Potensi dan Ancaman Bahaya Gempa Kota Surabaya

Firman Syaifuddin
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Exploring The Earth, Empowering Society

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- **Analisa Bahaya Gempa**

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- ***Multi Scenario Analysis***

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Latar Belakang

- Indonesia berada pada zona interaksi antar lempeng tektonik sehingga menjadikan wilayah Indonesia banyak terjadi gempa (Milson et al., 1992).
- Indonesia terletak pada zona tektonik sangat aktif, dikarenakan berada pada zona pertemuan antar 3 lempeng tektonik besar dan 9 lempeng tektonik kecil yang menjadikan Indonesia memiliki tatanan taktonik yang komplek (Bock et al, 2003).
- Berdasarkan hasil studi geodetic deformasi permukaan di Pulau Jawa dengan menggunakan pengamatan GPS ditunjukan adanya kemenerusan dari Flores back arc thrust kearah barat di Pulau Jawa sejauh 300 km yang berada pada Zona Kendeng (Koulali et al., 2016).
- Dua segemen patahan Kendeng yaitu patahan Kendeng segmen Surabaya dan segmen Waru dinyatakan aktif oleh Pusat Gempa Nasional (Pusgen) yang melintasi Kota Surabaya dan sekitarnya pada buku revisi Peta Sumber dan Bahaya Gempa Indonesia (Pusgen, 2017).
- Beberapa studi patahan aktif diinterpretasikan berdasarkan data pengamatan GPS dan studi geologi permukaan sehingga belum mampu menjelaskan secara rinci geometri patahan yang ada.
- Keterbatasan data dan masih kurangnya penelitian tentang kedalaman dan dimensi Patahan Kendeng segmen Surabaya dan segmen Waru.

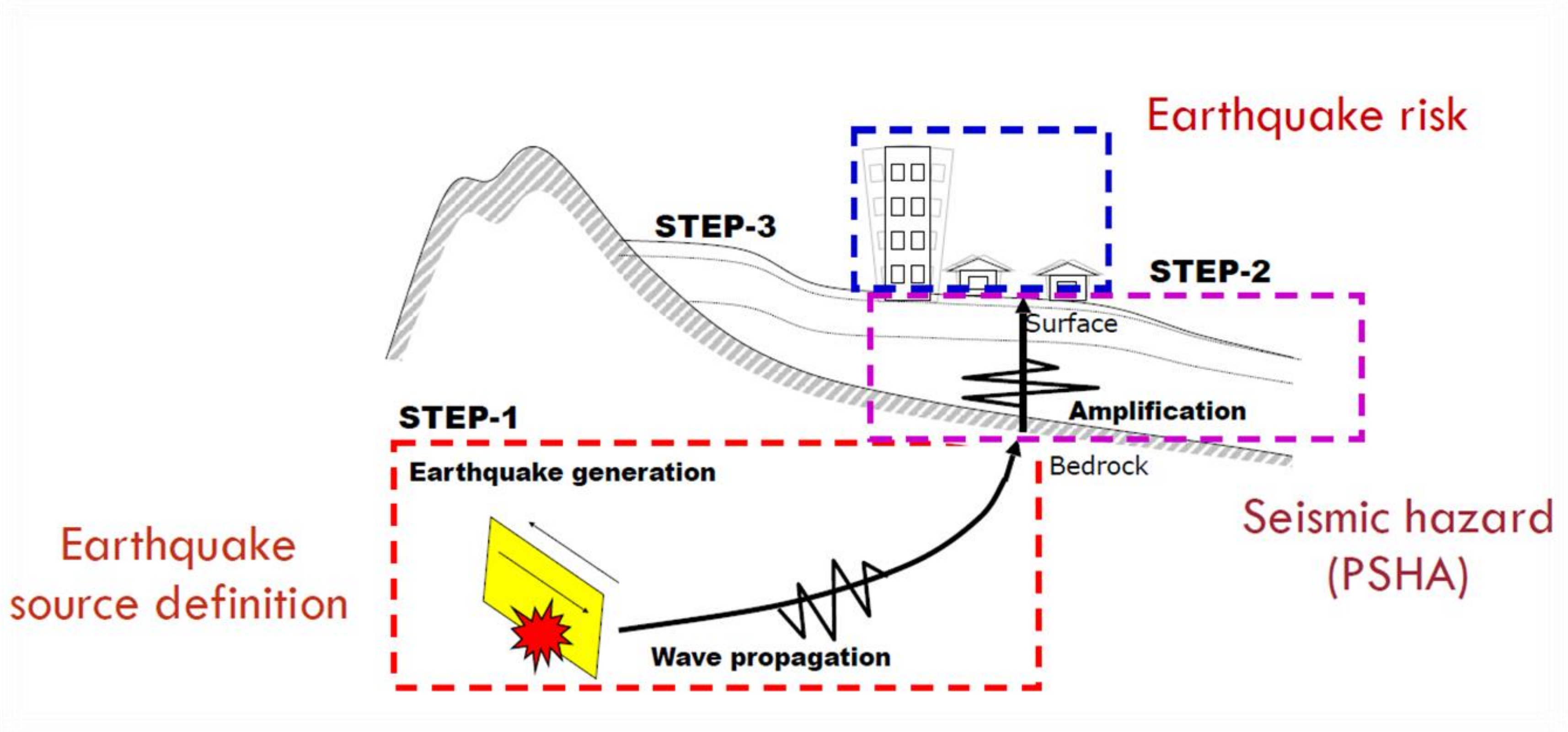
Analisa Bahaya Gempa

Seismic Hazard Analysis

Improving the ability of the built environment to resist earthquakes requires research in at least three areas:

a) **Quantification of earthquake effects, such as ground shaking, into a form suitable for use by design engineers (e.g., structural and geotechnical engineers),**
b) Improvement of design practices, and
c) Knowledge of the types of damage that occur as a consequence of earthquakes.

Analisa Bahaya Gempa



1. Pendefinisian Sumber
2. Fungsi Atenuasi Gelombang dan Deliniasi Efek Lokal (Amplifikasi)
3. Perhitungan Resiko Bahaya

Irwan Meilano, 2016

Earthquake Source Identification And Characterization

Although the kinematic model of plate tectonics provides the framework for understanding and predicting the long-term occurrence of earthquakes, it cannot predict the sequence of occurrence of future earthquakes, or the detailed characteristics of an individual member of the earthquake sequence.

Unique seismic sources are defined to account for distinct differences in the following criteria:

- Earthquake recurrence rate
- Maximum earthquake magnitude (Mmax)
- Expected future earthquake characteristics (e.g., style of faulting, rupture orientation, depth distribution) Probability of activity of tectonic feature(s).

DATA TYPE	SEISMIC SOURCE							
	INDIVIDUAL FAULTS						AREA/VOLUME SOURCES	
	Location	Activity	Length	Dip	Depth	Style	Area	Depth
Geological/Remote Sensing								
Detailed mapping	X	X	X	X		X		
Geomorphic data	X	X	X			X	X	
Quaternary surface rupture	X	X	X			X		
Fault trenching data	X	X		X		X		
Paleoliquefaction data	X	X					X	
Borehole data	X	X		X		X		
Aerial photography	X	X	X					
Low sun-angle photography	X	X	X					
Satellite imagery	X		X				X	
Regional structure	X			X		X	X	
Balanced Cross Section	X			X	X		X	
Geophysical/Geodetic								
Regional potential field data	X		X				X	X
Local potential field data	X		X	X	X	X		
High resolution reflection data	X	X		X		X		
Standard reflection data	X			X		X		
Deep crustal reflection data	X			X	X		X	X
Tectonic geodetic/strain data	X	X		X	X	X	X	X
Regional stress data						X	X	
Seismological								
Reflected crustal phase data								X
Pre-instrumental earthquake data	X	X			X	X	X	
Teleseismic earthquake data							X	
Regional network seismicity data	X	X	X	X	X		X	X
Local network seismicity data	X	X	X	X	X			X
Focal mechanism data				X		X		

Footnote: * Length includes both total fault length and information on segmentation.

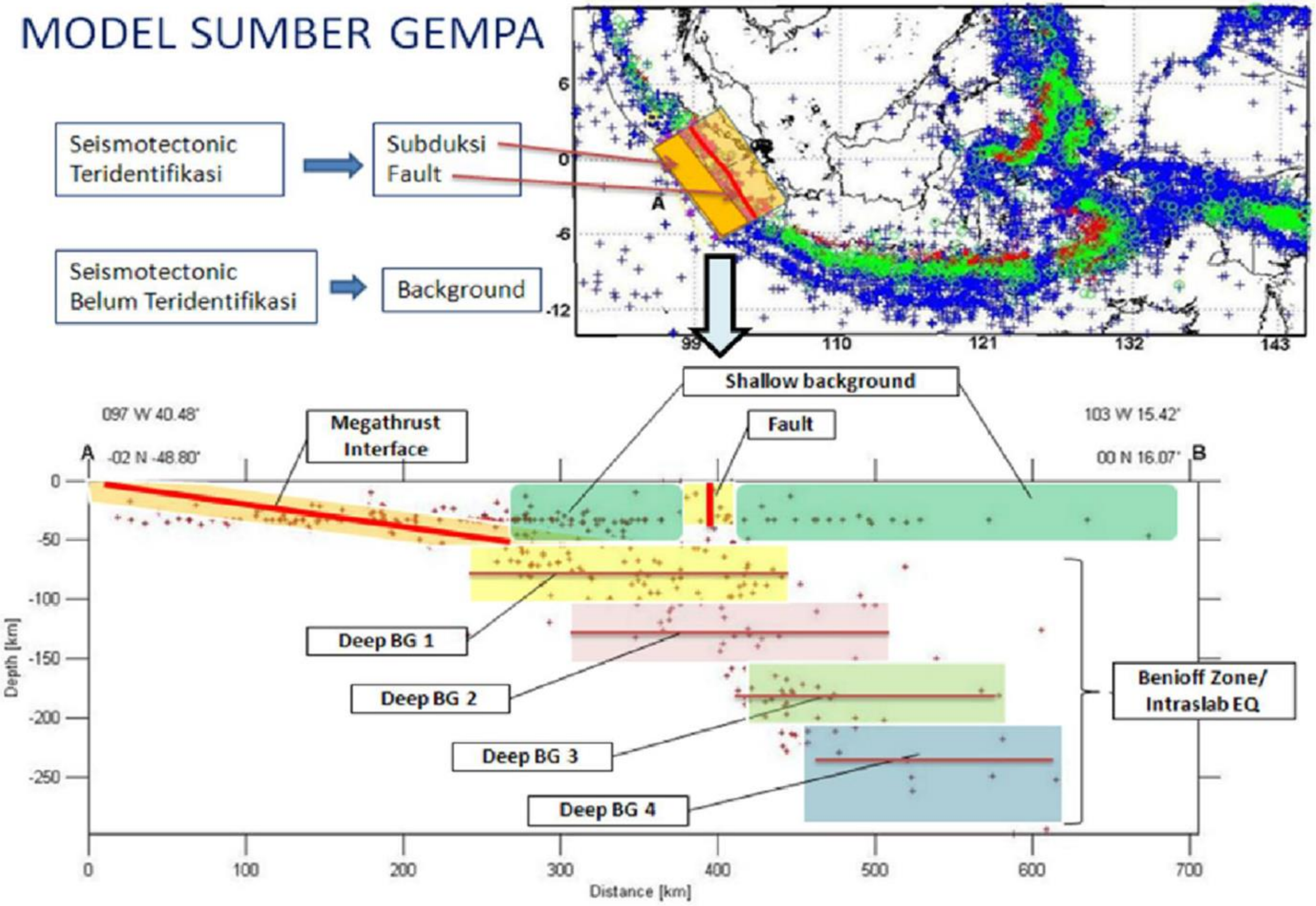
Earthquake Source Identification And Characterization

Klasifikasi Model Jenis Sumber Gempa

1. Model Sumber gempa Subduksi
2. Model Sumber Gempa *Fault / sesar*
3. Model Sumber Gempa *Background* (*Gridded Seismicity*)
   1. Shallow background source (0–50 km)
   2. Deep background source (50–100 km)
   3. Deep background source (100–150 km)
   4. Deep background source (150–200 km)
   5. Deep background source (200–300 km).

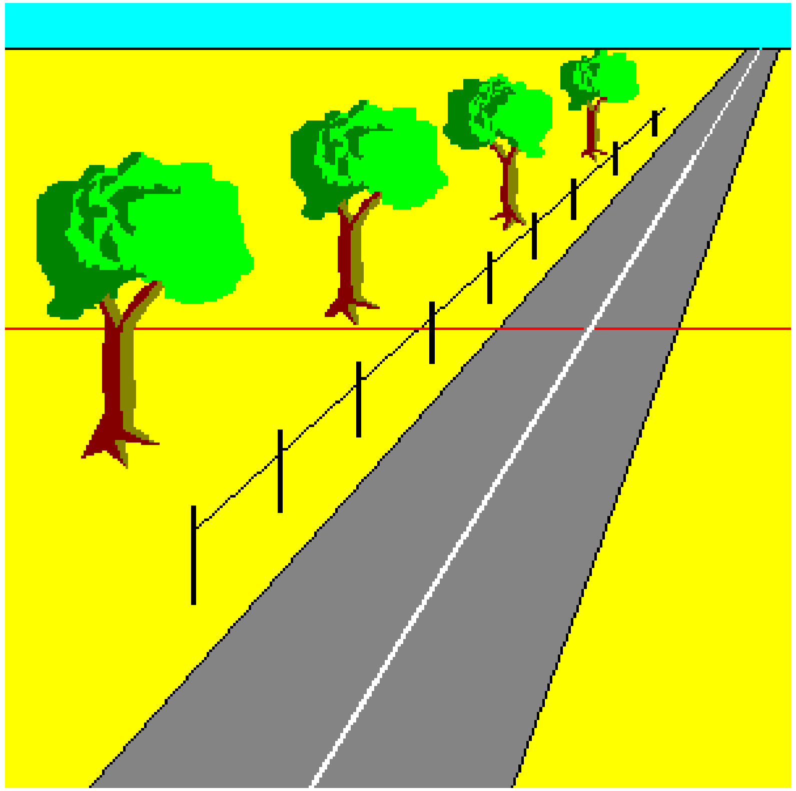
Hasil Studi Tim Revisi Peta Gempa Indonesia 2010, SNI 1726:2012

MODEL SUMBER GEMPA

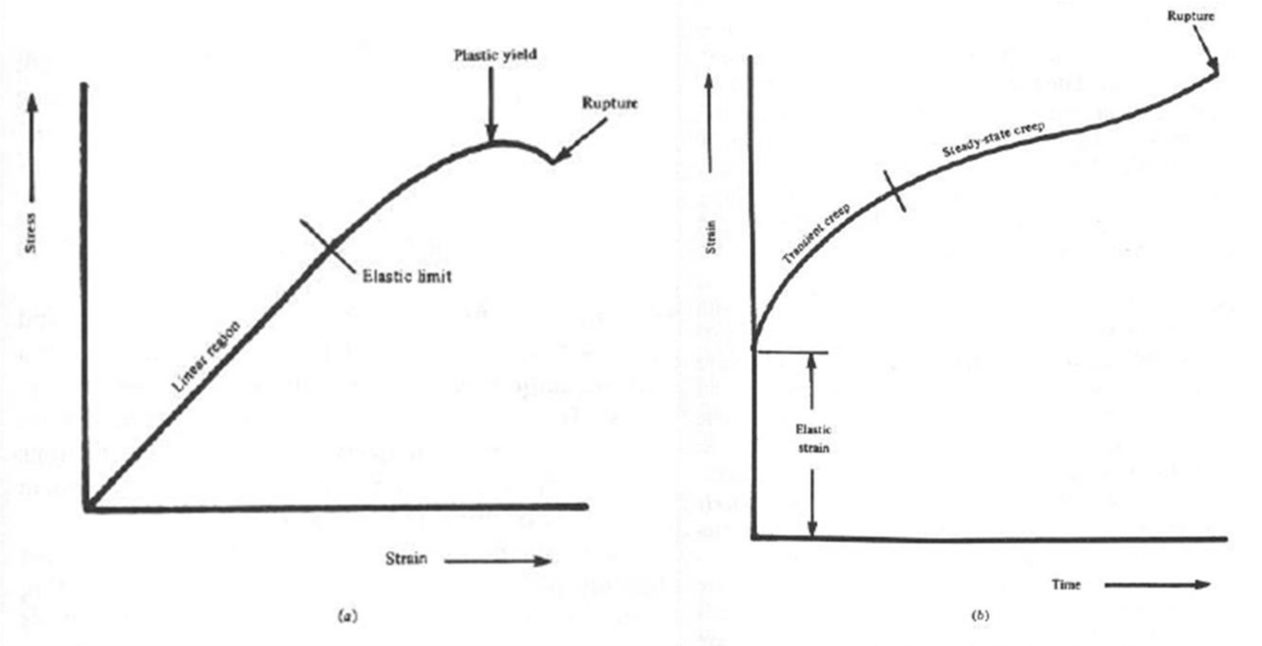


Gambar III.31. Ilustrasi model sumber gempa fault, subduksi dan background.

M Asrurifak, 2010



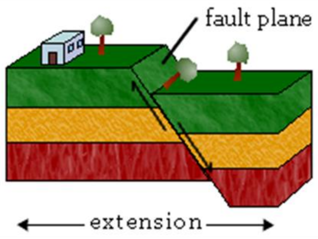
Elastic Rebound



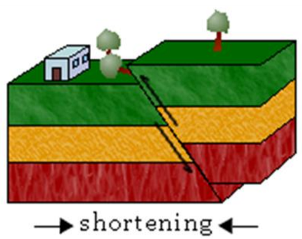
Elastic rebound theory

Fig. 2.4 Stress–strain–time relationships. (a) Stress versus strain; (b) strain versus time.

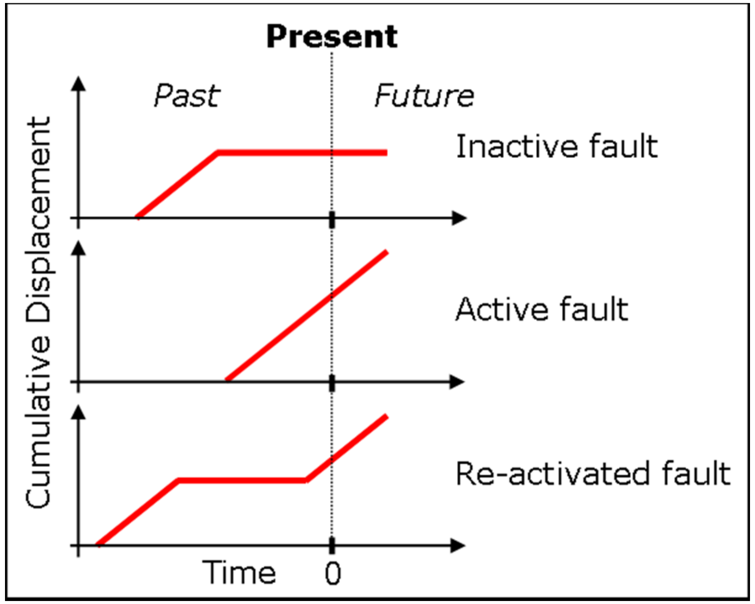
Pure normal fault
Dip $0^0 < \delta < 90^0$ rake -90^0

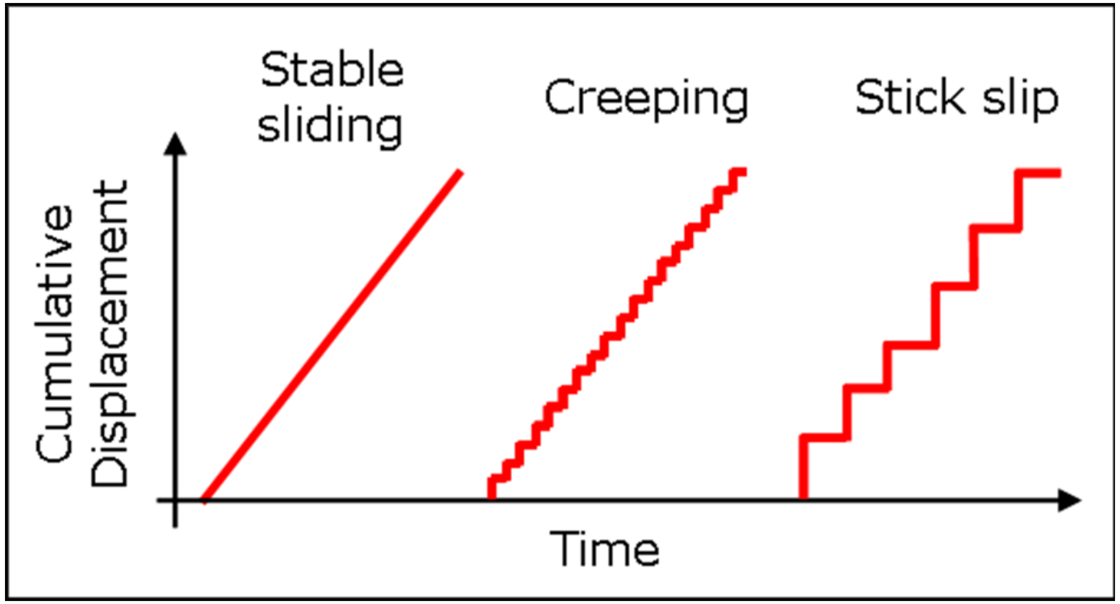


Pure thrust fault
Dip $0^0 < \delta < 90^0$ rake $+90^0$



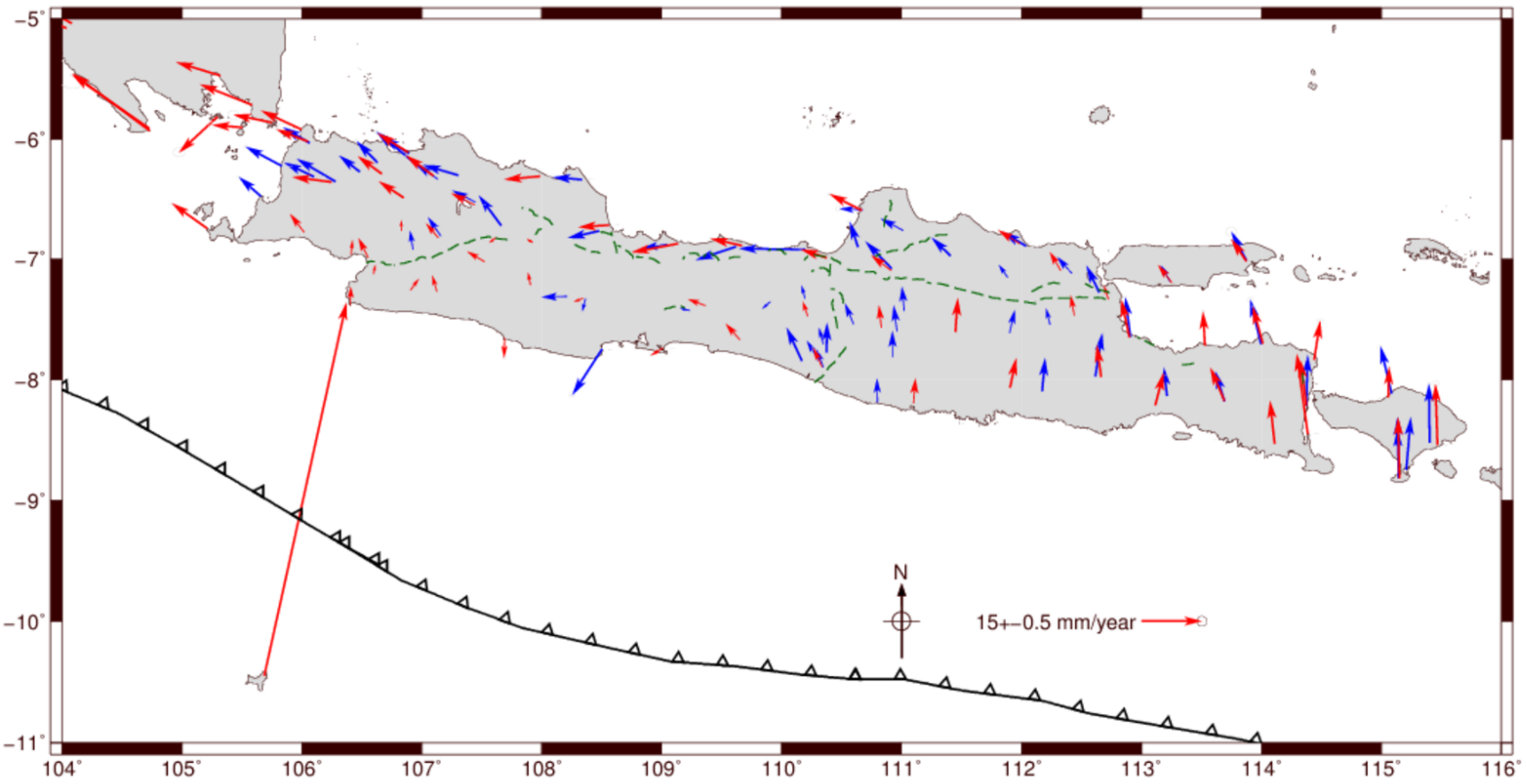
Understanding Active Faulting





The activity of a fault is generally defined by the way it ***cumulates displacement*** over geologic time. An active fault is one that cumulated some displacement in the recent past (see diagrams) so that we can speculate ***it is very likely that the fault will be offset again in the near future***. There is not a fixed rule about what geological time scale should be used to address the activity of a fault. In addition to the time period of activity, active faults may exhibit different forms of behavior as shown by the diagram or some combinations of them. The stick-slip behavior is usually associated with the active fault that can release a number of sizable earthquakes.

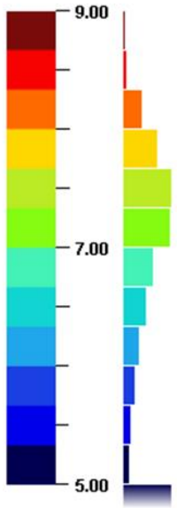
http://diss.rm.ingv.it/diss/index.php/help/50-understanding-active-faulting

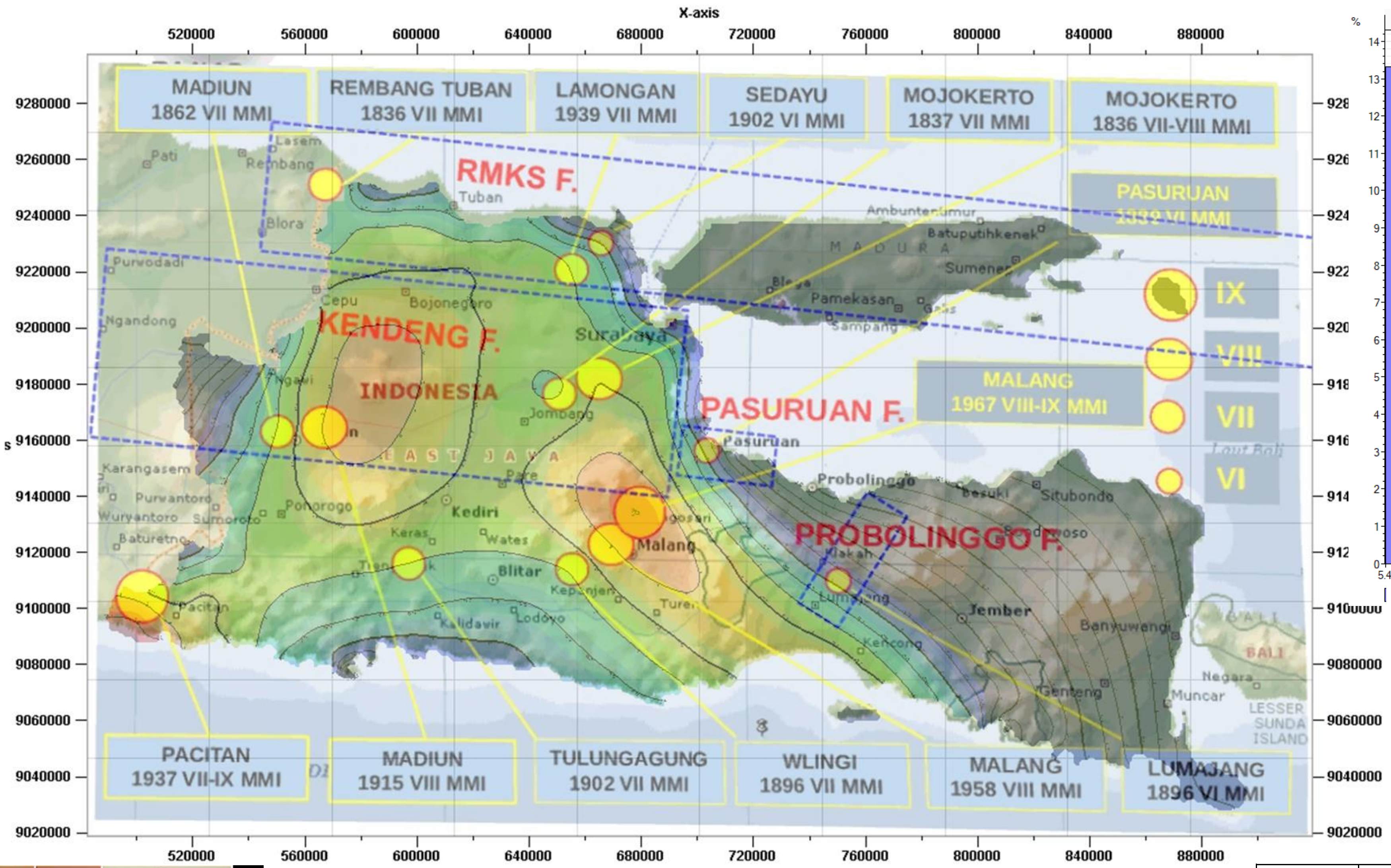


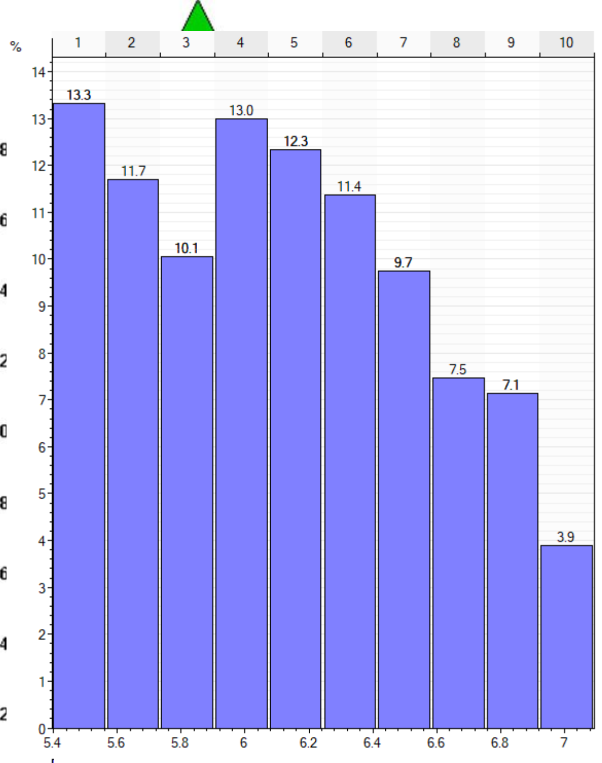
Persebaran titik GPS di Pulau Jawa. Vektor berwarna merah adalah stasiun kontinu. Vektor berwarna biru adalah stasiun GPS berkala. (Susilo dkk. 2016)

Potensi Sumber Gempa di Sekitar Kota Surabaya

Intensity (MMI)





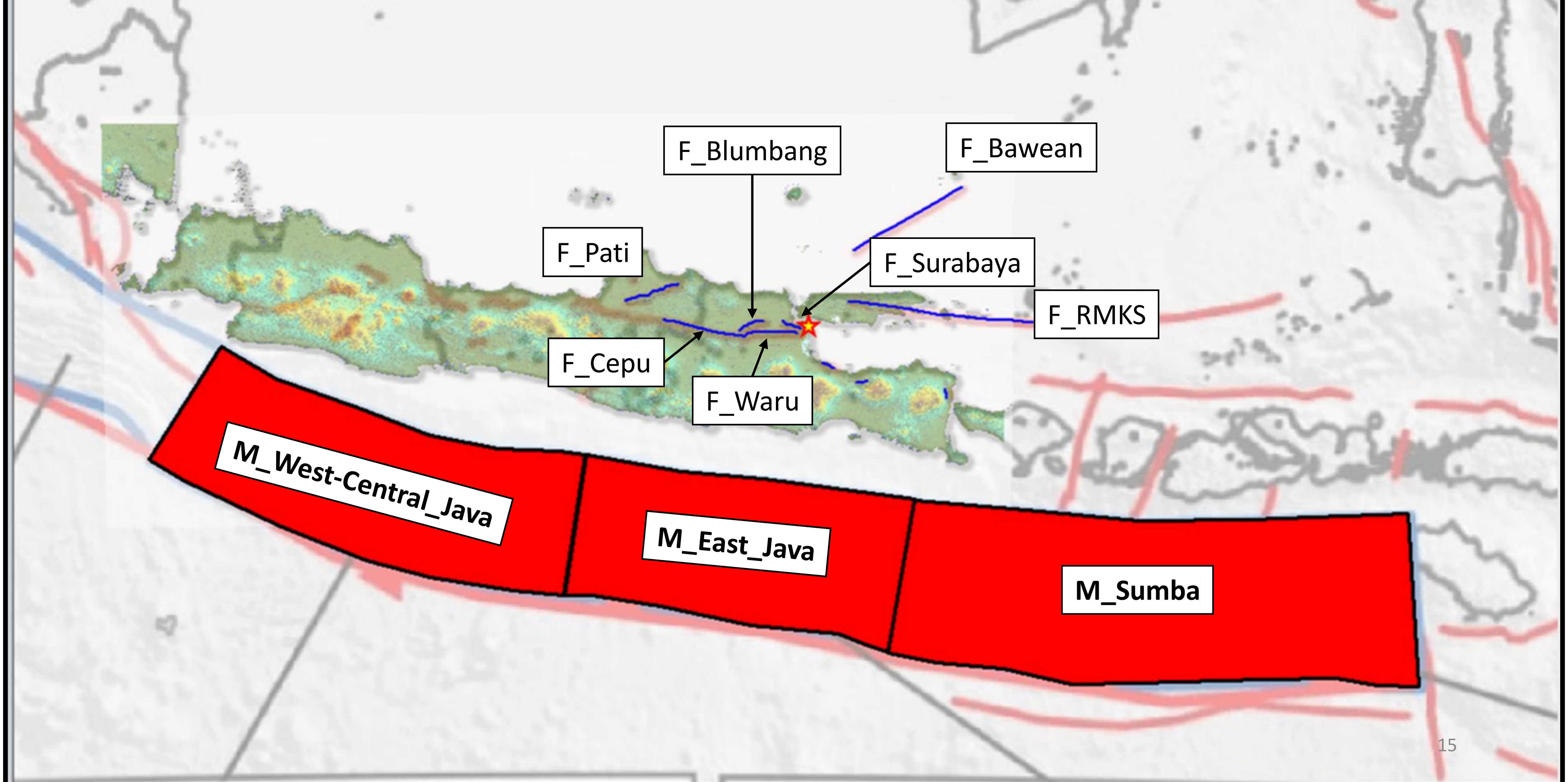


Surabaya Area
MMI ~ V - VII
PGA ~ 0.039 g – 0.34 g

Historical Eq. Report ~1836 - 1967

Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	Perceived shaking	Potential damage
I	< 0.0017	< 0.1	Not felt	None
II–III	0.0017 – 0.014	0.1 – 1.1	Weak	None
IV	0.014 – 0.039	1.1 – 3.4	Light	None
V	0.039 – 0.092	3.4 – 8.1	Moderate	Very light
VI	0.092 – 0.18	8.1 – 16	Strong	Light
VII	0.18 – 0.34	16 – 31	Very strong	Moderate
VIII	0.34 – 0.65	31 – 60	Severe	Moderate to heavy
IX	0.65 – 1.24	60 – 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy

Seismic Source



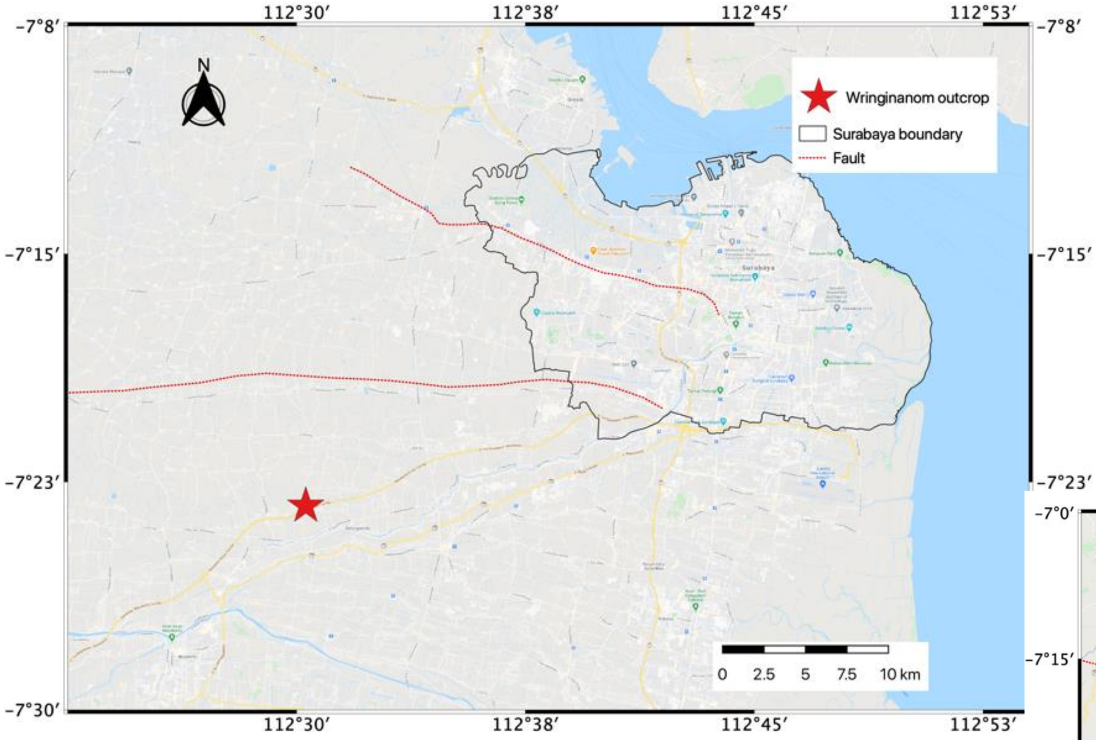
No	Fault_Name	Slip-Rate mm/yr	Mechanism	Dip	Top	Bottom	L (km)	Mmax
1	F_Bawean	0.5	Strike-slip	90	3	18	156	7.6
2	F_Blumbang	0.05	Reverse-slip	45S	3	18	31	6.6
3	F_Cepu	0.1	Reverse-slip	45S	3	18	100	6.5
4	F_Pati	0.1	Strike-slip	90	3	18	69	6.5
5	F_RMKS	1.5	Strike-slip	90	3	18	230	7.8
6	F_Surabaya	0.05	Reverse-slip	45S	3	18	25	6.5
7	F_Waru	0.05	Reverse-slip	45S	3	18	64	6.5

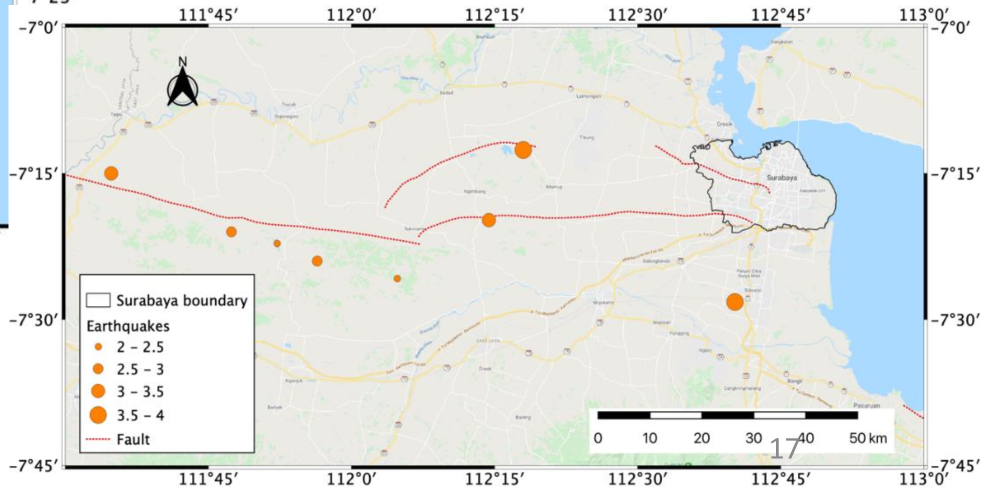
No	M_Name	Slip-Rate mm/yr	L (km)	W (km)	a Value	b Value	Mmax
1	M_East_Java	4	410	180	5.63	1.08	8.7
2	M_Sumba	4	624	196	5.63	1.11	8.5
3	M_West-Central_Java	4	505	170	5.5	1.08	8.7

No	Background	Min Depth	Max Depth	a-Value	b-Value	Mmax
1	Shallow	10	50	2.96	1	6.5
2	Deep	50	300	5.6	1	7.8

Seismic Source Parameters

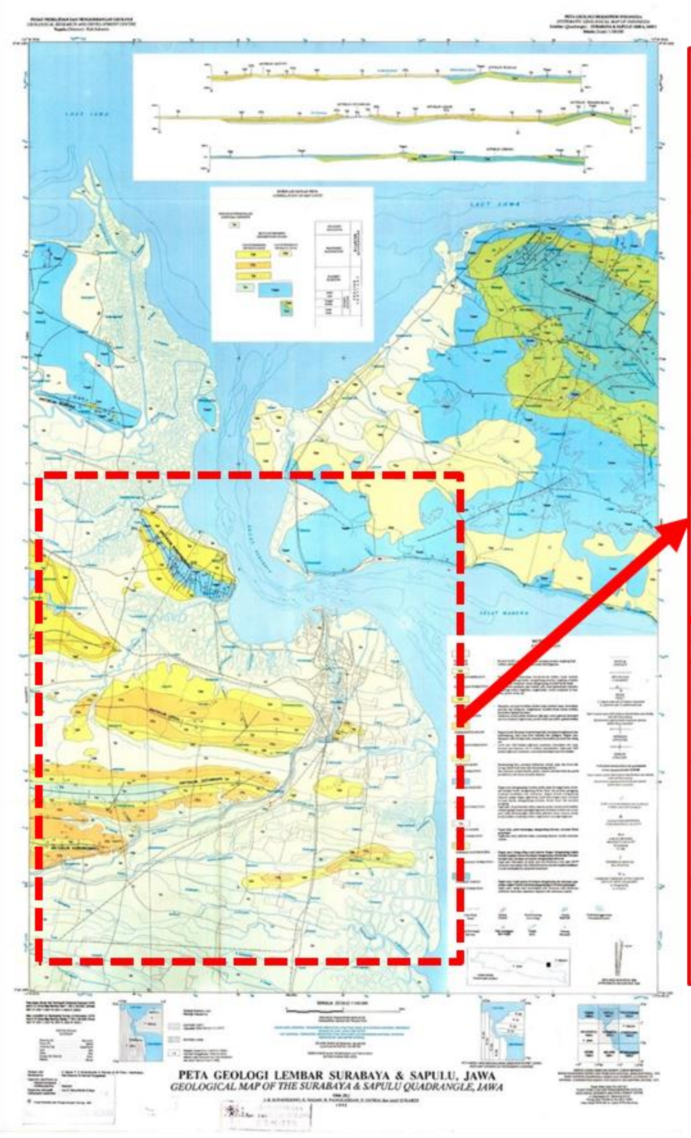
Identifying Surabaya Earthquake Hazard

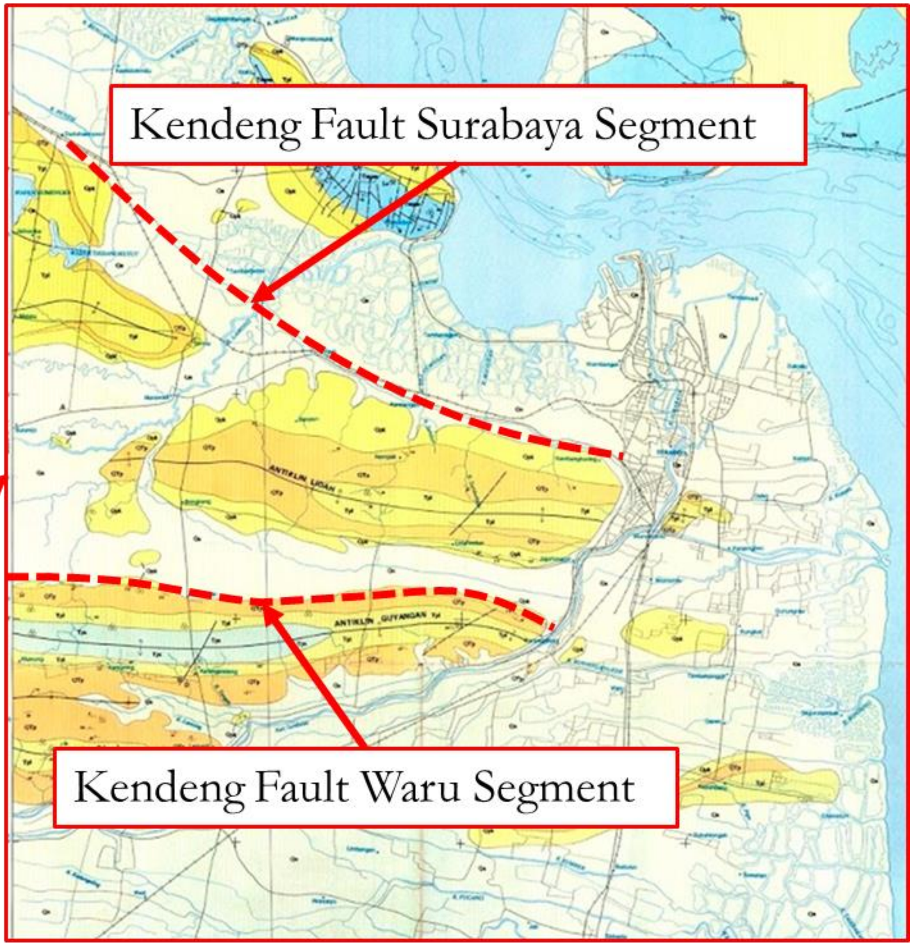




Identifikasi dan Karakterisasi Potensi Sumber Gempa

Geologi Kota Surabaya





PusGen, 2017

In general, there are three directions of the general pattern of geological structures at work in this region :

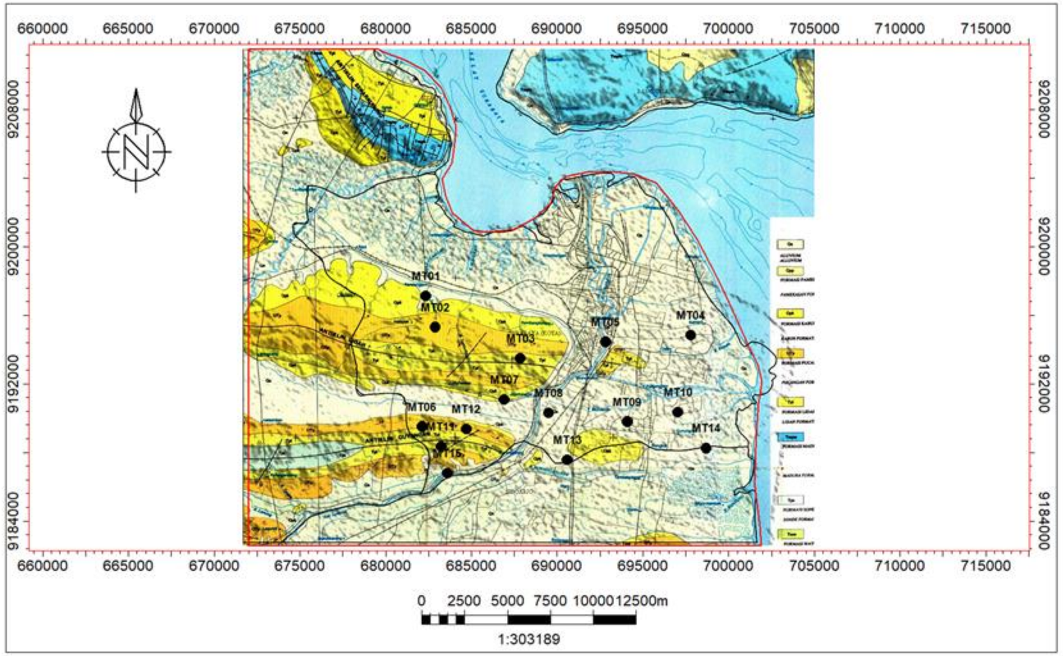
1. Northeast-Southwest (NE-SW) called Meratus trend,
2. North-South (NS) pattern called Sunda trend,
3. East-West (EW) patterns.

The city of Surabaya is the dominant lowland area, which 80% are alluvial deposits and the rest is low hills formed by weathered soil from tertiary / old rocks

Surabaya Sapuluh Geological Sheet (PPPG, 1992)

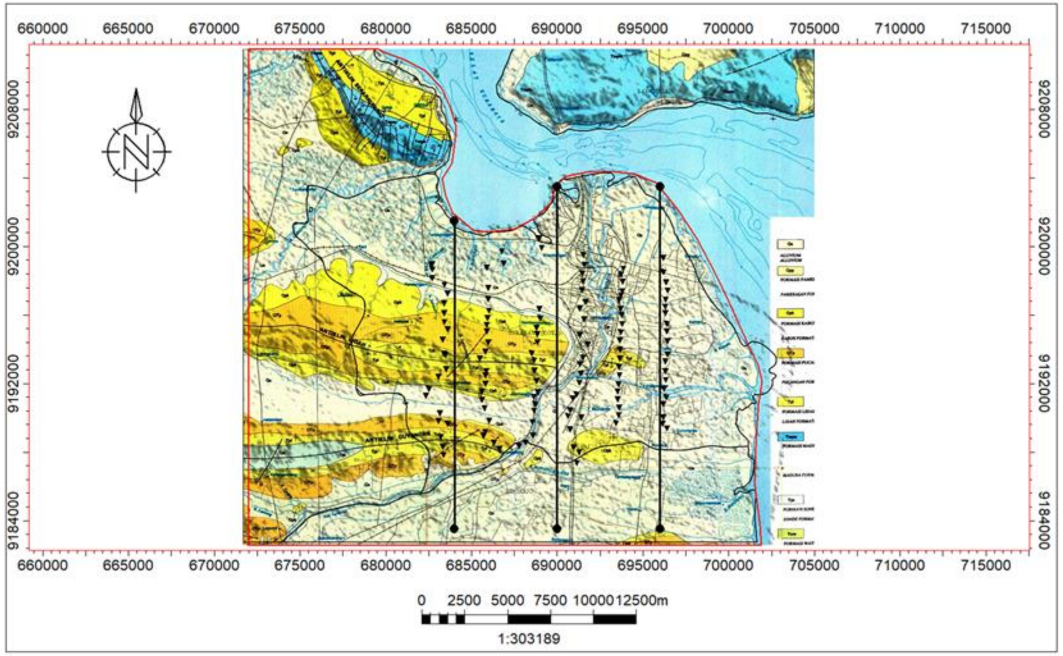
Identifikasi dan Karakterisasi Potensi Sumber Gempa

Pengukuran Metoda Magnetotelluric Kota Surabaya



15 Titik pengukuran metoda magnetotelluric

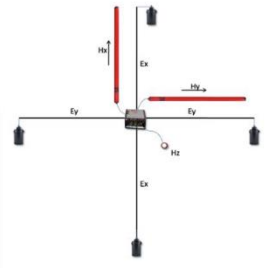
Pengukuran Metoda Gravitasi Kota Surabaya



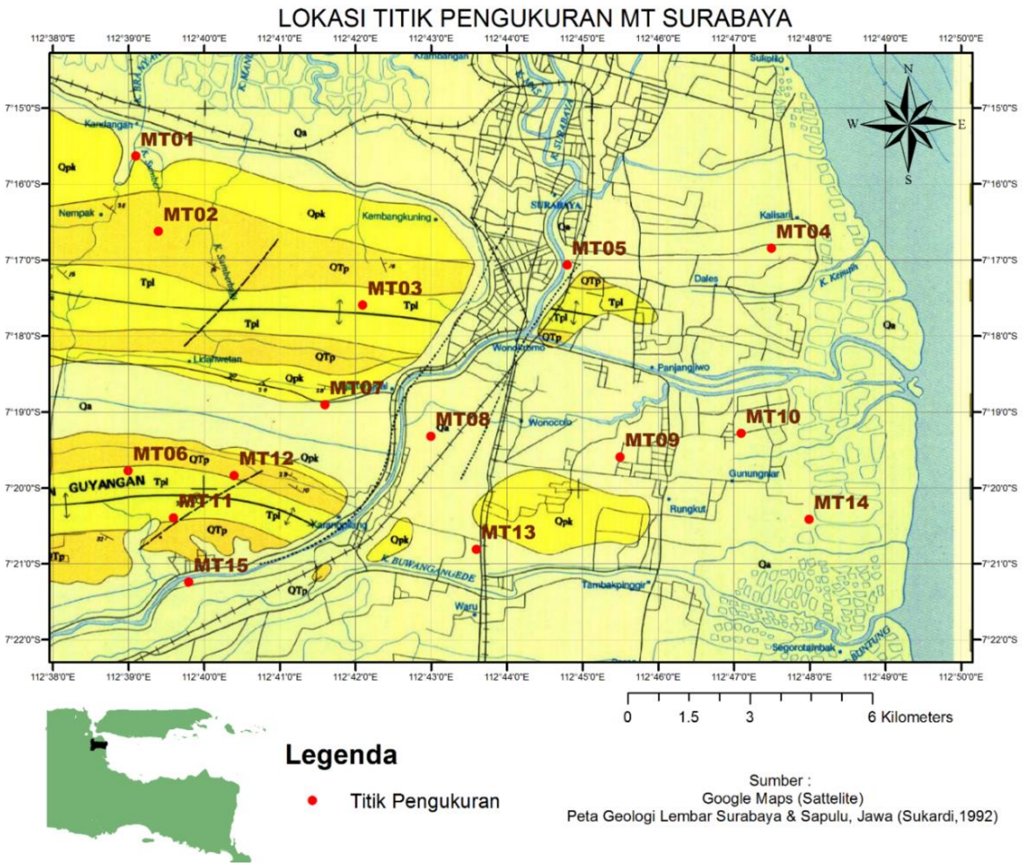
130 Titik pengukuran metoda gravitasi

Magnetoteluric Method

- The measurement of Magnetoteluric Method measurement data was carried out over the city of Surabaya as many as 15 sounding points
- The measurement path crosses the active structures found on the geological map. The measured data is a magnetic field in the direction of x, y, z or Hx, Hy, and Hz. While the electric field is measured in the direction of x and y or Ex and Ey. By default, the directions x, y, and z are east-west, north south, and up.



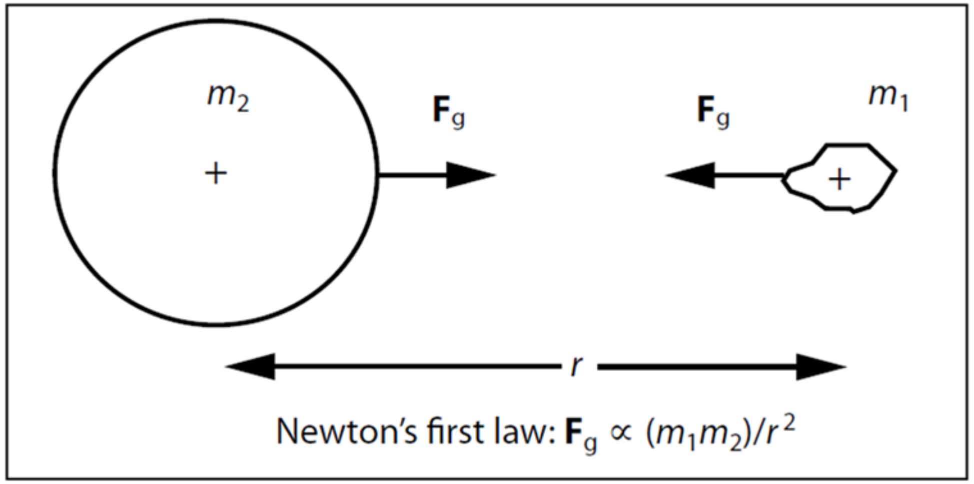
Arrangement of instrument layout magnetotelluric data acquisition



Magnetotelluric stations points

Gravity Method

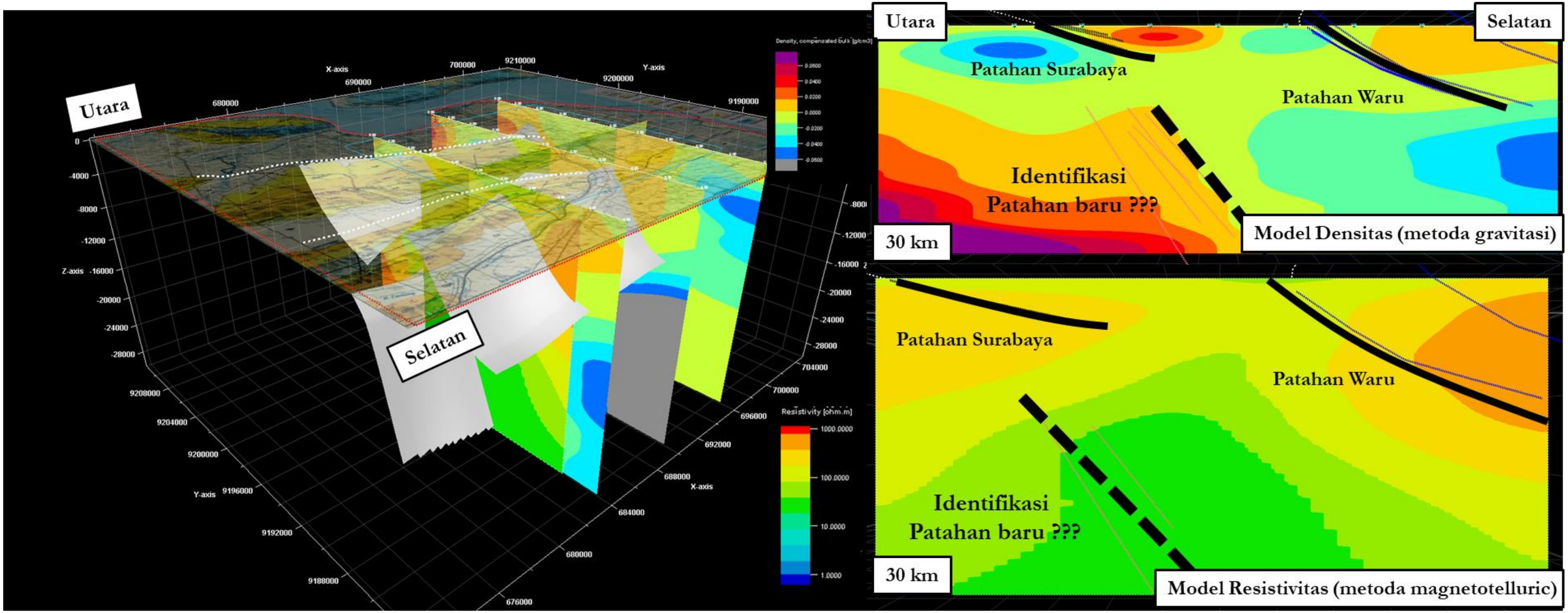
The gravity method is one of the geophysical methods that utilize the potential force of gravity to describe the condition of the earth's subsurface. Gravity method has been more used to determine subsurface conditions are relatively shallow and commonly used in oil and gas exploration to map sedimentary basins.

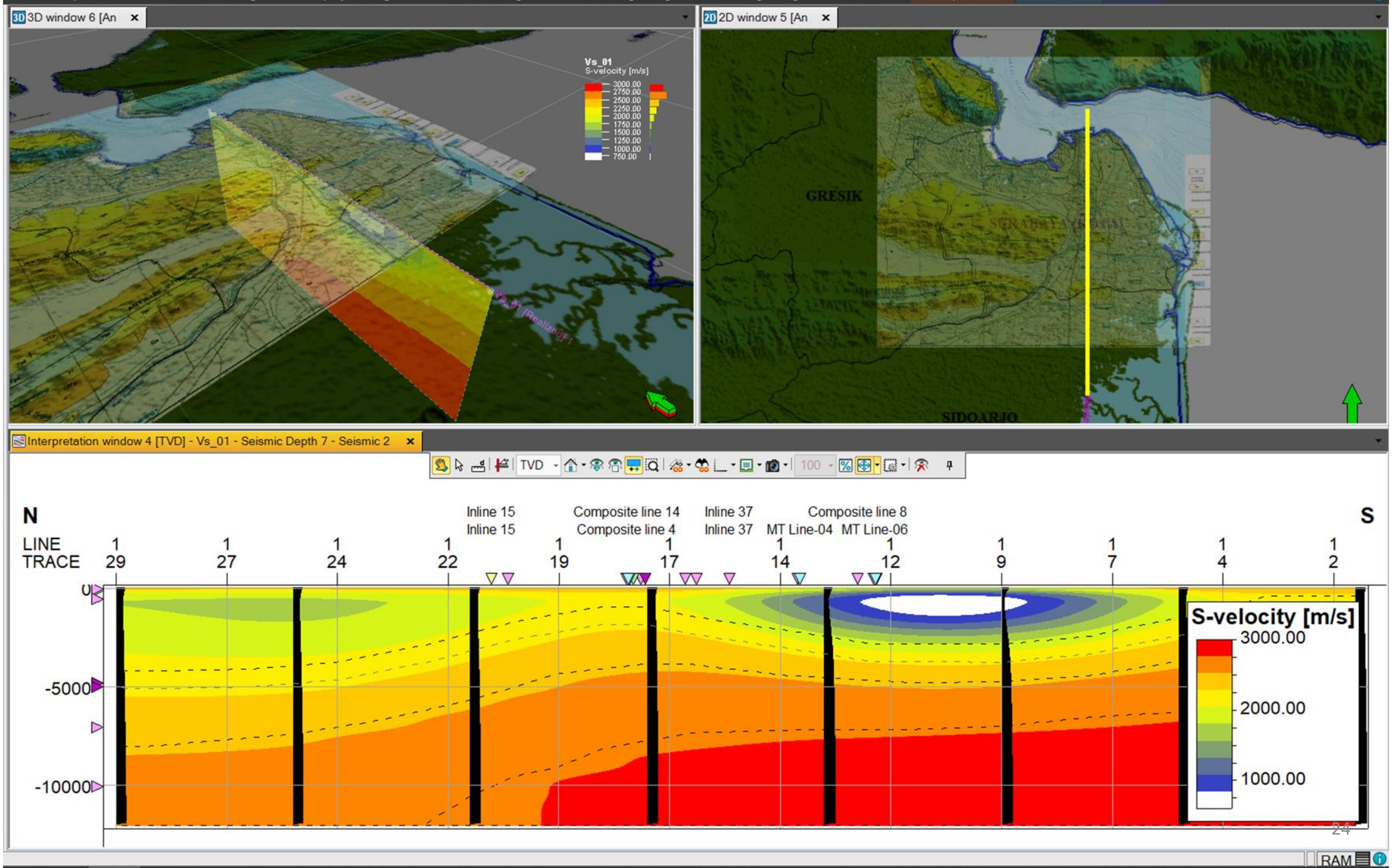


IDENTIFIKASI STRUKTUR PATAHAN

YANG MELINTASI KOTA SURABAYA

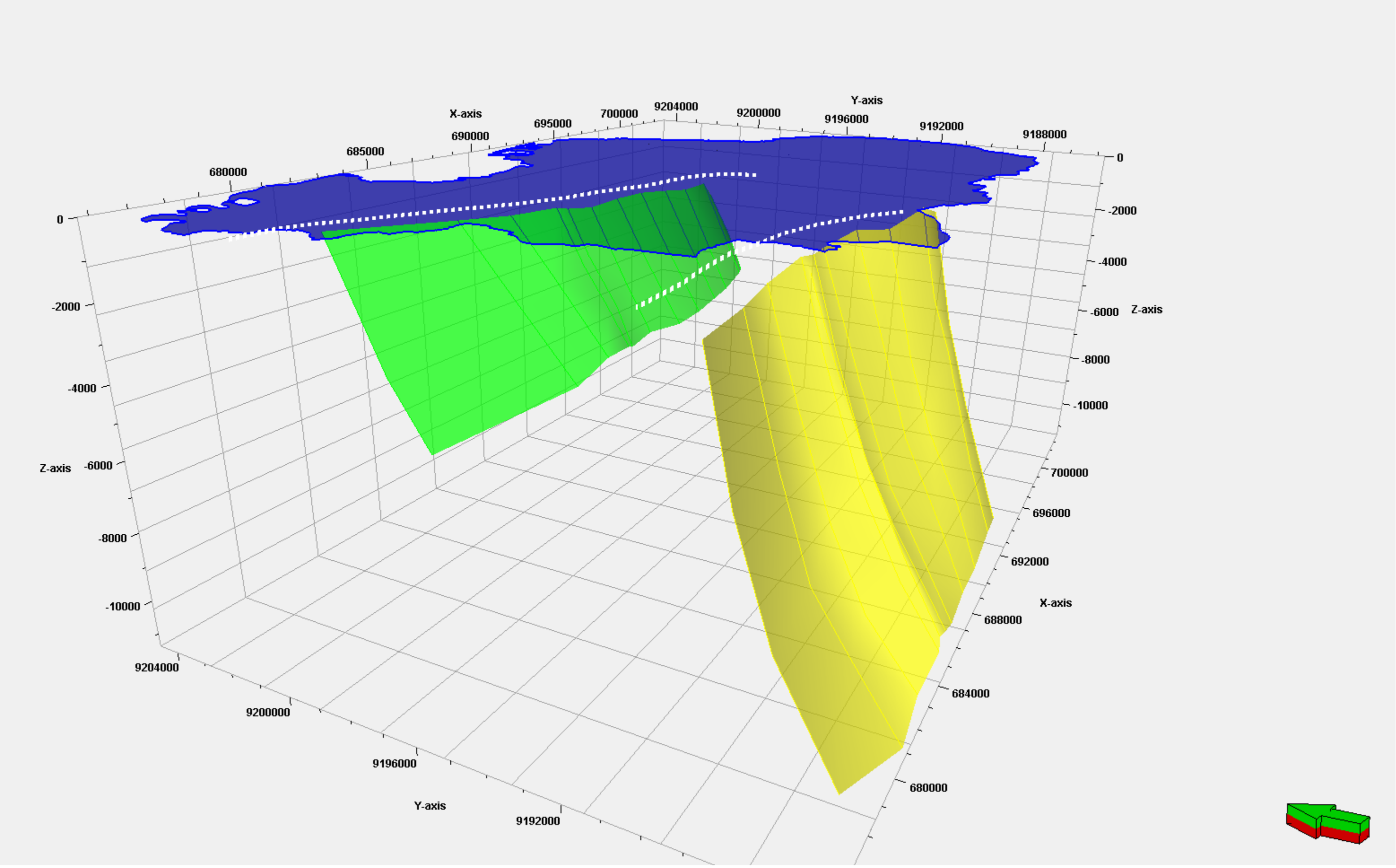
(Interpretasi Sturktur Patahan Berdasarkan data Magnetotelluric dan Gravitasi)




3D window 6 [An
Vs_01
S-velocity [m/s]
3000.00
2750.00
2500.00
2250.00
2000.00
1750.00
1500.00
1250.00
1000.00
750.00
2D window 5 [An
GRESIK
SIDOARJO
Interpretation window 4 [TVD] - Vs_01 - Seismic Depth 7 - Seismic 2
TVD
100
N
S
Inline 15
Inline 15
Composite line 14
Composite line 4
Inline 37
Inline 37
Composite line 8
MT Line-04
MT Line-06
LINE
TRACE
1 1 1 1 1 1 1 1 1 1 1 1
29 27 24 22 19 17 14 12 9 7 4 2
0
-5000
-10000
S-velocity [m/s]
3000.00
2000.00
1000.00
RAM

Fault Geometry

(Interpreted from Gravity and Magnetotelluric data)



Kendeng Fault Surabaya Segment

Depth ± 0 – 7,5 Km

Dip ± 56°

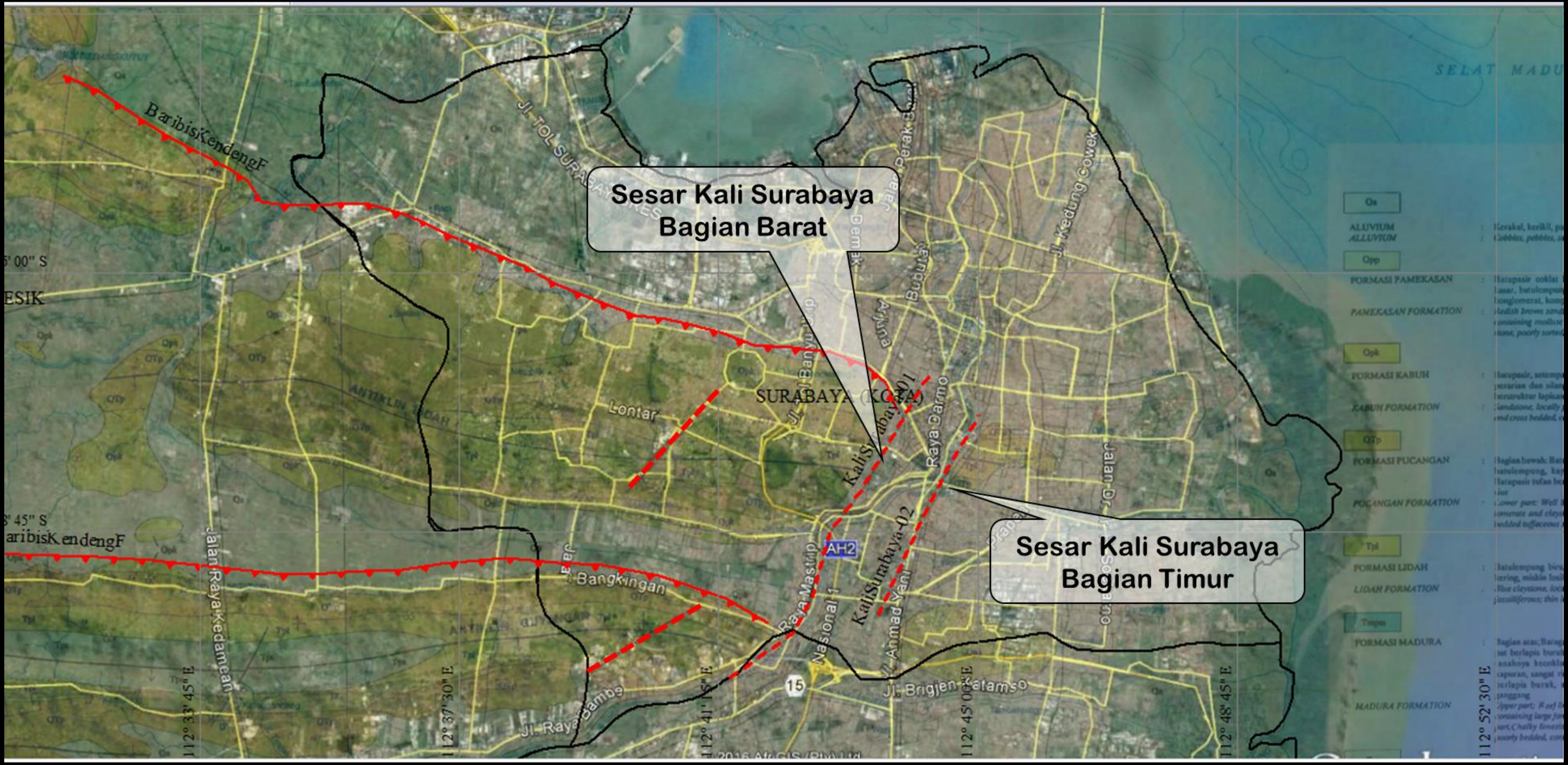
Length ± 25 km

Kendeng Fault Waru Segment

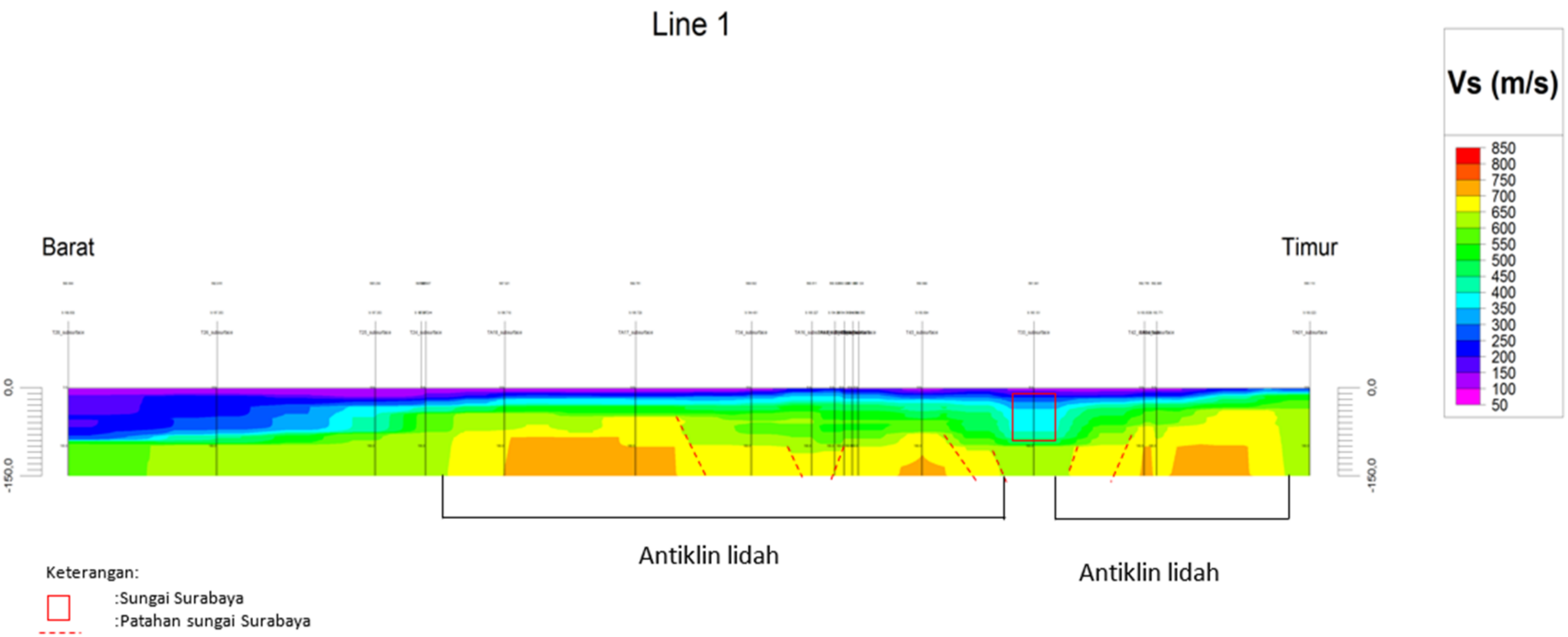
Depth ± 0 – 11 Km

Dip ± 54°

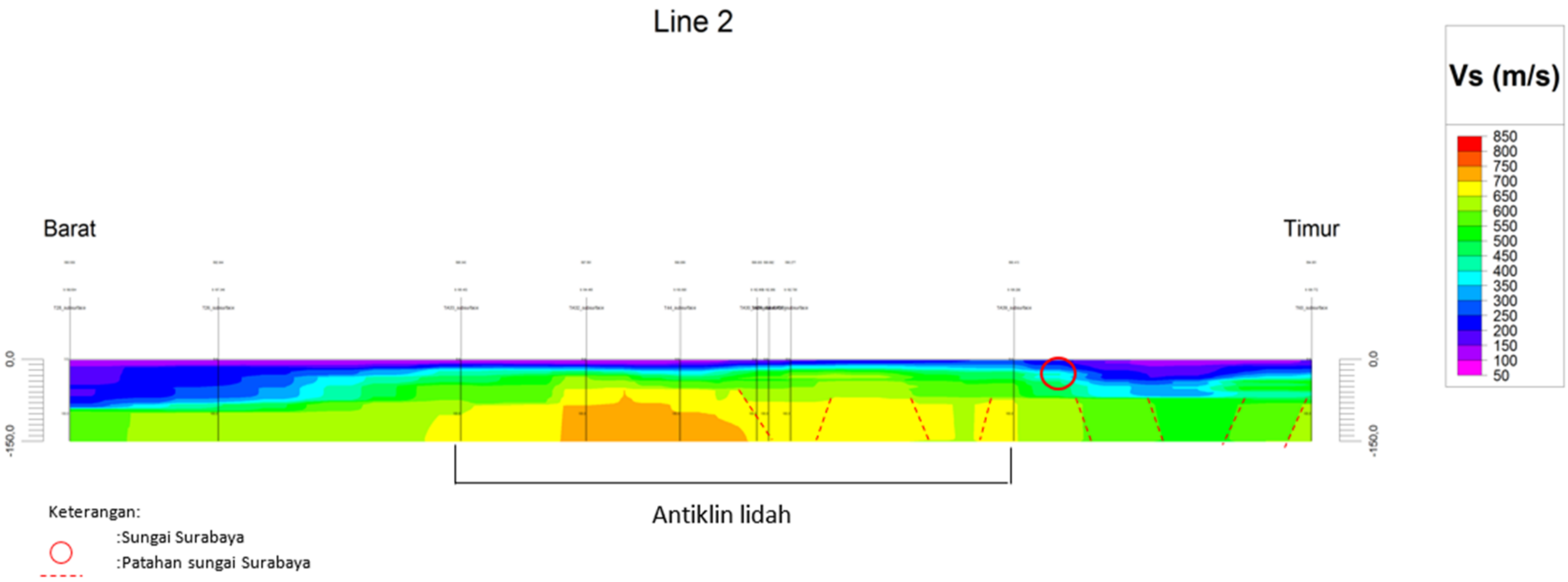
Length ± 64 km



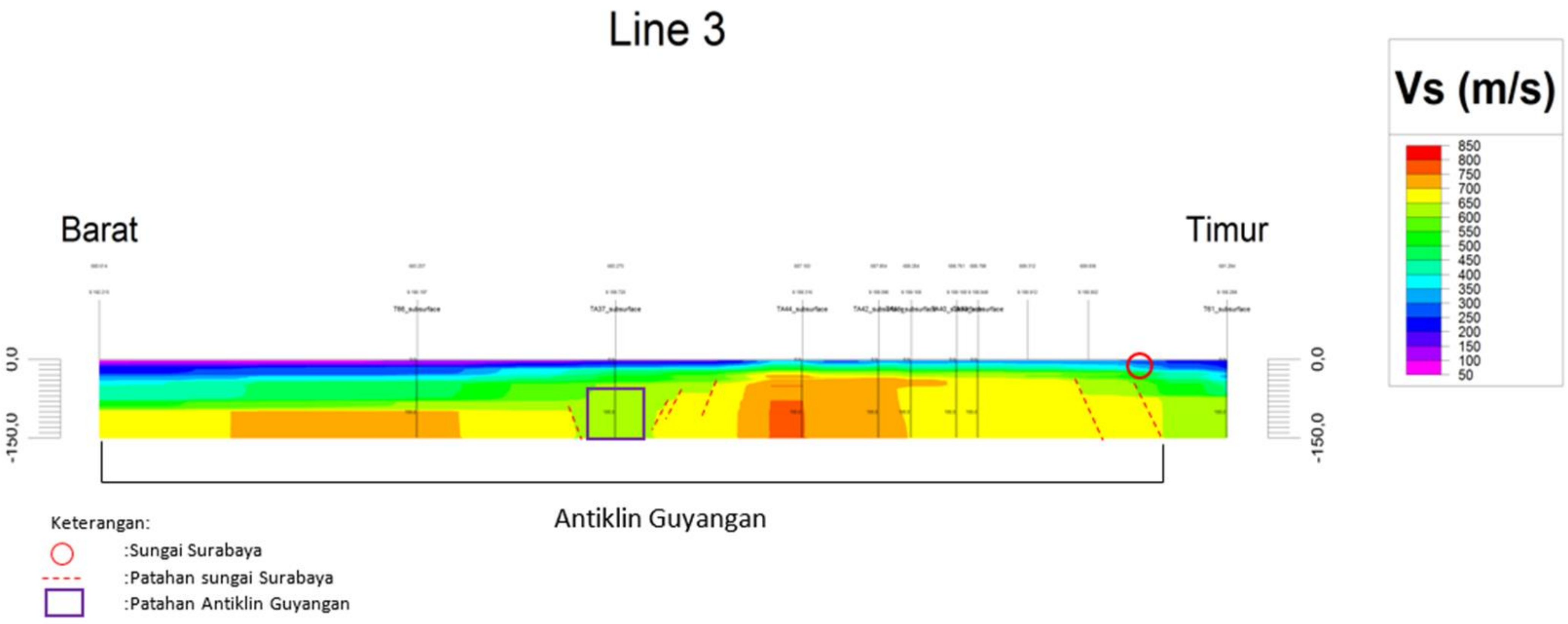
Sesar Kali Surabaya
Bagian Barat
Sesar Kali Surabaya
Bagian Timur
BaribisKendengF
SURABAYA (KOTA)
KaliSurabaya-01
KaliSurabaya-02
SELAT MADU



Gambar 4. 7 Hasil inversi HVSR pada sayatan pertama dengan kedalaman maksimal 150 meter dan nilai kecepatan geser (Vs) 0-800 m/s



Gambar 4. 8 Hasil inversi HVSR pada sayatan kedua dengan kedalaman maksimal 150 meter dan nilai kecepatan geser (Vs) 0-800 m/s



Gambar 4. 9 Hasil inversi HVSR pada sayatan kedua dengan kedalaman maksimal 150 meter dan nilai kecepatan geser (Vs) 0-800 m/s

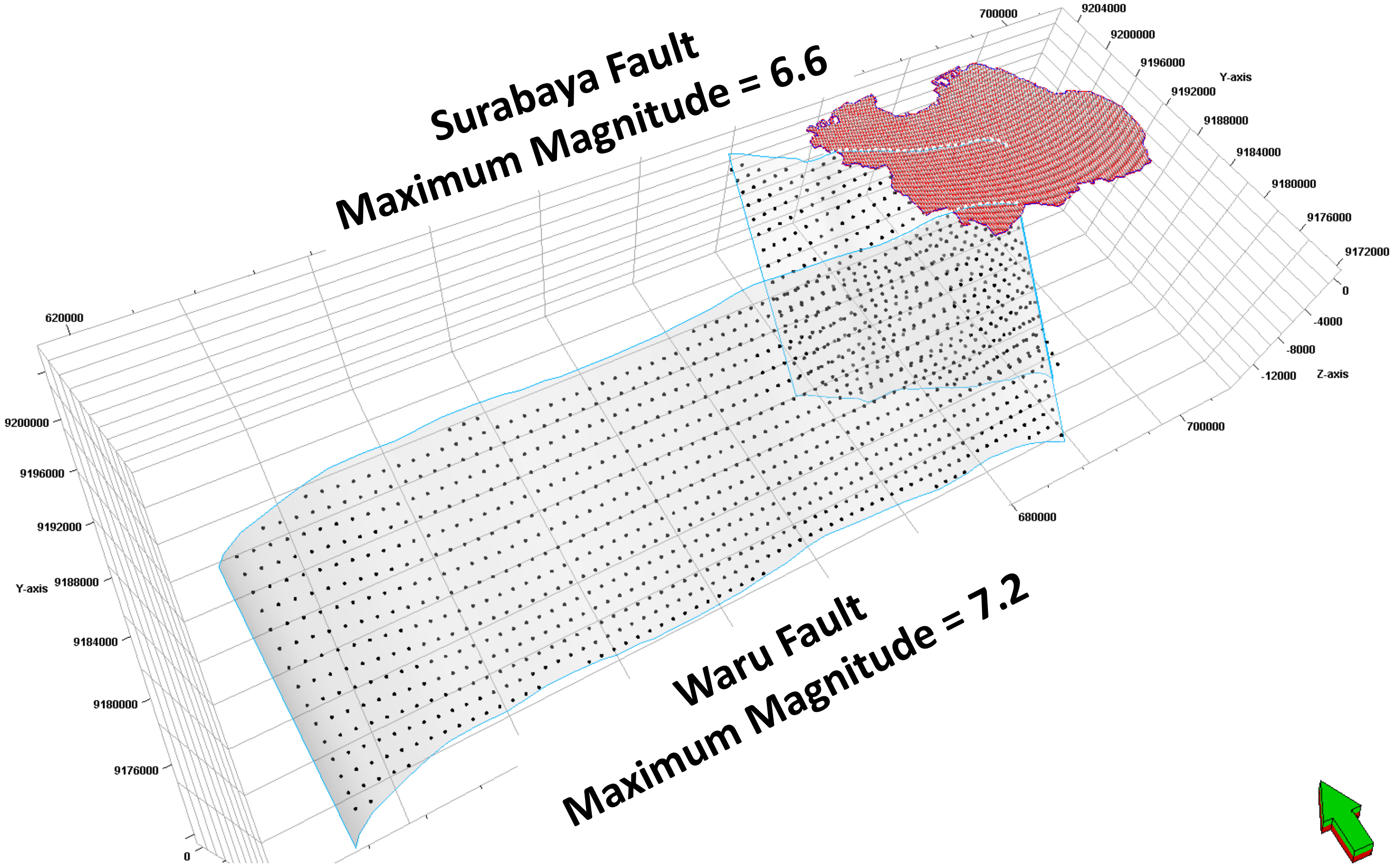
Multi Scenario Analysis

Multi Scenario

- Eq Source
  - Kendeng Fault Waru Segment
  - Kendeng Fault Surabaya Segment
- PGA Value
  - Max
  - Period 0.2 second
  - Period 1 second
- Possible Source distance
  - Closest distance
  - Mean distance
  - Maximum distance

- GMPE
  - (Boore dan Atkinson, 2014)
  - (Campbell dan Bozorgnia, 2014)
  - (Chiou dan Youngs, 2014)
- Return Period based on slip-rate
  - SR = 0.05 mm
  - SR = 0.1 mm
  - SR = 0.5 mm
- T_eval
  - 500 yrs
  - 1000 yrs
  - 2500 yrs

Maximum Magnitude



Calculation based on :

- Wells and Coppersmith (1994) all fault types (Length , Width and Area Fault geometry)
- Somerville et al (1999) (Area Fault plane)

Return Period & Occurrence probability

Return Period

Surabaya Fault			
	Slip Rate (mm)		
	0.05	0.1	0.5
TR (yrs)	19.312	9.656	1.931

Waru Fault			
	Slip Rate (mm)		
	0.05	0.1	0.5
TR (yrs)	56.653	28.327	5.665

Occurrence probability

Surabaya Fault			
	Slip Rate (mm)		
Time	0.05	0.1	0.5
500	2.56%	5.05%	22.81%
1000	5.05%	9.84%	40.42%
2500	12.14%	22.81%	72.60%

Waru Fault			
	Slip Rate (mm)		
Time	0.05	0.1	0.5
500	0.88%	1.75%	8.45%
1000	1.75%	3.47%	16.18%
2500	4.32%	8.45%	35.68%

Return Period & Occurrence probability

Surabaya Fault (Mmax=6.6)	
Time	Slip Rate (0.05 mm)
Return Period	19.312 yrs
500	P = 0.0275353766746265
1000	P = 0.0543125563806394
2500	P = 0.130300827594083

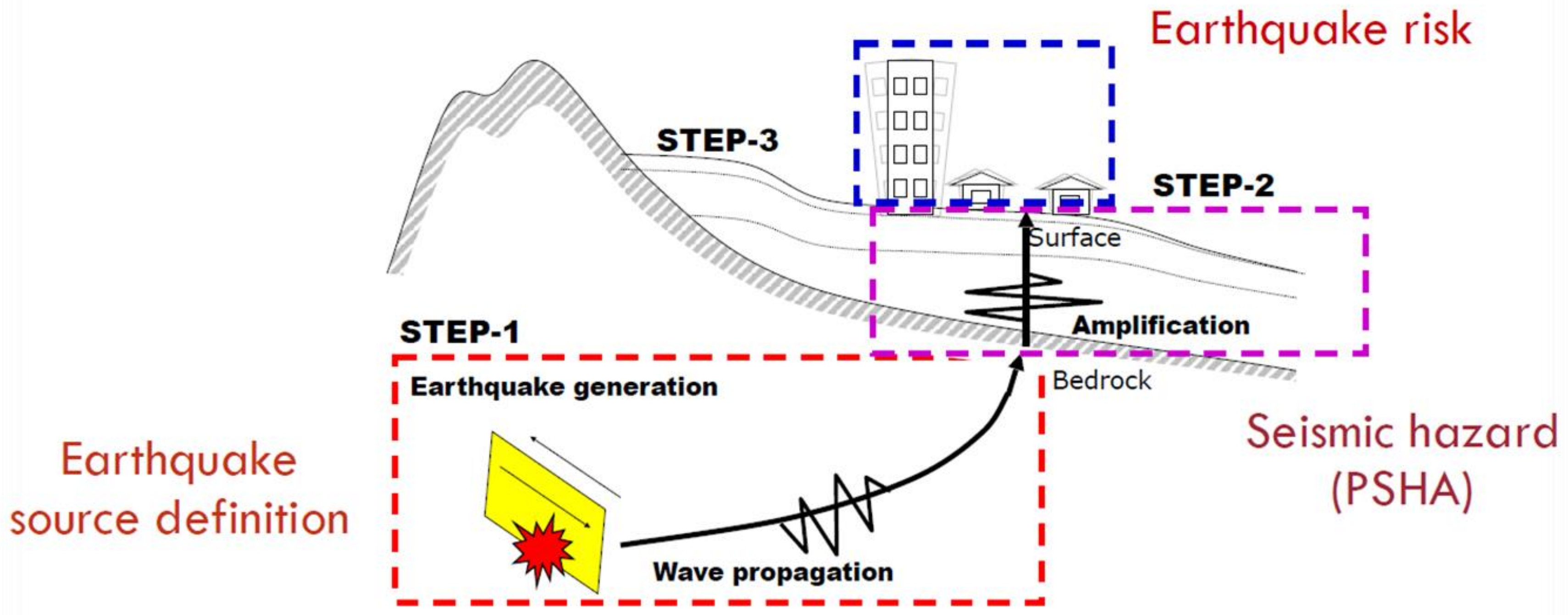
Shallow Background (Mmax=6.5)	
Time	a=2.96 b=1 z=10 km
Return Period	3.467 yrs
500	0.128195444162614 g
1000	0.149033144731474 g
2500	0.181806154907368 g

Waru Fault (Mmax=7.2)	
Time	Slip Rate (0.05 mm)
Return Period	56.653 yrs
500	P = 0.00895341073310196
1000	P = 0.0178266579024484
2500	P = 0.0439725633276267

Deep Beniof (Mmax=7.8)	
Time	a=4.8 b=1 z=60 km
Return Period	1.000 yrs
500	0.0999308182902947 g
1000	0.11616424524068 g
2500	0.14173356569485 g

Ground Shaking Calculation

Analisa Bahaya Gempa



1. Pendefinisian Sumber
2. Fungsi Atenuasi Gelombang dan Deliniasi Efek Lokal (Amplifikasi)
3. Perhitungan Resiko Bahaya

Irwan Meilano, 2016

No	Fault_Name	Slip-Rate mm/yr	Mechanism	Dip	Top	Bottom	L (km)	Mmax
1	F_Bawean	0.5	Strike-slip	90	3	18	156	7.6
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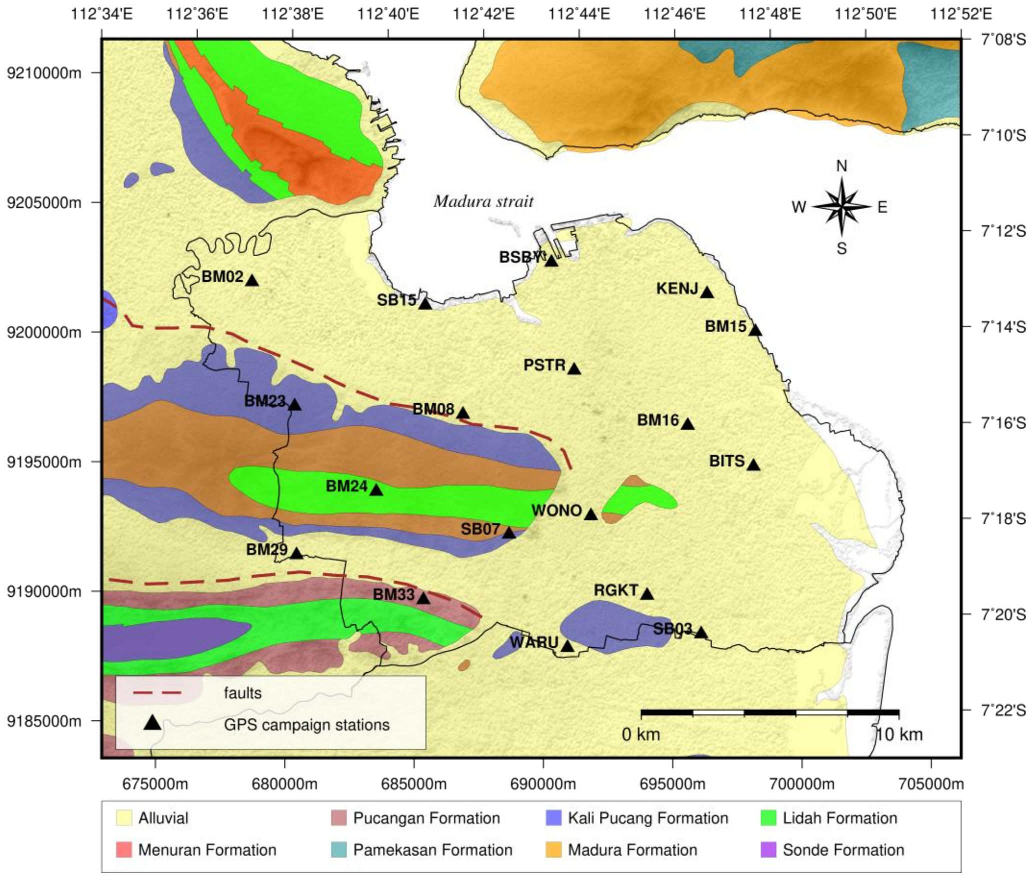
3	F_Cepu	0.1	Reverse-slip	45S	3	18	100	6.5
4	F_Pati	0.1	Strike-slip	90	3	18	69	6.5
5	F_RMKS	1.5	Strike-slip	90	3	18	230	7.8
6	F_Surabaya	0.05	Reverse-slip	45S	3	18	25	6.5
7	F_Waru	0.05	Reverse-slip	45S	3	18	64	6.5

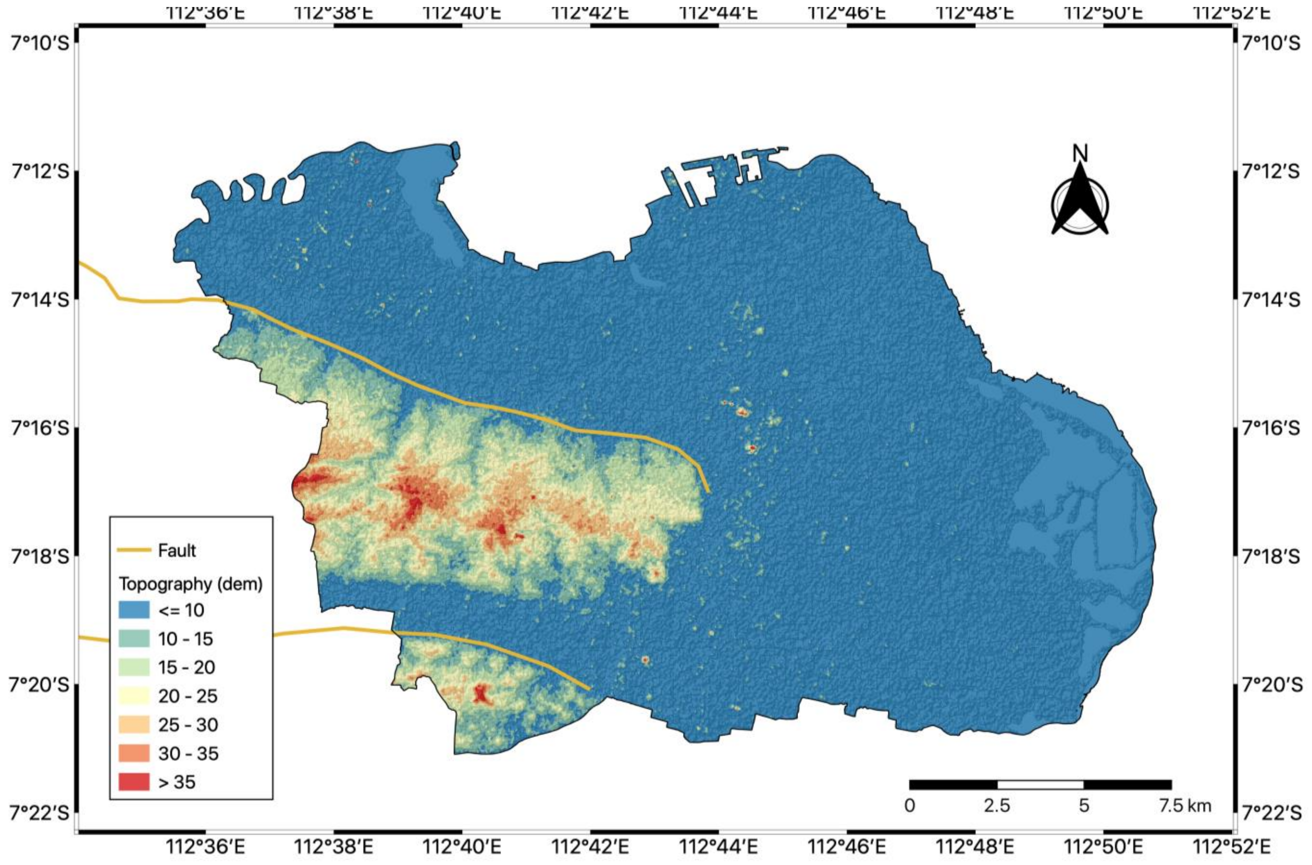
No	M_Name	Slip-Rate mm/yr	L (km)	W (km)	a Value	b Value	Mmax
1	M_East_Java	4	410	180	5.63	1.08	8.7
2	M_Sumba	4	624	196	5.63	1.11	8.5
3	M_West-Central_Java	4	505	170	5.5	1.08	8.7

No	Background	Min Depth	Max Depth	a-Value	b-Value	Mmax
1	Shallow	10	50	2.96	1	6.5
2	Deep	50	300	5.6	1	7.8

Seismic Source Parameters

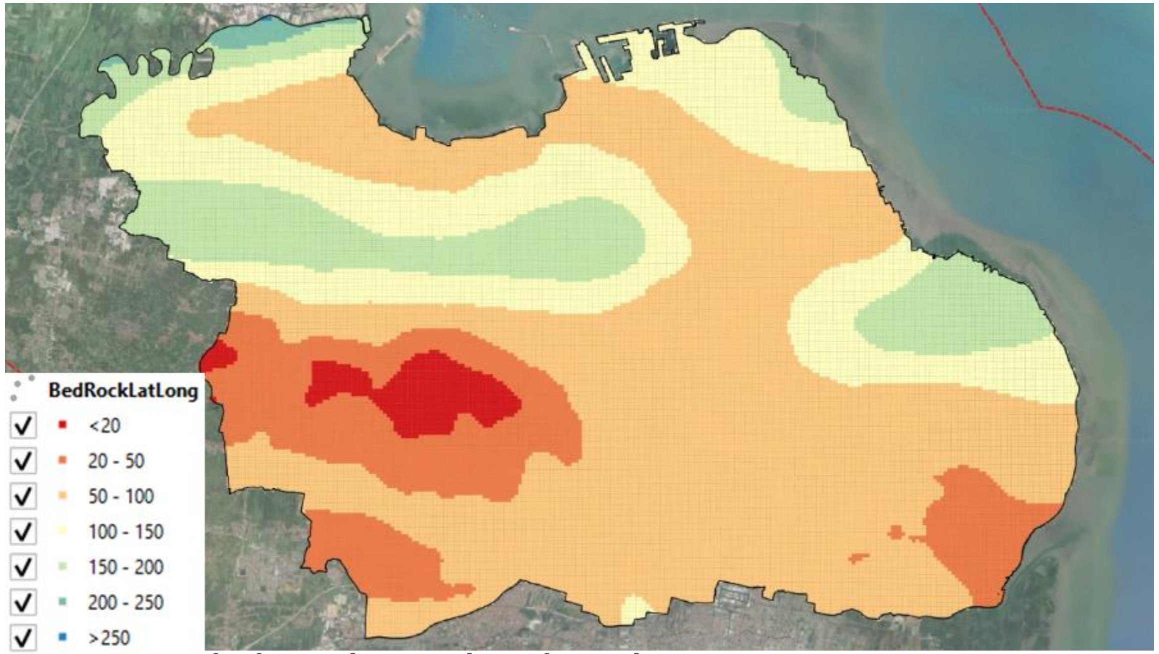
Topographic and Geological Profile



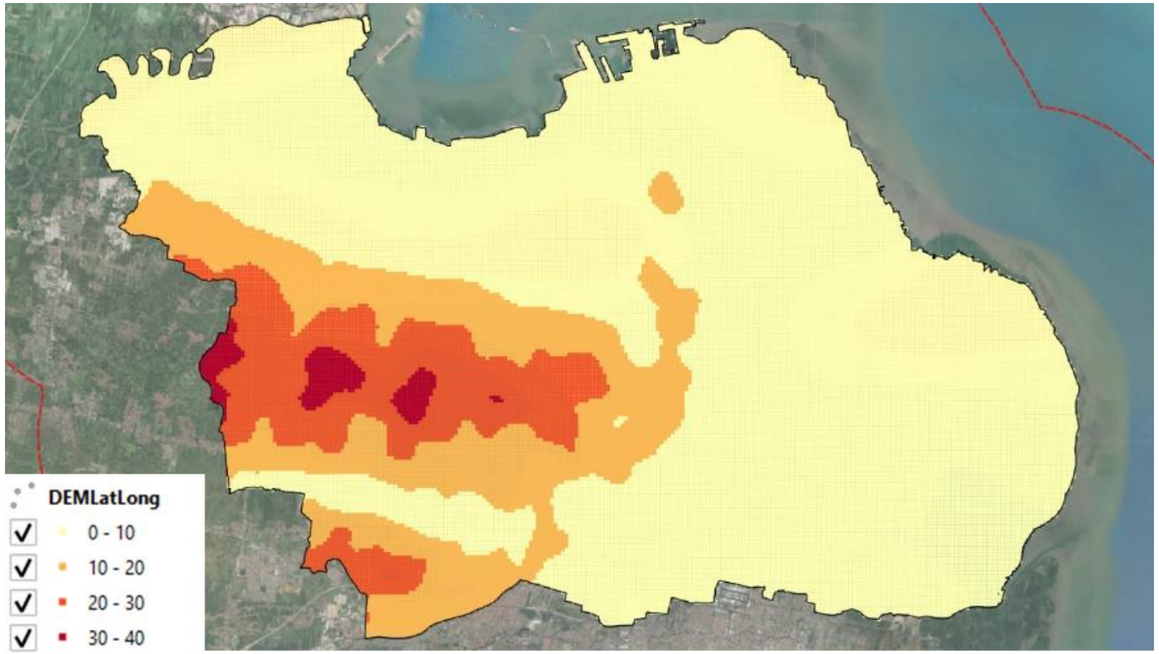


Site characterisation data

Estimated depth to bedrock



Digital elevation model of Surabaya



DEM and depth-to-bedrock

Attenuation Fucntion Seismic Hazard Map 2017 (PusGeN)

a. Sumber gempa *shallow crustal*, untuk model sumber gempa *fault* dan *shallow background*:

(1) Boore-Atkinson NGA. (Boore dan Atkinson, 2014)

(2) Campbell-Bozorgnia NGA. (Campbell dan Bozorgnia, 2014)

(3) Chiou-Youngs NGA. (Chiou dan Youngs, 2014)

b. Sumber gempa subduksi *interface* (*Megathrust*), untuk model sumber gempa subduksi:

(1) BCHYDRO (Abrahamson dkk., 2012)

(2) Atkinson-Boore BC *rock and global source subduction*. (Atkinson dan Boore, 2003)

(3) Zhao dkk., *with variable Vs30* (Zhao dkk., 2006)

c. Sumber gempa *Benioff* (*deep intraslab*), untuk model sumber gempa *deep background*:

(1) AB *intraslab seismicity* Cascadia *region* BC-rock *condition*. (Atkinson-Boore, Cascadia 2003)

(2) *Geomatrix slab seismicity rock*, 1997 *srl*. July 25 2006. (Youngs dkk., 1997)

(3) AB 2003 *intraslab seismicity worldwide data region* BC-rock *condition*. (Atkinson Boore, Wordwide 2003)

Soil Classification (SNI 1726-2012)

SNI 1726:2012

SNI

Badan Standardisasi Nasional

Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung

ICS 91.120.25;91.080.01 Badan Standardisasi Nasional BSN

5.2 Analisis respons situs untuk tanah kelas situs *SF*

Analisis respons situs menurut 6.10.1 harus dilakukan untuk tanah kelas situs *SF*, jika tidak, pengecualian terhadap 5.3.1 terpenuhi.

5.3 Definisi kelas situs

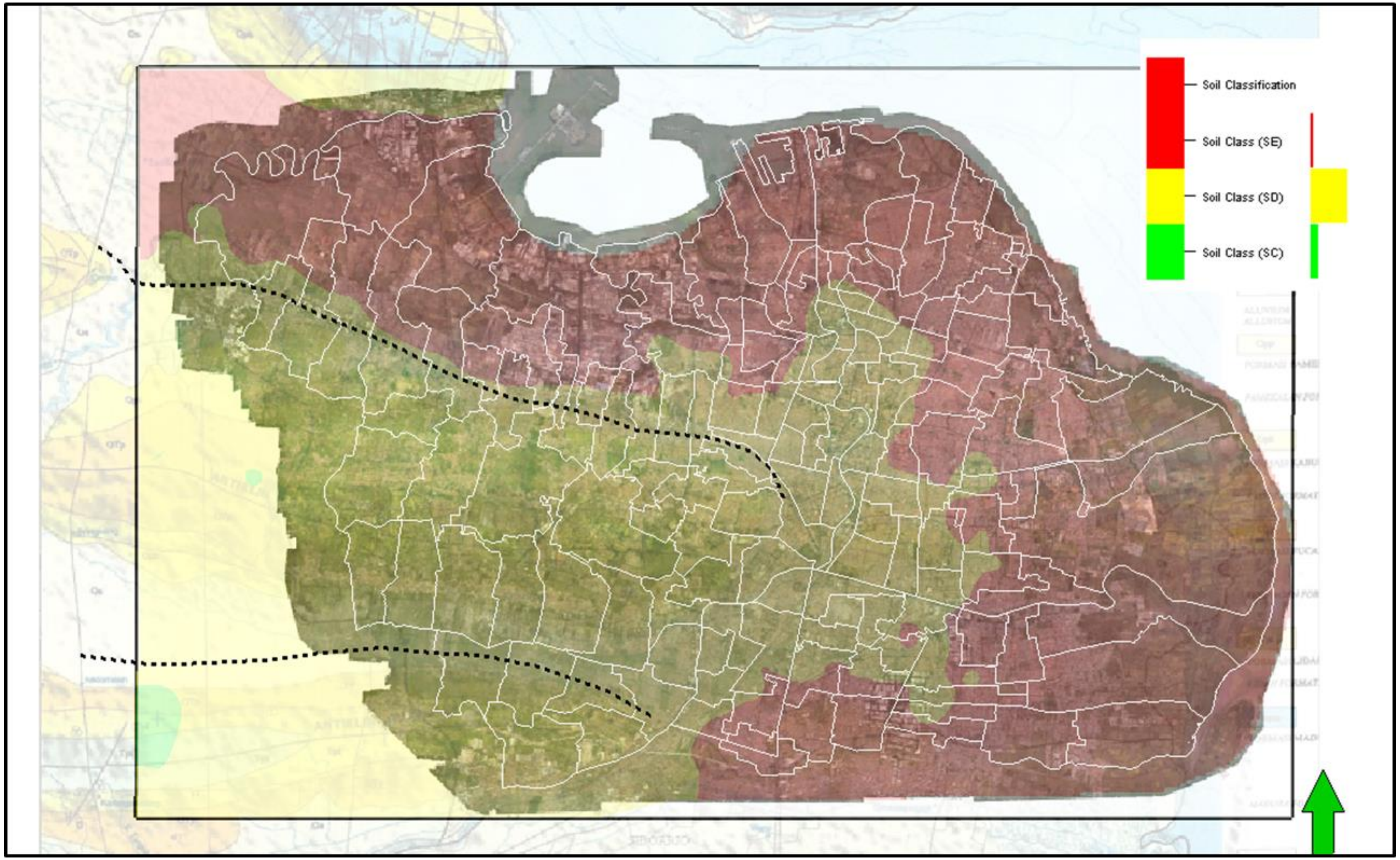
Tipe kelas situs harus ditetapkan sesuai dengan definisi dari Tabel 3 dan pasal-pasal berikut.

Tabel 3 Klasifikasi situs

Kelas situs	$\bar{v}_s$ (m/detik)	$\bar{N}$ atau $\bar{N}_{ch}$	$\bar{s}_u$ (kPa)
SA (batuan keras)	>1500	N/A	N/A
SB (batuan)	750 sampai 1500	N/A	N/A
SC (tanah keras, sangat padat dan batuan lunak)	350 sampai 750	>50	$\geq$100
SD (tanah sedang)	175 sampai 350	15sampai 50	50 sampai100
SE (tanah lunak)	< 175	<15	< 50
	Atau setiap profil tanah yang mengandung lebih dari 3 m tanah dengan karateristik sebagai berikut : 1. Indeks plastisitas, $PI > 20$, 2. Kadar air, $w \geq 40\,\%$, 3. Kuat geser niralir $\bar{s}_u < 25$ kPa		
SF (tanah khusus,yang membutuhkan investigasi geoteknik spesifik dan analisis respons spesifik-situs yang mengikuti 6.10.1)	Setiap profil lapisan tanah yang memiliki salah satu atau lebih dari karakteristik berikut: - Rawan dan berpotensi gagal atau runtuh akibat beban gempa seperti mudah likuifaksi, lempung sangat sensitif, tanah tersementasi lemah - Lempung sangat organik dan/atau gambut (ketebalan $H > 3$ m) - Lempung berplastisitas sangat tinggi (ketebalan $H > 7{,}5$ m dengan Indeks Plasitisitas $PI > 75$) Lapisan lempung lunak/setengah teguh dengan ketebalan $H > 35$ m dengan $\bar{s}_u < 50$ kPa		

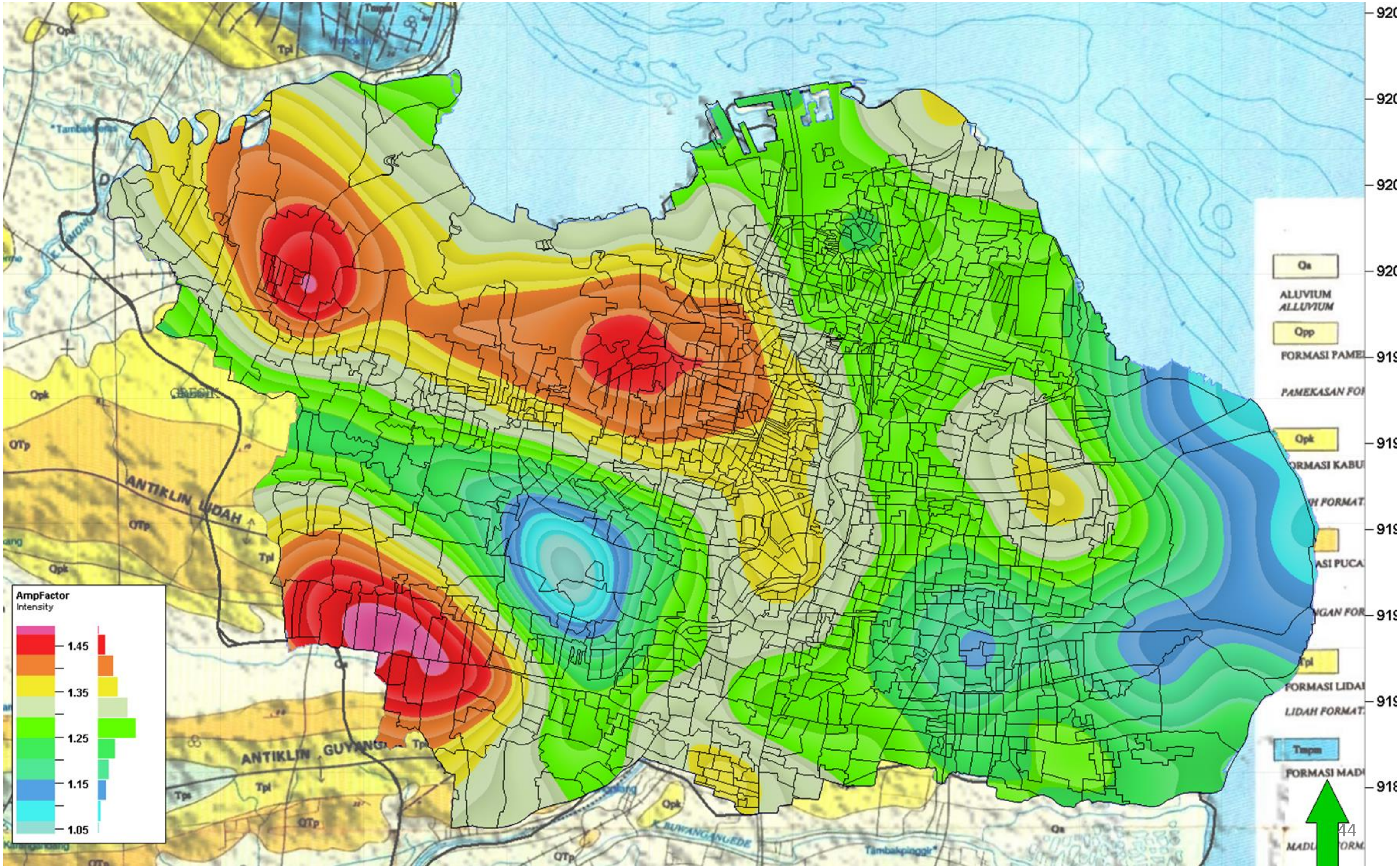
CATATAN: N/A = tidak dapat dipakai

Seismic Soil Site Class maps
based on the average values of Vs30 and N-SPT30

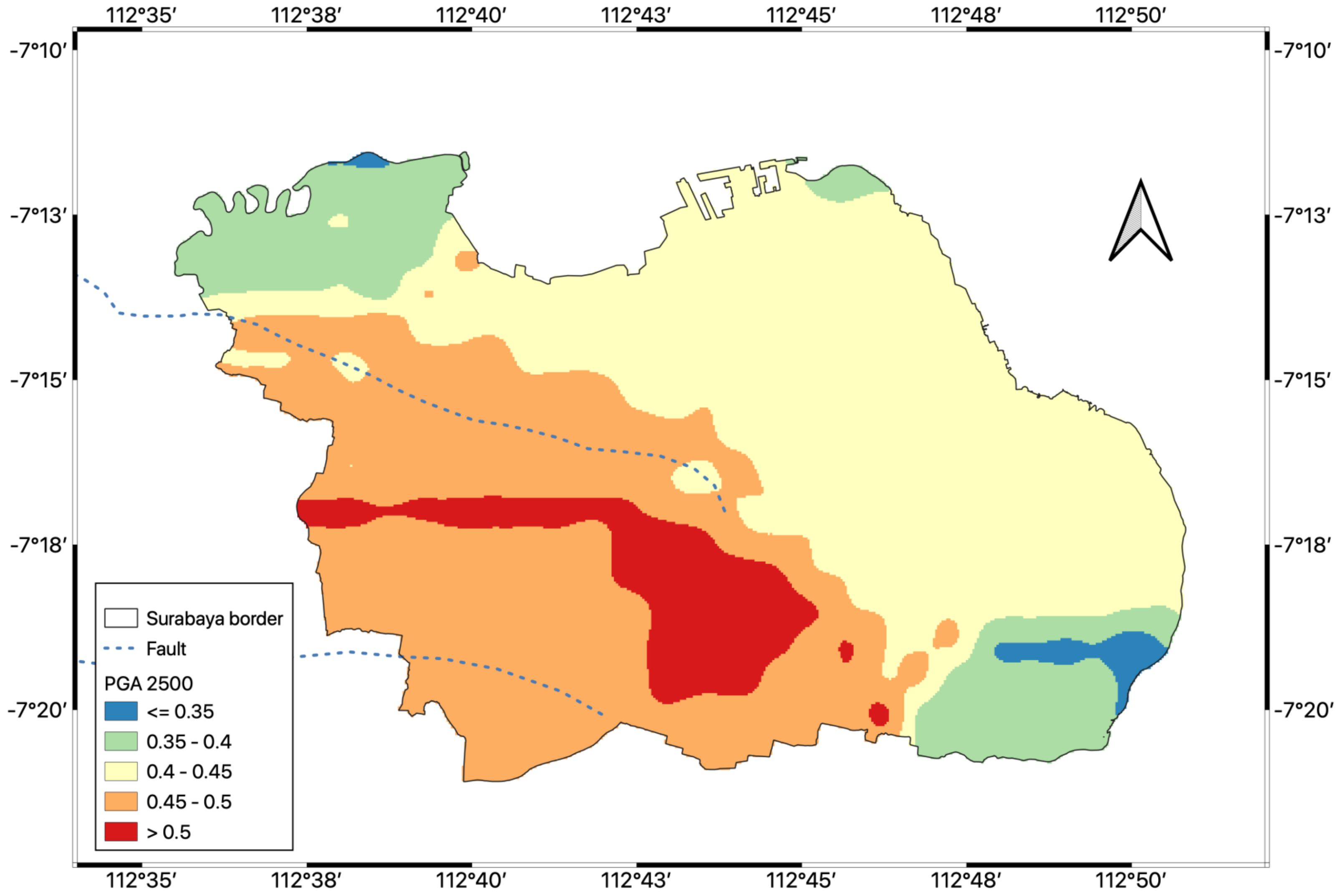


Seismic Amplification Mapping

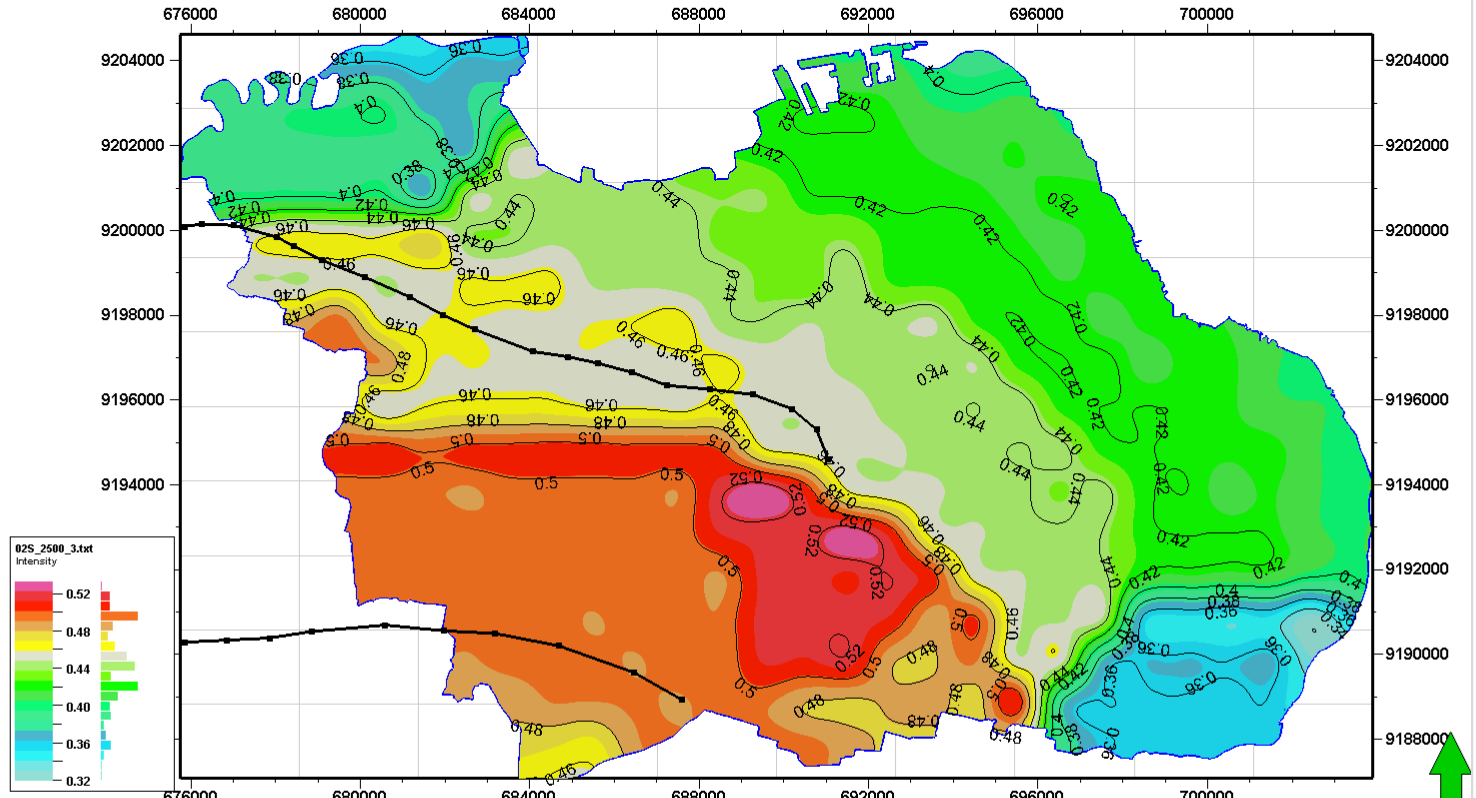
Amount of amplification can be estimated from impedance contrast between bedrock and surface sediment (Roser and Gosar, 2010).

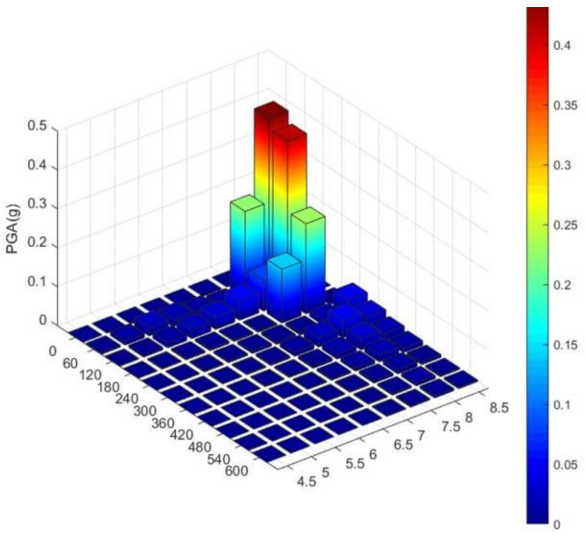

AmpFactor
Intensity
1.45
1.35
1.25
1.15
1.05
ANTIKLIN LIDAH
ANTIKLIN GUYANGAN
ALUVIUM
ALLUVIUM
FORMASI PAMEKASAN
PAMEKASAN FORMATION
FORMASI LIDAH
LIDAH FORMATION

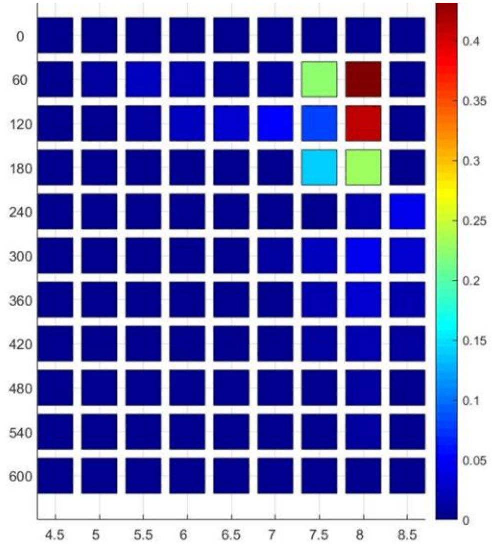
PGA 2500

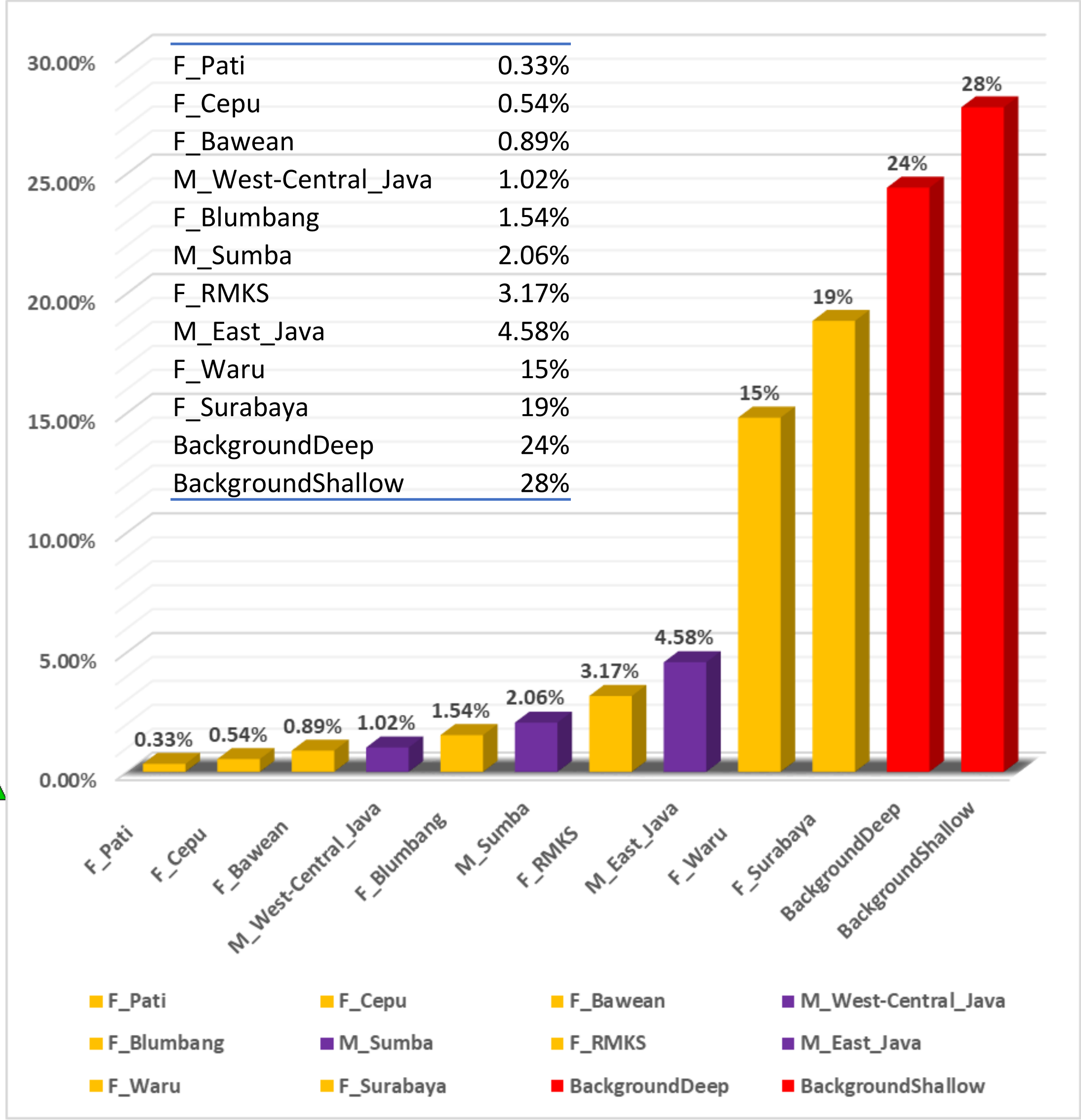


Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	Perceived shaking	Potential damage
I	< 0.0017	< 0.1	Not felt	None
II–III	0.0017 – 0.014	0.1 – 1.1	Weak	None
IV	0.014 – 0.039	1.1 – 3.4	Light	None
V	0.039 – 0.092	3.4 – 8.1	Moderate	Very light
VI	0.092 – 0.18	8.1 – 16	Strong	Light
VII	0.18 – 0.34	16 – 31	Very strong	Moderate
VIII	0.34 – 0.65	31 – 60	Severe	Moderate to heavy
IX	0.65 – 1.24	60 – 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy



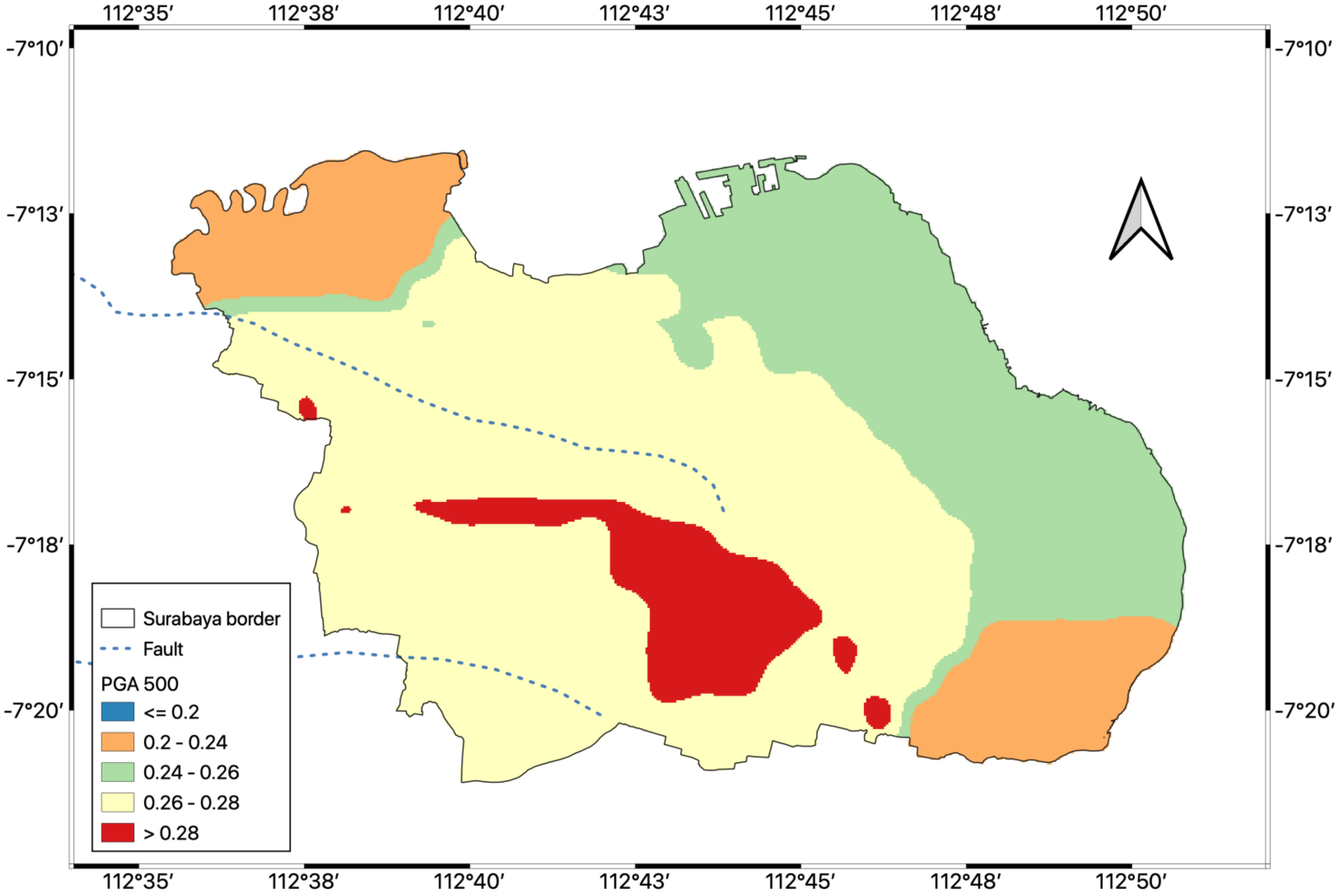




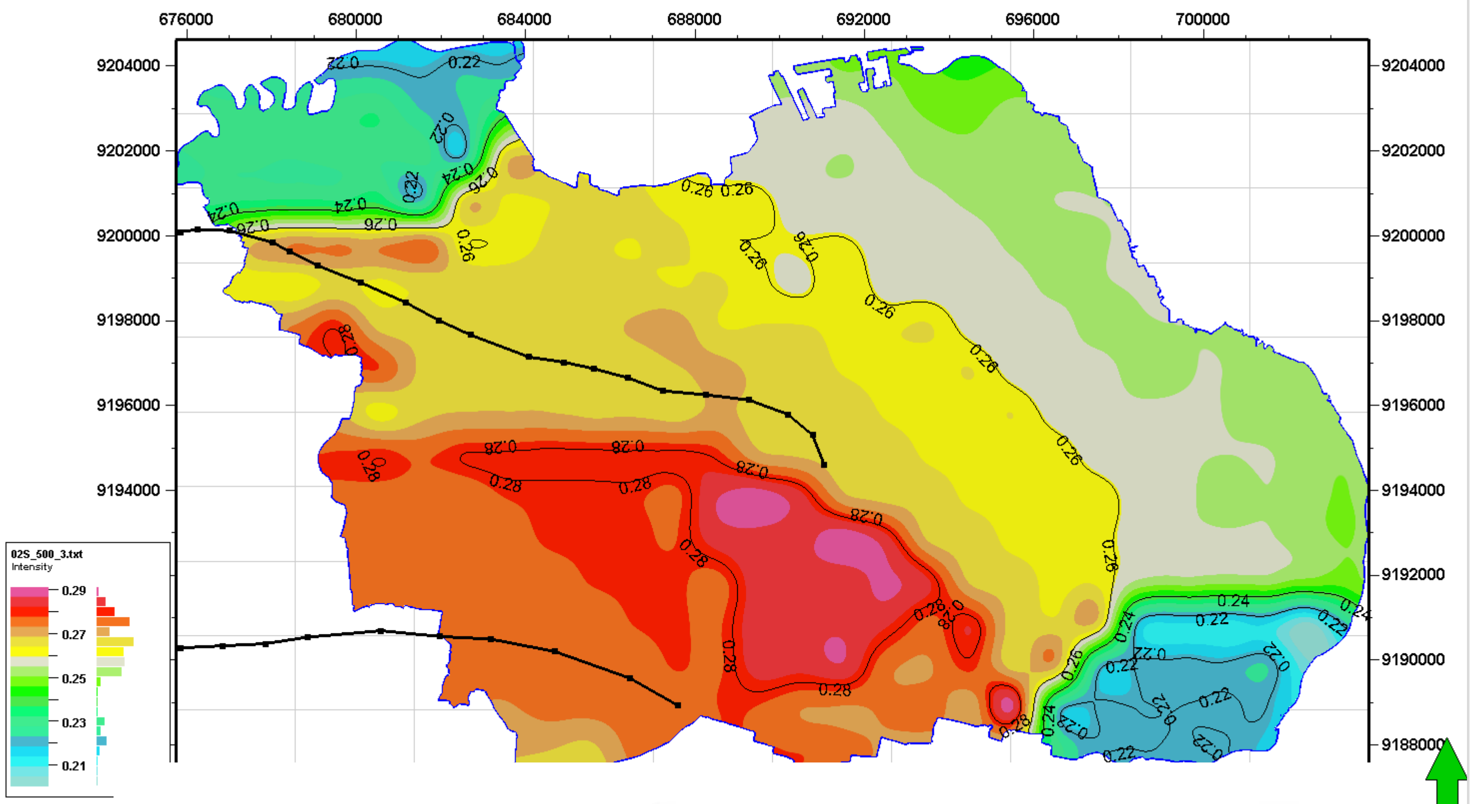


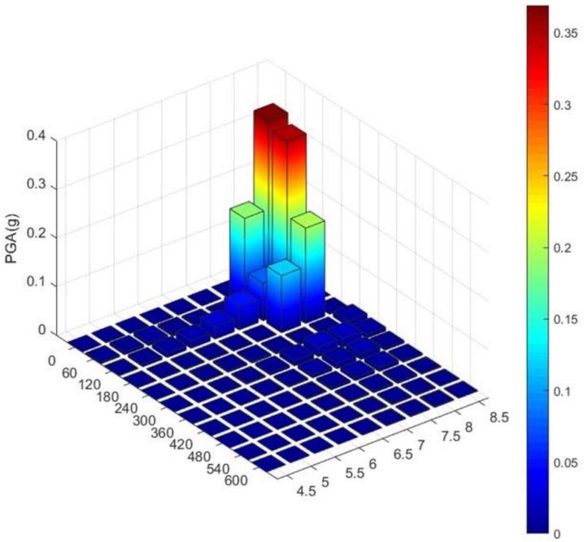
- **Tr=2475yrs, PGA_{rock}=0.32-0.53g (0.44g at Mu)**
- PuSGEN\GEM: T_r=2475yrs, PGA_{rock}=0.40g

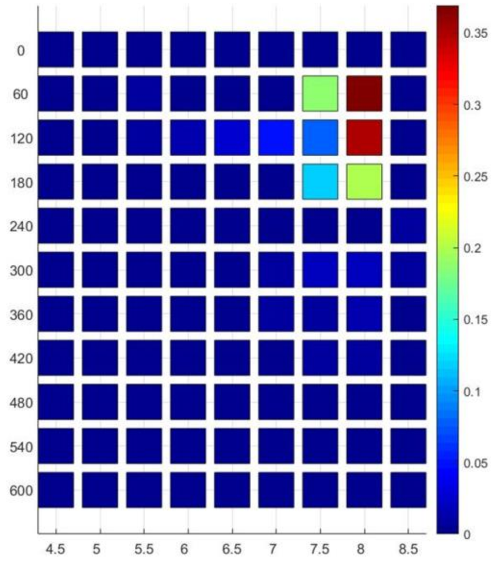
PGA 500

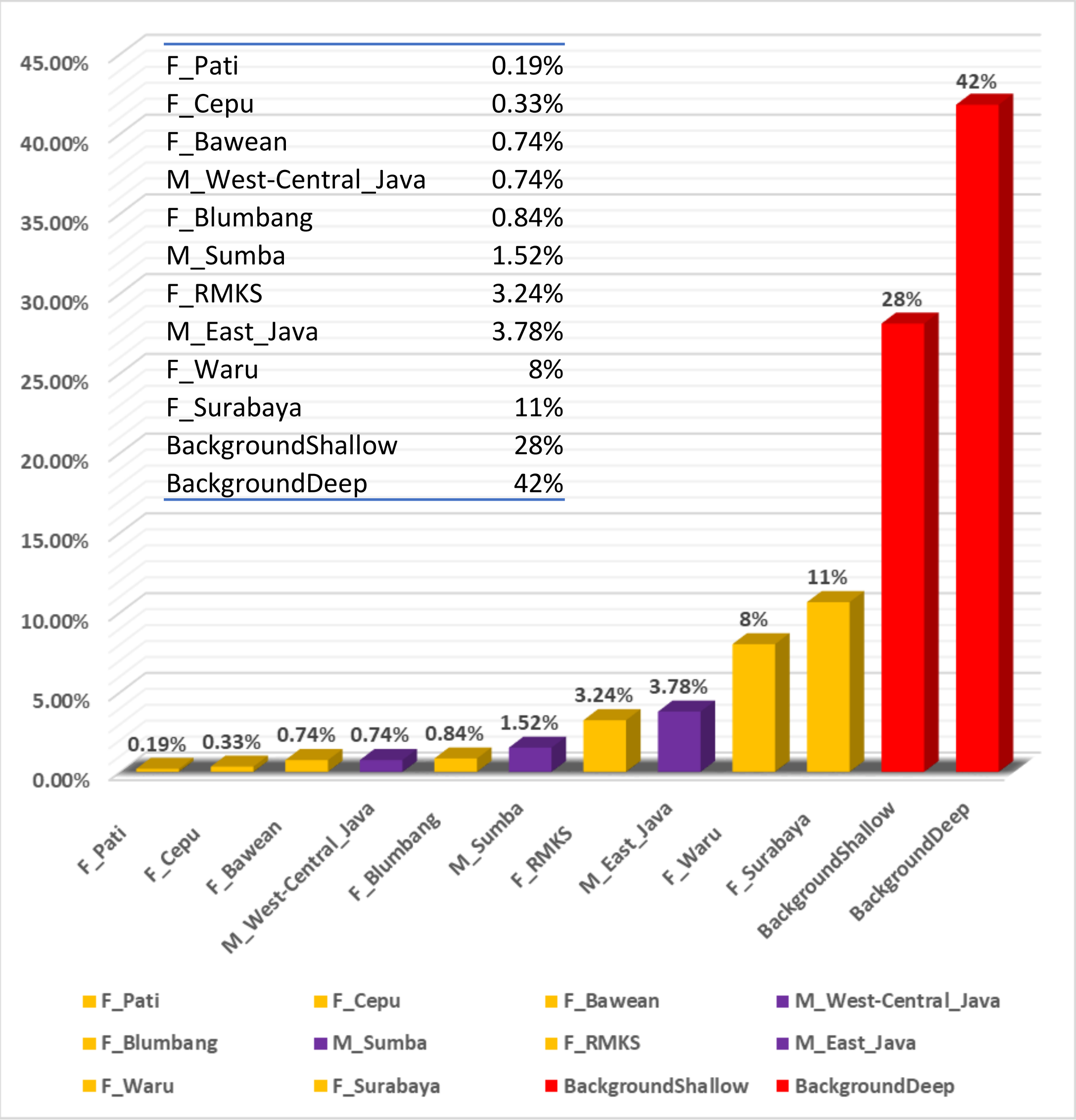


Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	Perceived shaking	Potential damage
I	< 0.0017	< 0.1	Not felt	None
II–III	0.0017 – 0.014	0.1 – 1.1	Weak	None
IV	0.014 – 0.039	1.1 – 3.4	Light	None
V	0.039 – 0.092	3.4 – 8.1	Moderate	Very light
VI	0.092 – 0.18	8.1 – 16	Strong	Light
VII	0.18 – 0.34	16 – 31	Very strong	Moderate
VIII	0.34 – 0.65	31 – 60	Severe	Moderate to heavy
IX	0.65 – 1.24	60 – 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy









- **Tr=475yrs, PGA_{rock}=0.2-0.29g (0.26g at Mu)**
- PuSGEN\GEM: T_r=475yrs, PGA_{rock}=0.19g

Kesimpulan

- Potensi sumber gempa sangat menentukan dalam perhitungan bahaya gempa, oleh karena itu informasi geometri dan lokasi sumber sangat penting. Berdasarkan penelitian sebelumnya, telah dinyatakan bahwa ada dua sesar aktif di daerah studi yang melintasi kota Surabaya. Berdasarkan hasil identifikasi diketahui Patahan Kendeng segmen Waru dan Surabaya memiliki kedalaman mulai dari 0 hingga 11 km.
- Kota Surabaya yang secara geologi didominasi oleh endapan alluvium terdiri dari kelas tanah lunak (SE) dan menengah (SD) berdasarkan data N-SPT30 dan Vs30 sesuai dengan SNI 1726-2012 tentang "Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan. Kelas situs tanah lunak membentang sejajar dengan garis pantai di pantai utara dan timur Surabaya.
- Wilayah Kota Surabaya memiliki tingkat amplifikasi tanah yang tinggi terhadap gempa mulai dari 1 hingga 1.4. Hal ini terjadi karena sifat fisik lapisan tanah Kota Surabaya didominasi oleh endapan alluvium.

SARAN

- Verifikasi potensi sumber gempa disekitar Kota Surabaya melalui penelitian lebih detail.
- Perlunya dilakukan analisa bahaya gempa khusus wilayah Kota Surabaya dengan menggunakan data yang lebih lengkap.

- TERIMA KASIH -

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