



Site and Structural Response to Earthquake^{*)}

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^{*)} Kuliah Tamu Magister Teknik Sipil Universitas Tadulako, Palu, 10 September 2022

Paper Outlines :

- 1. Pendahuluan**
- 2. Site Effects**
- 3. Intensity Prediction Equation (IPE)**
- 4. Ground Motion Prediction Equation (GMPE)**
- 5. The Probabilistic seismic Hazards Analysis (PSHA)**
- 6. Site Characteristics**
- 7. Earthquake Predictions**
- 8. Structural Response**
- 9. Seismic Intensity Measures (SIMs)**
- 10. Kesimpulan**



Disaster Risk Reduction Center

1. Pendahuluan

- Indonesia adalah salah satu negara yang rawan bencana khususnya gempa Bumi
- Banyak kajian baik di bidang Geotechnical & Earthquake Engineering
- Sulawesi Tengah khususnya Palu menjadi objek kajian kegempaan yang menarik
- Pada presentasi ini hanya akan disajikan beberapa contoh kajian Kegempaan

1 Seismic Retrofitting Of Buildings
2 Seismic Behavior Analysis Of Bridges
3 Failure Of Foundation Due To Earthquake
4 Advanced Earthquake Resistant Technique
5 Innovations In Earthquake Proof Structure
6 Seismic Behavior & Design Of RC Shear Walls
7 Earthquake & Earthquake Resistant Techniques
8 The Seismic Controlling Methods And Devices
9 Role Of Building Codes In Seismic Assessment
10 Analysis For Seismic Retrofitting Of Buildings
11 Energy Dissipation Devices For Seismic Design
12 Seismic Analysis and Up-gradation Of Structures
13 Earthquake Resistant Design and its Impact
14 Steel Bracing Of RC Frames For Seismic Resistance
15 Recent Advances In Seismic Retrofitting Of Buildings
16 Calculation Of Earthquake - Actions On Buildings
17 Evaluation Of Earthquake Affected Structures
18 Earthquake Vibration Control Using Modified Structures
19 Seismic Response Of RC Frame Buildings
20 Seismic Design Force For Single-span Slab

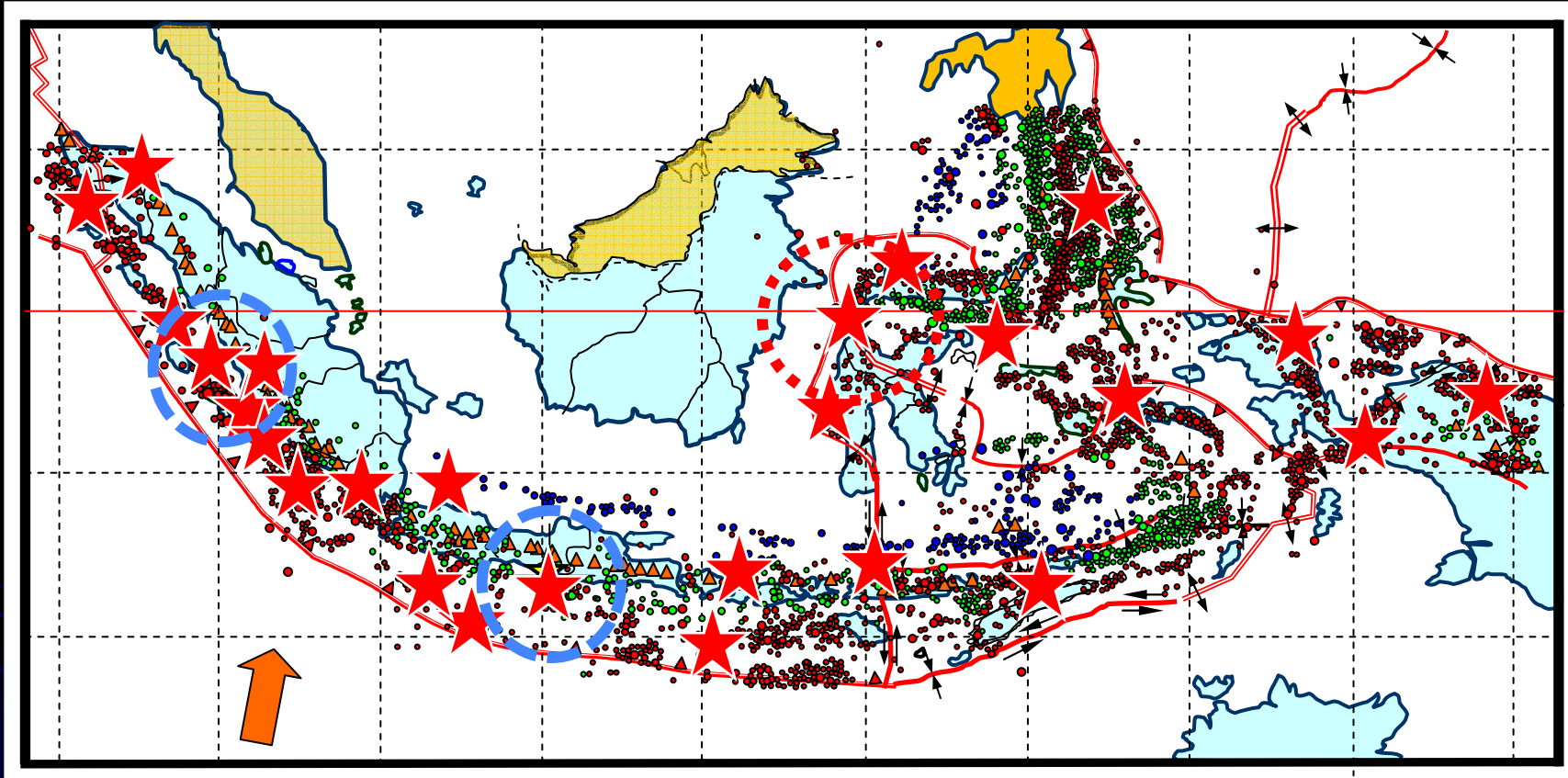
Good geotechnical research topics fall in following areas:

1. Improvement in Bearing Capacity and Soil-Reinforcement Friction
2. Reinforced soil slopes and walls
3. Ground Improvement techniques using Basal reinforcement, Wick Drains, stone columns, compaction piles, vibrofloatation
4. Seismic analysis of reinforced soil structures, embankment and reinforced soil footings
5. Problems of liquefaction and their remedial measures
6. Marine geotechnical structures like quay walls, artificial islands, gravity offshore platforms

Various research approaches for these topics can be:

- Experimentation - Physical modeling like Model scale testing or full-scale testing or centrifuge modeling. It depends on facility available in your university
- Numerical modeling - One should be well versed in finite element software like Abaqus, Plaxis or Flac. Knowledge of Python will help in writing user subroutines.
- Artificial Intelligence based - You should be well versed in R or MATLAB. You can develop new empirical relationships between various soil parameters based on past

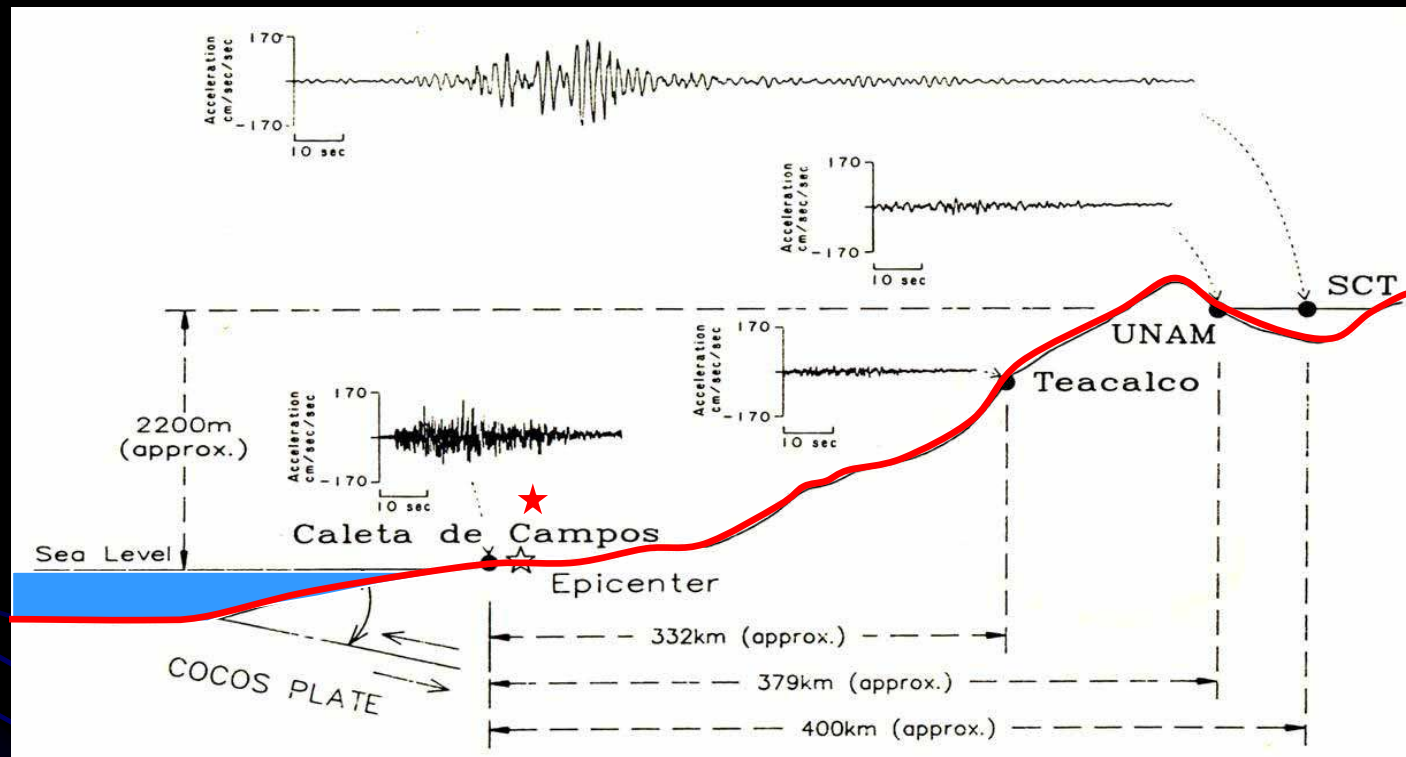
- **Kejadian2 Gempa di Indonesia**



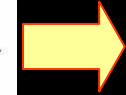
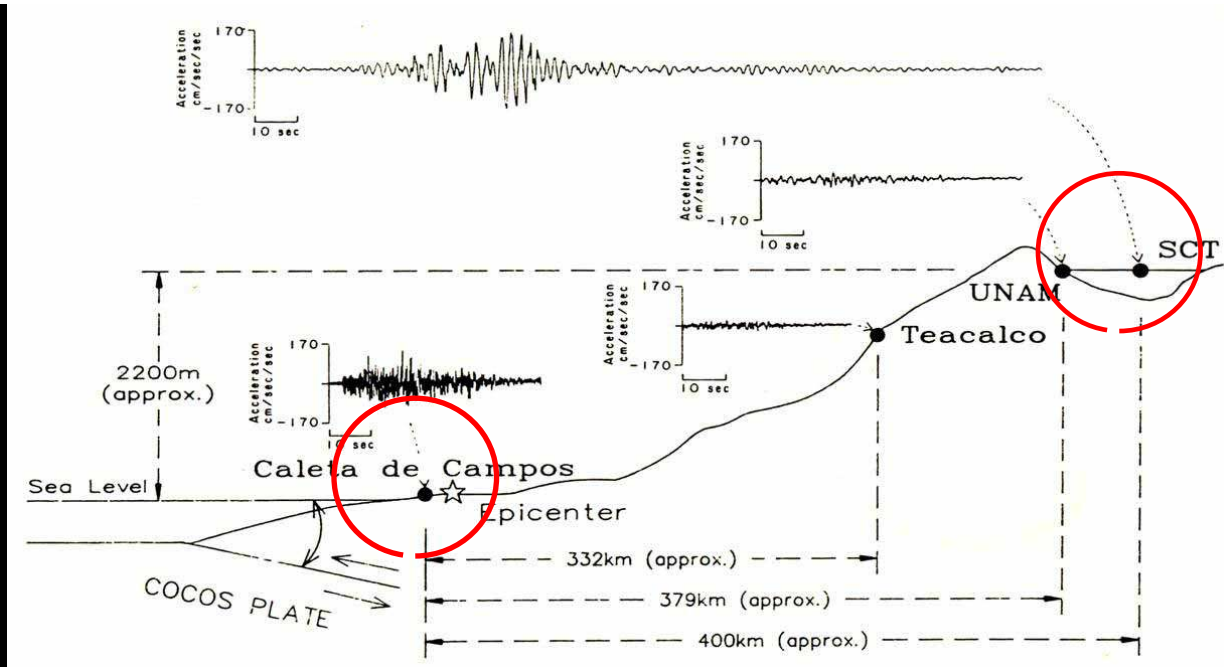
Hampir seluruh wilayah Indonesia merupakan daerah yang rawan terhadap bencana alam gempa bumi, kecuali pantai Sumatra timur, Kalimantan dan Papua selatan. Namun demikian rekaman gempa tidak pernah jelas, apakah ada atau tidak, dan seandainya ada pada kenyataannya sulit untuk diperoleh

2. Site Effects

Site effects sering terjadi dan dimulai dari kasus gempa Mexico, 9 September 1985. Site Effects terjadi di gempa Yogyakarta dan Palu.



- Di daerah episenter (dekat) rekaman gempa mempunyai frekuensi tinggi
- Di daerah rock site dan jauh (di Teacalco dan UNAM) percepatan tanah sudah sangat kecil karena energi gempa sudah berjalan ± 350 km pada tanah keras
- Di daerah soft-soil (SCT, tanah endapan) dan jauh percepatan tanah membesar dengan kandungan frekuensi rendah. Ini adalah pengaruh kondisi tanah setempat.
- Mengapa demikian ?



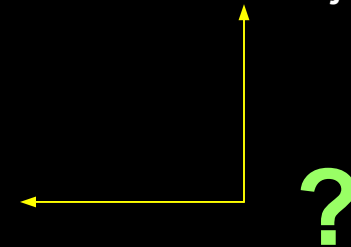
Mexico City (400 km away) :

1. > 10 000 deaths
2. ± 1132 building collapse
3. Thousands injured



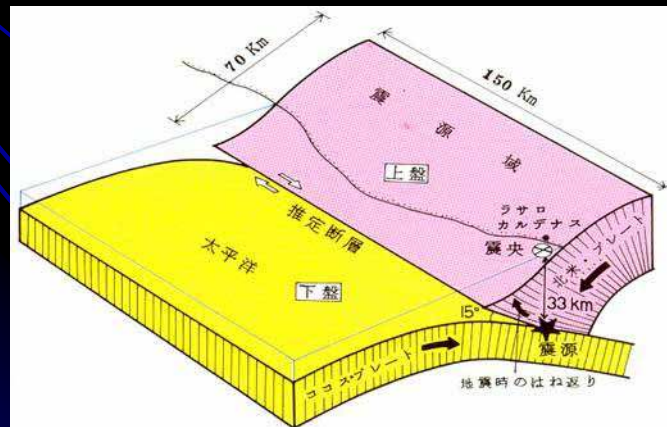
At epicenter area :

1. there was damage to only several buildings
2. Liquefaction occurred in several places



?

EQ mechanism



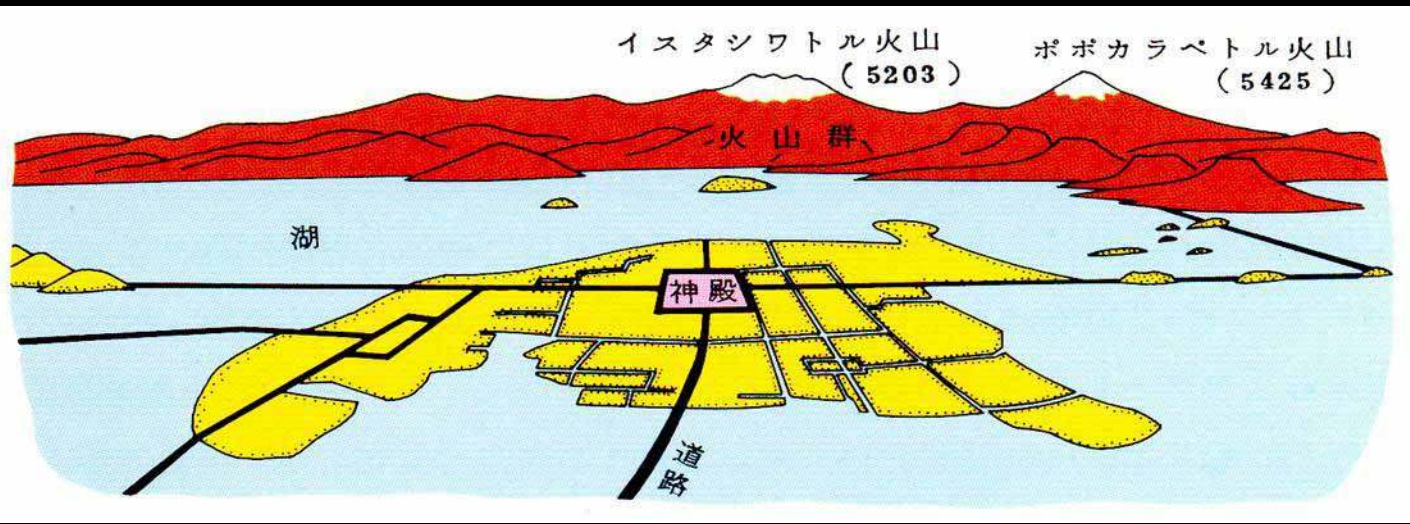
Earthquake Characteristics :

Date : September, 19, 1985

Magnitude : $M_L + 8,1$

Focal Depth : Approx. 33 km

Max. Acc : 168 cm/dt² (0.17 g)

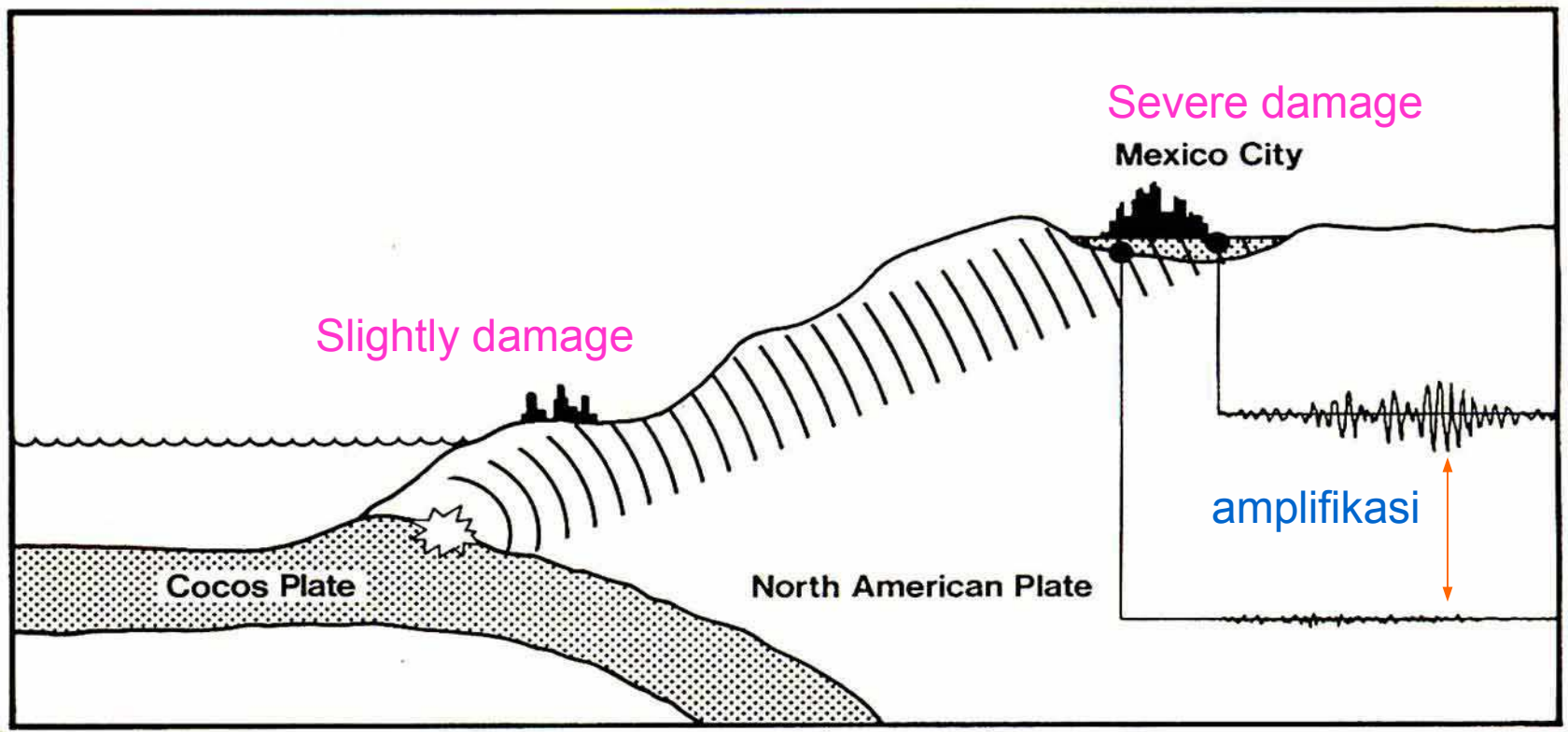


Mexico soil deposit :

1. Very deep deposit
2. Low water level
3. High PI
4. Very soft soil

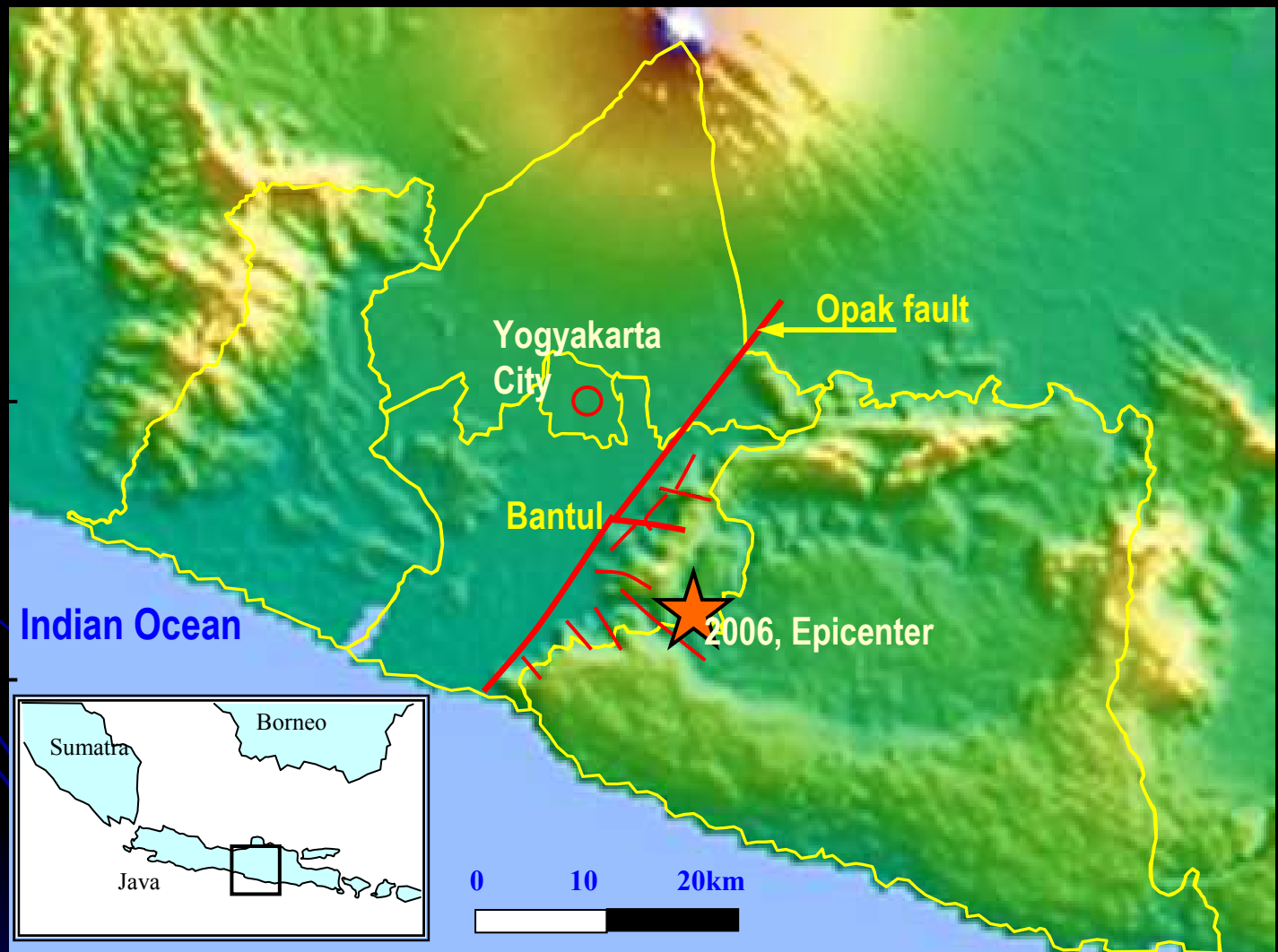
Induce/lead to :
Severe ground settlement

Kota Mexico terletak di atas endapan danau purba

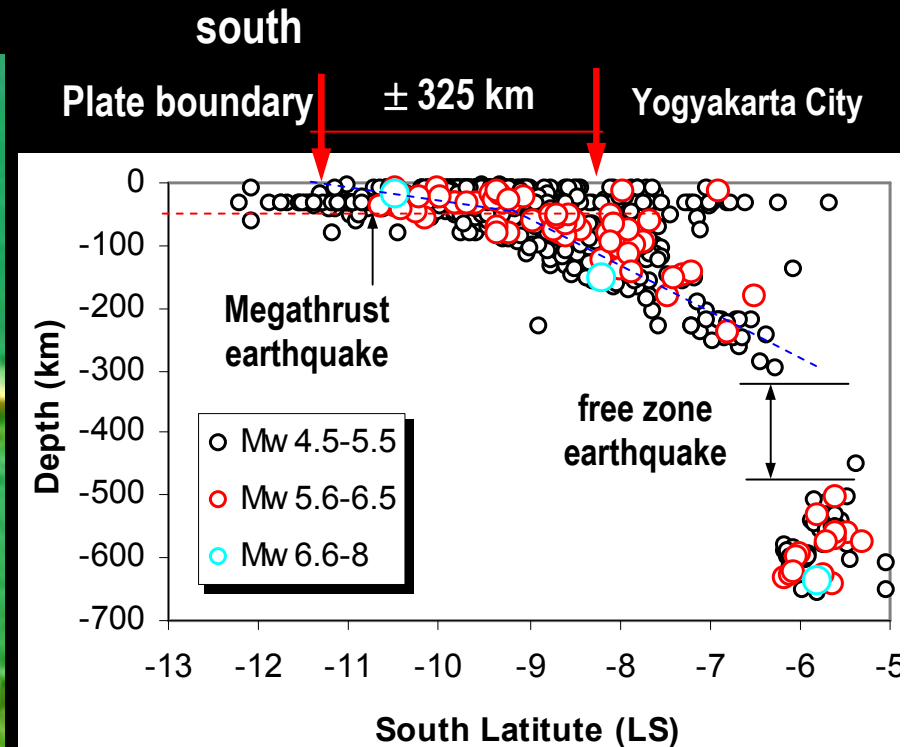
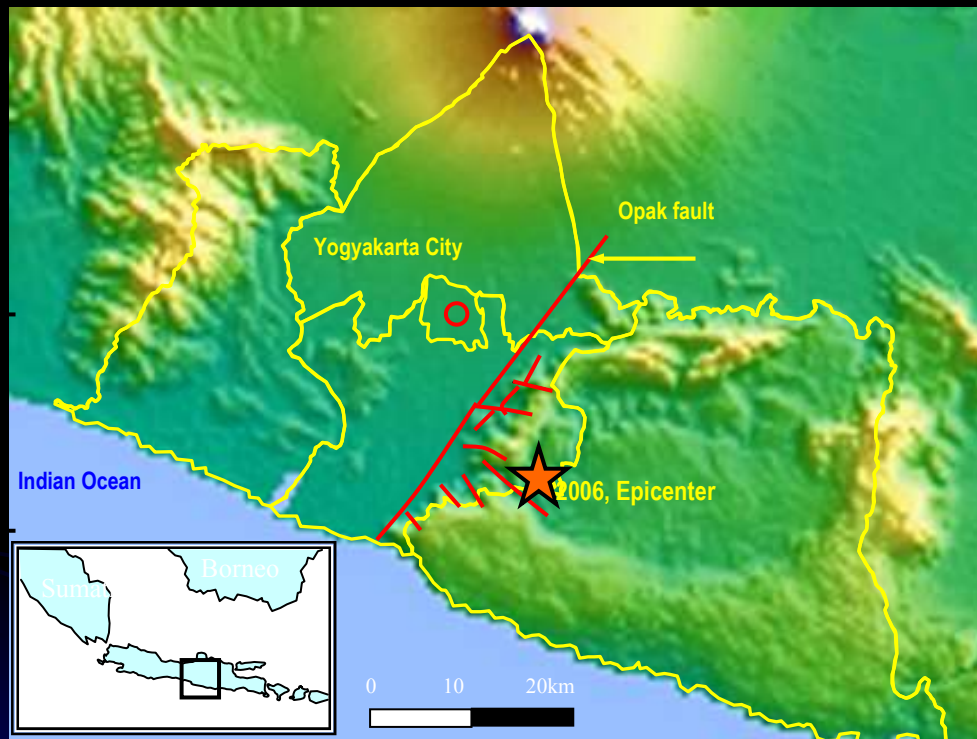


Site Effects di Gempa Yogyakarta 2006

Kabupaten Bantul Yogyakarta sebagian besar merupakan tanah endapan

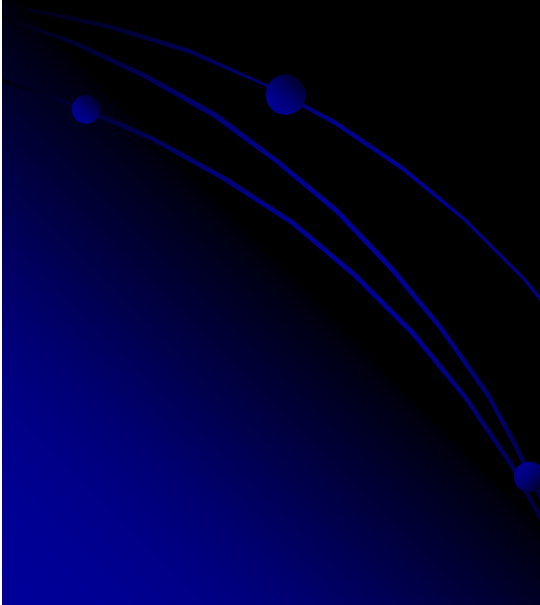
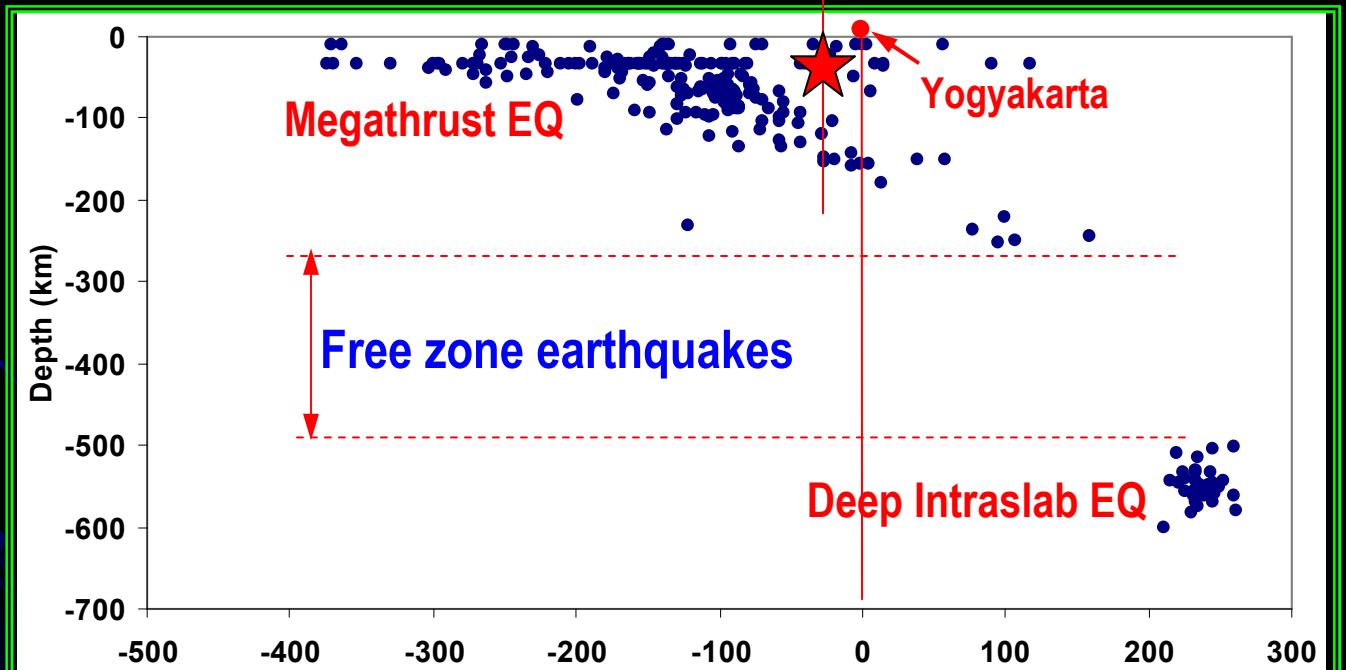
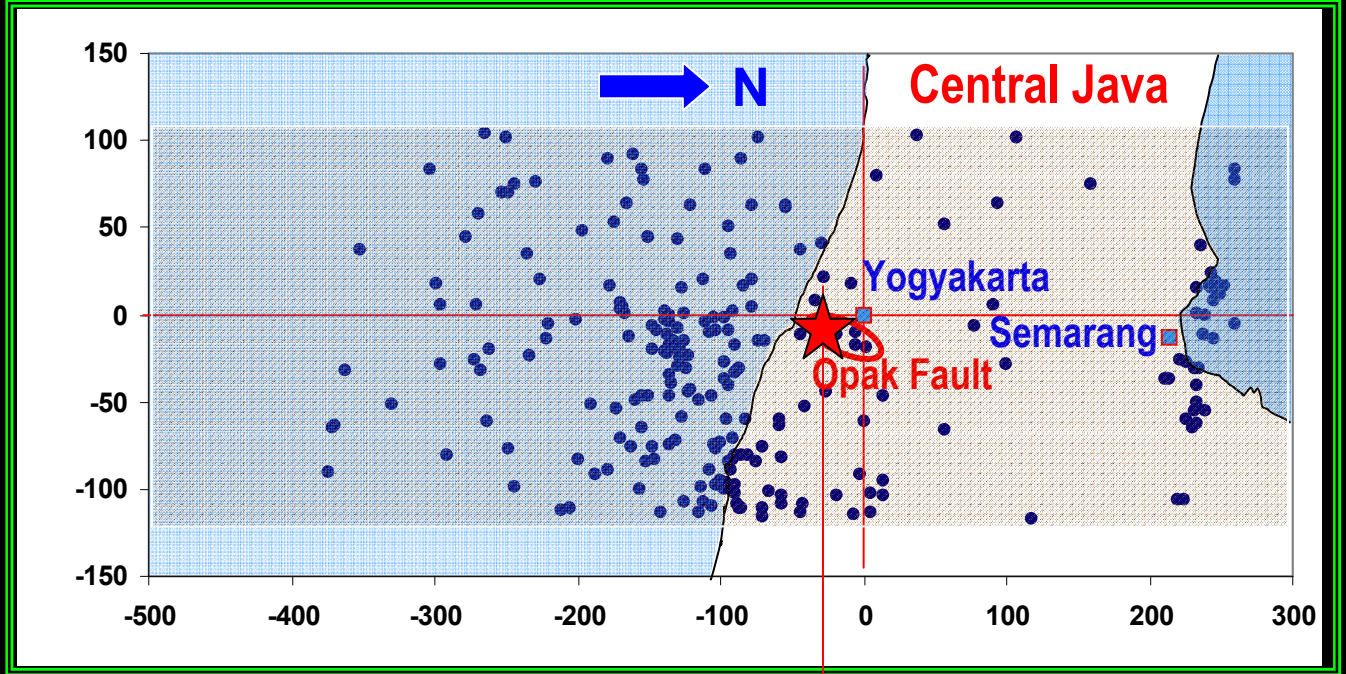


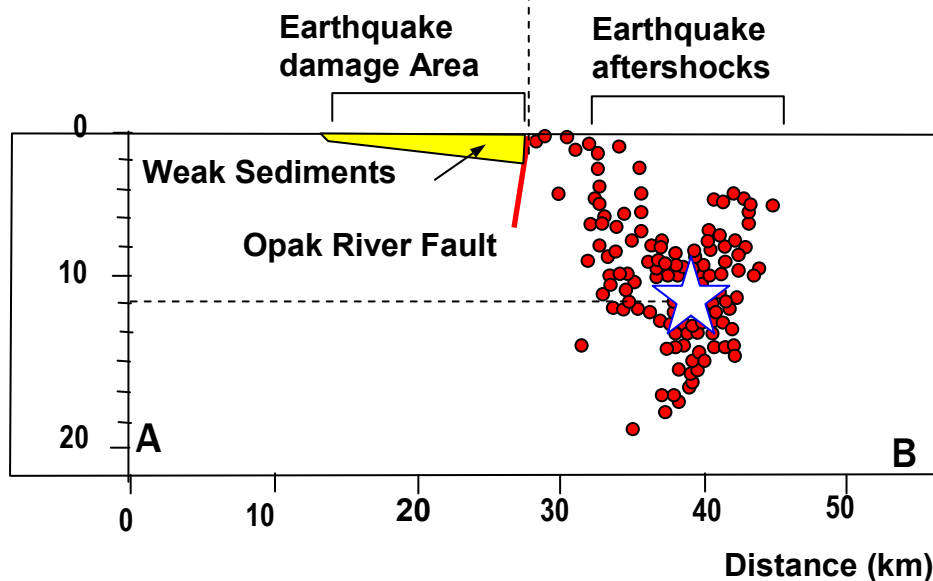
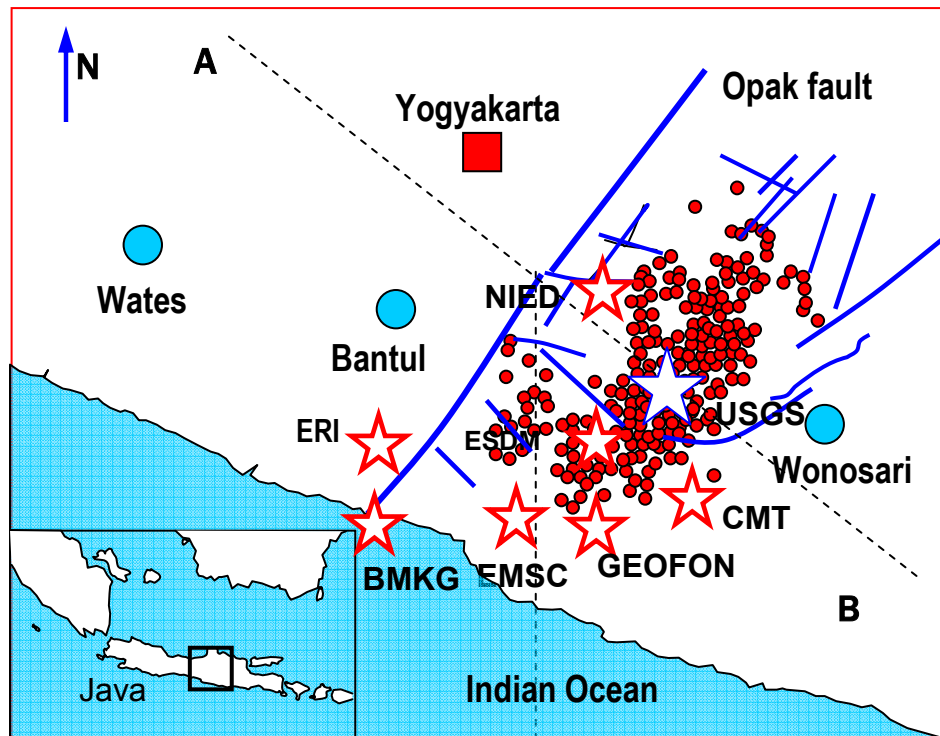
4. Karakter-2 gempa di Jawa dan Sumatra



Sudah disampaikan oleh banyak peneliti bahwa Kabupaten Bantul adalah daerah endapan yang rawan terhadap kejadian gempa (**site effects**)

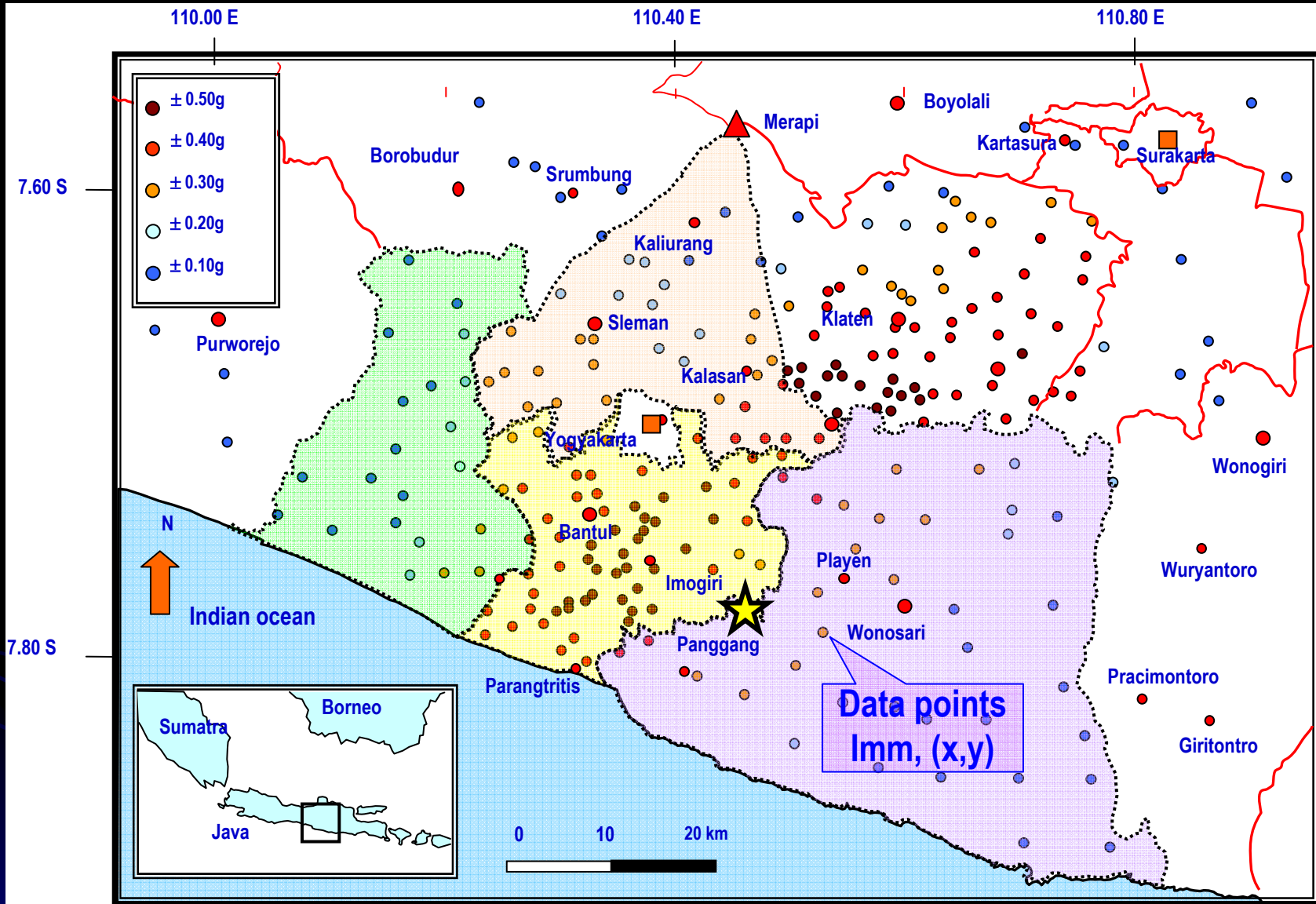
Gempa-2 di Yogyakarta





- Most of the past researches were more emphasized on the :
- Earthquake parameters (Walter, 2006, Tsuji et al., 2009)
 - Ground motions (Elnashai, 2006)
 - Damage of buildings (Boen, 2006; Miura et al., 2007)
 - Site Effects (Kertapati, 2006, Marjiono, 2007)
 - Damage of buildings by satellite image (Yamasaki & Matsuoka 06)
 - It is necessary to extent the research on the seismic intensity, gr. acceleration & build. damage

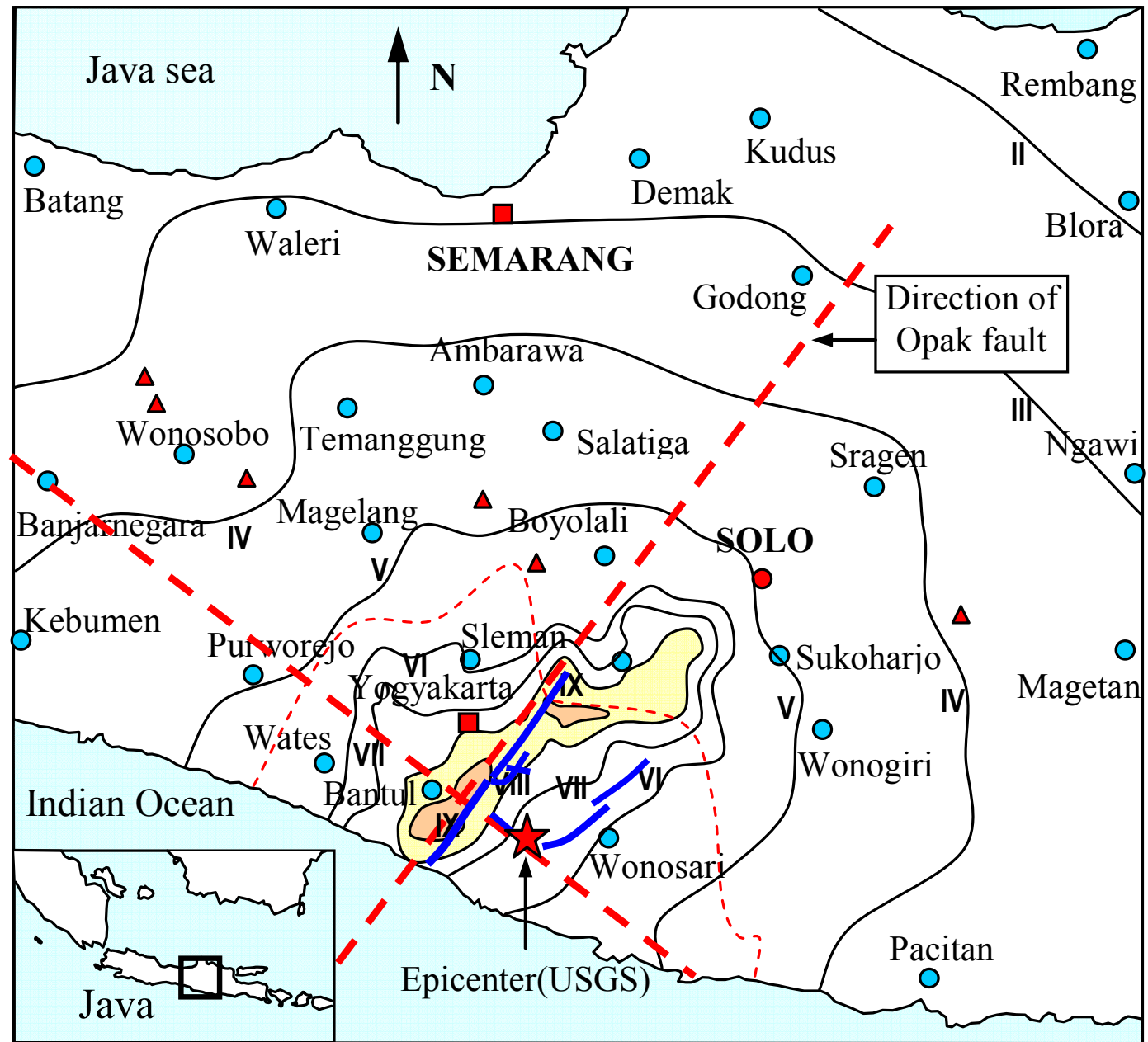
Aftershocks of Yogyakarta Earthquake (Walter et al, 2006)

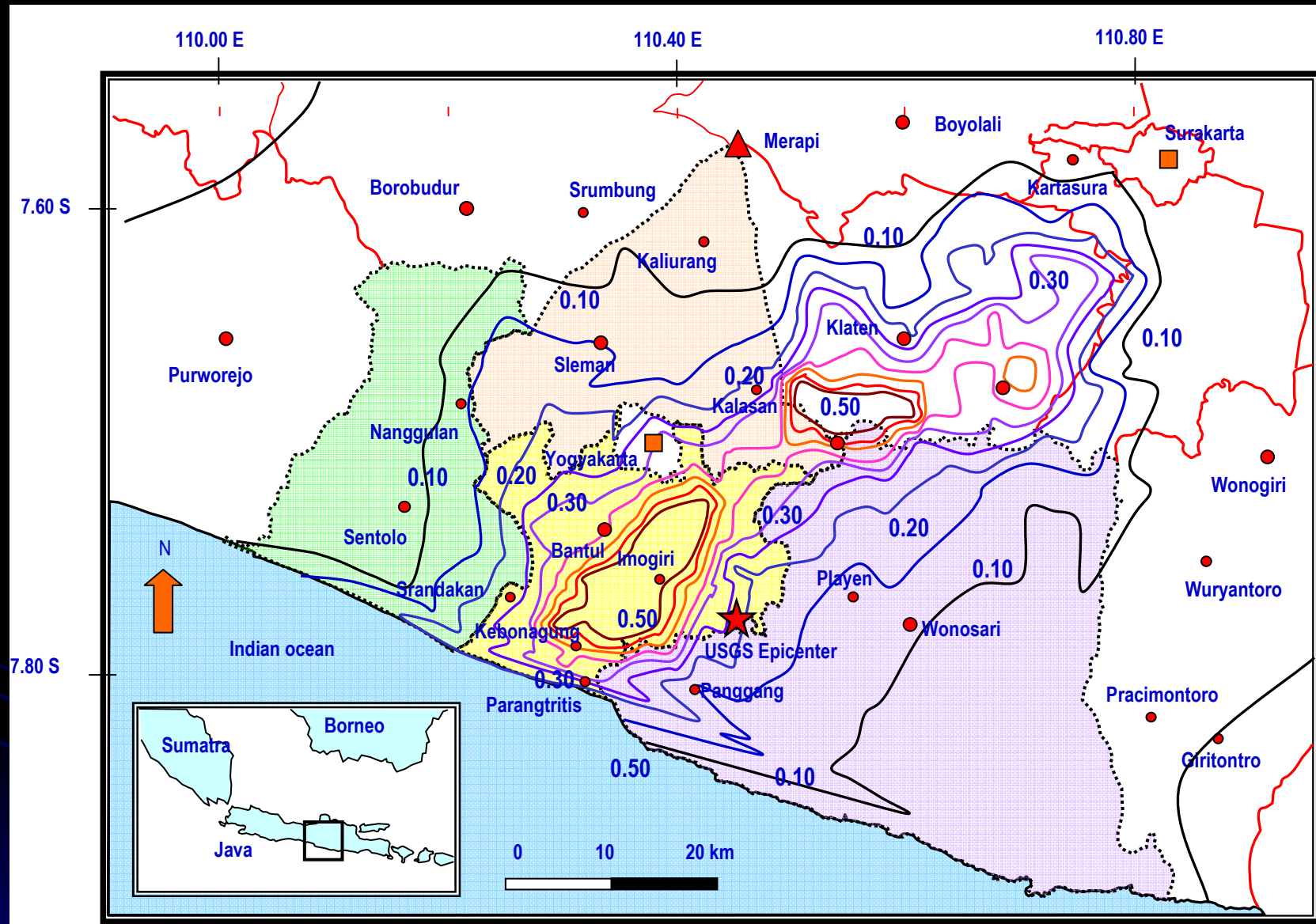


Data percepatan tanah : Lebih dari 320 data lapangan tentang percepatan tanah telah diteliti, dikompilasi dan dihitung.

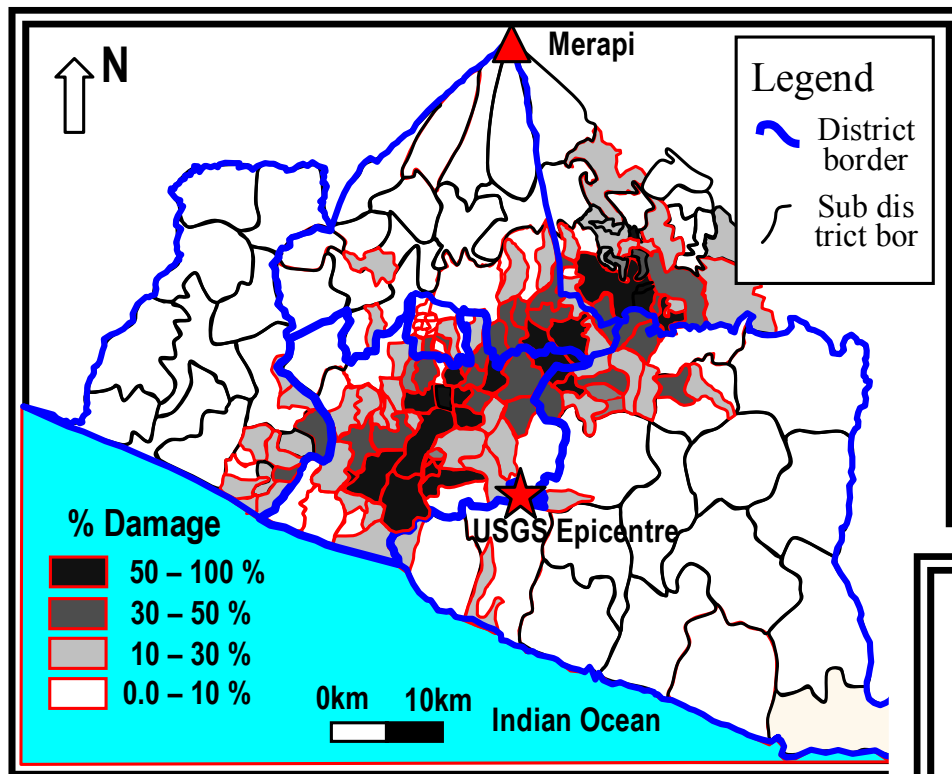
Isoseismal gempa Yogyakarta 2006

Siapa yg tertarik dng Volcanic Intensity ?

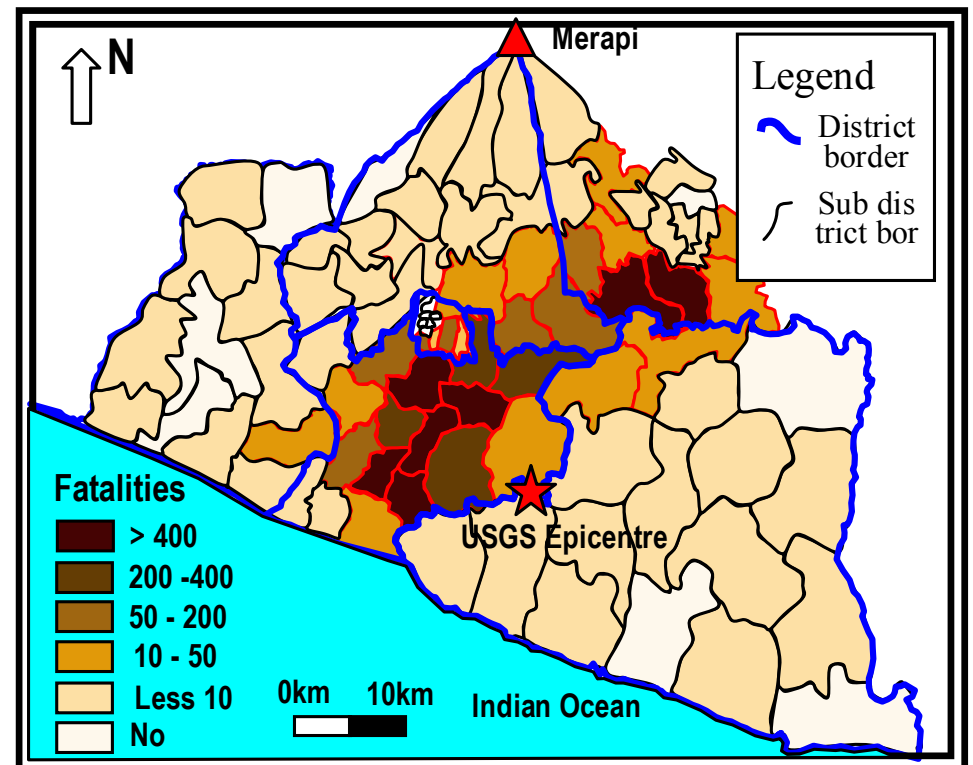




The spatial ground acceleration map of the 27th May 2006 Yogyakarta earthquake (Upper bound). The max. PGA is 0.52 g (Widodo.2018) confirm to Elnashai et al.(2006) prediction.



Verifikasi hasil



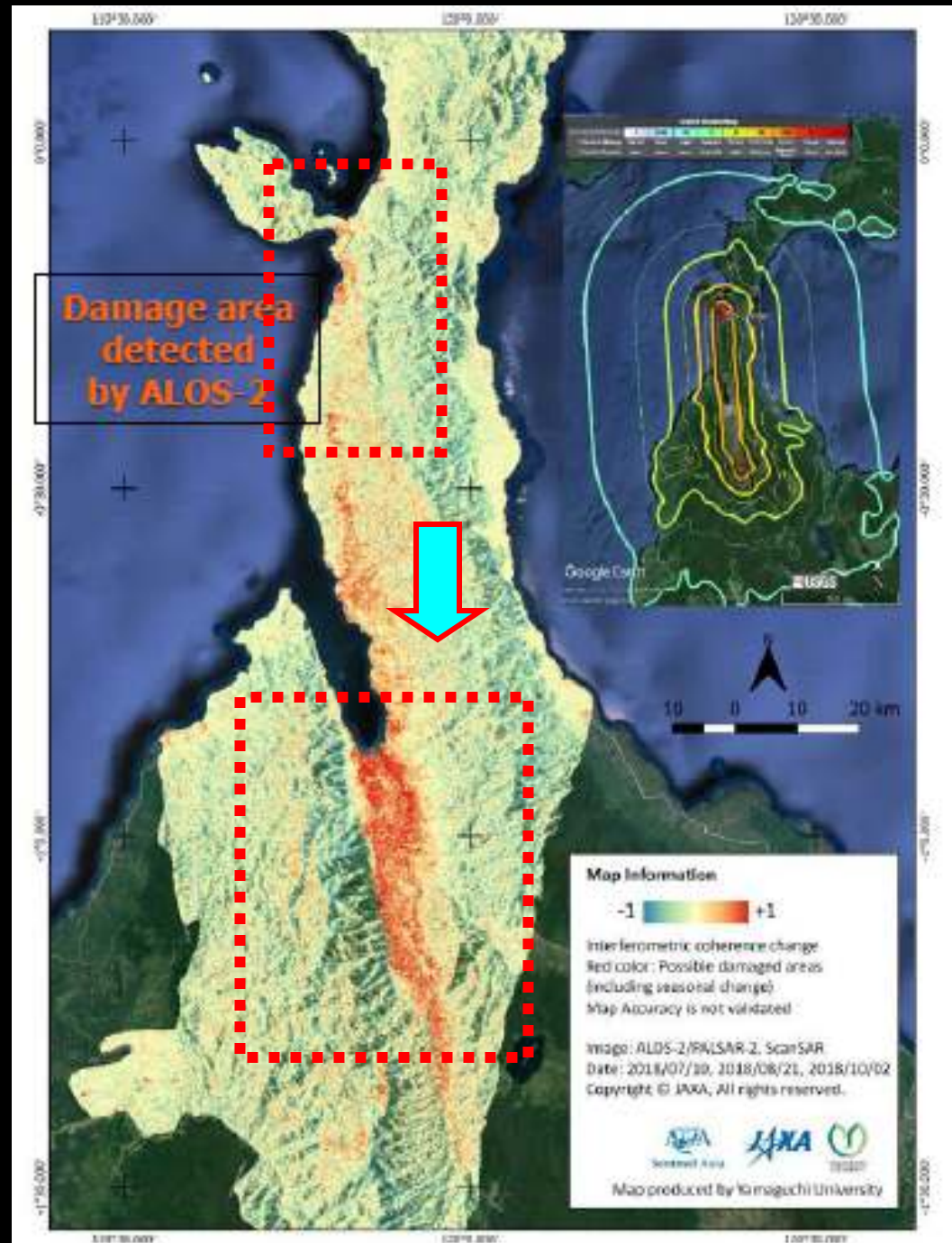
Verifikasi hasil

Representasi yang senada untuk gempa Palu sangat penting dan ditunggu

Indikasi Site Effects

Penelitian untuk membuat
**Intensity Prediction Equation
(IPE)** di Palu sangat ditunggu

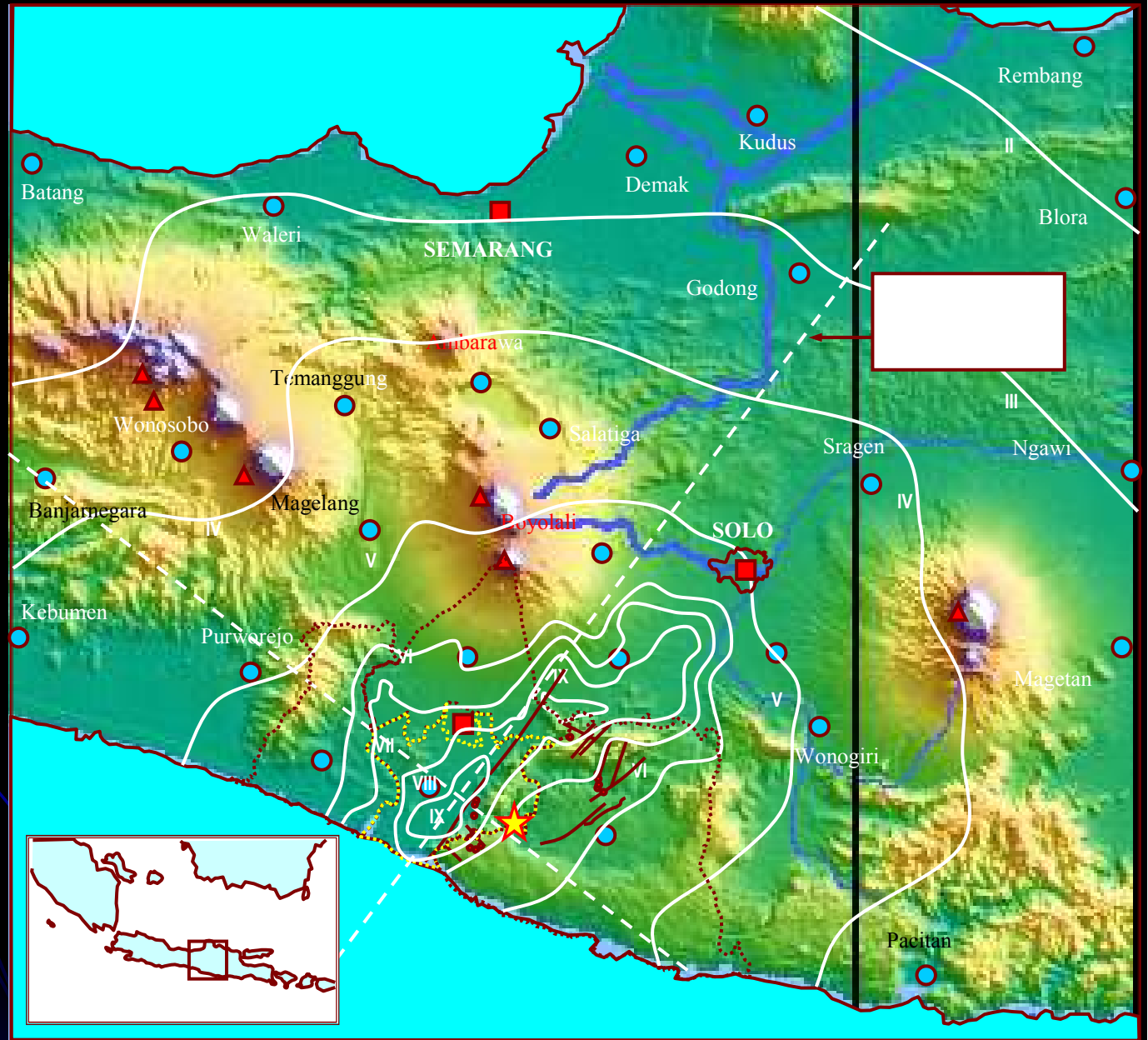
Lekkas dkk, 2018



3. Intensity Prediction Equation (IPE)

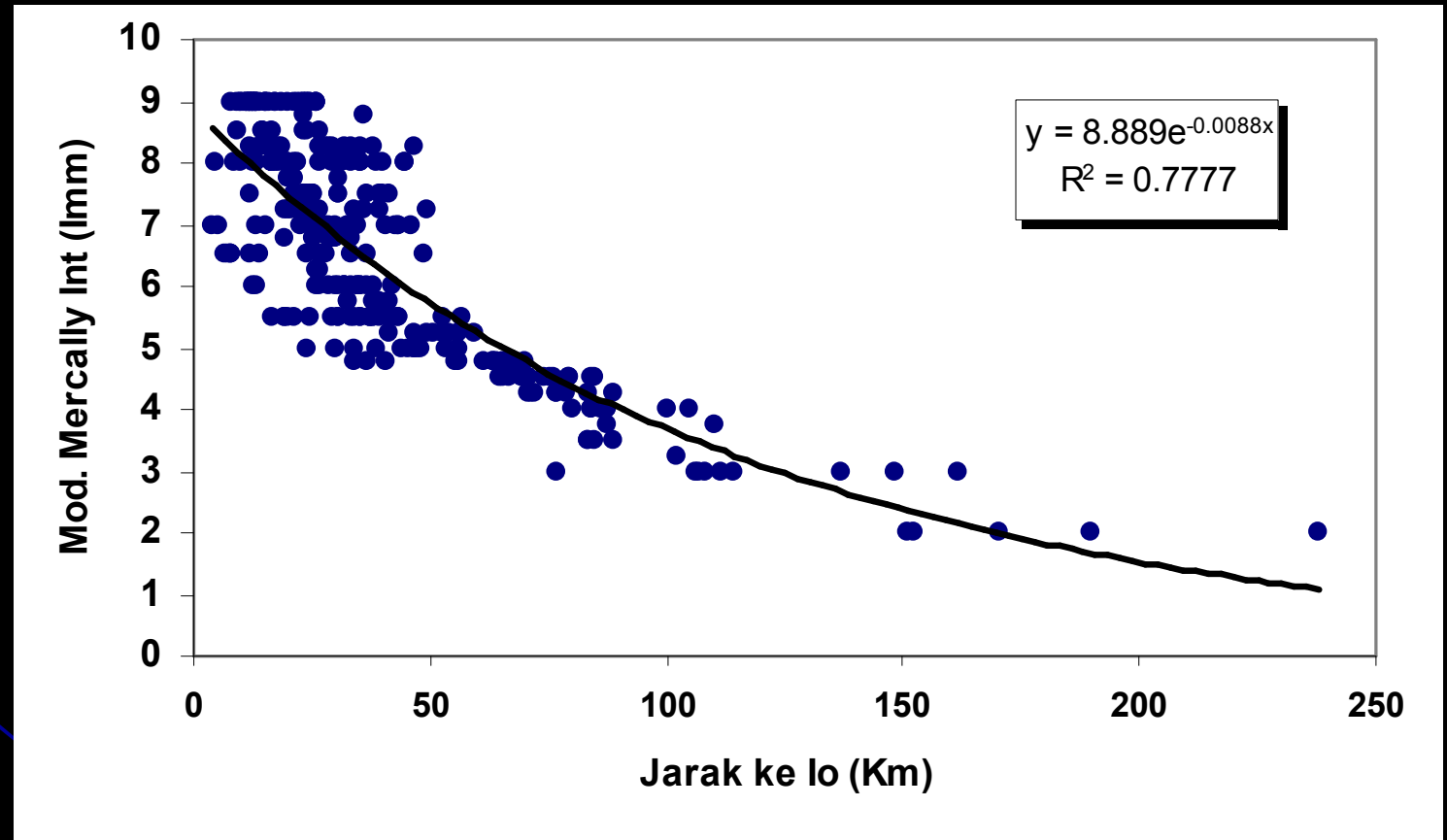
Wijaya, 2009

Site Effects sudah tampak, intensitas gempa maksimum lo tidak terjadi di daerah episenter



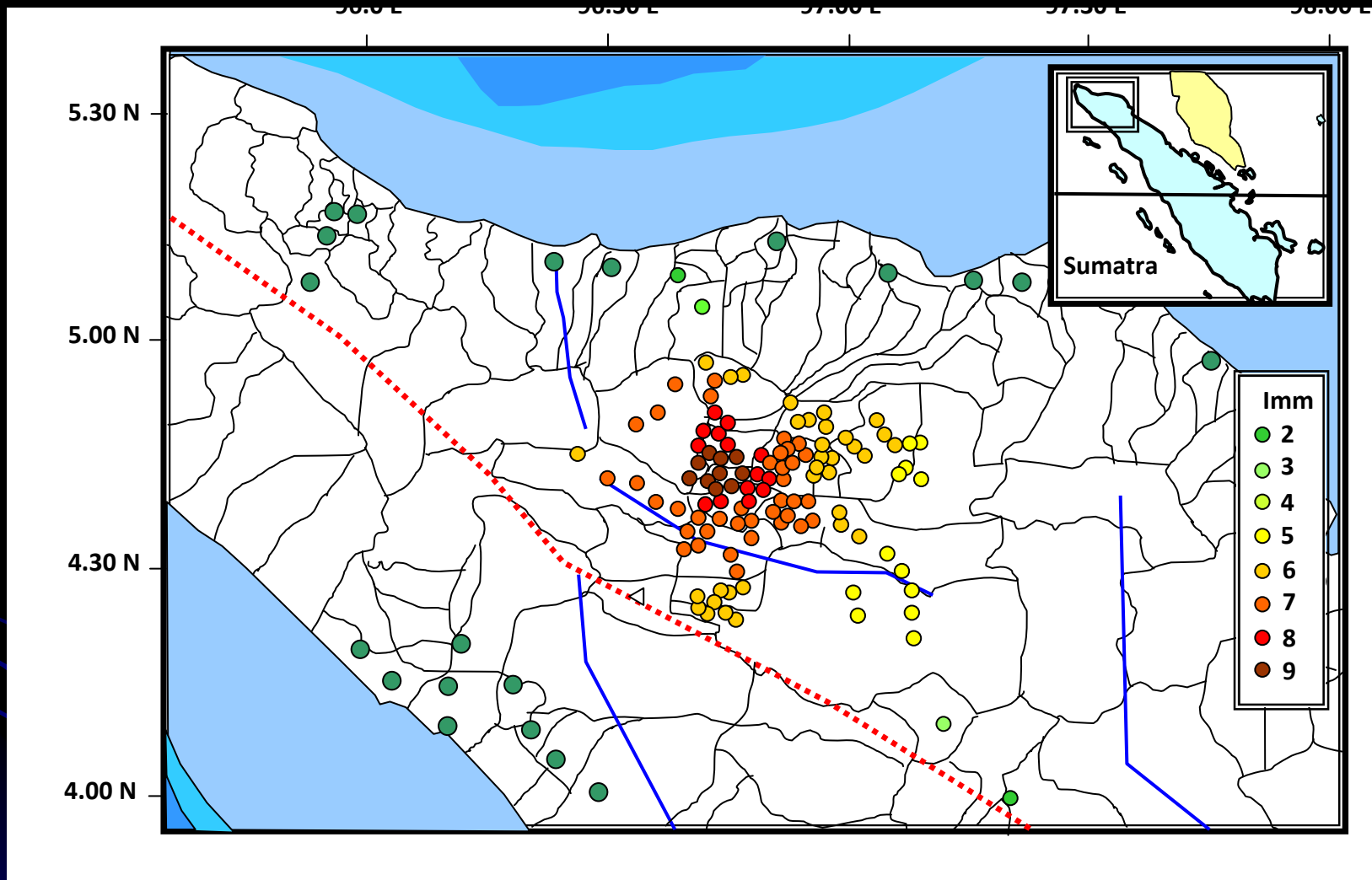
Intensity Prediction Equation (IPE) Gempa Yogyakarta (Wijaya, 2009)

Gempa
Yogyakarta
M6.3, 27 Mei
2006

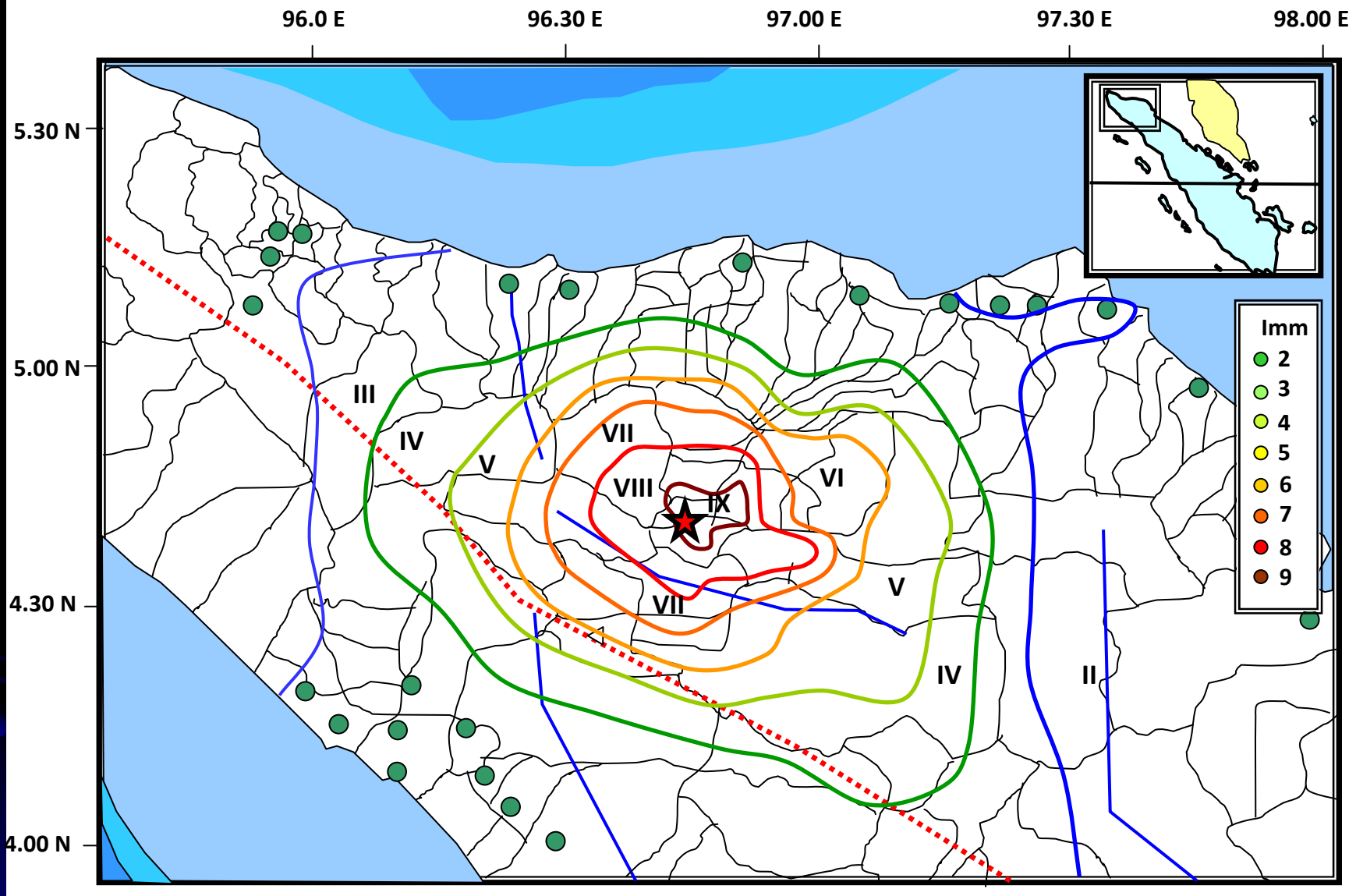


Salah satu hasil: Hubungan antara jarak dengan Intensitas Gempa Imm (Wijaya, 2009) yang merupakan fungsi **eksponensial**

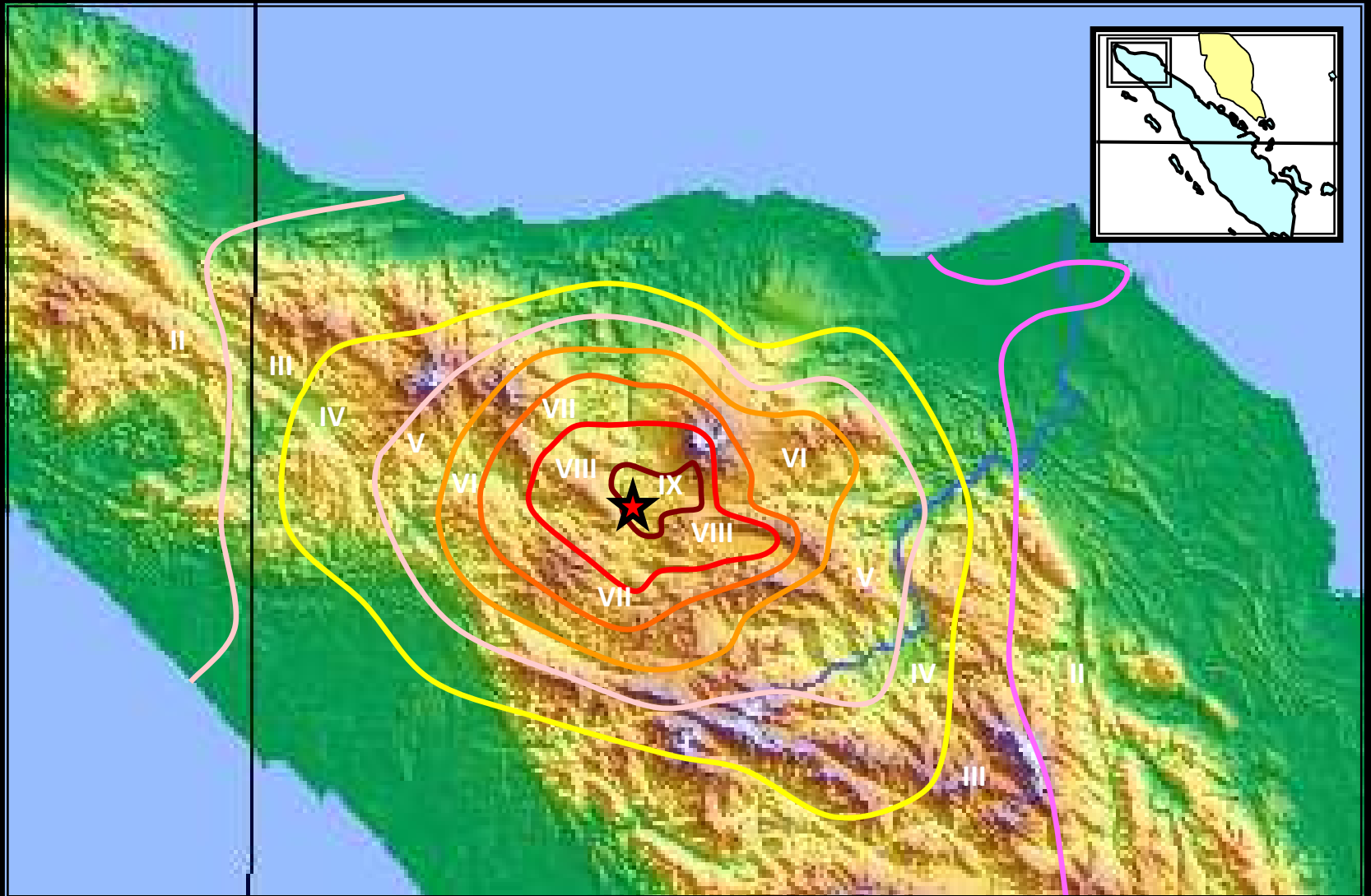
Intensitas Gempa Bener Meriah (Rafshanjani,2015)



Gempa Bener Meriah M6.1, 2 Juli 2013 dengan mekanisme gempa Left-lateral strike-slip (Gunawan dkk, 2018), Depth 10 km, 18000 rumah roboh dan korban manusia 43 orang.

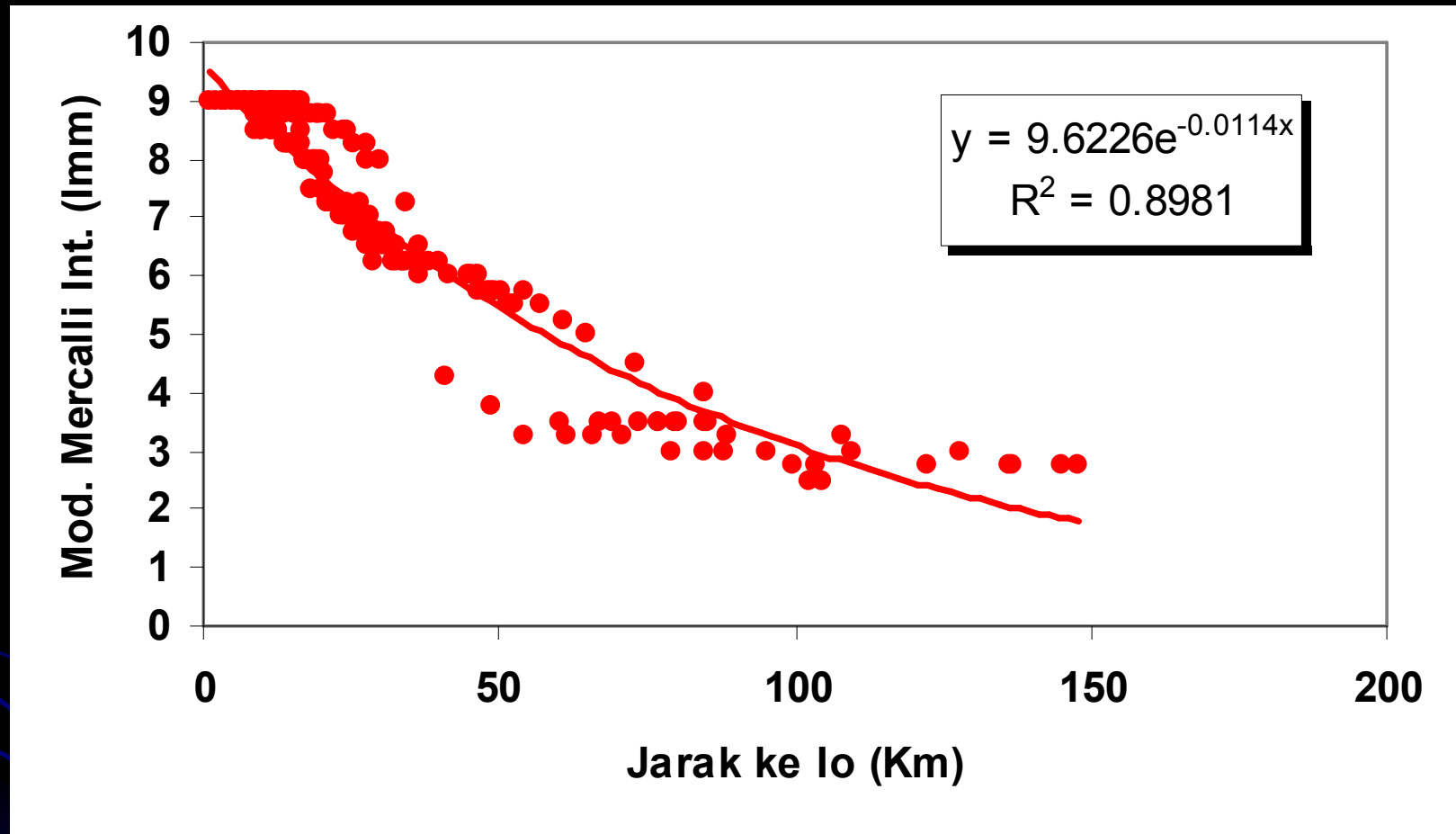


Isosiemal hasil penelitian (Rafshanjani, 2013). Tampak bahwa Iloseismal mendekati bentuk lingkaran



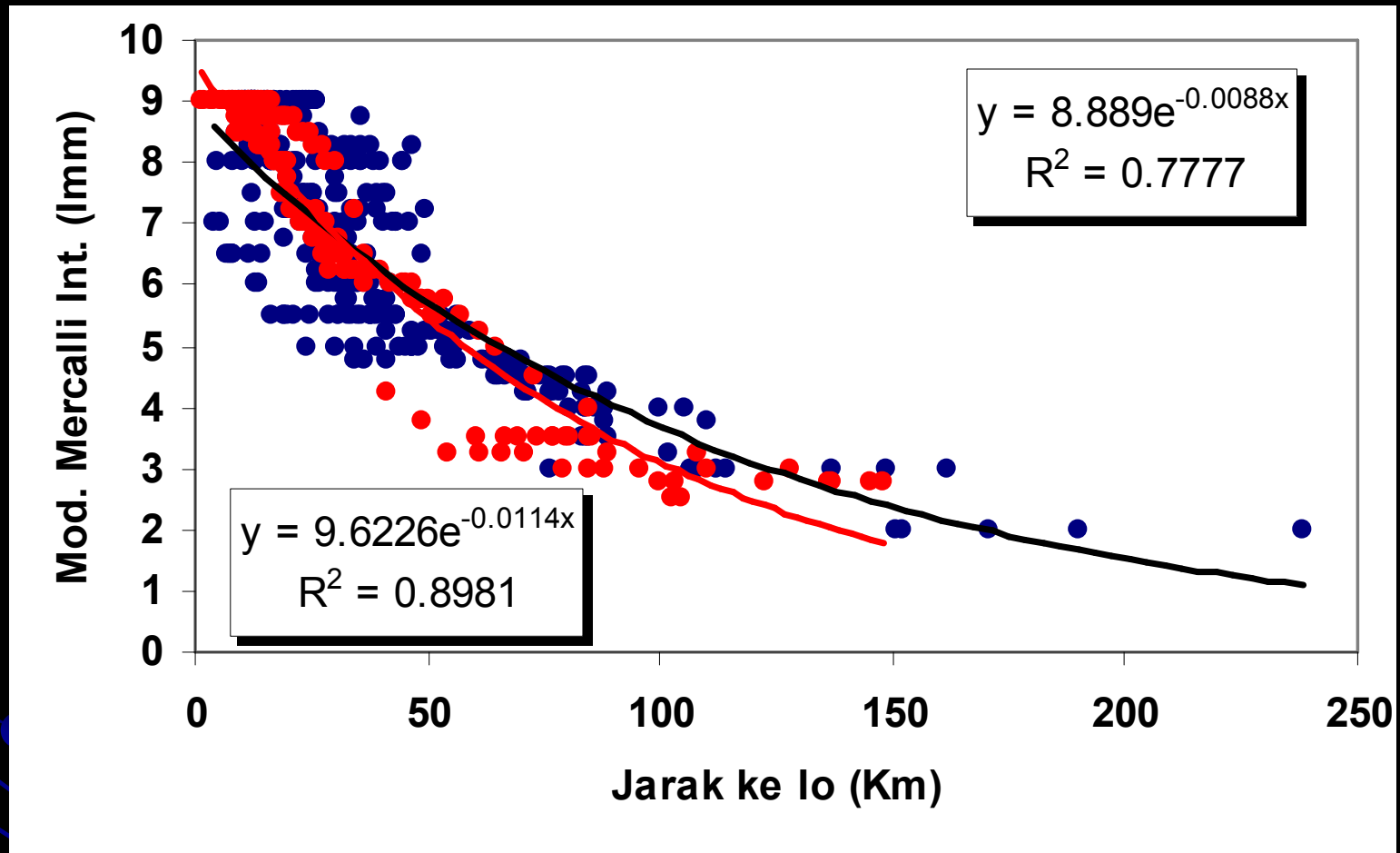
- Gempa terjadi pada daerah dataran tinggi/pengunungan yang secara umum merupakan tanah keras.
- Akibat dari tanah/batuan di site, maka kondisi tersebut akan berpengaruh terhadap kemampuan tanah/batuan untuk menyerap energi gempa

Intensity Prediction Equation (IPE) gempa Bener Meriah 2013



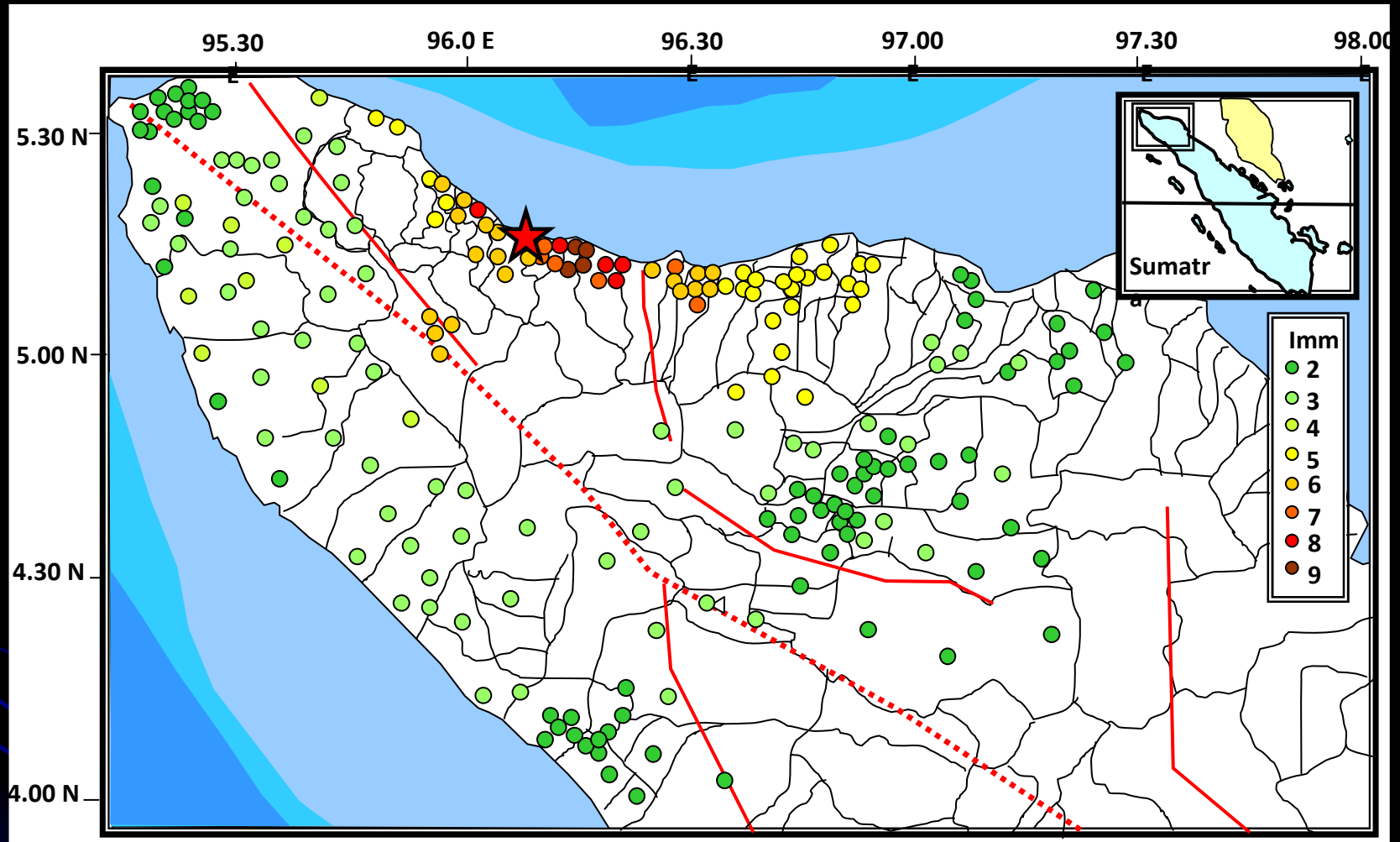
Hubungan antara jarak dari dari Io (Km) dengan Modified Mercalli Intensity (Imm). Atenuasi intensitas gempa yang diperoleh juga berpola fungsi **eksponensial (Rafsanjani, 2015)**

Perbandingan IPE gempa Yogyakarta 2006 dan Bener Meriah 2013

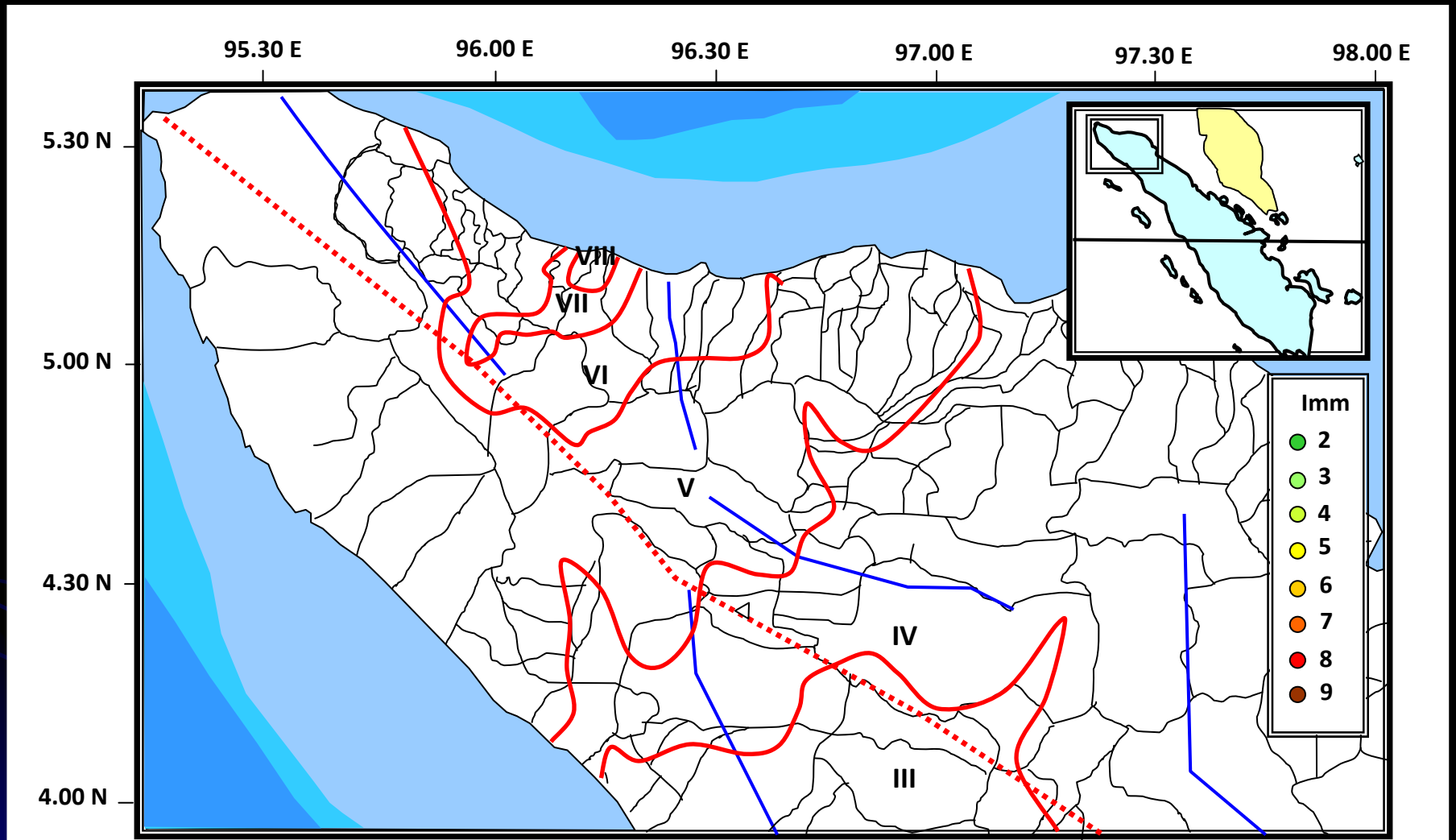


- Perbandingan Atenuasi Intensitas, gempa Yogyakarta (2006) dan Gempa Meriah Bener (2013)
- Tampak bahwa Intensitas gempa Meriah Bener (2013) beratenuasi lebih cepat daripada Gempa Yogyakarta (2006)

Intensitas Gempa Pidie Jaya (Chairunissa,2020)



- Gempa Pidie Jaya M6.5, 7 Desember 2016 mengakibatkan lebih dari 3000 rumah roboh dan korban manusia lebih dari 100 orang (Muzli dkk, 2018)
- Mekanisme gempa left-lateral strika-slip. Kerusakan terjadi disepanjang pantai karena merupakan tanah endapan yang berakibat amplifikasi (Muzli dkk, 2018)

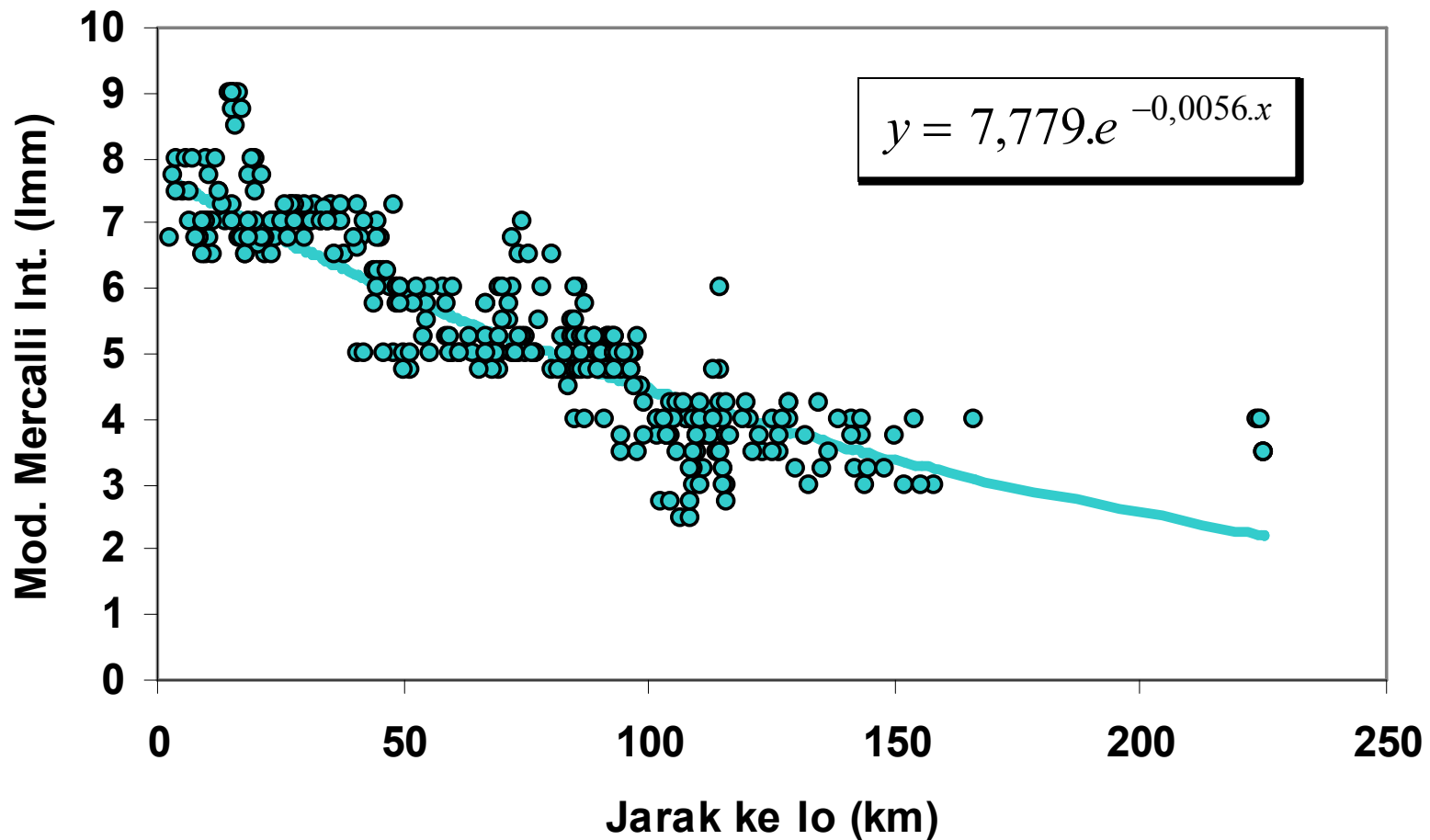


Isoseismal gempa Pidie Jaya, 7 Desember 2018 (Chairunissa, 2020). Kerusakan yang terjadi lebih banyak terjadi sepanjang pantai.



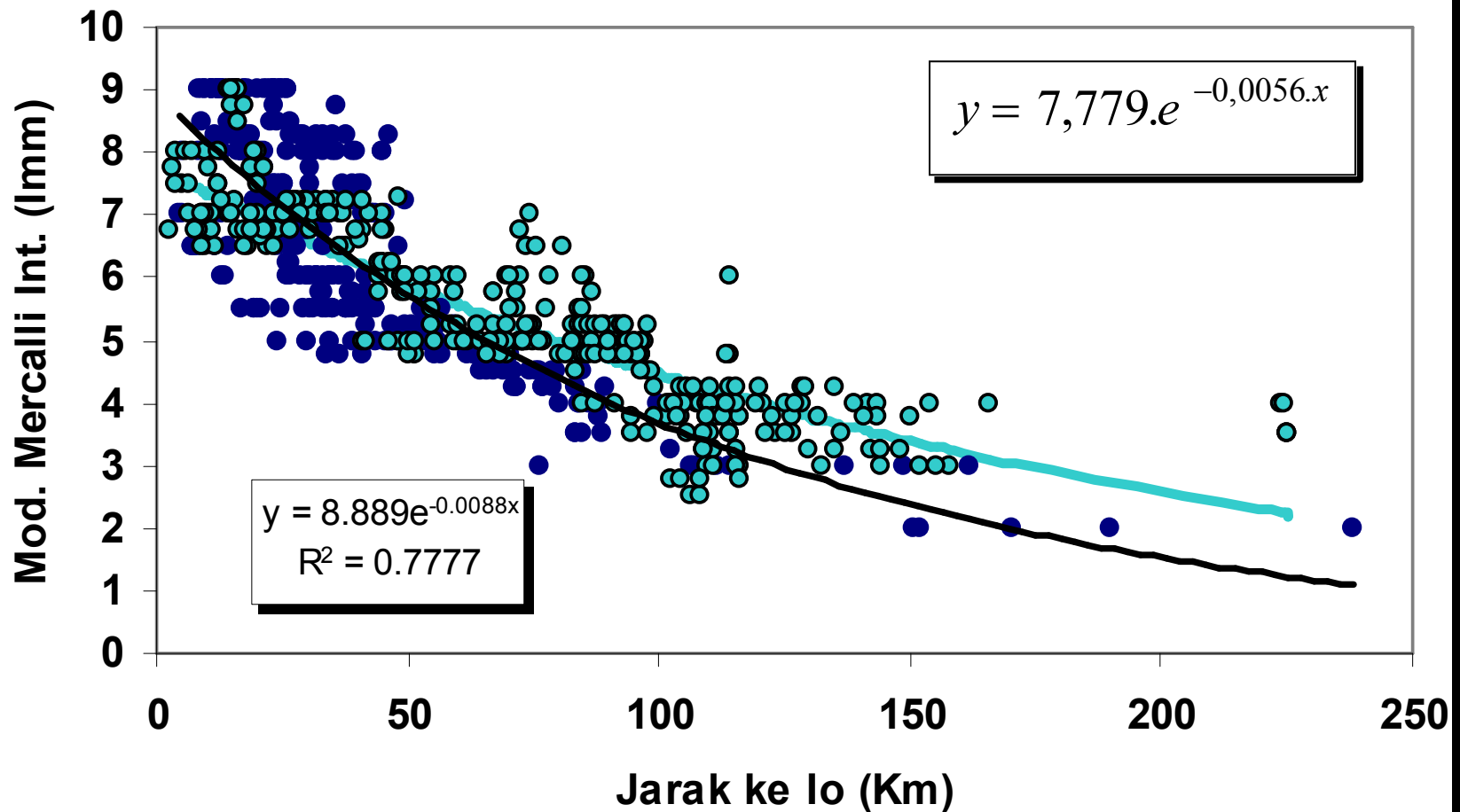
- Tampak bahwa tanah endapan terdapat disepanjang pantai, dimana kerusakan terjadi
- Kondisi tersebut akan berpengaruh terhadap atenuasi intensitas gempa.

Intensity Prediction Equation (IPE) gempa Pidie Jaya, 2016



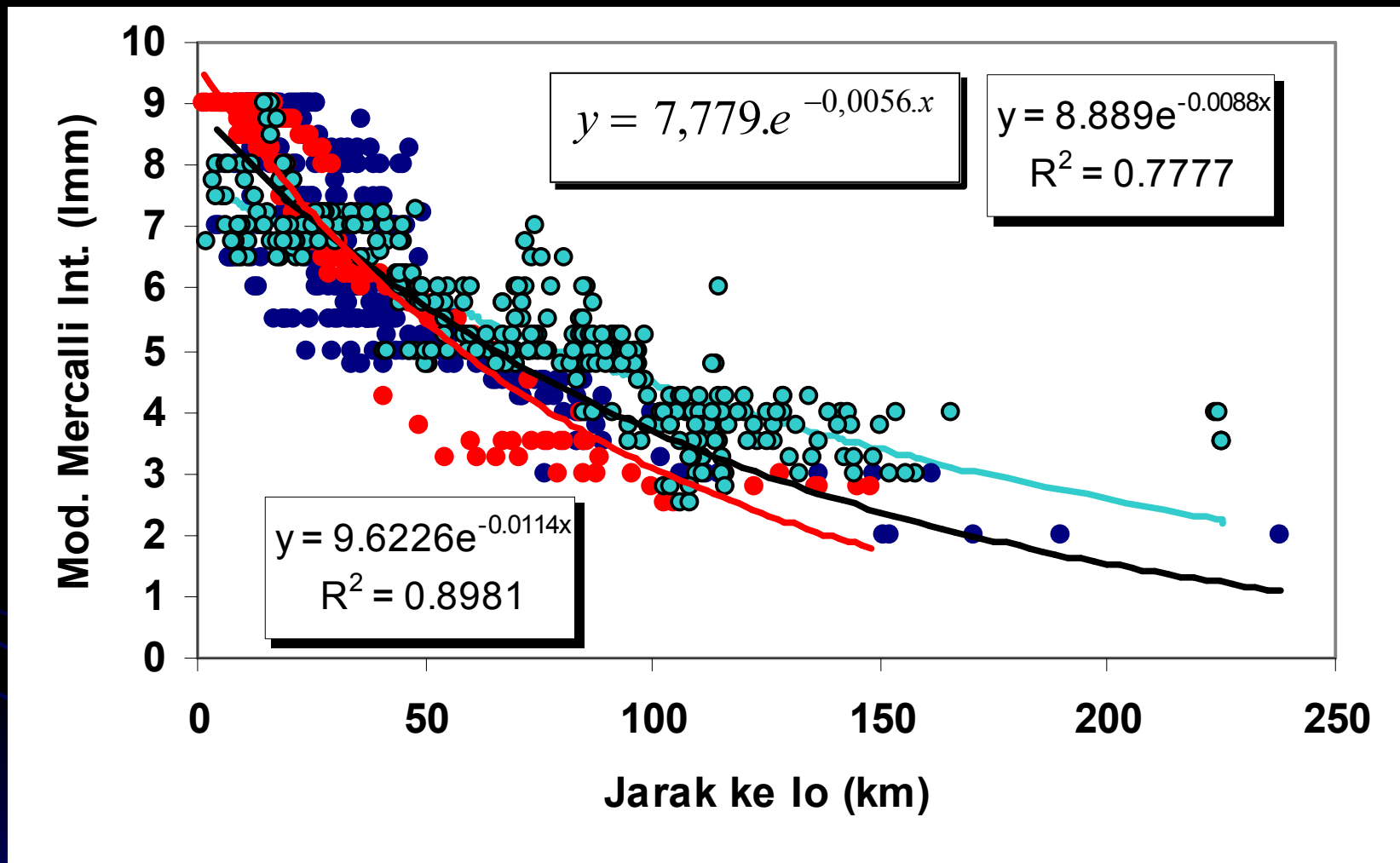
- Atenuasi intensitas gempa, gempa Pidie Jaya 7 Desember 2018. Senada dengan hasil-2 sebelumnya, fungsi atenuasi intensitas gempa yang dimaksud juga berpola **eksponensial (Chairunissa, 2020)**

Perbandingan IPE gempa Yogyakarta 2006 dan Pidie Jaya 2016



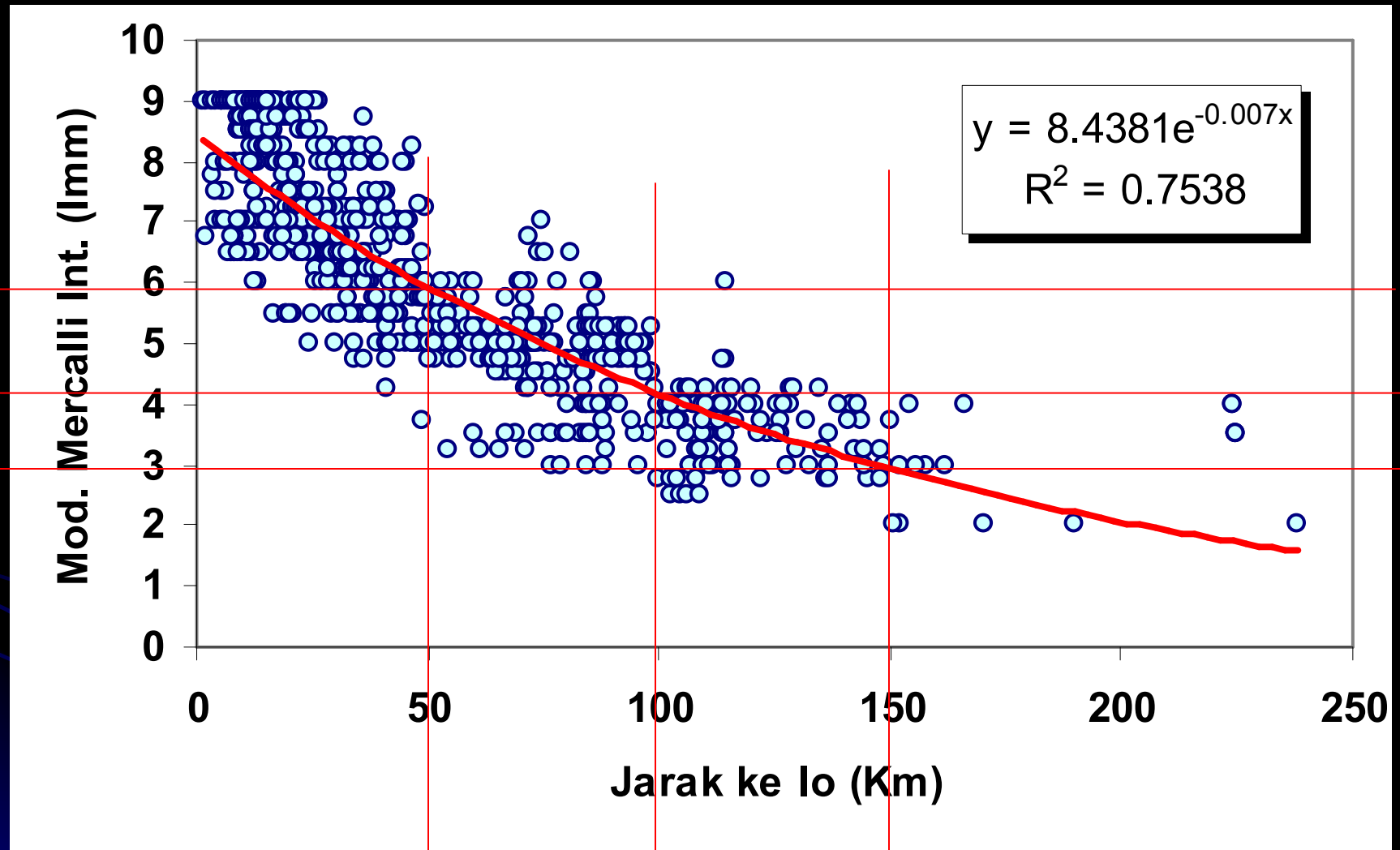
Intensitas gempa gempa Pidie Jaya (2016) Jaya beratenuasi lebih lambat dibanding dengan gempa Yogyakarta (2006)

Perbandingan Atenuasi Intensitas Gempa Dangkal



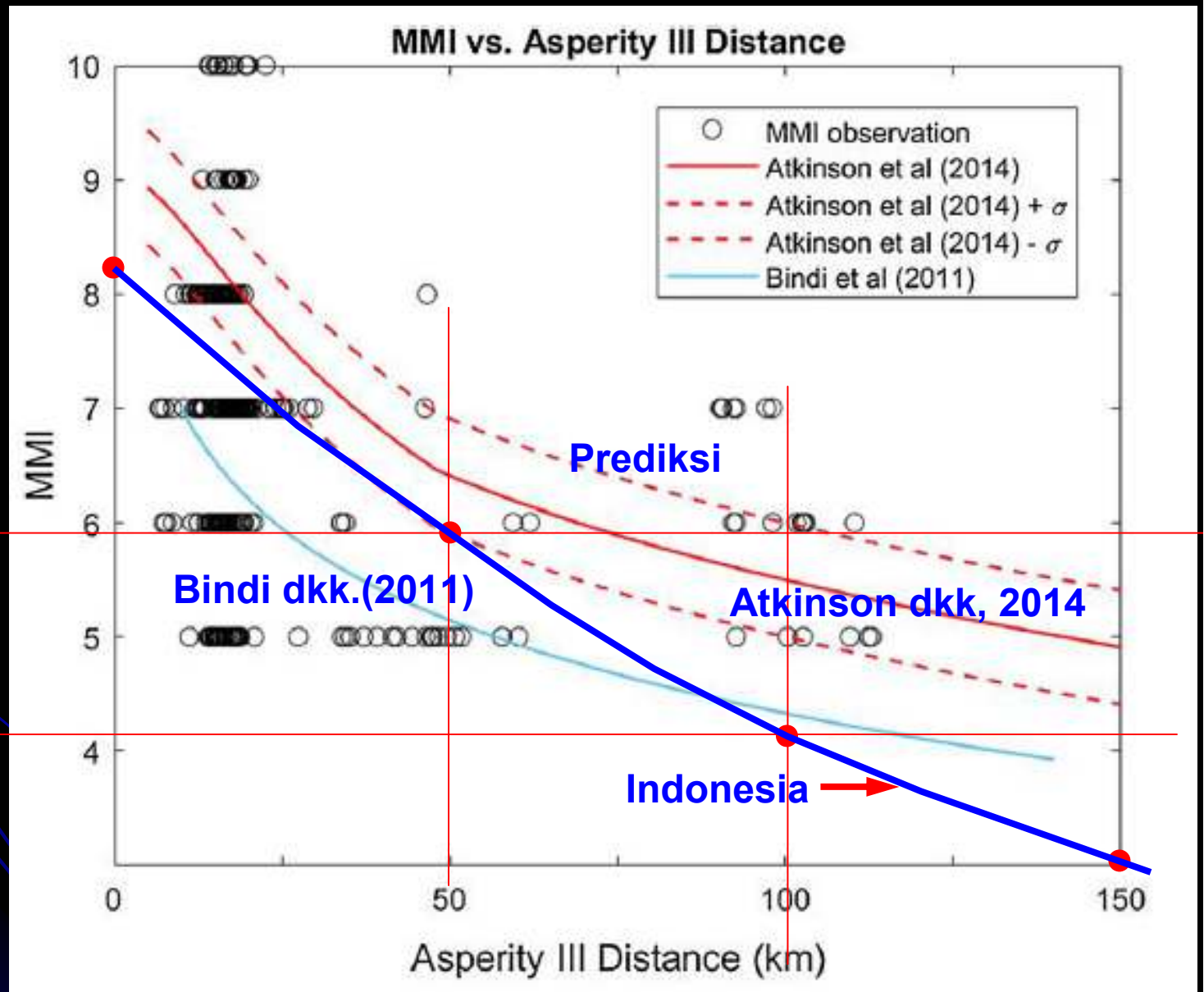
- Perbandingan Atenuasi Intensitas gempa : a) Gempa Yogyakarta (2006); b) gempa Bener Meriah (2013) dan c) Gempa Oidie Jaya (2016)
- Atenuasi Intensitas gempa Yogyakarta (2006) tampak moderat diantara

Gabungan Intensity Prediction Equation (IPE)



Atenuasi Intensitas gempa gabungan : a) Gempa Yogyakarta (2006);
b) gempa Bener Meriah (2013) dan c) Gempa Oidie Jaya (2016)

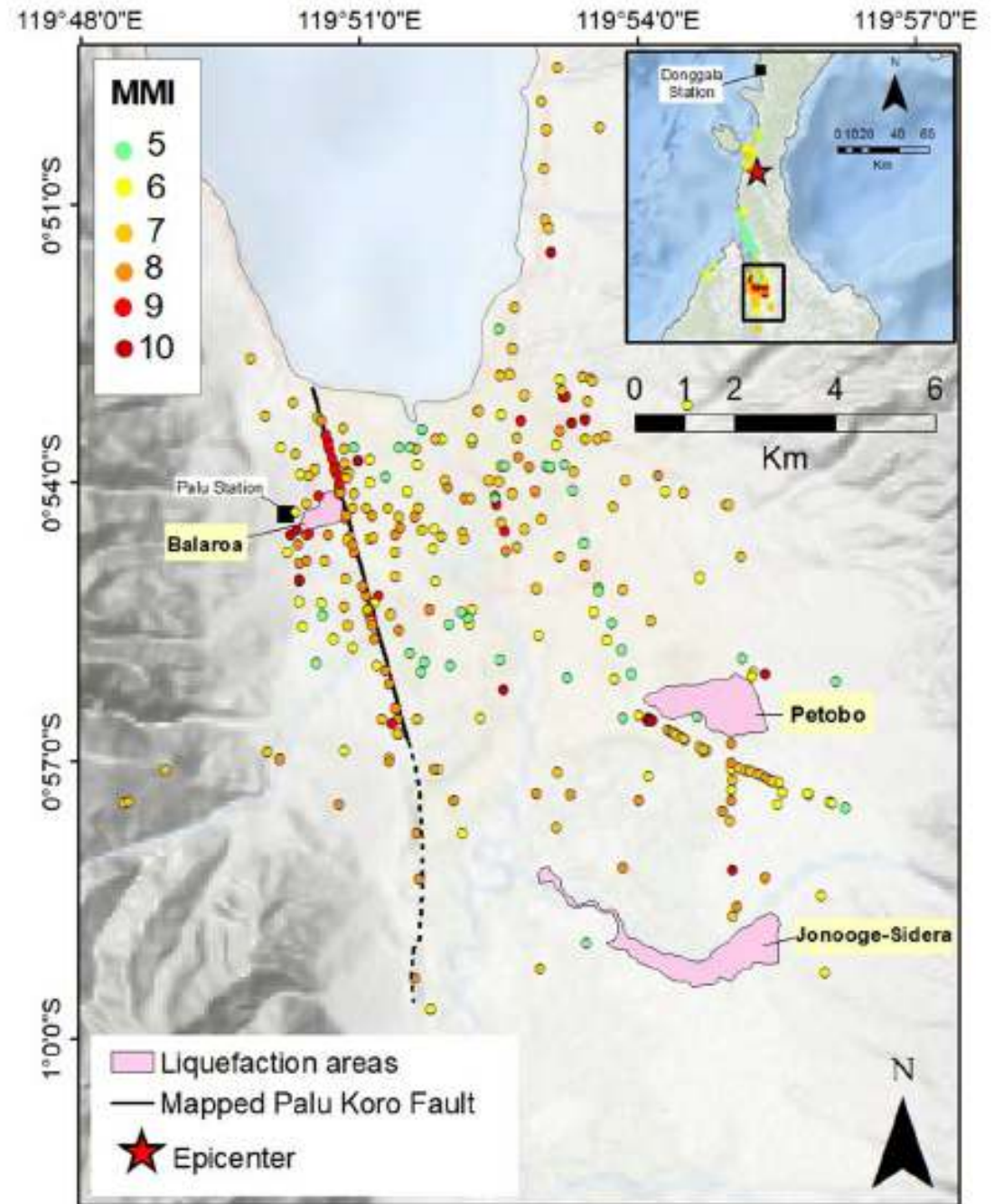
Perbandingan Intensity Prediction Equation (IPE)



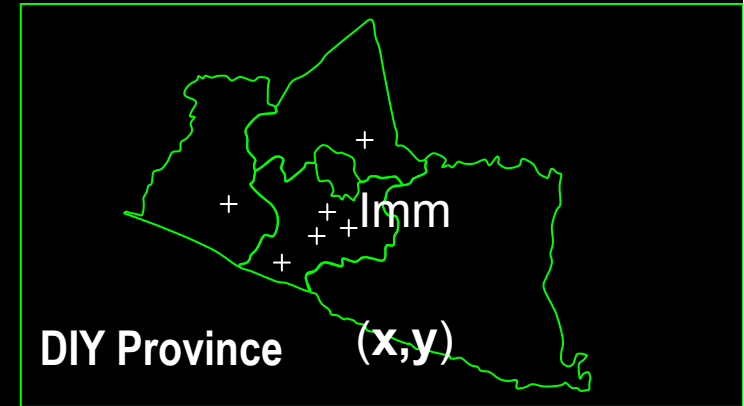
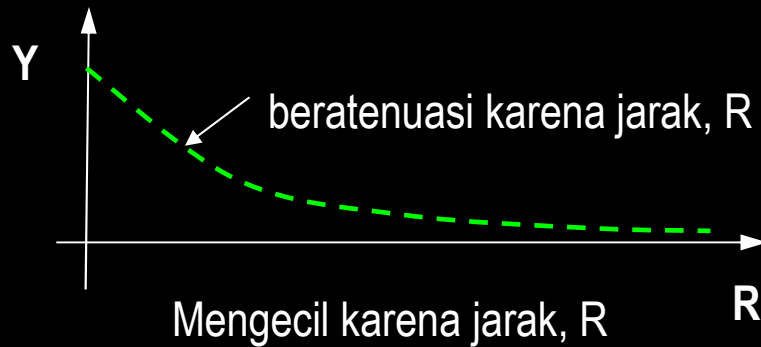
IPE gabungan beratenuasi lebih cepat dari prediksi-2

Intensitas Gempa Palu

Cilia dkk. (2021)



4. Ground Motion Prediction Equation (GMPE)



$$\ln A = a + bM - \ln R + c \cdot R_{ij}$$

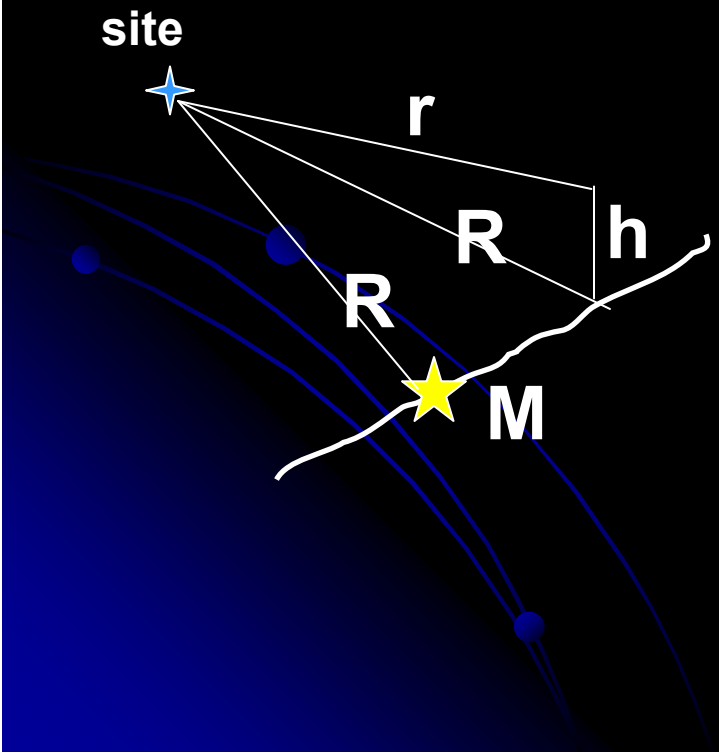
$$\ln A + \ln R = a + b \cdot M + c \cdot R_{ij}$$

$$y = a + b \cdot M + c \cdot R_{ij}$$

$$\begin{bmatrix} 1 & M_1 & R_1 \\ 1 & M_2 & R_2 \\ 1 & M_3 & R_3 \\ \dots & \dots & \dots \\ 1 & M_n & R_n \end{bmatrix} \begin{Bmatrix} a \\ b \\ c \end{Bmatrix} = \begin{Bmatrix} y_1 \\ y_2 \\ y_3 \\ \dots \\ y_n \end{Bmatrix}$$

Pers. simultan

Nilai a,b,c dapat dicari



Ground motion prediction equations 1964–2021

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<https://www.strath.ac.uk>

Thursday 31st

GMPE di beberapa Negara

Ground-Motion Prediction Equations for Subduction Slab Earthquakes in Japan Using Site Class and Simple Geometric Attenuation Functions

by John X. Zhao, Fei Jiang, Pan Shi, Hao Xing, Haifeng Huang, Ruibin Hou, Yingbin Zhang, Pengcheng Yu, Xiaowen Lan, David A. Rhoades, Paul G. Somerville, Kojiro Irikura, and Yoshimitsu Fukushima

Ground motion prediction equation for crustal earthquakes in Taiwan

Van-Bang Phung^{1,2}, Chin Hsiung Loh¹, S Brian SJ Chiou⁴, and Bor-Shouh Huang²

Ground motion prediction equation for north India, applicable for different site classes

September 2020 · *Soil Dynamics and Earthquake Engineering* 139(106425):1-12

DOI: [10.1016/j.soildyn.2020.106425](https://doi.org/10.1016/j.soildyn.2020.106425)

Lab: [Abhishek Kumar's Lab](#)

The first peak ground motion attenuation relationships for North of Vietnam

Le Minh Nguyen^{a,d}, Ting-Li Lin^{a,f,*}, Yih-Min Wu^a, Bor-Shouh Huang^b, Chien-Hsin Chang^c, Win-Gee Huang^b, Tu Son Le^d, Quoc Cuong Nguyen^d, Van Toan Dinh^e

^a Department of Geosciences, National Taiwan University, Taipei 106, Taiwan

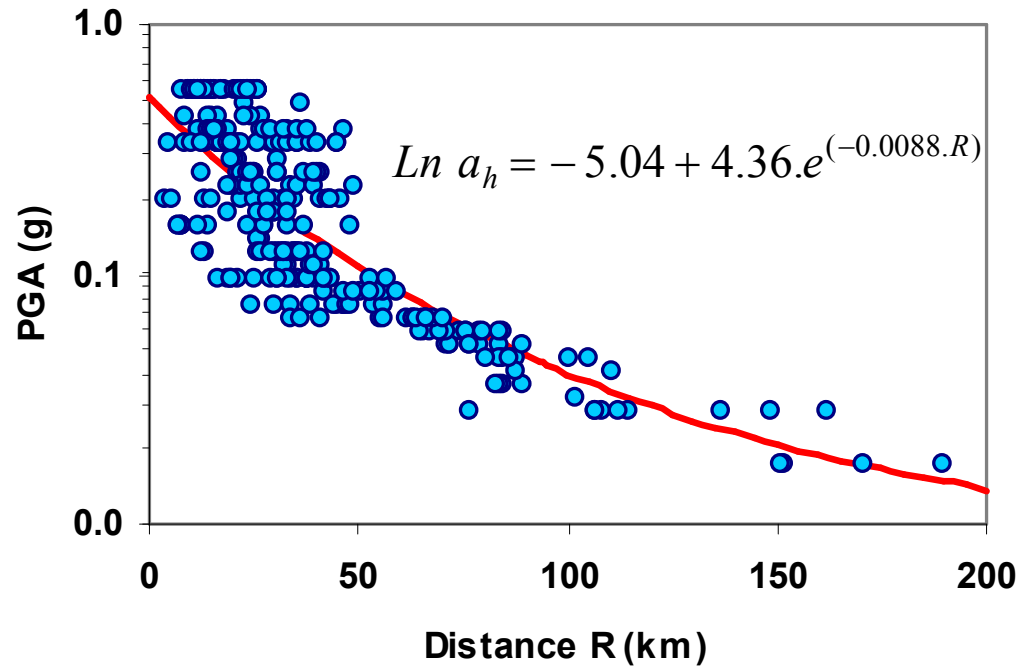
^b Institute of Earth Sciences, Academia Sinica, P.O. Box 1-55, Nankang, Taipei 115, Taiwan

^c Central Weather Bureau, Taipei 100, Taiwan

^d Institute of Geophysics, Vietnamese Academy of Science and Technology, Hanoi, Viet Nam

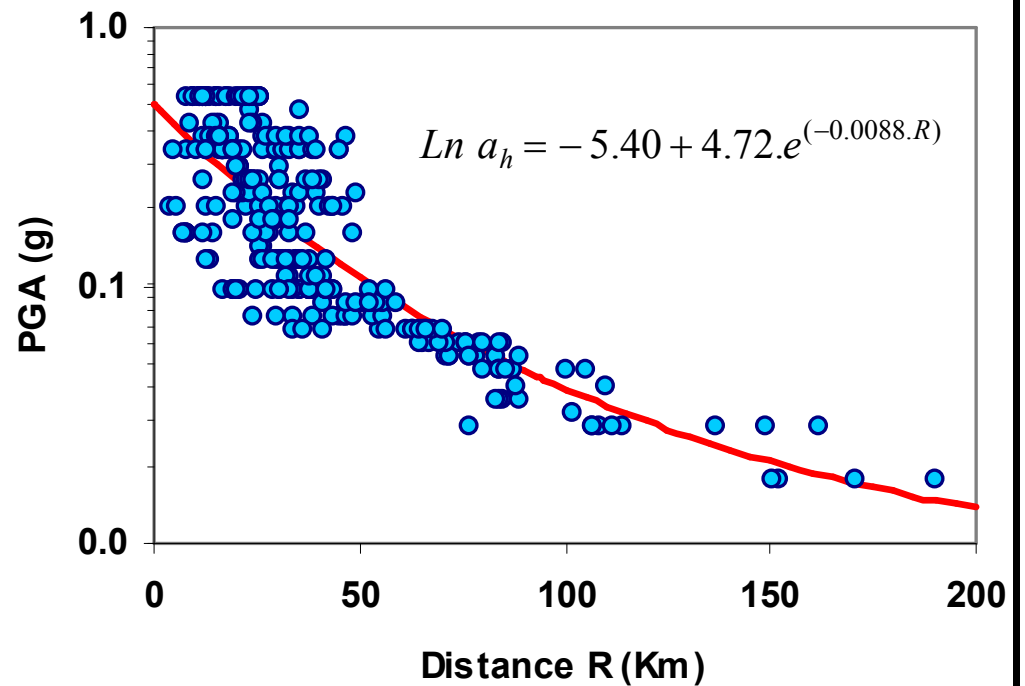
^e Institute of Geological Sciences, Vietnamese Academy of Science and Technology, Hanoi, Viet Nam

^f Department of Earth Sciences, National Cheng Kung University, Tainan 701, Taiwan



Apabila Atenuasi dan karakteristik tanah Yogyakarta dipakai sebagai wakil, maka setelah melalui proses analisis, atenuasi percepatan tanah adalah sebagai berikut (Widodo, 2018)

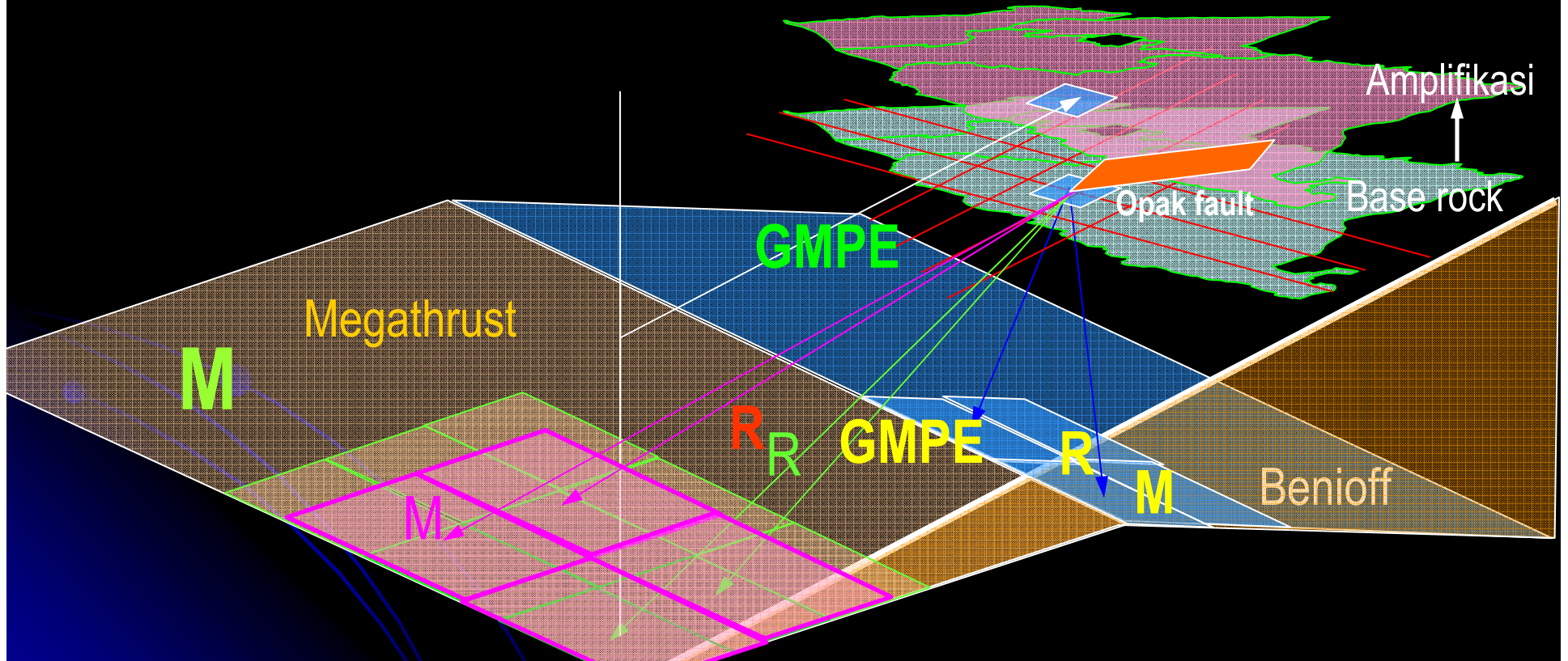
Berdasar Campbel dan Bozorgnia (2007)



Berdasar Akkar, Sandikkaya dan Bommer (2014)

5. Probabilistic Seismic Hazard Analysis, PSHA by Total Probability Theorem

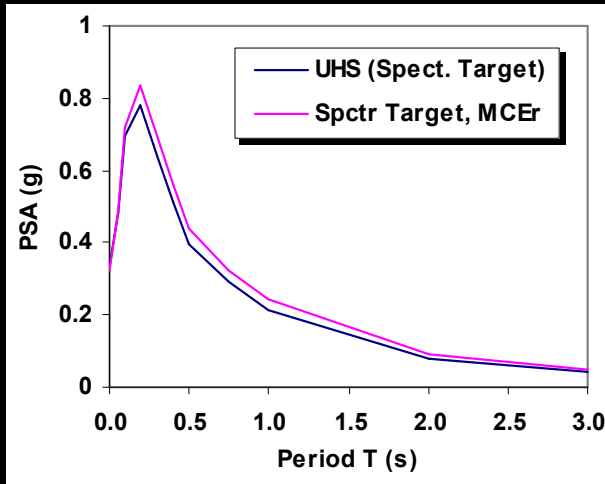
- GMPE merupakan salah satu komponen pokok pada Probabilistic Seismic Hazard Analysis, PSHA) by Total Probability Theorem



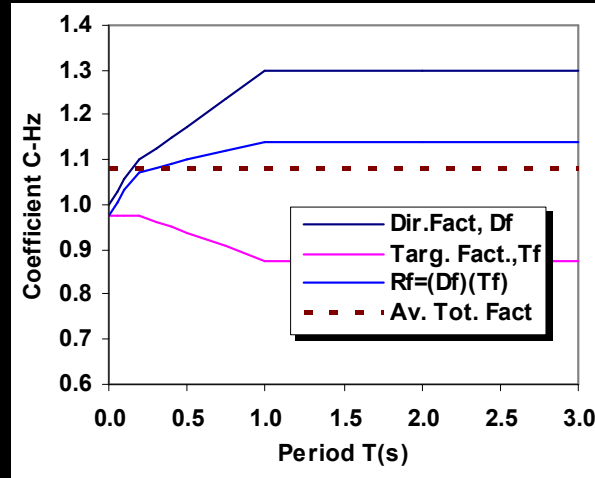
Tiling process in the PSHA **M**

$$\lambda(IM > x) = \sum_{i=1}^n v(M > m_{\min}) \iint P(IM > x | m, r) f_M(m) f_R(r) dr dm$$

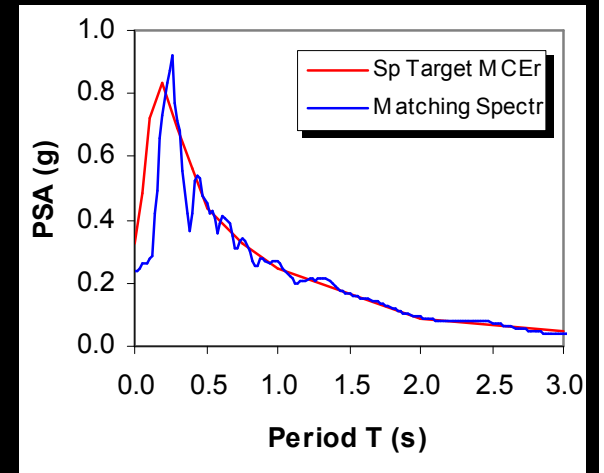
Site Response Analysis



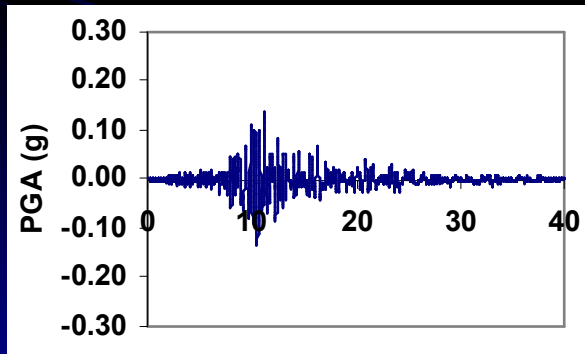
Spektra Target



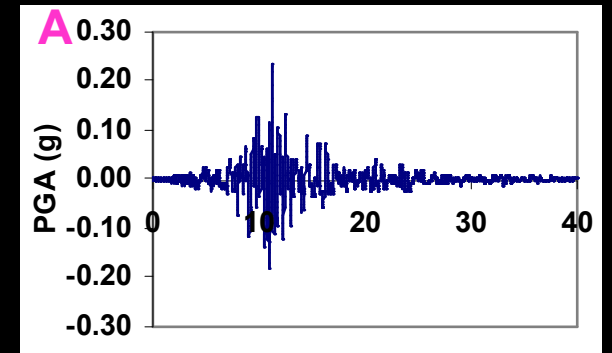
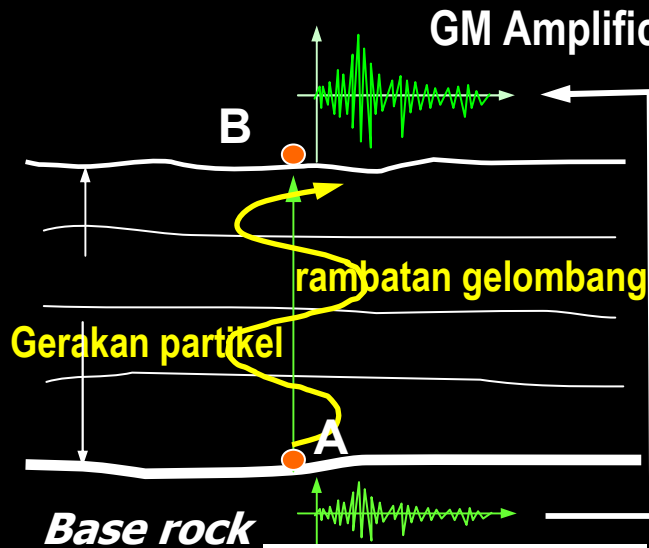
Risk Factor to MCEr



Matching Spectra

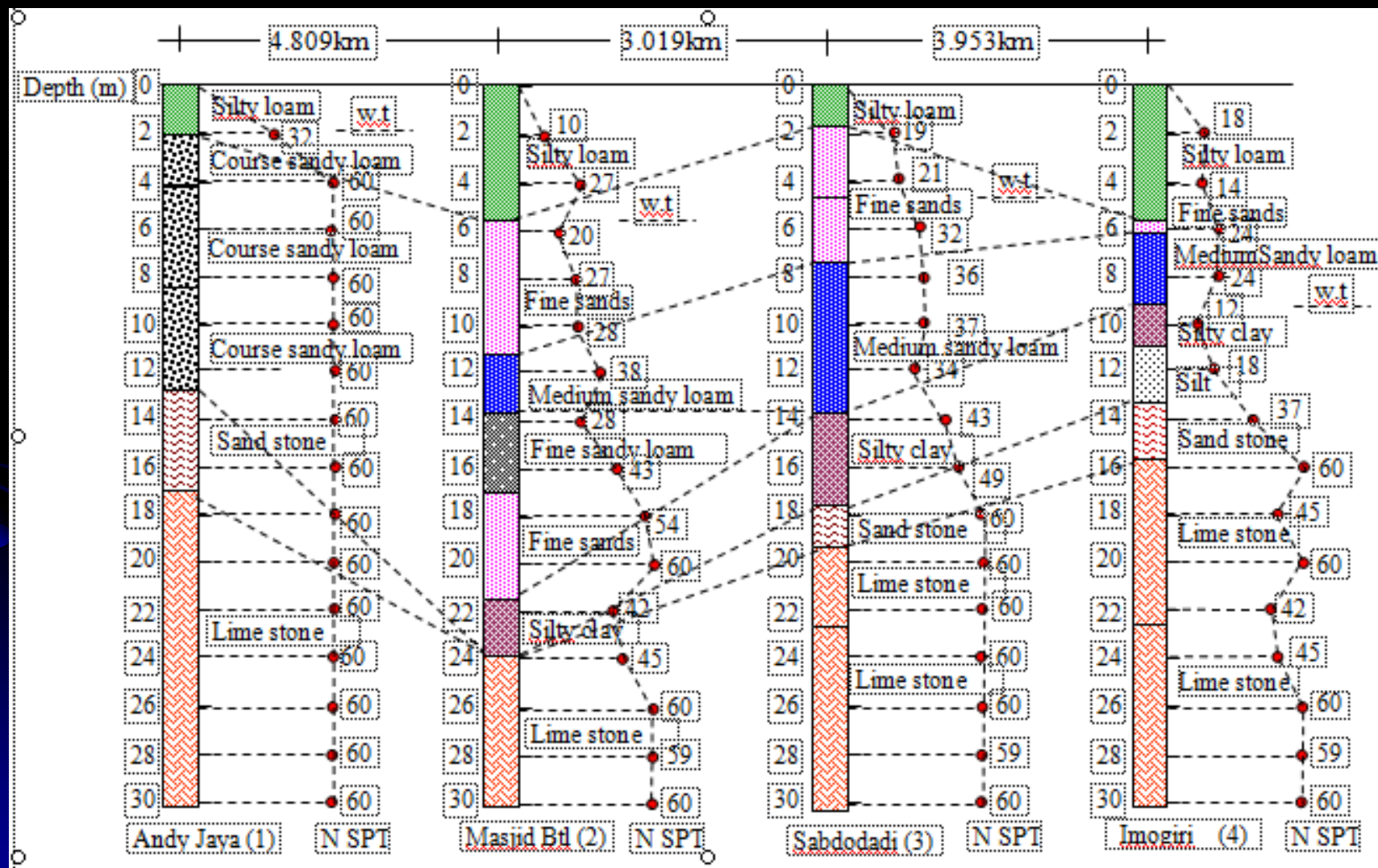


Original Accelerogram

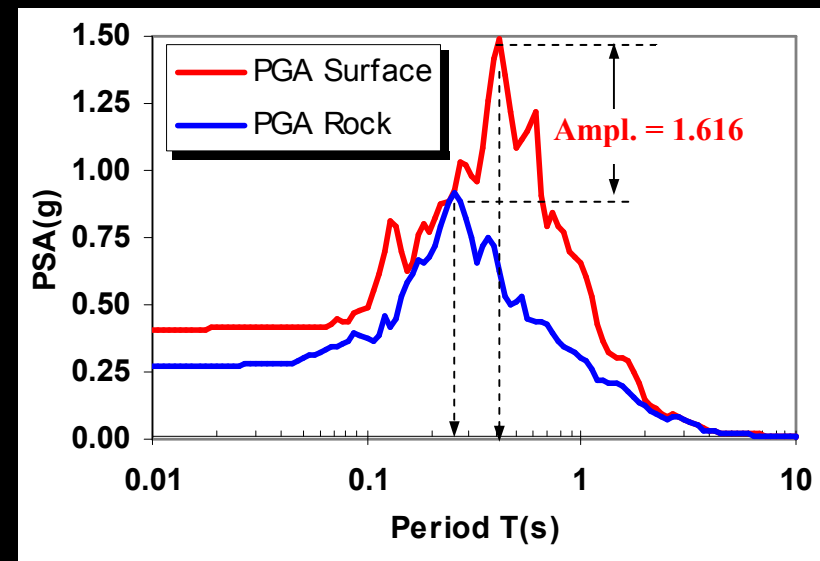
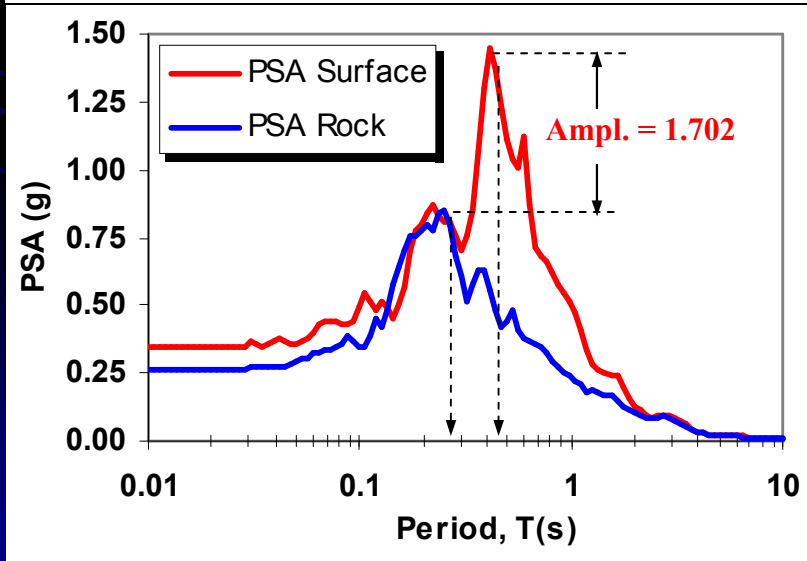
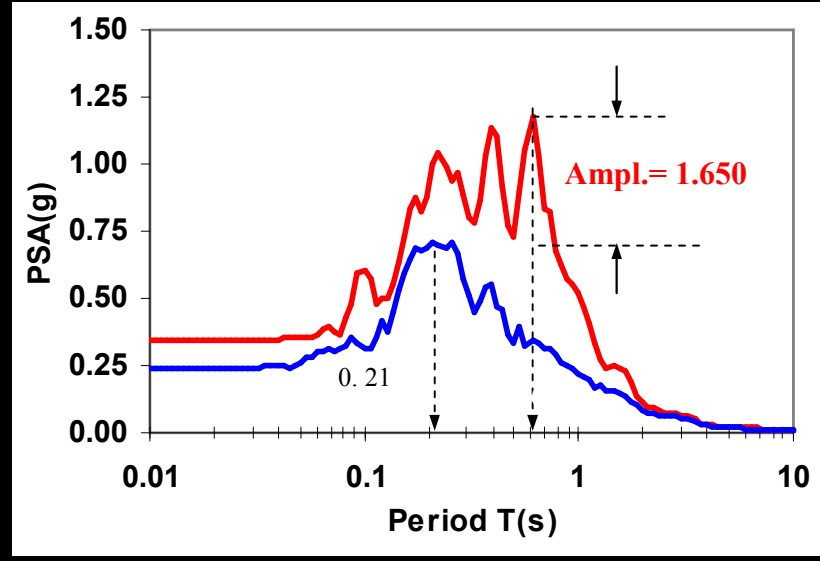
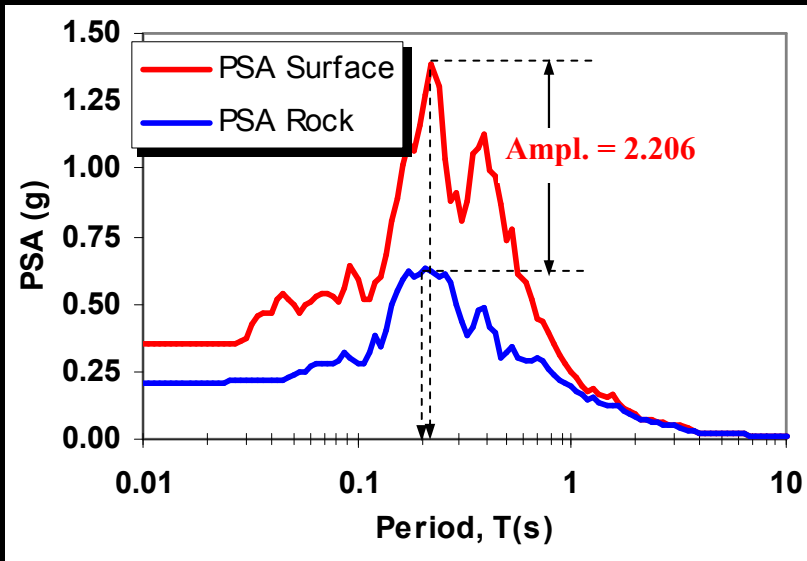


Matched Accelerogram

Soil Profile



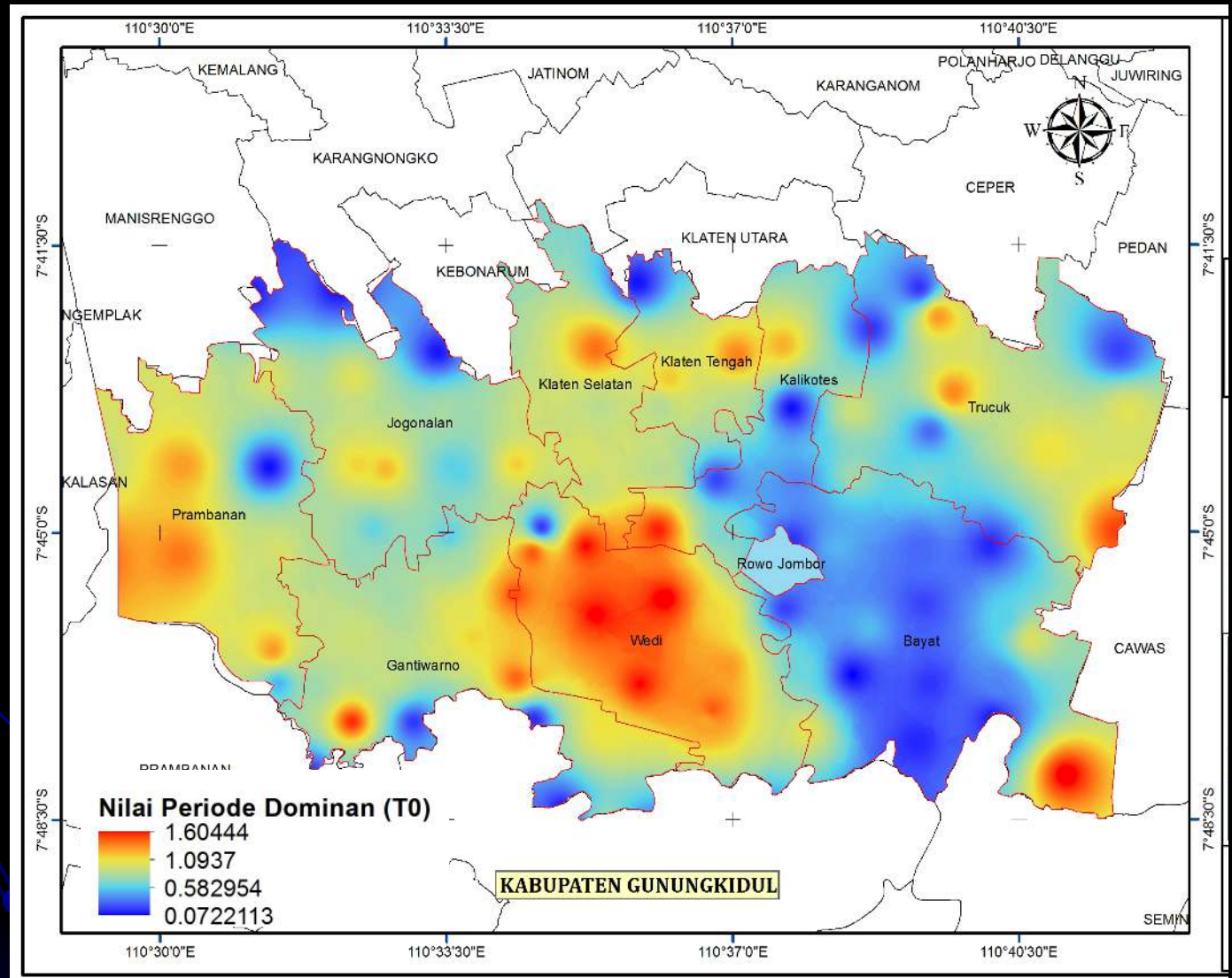
Amplifikasi Spektrum



6. Site Characteristics (HVSr Method)

Periode Getar Tanah Endapan T, Kab. Klaten Jateng (Arifudin,2019)

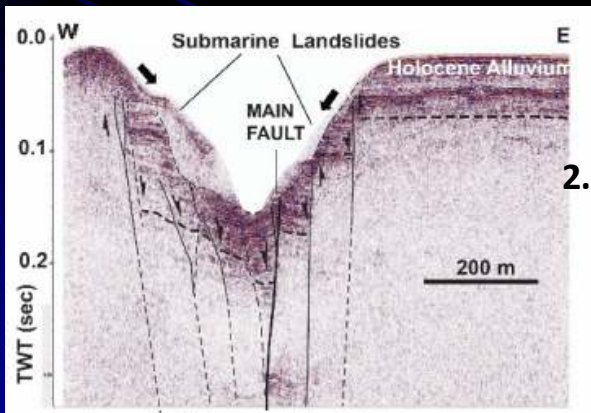
- 1.Site Frequency fo
- 2.Site Period, T
- 3.Site Class
- 4.Sedimentary Depth H
- 5.Sheer Wave Vel. Vs
- 6. Site Vulnerability Kg
- 7.Sheer Strain
- 8.Peak Ground Acc.



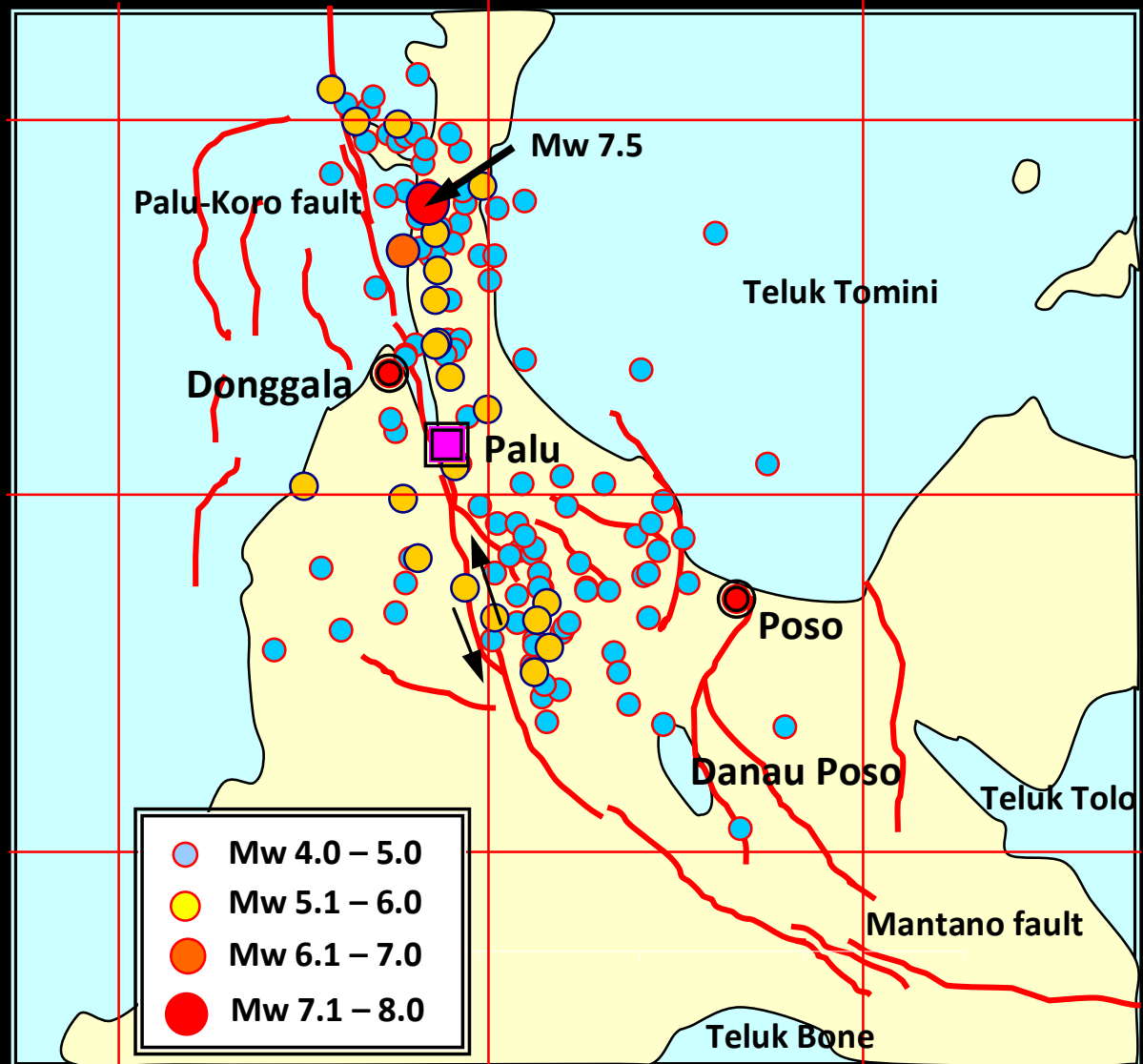
7. Earthquake Prediction

Gempa Palu, Mw7.5, 28 September 2018

Submarine landslides



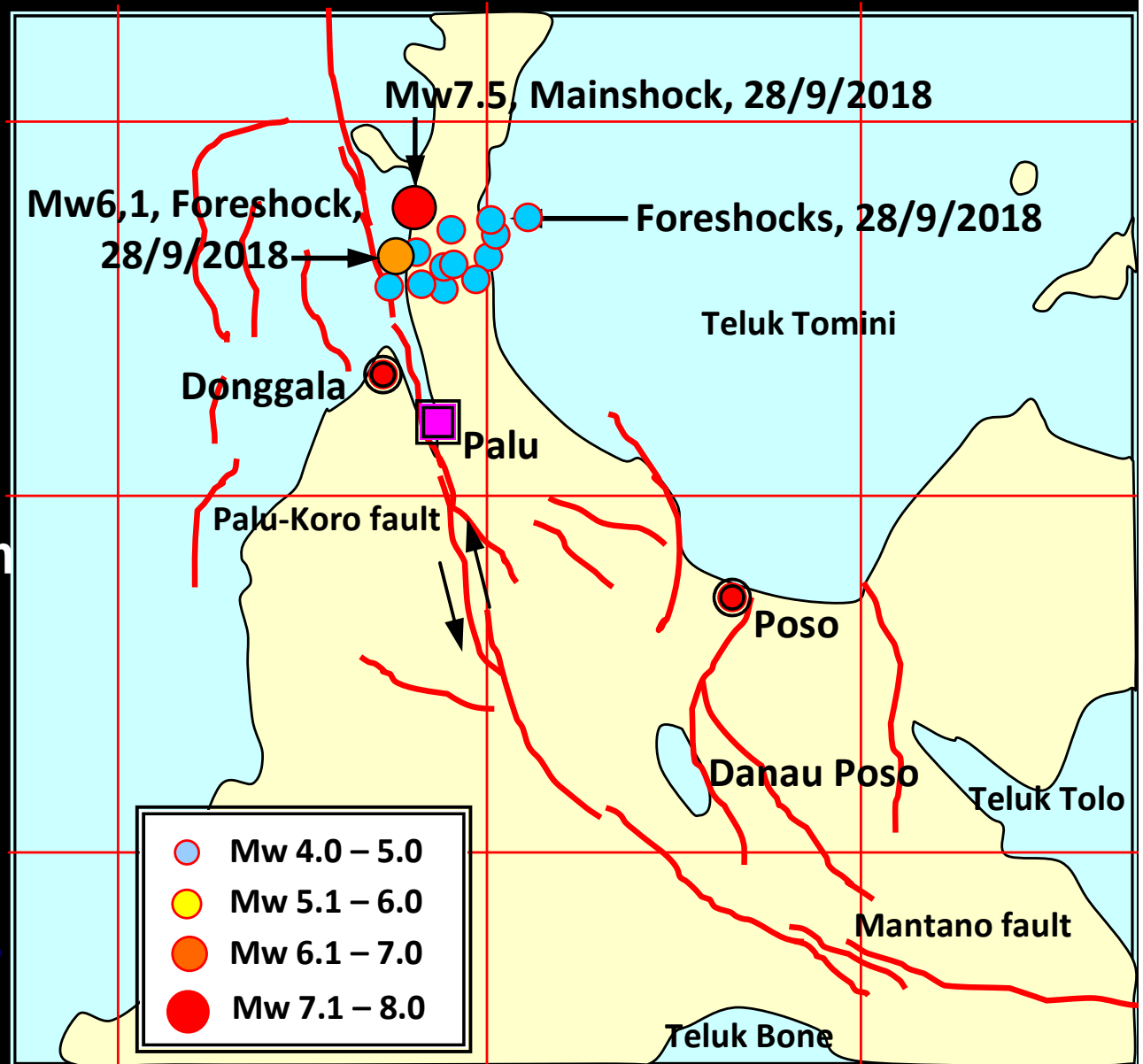
(Natawidjaja dkk, 2019)



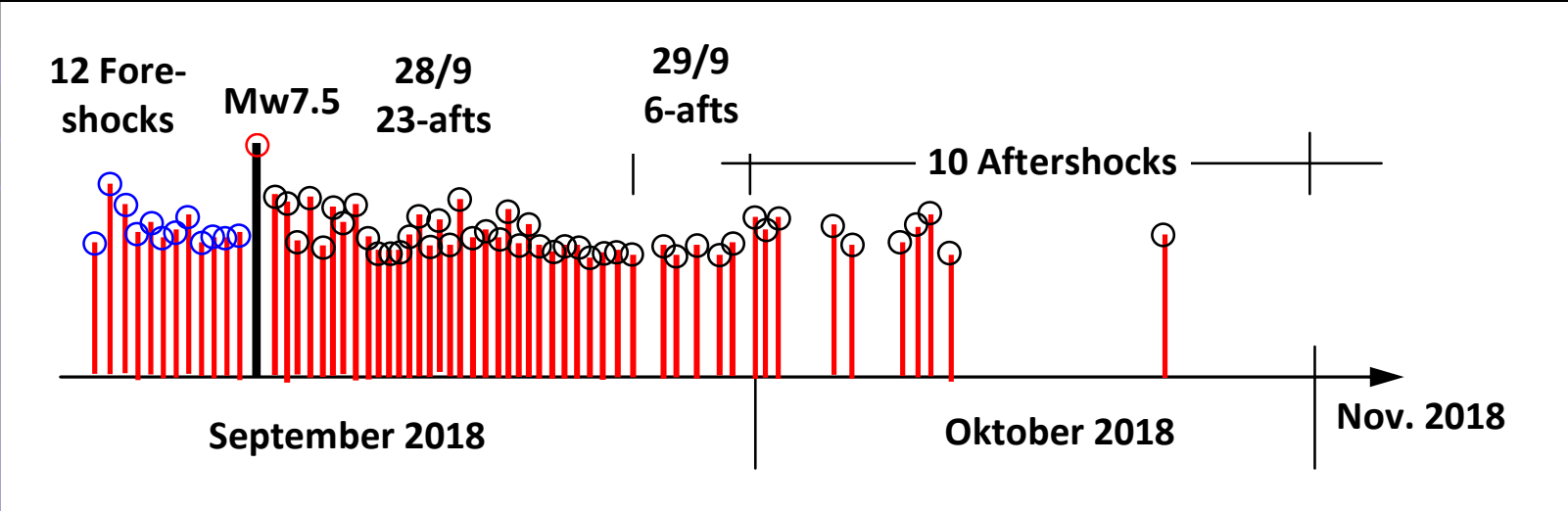
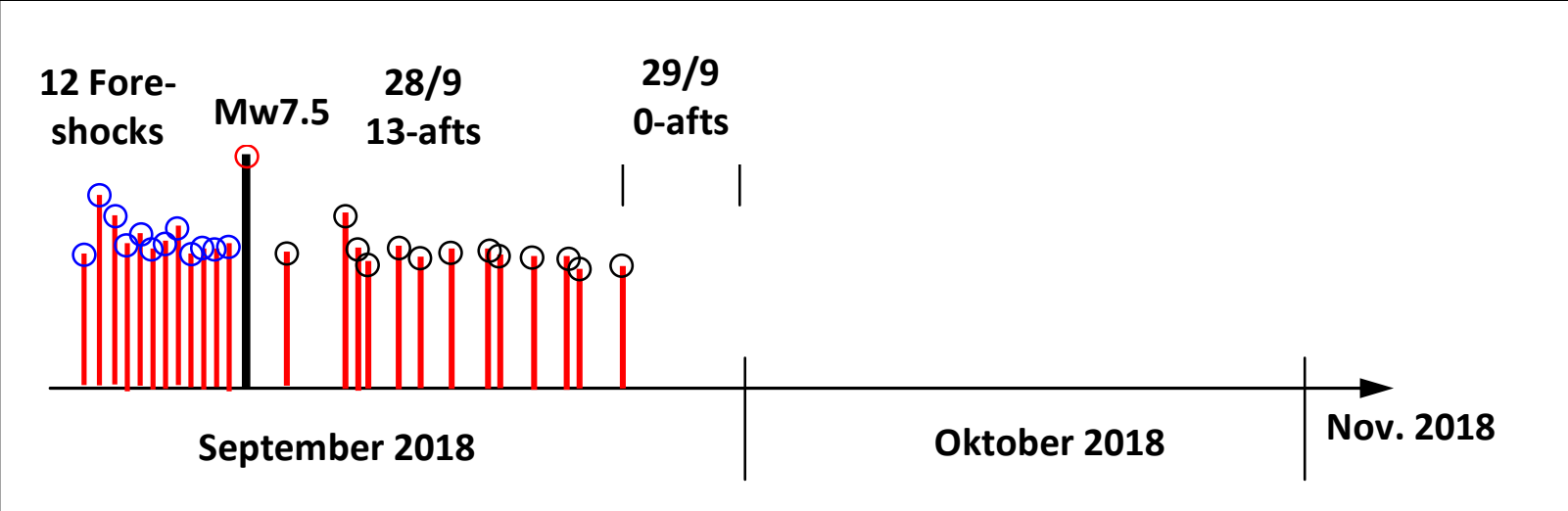
Episenter gempa kedalaman < 50 km (Sept.- Des., 2018)

Foreshocks Gempa Palu 2018

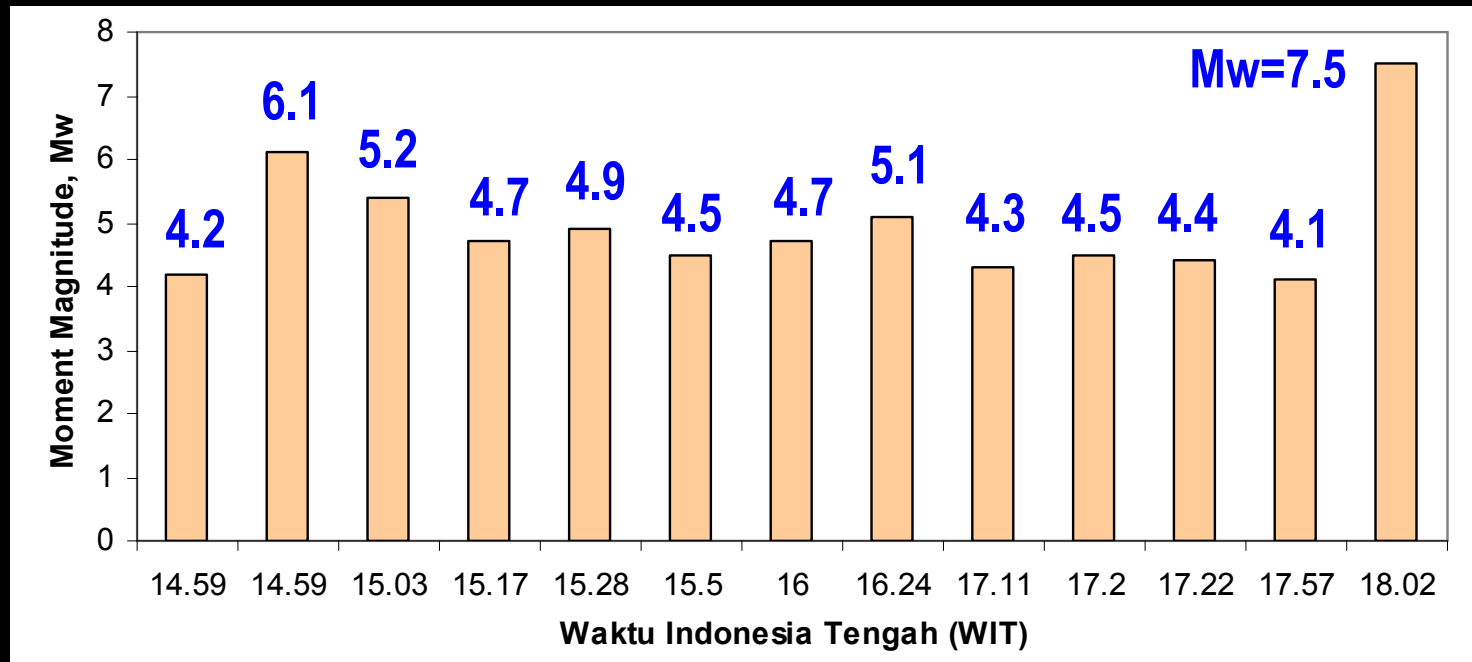
Data gempa Foreshocks dapat dipakai untuk memprediksi kejadian gempa Mainshok



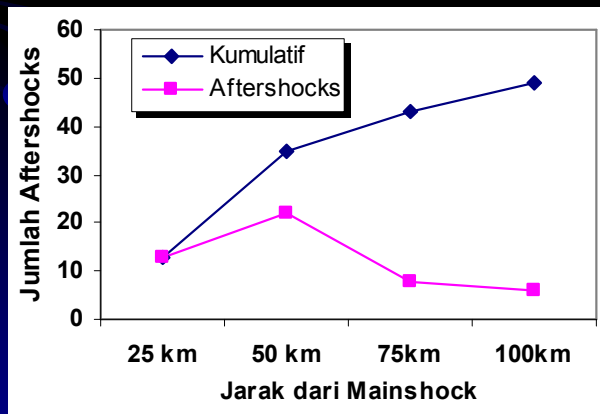
Foreshocks, Mainshock dan Aftershocks



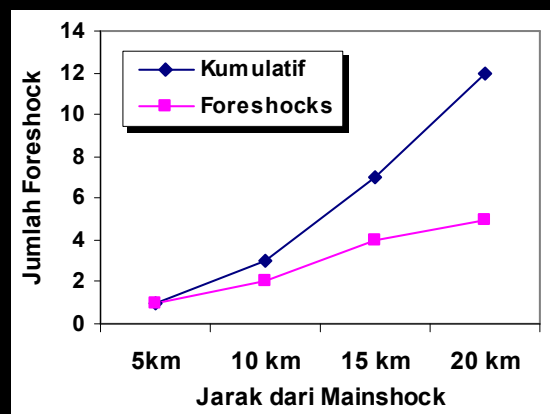
Foreshocks



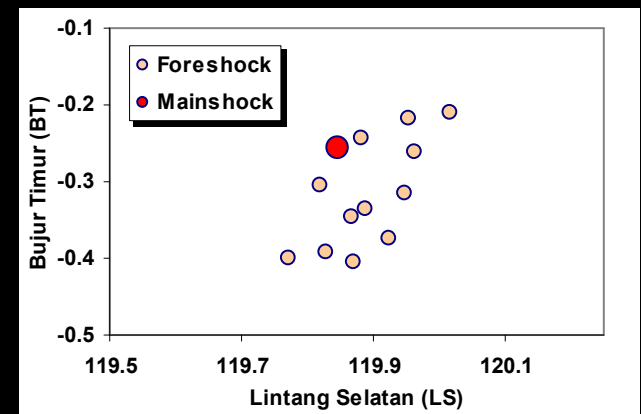
Data Foreshocks sebagai bahan untuk prediksi Mainshock



Aftershocks



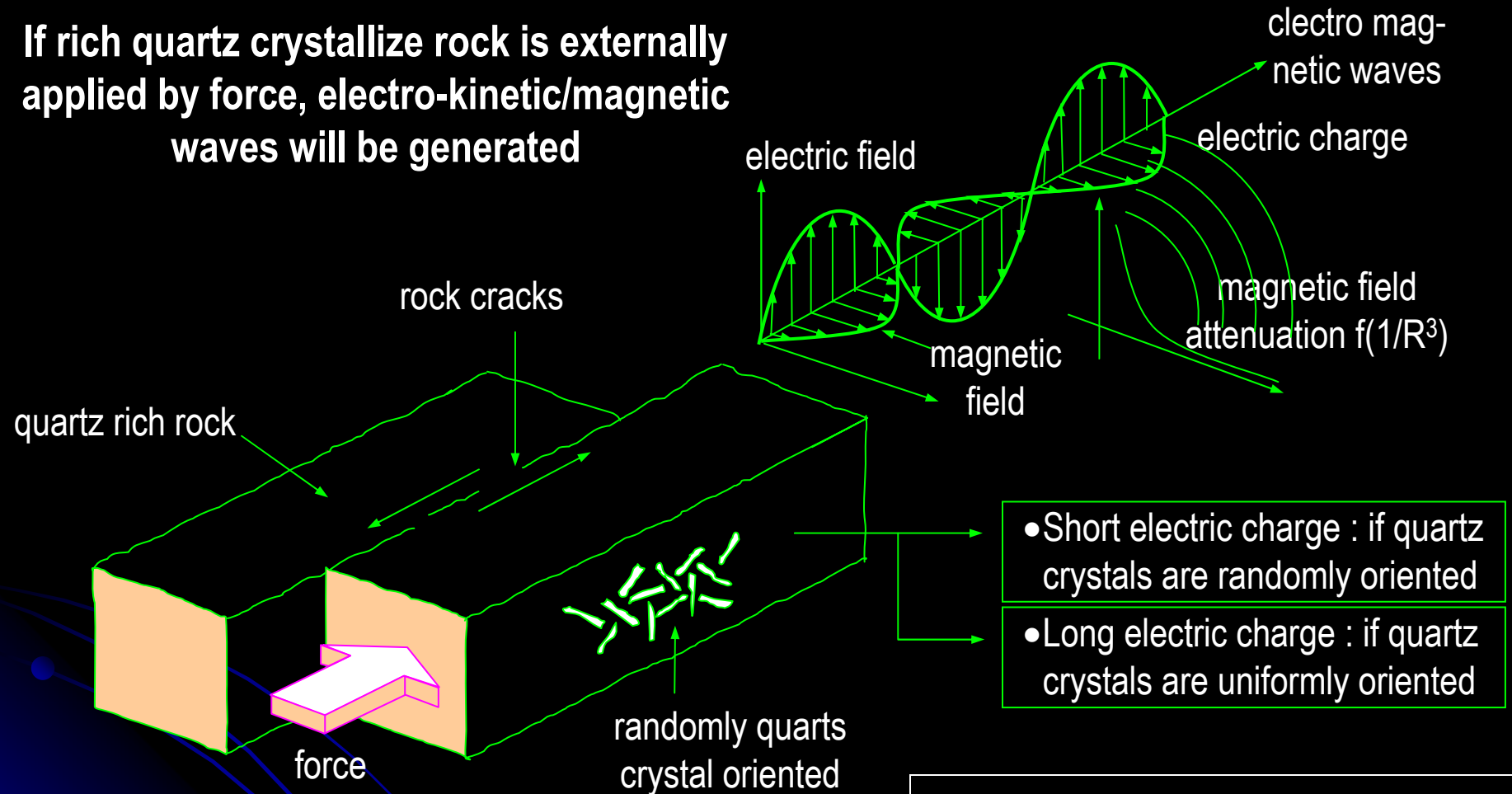
Foreshocks



Foreshocks

Piezo-Electric Theory

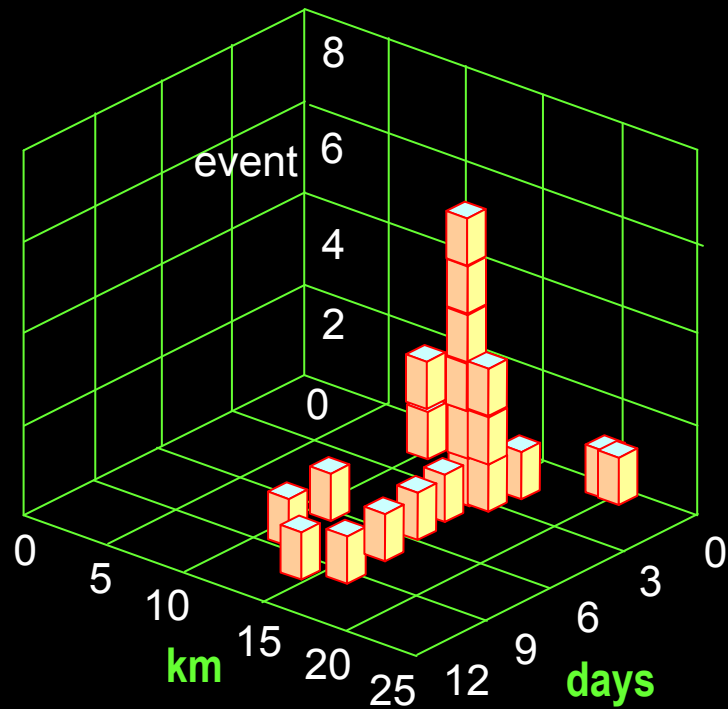
If rich quartz crystallize rock is externally applied by force, electro-kinetic/magnetic waves will be generated



Syarat :

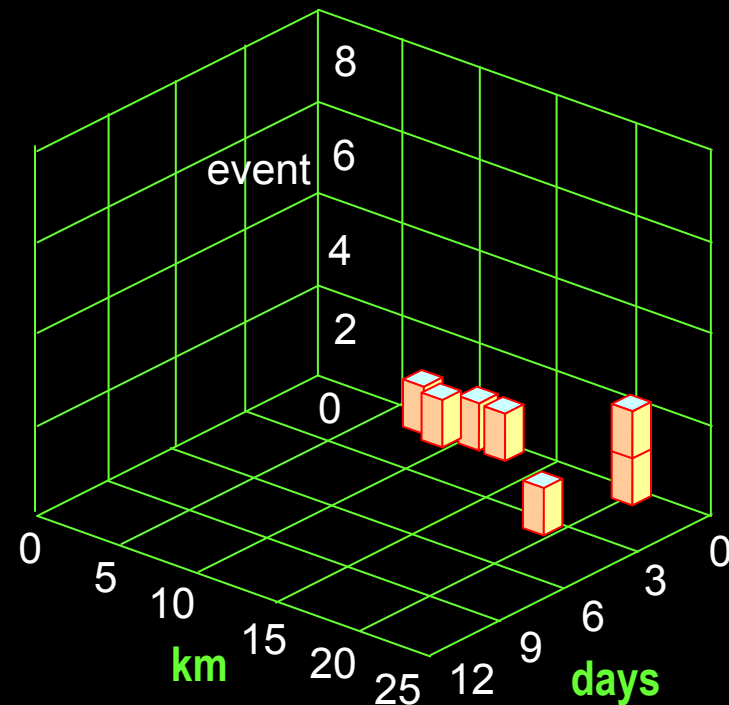
1. Unusual animal behavior
2. Unusual time
3. Unusual place
4. Unusual Numbers

Strange Animal Behavior Before Earthquake



a) Earthworms

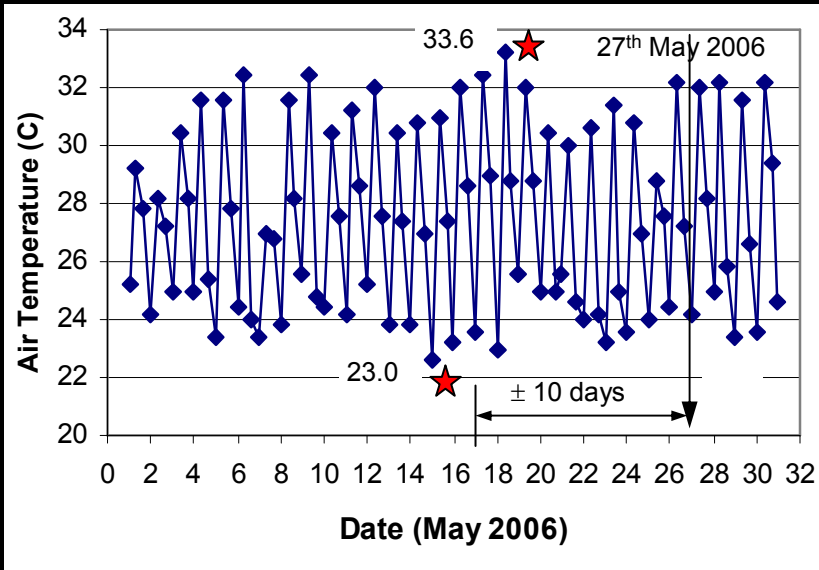
- In most cases, earthworms came out 1-3 days before earthquake
- In most cases, earthworms came out around 15 km from epicenter



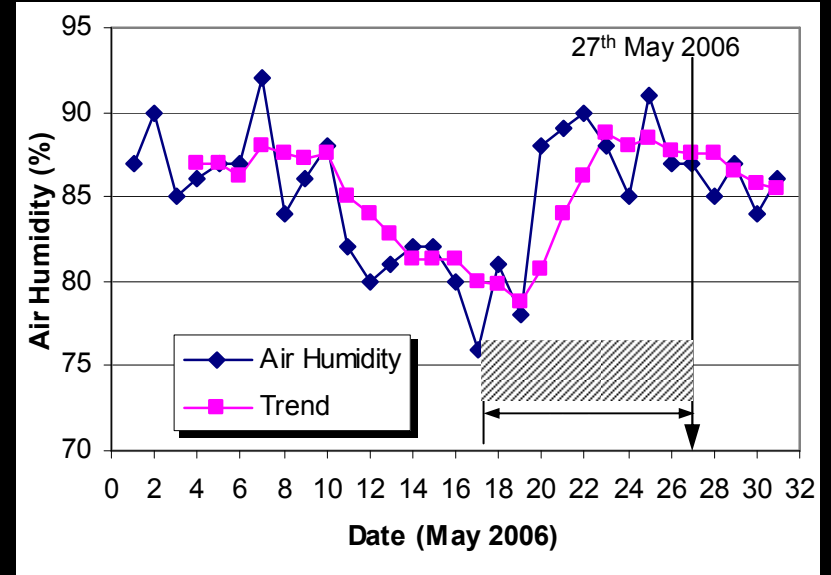
b) Bird Families

- Bird families detected anomaly mostly just 1-day before earthquake
- Most of earthworms detected anomaly earlier than bird families

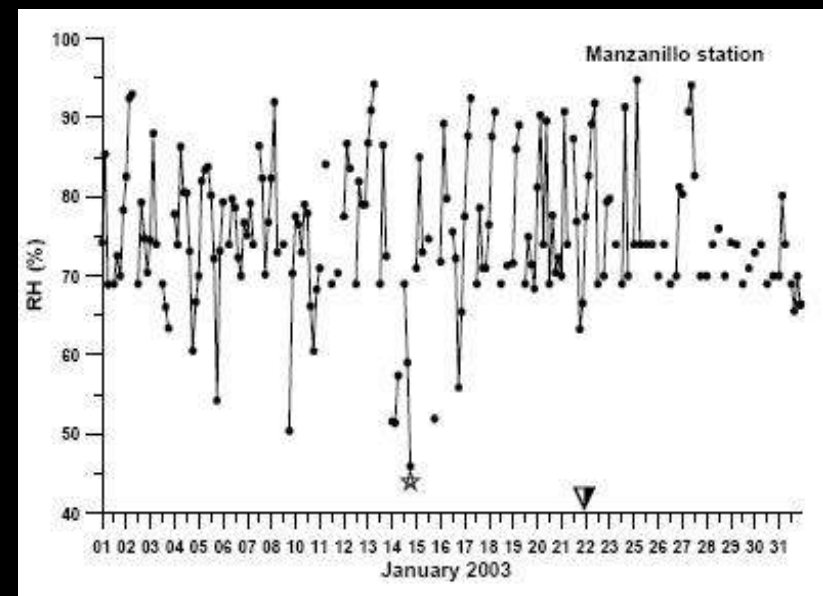
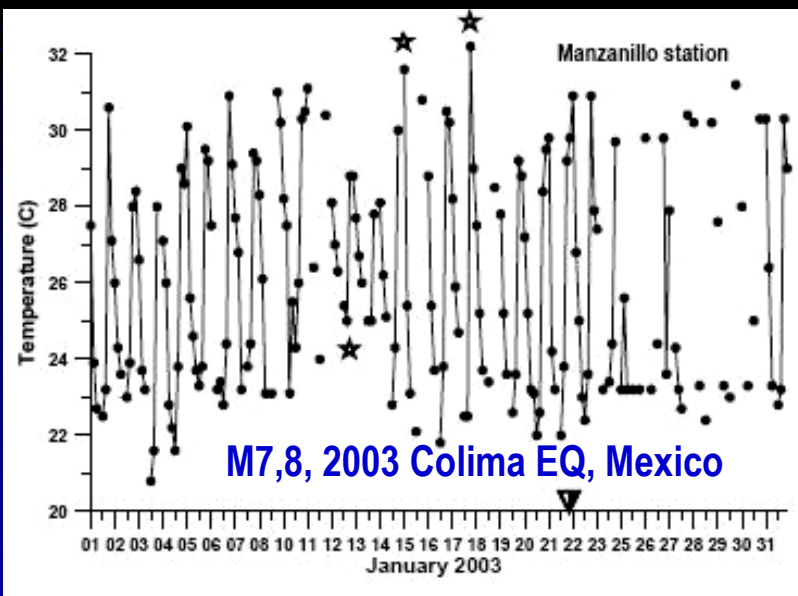
Thermal Anomaly



Yogya air temperature in May 2006

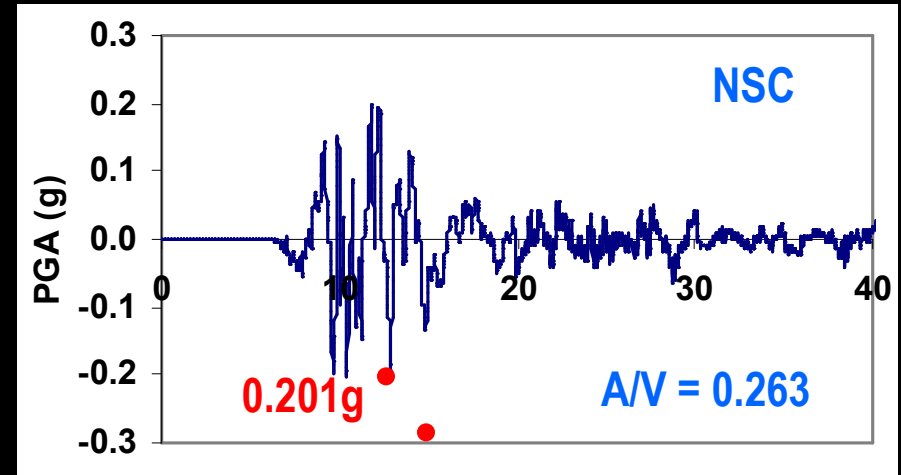
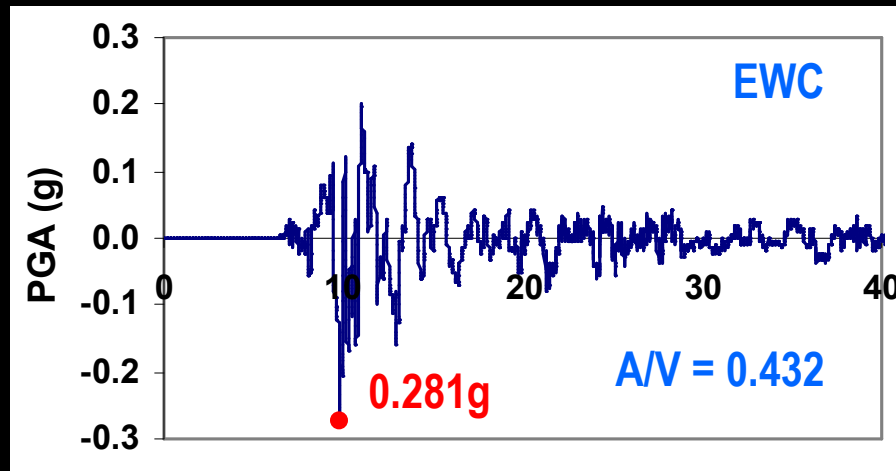


Yogya air humidity in May 2006



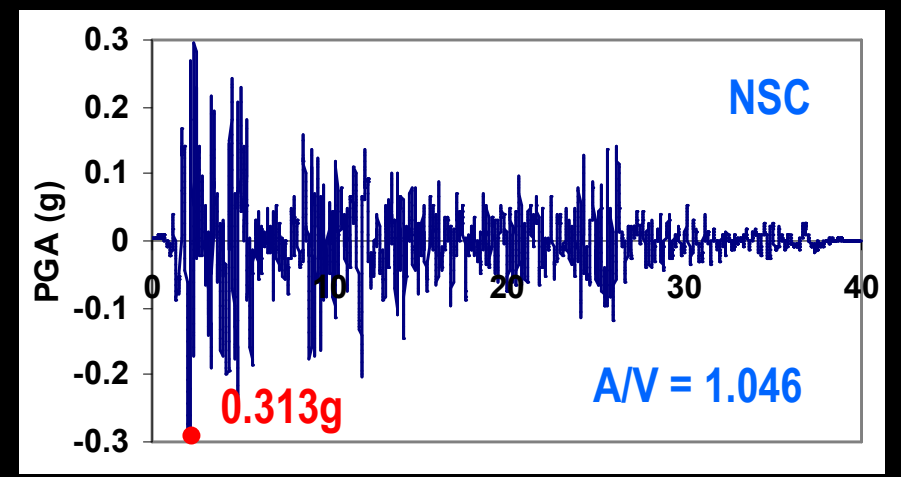
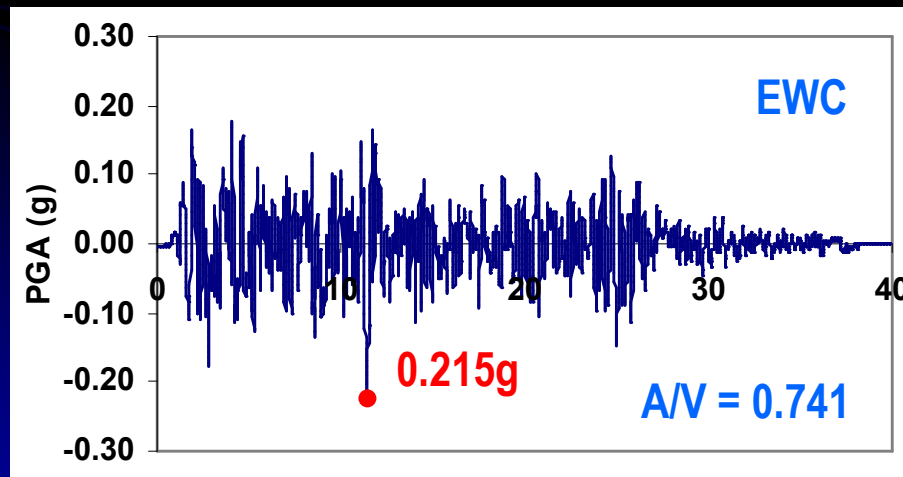
8. Structural Response : Case Study of Palu GM

Palu Ground Acceleration (Sahadewa dkk,2019)



Gempa Palu 2018, EWC (Low Frequency)

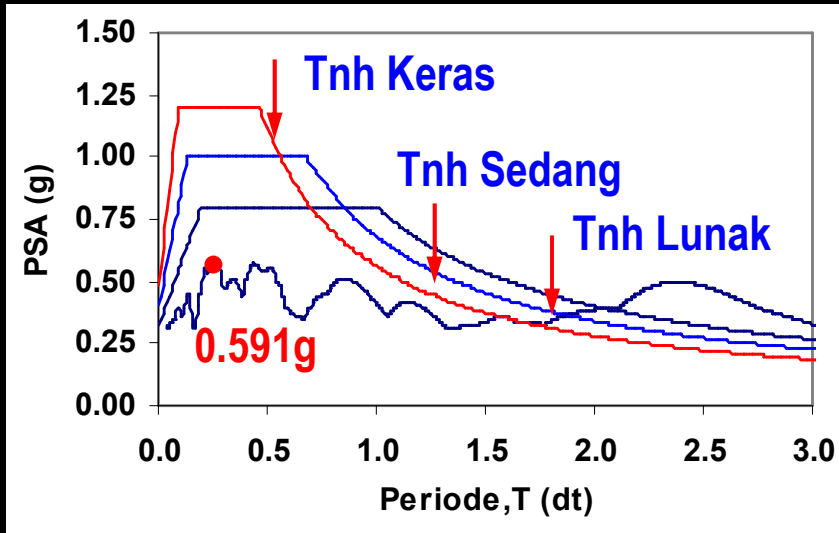
Gempa Palu 2018, NSC (Low Frequency)



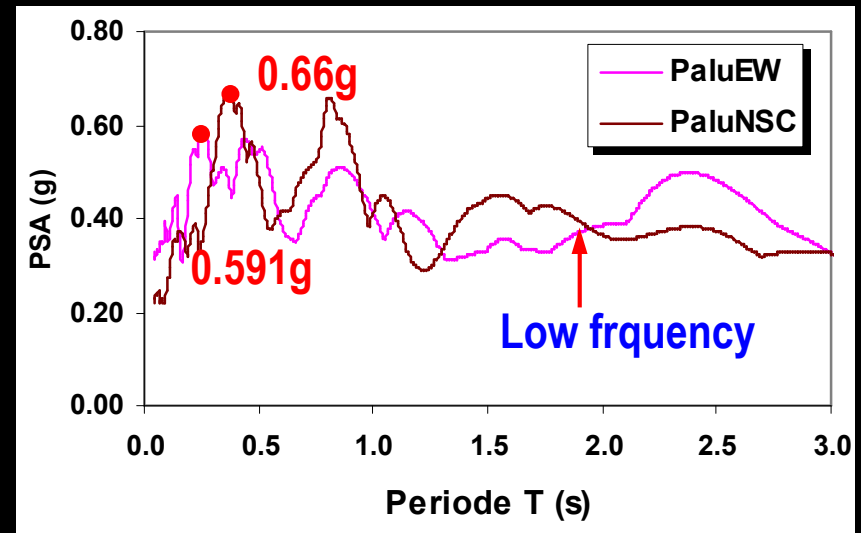
Gempa EL Centro 1940, EWC (Low Freq.)

Gempa EL Centro 1940, NSC (Medium Freq.)

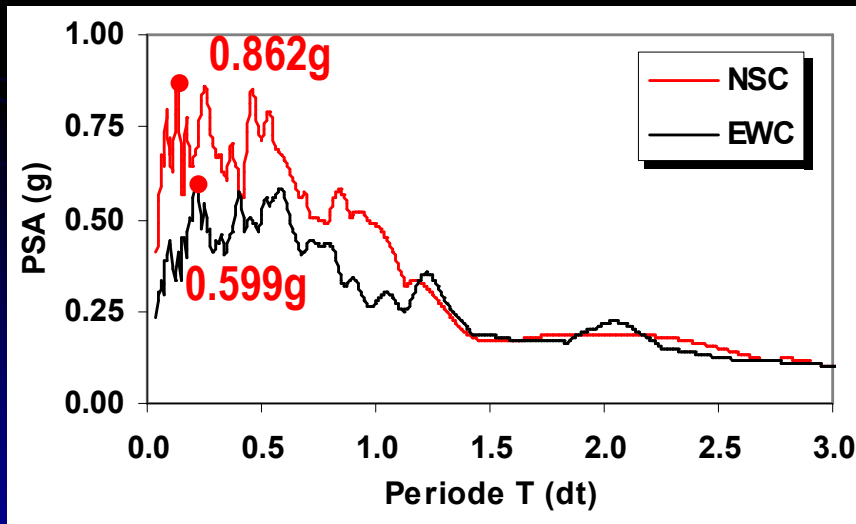
Respons Spektrum



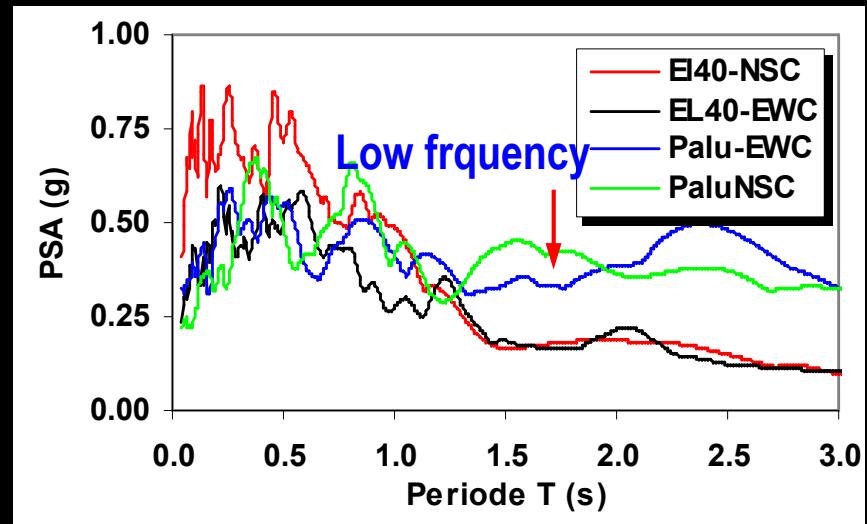
Gempa Palu 2018, EWC



Gempa Palu 2018, EWC dan NSC

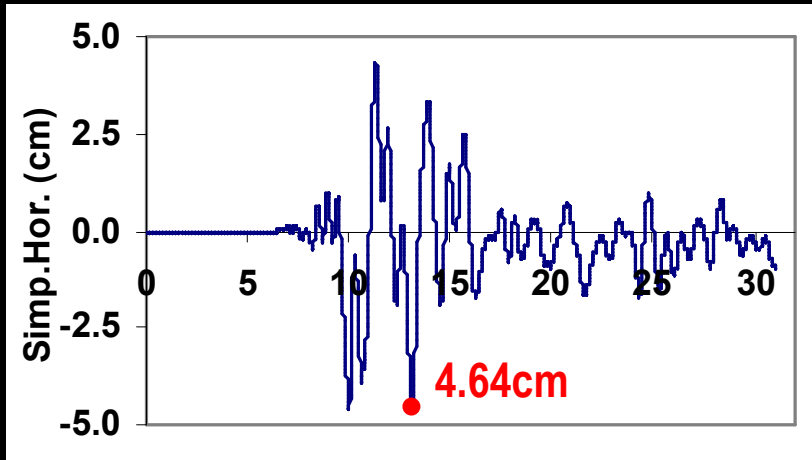


Gempa EL Centro 1940, EWC & NSC

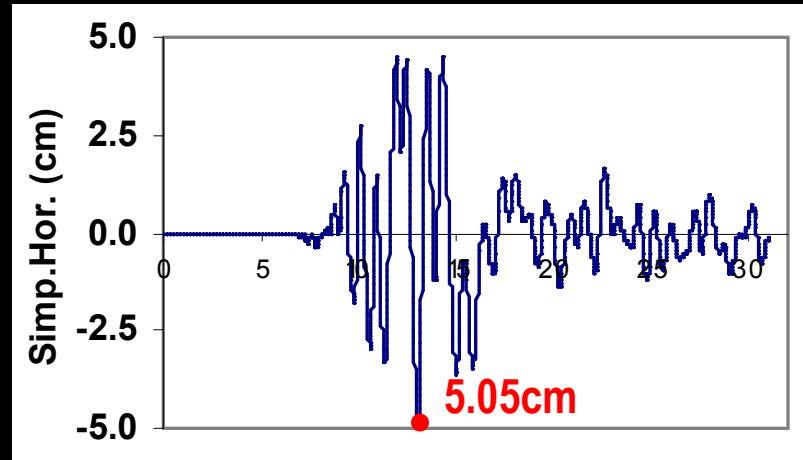


Gempa EL Centro 1940 & Palu 2018

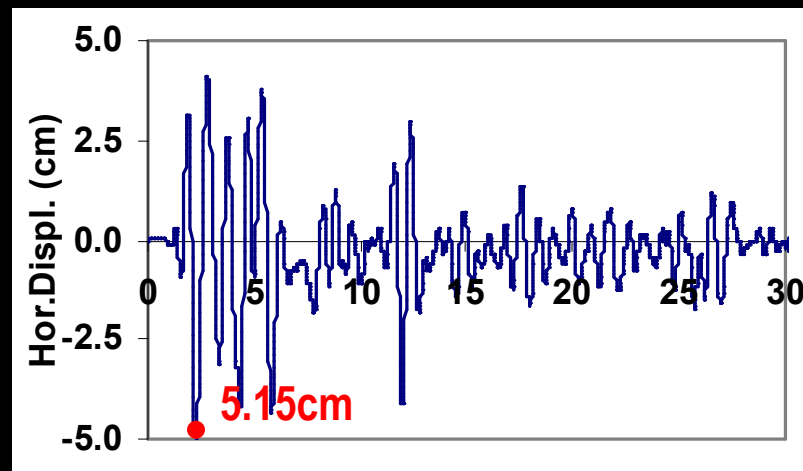
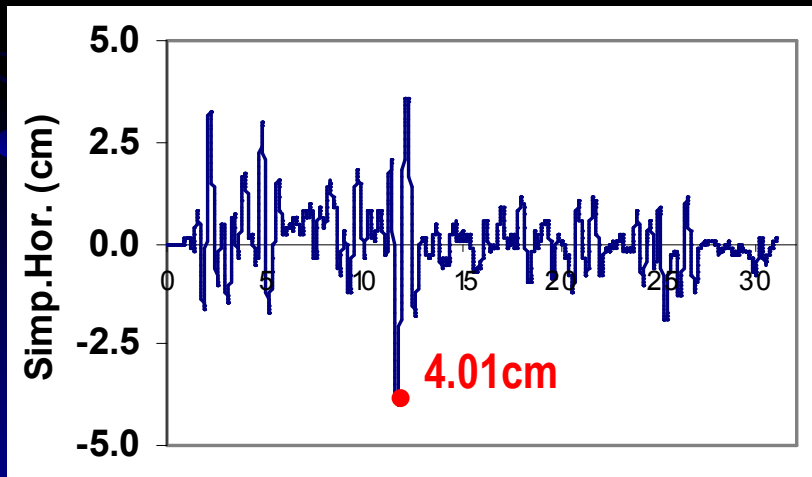
Simpangan Horizontal



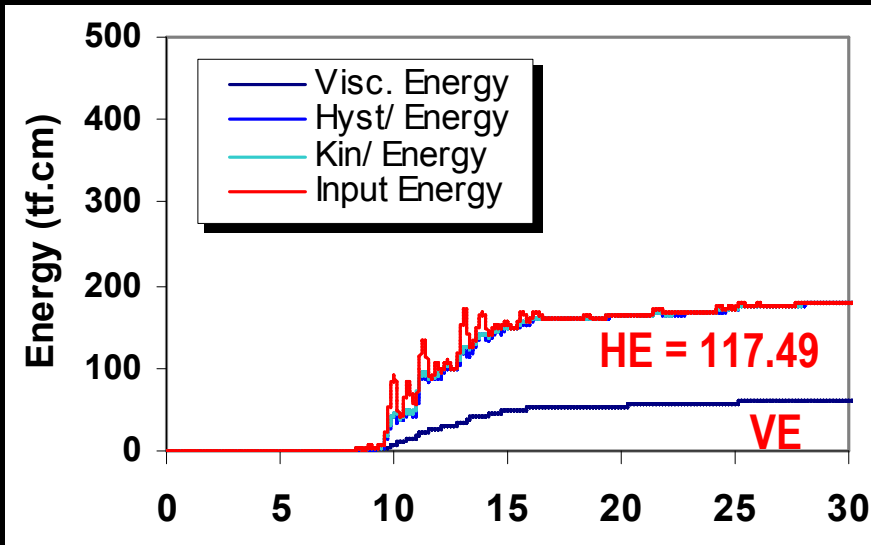
Gempa Palu 2018, EWC



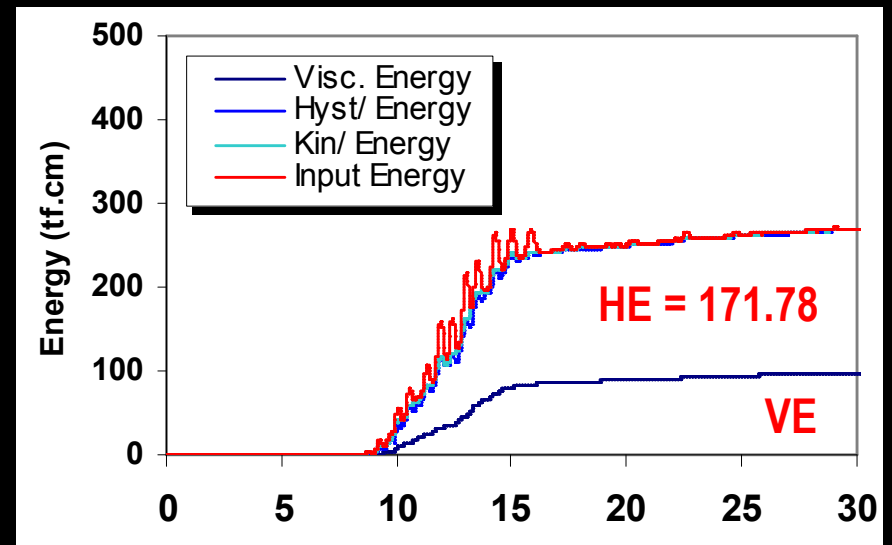
Gempa Palu 2018, NSC



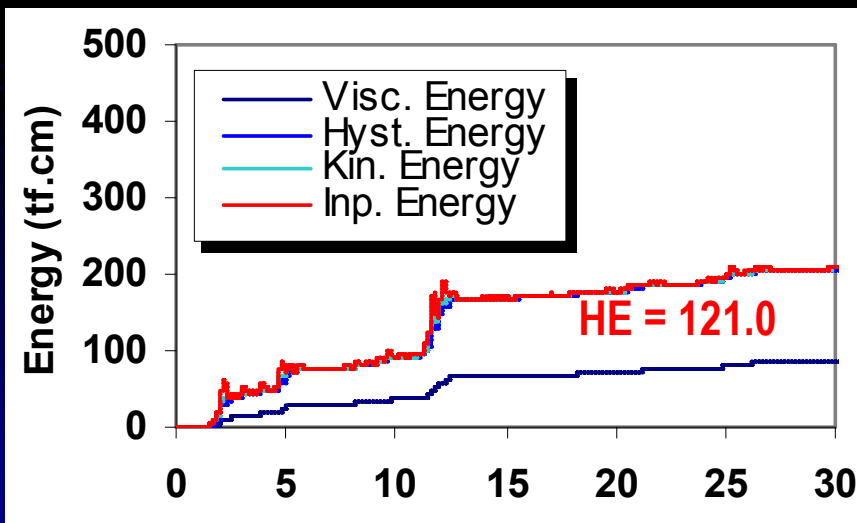
Input dan Absorption Energy



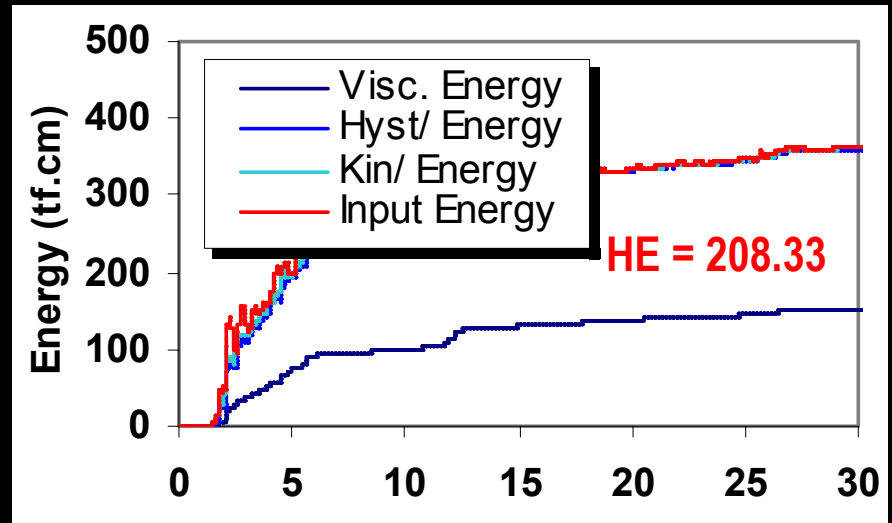
Gempa Palu 2018, EWC



Gempa Palu 2018, NSC

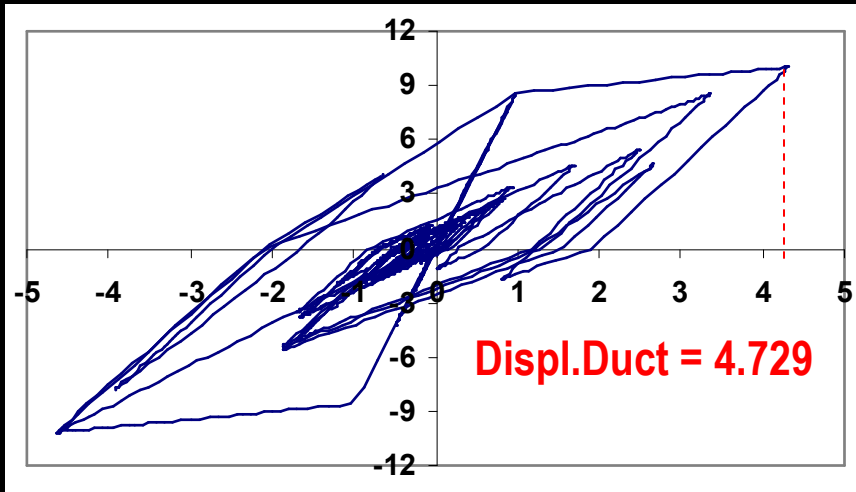


Gempa EL Centro 1940, EWC

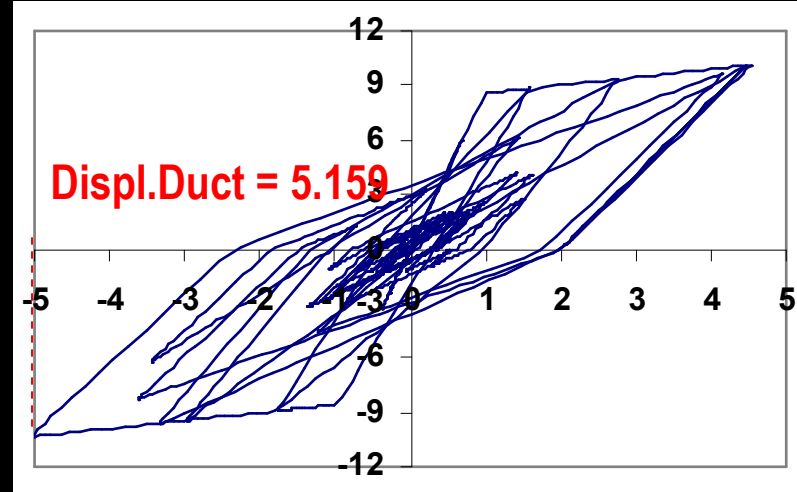


Gempa EL Centro 1940, NSC

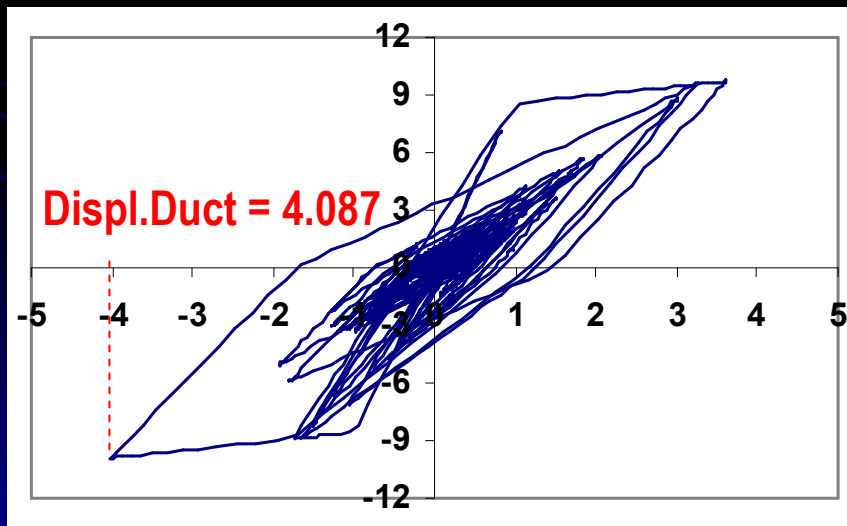
Hysteretic Energy Absorption



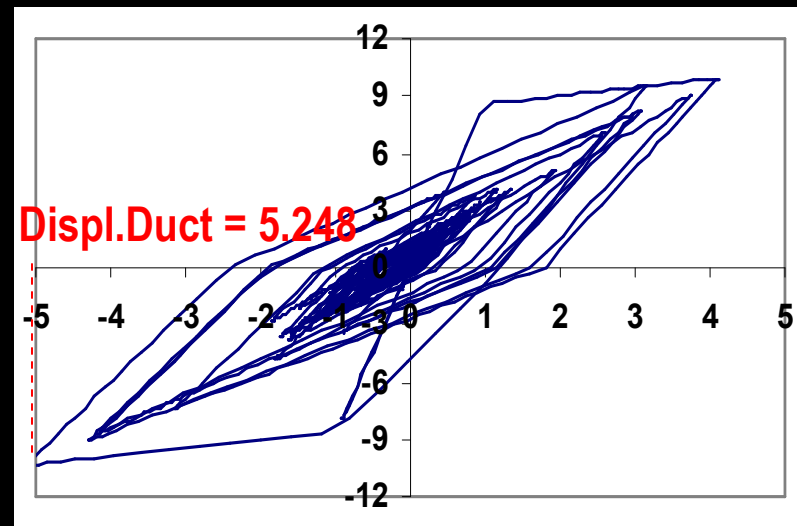
Gempa Palu 2018, EWC



Gempa Palu 2018, NSC

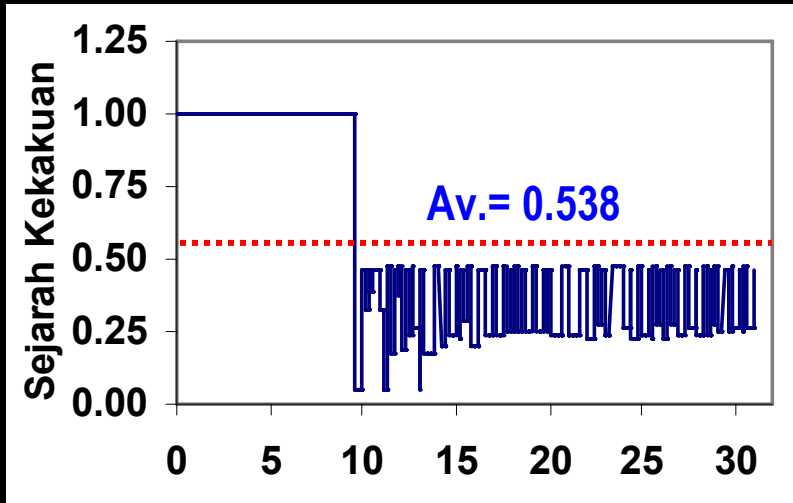


Gempa EL Centro 1940, EWC

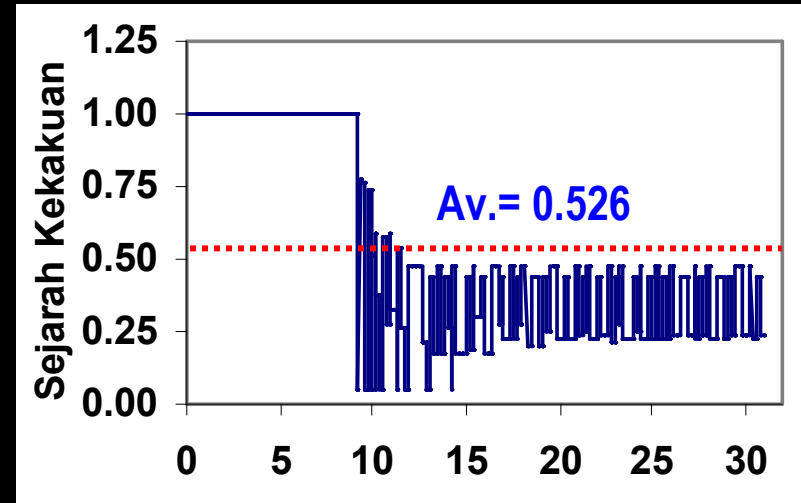


Gempa EL Centro 1940, NSC

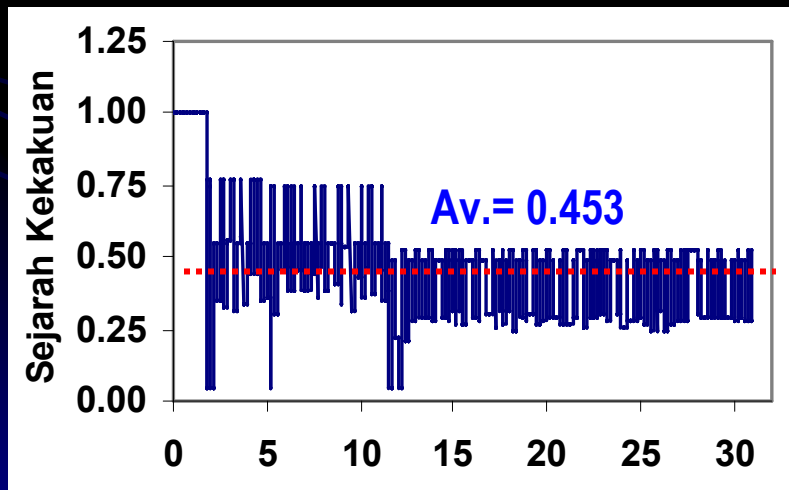
Stiffness History



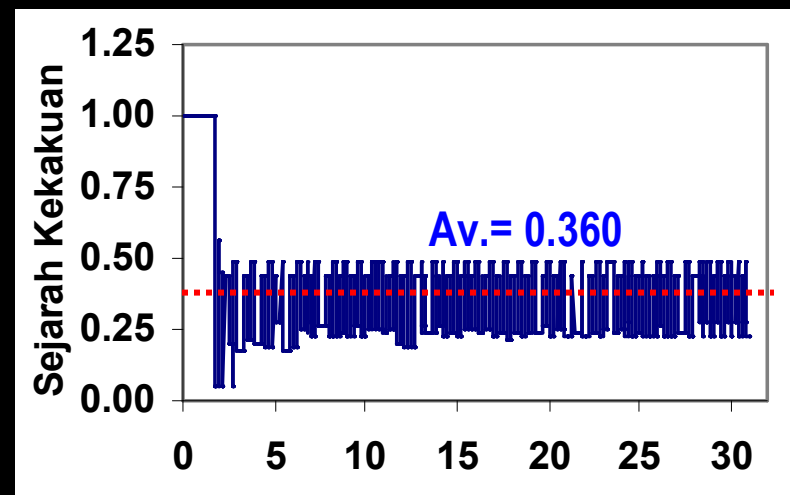
Gempa Palu 2018, EWC



Gempa Palu 2018, NSC

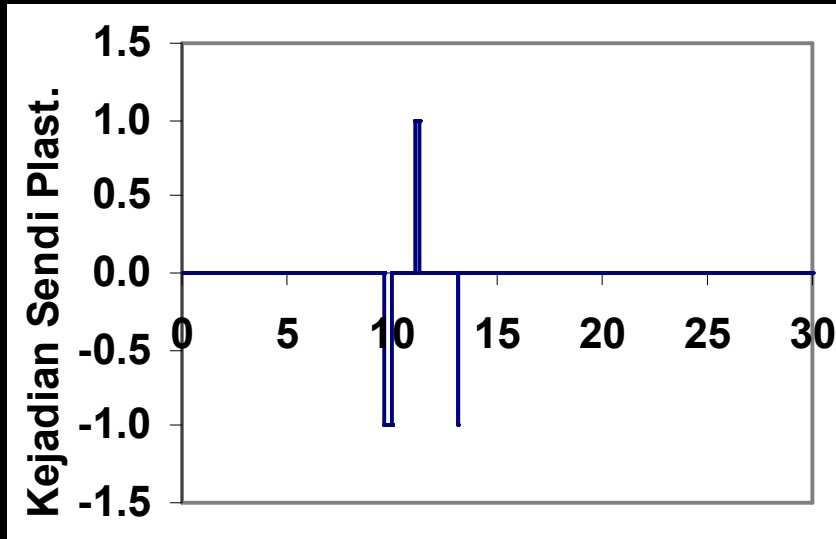


Gempa EL Centro 1940, EWC

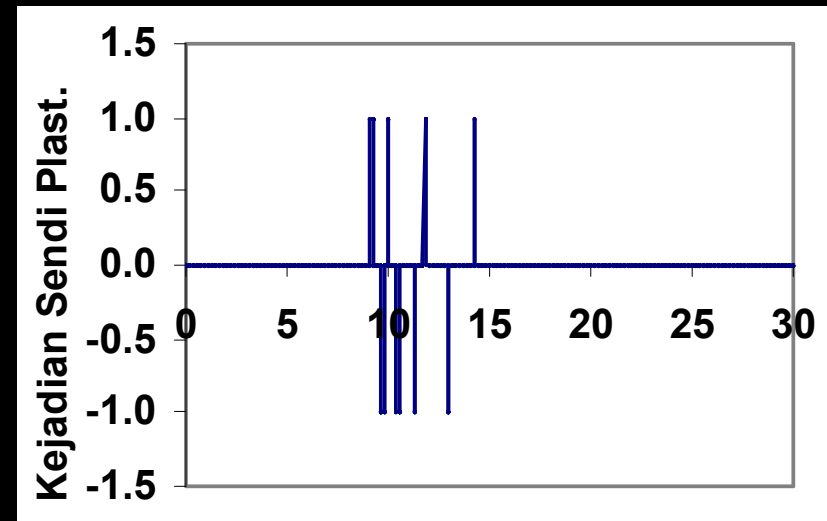


Gempa EL Centro 1940, NSC

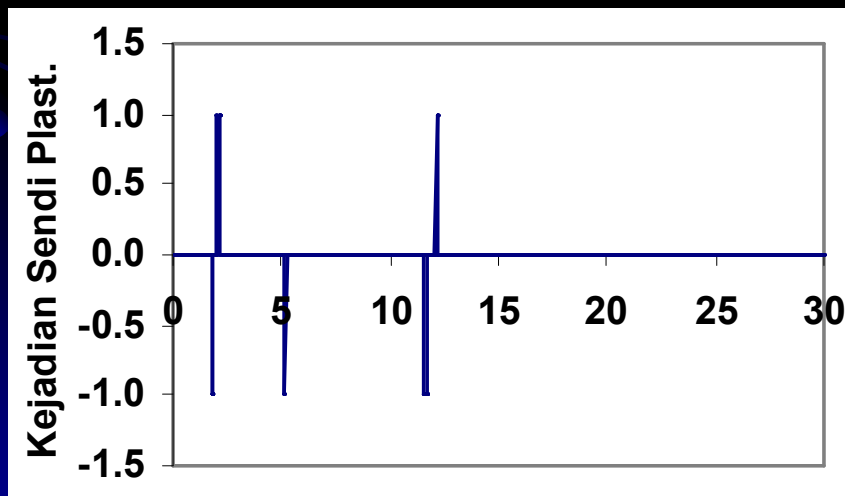
Kejadian Sendi Plastis



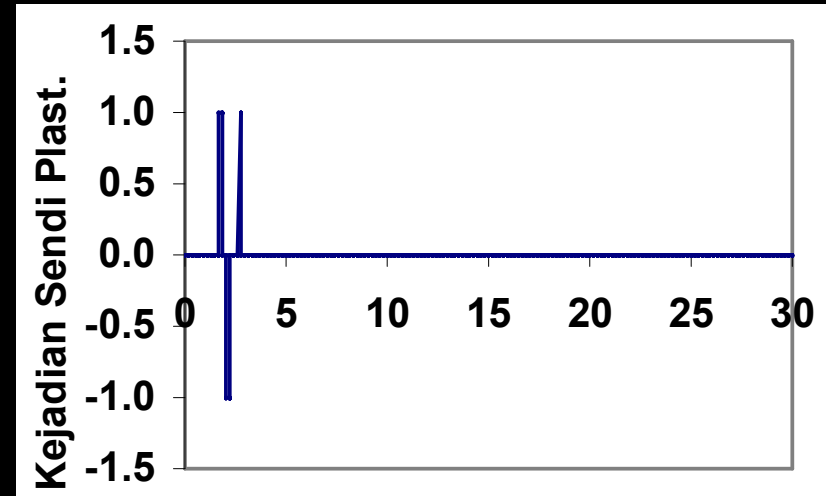
Gempa Palu 2018, EWC



Gempa Palu 2018, NSC

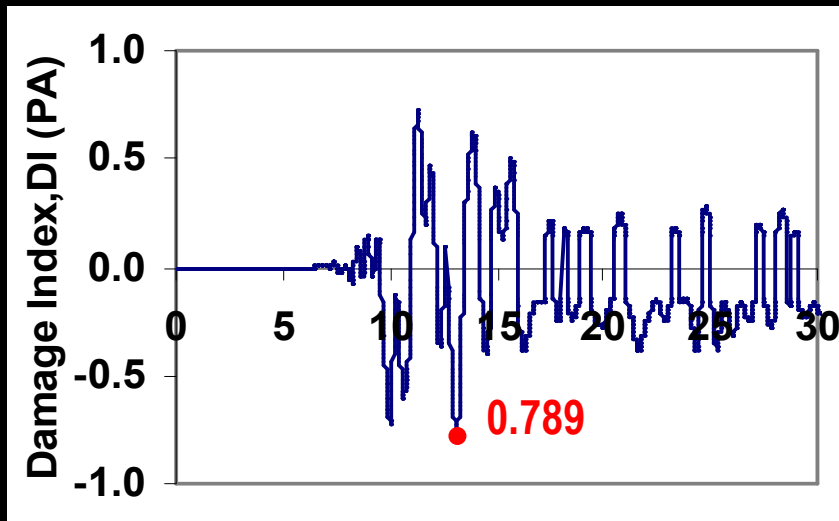


Gempa EL Centro 1940, EWC

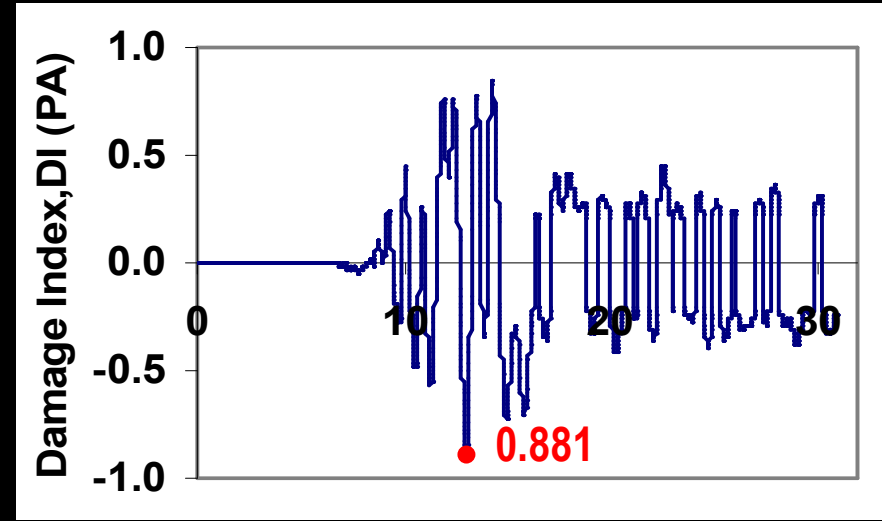


Gempa EL Centro 1940, NSC

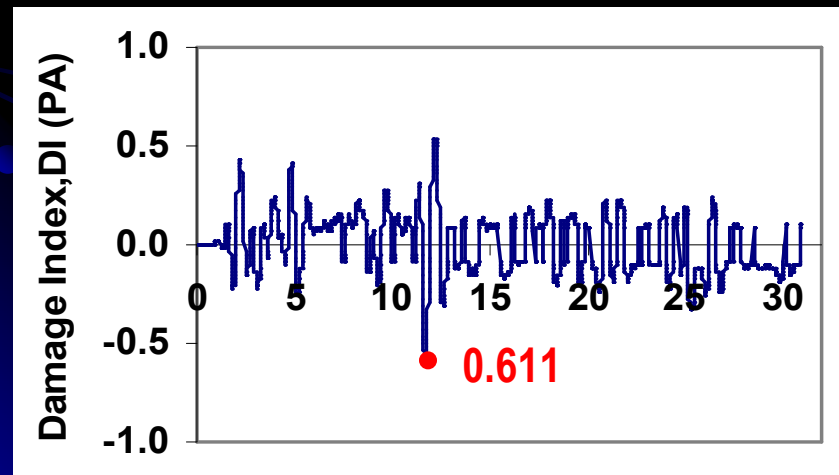
Indeks Kerusakan (Park & Ang Damage Index)



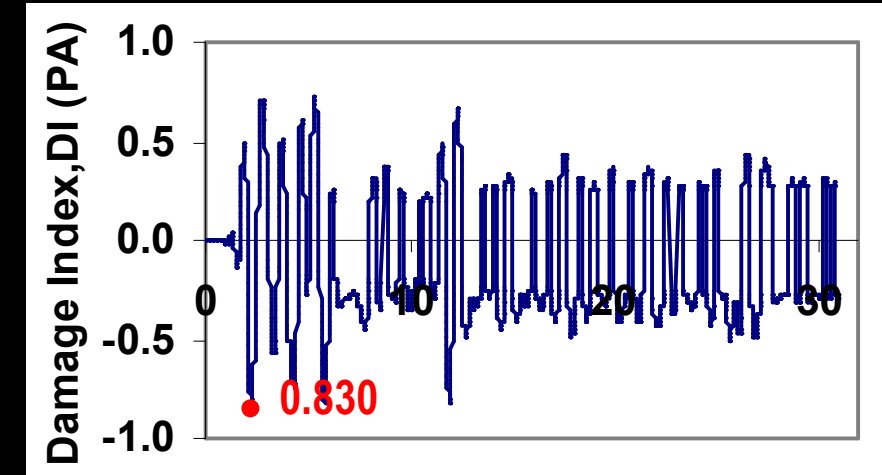
Gempa Palu 2018, EWC



Gempa Palu 2018, NSC



Gempa EL Centro 1940, EWC



Gempa EL Centro 1940, NSC

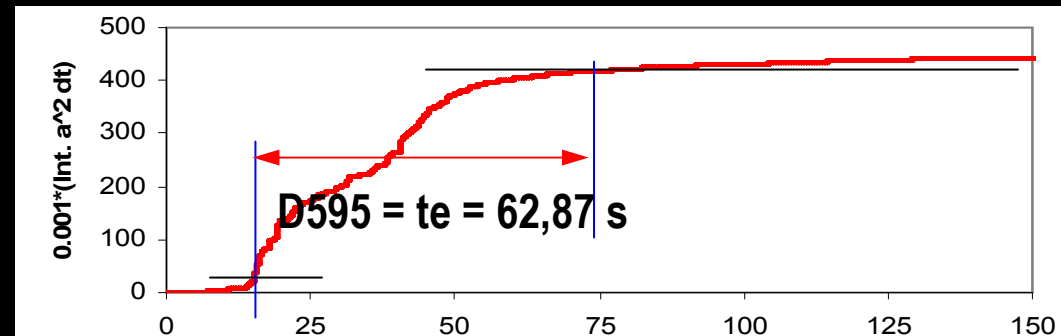
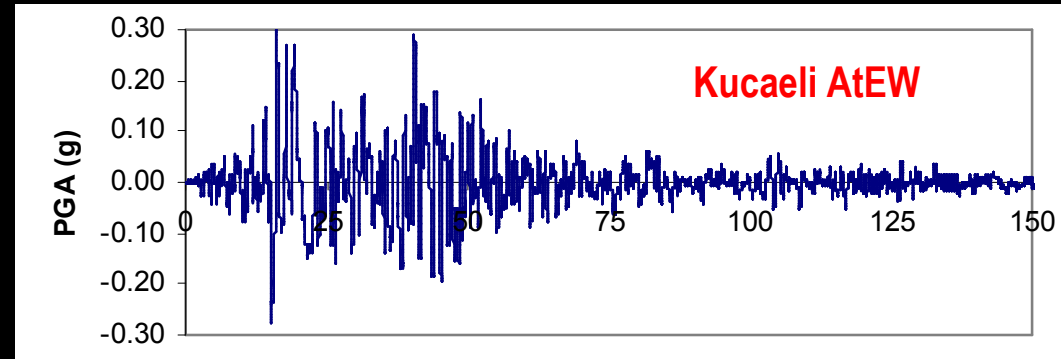
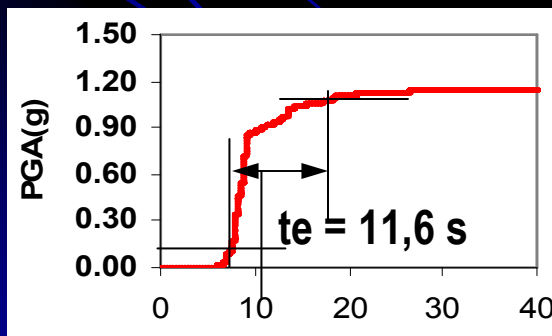
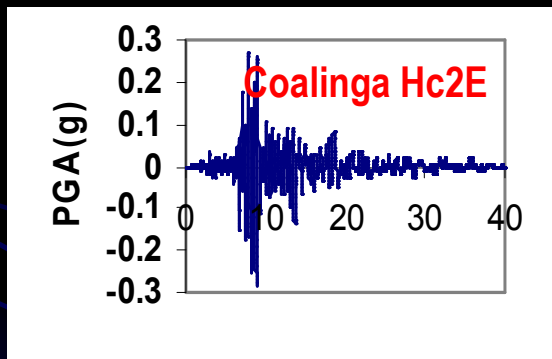
9. Seismic Intensity Measures (SIM)

Mathematical/Traditional SIM

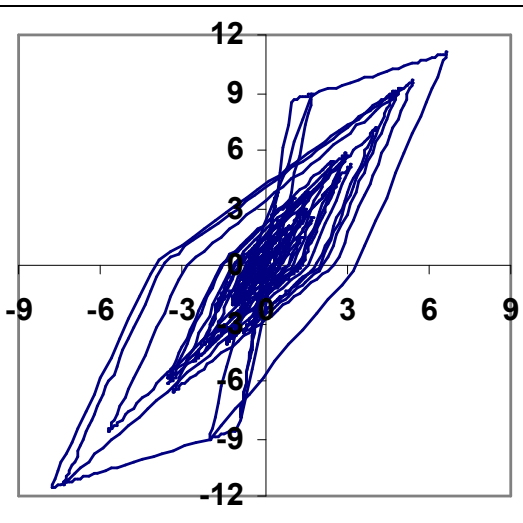
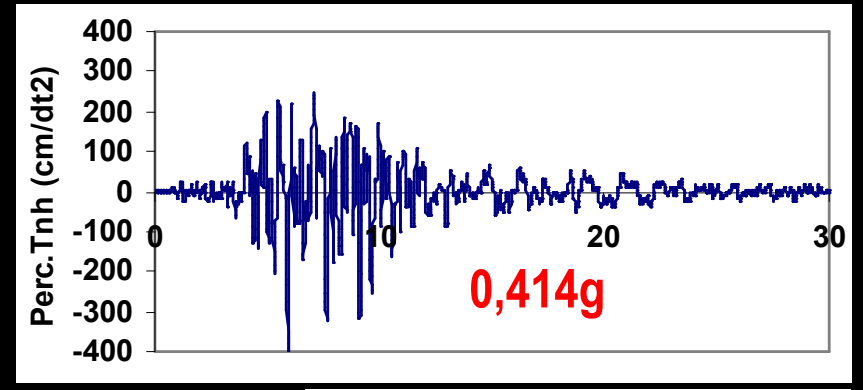
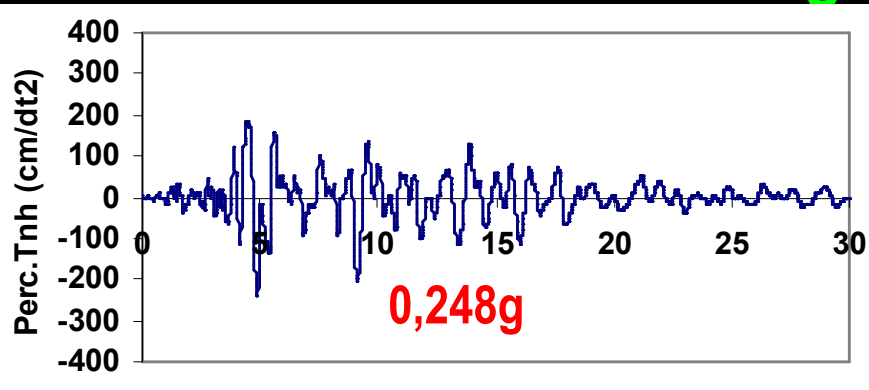
No	SIM name	Definition	No	SIM name	Definition
1	Peak Gr. Accelerat.	PGA (g)	11	Root mean Square $A_{rms,1}$	$RMS_{A1} = \sqrt{P_{E,1}}$ (cm/s ²)
2	Peak Ground Velocity	PGV (cm/s)	12	Earthquake Power, $P_{E,2}$	$P_{E,2} = \frac{1}{t_e} \int_{0.05}^{0.95} \ddot{u}_g^2 dt$ (cm/s ²)
3	Peak Ground Displacement	PGD (cm)	13	Root mean Square $A_{rms,2}$	$A_{rms,2} = \sqrt{P_{E,2}}$ (cm/s ²)
4	A/V ratio	A/V (1/s)	14	Cum. Av. Velocity, CAV	$CAV = \int_0^{T_t} \ddot{u}_g dt$ (cm/s)
5	Total Duration, T_t	T_t (s)	15	Arias Intensity, I_A	$I_A = \frac{\pi}{2.g} \int_0^{t_e} \ddot{u}_g^2 dt$ (cm/s)
6	Zero crossing per unit time	$f_{o,1} = N_C / T_t$ (1/s) $f_{o,2} = N_C / t_e$ (1/s)	16	Potential Destructiveness, P_D	$P_D = \frac{I_A}{v_o^2}$ (cm/s)
7	Displacement parameter, $D_{p,1}$	$D_{p,1} = \frac{PGV}{f_{o,1}}$ (cm)	17	Damage Factor I_D	$I_D = \frac{2.g}{\pi} \frac{I_A}{PGA.(PGV)}$ -
8	Displacement parameter, $D_{p,2}$	$D_{p,2} = \frac{PGV}{f_{o,2}}$ (cm)	18	Specific Energy Intensity, SED	$SED = \int_0^{T_t} \dot{u}_g^2 dt$ (cm ² /s)
9	Significant Duration, t_e	$t_e = D_{595} = \int_{0.05}^{0.95} \ddot{u}_g^2 dt$ (s)	19	Velocity Intensity, I_v	$I_v = \frac{1}{PGV} \int_0^{T_t} \dot{u}_g^2 dt$ (cm)
10	Earthquake Power, $P_{E,1}$	$P_{E,1} = \frac{1}{T_t} \int_0^{T_t} \ddot{u}_g^2 dt$ (cm/s ²) ²	20	Housner Intensity, I_H	$I_H = \int_{0.1}^{0.95} SV dt$ (cm)

Earthquake Significant Duration D595

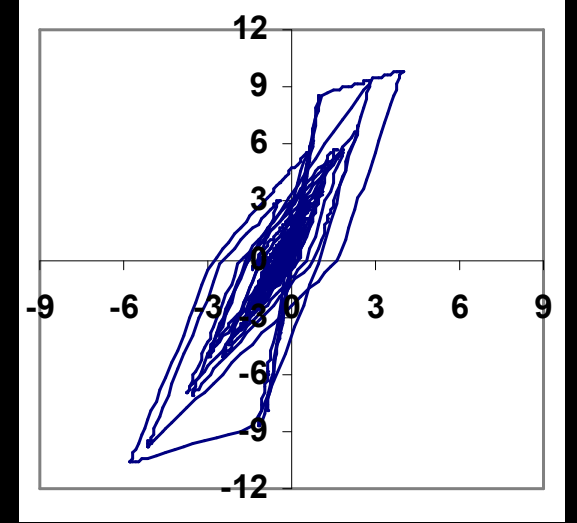
- Dilihat dari percepatan tanah maximum, gempa Coalinga mempunyai PGA = 0,281 g, sedangkan gempa Kucaeli dinormalisasikan menjadi PGA = 0,30 g. Dilihat dari PGA keduanya hampir sama
- Namun demikian gempa Coalingan hanya mempunyai durasi total sekitar 40 s dengan durasi efektif $t_e = 11,6$ s, sementara itu gempa Kucaeli mempunyai durasi total sekitar 150 s dan durasi efektif $t_e = 62,87$ s. Dilihat dari durasi gempa keduanya sangat berbeda.



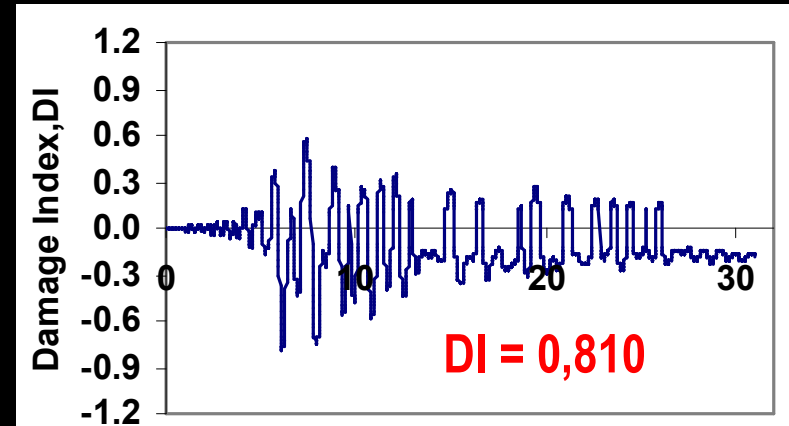
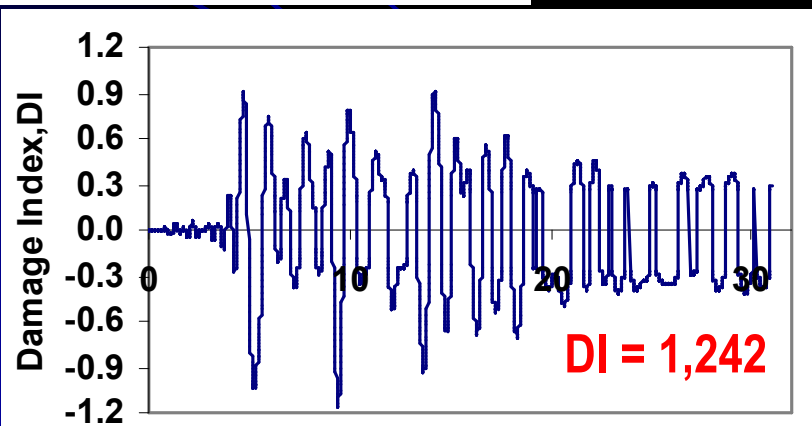
Pengaruh PGA



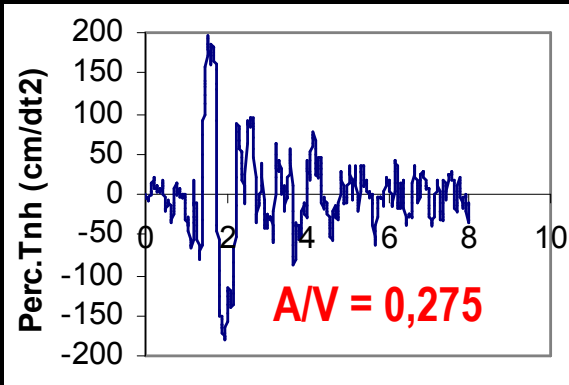
Coyote Lake Go2E



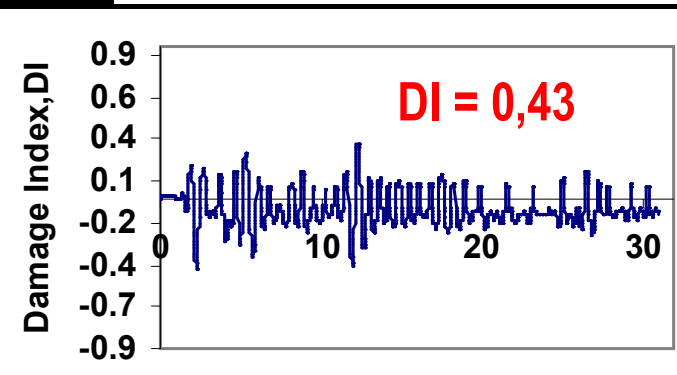
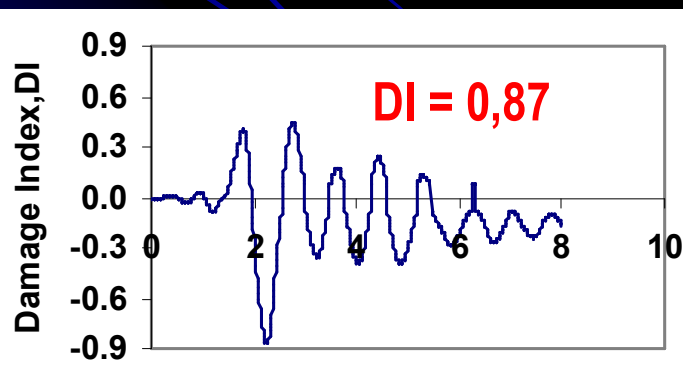
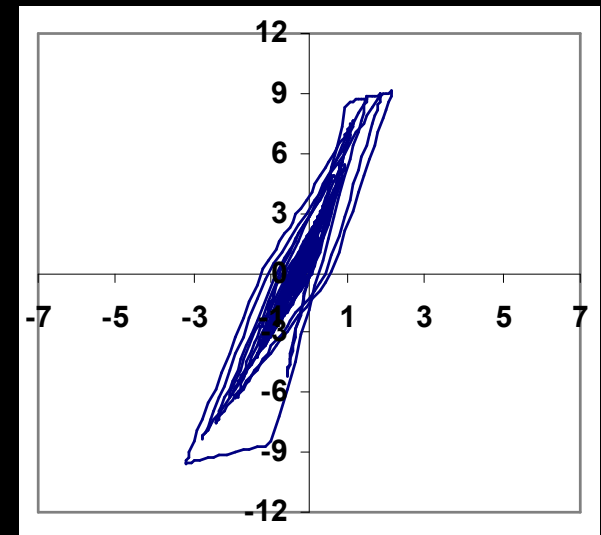
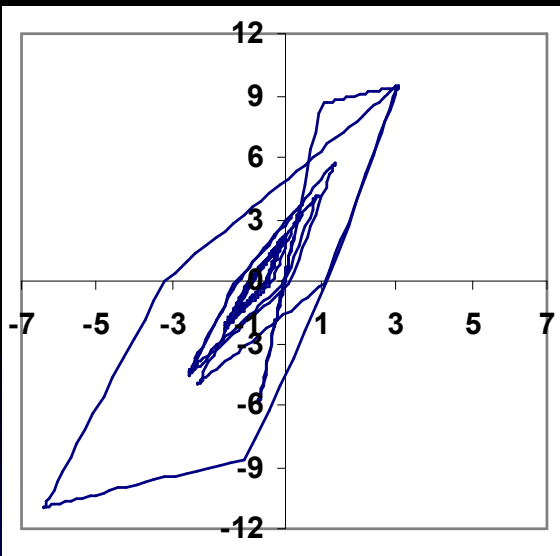
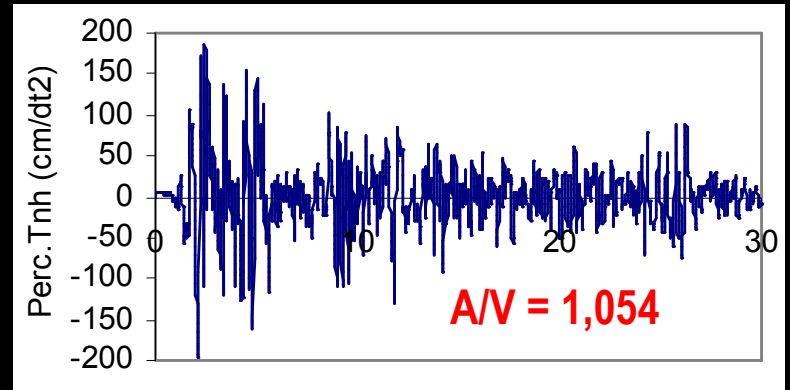
Wattier Narrow Frem E



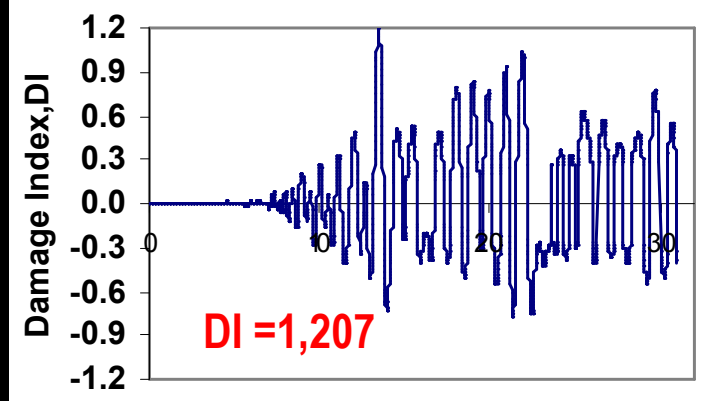
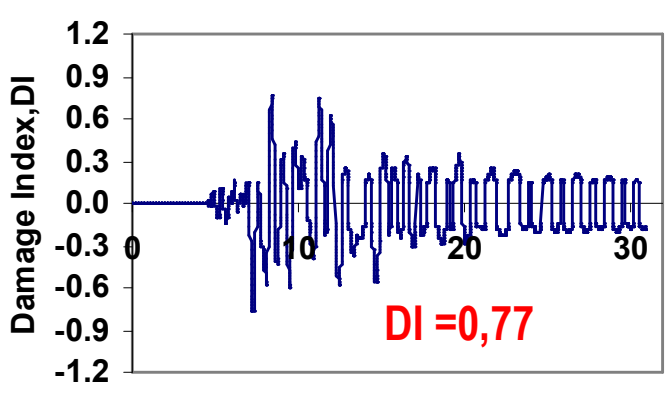
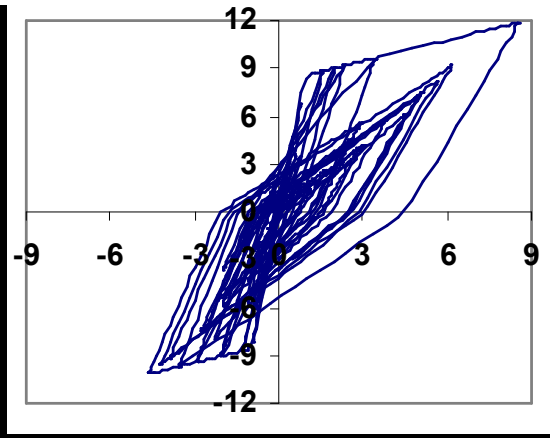
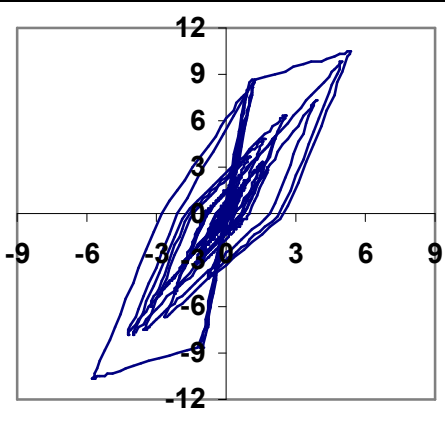
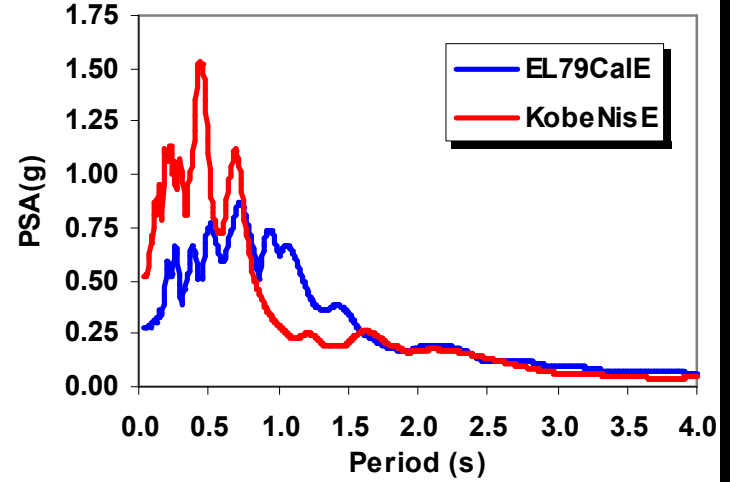
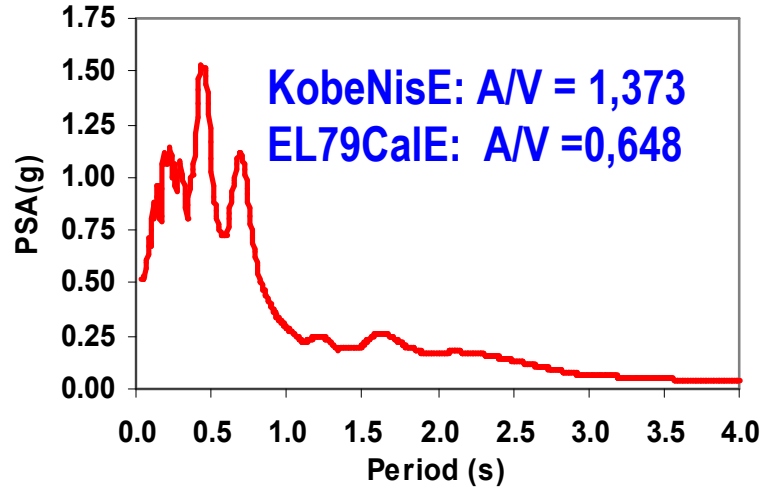
Efek Frequency Content



PGA antara 2-gempa sama yaitu 197,1 cm/dt²



Pengaruh Pseudo Spectral Acceleration (PSA)



10. Kesimpulan

- Sudah diketahui secara umum bahwa Indonesia termasuk wilayah rawan gempa bumi, oleh karenanya studi dan mitigasi bencana gempa bumi sangat diperlukan
- Masih banyak permasalahan kegempaan yang perlu diidentifikasi, diketahui dan dimengerti melalui studi/penelitian yang intensif dan kemudian didesiminasi kepada masyarakat banyak/banyak pihak
- Permasalahan yang dimaksud dapat dikategorikan sebagai site dan structural response akibat gempa, yang kedua-duanya terdapat banyak item bahasan/masalah yang sangat penting untuk diteliti
- Diperlukan banyak kerjasama antar Perguruan Tinggi (PT), Perguruan Tinggi dengan Instansi Pemerintah/Swasta dan masyarakat pemerhati.