanggal 14 Juni 2011 Pkl. 05:23:52 wib
   tinggi asap ± 500 mtr tekanan gas kuat terdengar suara Letusan
   (seluruh kaca di Pos bergetar)
2. Gambar digital letusan  dan infrasonik yd terekam.
3. Gambar digital stasiun Leker dan Infrasonik
4. Gambar Seismogram letusan tersebut (tanda panah merah)



# SEMERU VOLCANO, EAST JAVA



Pyroclastic flows from semeru volcano on May 21, 2018, 06:30 local time

# KELUD

2006

2007

2014

i

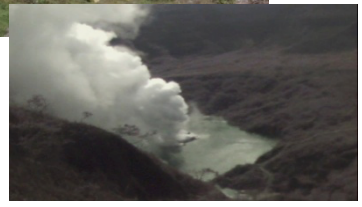
KELUD

ii

10 FEBRUARY,1990 iii

Ash Fall iv

i



ii

2007 iii

Lava Dome iv

i

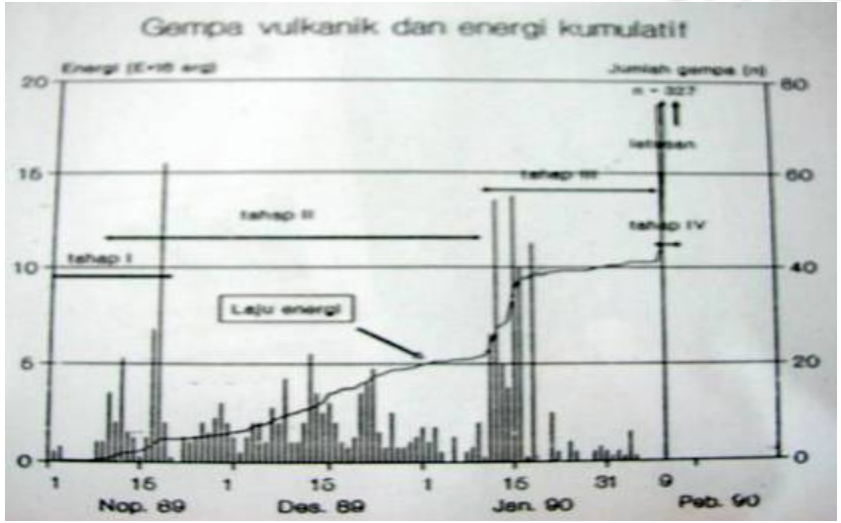
ii

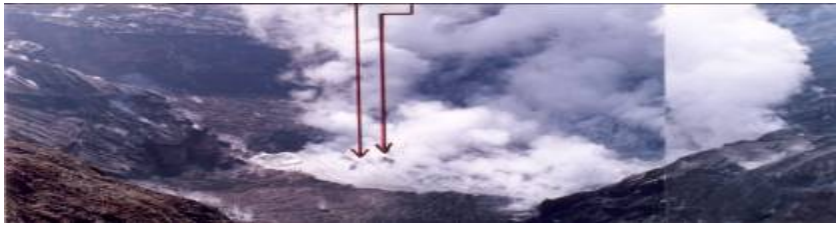
(copyright: Arif ahmad detik.com)

13 FEBRUARY,2014 iii

Pumice Fall iv

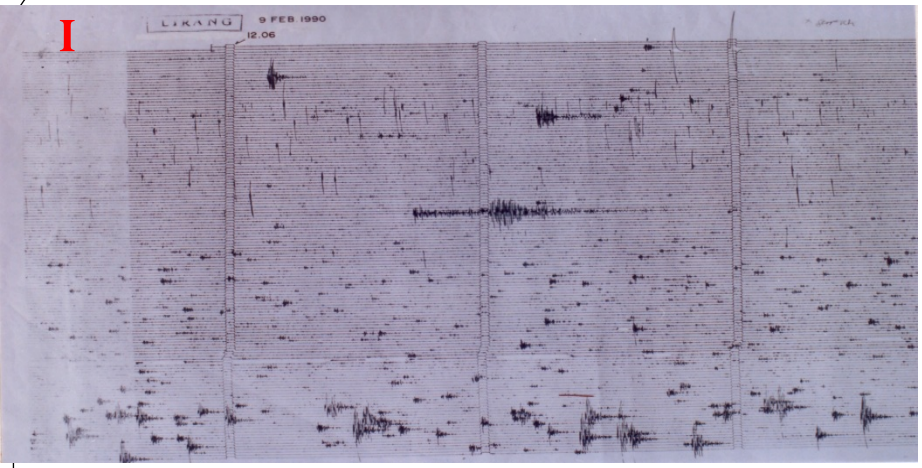
# G. KELUT 1990



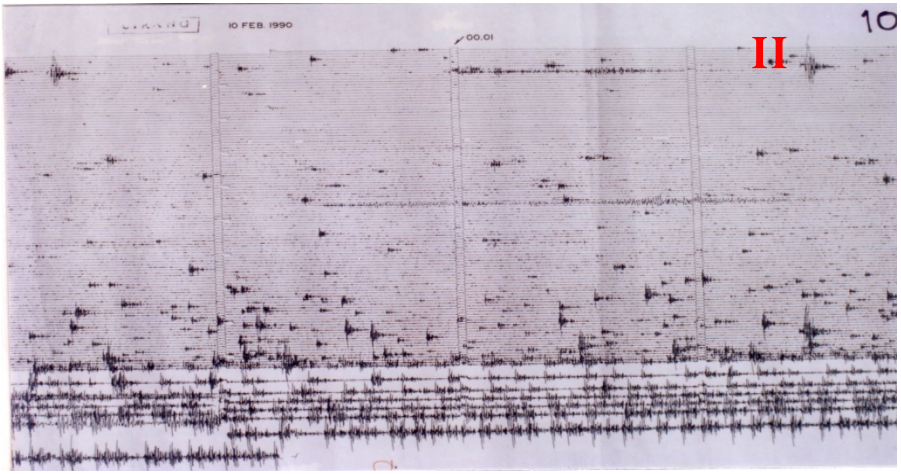



DAMPAK ABU LETUSAN KELUT 1990 TERHADAP BANGUNAN PADA JARAK SEKITAR 9 KM ARAH BARAT PUNCAK KELUT

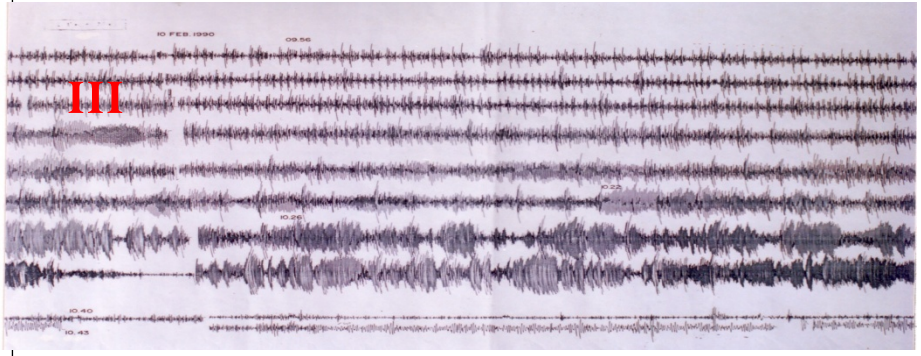
I


LIRANG
9 FEB. 1990
12.06

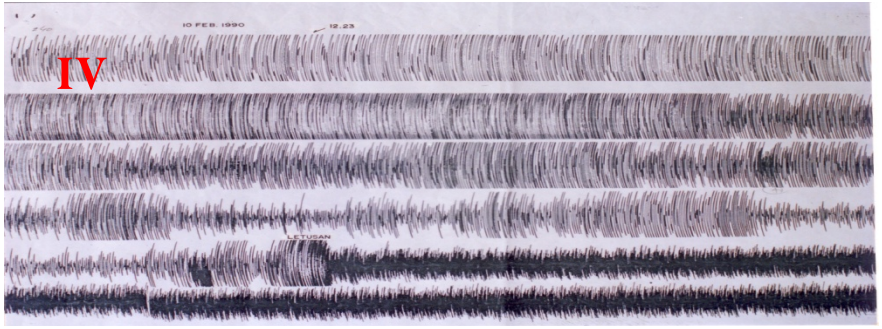
II


LIRANG
10 FEB. 1990
00.01
10

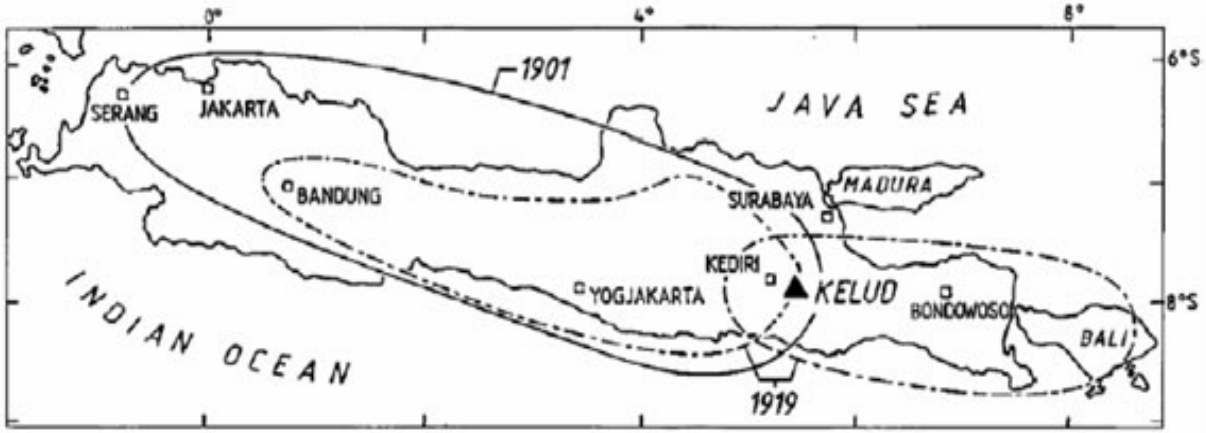
III


10 FEB. 1990
09.56
10.25
10.26
10.40
10.43

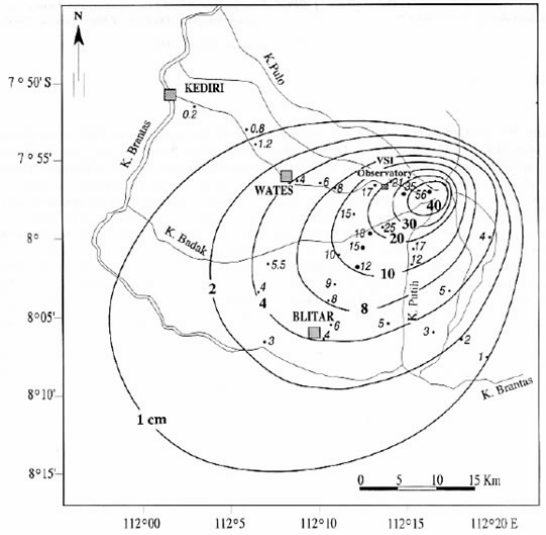
IV


10 FEB. 1990
12.23
LETUSAN

# ERUPTION IMPACT

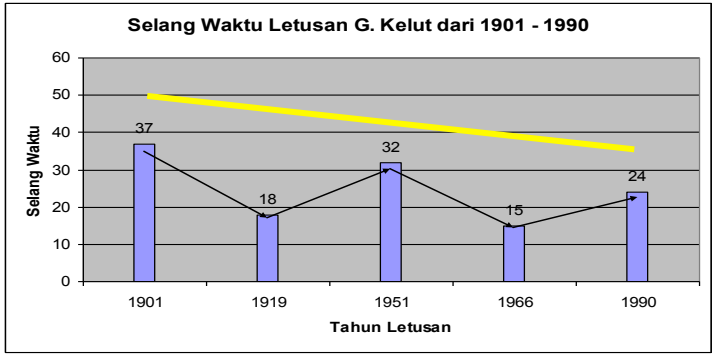



Ash fall of Kelud eruption in 1901 and 1919




Ash fall of Kelud eruption in 1990

# ALERT LEVEL ON KELUD CRISIS




## LEVEL I/NORMAL


11 September 2007

## LEVEL II/WASPADA



29 September 2007

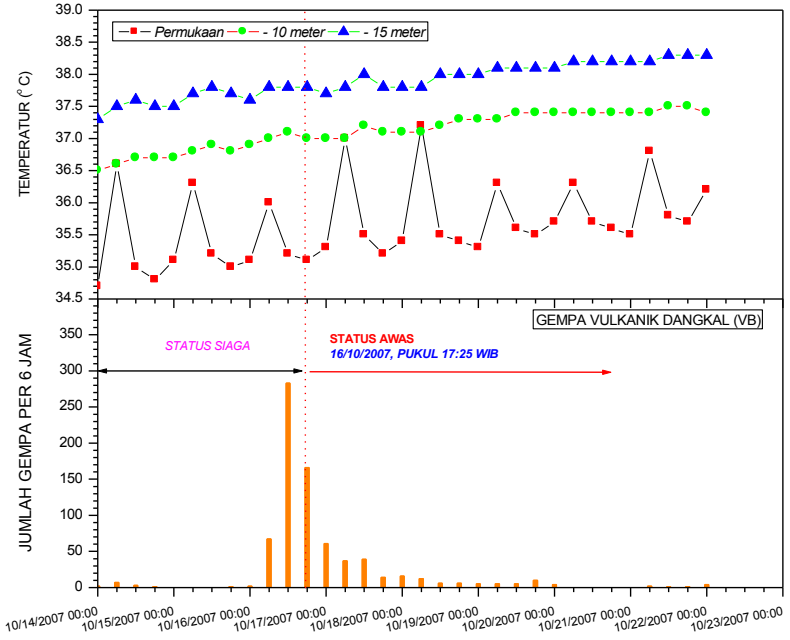
## LEVEL III/SIAGA

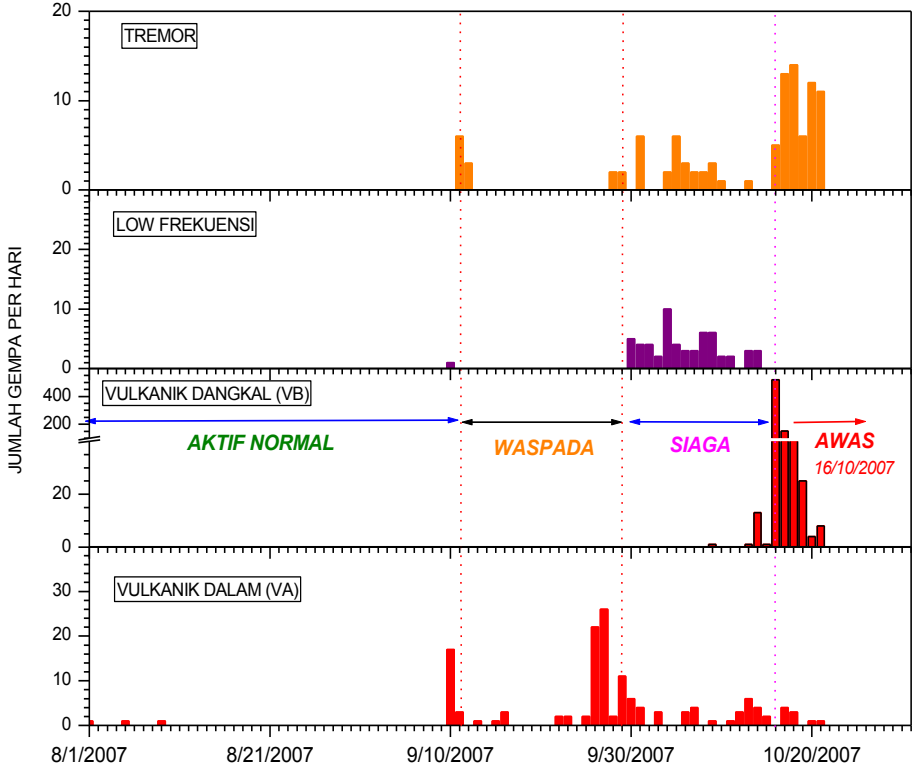

16 October 2007

## LEVEL IV/AWAS



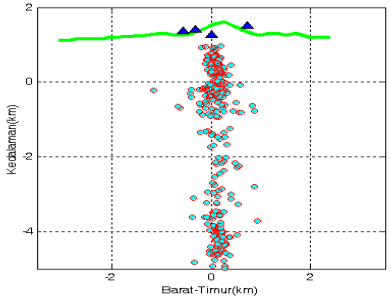
Seismic activity and temperatur of crater lake before lava dome formation (Kelud 2007)



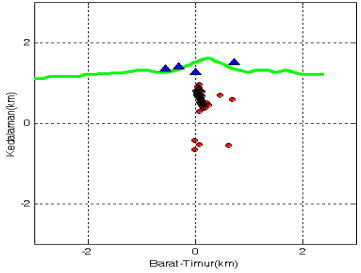
# Hipocenter distribution
## of volcanic earthquake before lava dome eruption in Kelud Volcano, (Est Java )

III

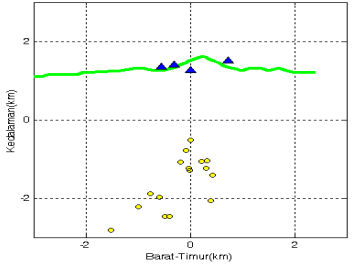



V

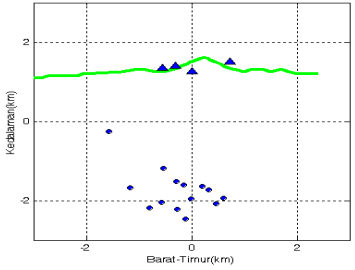
II




IV

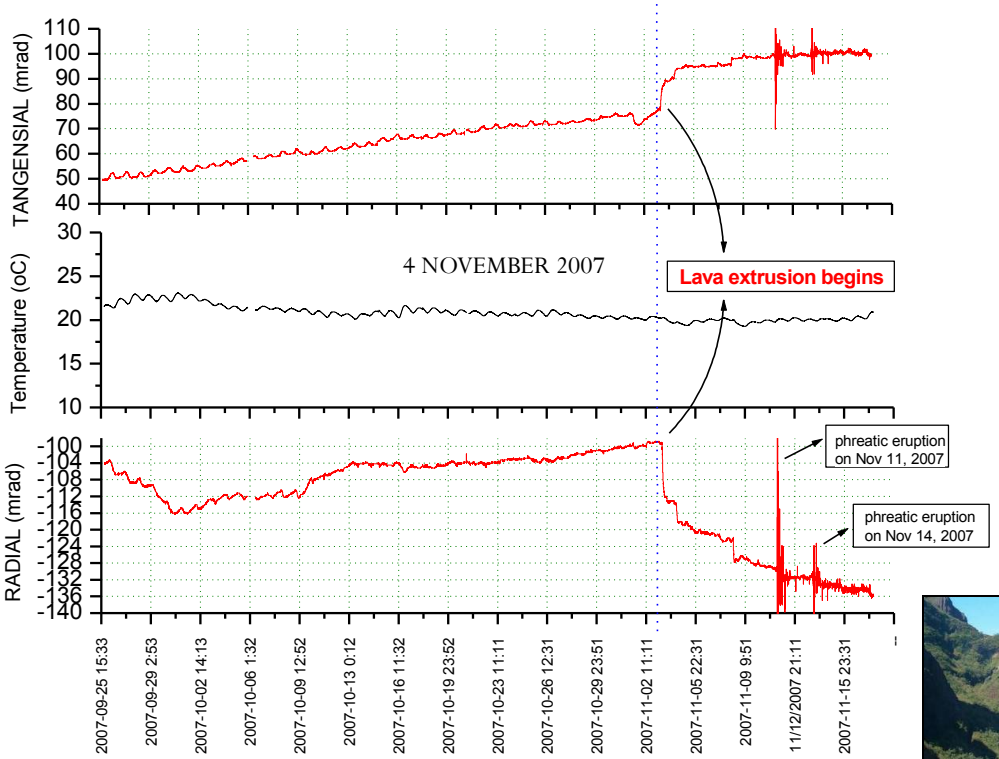



I




III

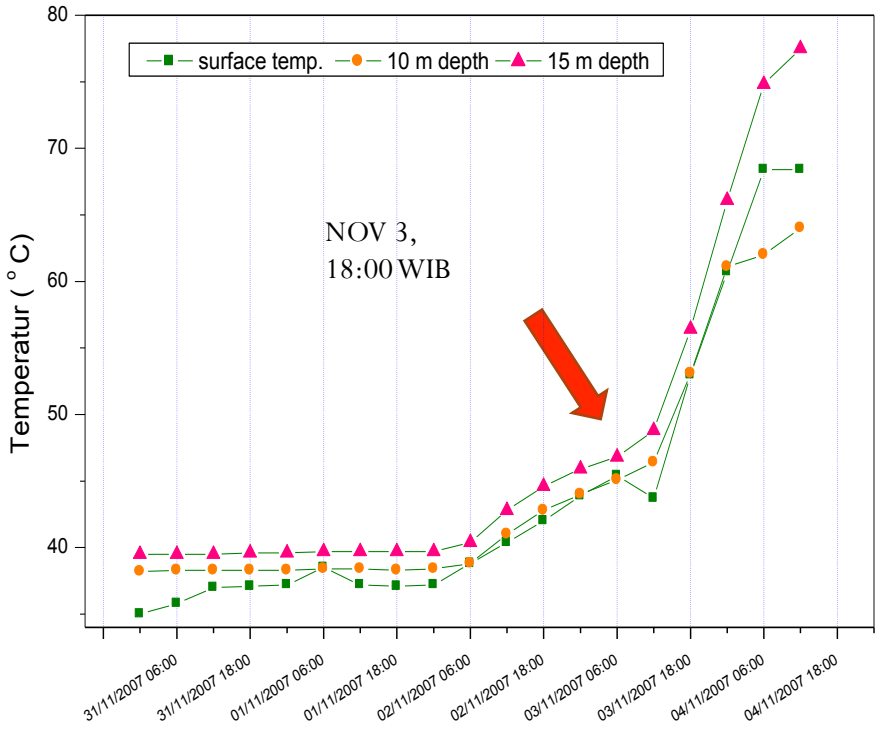
## DEFORMATION SIGNS (TILTMETER) DURING G. KELUD CRISIS (2007) :




4 NOVEMBER 2007

2006

# CONTOH KASUS : PENGAMATAN DAN PENGUKURAN TEMPERATUR KAWAH (Kelud 2007)




4 Nopember 2007 Pkl. 05.50 WIB

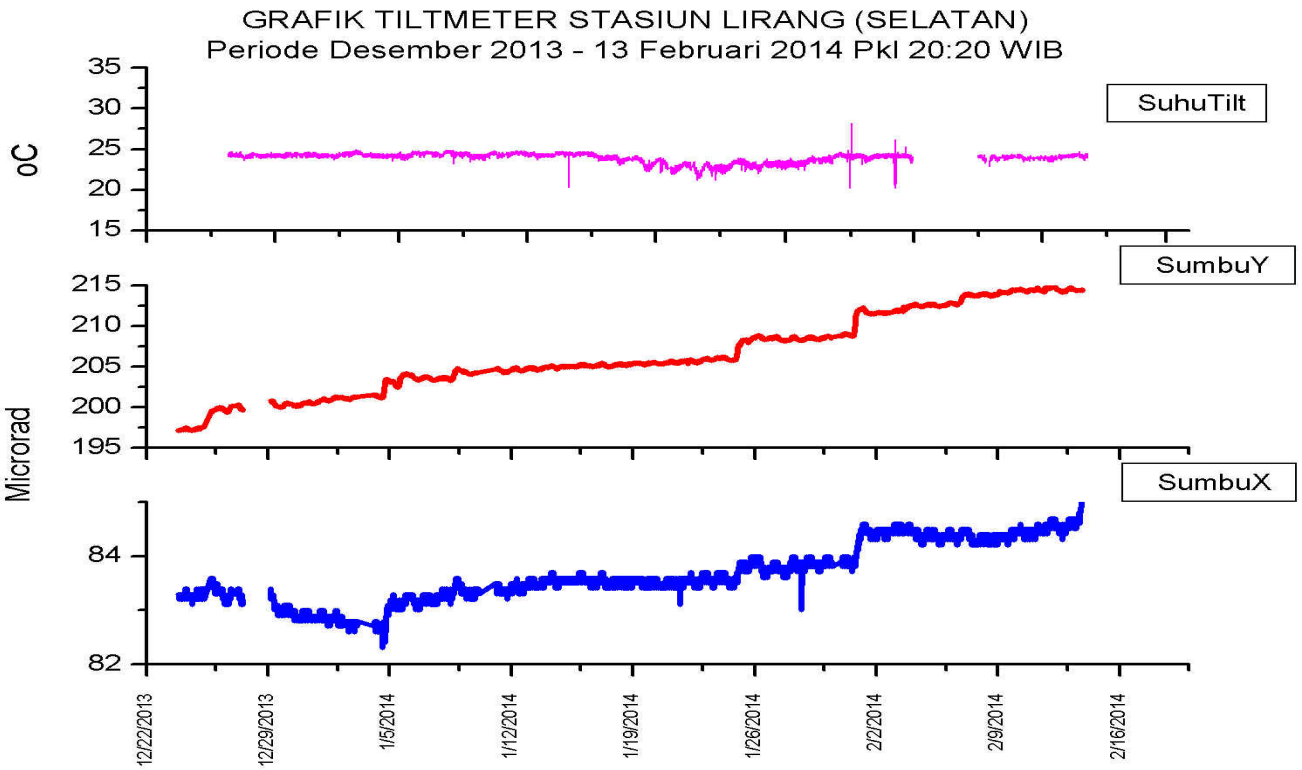
2 Nopember 2007 Pkl. 10.31 WIB

# Volcanic activity in the lava dome of G. Kelud on 8 Feb 2014

Buble gas in the crater lake (inlet) and fumarole gas emission on the top of lava dome

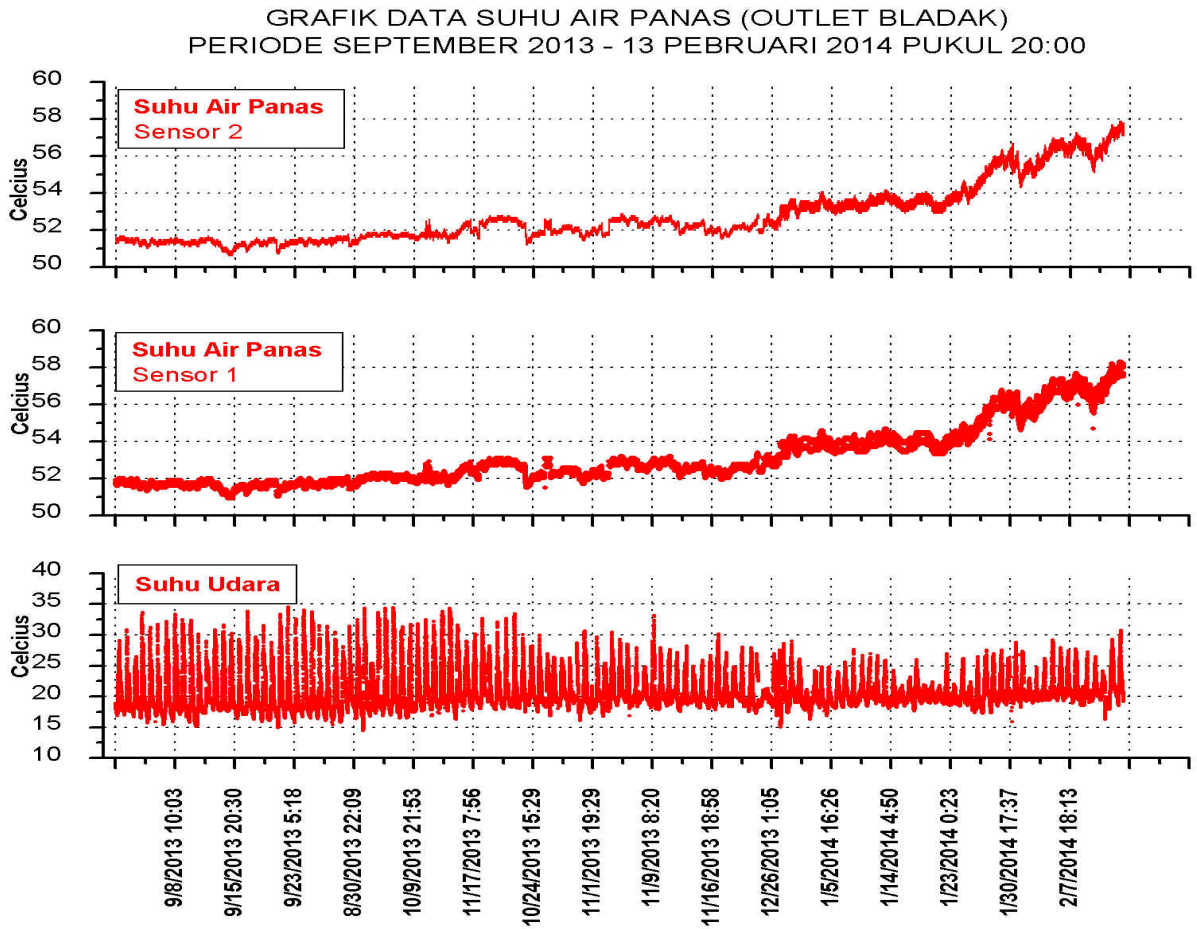
Lava DomeVolume = 16,28 million $m^3$

# DEFORMASI TILTMETER



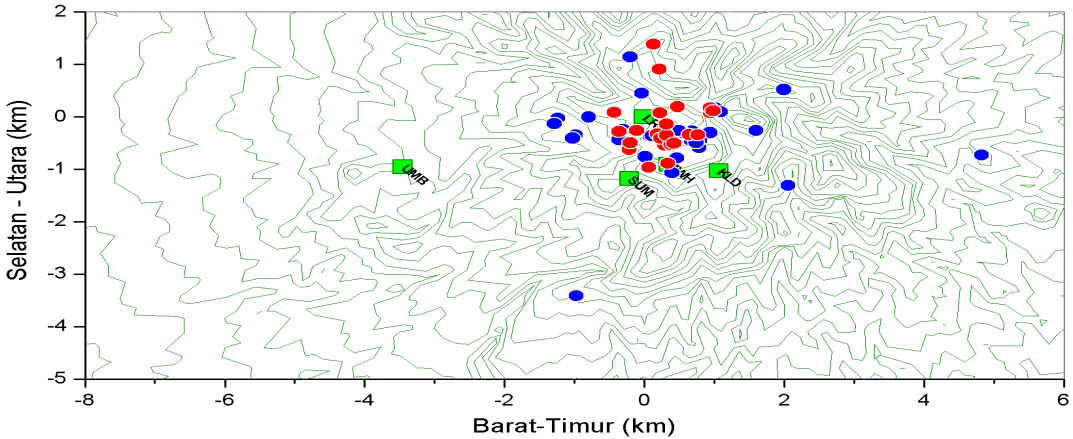

- Lokasi pengamatan deformasi dengan tiltmeter dilakukan di stasiun Lirang Selatan.
- Tiltmeter merekam data dengan baik, terindikasi adanya inflasi komponen Radial (Y)

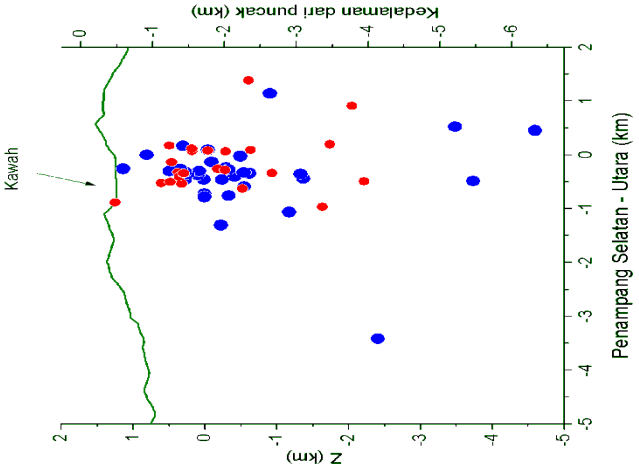
# SUHU AIR PANAS

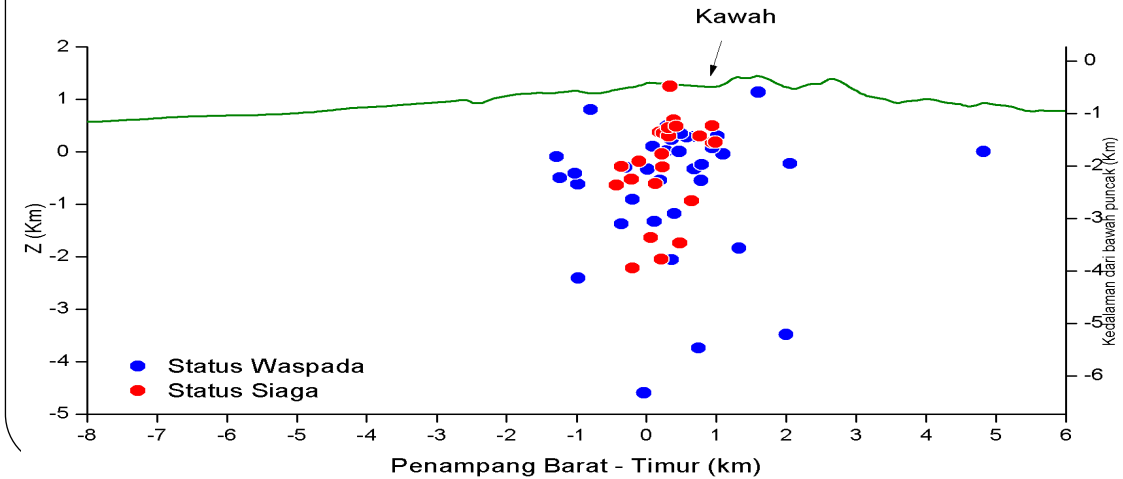



- Pengukuran suhu air panas dilakukan secara kontinyu di kawah G. Kelud
- Suhu air panas G. Kelud teramati meningkat sejak 10 September 2013.
- Peningkatan signifikan teramati sejak tanggal 23 Januari hingga 13 Februari 2014 sekitar 4°C

# Hypocenter and epicenter during kelud crisis in 2014

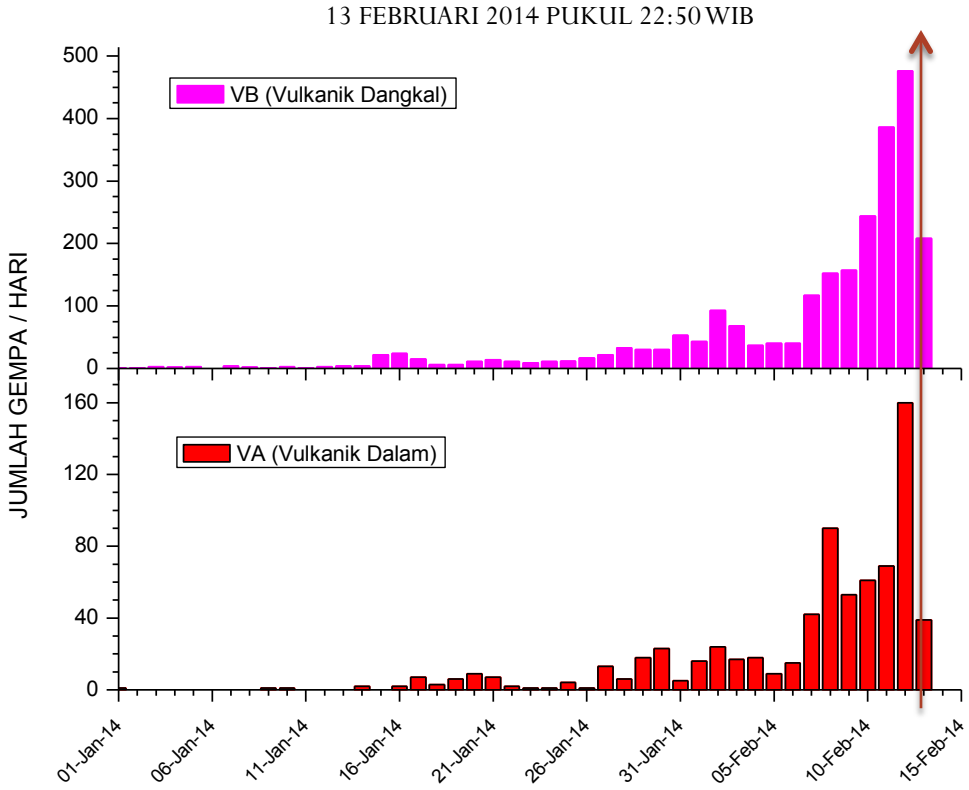


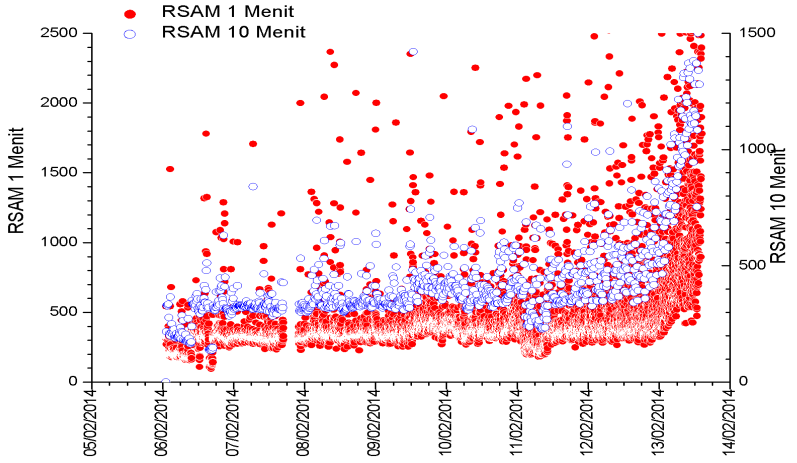



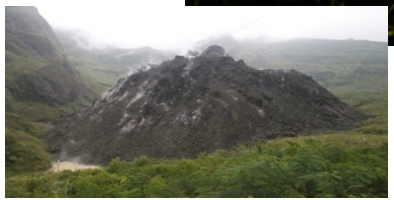




Gempa tersebar di sekitar G. Kelud dengan kedalaman di bawah 7 km dari bawah puncak. Pada periode 11-13 Februari, gempa berada pada kedalaman mencapai 4 km dan terkonsentrasi di sekitar 1 km.

# Seismic activity phenomena before Kelud eruption 2014

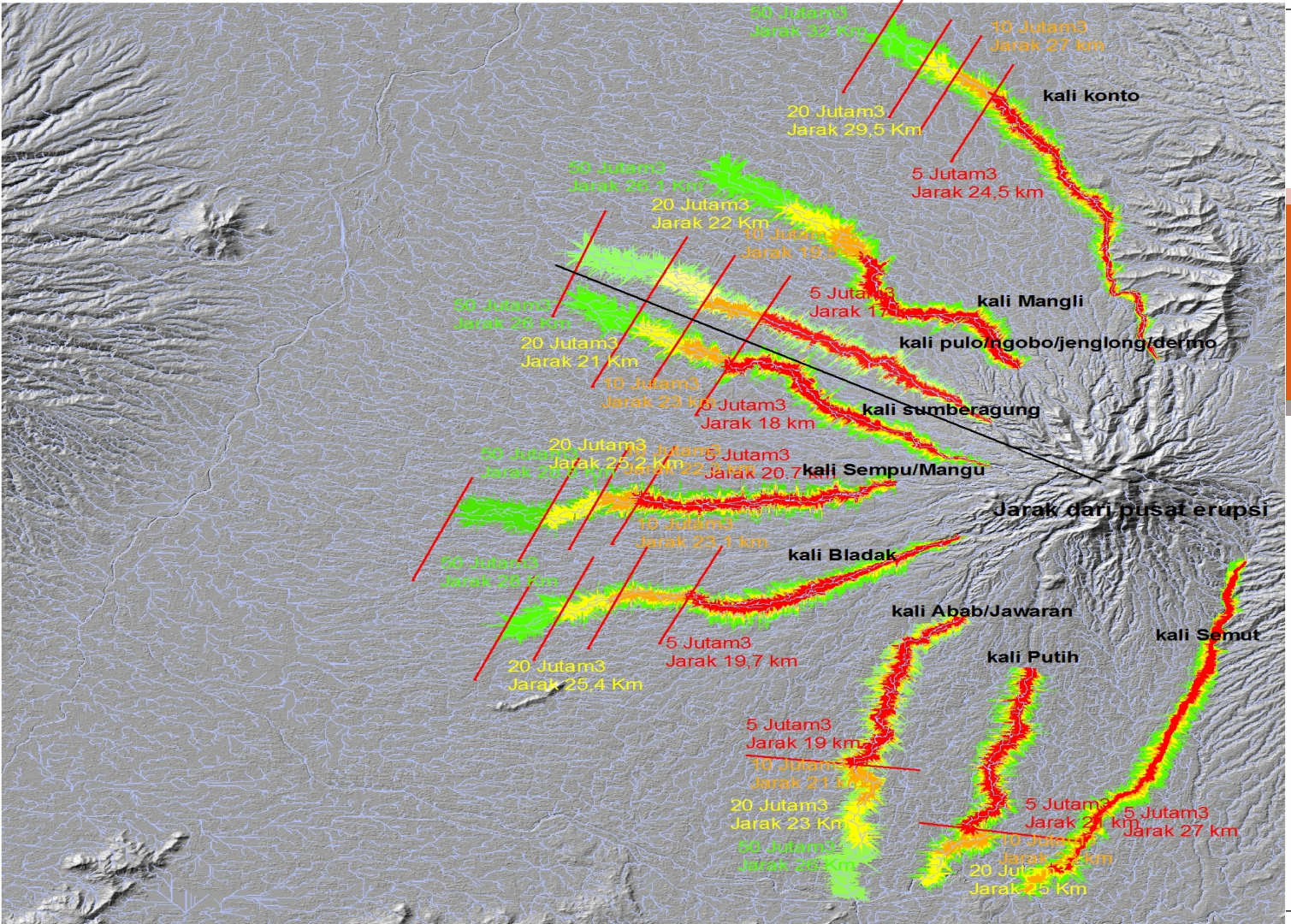


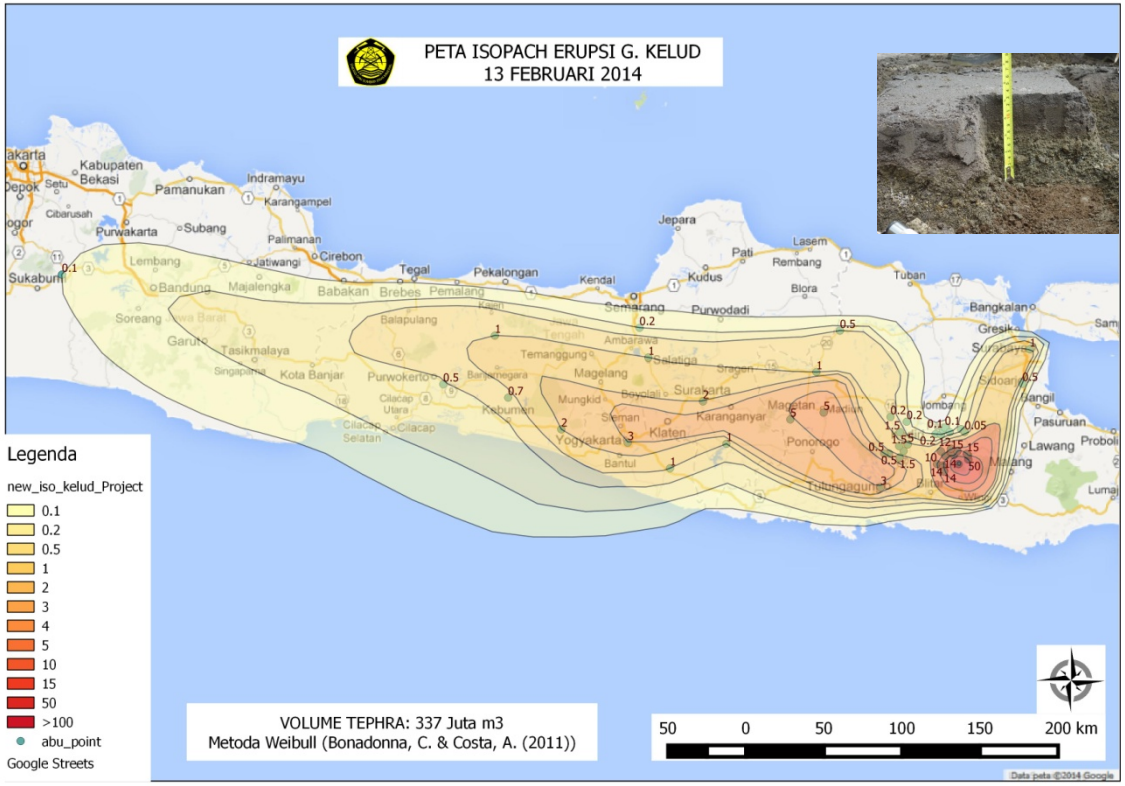



13 FEBRUARI 2014 ;
22:50 LOCAL TIME

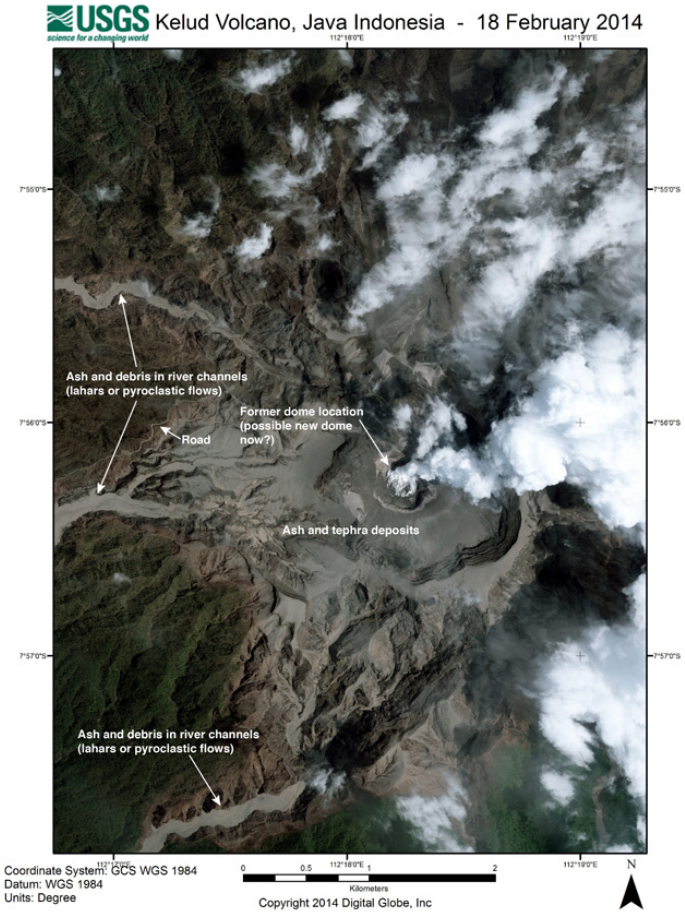
8 Februari 2014




# Lahar modelling – after eruption



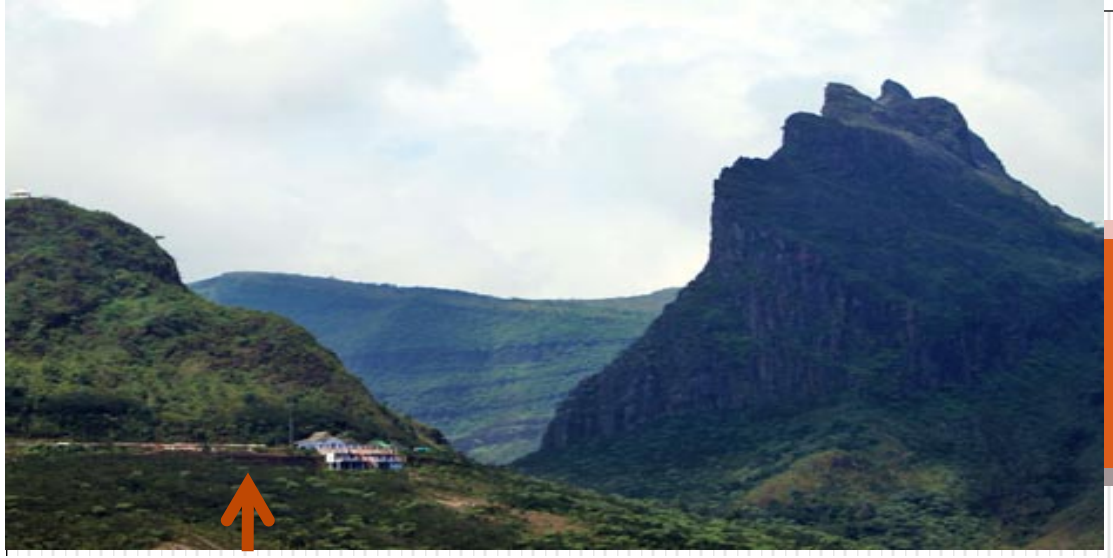



PUMICE FALL

ASH FALL LAYER COVERING PUMICE FALL

# Eruption impact



2008

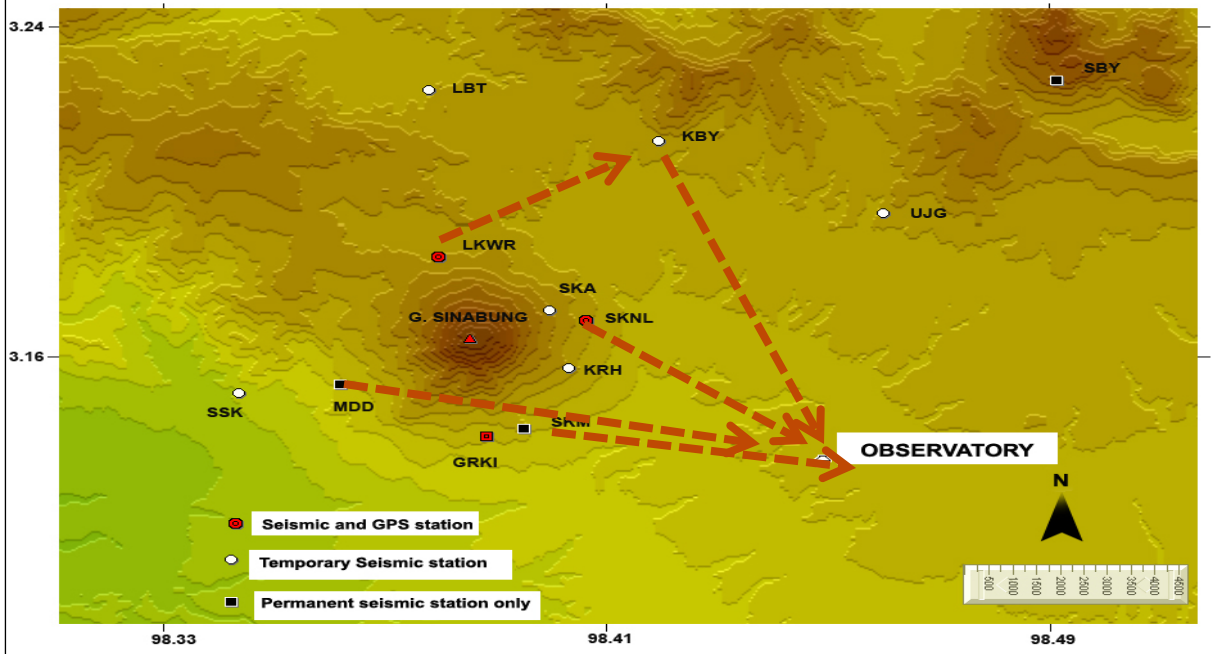

21 Feb 2014




# SINABUNG : 2010 - 2015



# Monitoring Instruments at Sinabung Volcano




- 4 Permanent seismic stations (3 stations are equipped by 1-component seismometer L-4C, and 1 station is equipped by 3-component seismometer, L22D)
- 6 Temporary seismic stations (Kinkei system with 3 component seismometer. KVS-300)
- 4 GPS continue stations s

# New Fissure at Lau Kawar (Northern part of G. Sinabung , Oktober , 15 2013)





Eruption column and rain of ash with small pyroclastic flow from Sinabung Volcano


OCTOBRE 2013
(*WASPADA* (2nd Level))

(Phreatic eruption )

*No juvenile clast*

NOVEMBER, 11, 2013 (SIAGA ( 3rd Level))

Ø clast : 1 cm in radius 5 Km from crater (November 4, 2013)

Ø clast -- 6 cm in radius 4 Km from crater ( November 23, 2013)

*Lithic and juvenile clast*

(Phreatic - phreatomagmatic eruption)

Dominated by Gas Emission)

28/11/13

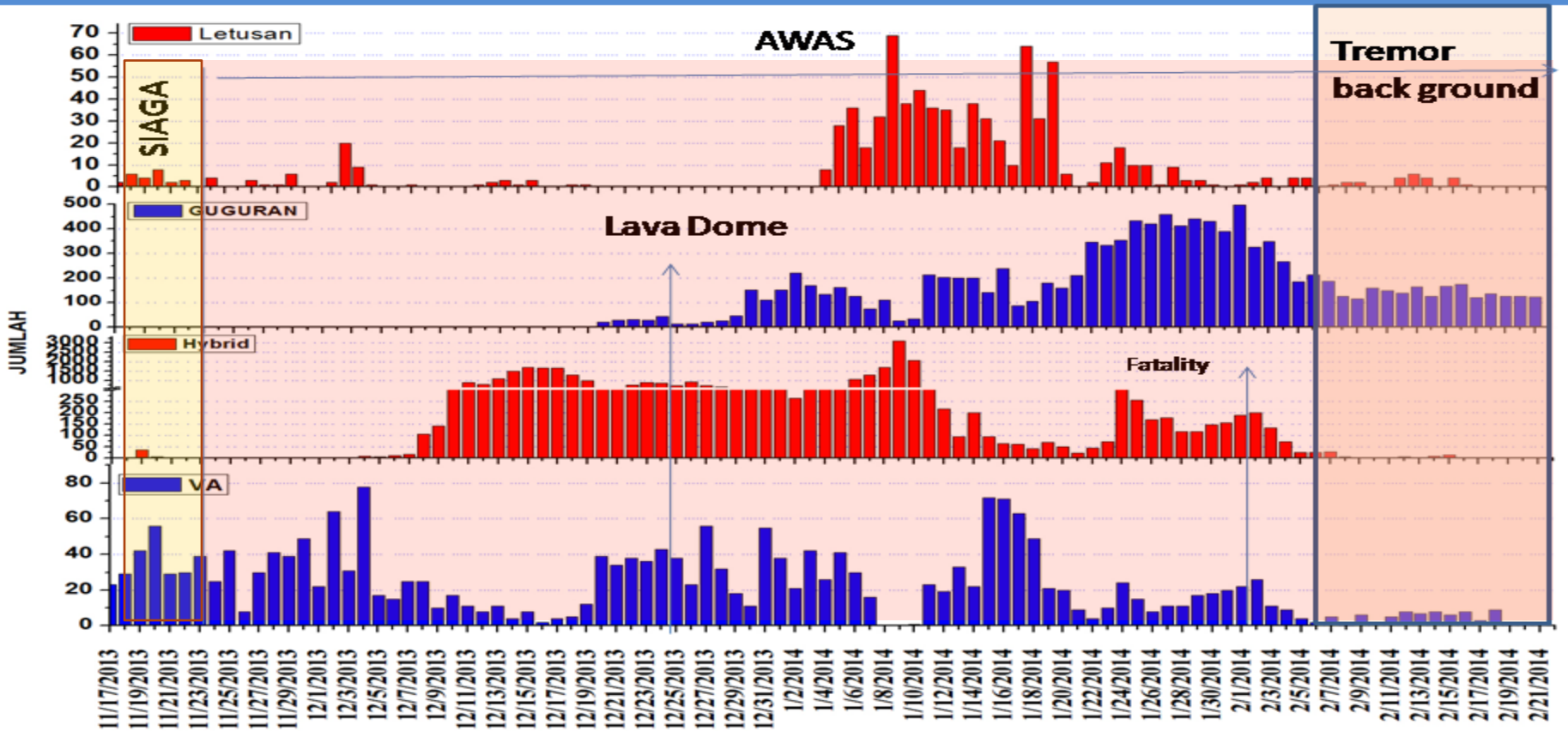
29/11/13

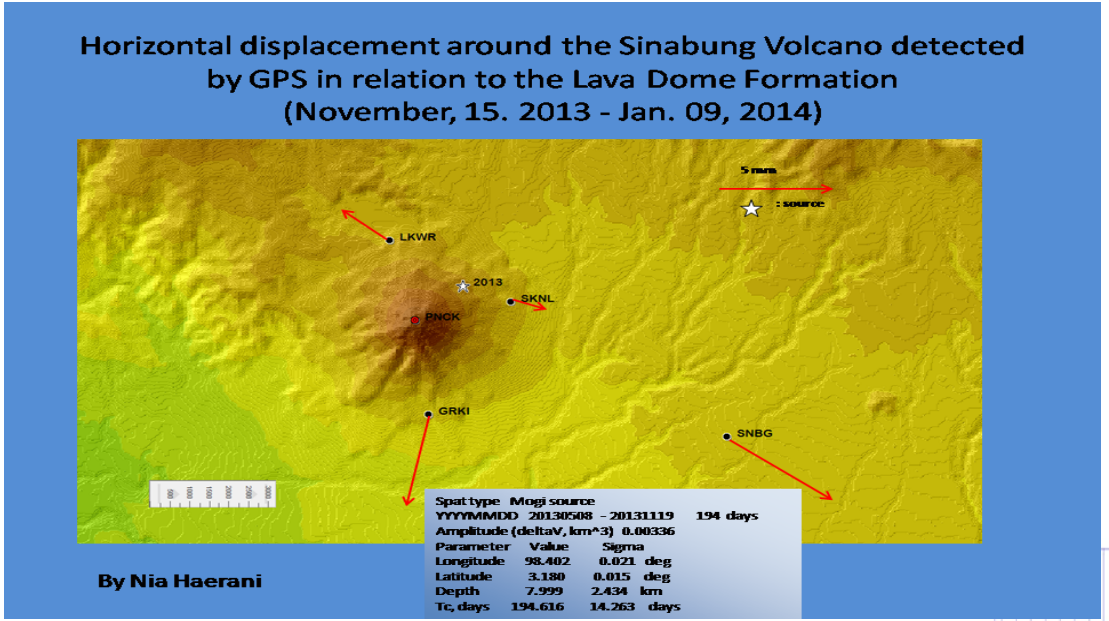
07/12/13

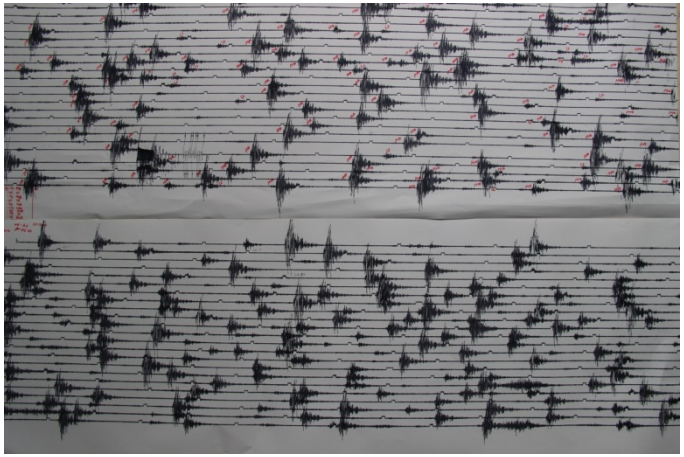
AWAS (Since December 24, 2013)

# Events Leading up to the lava dome formation of Sinabung :

## Seismic activity (on Daily Number) of Sinabung Volcano Nov.17 , 2013 to Feb. 21, 2014 (by PPGA)

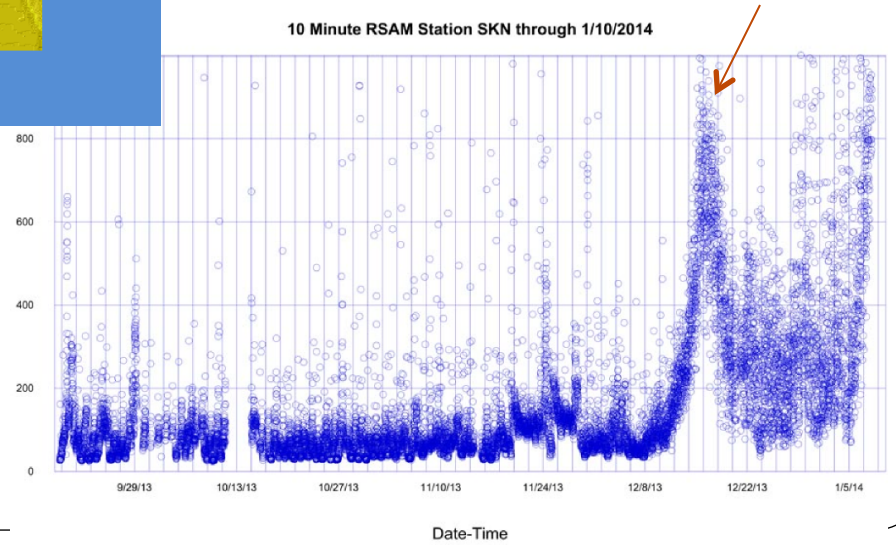




**10 January 2014; just before *en masse* collapse;**

**dome reaches ~3 Mm$^3$**

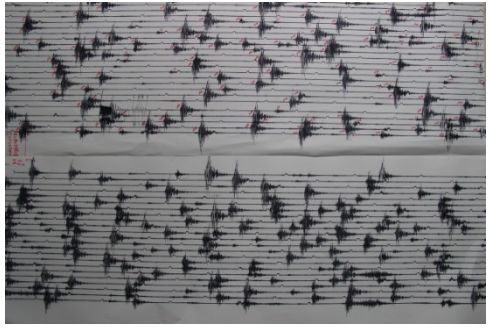


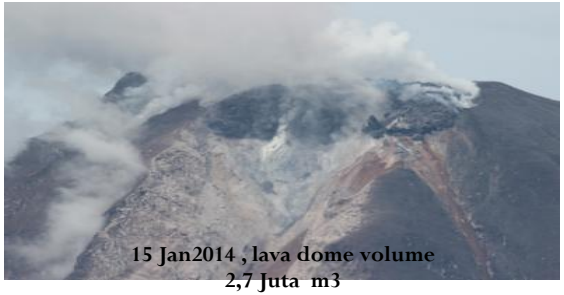
| Date | Dome volume (m3) | Rate (m3/menit) |
|---|---|---|
| 24 Desember 2013 | 495.967 | |
| 25 Desember 2013 | 836.829 | 236.7 |
| 26 Desember 2013 | 1.055.413 | 151.8 |
| 27 Desember 2013 | 1.137.019 | 56.7 |
| 28 Desember 2013 | 1.263.419 | 87.78 |
| 29 Desember 2013 | 1.509.086 | 170.58 |
| 30 Desember 2013 | 1.784.256 | 191.1 |
| 31 Desember 2013 | 2.054.840 | 187.92 |
| 1 Januari 2014 | 2.366.445 | 216.42 |
| 5 Januari 2014 | 1.937.119 | -298.14 |
| 6 Januari 2014 | 1.731.091 | -143.1 |
| 8 Januari 2014 | 2.106.455 | 130.32 |

Dome growth December, 24, 2013 – January, 8 2014

# LAVA DOME – PF – LAVA FLOW



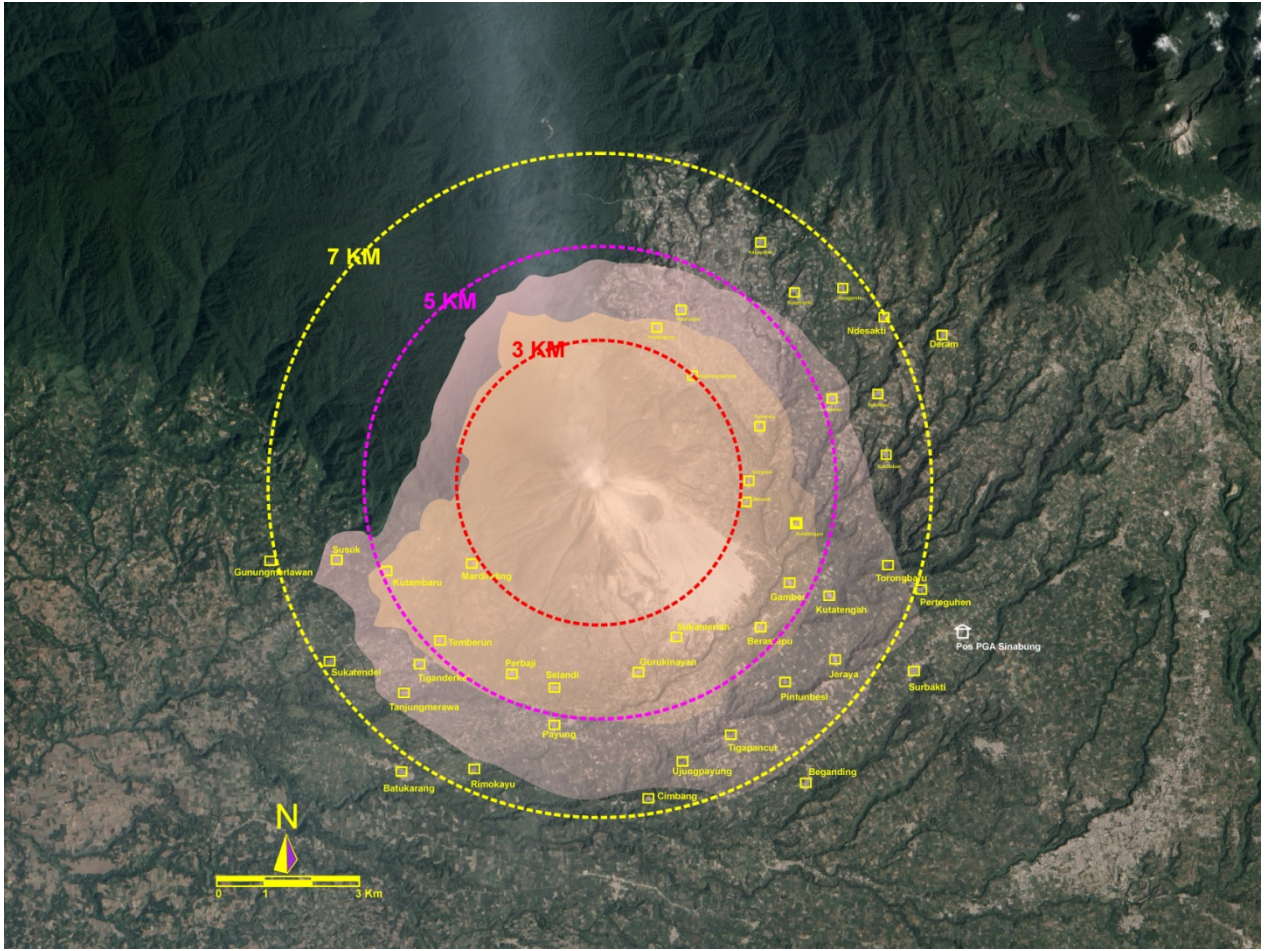






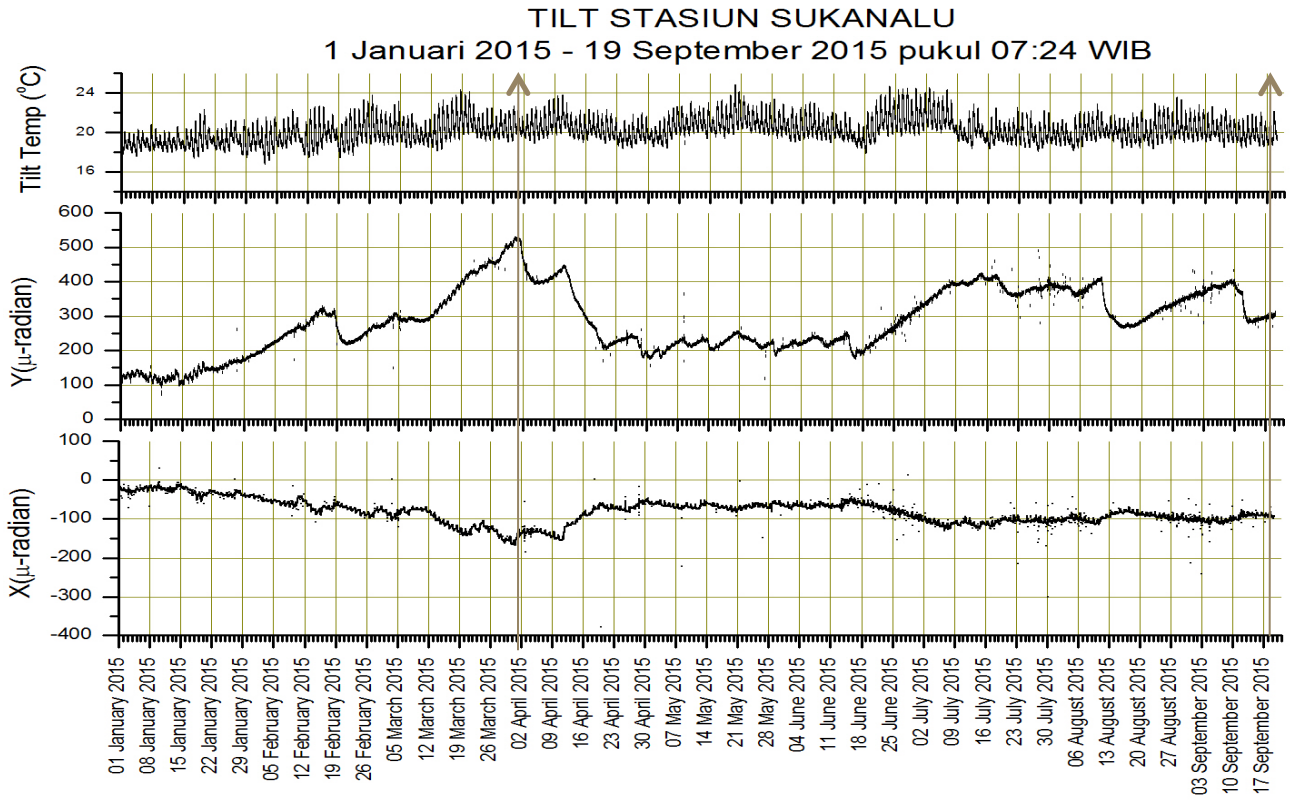



Pf's, 15 JAN 2014




HAZARD ZONE MAP - SINABUNG OVERLAYING WITH ERUPTION ZONE IMPACTED

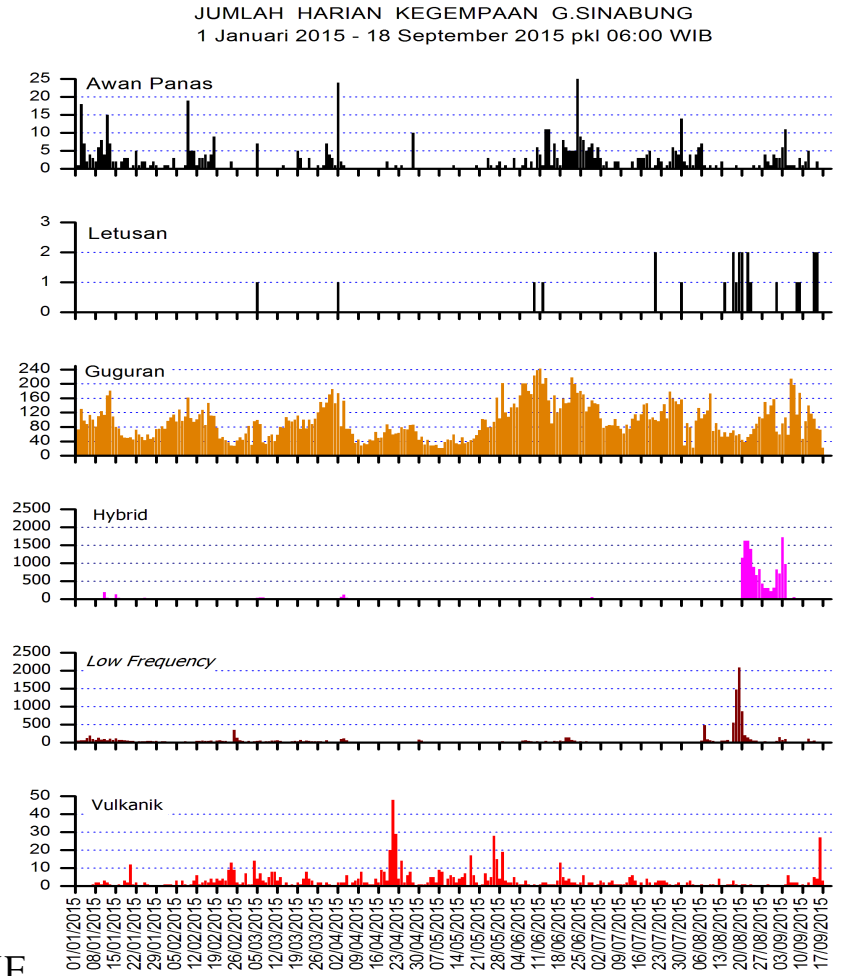
# DEFORMASI


TILT STASIUN SUKANALU
1 Januari 2015 - 19 September 2015 pukul 07:24 WIB
Tilt Temp (°C)
24
20
16
Y(μ-radian)
600
500
400
300
200
100
0
X(μ-radian)
100
0
-100
-200
-300
-400
01 January 2015
08 January 2015
15 January 2015
22 January 2015
29 January 2015
05 February 2015
12 February 2015
19 February 2015
26 February 2015
05 March 2015
12 March 2015
19 March 2015
26 March 2015
02 April 2015
09 April 2015
16 April 2015
23 April 2015
30 April 2015
07 May 2015
14 May 2015
21 May 2015
28 May 2015
04 June 2015
11 June 2015
18 June 2015
25 June 2015
02 July 2015
09 July 2015
16 July 2015
23 July 2015
30 July 2015
06 August 2015
13 August 2015
20 August 2015
27 August 2015
03 September 2015
10 September 2015
17 September 2015

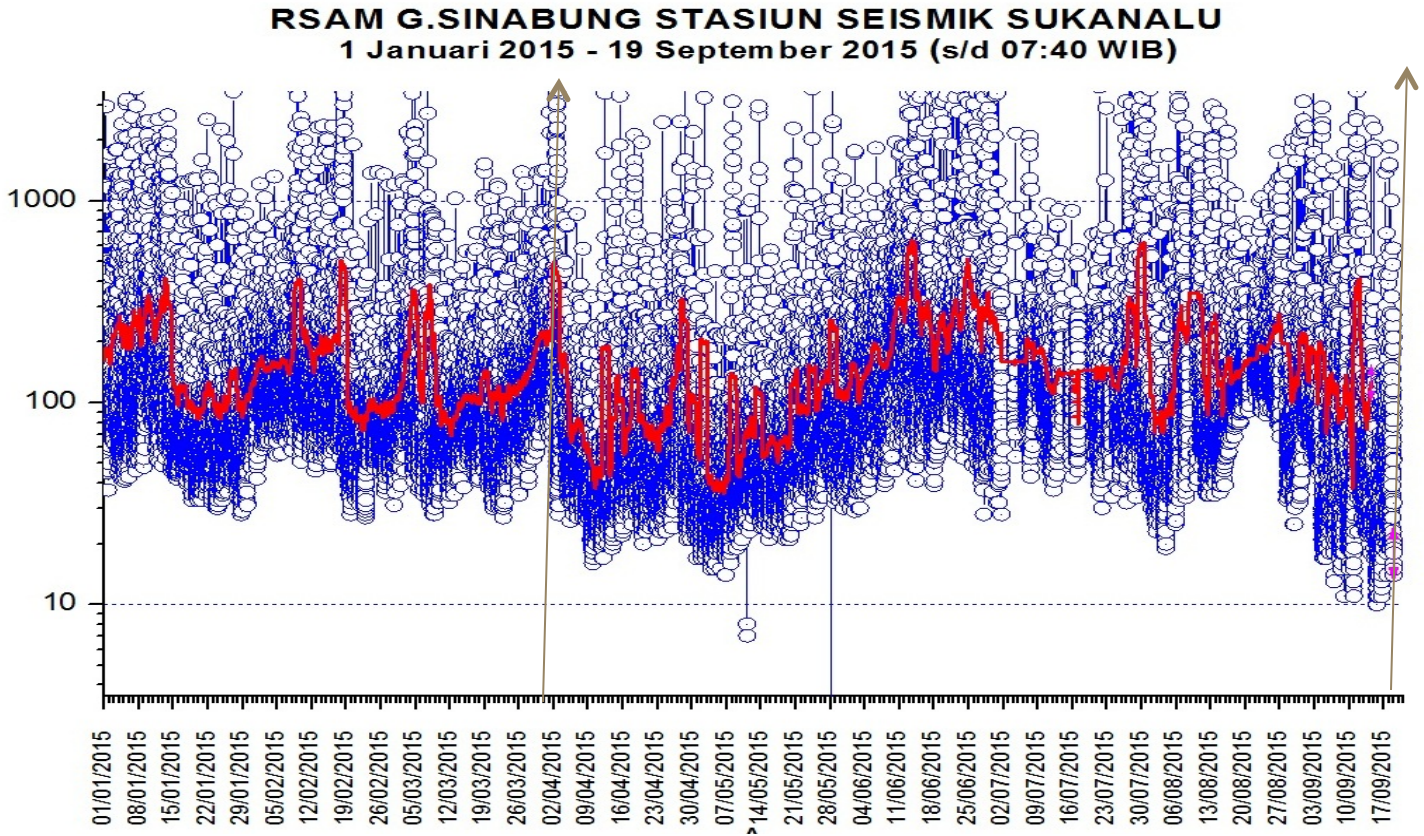
# Seismicity and eruption caracter during sept.2015

LAVA DOME

GUGURAN/AVALANCHE



# REAL SESIMIC AMPLITUDE MEASUREMENT (RSAM) - ENERGI



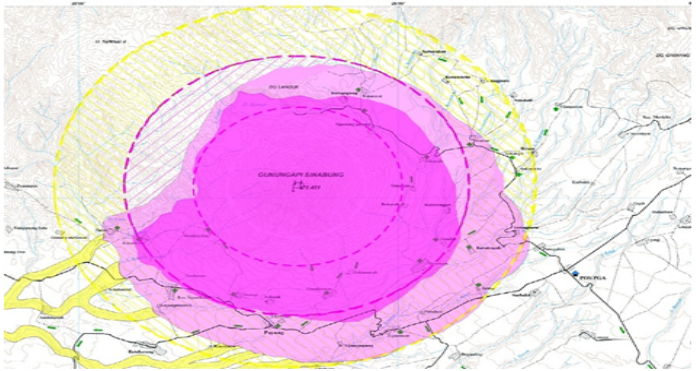
# REMARKS

1. **Volcanological hazard in Indonesia can't avoid, however we can reduce the impact of geological hazards.**
2. **The Successful of the volcanological hazard mitigation depend on :**
   - **Data Accuracy and information.**
   - **Quick information from Government/Institution to community.**
   - **Application of Geological Hazard information to the Society/Local Community.**


TERIMA KASIH

**PETA KAWASAN RAWAN BENCANA (KRB) G. SINABUNG**

**Dalam status Awas G.Sinabung dalam radius 5 km tidak ada aktivitas masyarakat**



**Nama Desa dan Dusun yang diungsikan**

1. Ds. Mardinding
2. Ds. Perbaji
3. Ds. Selandi
4. Ds. Sukameriah
5. Ds. Guru Kinayan
6. Ds. Berastepu
7. Dsn. Sibintun
8. Ds. Gamber)
9. Ds. Bekerah
10. Ds. Simacem
11. Ds. Sukanalu
12. Ds. Kuta Tonggal
13. Ds. Sigarang-garang
14. Ds. Kuta Rakyat
15. Ds. Kuta Gugung
16. Dsn Lau Kawar
17. Kuta Tengah

Lokasi awan panas

**Kawasan Rawan Bencana III**
Sangat berpotensi terlanda awan panas, guguran lava, aliran lava dan gas racun

R = 3 km
Sangat berpotensi terlanda hujan abu lebat dan lontaran batu (pijar) Ø > 6 cm

**Kawasan Rawan Bencana II**
Berpotensi terlanda awan panas, guguran lava dan aliran lava dan gas beracun

R = 5 km
Berpotensi terlanda hujan abu lebat Dan lontaran batu (pijar) Ø = 2-6 cm

**Kawasan Rawan Bencana I**
Berpotensi terhadap aliran lahar Hujan dan perluasan awan panas

R = 7 km
Berpotensi tehadap hujan abu dan Kemungkinan dapat terkena lontaran batu (pijar) Ø < 2 cm

# SINABUNG – HAZARD ZONE MAP

KRB MAP (III,II) : FLOW PRODUCT (Red (III) and pink (II) in color), Primery Hazard (Pyroclastic flow, lava, and vulcanic gas) )

Piroclastic Flow : Sinabung

Lava : Sinabung

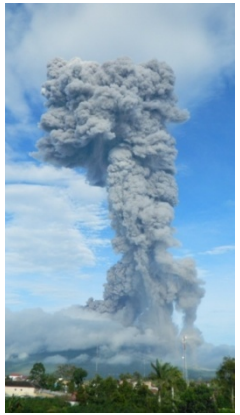
CO2 + H2O (Dieng Volcano)

KRB (I) : Flow (Yellow)
Secondary Hazard:Lahar

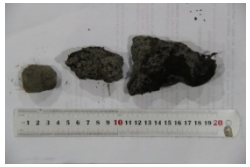
Lahar Papandayan 2002

Lahar Sinabung 2014

KRB MAP (III,II) : FALL PRODUCT (CIRCULAR FORM)
Primery Hazard Fall with size ( ash < 2 mm;
2 mm >lapilli < 64 mm; Block/bomb > 64 mm))



Pyroclastic Fall : Sinabung



Sinabung

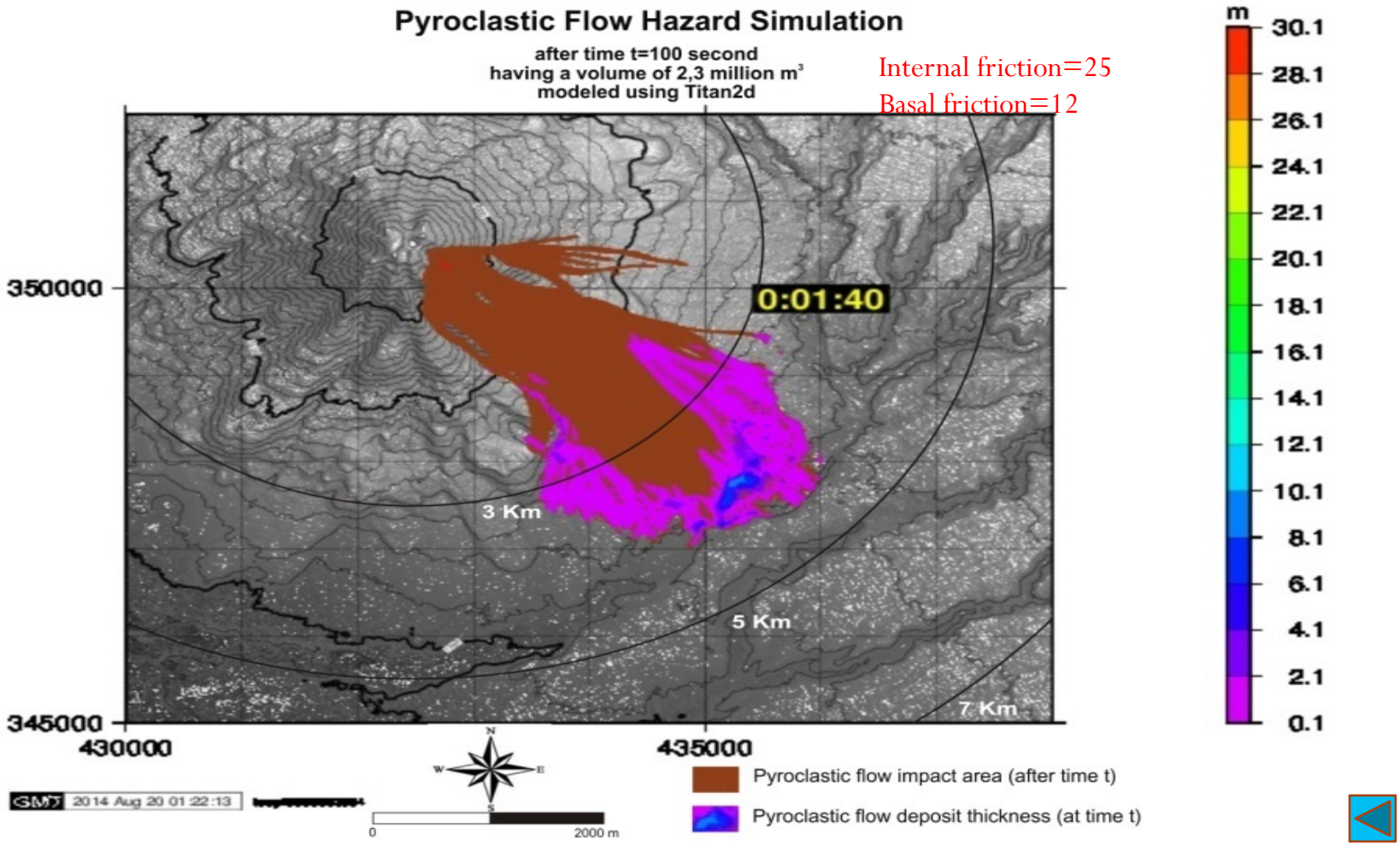
Pyroclastic Fall : Rinjani

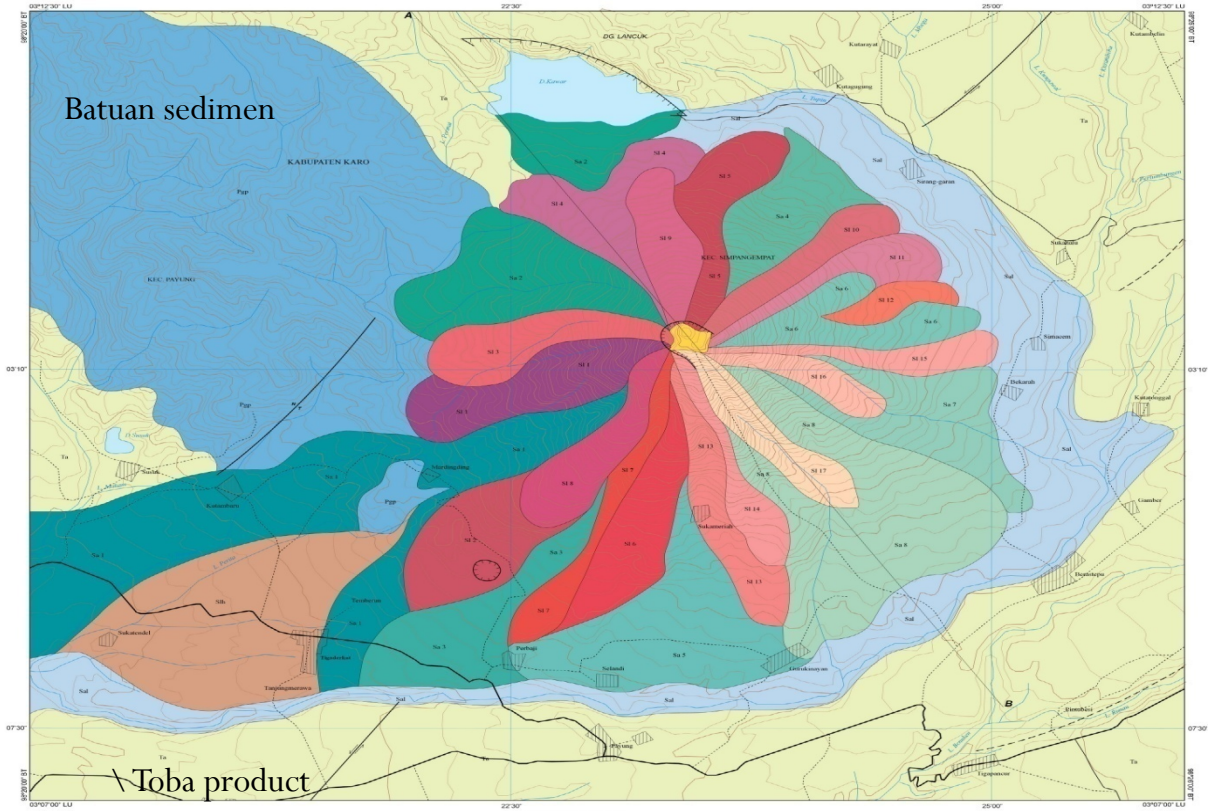
Pyroclastic with size 1 meter is found until 3 Km from crater to the west

Pyroclastic with size about 10 cm is found until 7 Km from Kelud crater to the west

# VOLCANIC HAZARD MODELING

- PYROCLASTIC FLOW MODELING : TITAN 2 D
- PYROCLASTIC FALL MODELLING :
- LAHAR MODELING : LAHAR Z


Pyroclastic Flow Hazard Simulation
after time t=100 second
having a volume of 2,3 million m³
modeled using Titan2d
Internal friction=25
Basal friction=12
0:01:40
3 Km
5 Km
7 Km
350000
345000
430000
435000
m
30.1
28.1
26.1
24.1
22.1
20.1
18.1
16.1
14.1
12.1
10.1
8.1
6.1
4.1
2.1
0.1
GMT 2014 Aug 20 01:22:13
0
2000 m
Pyroclastic flow impact area (after time t)
Pyroclastic flow deposit thickness (at time t)




# Geologic Map of G. SINABUNG

**KORELASI SATUAN PETA**
***CORRELATION OF MAP UNIT***

| UMUR *AGE* | KHULUK | GUMUK | KEGIATAN ERUPSI *ERUPTION ACTIVITY* | SATUAN BATUAN / *ROCK UNIT* | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | LAVA | PIROKLASTIK ALIRAN *FLOW* | PIROKLASTIK JATUHAN *FALL* | SKUNDER | SEDIMEN *SEDIMENT* |
| K U A R T E R | G. SIBUAL BUALI | | Pusat | Sl 17 | Sa 8 | | | Sal |
| | | | | Sl 16 | | | | |
| | | | | Sl 15 | Sa 7 | | | |
| | | | | Sl 14 | | | | |
| | | | | | Sa 6 | | | |
| | | | | Sl 13 | | | | |
| | | | | Sl 12 | Sa 5 | | | |
| | | | | Sl 11 | | | | |
| | | | | Sl 10 | | | | |
| | | | | Sl 9 | Sa 4 | | | |
| | | | | Sl 8 | | | | |
| | | | | Sl 7 | | | | |
| | | | | Sl 6 | | | | |
| | | | | Sl 5 | Sa 3 | | | |
| | | | | Sl 4 | | | | |
| | | | | Sl 3 | | | | |
| | | | | Sl 2 | Sa 2 | | | |
| | | | | Sl 1 | | | Slh | |
| | | | | | Sa 1 | | | |
| 10" | | | | | Ta | | | |
| | | | | | | | | Pup |

- Red color : Lava Flow
- Green color : Pyroclastic flow

Carbon Dating of the latest volcanic product of Pyroclastic flow (Block and Ash Type) indicates the age of formation to be 1200 years BP.

(Setsuya Nakada, 2011 in Prambada )

Carbon Dating of the latest volcanic product of Pyroclastic flow (Block and Ash Type) indicates the age of formation to be 1200 years BP. (Setsuya Nakada, 2011 in Prambada )

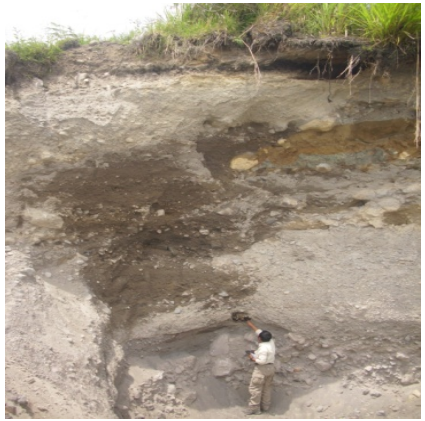
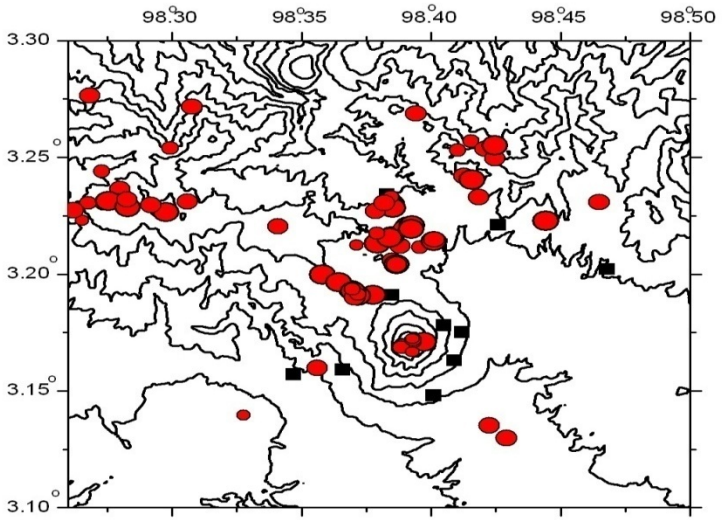
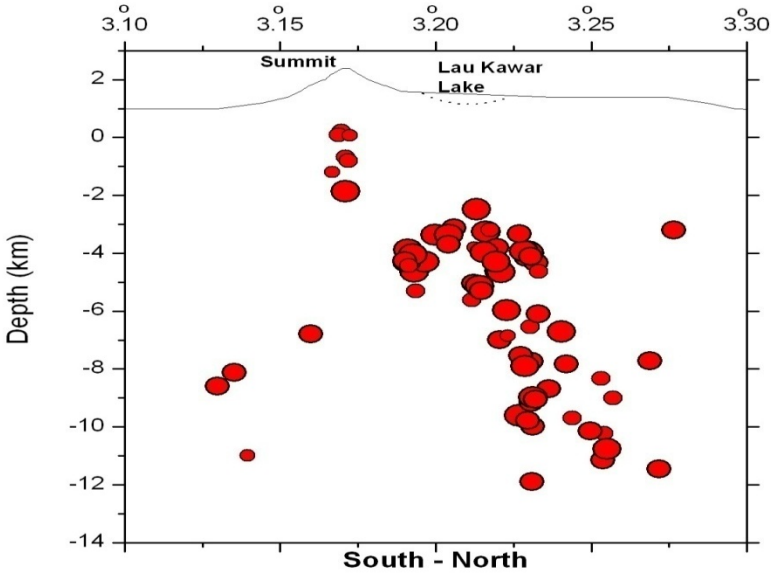


*Foto : Budi, PVMBG, 2010*

# Distribution of Magnitude



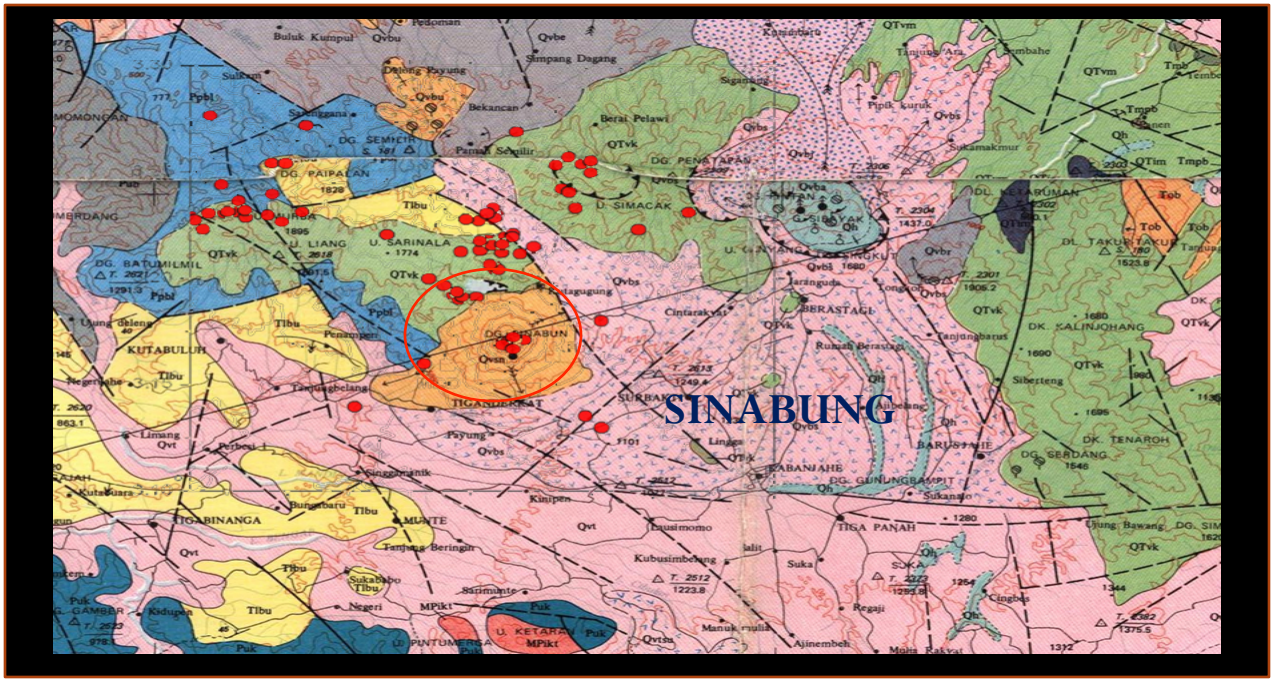




Mag >2

1.5 <Mag 2

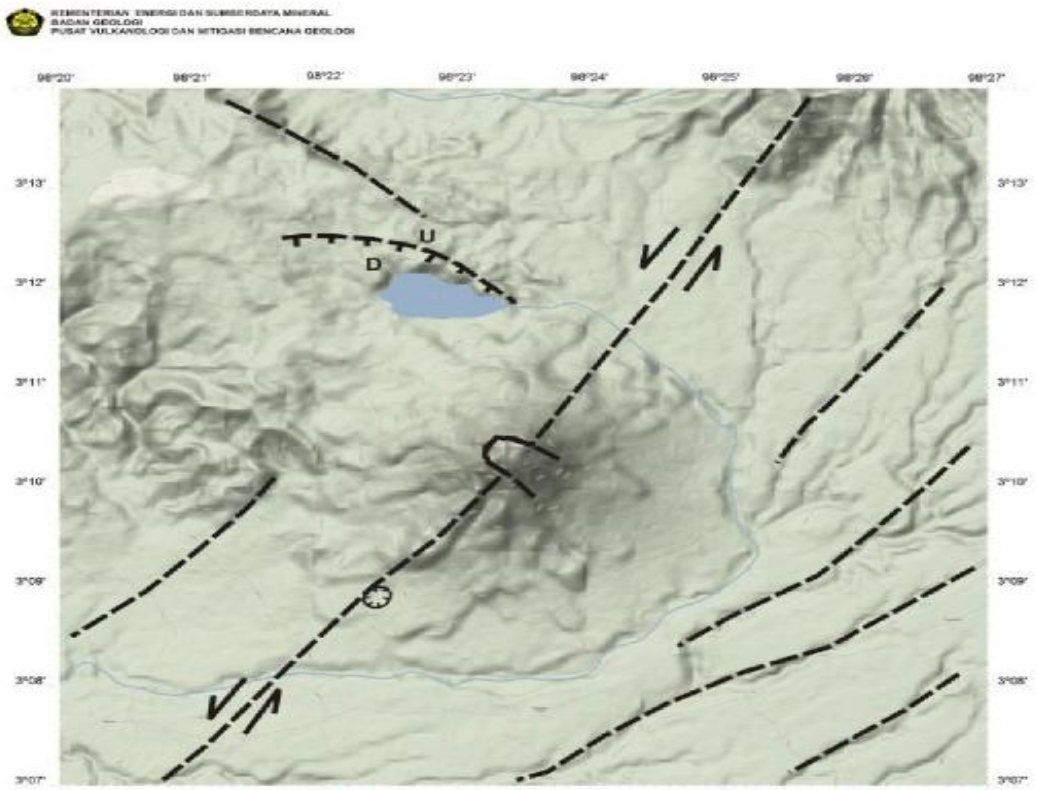
- Mostly VTB earthquakes magnitude is below 1
- Mostly VTA earthquakes magnitude is between 1.5 - 2

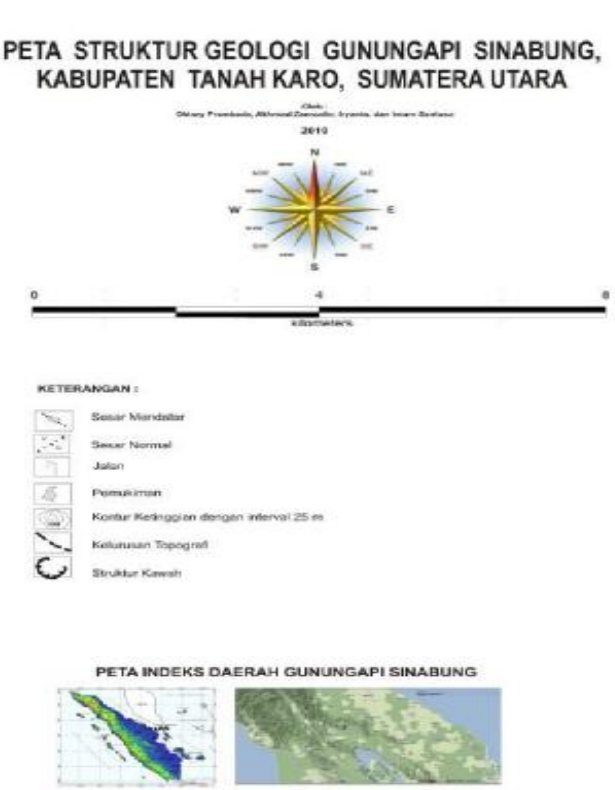
# Distribution of VT earthquakes compare to geological structure

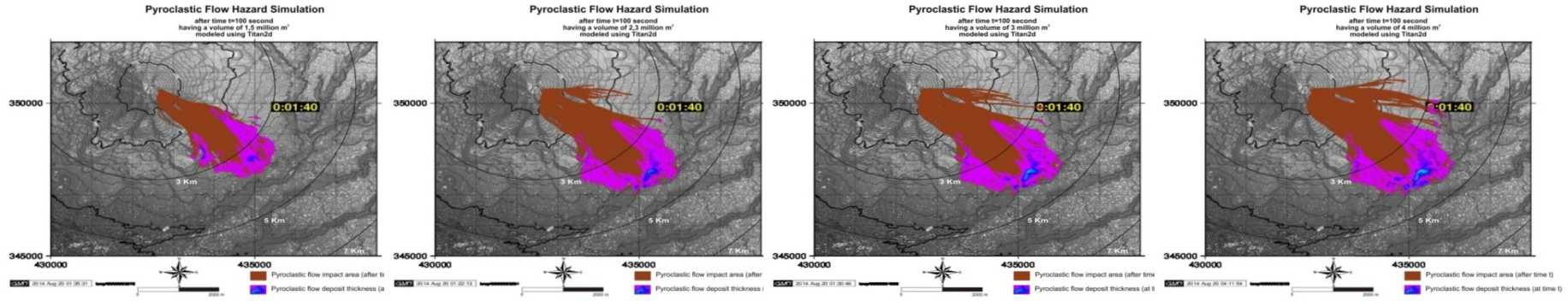


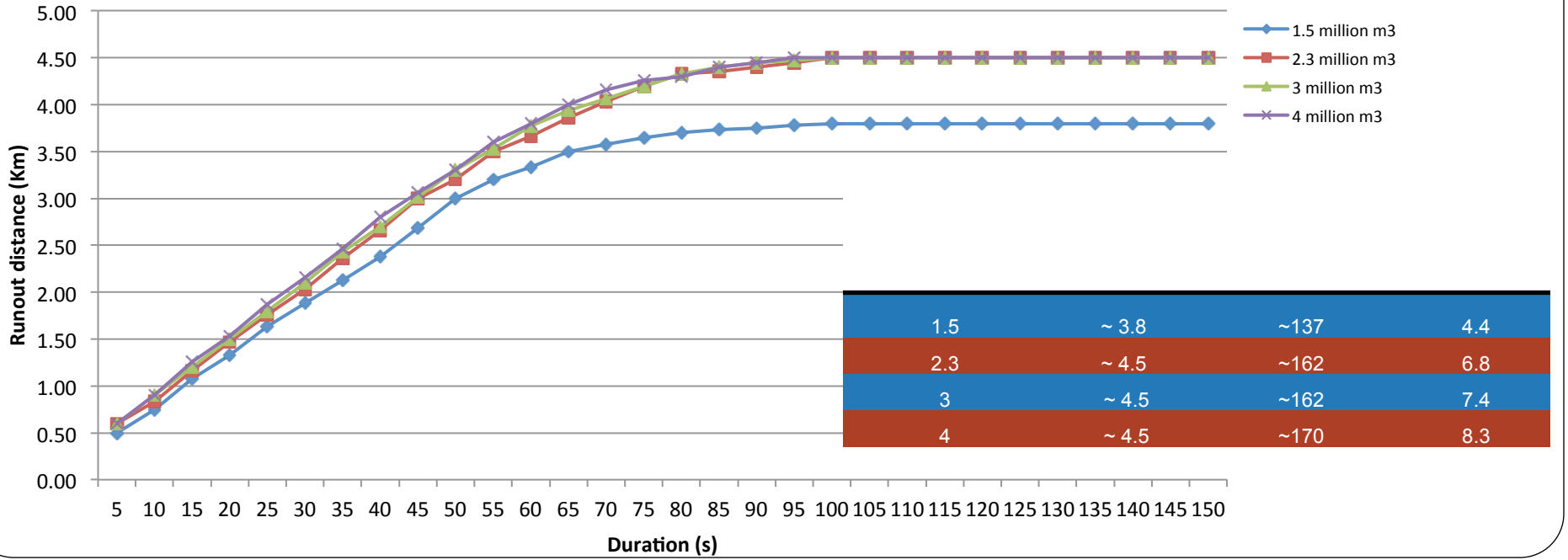

Geological Map of The Medan Quadrangle, Sumatera (Cameron, N.R. 1982)

# GEOLOGIC STRUCTURE FEATURE OF SINABUNG VOLCANO



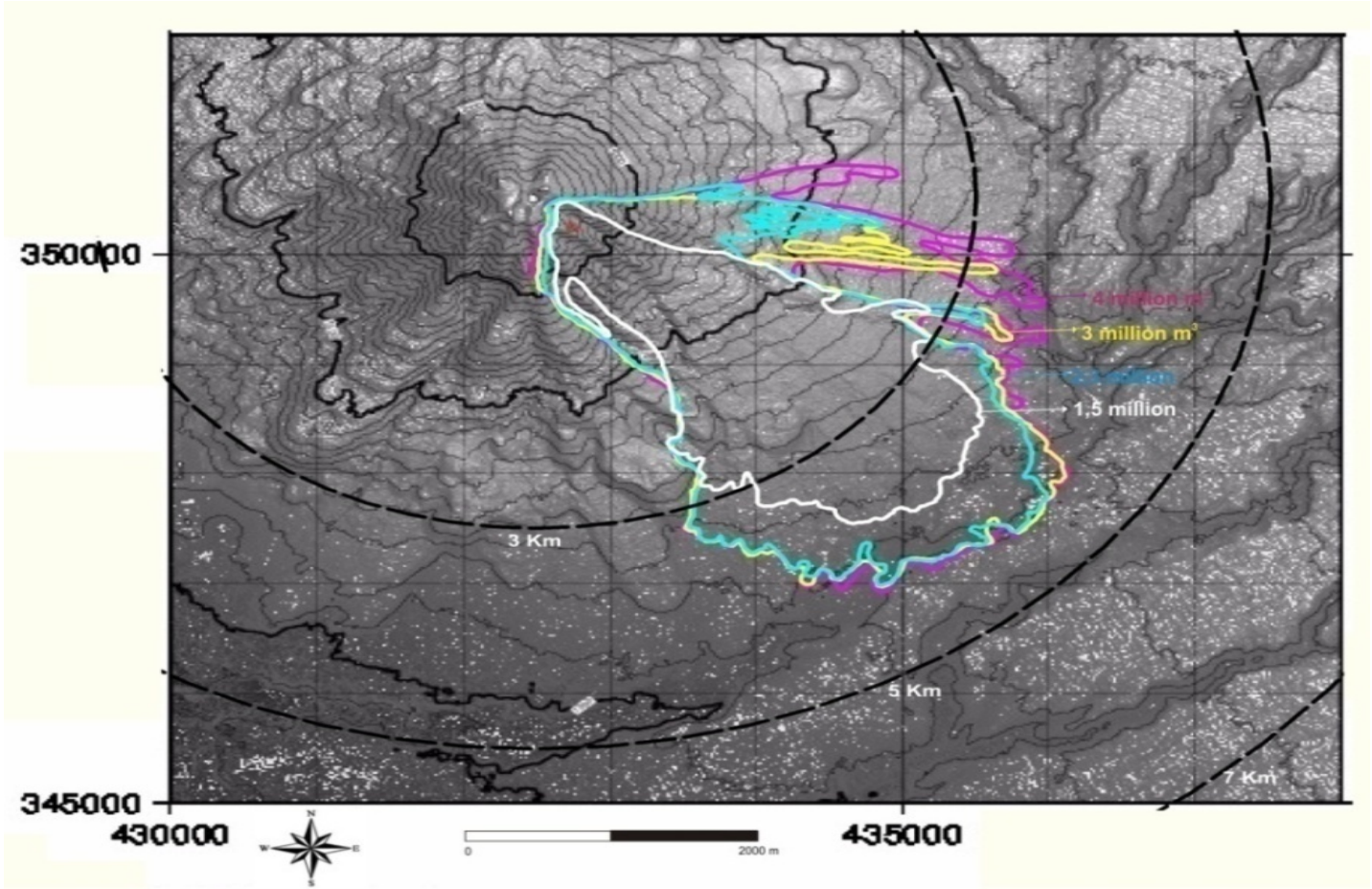





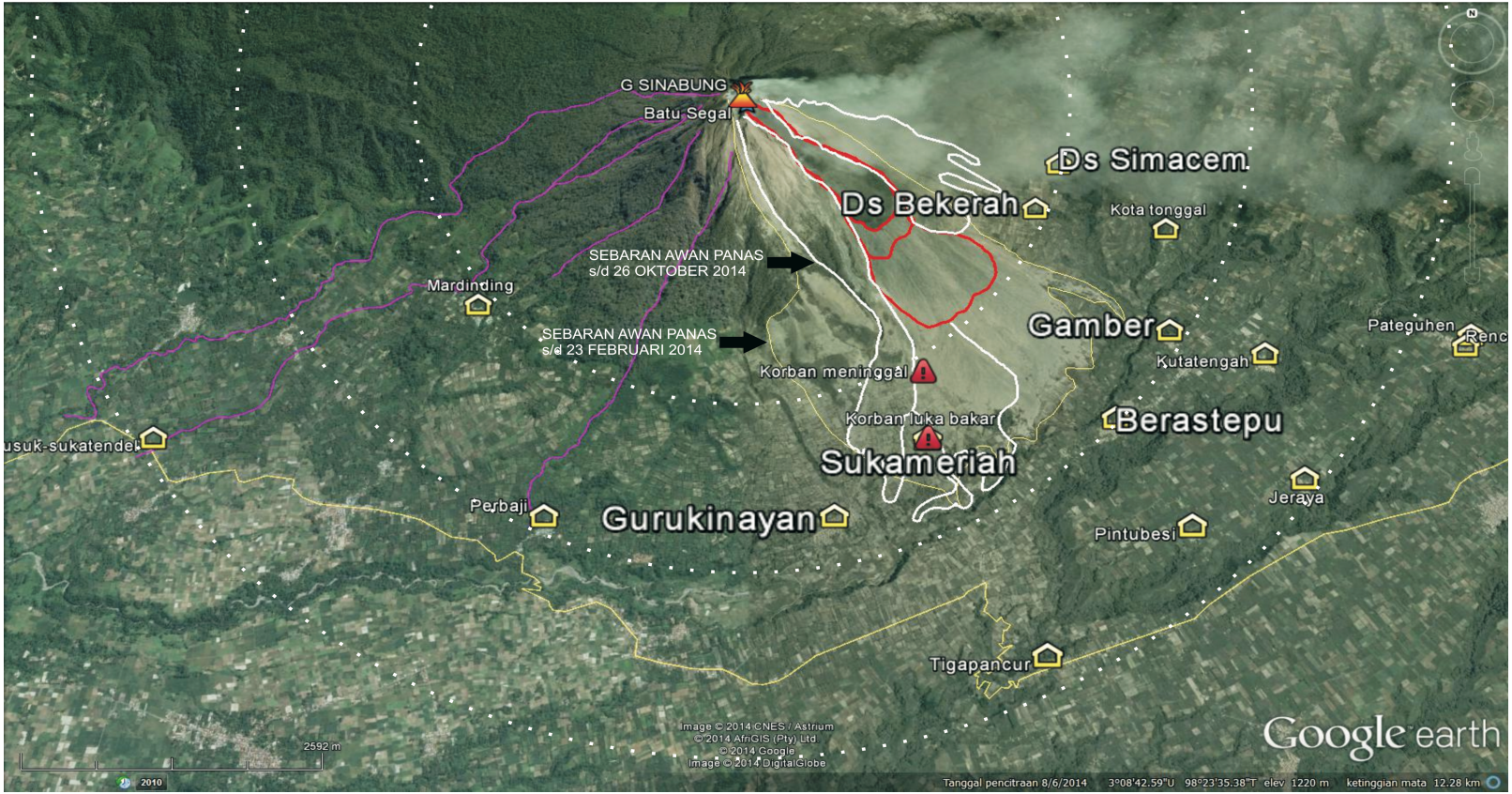




| | | | |
|---|---|---|---|
| 1.5 | ~ 3.8 | ~137 | 4.4 |
| 2.3 | ~ 4.5 | ~162 | 6.8 |
| 3 | ~ 4.5 | ~162 | 7.4 |
| 4 | ~ 4.5 | ~170 | 8.3 |

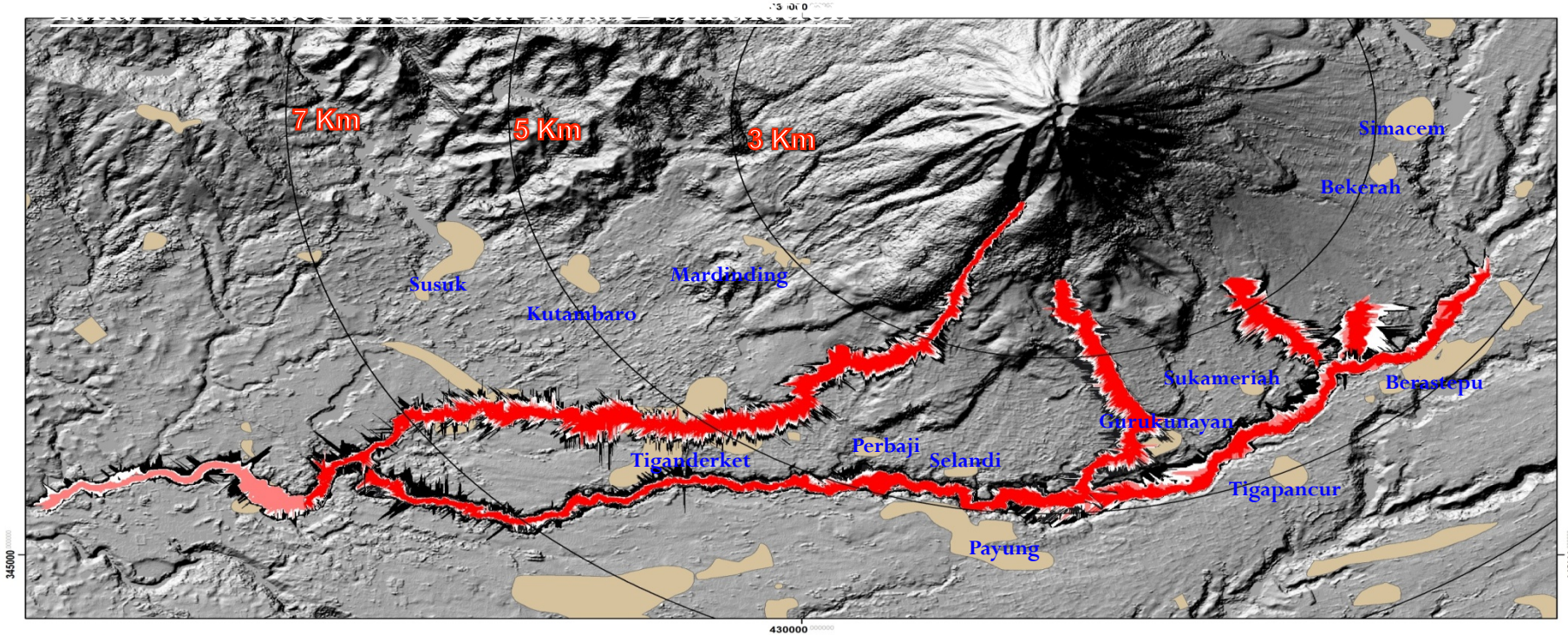
# Pyroclastic flow impacted area from the simulation



# Pyroclastic flow distribution and area potentially impacted



Pyroclastic flow
impact on April 2015


Legend

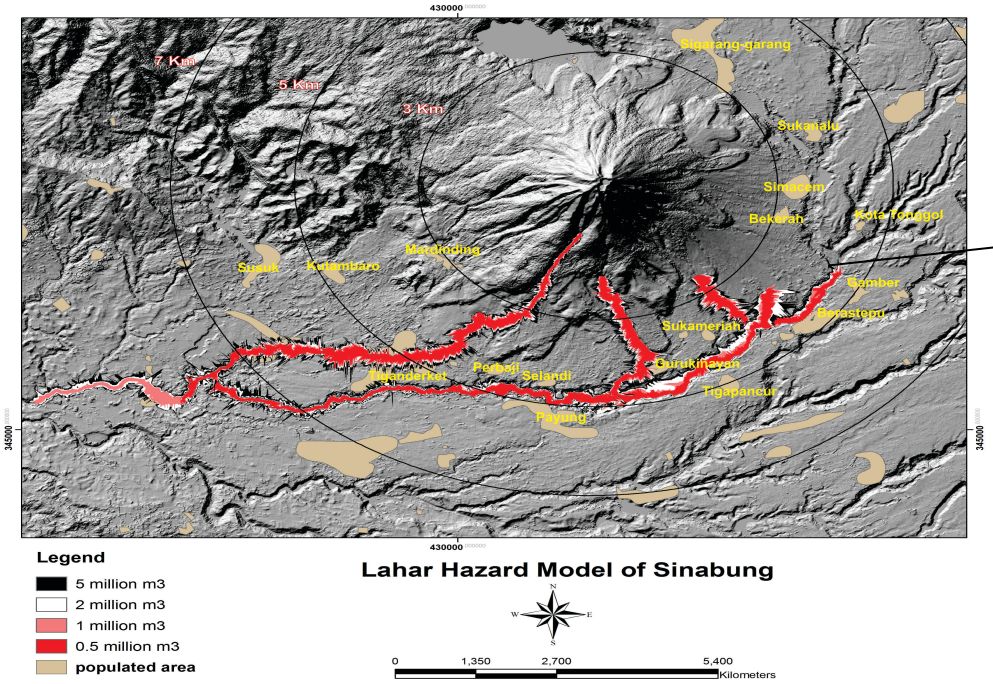
- 500.000 m3
- 1.000.000 m3
- 2.000.000 m3
- 5.000.000 m3
- populated area

## Lahar Hazard Model of Sinabung

N
W
E
S

0 1,050 2,100 4,200

Kilometers




Lahar occured on 29 October 2013 (in the valley between Sukameriah-Bekerah village)

**Legend**

- 5 million m3
- 2 million m3
- 1 million m3
- 0.5 million m3
- populated area

**Lahar Hazard Model of Sinabung**

0 1,350 2,700 5,400 Kilometers

Lahars can flow through the rivers that disgorge at Sinabung (Lau Borus River) and potentially threaten the villages of Sukameriah, Gurukinayan, Bekerah village and villages near Lau Borus river, such as Payung, Selandi, Berastepu village . Lahar from the summit can also flow through to the valley and potentially threaten the several villages of Tiganderket district.

# Secondary hazard : Sinabung Lahar on August 2014

# TINGKAT KEGIATAN DAN ANCAMAN LETUSAN/AKTIVITAS GUNUNGAPI

| | |
|---|---|
| Level 1 (Normal) | Berdasarkan hasil pengamatan secara visual dan atau instrumental dapat teramati fluktuasi tetapi tidak memperlihatkan peningkatan kegiatan. Ancaman bahaya berupa gas-gas beracun dapat terjadi di sekitar pusat erupsi berdasarkan karakteristik masing-masing gunungapi. |
| Level II (WASPADA ) | Berdasarkan hasil pengamatan secara visual dan atau instrumental mulai teramati atau terekam gejala peningkatan kegiatan gunungapi. Pada beberapa gunungapi dapat terjadi erupsi tetapi hanya menimbulkan ancaman bahaya di sekitar pusat erupsi berdasarkan karakteristik masing-masing gunungapi. |
| Level III (SIAGA) | Berdasarkan hasil pengamatan secara visual dan atau instrumental teramati peningkatan kegiatan yang semakin nyata. Kegiatan dapat berupa erupsi tetapi tidak mengancam pemukiman dan atau aktivitas masyarakat di sekitar gunungapi berdasarkan karakteristik masing-masing gunungapi. |
| Level IV (AWAS) | Berdasarkan hasil pengamatan secara visual dan atau instrumental peningkatan kegiatan dapat diikuti atau telah terjadi erupsi yang berpotensi mengancam pemukiman dan atau aktivitas masyarakat di sekitar gunungapi. |

# Local Government and Community Response In Volcanic Activity

**Level I**
***NORMAL***

Volcanic activity stays in normal state

**Level II**
***WASPADA***

The activity begins to increase

**Level III**
***SIAGA***

The activity shows some eruption showing some minor eruptions and but not yet threat people settlement

**Level IV**
***AWAS***

The volcano starts to main erupt, may lead to the main eruption and threat people settlement

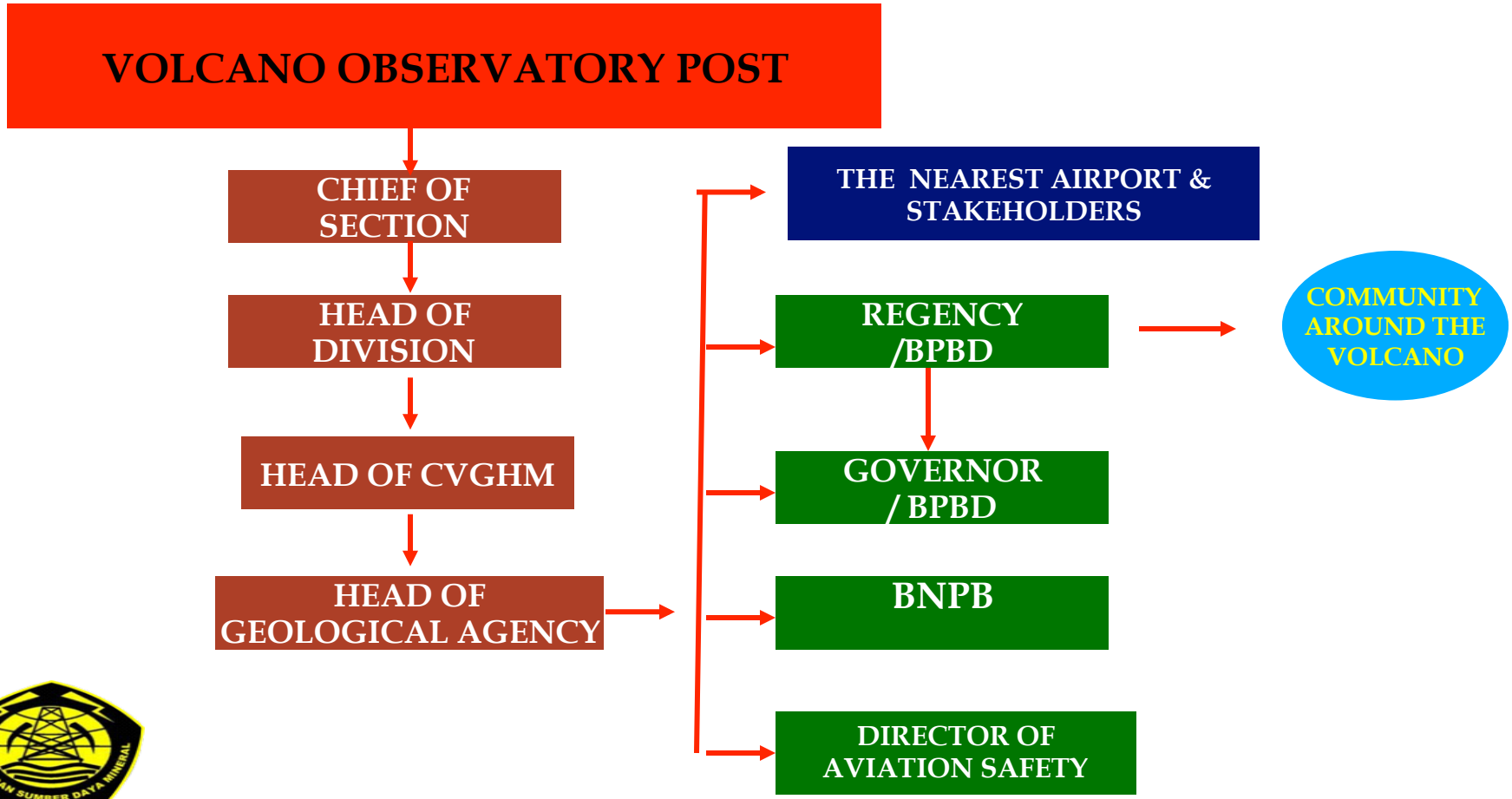
**Limited activities on Volc. Hazard Zone II, III**

**No activities on Volc. Hazard Zone II, III**

**Evacuation Volc. Hazard Zone II, III**


Volcanic Hazard Zone Map

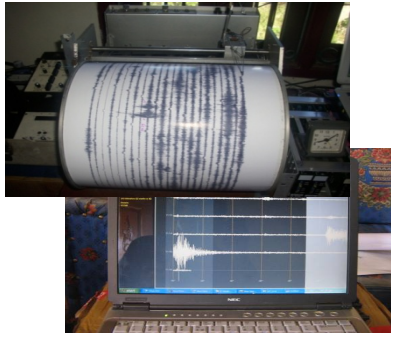
# INFORMATION DISTRIBUTION FOR INCREASING OF VOLCANIC ACTIVITY



# DISASTER MITIGATION SERVICES OF SINABUNG ERUPTION 2010

HEAD OF BNPB

PRESIDENT



VOLCANO MONITORING

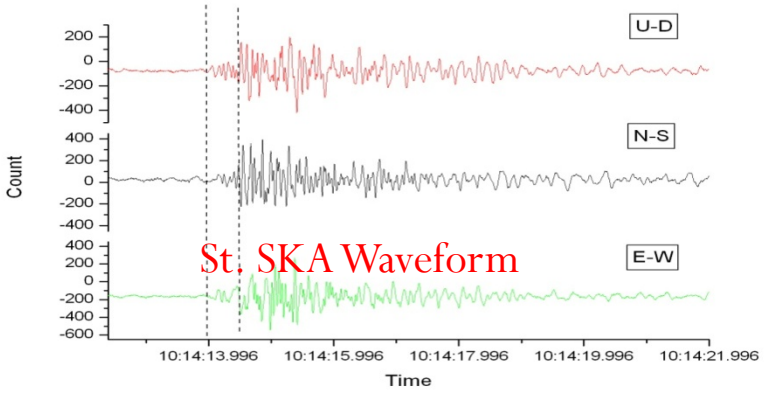
LOCAL GOVERNEMENT ( HEAD OF REGENCY, GOVERNOR)

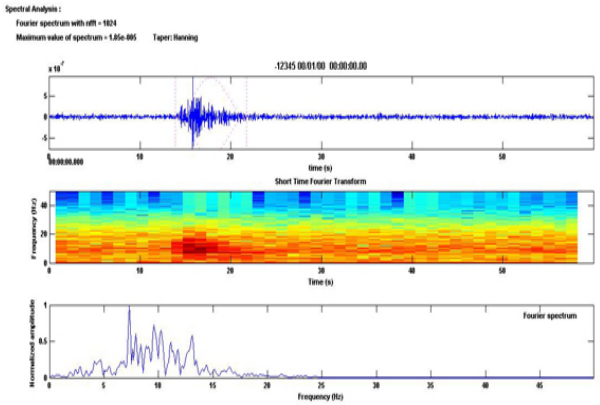
PERS -MEDIA

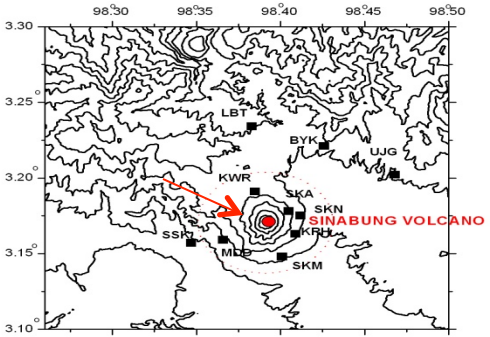
COMMUNITY

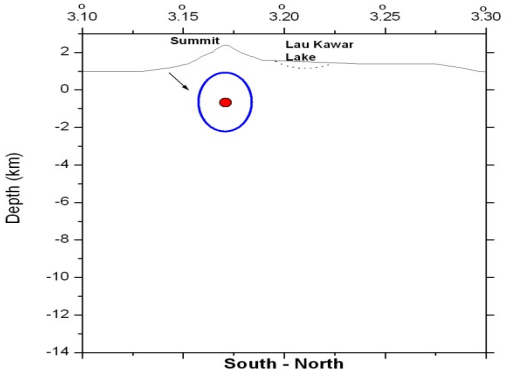
# VTB Earthquakes at Sinabung Volcano

- ❑ S-P arrival time less than 1 second
- ❑ Shallow volcanic earthquakes
- ❑ High frequency content (5 – 15 Hz)
- ❑ Only record by seismic station near the summit



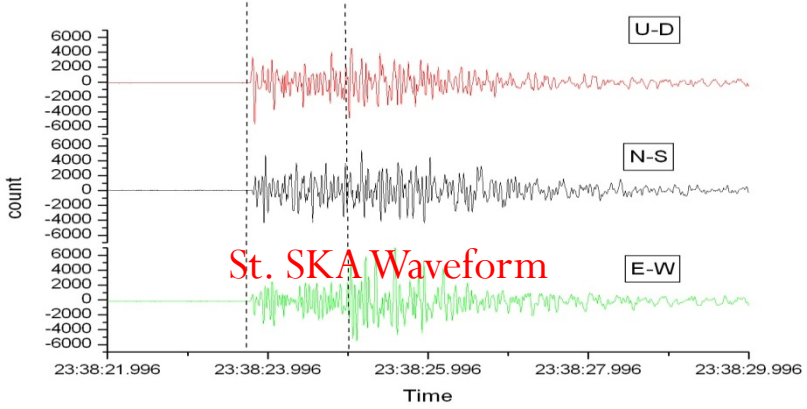



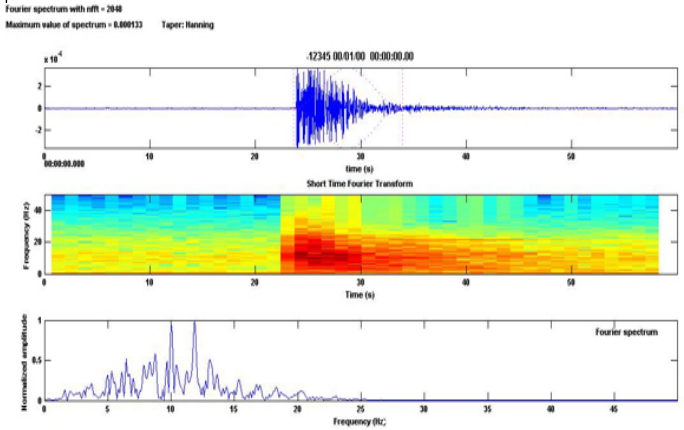



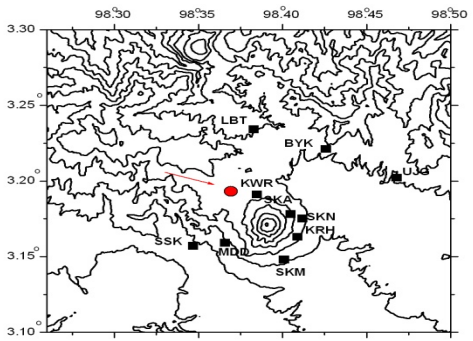



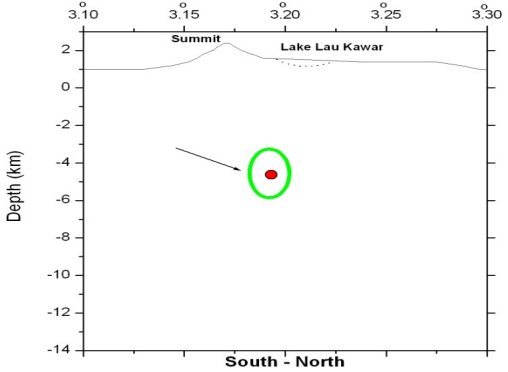
# VTA Earthquakes at Sinabung Volcano

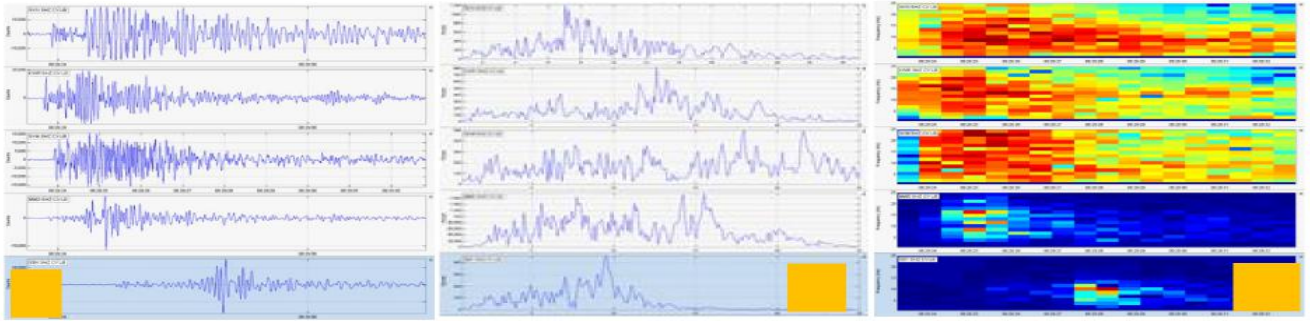
- S-P arrival time between 1 – 3.5 seconds
- Deep volcanic earthquakes
- High frequency content (5 – 20 Hz)
- Record by seismic station outside the volcano



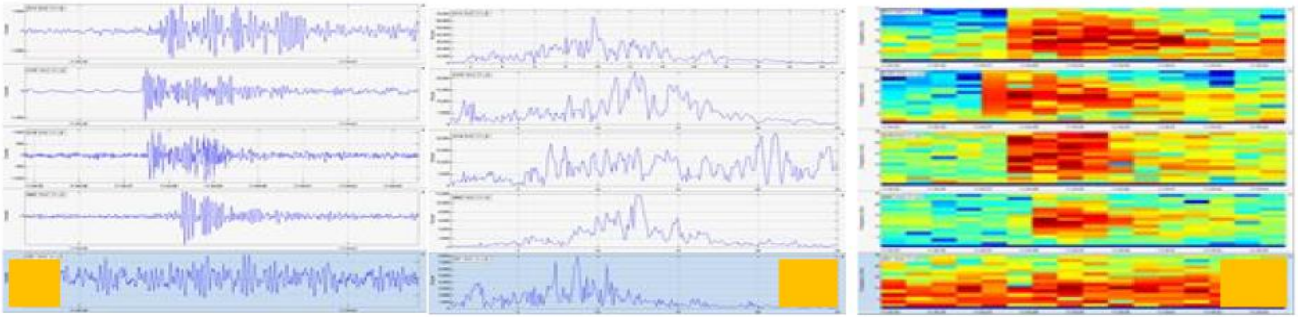



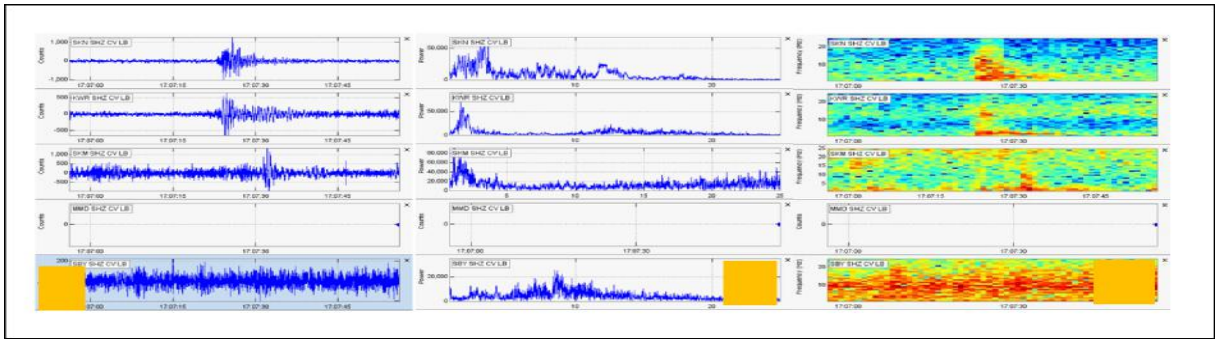





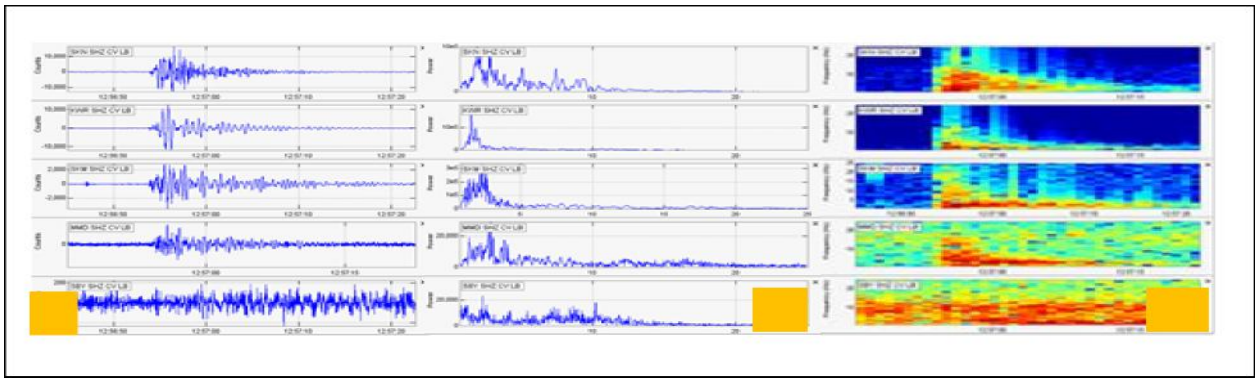
•**Gempa Vulkano-Tektonik Dalam tipe A (VT Tipe A)** ? *clear onset of P-wave* dengan selisih waktu tiba Ts-Tp = 1 hingga 3,5 detik



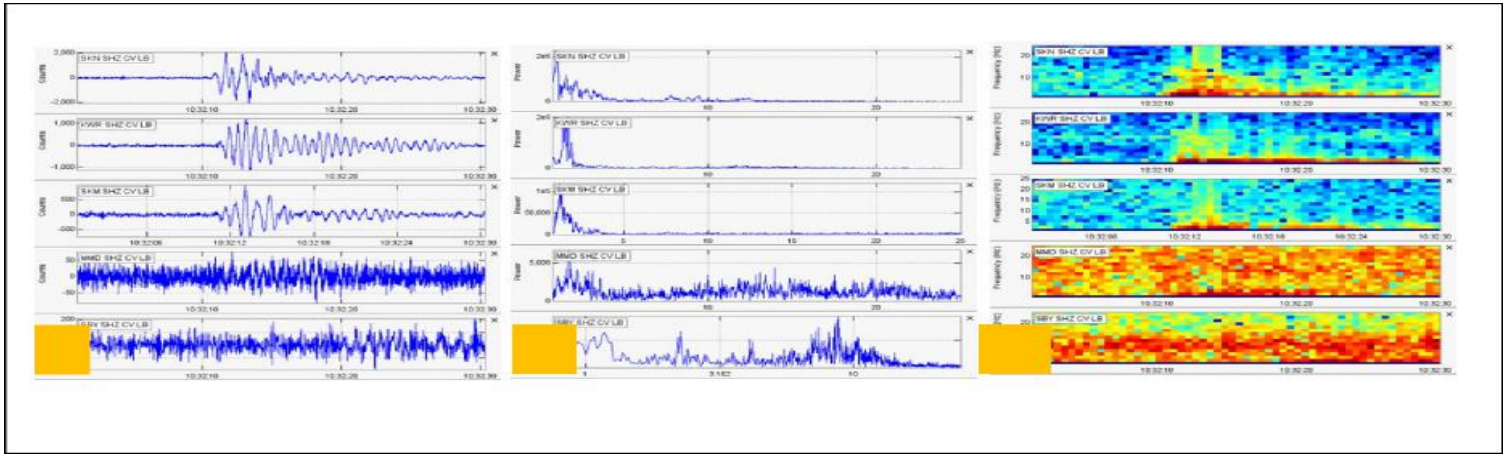
**Gempa Vulkano-Tektonik Dangkal tipe B (VT Tipe B)** ? selisih waktu tiba gelombang P dan S kurang dari 1 detik



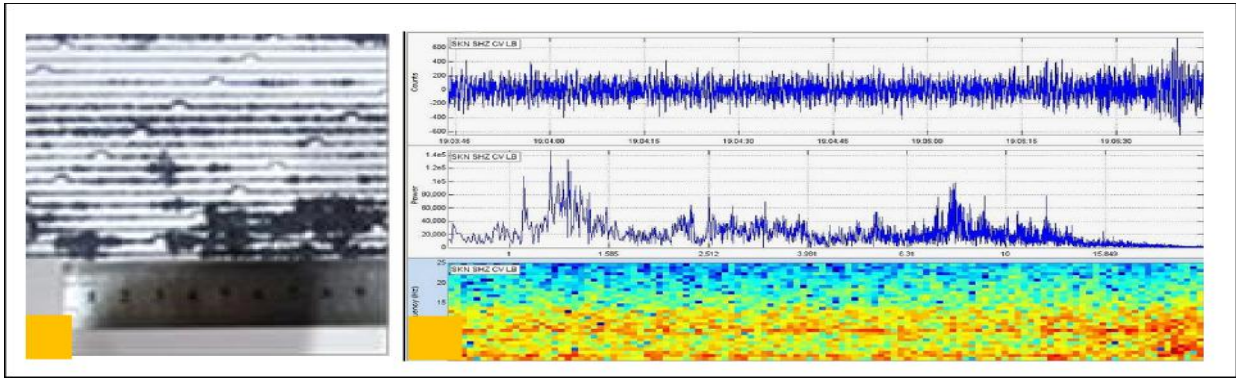
*Hybrid events*



*Low frequency*

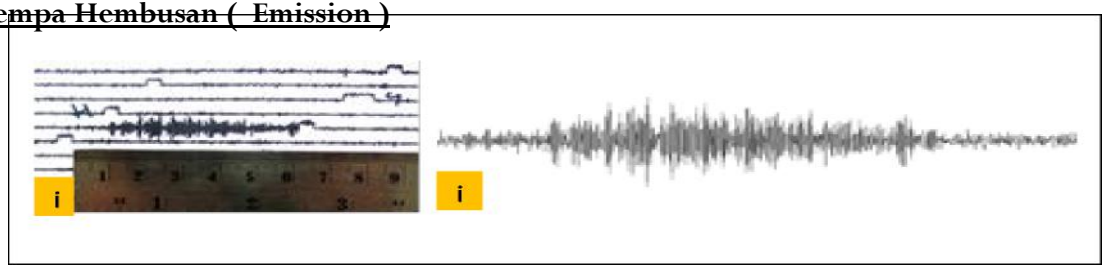


***T-type earthquake (Tornillo),***

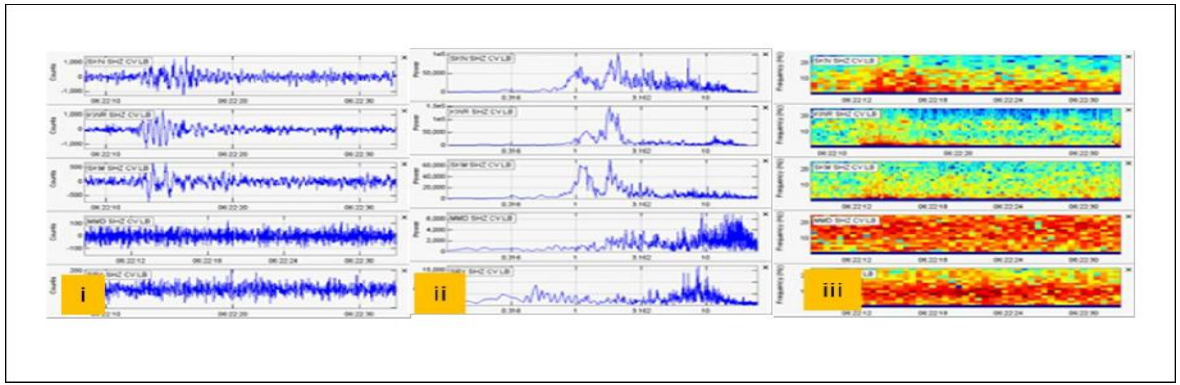


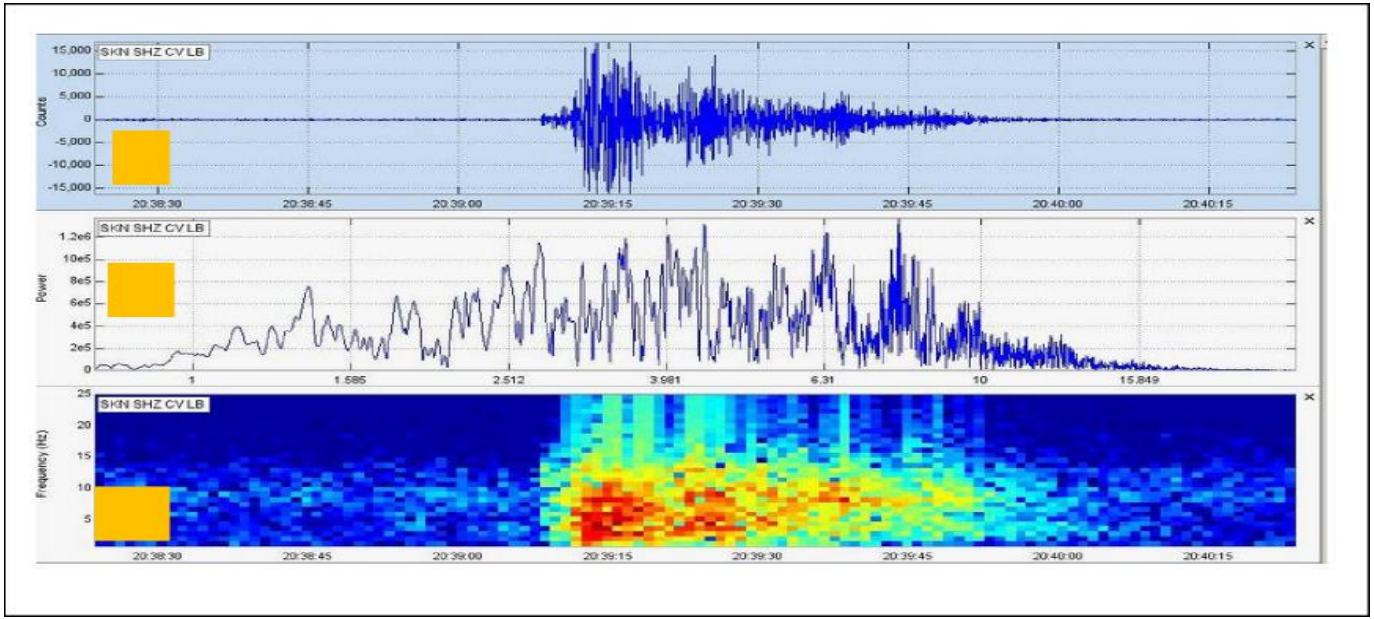
***Tremor,***

## Gempa Hembusan ( Emission )

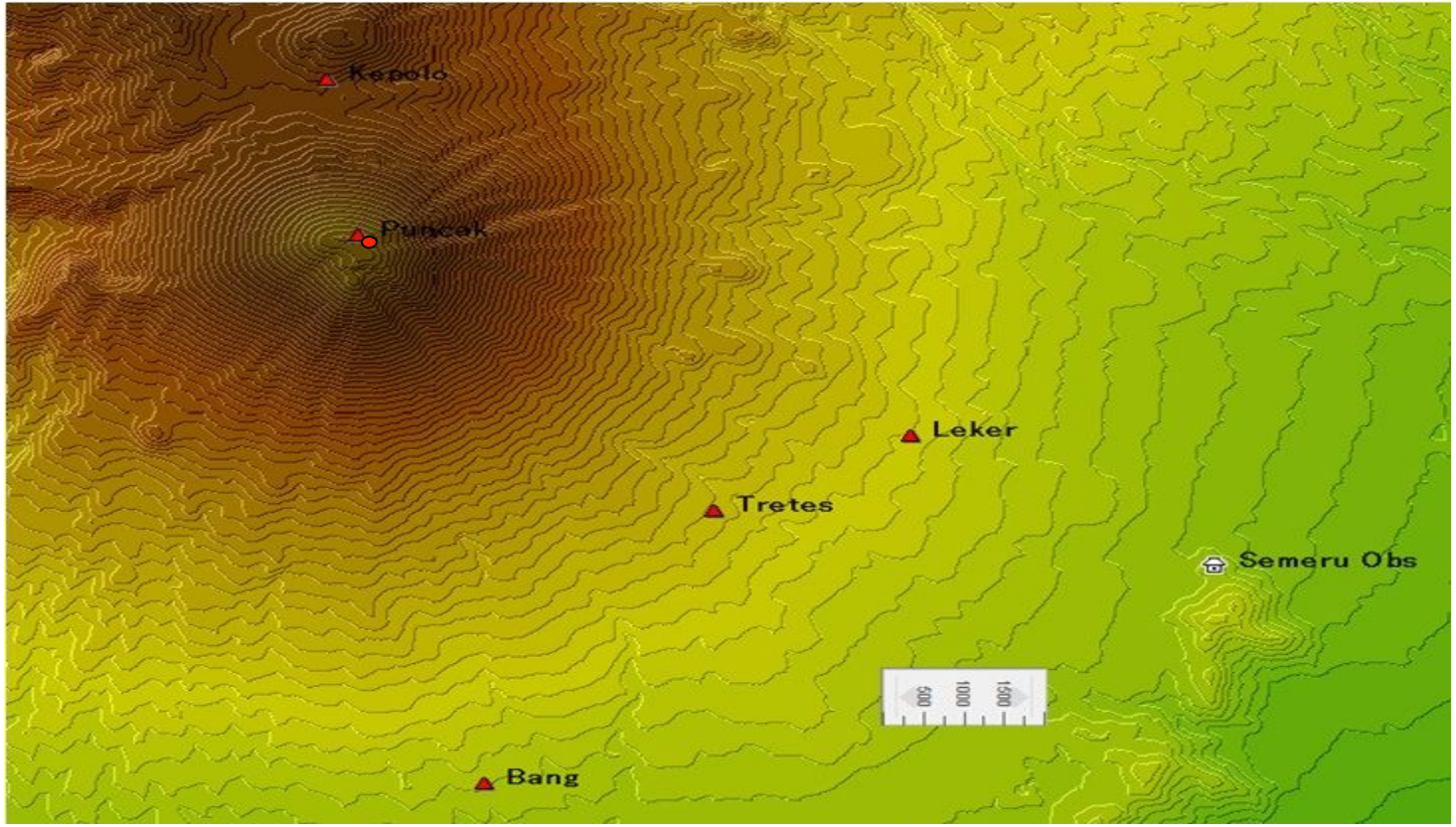



## •Gempa Letusan (Explosion Event)




SKN SHZ CV LB
Counts
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
20:38:30
20:38:45
20:39:00
20:39:15
20:39:30
20:39:45
20:40:00
20:40:15
SKN SHZ CV LB
Power
1.2e6
10e5
8e5
6e5
4e5
2e5
0
1
1.585
2.512
3.981
6.31
10
15.849
SKN SHZ CV LB
Frequency (Hz)
25
20
15
10
5
20:38:30
20:38:45
20:39:00
20:39:15
20:39:30
20:39:45
20:40:00
20:40:15

# Monitoring network




*Seismic station*

*Tiltmeter*

# Typical of seismic earthquake

*A-type (deep volcanic type)*

*B-type (shallow volcanic type)*

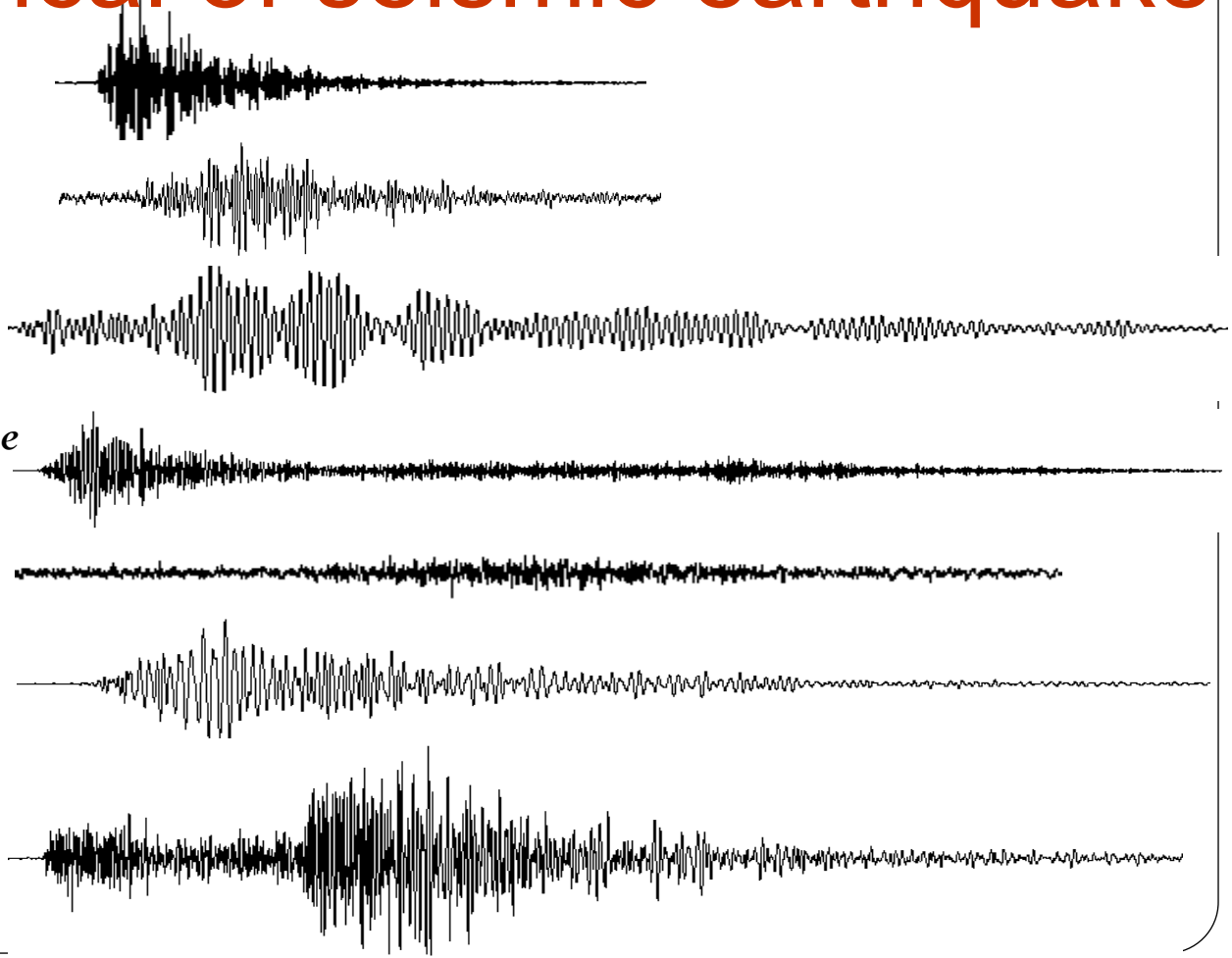
*Volcanic tremor*

*Pyroclastic flow/glowing avalanche*

*Avalanche*

*Explosion*

*Tectonic*



# Seismicity

*Level of activity*

- *1 (Normal)*
- *2 (Waspada)*
- *3 (Siaga)*
- *4 (Awas)*