SEISMIC AND VOLCANIC HAZARD CONSIDERATION DURING NPP SITING IN INDONESIA

Regional WS on Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements

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Indonesia

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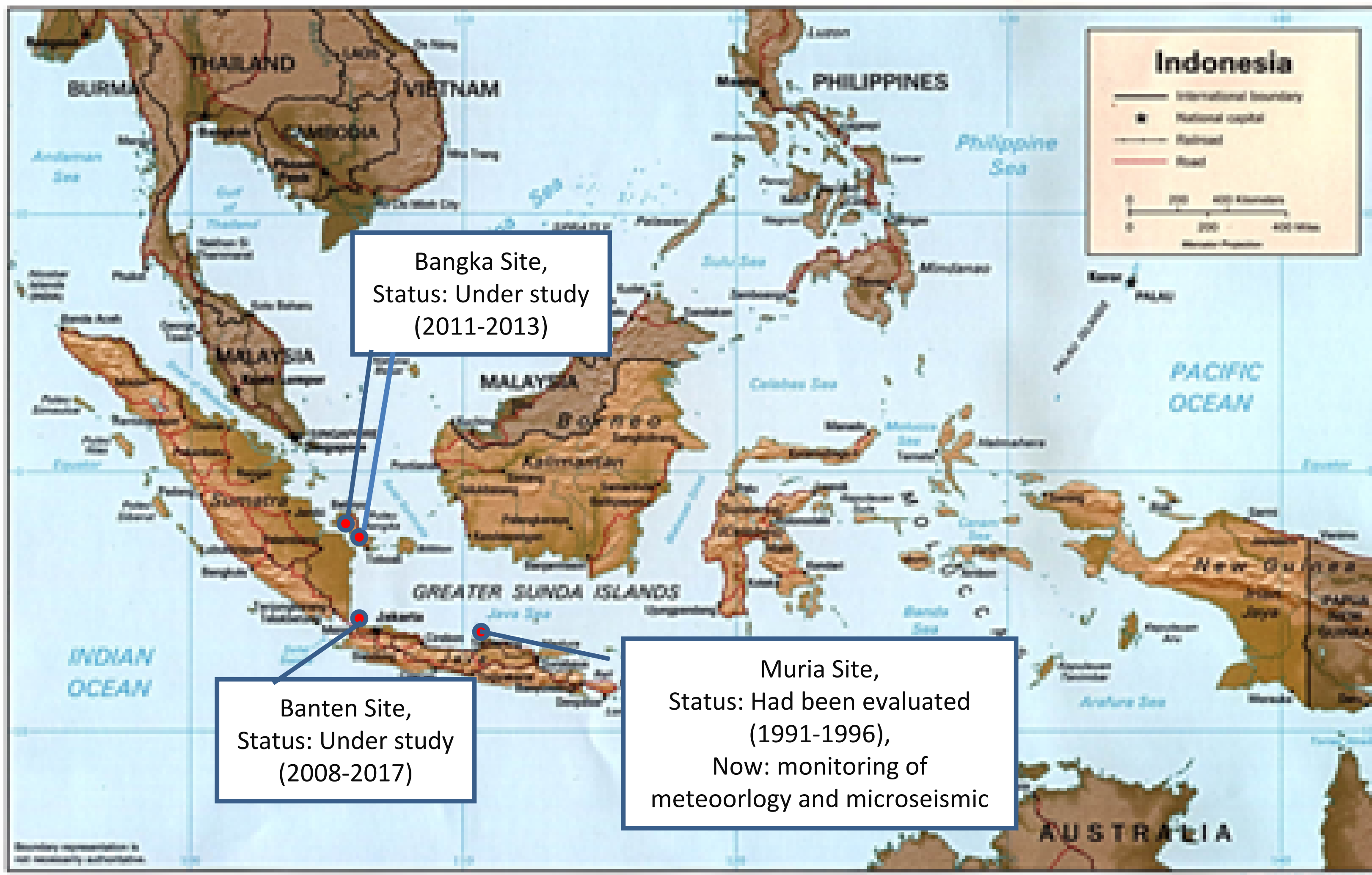
1 Location of Sites

Map of Indonesia



2 Indonesia Regulation

ESTABLISHMENT OF REGULATORY BODY

- BAPETEN was established in 1998 based on the Act No. 10 Year 1997 on Nuclear Energy

Article 4

(1) The Government establishes a Regulatory Body, under and directly responsible to the President. The Regulatory Body shall have the task to control any activity using nuclear energy.

(2) To accomplish the task under clause (1), the Regulatory Body establishes regulations, conduct licensing processes and inspections.

HIERARCHY OF NATIONAL REGULATORY REGARDING THE NPP SITING

Act no 10 Year1997 on Nuclear Energy

↓

GR No 43 Year 2006: Licensing of Nuclear Reactor

↓

Bapeten Chairman decree no 01-P/Ka BAPETEN/VI-99: Guidance for Nuclear Reactor Site Determination

BCR No 5/2007: **Provision for Site Evaluation of Nuclear Reactor** (~NS-R-3)

BCR No 1/2008, **Power Reactor Site Evaluation : Aspects of Seismology (NS-G-3.3)**

BCR No 2/2008, **Power Reactor Site Evaluation** : Aspect of Volcanology (PSSS No 1)

BCR No 3/2008, **Power Reactor Site Evaluation** : Aspect of Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution **(NS-G-3.2)**

BCR No 4/2008 **Power Reactor Site Evaluation** : Aspect of Geotechnics and Foundation (NS-G-3.6)

BCR No 5/2008 **Power Reactor Site Evaluation** : Aspect of Meteorologi (NS-G-3.4)

BCR No 6/2008 **Power Reactor Site Evaluation** : Aspect of External Human Induced Events (NS-G-3.1)

BCR No 6/2008 **Power Reactor Site Evaluation** : Aspect of Flooding (NS-G-3.5)

BCR No 5/2007: General Requirement for Seismic Hazard

In the evaluation of the suitability of a site for a nuclear installation, the following factors should be considered/evaluated:

1. Geological and seismic condition at the region and aspects of geological engineering and geotechnic at the site area
2. Database of Seismic in the site region should be established
3. Seismic hazard should be determined based on the seismotectonic evaluation.
4. Hazards due to earthquake induced ground motion shall be assessed for the site with account taken of the seismotectonic characteristics of the region and specific site conditions.
5. A thorough uncertainty analysis should be performed

BCR No 5/2007: General Requirement for Seismic Hazard (Cont')

In the evaluation of the suitability of a site for a nuclear installation, the following factors should be considered/evaluated:

1. Potential of surface faulting should be considered and evaluated using appropriate method and detail investigation

2. A Fault shall be considered capable if, on the basis of geological, geophysical, geodetic or seismological data, one or more of the following:

   – It shows evidence of past movement or movements (significant deformations and/or dislocations) of a recurring nature within such a period that it is reasonable to infer that further movements at or near the surface could occur. In highly active areas, where both earthquake data and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods may be required
   – A structural relationship with a known capable fault has been demonstrated such that movement of one may cause movement of the other or near the surface
   – The maximum potential earthquake associated with a seismogenic structure is sufficiently large and at such a depth that is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface should occur

BCR No 1/2008: Power Reactor Site Evaluation: Aspect Seismology (status:uder revision)

The geological, geophysical and seismological characteristics of the region around the site and the geotechnical characteristics of the site area should be investigated and evaluated.

Investigations should be conducted on four scales — regional, near regional, site vicinity and site area — thus leading to progressively more detailed investigation

The size of the region to be investigated, the type of information to be collected and the scope and detail of the investigations should be determined according to the nature and complexity of the seismotectonic environment

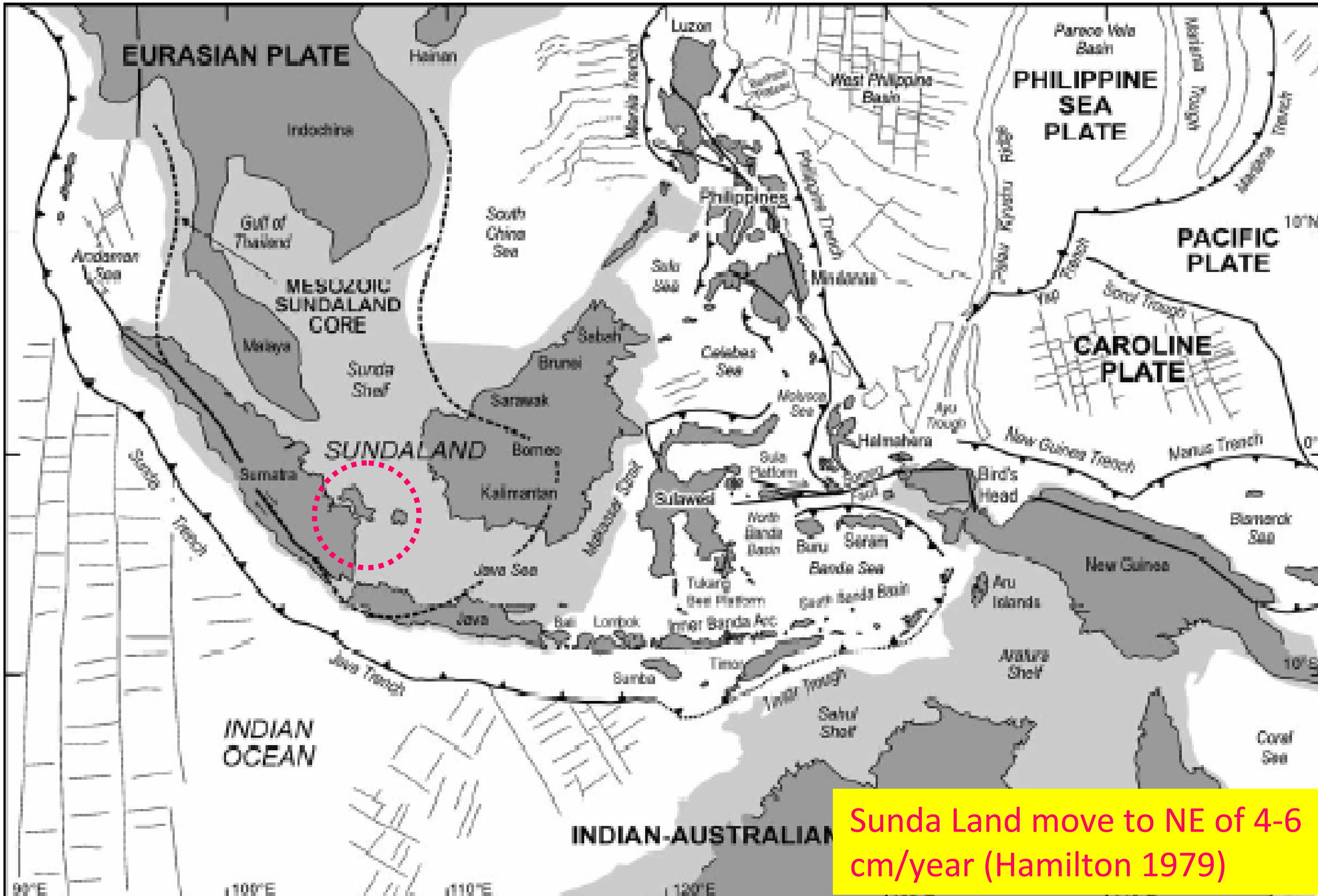
The ultimate purpose of the data compilation and seismic hazard analysis described here is to determine the ground motion and fault displacement hazards for a nuclear power plant site

BCR No 1/2008: Power Reactor Site Evaluation: Aspect Seismology (cont')

- Establishment of Database :
  - Geology
  - Geophysics
  - Geotechnics
  - Seismology: Historical and instrumental data (National and World wide instrumental earthquake catalogues as well site specific instrumental data)
  - Other relevan information to evaluate ground motion, faulting and other geological hazard.
- Database should be in GIS format
- Establishment of **Seismotectonic Model** based on seismological,geophysical and geological databases:
  - Seismogenic
  - Characterization

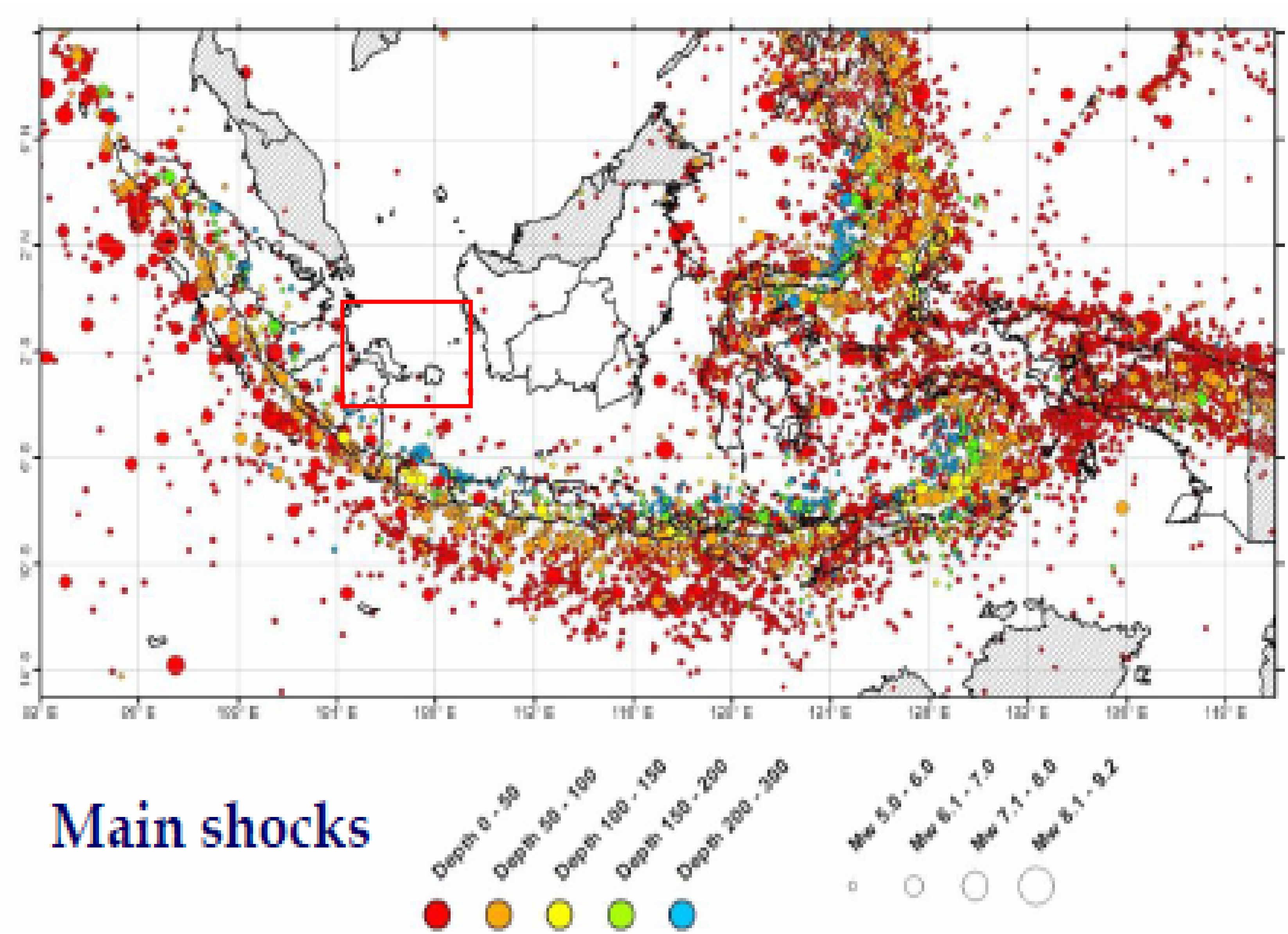
3 Indonesia Geodynamic

TECTONIC SETTING OF INDONESIA

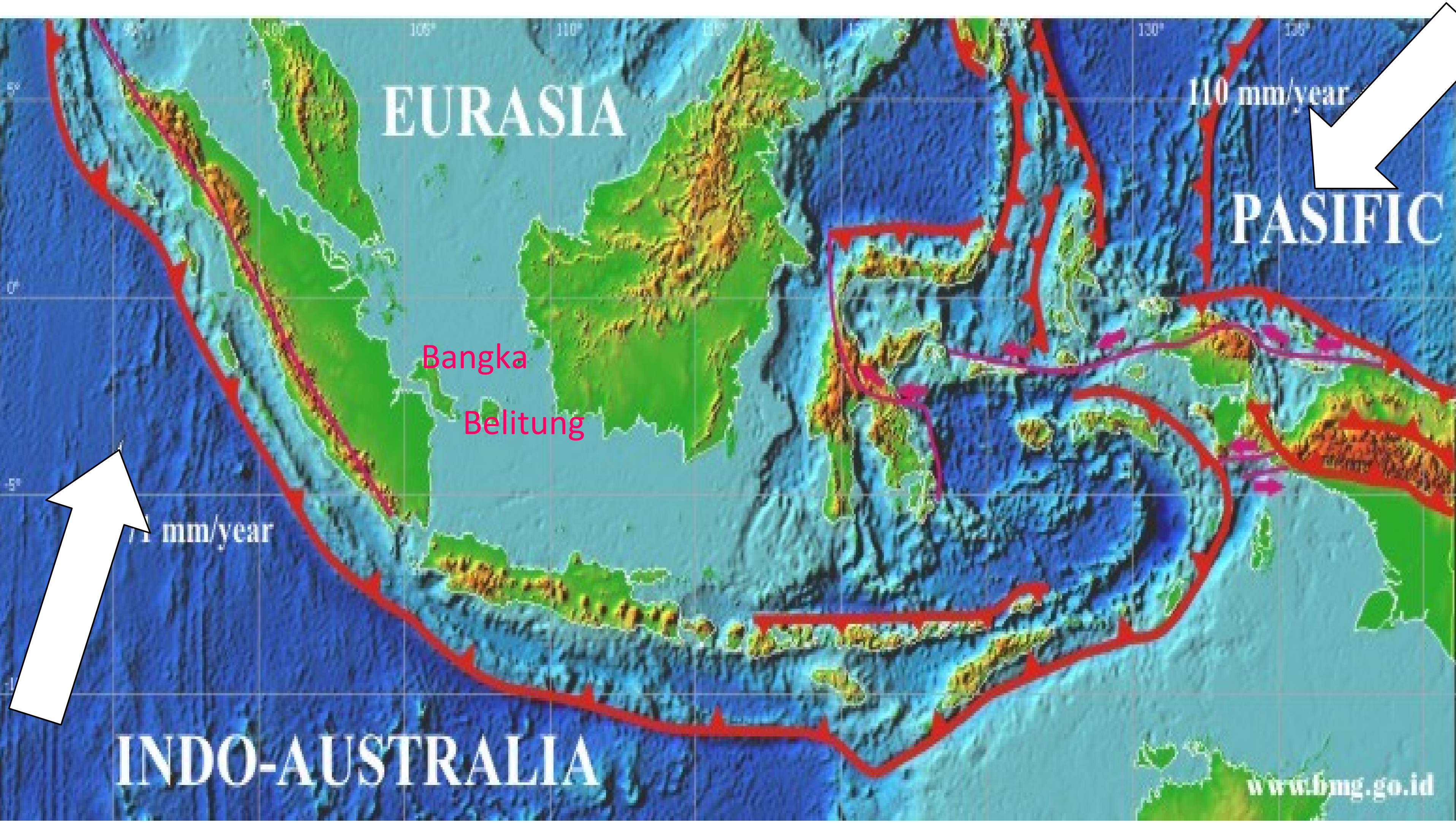


Sunda Land move to NE of 4-6 cm/year (Hamilton 1979)

EARTHQUAKE DISTRIBUTION OF INDONESIA

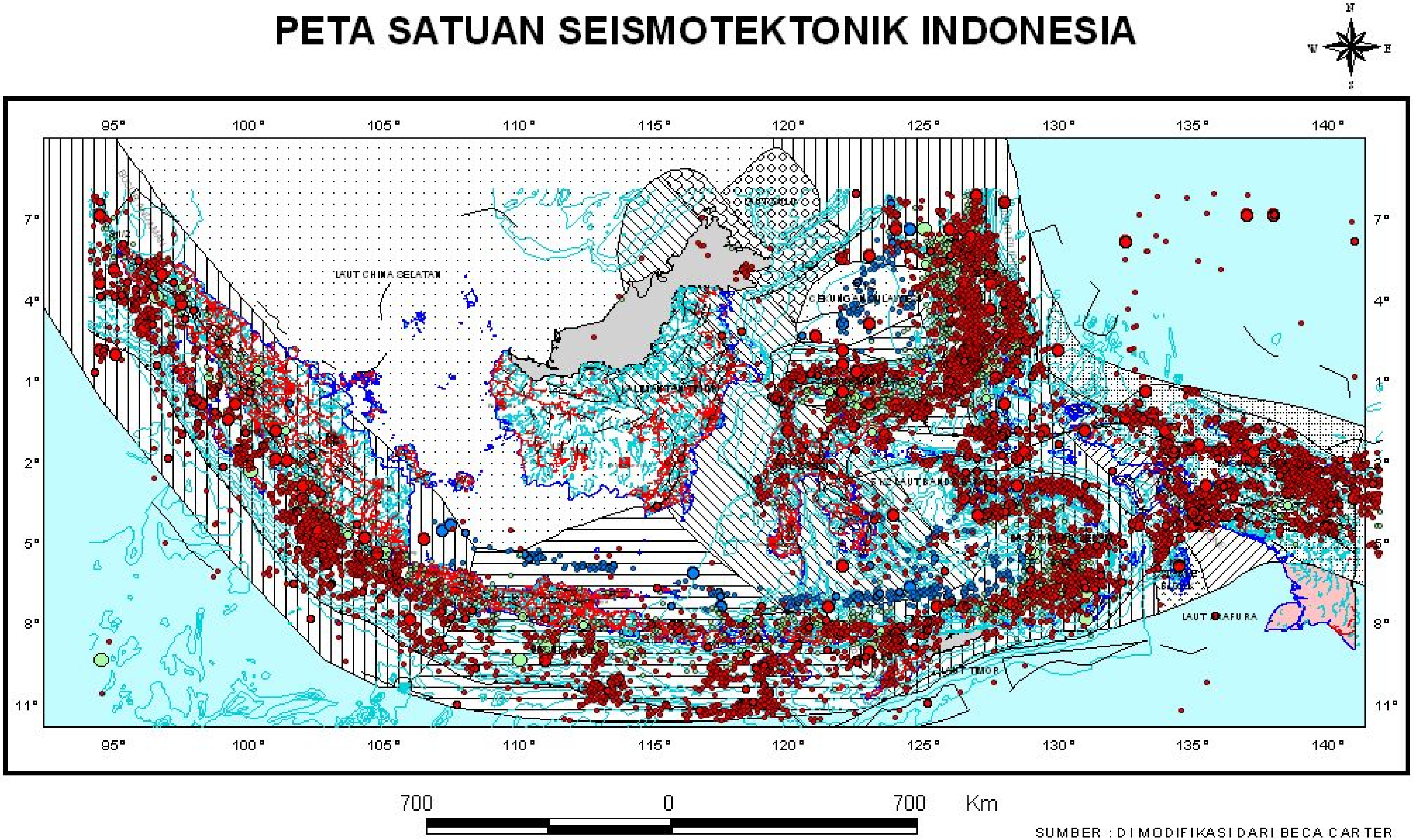


TECTONIC SETTING OF INDONESIA



SEISMOTECTONIC MAP OF INDONESIA

PETA SATUAN SEISMOTEKTONIK INDONESIA



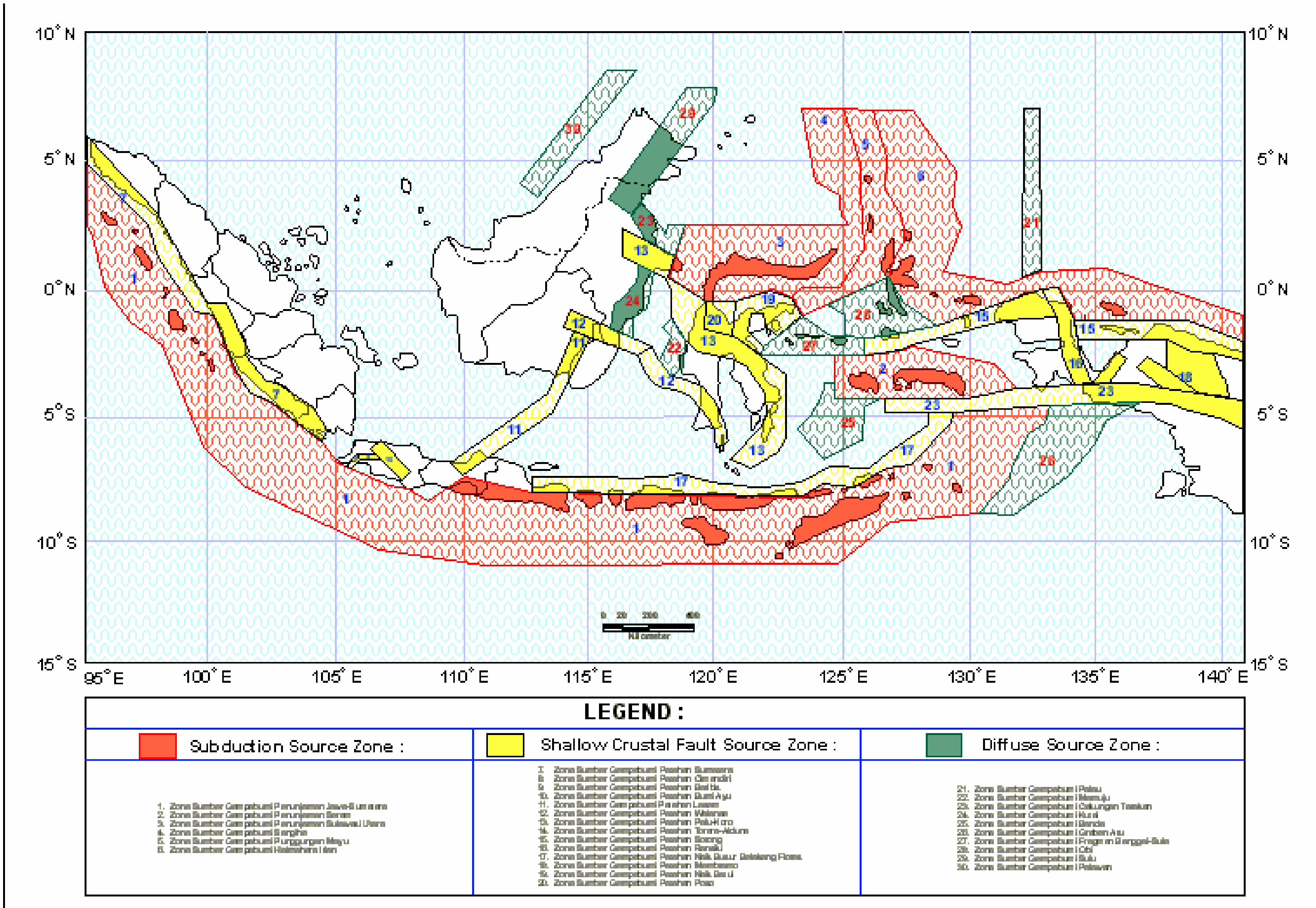
SUMBER : DIMODIFIKASI DARI BECA CARTER HOLLING & FERNER Ltd (1978)

Legenda :

Id daerah arsiran :

- Busur sangat aktif
- Tepian benua aktif
- Busur aktif
- Lajur perlipatan dan hancuran
- Lajur lipatan lemah dan hancuran
- Punggungan aktif
- Blok aktif
- Daerah deformasi
- Daerah stabil
- Batas Pantai
- Luar Indonesia

SEISMIC ZONE OF INDONESIA

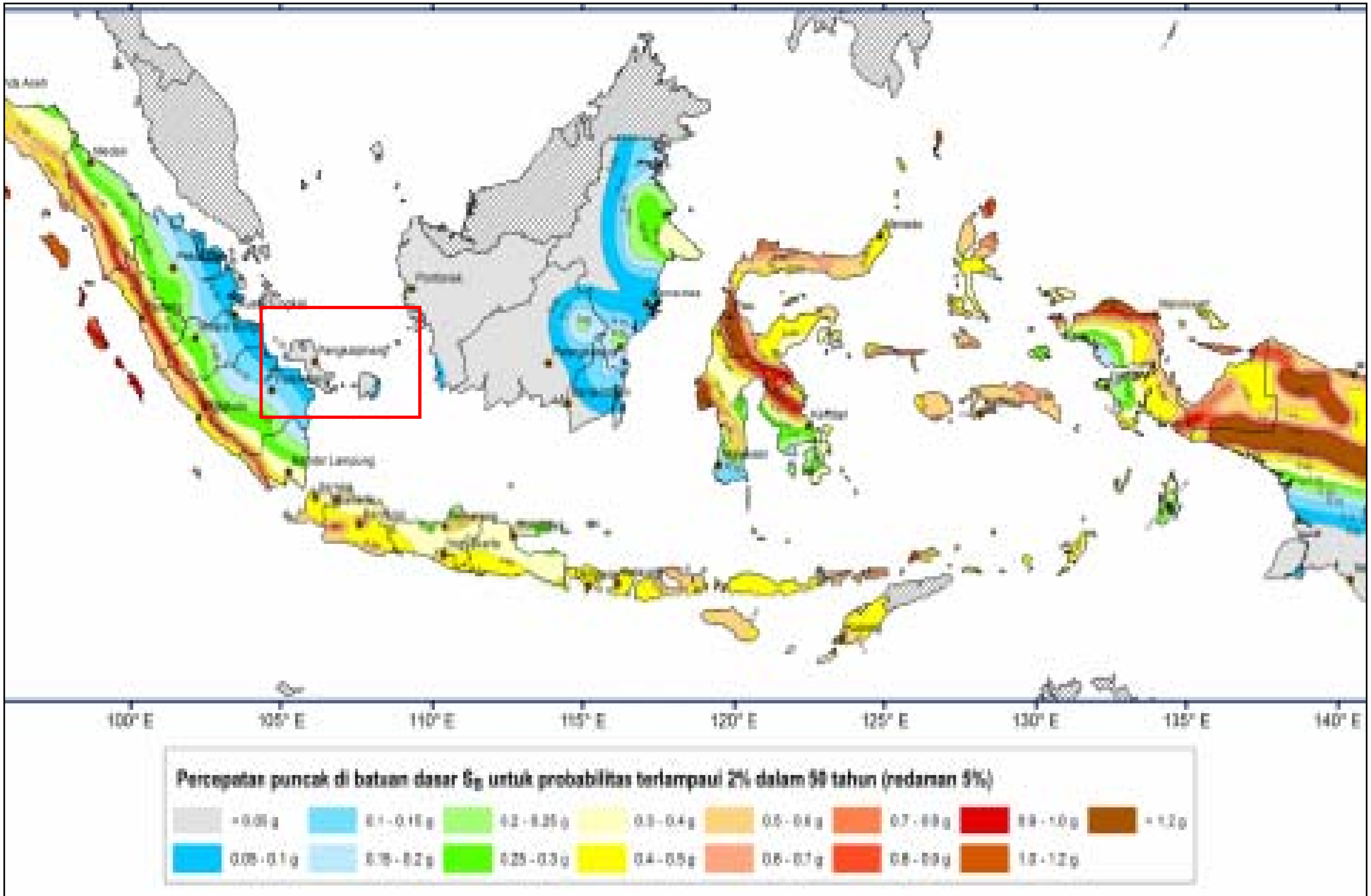


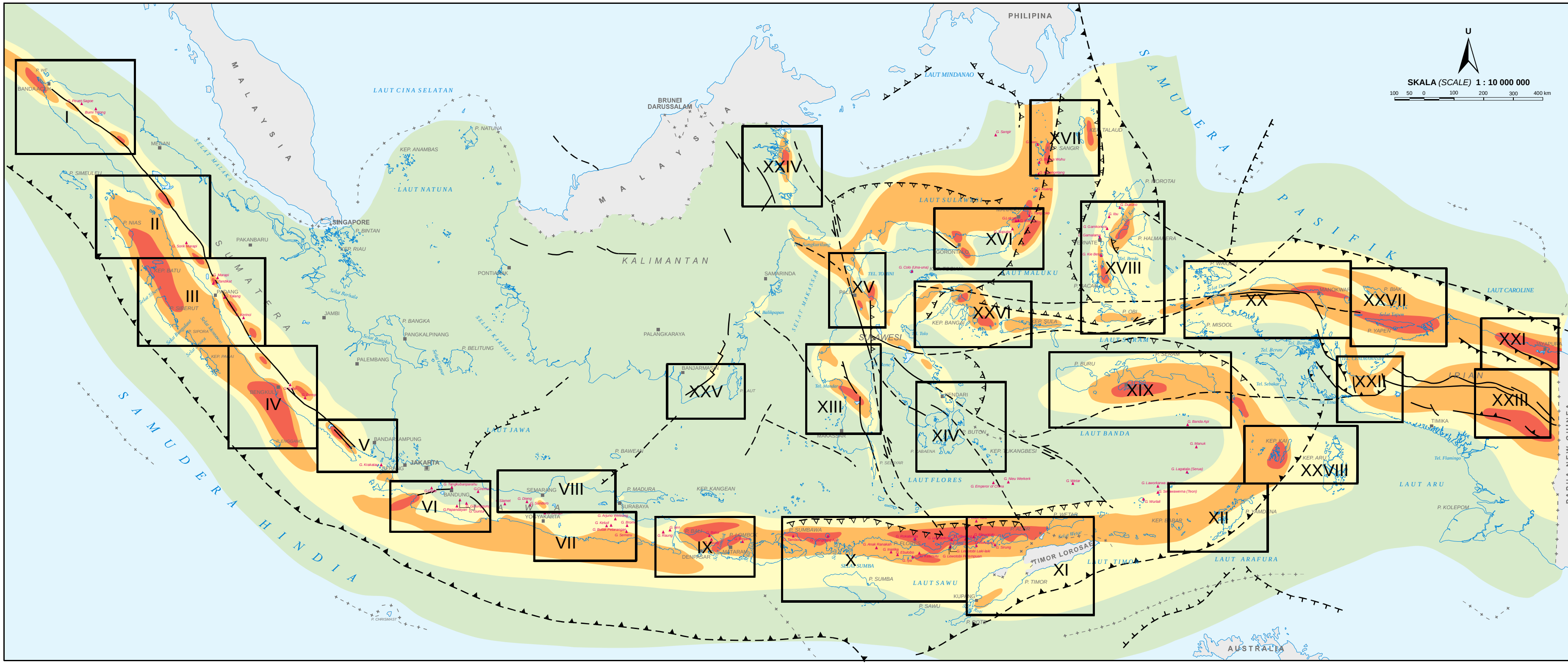
Kertapati, 2000

Figure2. Seismic Source Area For Development of Seismic Hazard Map of Indonesia

Peak Ground Acceleration (PGA) of Indonesia

Peak Ground Acceleration (PGA) of Indonesia for 2% probability of exceedance in 50 years (2,500 years earthquake)
(Masyhur Irsyam, 2010)





SKALA *(SCALE)* MMI

MMI < V	MMI V- VI	MMI VI- VII	MMI >VII

PETA RAWAN BENCANA GEMPABUMI

Sesar utama di darat
Main fault on land

Sesar sungkup utama di darat
Main thrustfault on land

Sesar utama lepas pantai
Main fault offshore

Sesar turun lepas pantai
Normal fault offshore

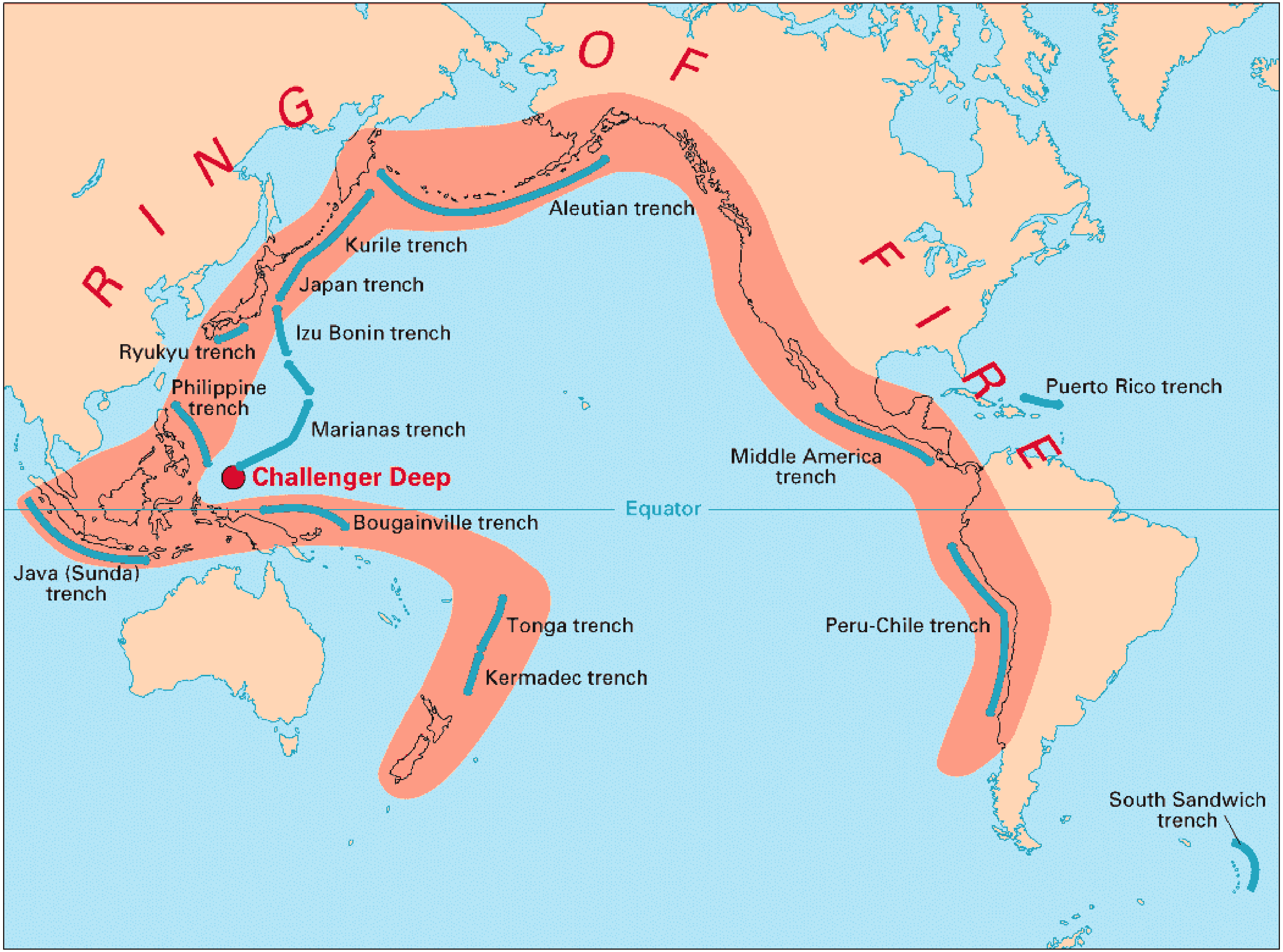
Sesar belakang busur lepas pantai
Back-Arc thrust offshore

Lajur tunjaman lepas pantai
Subduction zone offshore

NOMOR WILAYAH GEMPABUMI MERUSAK
REGION NUMBER OF DESTRUCTIVE EARTHQUAKE

I	Aceh
II	Sumatera Utara *(North)*
III	Sumatera Barat *(West)*
IV	Bengkulu
V	Lampung
VI	Jawa Barat *(West)*
VII	Yogyakarta
VIII	Lasem
IX	Bali - Lombo
X	Flores - Sumbawa
XI	Timor - Alor
XII	Yamdena
XIII	Sulawesi Selatan *(South)*
XIV	Sulawesi Tenggara *(Southeast)*
XV	Sulawesi Tengah *(Central)*
XVI	Sulawesi Utara *(North)*
XVII	Sangir & Talaud
XVIII	Halmahera
XIX	Ambon
XX	Kepala Burung *(Bird Head)*
XXI	Jayapura
XXII	Paniai & Nabire
XXIII	Wamena (Jayawijaya)
XXIV	Tarakan
XXV	Kalimantan Selatan *(South)*
XXVI	Peleng
XXVII	Biak
XXVIII	Aru

Pacific Ring of Fire (USGS)



4 Criteria and Requirements

4a Criteria and Requirements for Seismotectonic

DEFINITION AND CRITERIA OF CAPABLE FAULT

Definition:

Faults that have the potential to significantly for displacement on or near the ground surface

Age of capable fault to be 120,000 -130,000 year, or in seismic reflection is the boundary between Quaternary 2 (Q2) which is assumed to 126,000 year ago (after the Pleistocene)

Criteria:

- In the site vicinity, there are should be no capable faults
- PGA in the site with return period 2500 year < 0.5 g

Criteria of Seismotectonic

IAEA SSG-9

- Capable Fault: A fault that has a significant potential for displacement at or near the ground surface.
- In highly active areas, where both earthquake data and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years (e.g. Upper Pleistocene–Holocene, i.e. the present) may be appropriate for the assessment of capable faults.

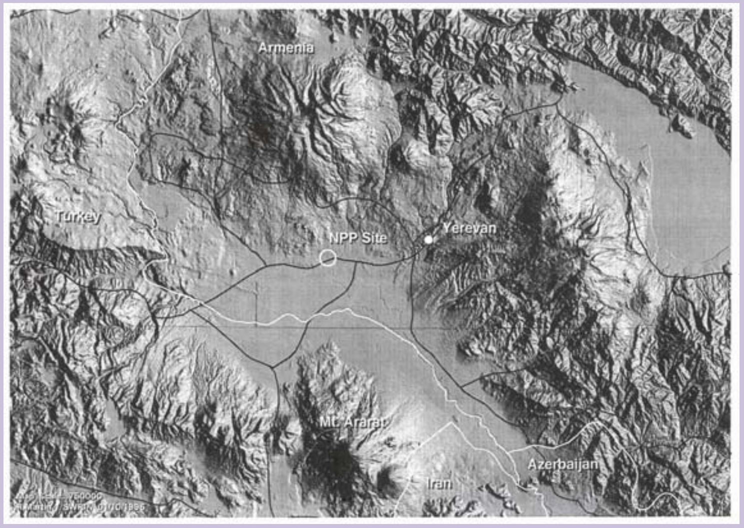
Criteria of Seismotectonic

US NRC 10 CFR 100

- A *capable fault* is a fault which has exhibited one or more of the following characteristics:
  - Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years.
  - Macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.
  - A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

- Japan Regulation
- The former Seismic Guide required that active faults (*2) in “the past 50 thousand years” be taken into account in seismic design. The revised Seismic Guide requires consideration of all active faults in the design, which might have raised the likelihood of seismic activities in the late Pleistocene age (“the past 120-130 thousand years”).

4b Criteria and Requirements for Volcanology



Definition and Criteria of Capable Volcano

- Definition of Capable Volcano:
  - Historical volcanic activity (volcanic activity 1600 a.d., Indonesia type A)
  - Manifestation of magmatic activity at present (Indonesia: Type B and C). Type B is characterized by its cone morphology, while type C is characterized by fumarolic activity but unclear cone morphology
  - Composite and monogenetics type that have age less than 2 M.a. need to be confirmed both probabilistic and deterministic approach to evaluate their reactivation of capabilities.
  - Last activity time < maximum repose interval
  - Quaternary Composite Type, Pliocene Caldera Type should be assessed in both problst. and detm. approach
- Criteria
  - Potential site is not located in the SDV radius of capable volcano such as phyroclastic flow, phyroclastic fall, lava flow

Definition and Criteria of Capable Volcano

- IAEA DS 405
  - 2.16. The concept of the capable volcano is introduced to define the potential of a volcano or volcanic field to produce hazardous phenomena that may affect the site of a nuclear installation.
  - A capable volcano or volcanic field is one that
    - (1) may experience volcanic activity during the performance period of the nuclear installation and
    - (2) such an event has the potential to produce phenomena that may affect the site of the nuclear installation.

- PERKA BAPETEN 02/2008
  - Gunung api aktif (active volcano) adalah gunung api yang meletus, mempunyai riwayat letusan atau bukti lain bahwa gunung api tersebut tidak diam atau tidak sedang istirahat.
  - Gunung api yang memiliki kapabilitas (capable volcano) adalah gunung api yang sangat mungkin aktif di masa mendatang selama umur reaktor daya.

Definition and Criteria of Capable Volcano: Methodological Approach (DS 455)

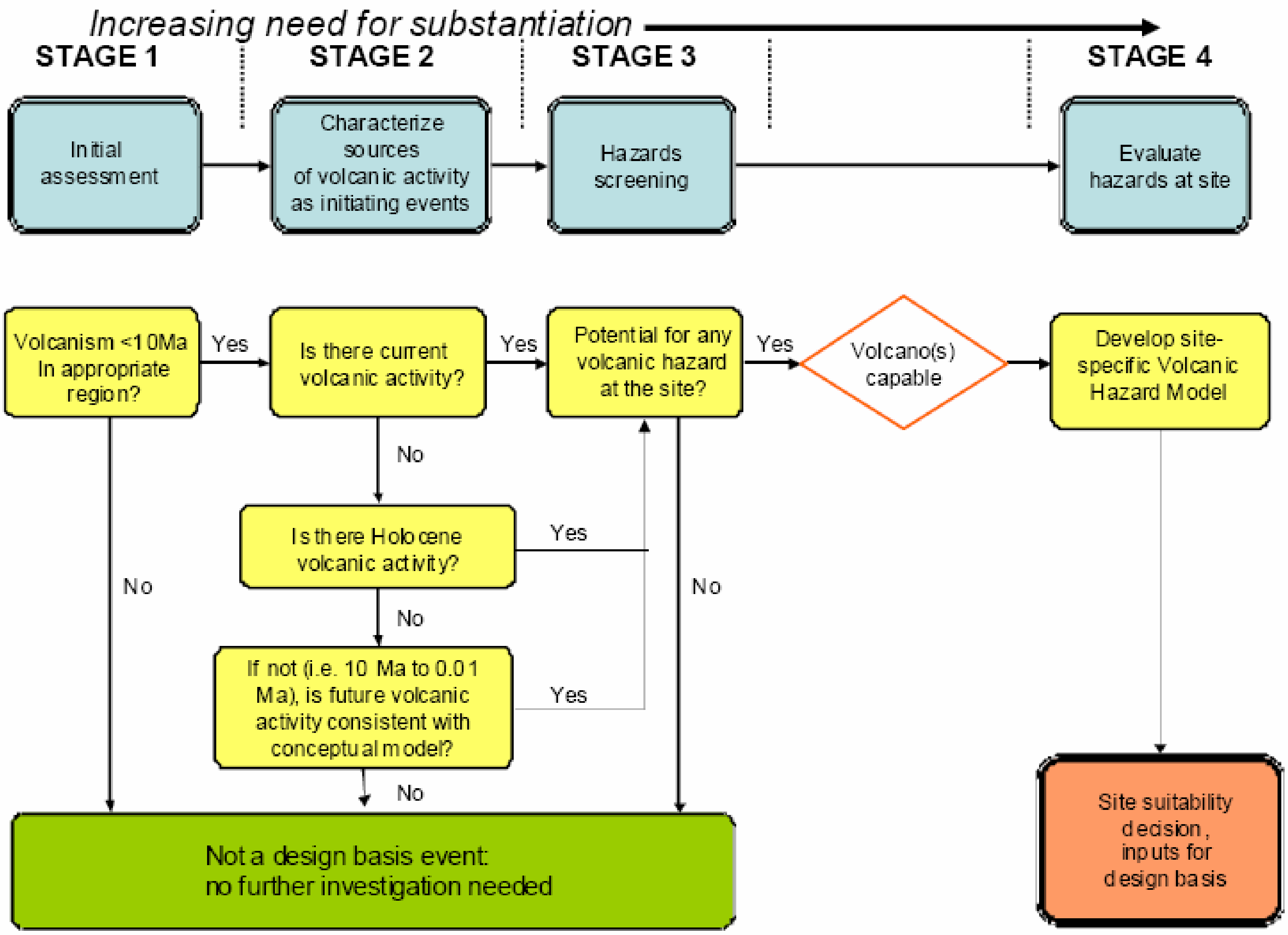


Table 1. Volcanic phenomena and associated characteristics that could affect nuclear installations, with implications for site selection and evaluation, and design.

Phenomena	Potentially Adverse Characteristics for Nuclear Installations	Considered as exclusion criteria at Site Selection Stage	Can Design[1] and Operation mitigate the effects?
Tephra fall	Static physical loads, abrasive and corrosive particles in air and water	No	Yes
Pyroclastic density currents: Pyroclastic flows, surges, and blasts	Dynamic physical loads, atmospheric overpressures, projectile impacts, temperatures >300 °C, abrasive particles, toxic gases	Yes	No
Lava flows and lava domes	Dynamic physical loads, water impoundments and floods, temperatures > 700 °C	Yes	No
Debris avalanches, landslides and slope failures	Dynamic physical loads, atmospheric overpressures, projectile impacts, water impoundments and floods	Yes	No
Debris flows and lahars, floods	Dynamic physical loads, water impoundments and floods, suspended particulates in water	Yes	Yes
Opening of new vents	Dynamic physical loads, ground deformation, volcanic earthquakes	Yes	No
Volcano generated Missiles	Particle impacts, static physical loads, abrasive particles in water	Yes	Yes
Volcanic gases and aerosols	Toxic and corrosive gases, water contamination, gas-charged lakes	No	Yes
Tsunamis, seiches, crater lake failure, glacial burst	Water inundation	Yes	Yes
Atmospheric phenomena	Dynamic overpressures, lightning strikes, downburst winds	No	Yes
Ground deformation	Ground displacements > 1 m, landslides	Yes	No
Volcanic earthquakes and seismic events	Continuous tremor, multiple shocks, usually < M 5	No	Yes
Hydrothermal systems and groundwater anomalies	Thermal water > 50 °C, corrosive water, water contamination, water inundation or upwelling, alteration, landslides	Yes	No

Note: A *Yes* in the site selection stage column indicates that the presence of a significant hazard from this phenomenon generally constitutes a site exclusion criterion, i.e. the site is not suitable for locating a nuclear installation. The design and operation column indicates the general practicality of mitigating potential hazard associated with particular phenomena, by either facility design or operational planning. A *Yes* in both columns indicates that although a design basis may be achievable, sites with this hazard are usually avoided. Volcanism is a complex process and one type of phenomena often gives rise to another.

Scale of Seismotectonic and Volcanic Investigation

Site vicinity

Objectives:
- Neotectonic fault history
- Potential for surface faulting

Near regional scale

Objectives:
- Detailed seismotectonic characterization
- Latest faults movements

Regional scale

Objectives:
- General geodynamic setting
- Characterization of geological features
- Delineation of seismogenic sources

Site area
(~1 km²)

Objectives:
- Permanent ground displacement
- Dynamic properties of foundation materials

5 km
(maps scale 1:5 000)

25 km
(maps scale 1:50 000)

300-500 km
(maps scale 1:500 000)

A need for application of increased efforts

5 Implementation of Seismotectonic Study during NPP Siting

SEISMOTECTONIC INVESTIGATION
TO CONFIRM SUPPOSED CAPABLE FAULT

Identify all active faults from scientific publications

Regional tectonics pattern

Interpretation of topographic data and satellite imagery: grouping of old fault, active fault, possible active

Lineament

Field confirmation to identify the lineament: fault plane, brecsiation track, measurement of fractures, kinematics analysis, etc

Confirmation: Seismic catalogues

Geophisics survey: Geoelectric, gravity, geomagnet, seismic refraction, CSAMT, etc

Geophisics survey: Seismic Reflection

Age Dating

Microearthquake monitoring

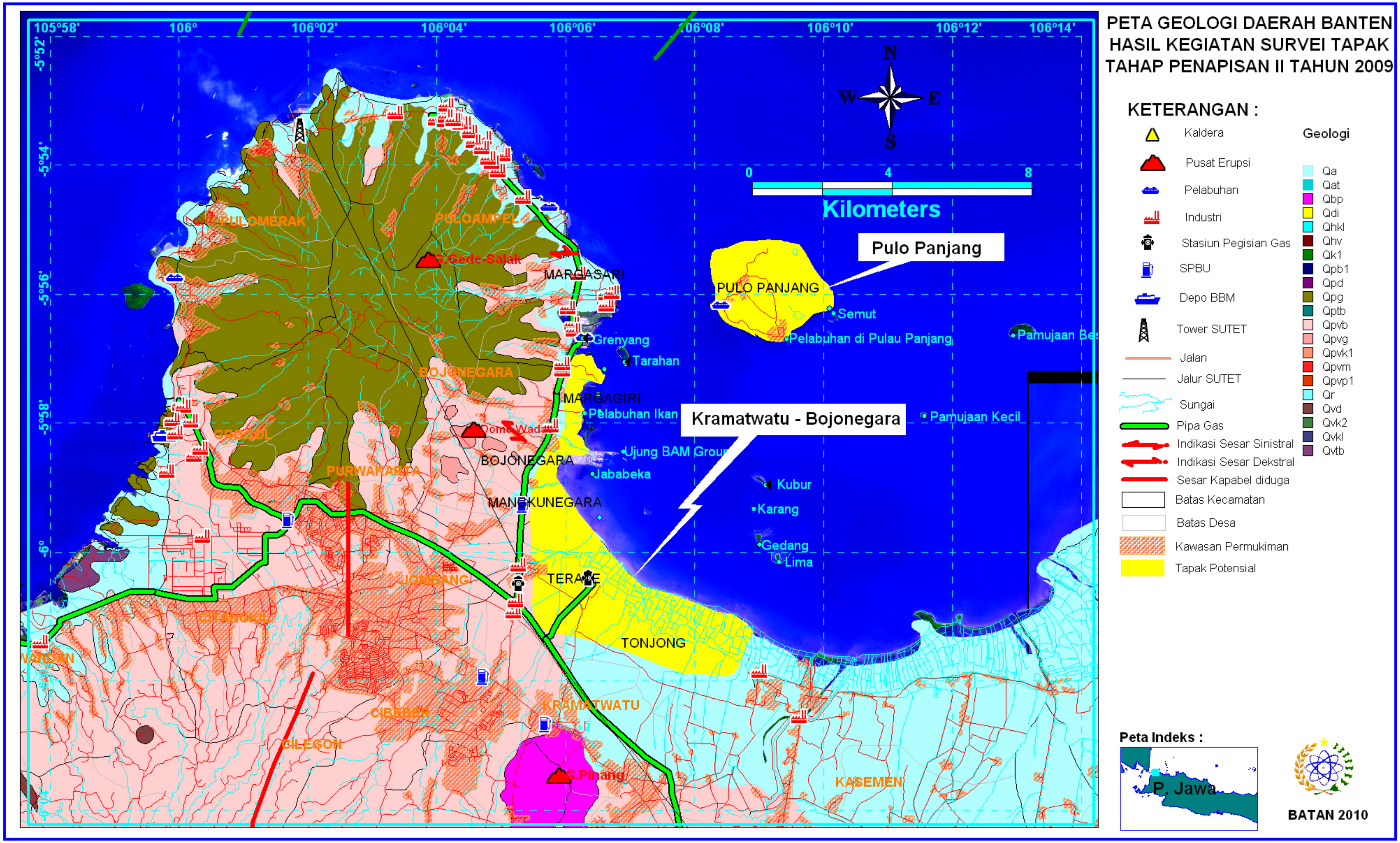
Trenching

Morphometry Analysis

CONCEPT OF TECTONIC IN THE SITE : Fault pattern and characteristics as the basis for PSHA and DSHA

CASE STUDY: BANTEN SITE

BANTEN SITE


PETA GEOLOGI DAERAH BANTEN
HASIL KEGIATAN SURVEI TAPAK
TAHAP PENAPISAN II TAHUN 2009
KETERANGAN :
Kaldera
Pusat Erupsi
Pelabuhan
Industri
Stasiun Pegisian Gas
SPBU
Depo BBM
Tower SUTET
Jalan
Jalur SUTET
Sungai
Pipa Gas
Indikasi Sesar Sinistral
Indikasi Sesar Dekstral
Sesar Kapabel diduga
Batas Kecamatan
Batas Desa
Kawasan Permukiman
Tapak Potensial
Geologi
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Qat
Qbp
Qdi
Qhkl
Qhv
Qk1
Qpb1
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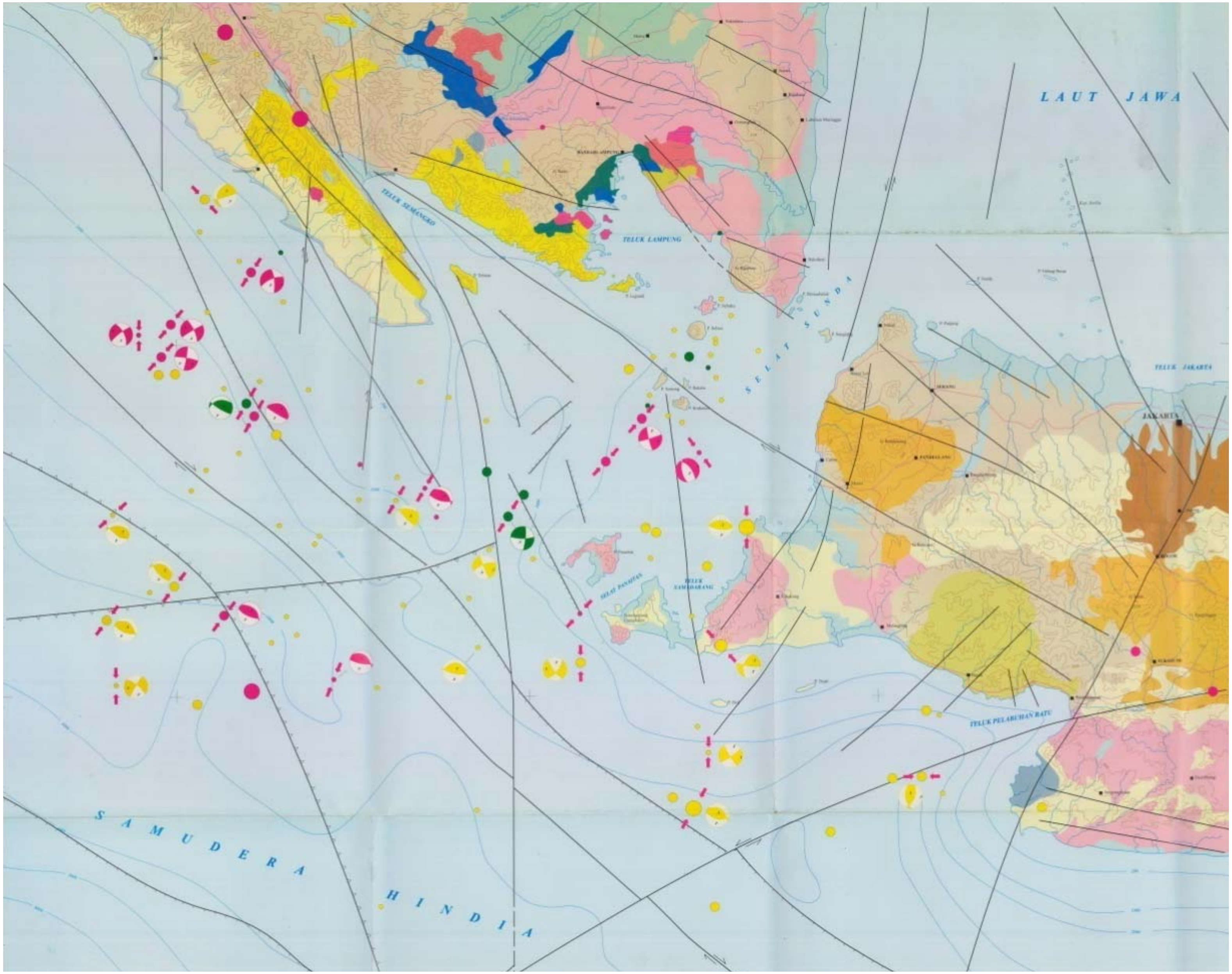
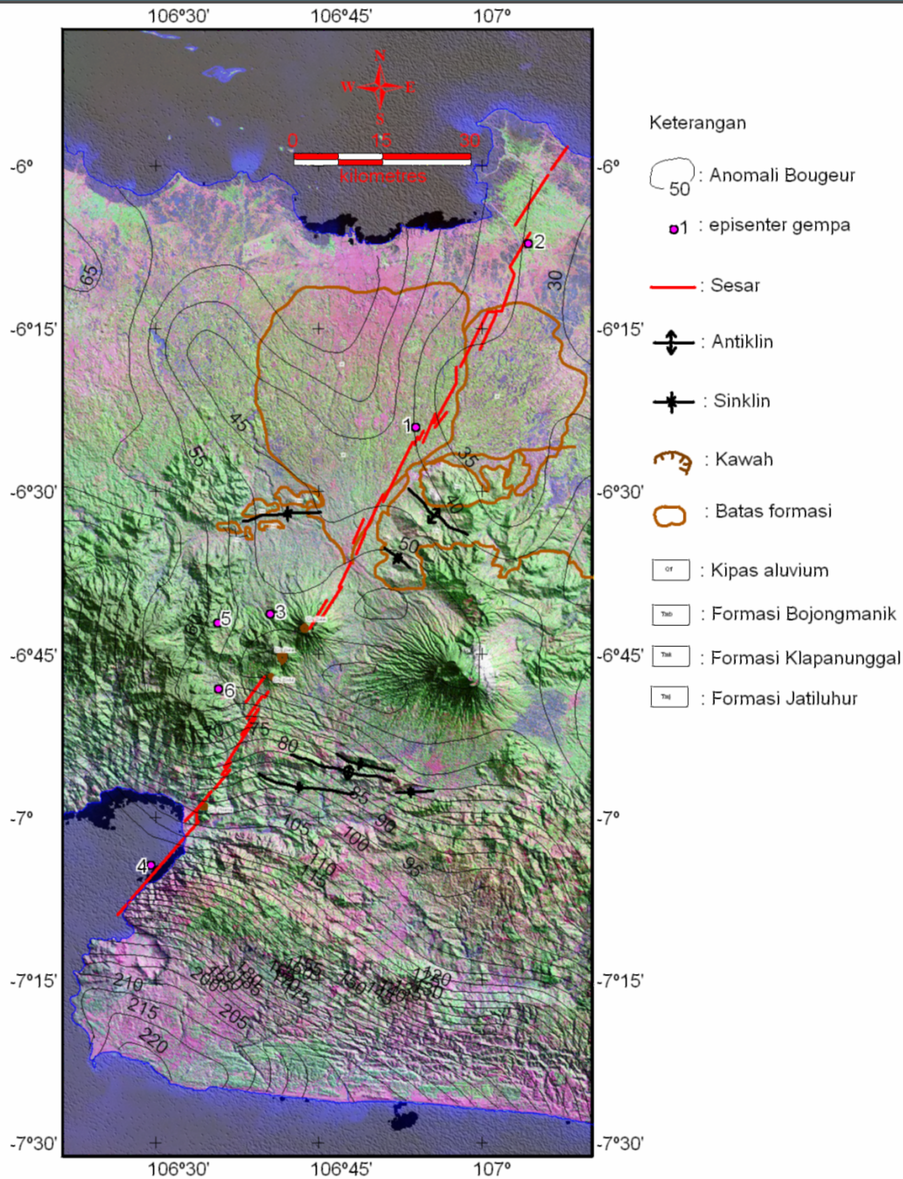
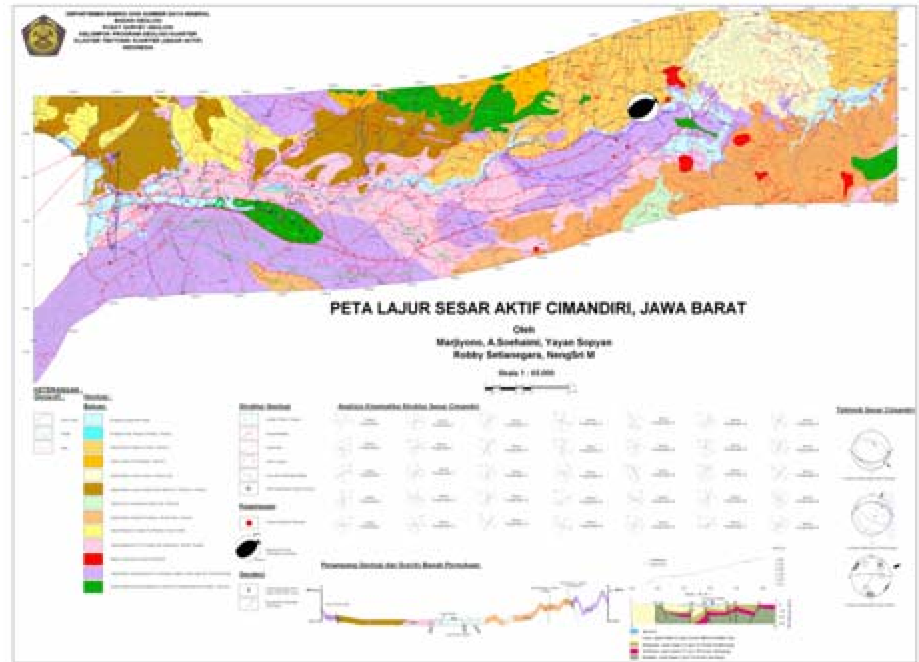
Pulo Panjang
Kramatwatu - Bojonegara
PULO PANJANG
Semut
Pelabuhan di Pulau Panjang
Pamujaan Kecil
Kubur
Karang
Gedang
Lima
Grenyang
Tarahan
Pelabuhan Ikan
Ujung BAM Group
Jababeka
PULOMERAK
PULOAMPEL
G.Gede-Salak
MARGASARI
BOJONEGARA
MARGAGIRI
GROGOL
PURWAKARTA
MANGKUNEGARA
JOMBANG
TERATE
TONJONG
CIBEBER
CILEGON
KRAMATWATU
G.Pinang
KASEMEN
105°58'
106°
106°02'
106°04'
106°06'
106°08'
106°10'
106°12'
106°14'
-5°52'
-5°54'
-5°56'
-5°58'
-6°

IDENTIFICATION OF FAULTS BASED ON SCIENTIFIC PUBLICATION (Suhaemi, 2004)

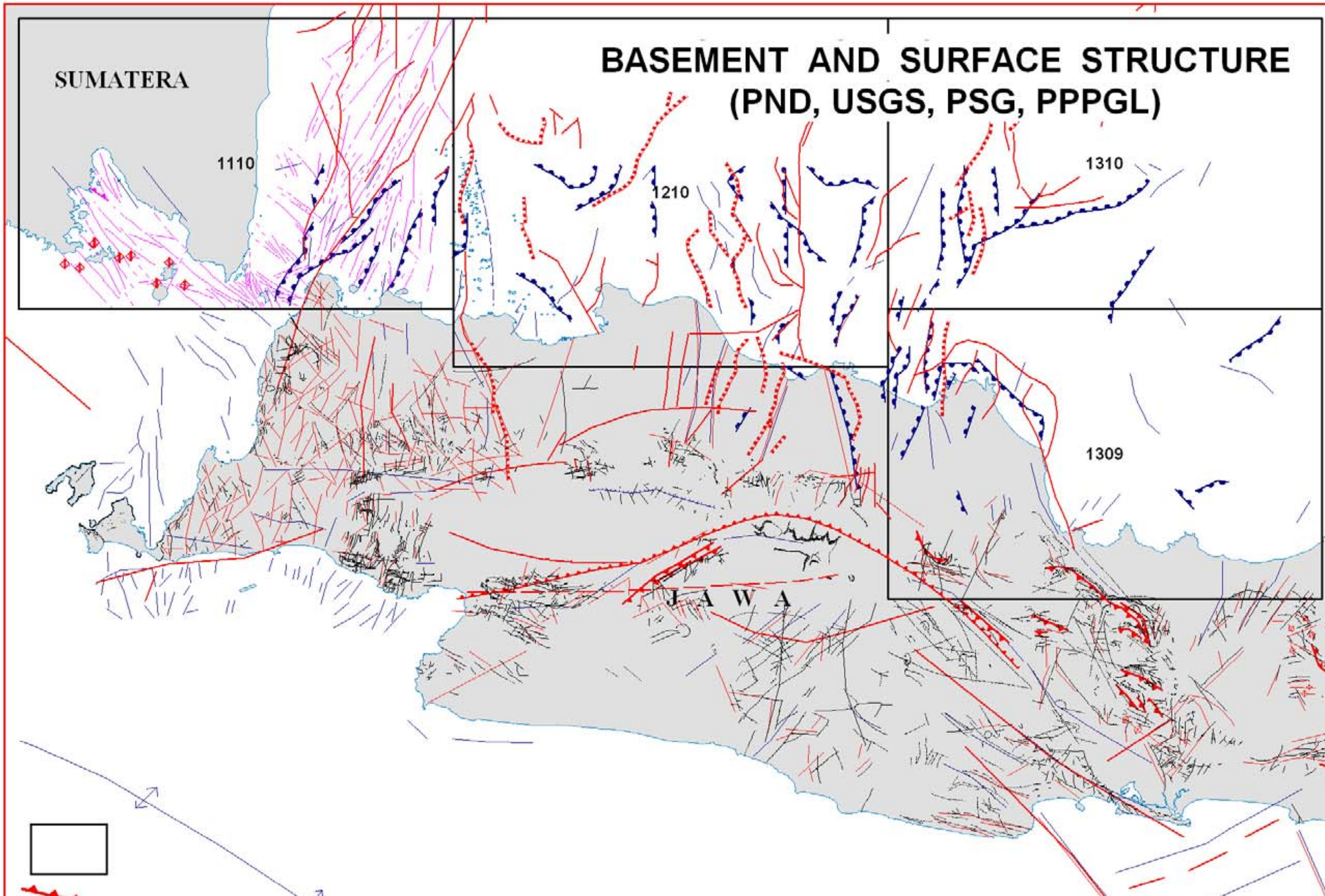


IDENTIFICATION OF FAULTS BASED ON SCIENTIFIC PUBLICATION, CITARIK (Sidarto, 2008) AND CIMANDIRI FAULT (SUHAEMI, 2008)

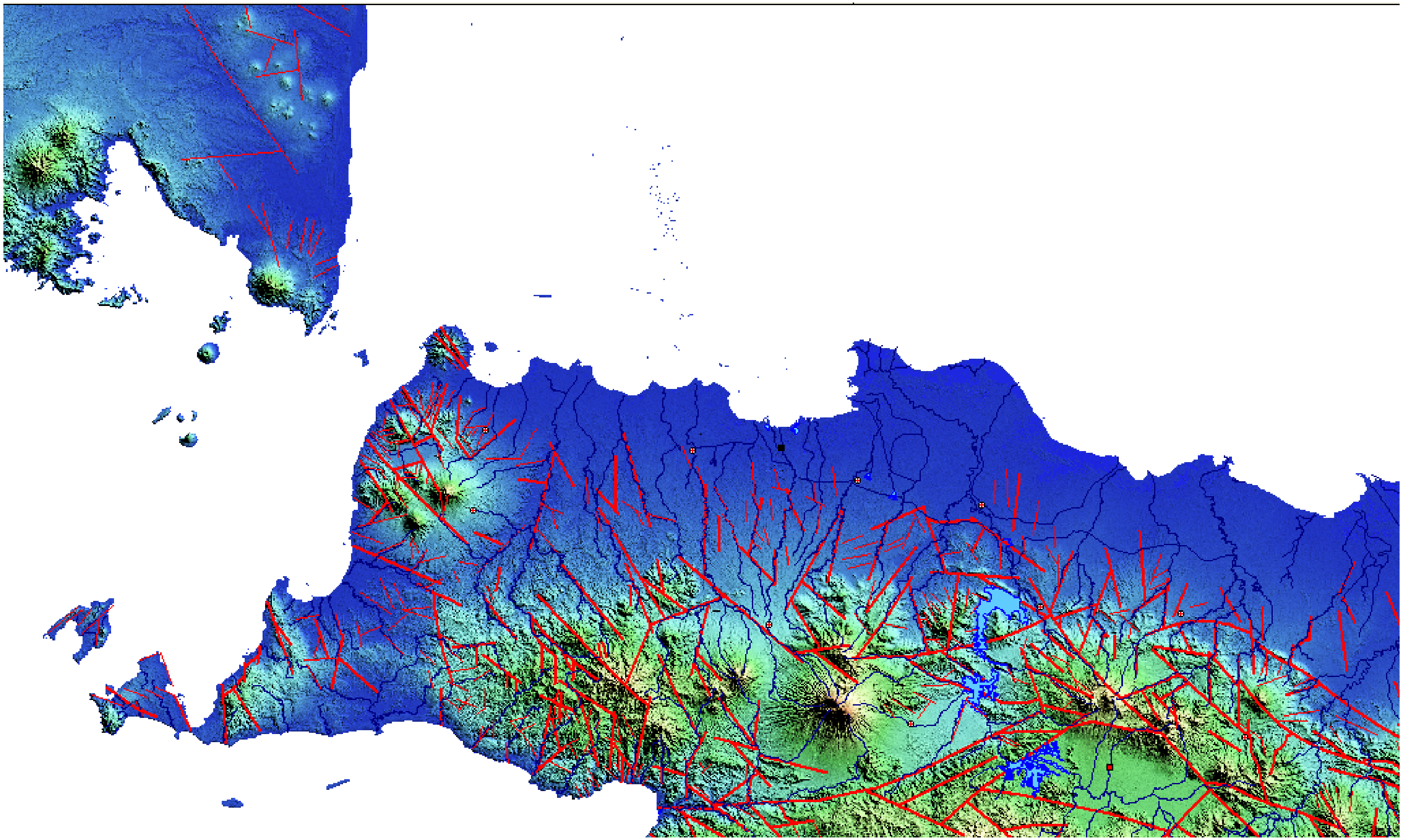




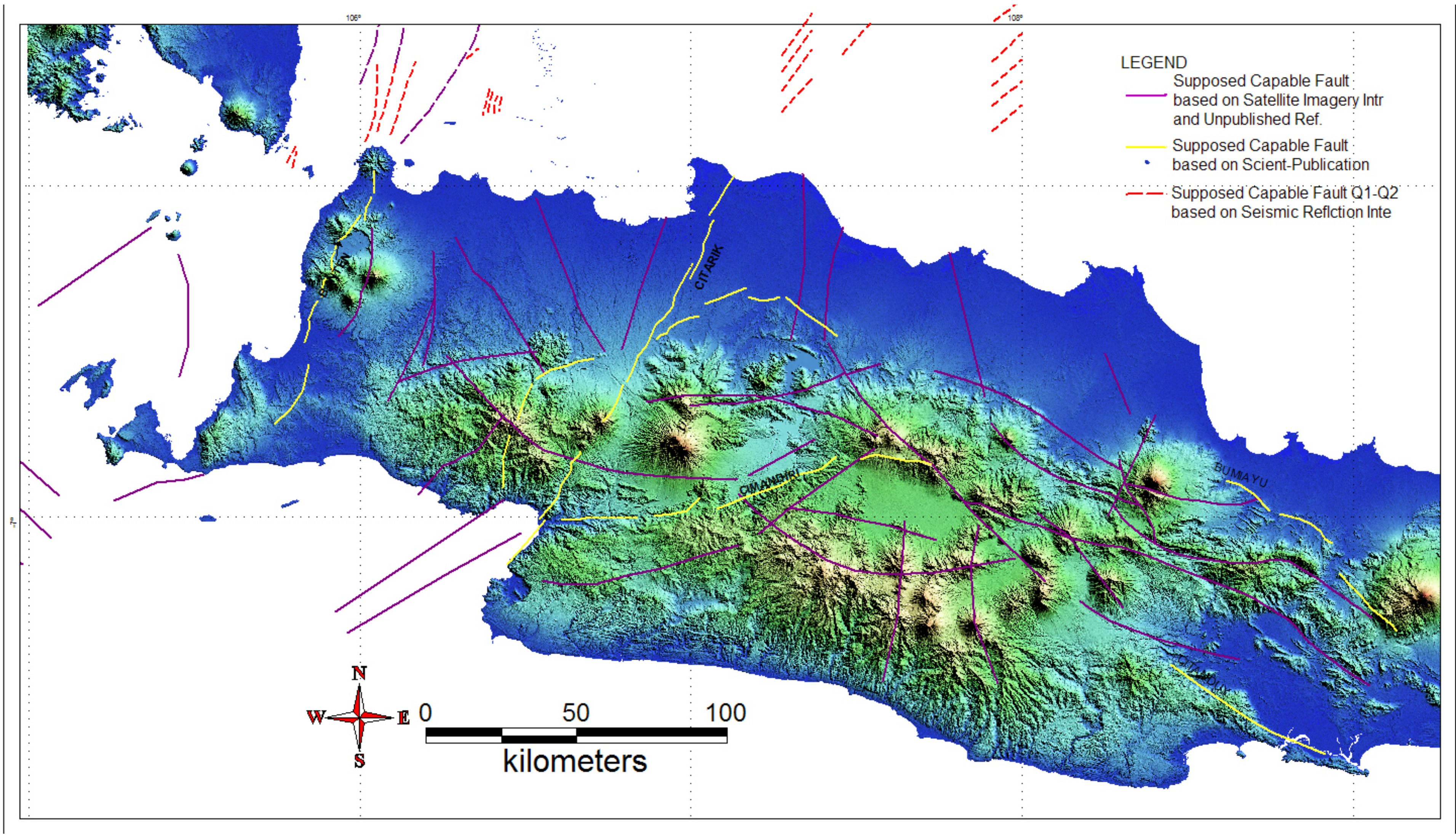
REGIONAL TECTONIC MAP (Reference)



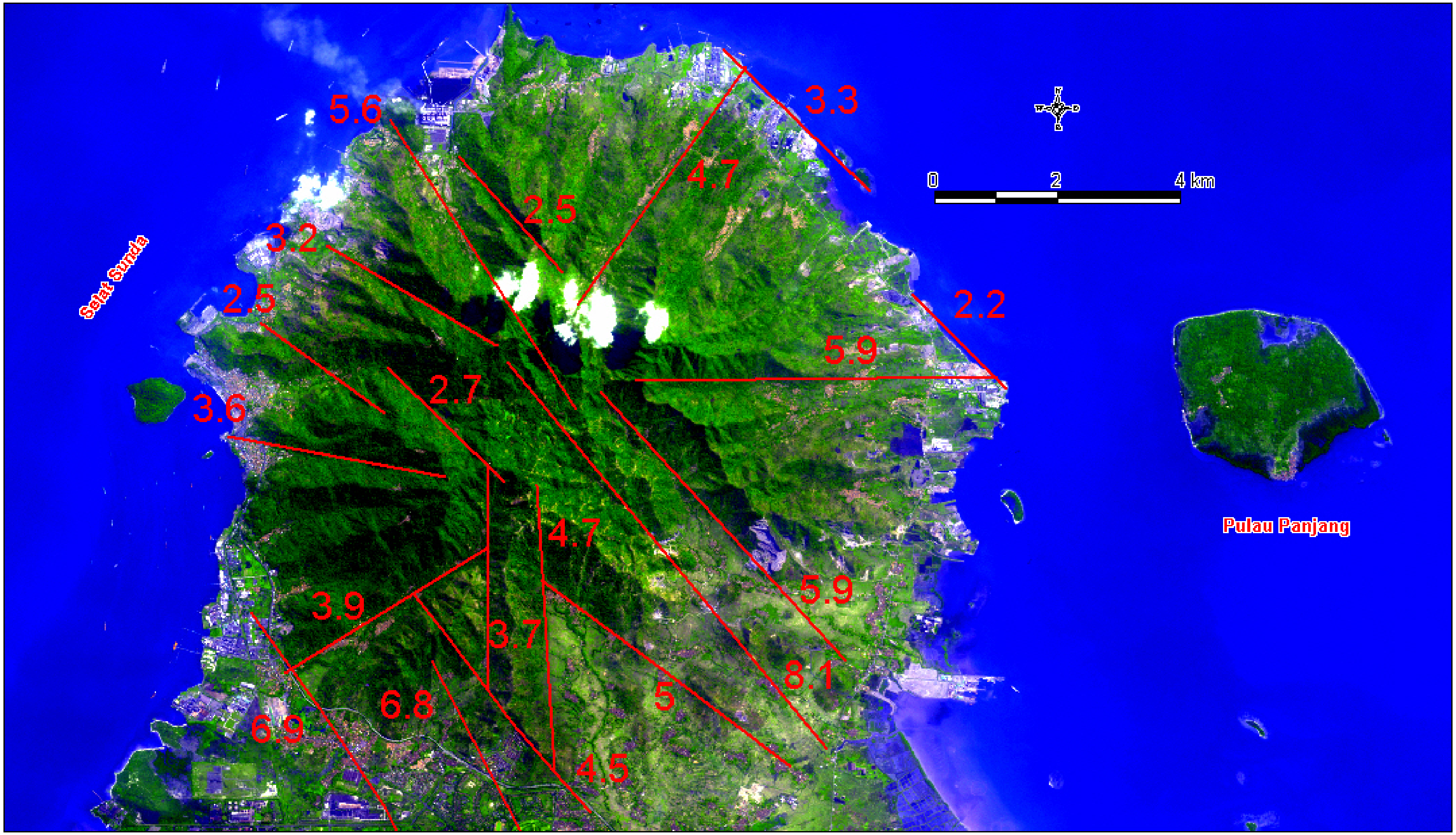
Interpretation of Lineament Using Landsat and DEM



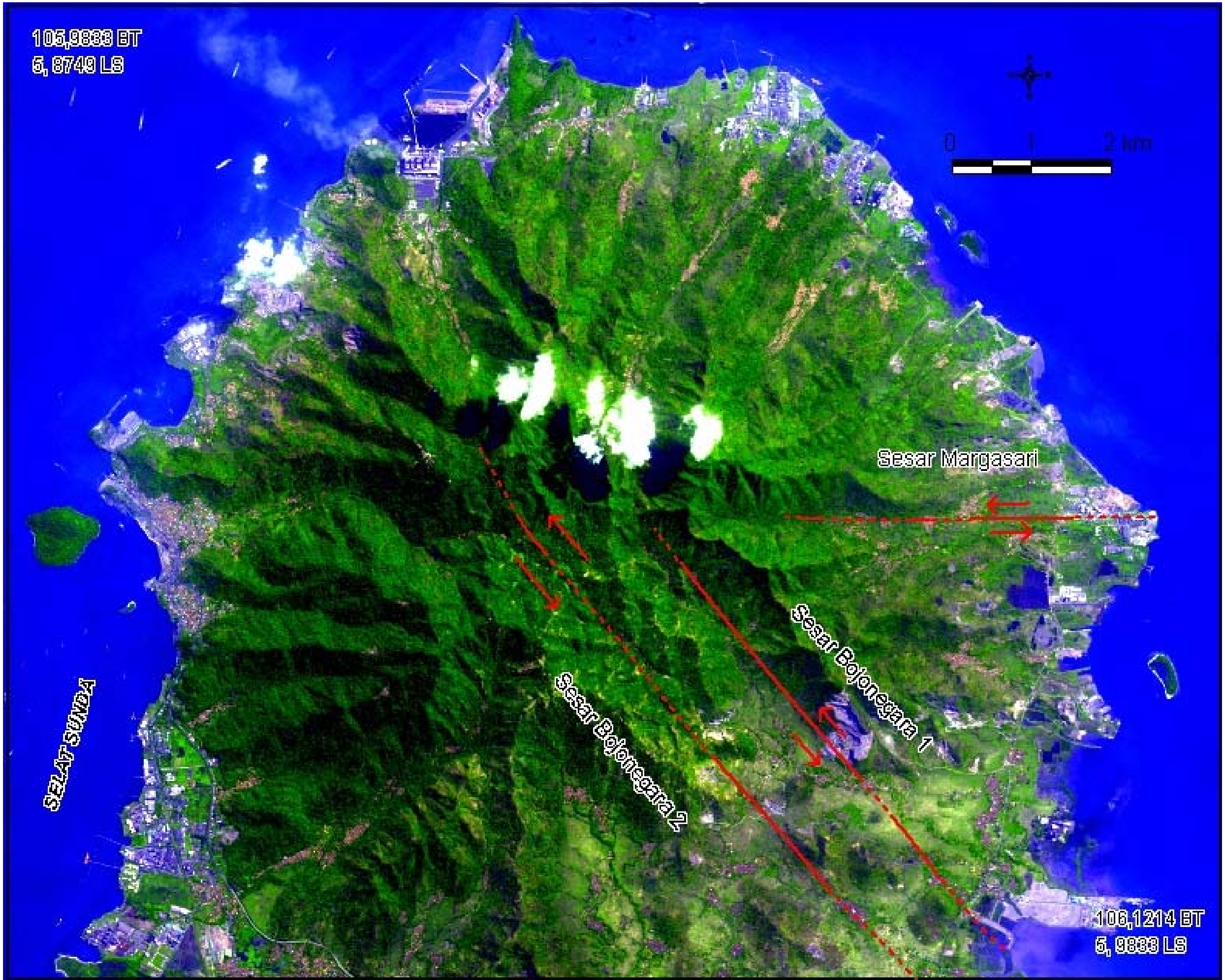
IDENTIFICATION OF FAULTS BASED ON SCIENTIFIC PUBLICATION AND SATELLITE IMAGERY INTERPRETATION



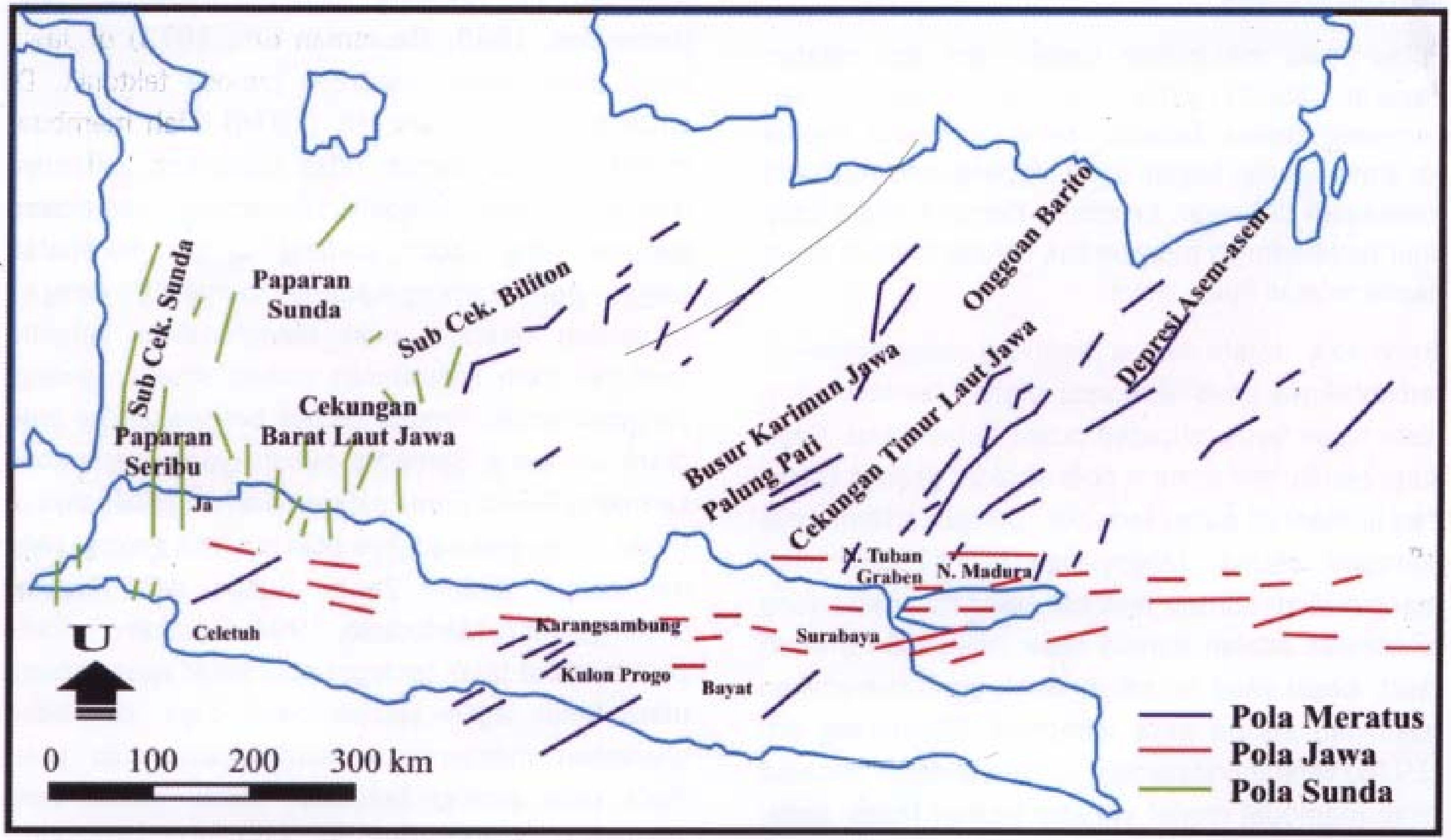
Interpretastion of Lineament Using SPOT



Interpretation of Lineament Using SPOT Combined With Field Survey



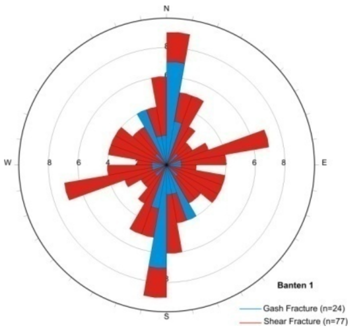
STRUCTURE PATTERN

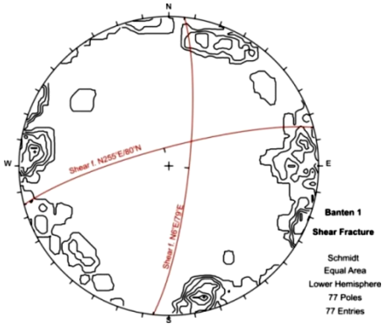


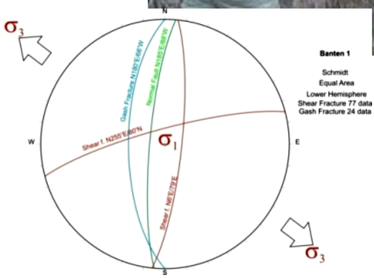
Gambar 2. Pola struktur Jawa dan sekitarnya (Pulunggono dan Martodjojo, 1994).

GEOLOGICAL FIELD SURVEY

Banten-1



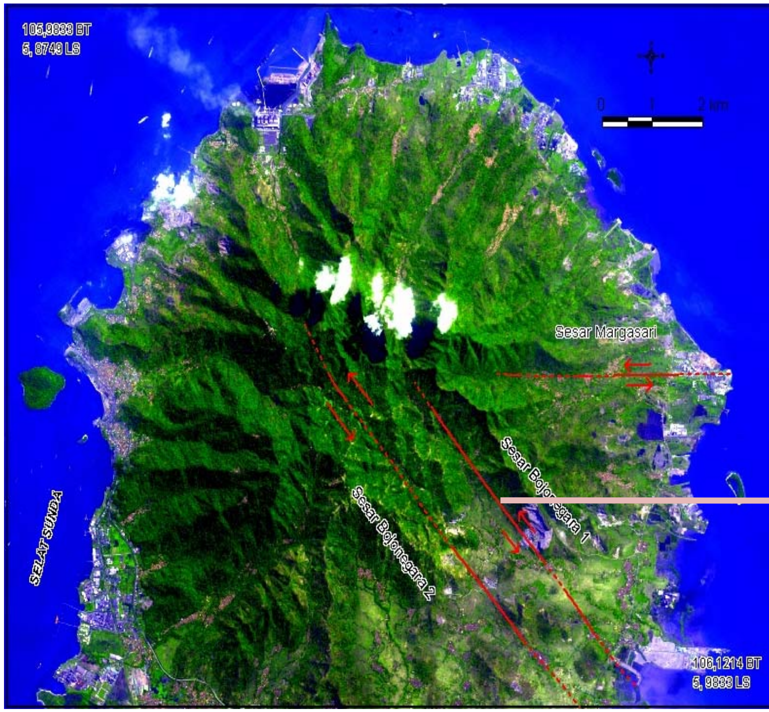


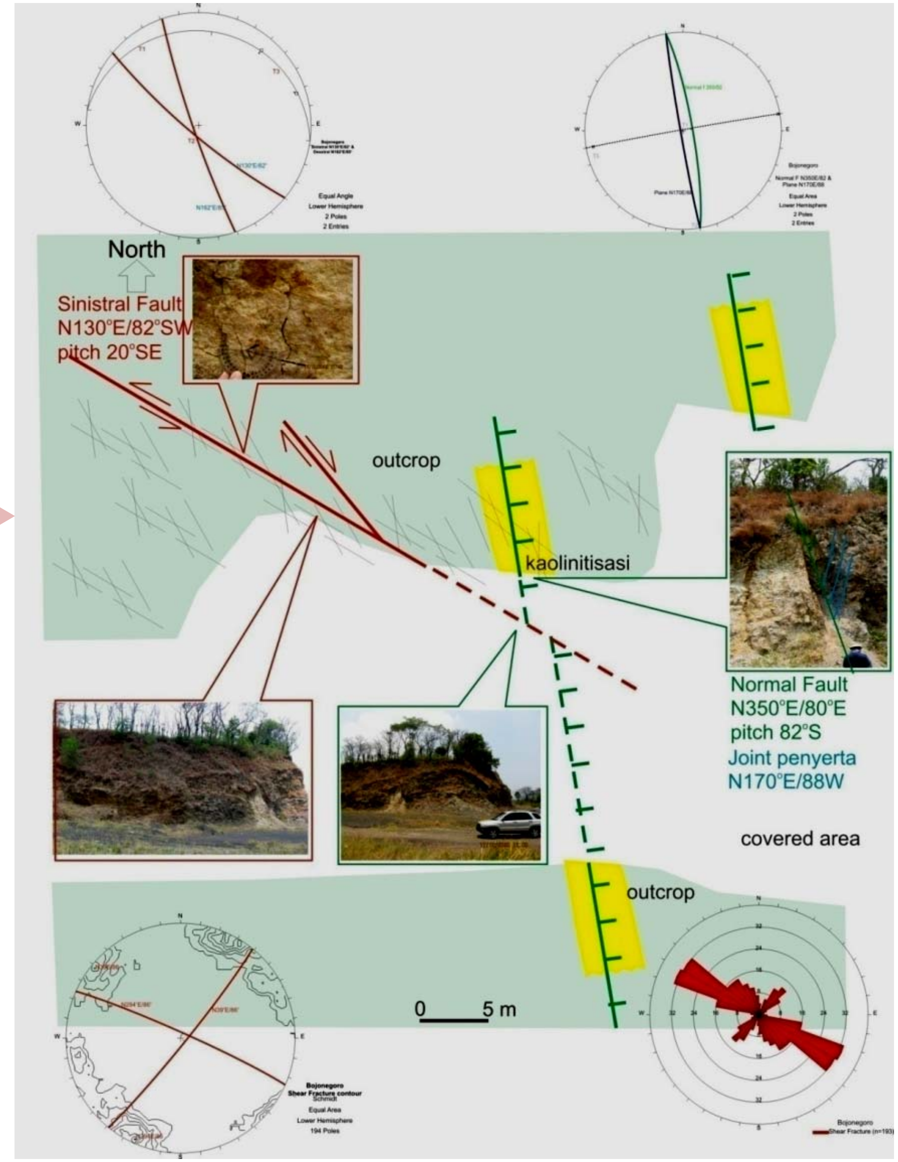


Rose diagram of shear and gash fracture of Banten-1 fault

Contour diagram of Shear Fracture at Banten-1 fault (left), Analysis of Shear Fracture, Gash Fracture and fault at Banten-1 Fault (right)

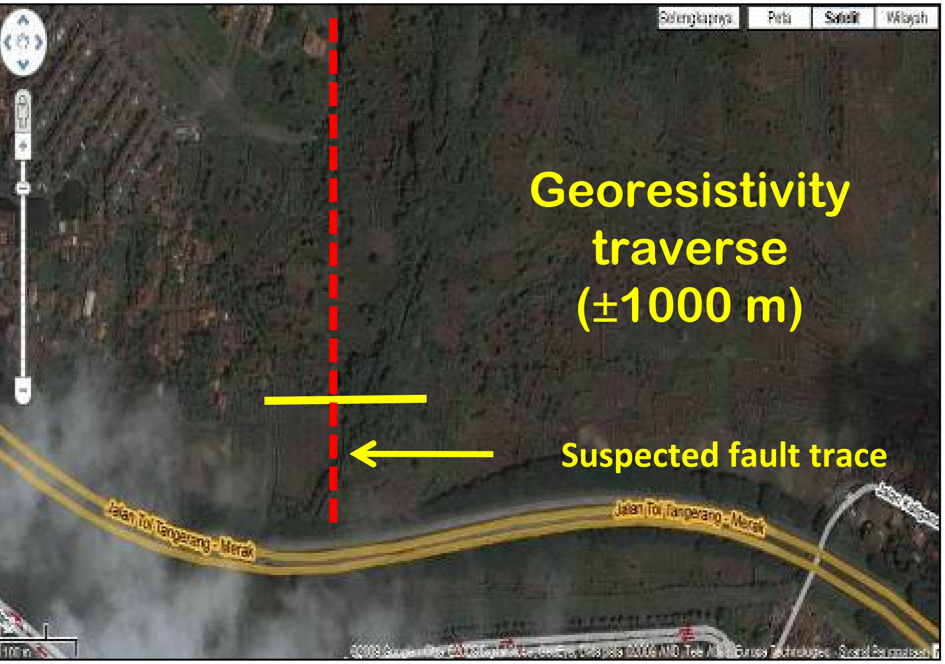
Montage Outcrop Data and Location of Sinistral Fault of Bojanegara

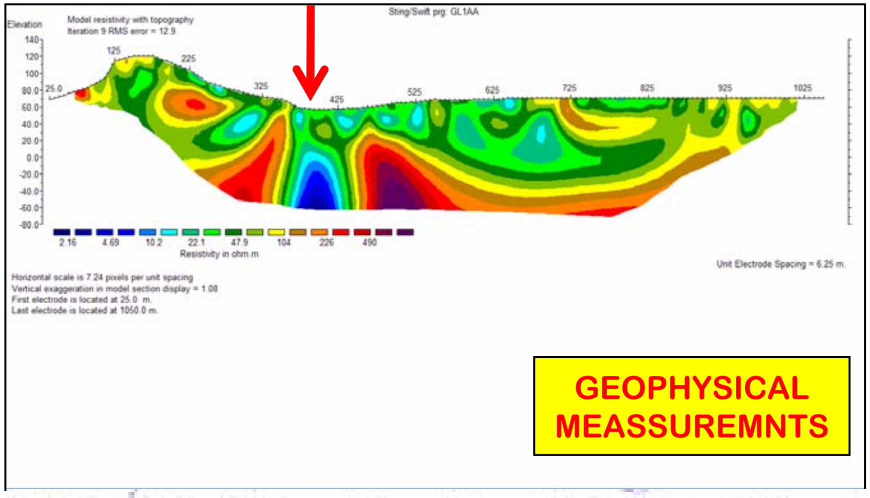


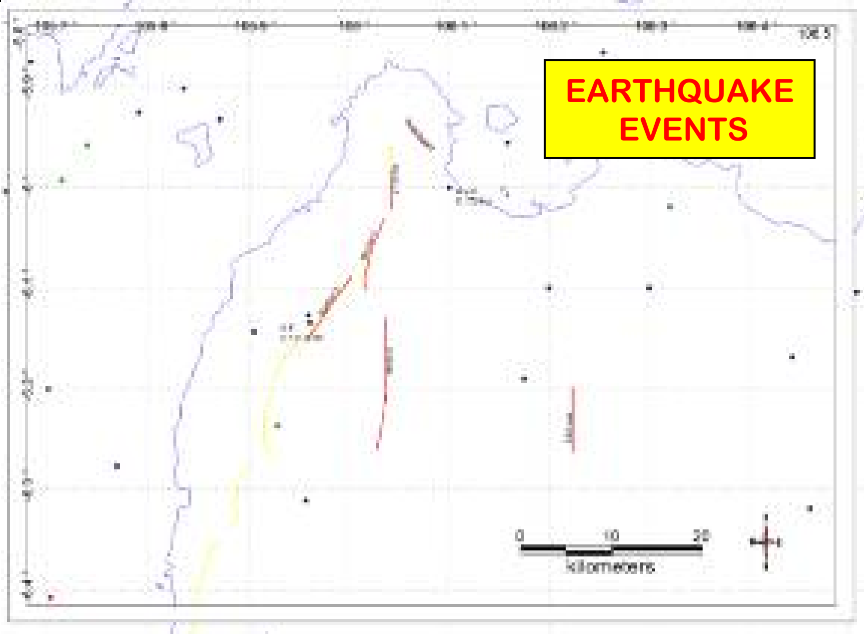


GEORESISTIVITY SURVEY TO CONFIRM SUSPECTED FAULT

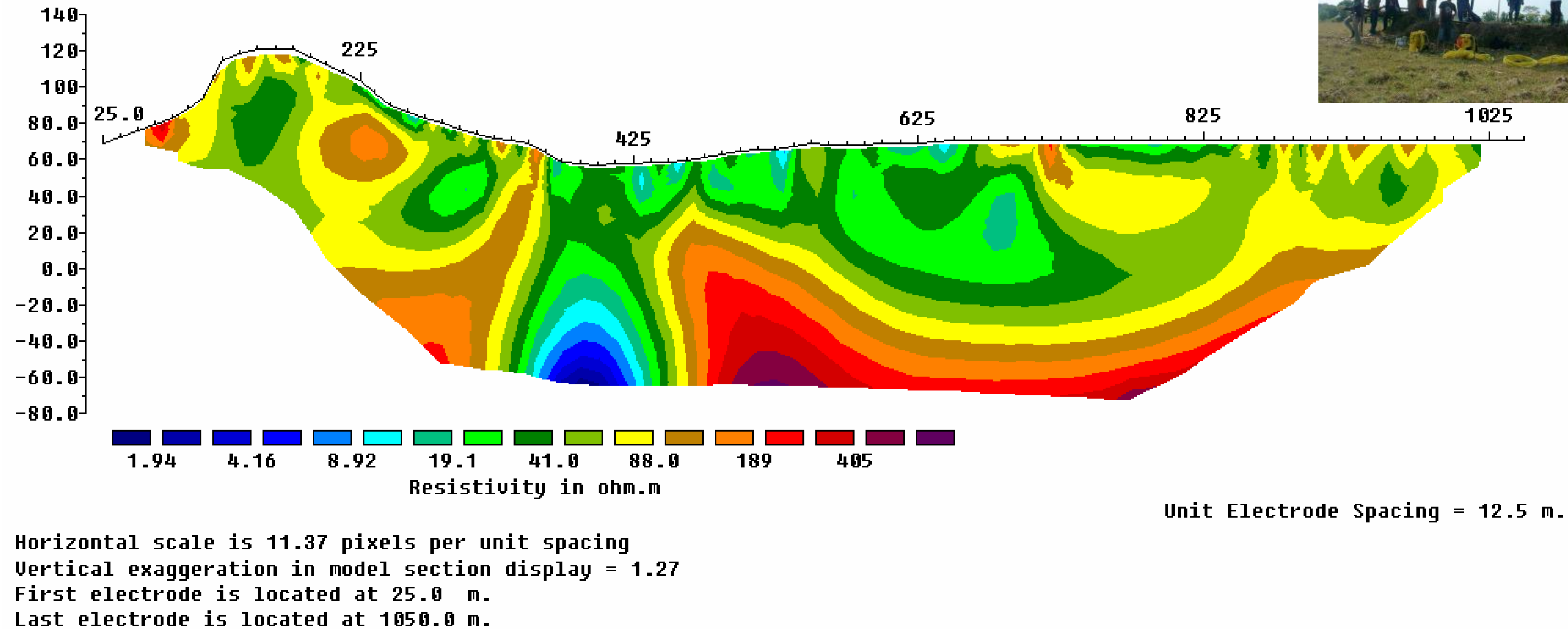
BANTEN-1 FAULT







GEORESISTIVITY SURVEY TO CONFIRM SUSPECTED FAULT

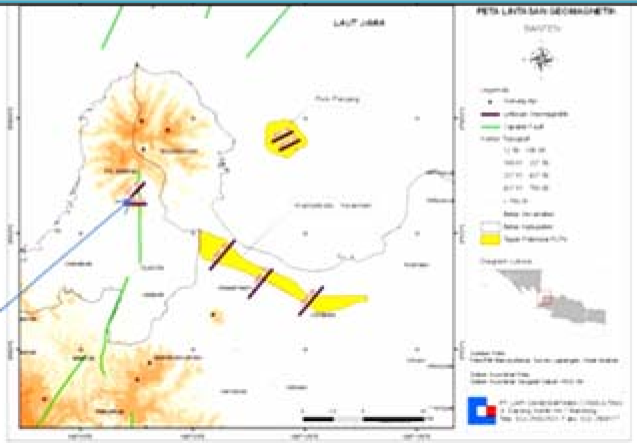


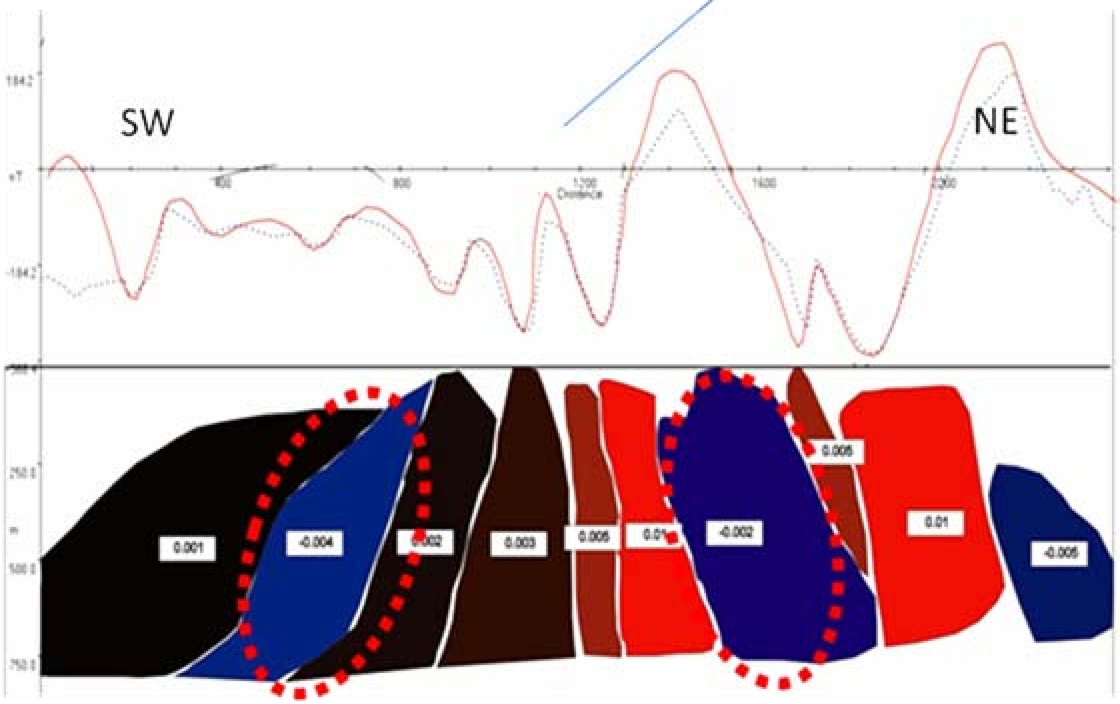
Hasil inversi tahanan jenis 2D dengan topografi untuk lintasan Banten 1 di Bukit Palm, Cilegon

GEOMAGNET SURVEY TO CONFIRM SUSPECTED FAULT

BANTEN-1 FAULT

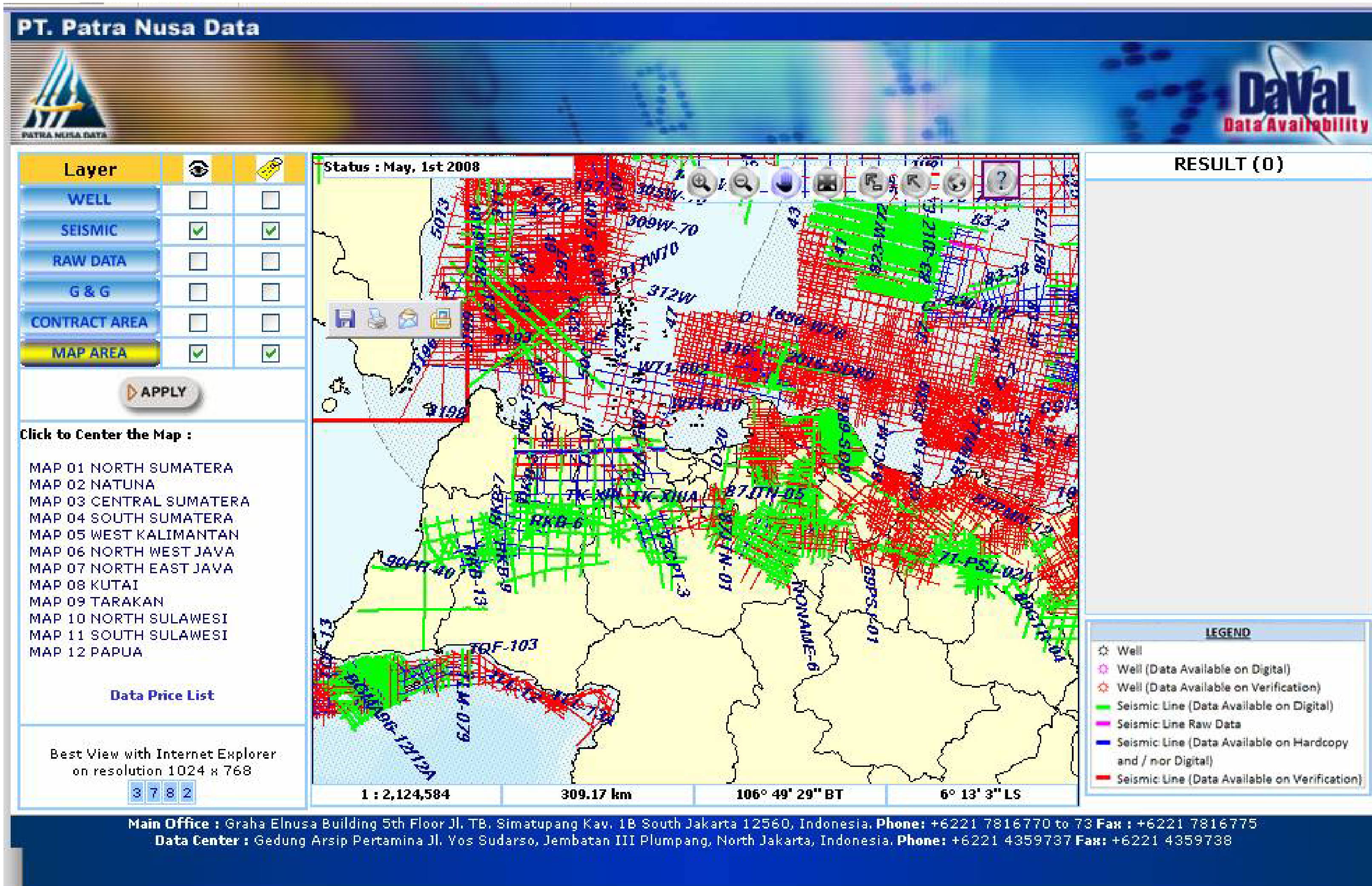
Crosssection 2D model of magnetic, Banten-1 Fault. Dash line indicate a zone of low susceptibility and may interpreted as fault zone.



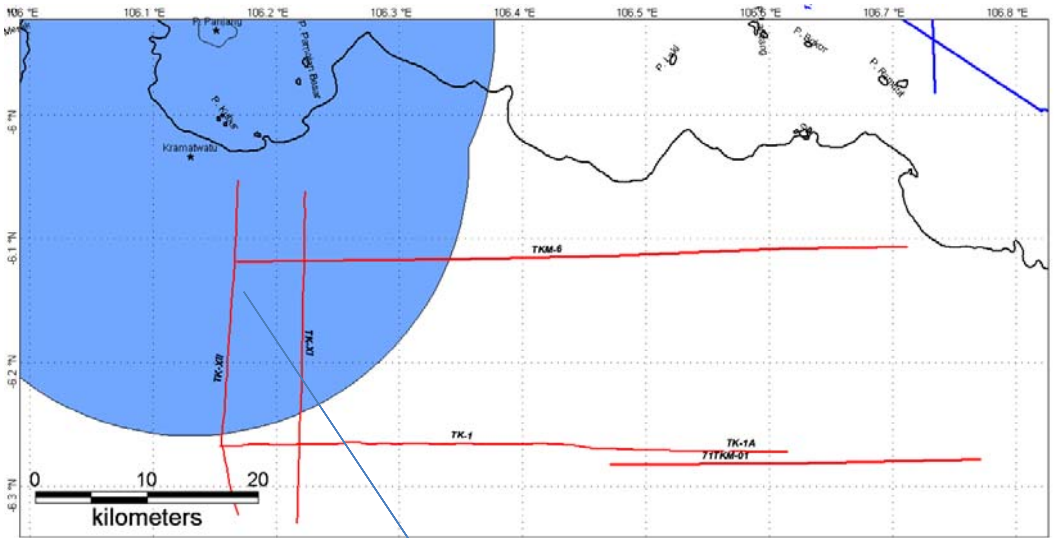


SEISMIC REFLECTION SECONDARY DATA TO CONFIRM SUSPECTED FAULT

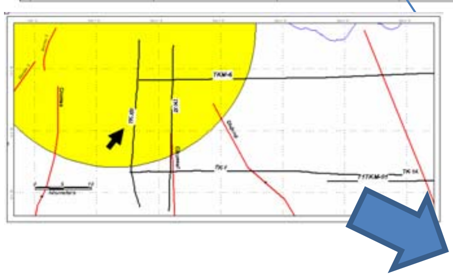
Availability Data of Seismic Reflection (oil company)

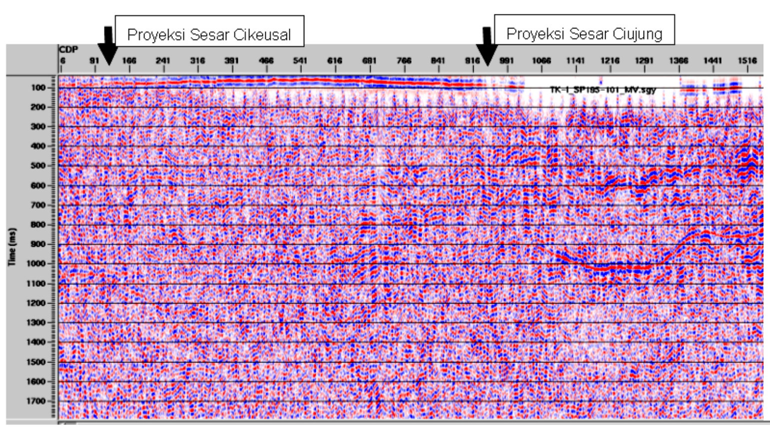


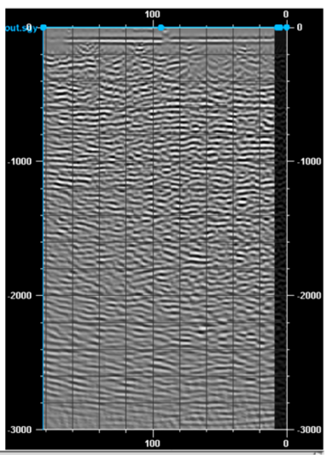
SEISMIC REFLECTION SECONDARY DATA TO CONFIRM SUSPECTED FAULT

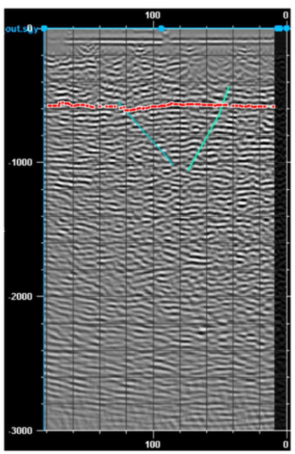


There are no good quality data of SR across the fault line, therefore it is dificult to conclude. It should be carried out seismic reflection survey covering supposed capable fault, Off-shore and on-shore fault, Off-shore and on-shore

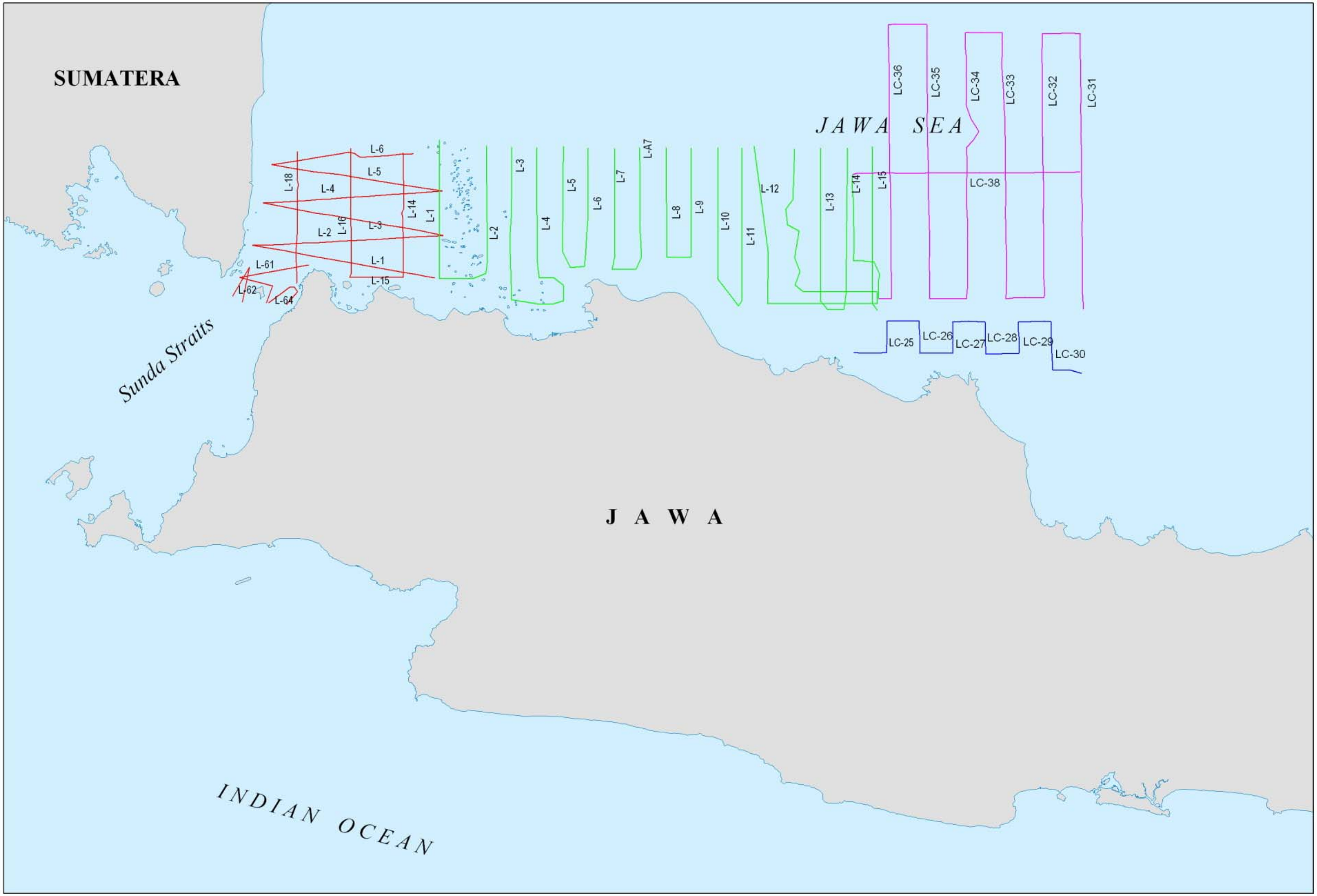




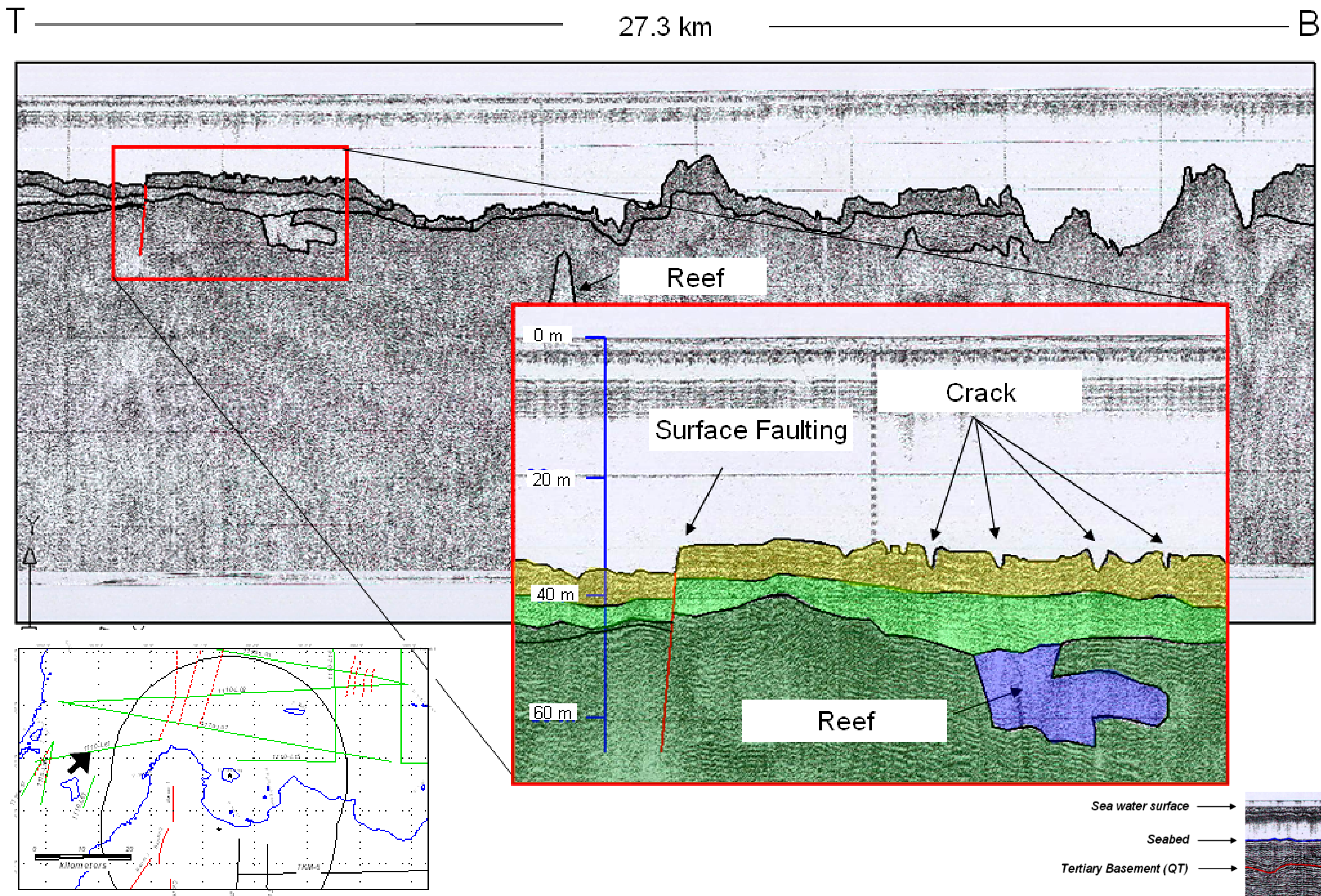


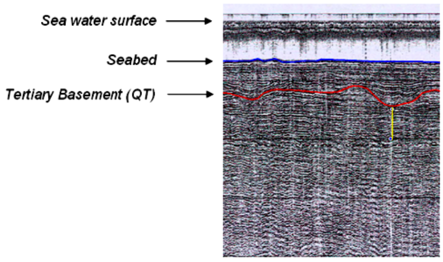


OFF-SHORE SINGLE CHANNEL SEISMIC REFLECTION (SECONDARY DATA) TO CONFIRM SUSPECTED FAULT (Seismic lines)

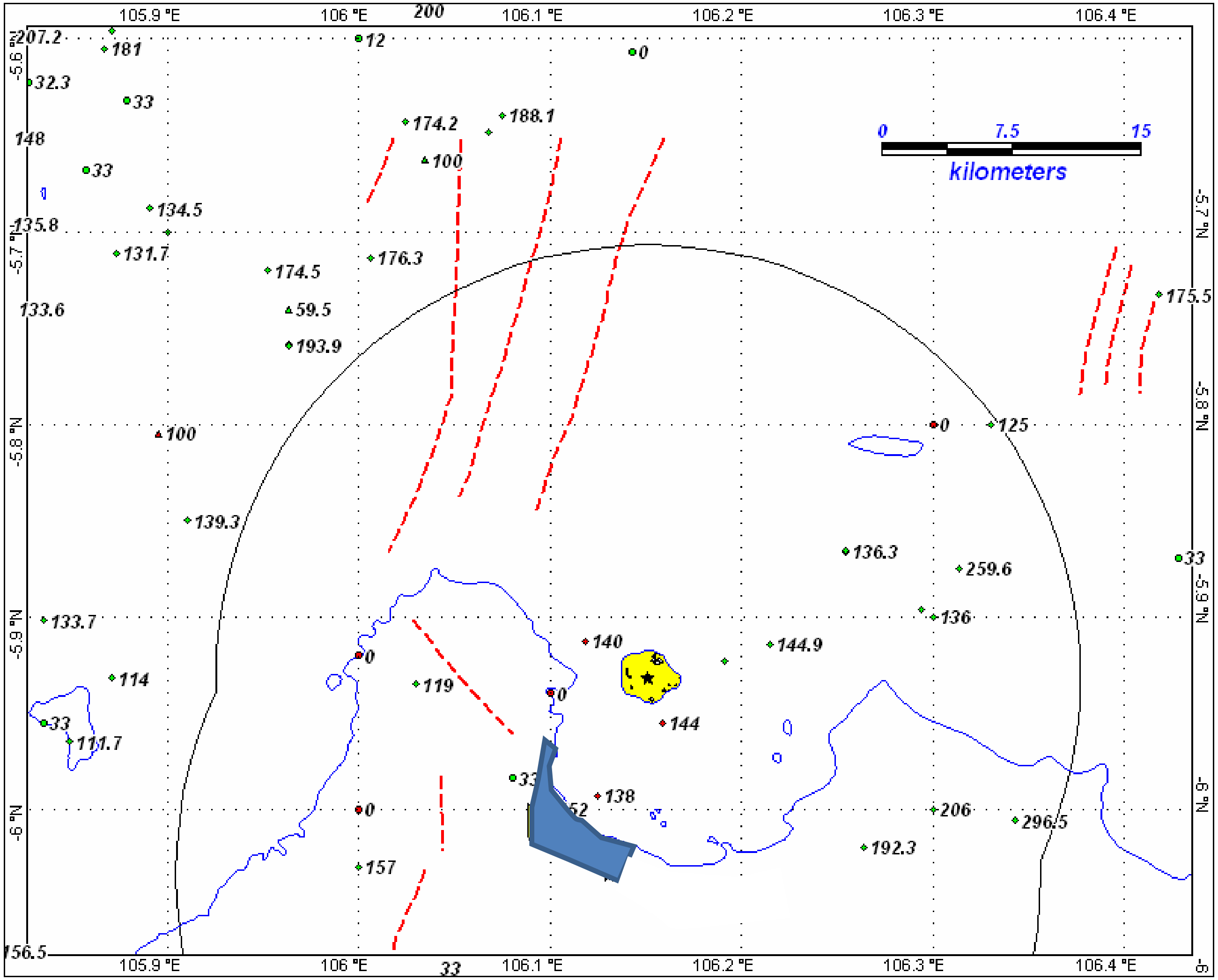


EXAMPLE OF SEISMIC REFLECTION INTERPRETATION

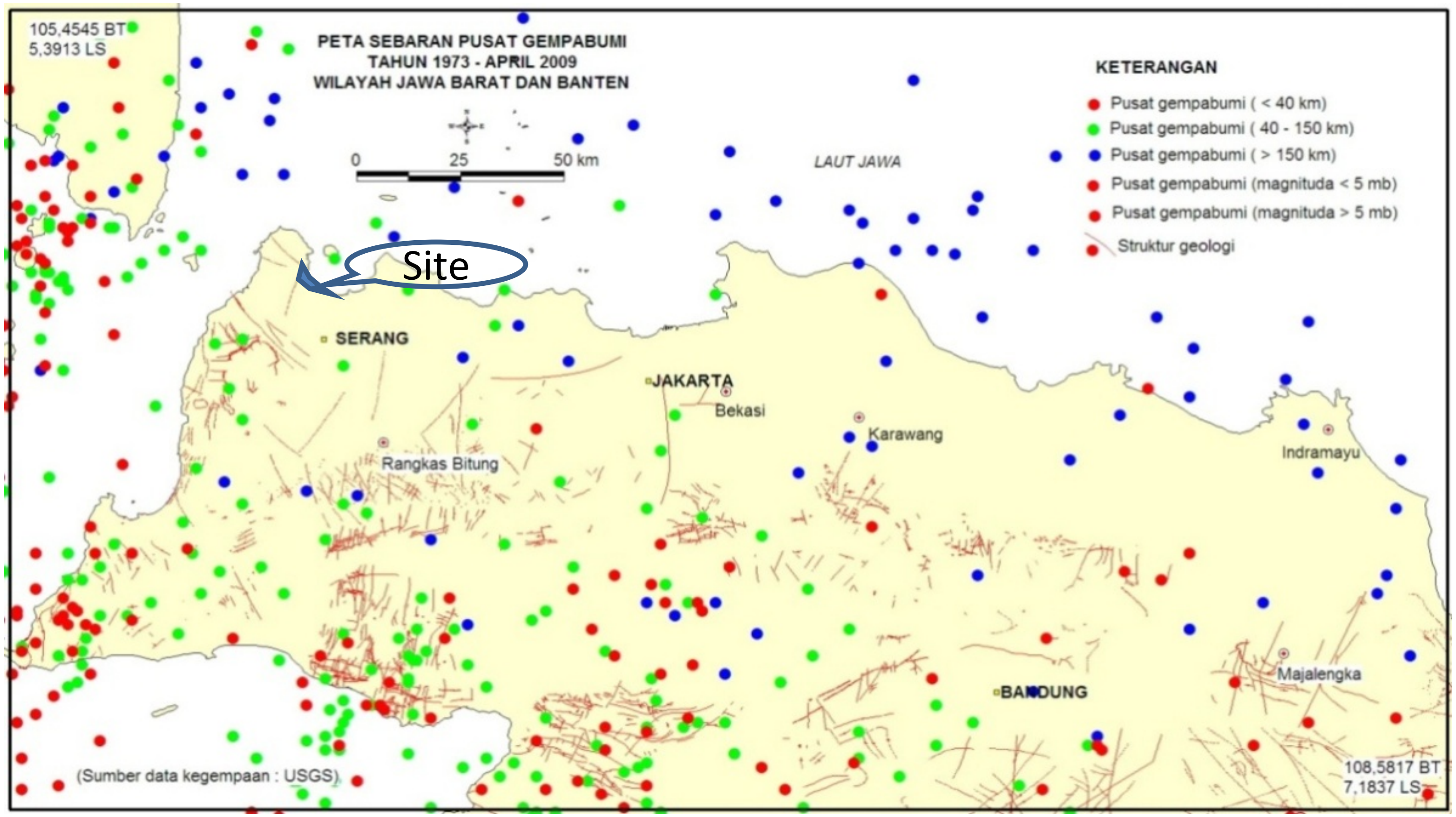




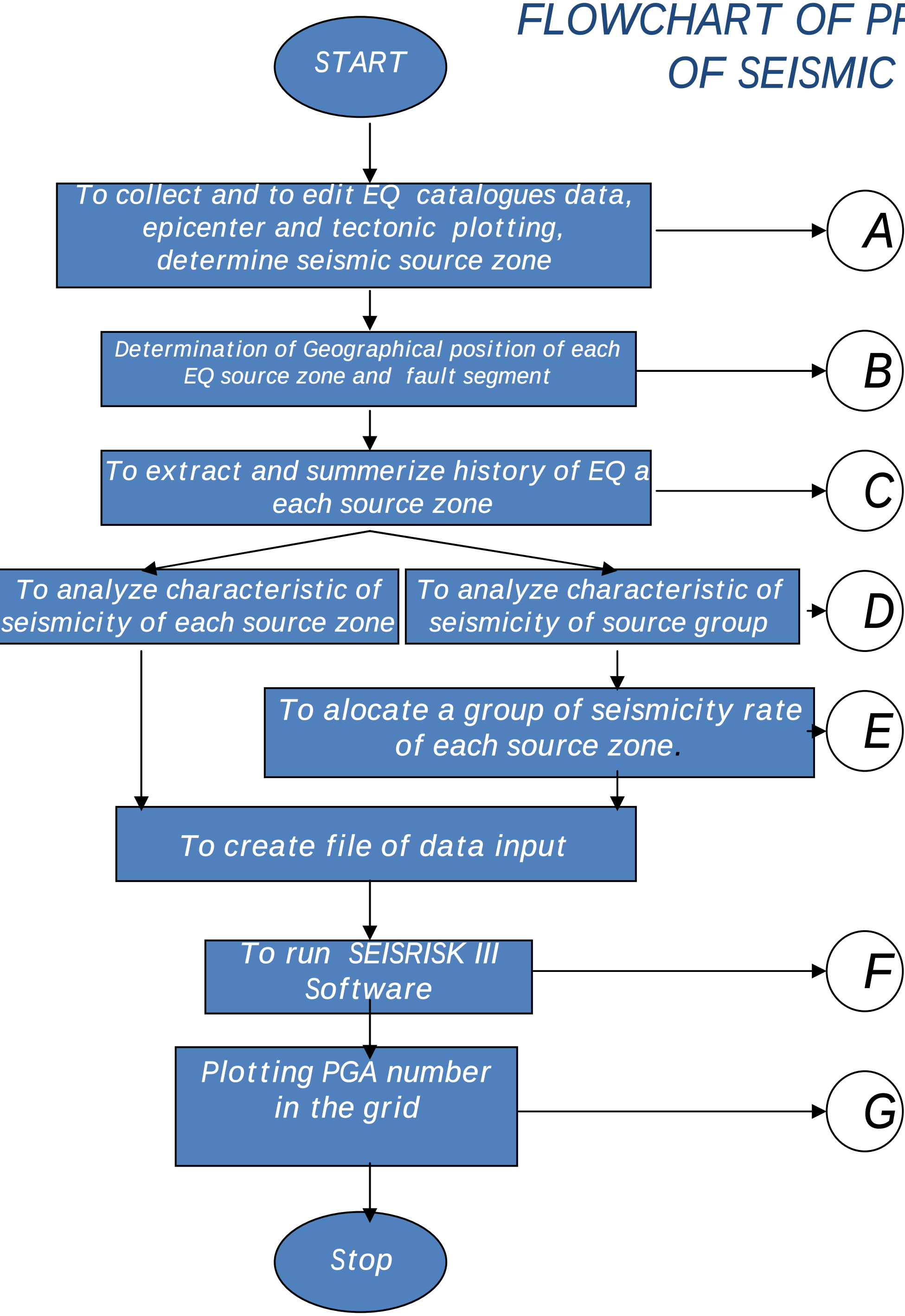
DISTRIBUTION OF EARTHQUAKE AT SEA CORRELATED WITH SUSPECTED FAULT INTERPRETED FROM SINGLE CANNEL SR



EARTHQUAKE DISTRIBUTION NEAR THE SITE



FLOWCHART OF PROBABILISTIC ANALYSIS OF SEISMIC HAZARD (PSHA)



A= To extract data from EQ catalogues and to design seismic source zone based on information of geology and tectonic.

B= To input coordinate of seismic source zone and segement of fault in the suitable format.

C= To select regional EQ catalogues into sub-catalogues for each EQ source zone (Zone-1 upto zone-12); To equal magnitude of catalogue into surface wave magnitude (Mb→Ms)

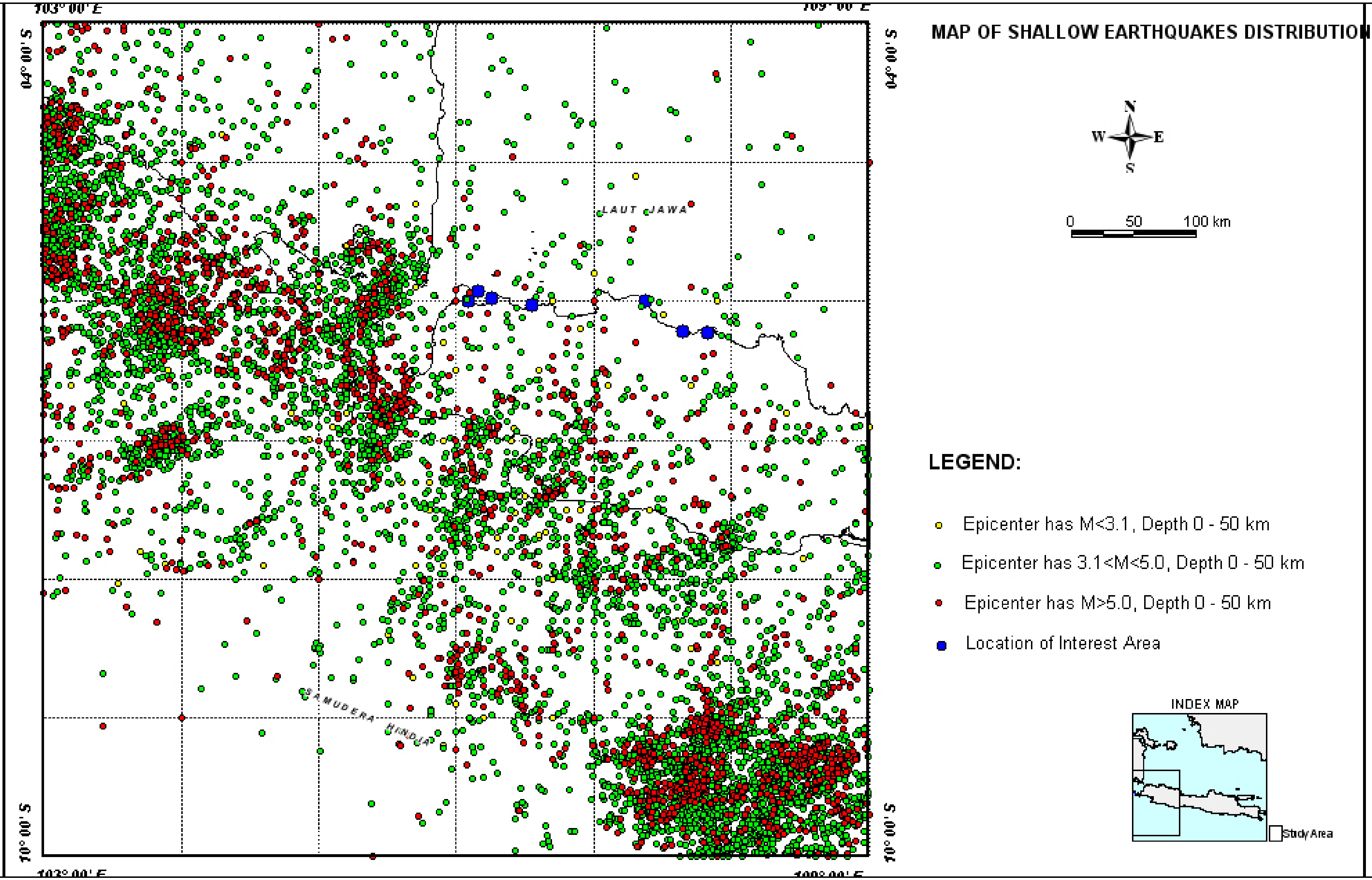
D= To create table of earthquake activity decay rate per 10 year from now until the beginning of the decade. To estimate earthquake events rate.

E= To combine some seismic source zone that do not have enough EQ data to be analyzed statistically. (Exp. Zone-7 combined with zone-8)

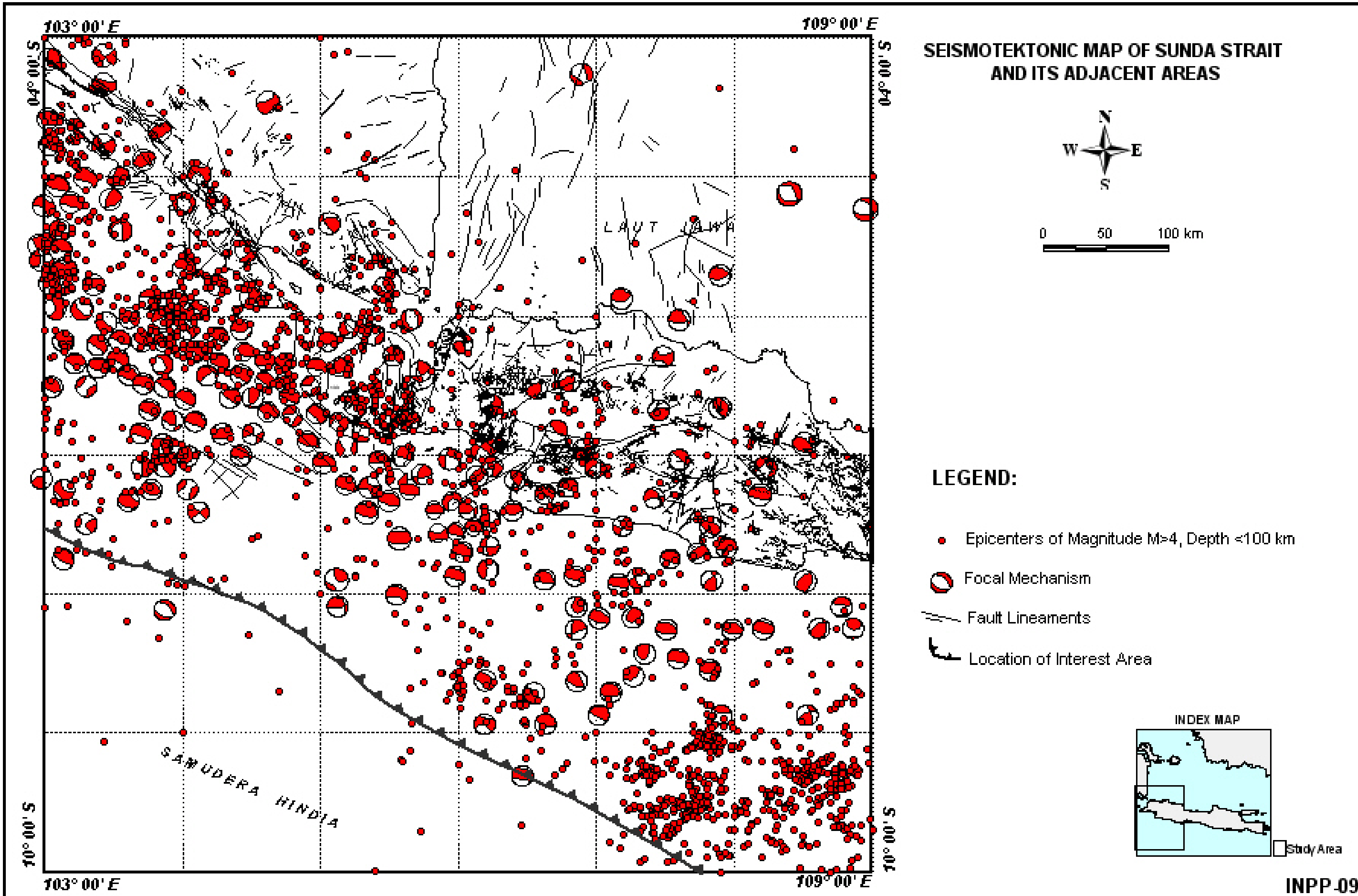
F= To run SEISRISK III S/W to calculate the value of ground motion hazard at each point at geographical grid as a result of analysis to be carried out.

G= Plotting of ground motion output value and countouring PGA number into the map.

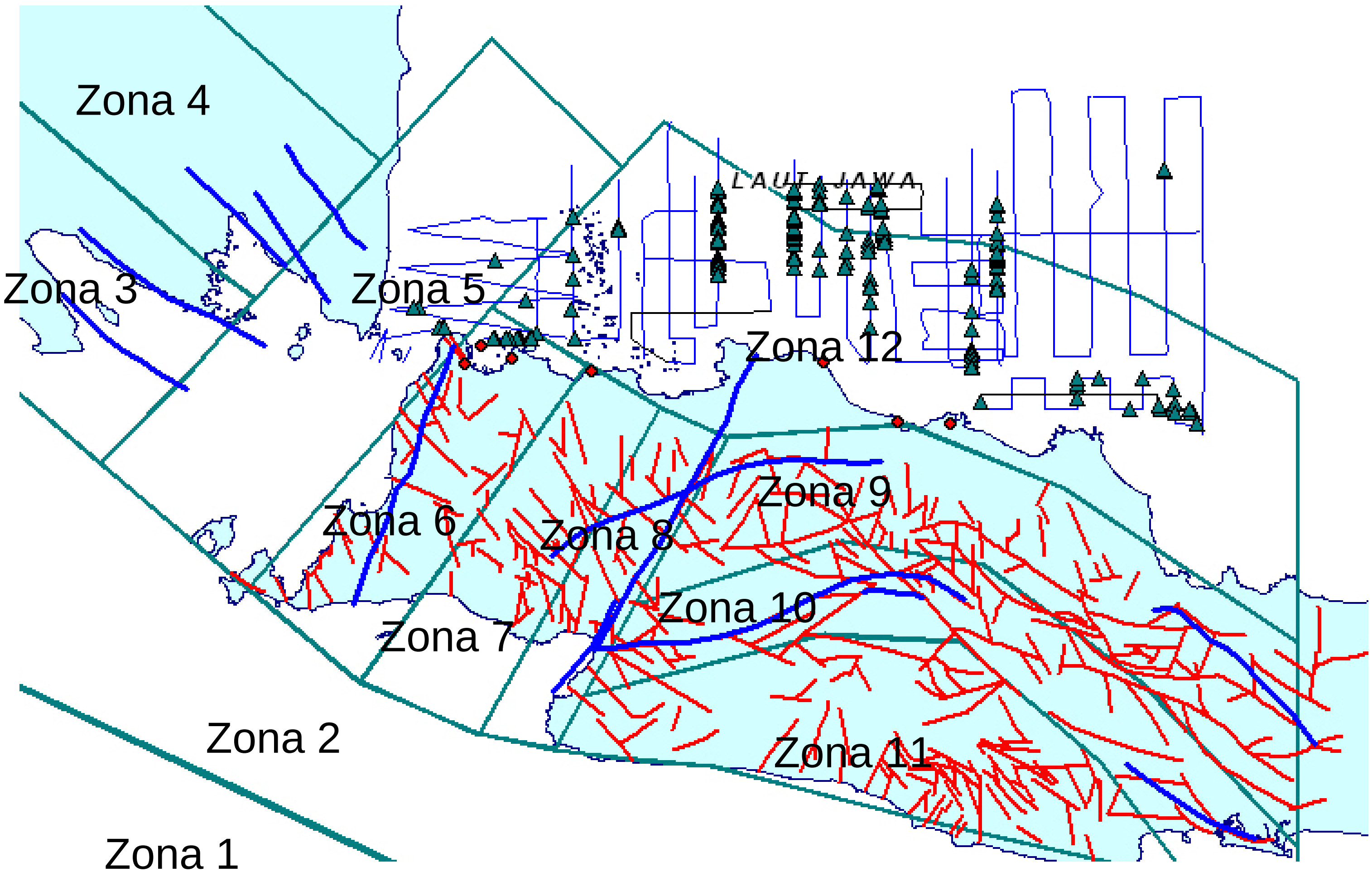
CATALOGUE OF EARTHQUAKE DISTRIBUTION WITH DEPTH 0-50 km



CATALOGUE OF SEISMOTECTONIC



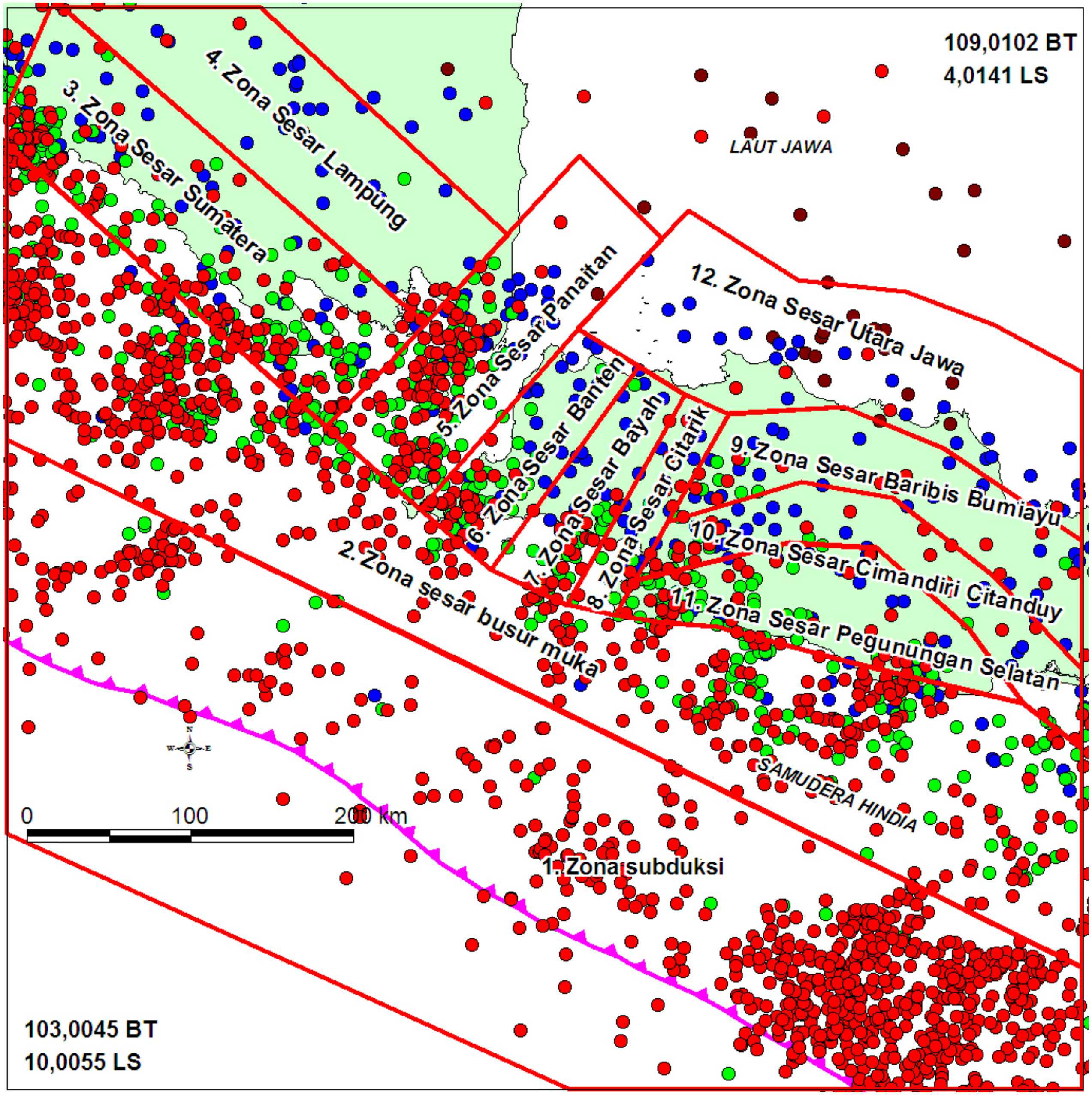
PLOTTING OF SEISMIC SOURCE ZONE



Zone 1: Subduction
Zona 2: Fore Arc
Zona 3: Sumatera Fault
Zona 4: Lampung Fault
Zona 5: Panaitan Fault
Zona 6 :Banten Fault

Zona 7: Bayah Fault
Zona 8: Citarik Fault
Zona 9: Baribis–Bumiayu Fault
Zona 10: Cimandiri – Citanduy Ft
Zona 11: Pegunungan Selatan Ft
Zona 12: Java north fault

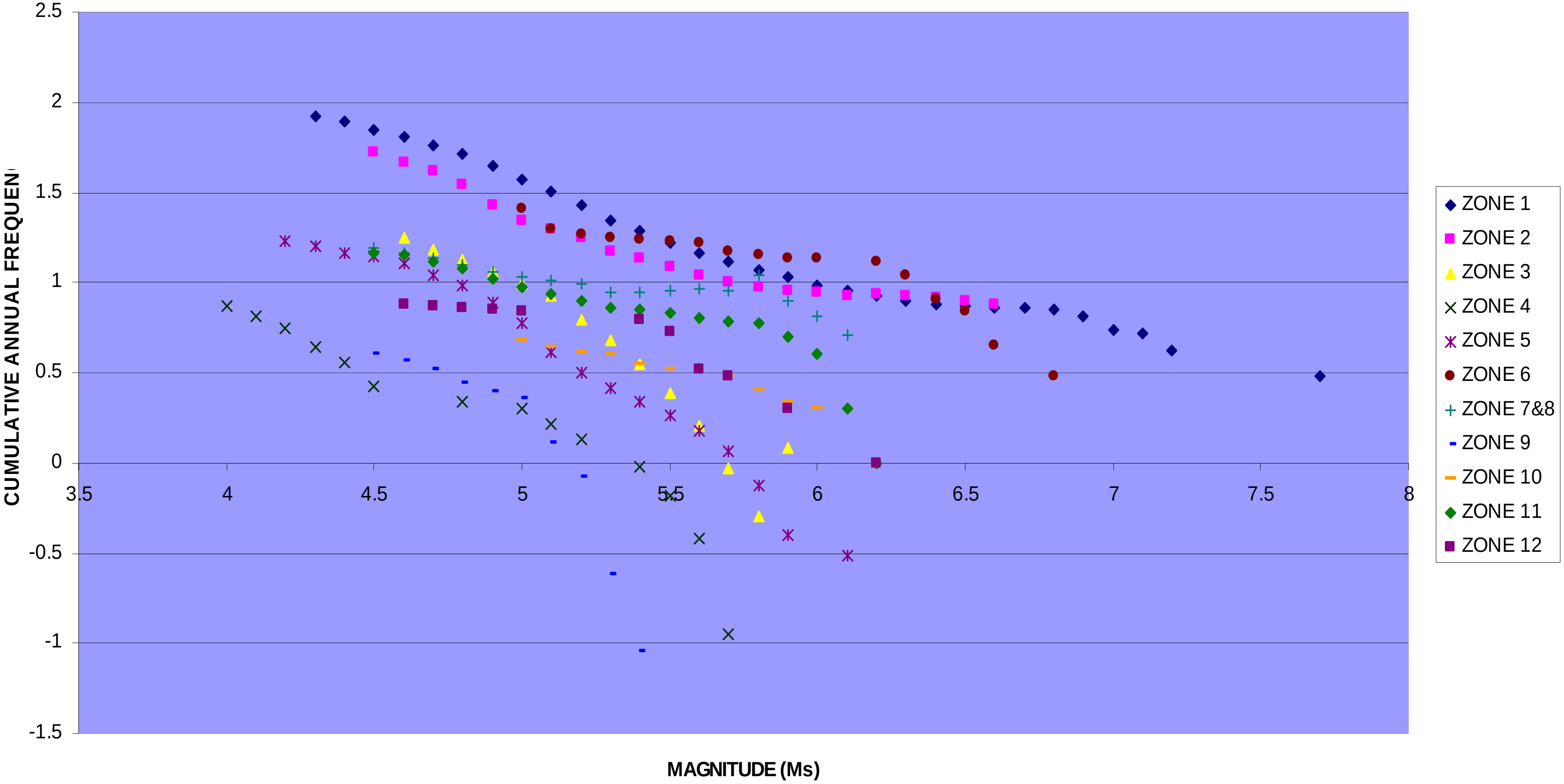
PLOTTING OF SEISMIC SOURCE ZONE



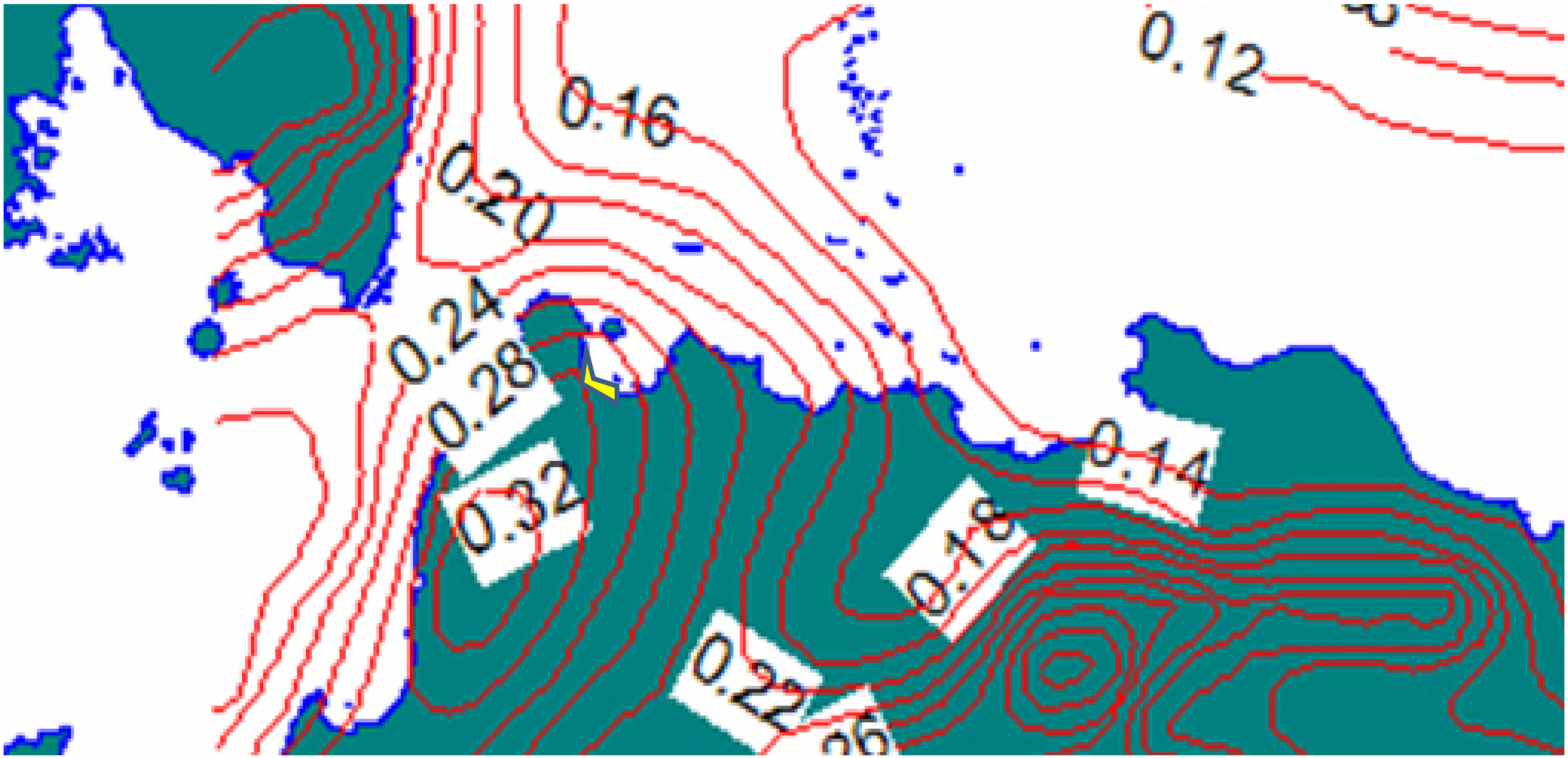
PARAMETER OF SEISMIC HAZARD

Seismic Source Zone	Number of Earthquake 1964-2008 M>5	Annual Rate of Earthquake M>5	Maximum Magnitude since 1964	Maximum Magnitude since 1800	b-value
1	761	18.83	7.7	8.1 (1903)	0.801
2	715	15.84	7.6	5.5	1.043
3	372	9.42	7.3	7.5 (1933)	1.359
4	38	1.45	7.0	N/A	0.810
5	163	4.28	6.8	6.5 (1852)	0.950
6	123	16.32	6.8	N/A	0.213
7&8	125	6.8	6.1	N/A	0.644
9	23	1.013	6.0	N/A	1.644
10	36	3.36	6.0	N/A	0.444
11	94	16.2	6.3	N/A	0.039
12	10	5.25	6.2	6.8 (1823)	0.580

SEISMICITY RATE

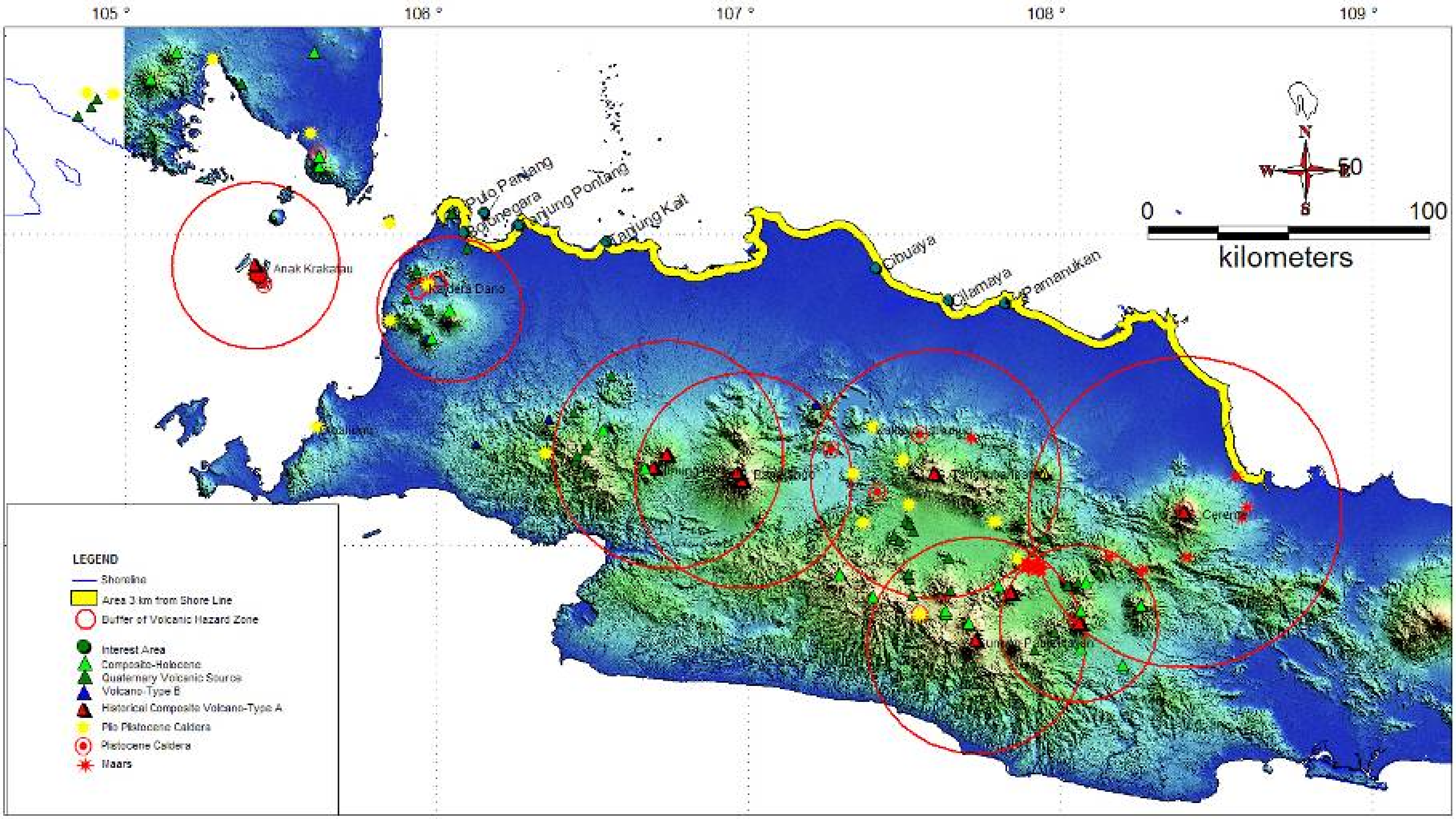


PLOTTING OF PGA MAP
(250 years of exceedance using uncertainty of 0.15)



6 Implementation of Volcanology Study during NPP Siting

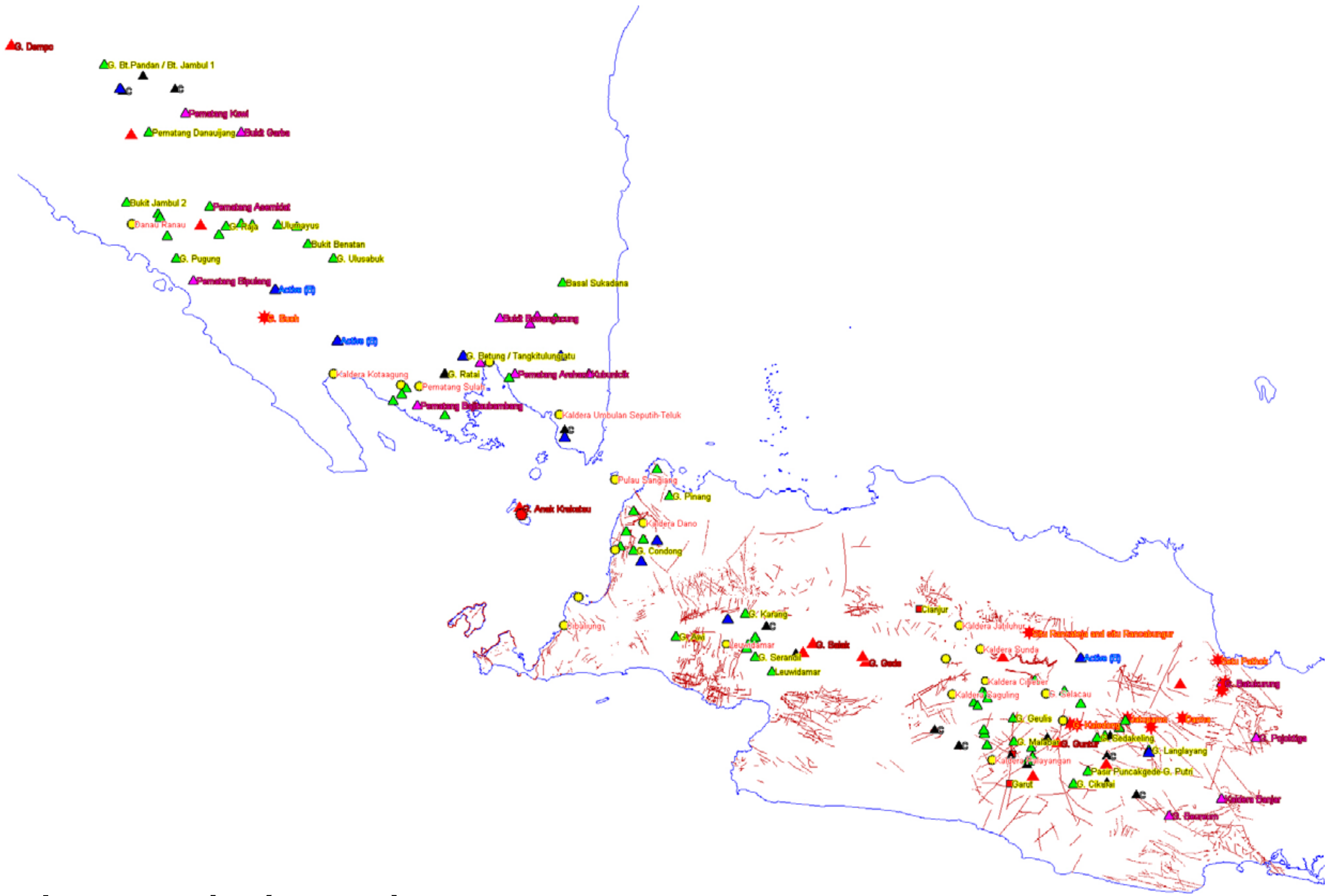
REGIONAL VOLCANIC HAZARD
(Initial Screening)



Classification of Volc. Eruption and Index of Volc Eruption (VEI: *Volcano Explosivity Index*) (Newhall and Self, 1982)

VEI	Description	Plume Height	Volume	Classification	How often	Example
0	non-explosive	<100 m	1000s m^3	Hawaiian	daily	Kilauea
1	gentle	100-1000 m	10.000s m^3	Haw/Strombolian	daily	Stromboli
2	explosive	1-5 km	1.000.000s m^3	Strom/Vulcanian	weekly	Galeras, 1992
3	severe	3-15 km	10.000.000s m^3	Vulcanian	yearly	Ruiz, 1985
4	cataclysmic	10-25 km	100.000.000s m^3	Vulc/Plinian	10's of years	Galunggung, 1982
5	paroxysmal	>25 km	1 km^3	Plinian	100's of years	St Helens, 1981
6	colossal	>25 km	10s km^3	Plin/Ultra-Plinian	100's of years	Krakatau, 1883
7	super-colossal	>25 km	100s km^3	Ultra-Plinian	1000's of years	Tambora, 1815
8	mega-colossal	>25 km	1,000s km^3	Ultra-Plinian	10,000's of years	Yellowstone, 2 Ma

Map of Volcanic Distribution at Lampung, Banten, and West Java Provinces



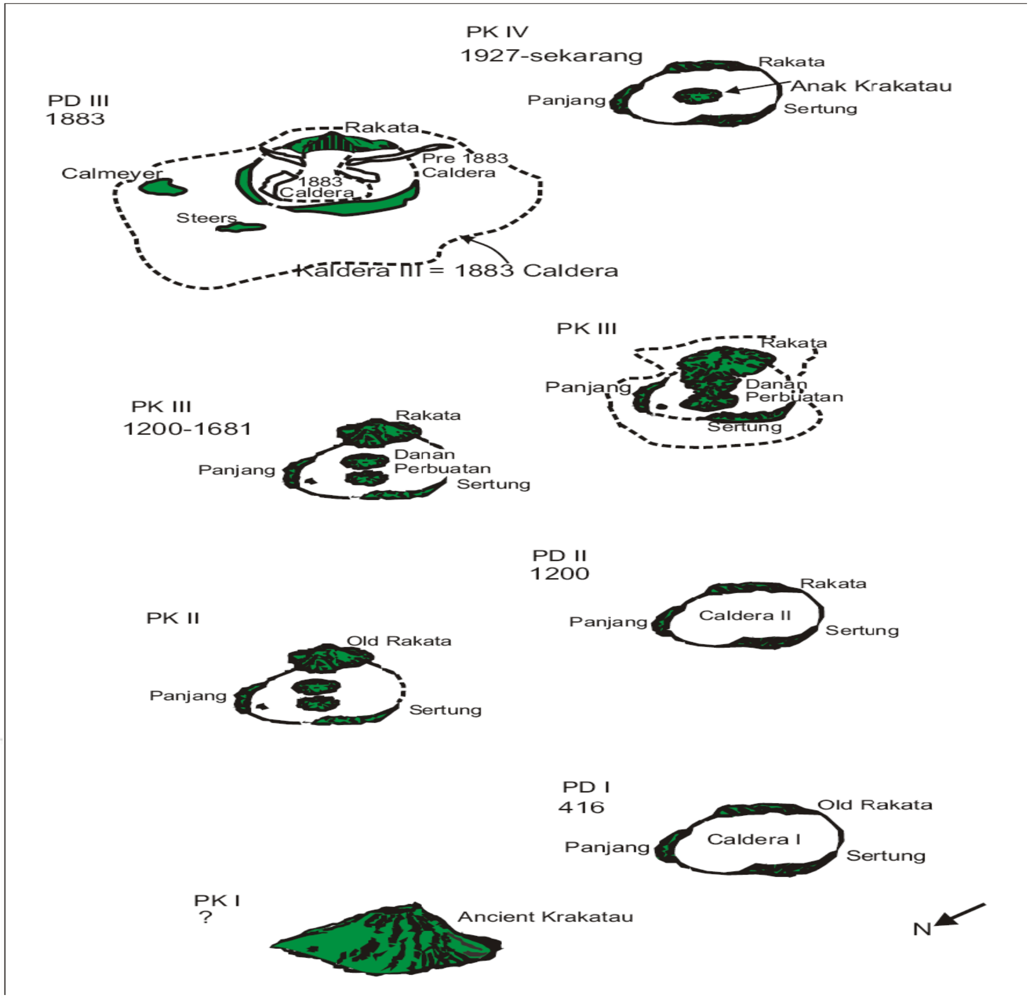
▲: Historical, composite (Type A);

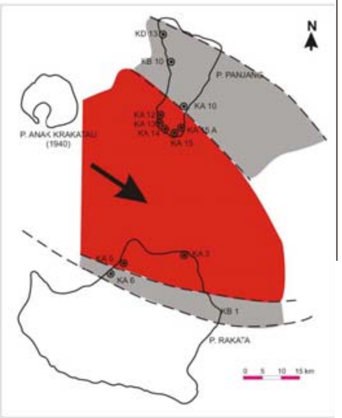
▲: Composite type B (fumarolic), ▲: Composite Type C; ▲: Composite <2 ma;

✸: Caldera Krakatau 1883, and ✸: Caldera Plio-Plistosen)

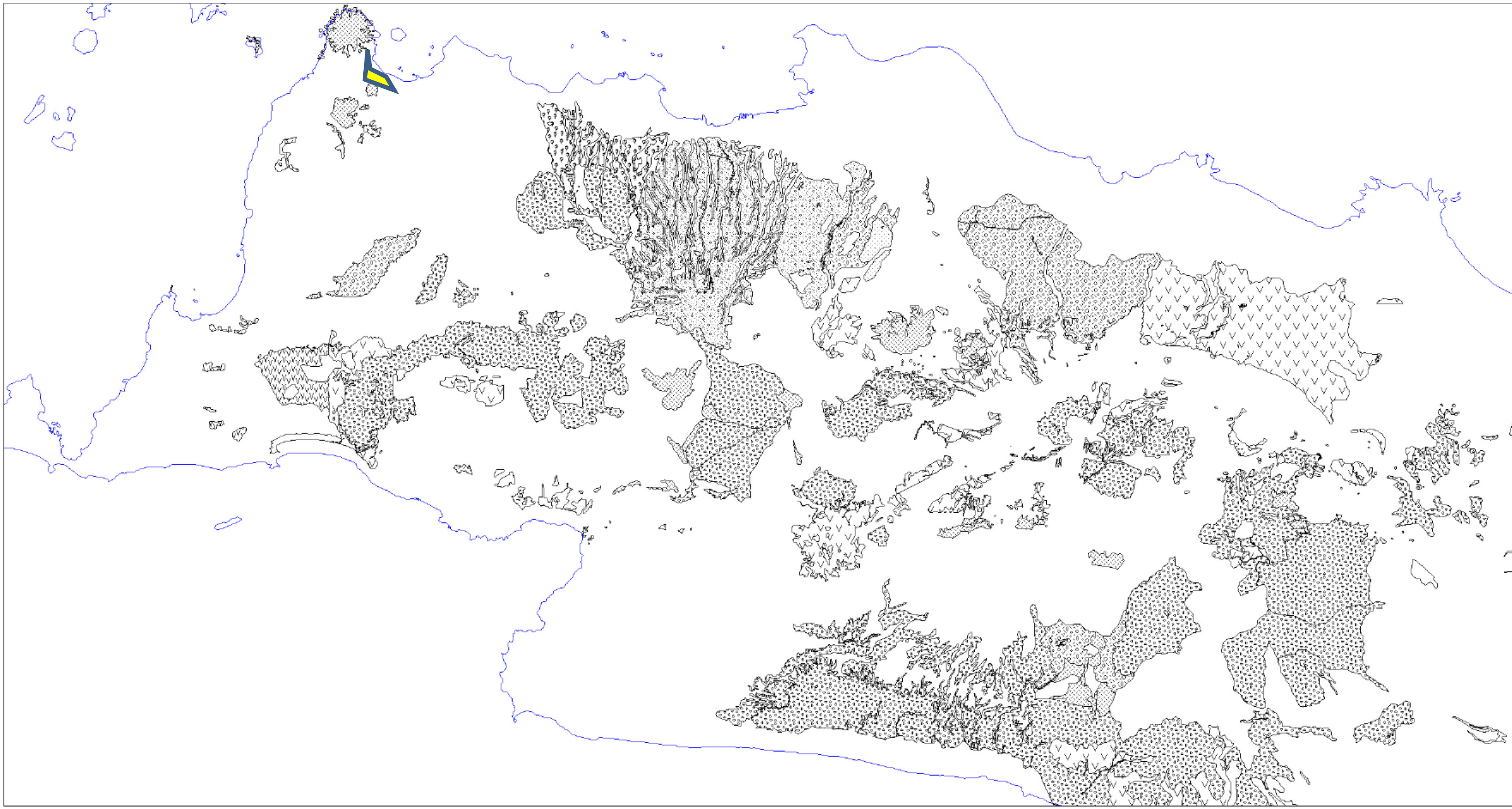
Evolution of Krakatau Volcano

Evolution of Krakatau Volc, consist of Development Phase-1 of Volcanic cone, Destruction-1, Cone development-2, Destruction-2, Cone development-3, and so on.

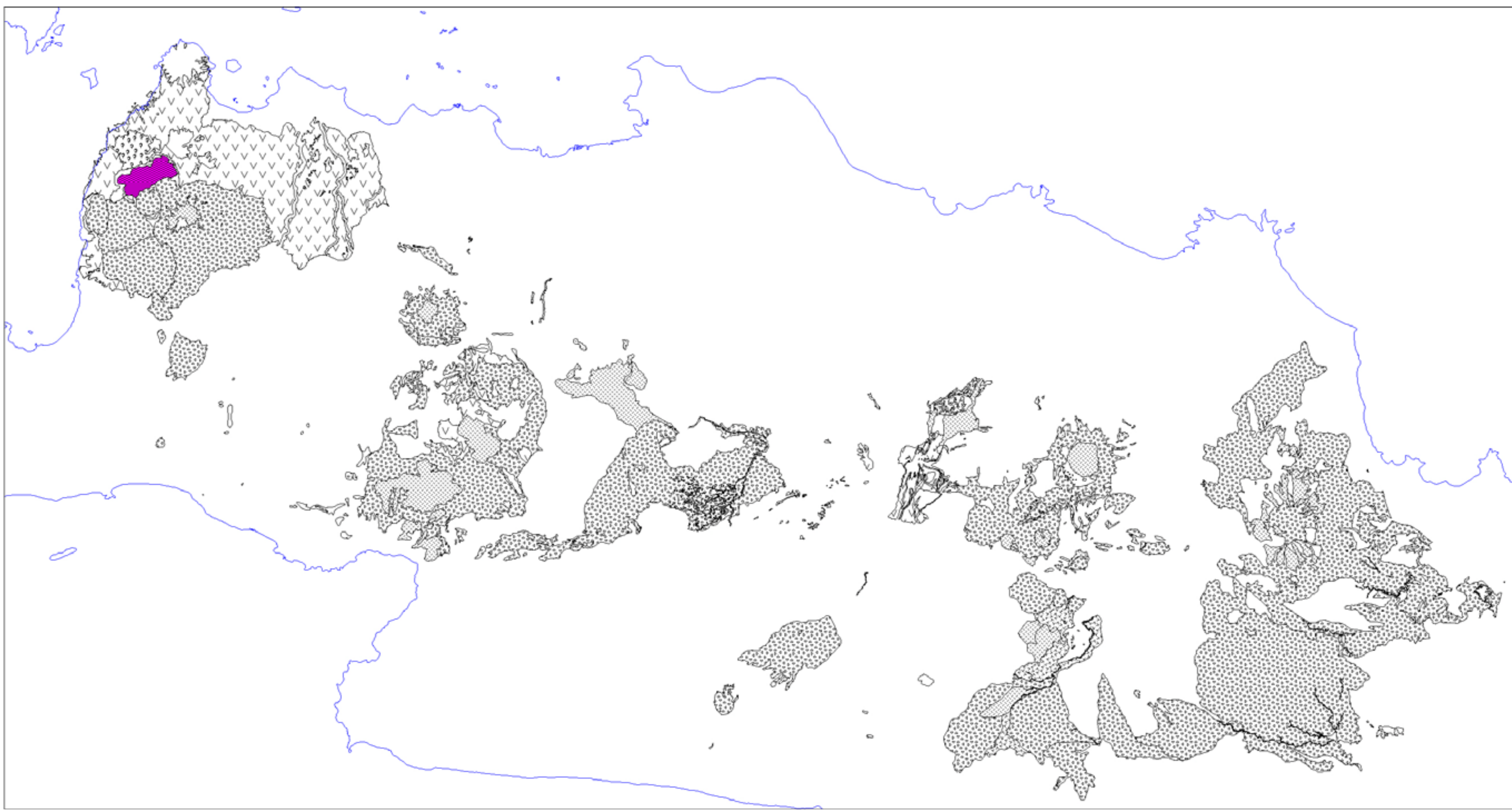


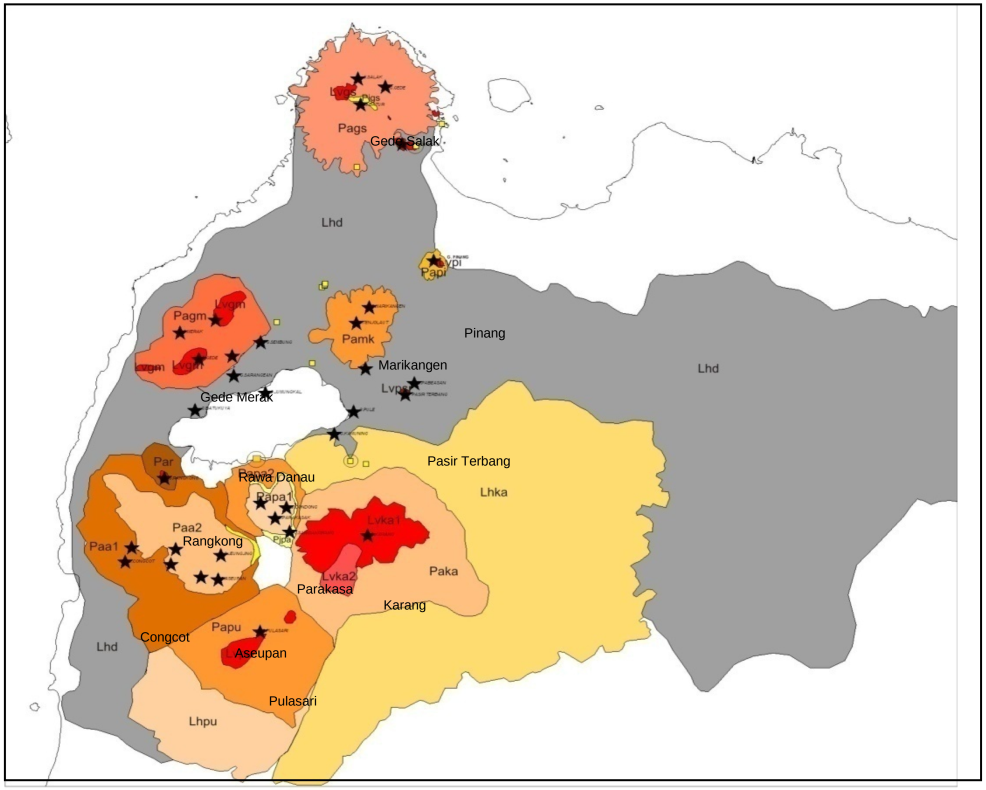


Distribution Map of Volcanic Rock (Plio-Plistocene)



Distribution Map of Volcanic Rock (Holocene)



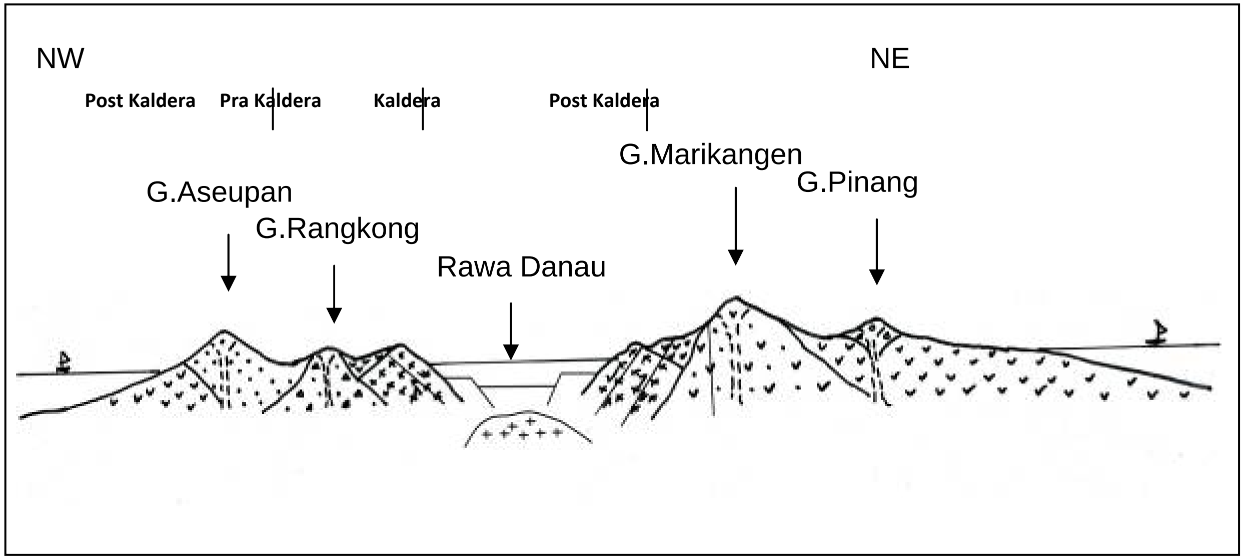


Pagm: Phyroclastic flow, Gede Merak
Lvgm:Lava Gede Merak
Pags: Phyroclastic flow, Salak
Pjgs: Phyroclastic flow, Gede Salak
Lvgs:" Lava Gede Salak

PETA GEOLOGI GUNUNGAPI KOMPLEKS RAWA DANAU

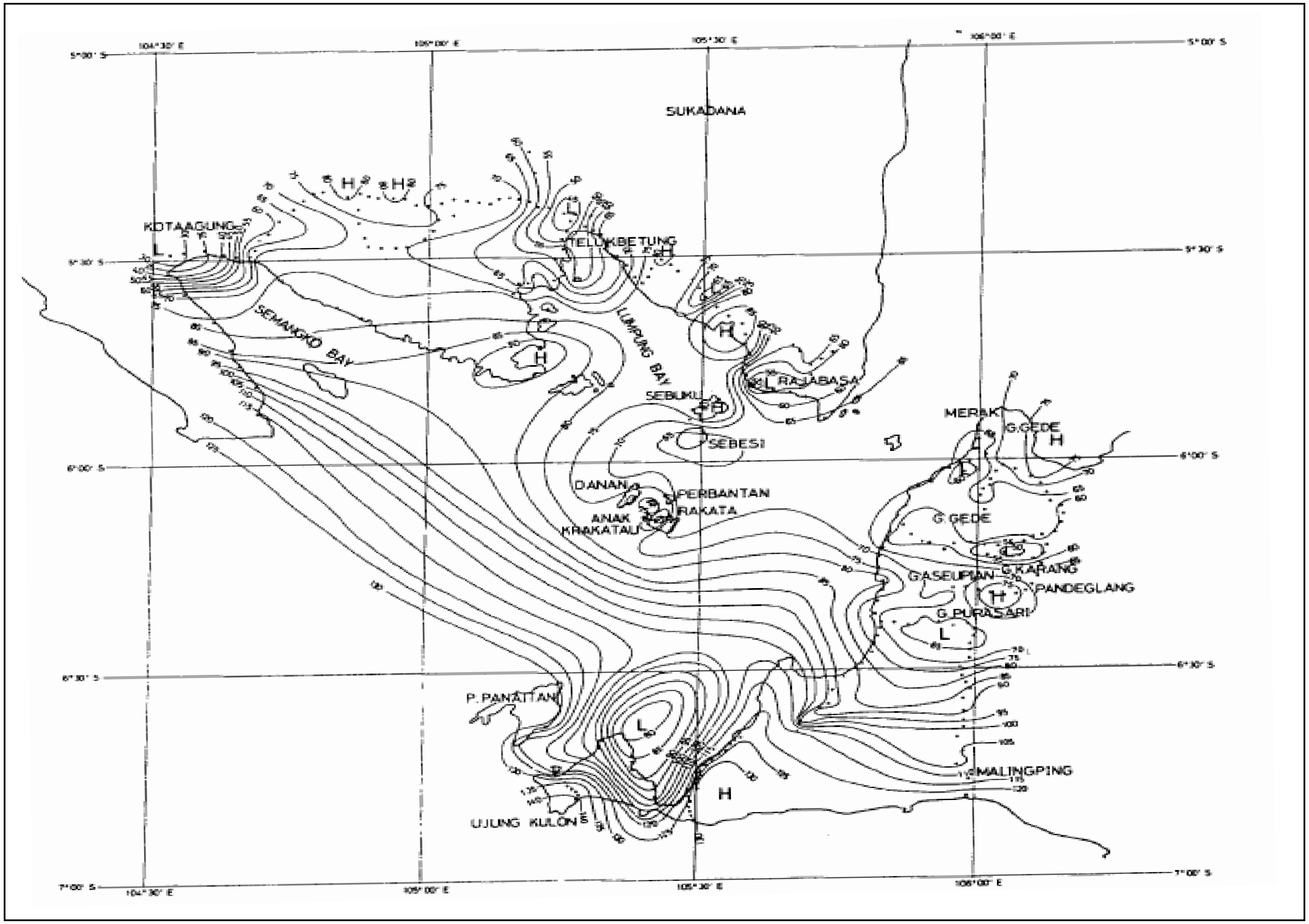
UMUR	GUNUNGAPI	LITHOLOGI
HOLOCENE	G. KARANG	Paka, Lvka1, Lvka2, Lhka
	G. PINANG	Papi, Lvpi
	G. PULASARI	Papu, Lvpu, Lhpu
	G. PARAKASAK	Papa1, Pjpa, Papa2
UPPER PLEISTOCENE	G. ASEUPAN	Paa1, Paa2
	DOME WADAS	Lvdw
	G. GEDE-SALAK	Pags, Pjgs, Lvgs
	DOME PASIRTERBANG	Lvpsr
	G. MARIKANGEN	Pamk
MIDDLE PLEISTOCENE	DANAU	Lhd
LOWER PLEISTOCENE	G. RANGKONG	Par, Lvr
	G. GEDE - MERAK	Pagm, Lvgm

Data of Eruption Characteristic Rawa Danau Complex. For eruption type, VEI, plume, description, frequency and ejection volume with asumtion from Newhall and Self (1982)

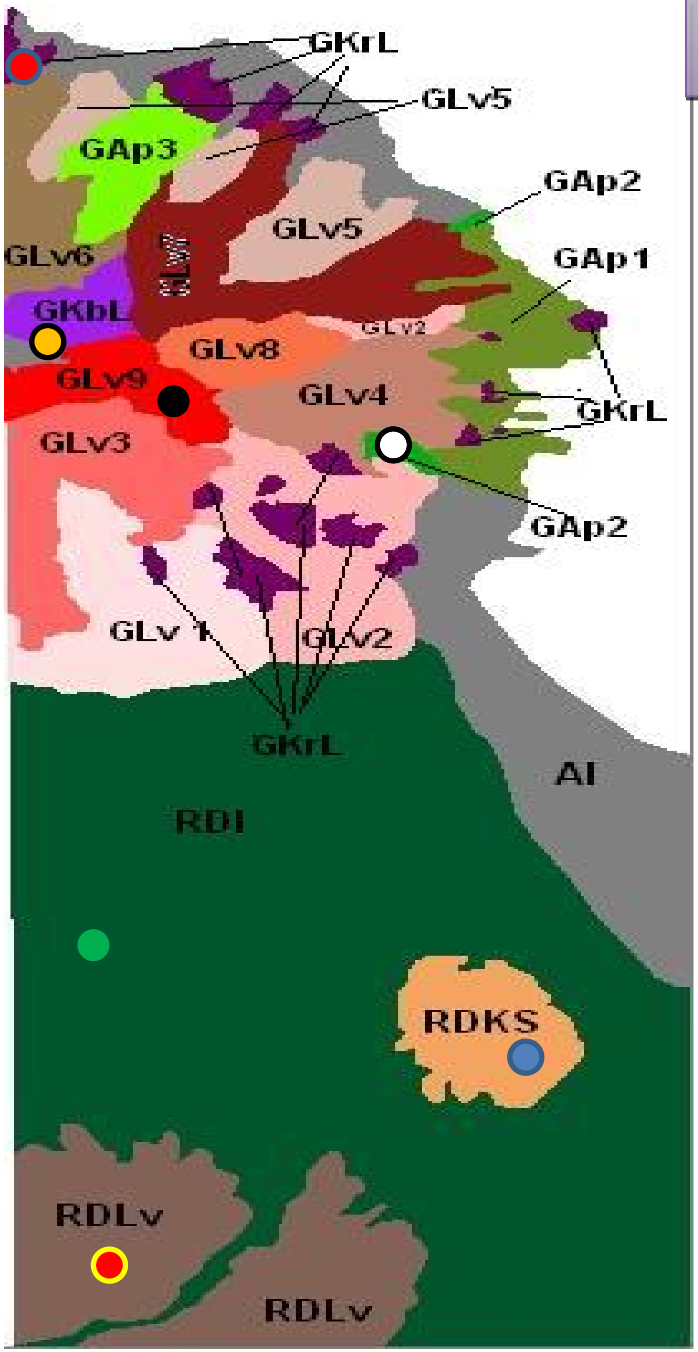


Nama Gunung	Umur	Periode	Tipe Erupsi	VEI	Plume	Deskripsi	Frekuensi	Volume ejecta
G.Karang								
G.Pinang								
G.Pulasari	Holosen							
G.Parakasak								
G.Aseupan								
Wadas Dome								
G.Gede-Salak	Pleistosen Akhir	Post kaldera	Vulkanian	3	1-5 km	Explosive	mingguan	> 1.000.000 (m³)
Pasirterbang Dome								
G. Marikangen								
Danau	Pleistosen Tengah, 70.000 tahun Yokoyama, et.al (1983)	Kaldera	Plinian	4	> 25 km	Paroksimal	tahunan	> 1 km³
G.Rangkong								
G. Merak	Pleistosen Awal	Pre Kaldera	Volkanian	3	1-5 km	Explosive	mingguan	> 1.000.000 (m³)
G. Gede								

Regional Bouger Anomaly: do not support the theory of Plinia Eruption of Rawadano Caldera



Volcano-Geological Mapping



Peta Geologi Gunungapi Daerah Telitian

Keterangan :

Batuan Sekunder

Aluvial (AL)

Satuan Kubah Lava Gede (GKbL)

Satuan Lava Kerucut Samping Gede (GKrL)

Satuan Gede Lava

Gede Lava 9 (GLv 9)

Gede Lava 8 (GLv 8)

Gede Lava 7 (GLv 7)

Gede Lava 6 (GLv 6)

Gede Lava 5 (GLv 5)

Gede Lava 4 (GLv 4)

Gede Lava 3 (GLv 3)

Gede Lava 2 (GLv 2)

Gede Lava 1 (GL 1)

Aliran Piroklastik 3 Gede (GAp 3)

Aliran Piroklastik 2 Gede (GAp 2)

Aliran Piroklastik 1 Gede (GAp 1)

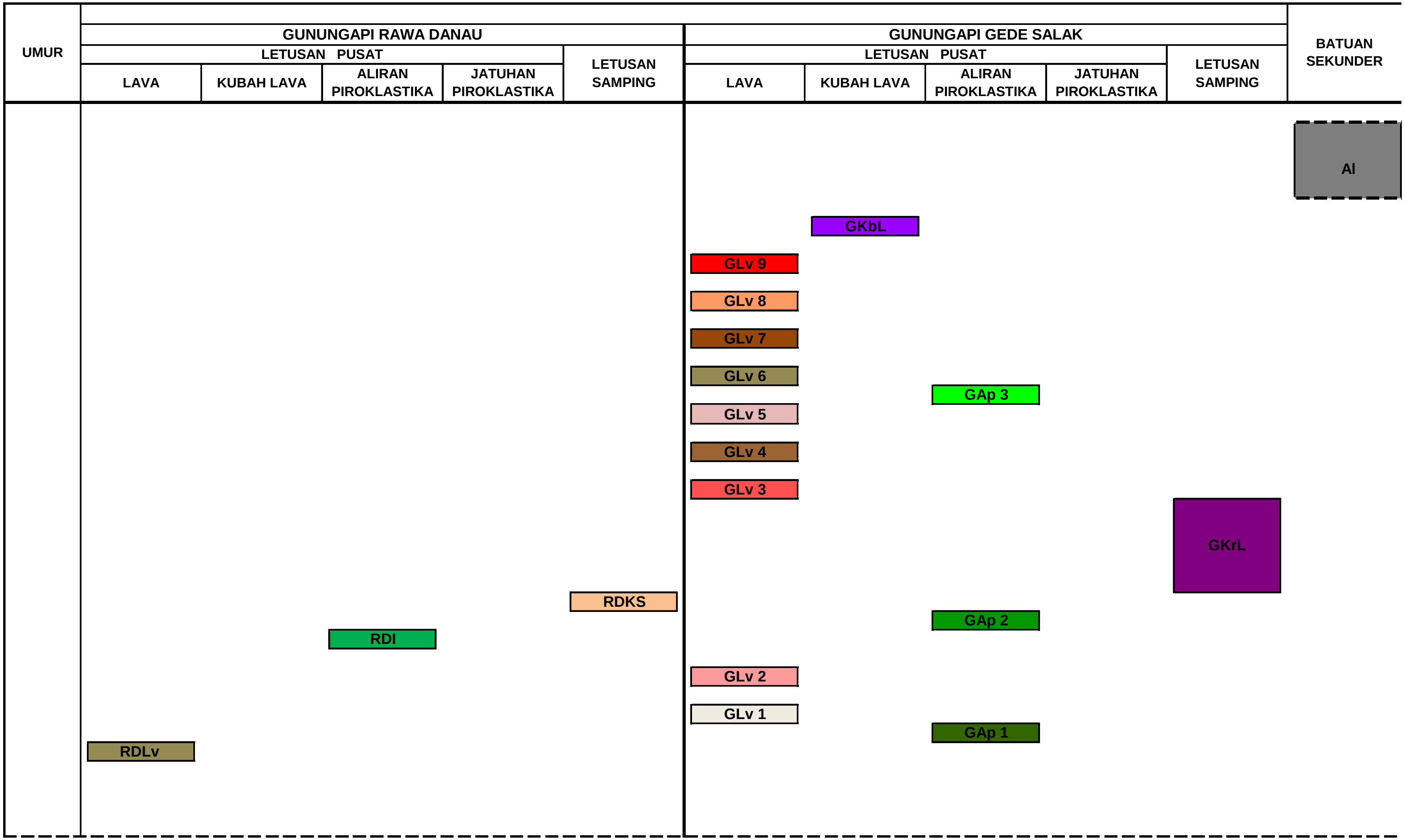
Satuan Kerucut Cinder Rawa Danau (RDKS)

Satuan Ignimbrit Rawa Danau (RDI)

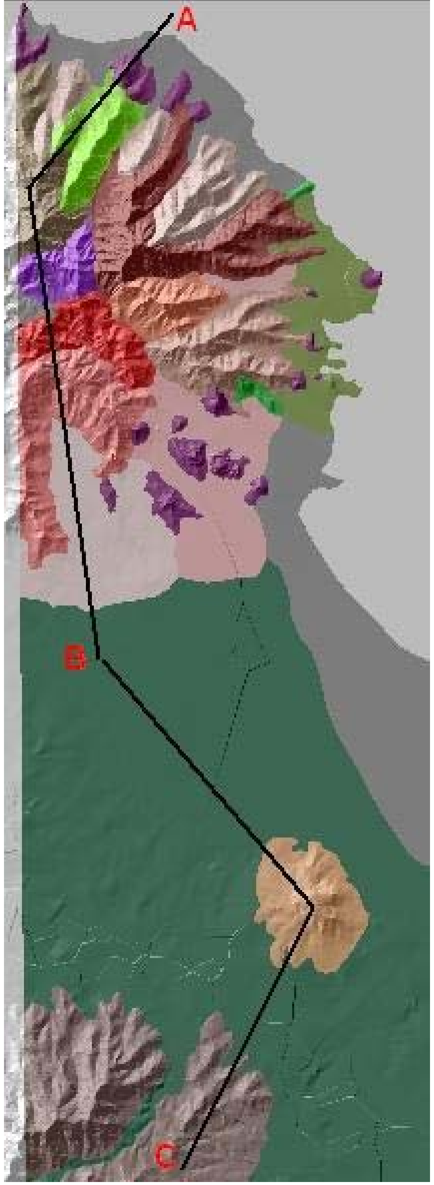
Satuan Aliran Lava Rawa Danau (RDLv)

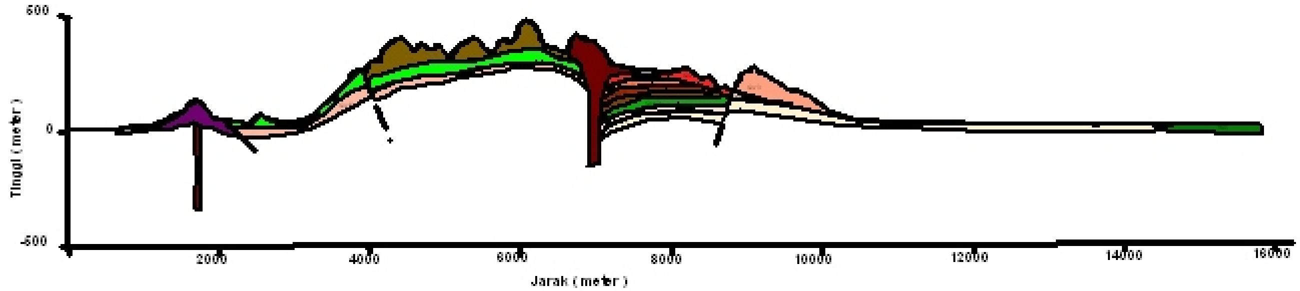
PENAMPANG

Volcano-Geological Mapping



GEOLOGICAL CROSS SECTION





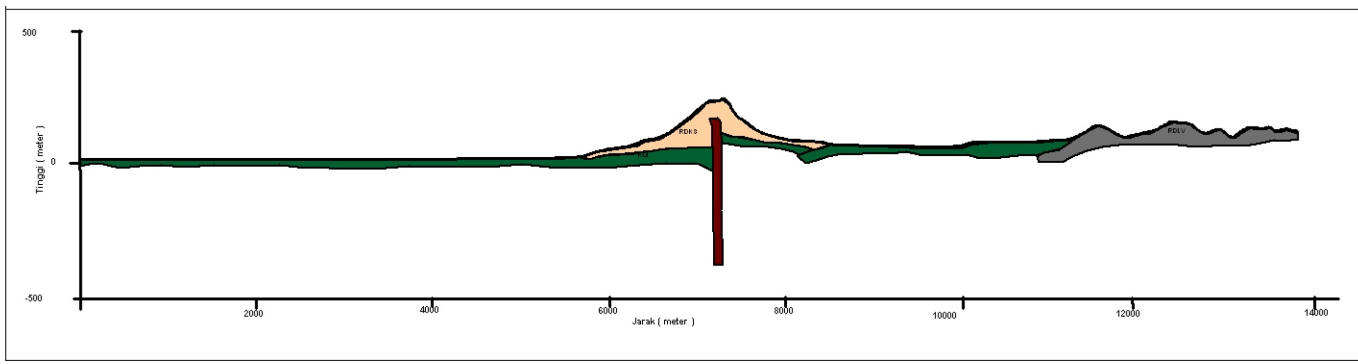
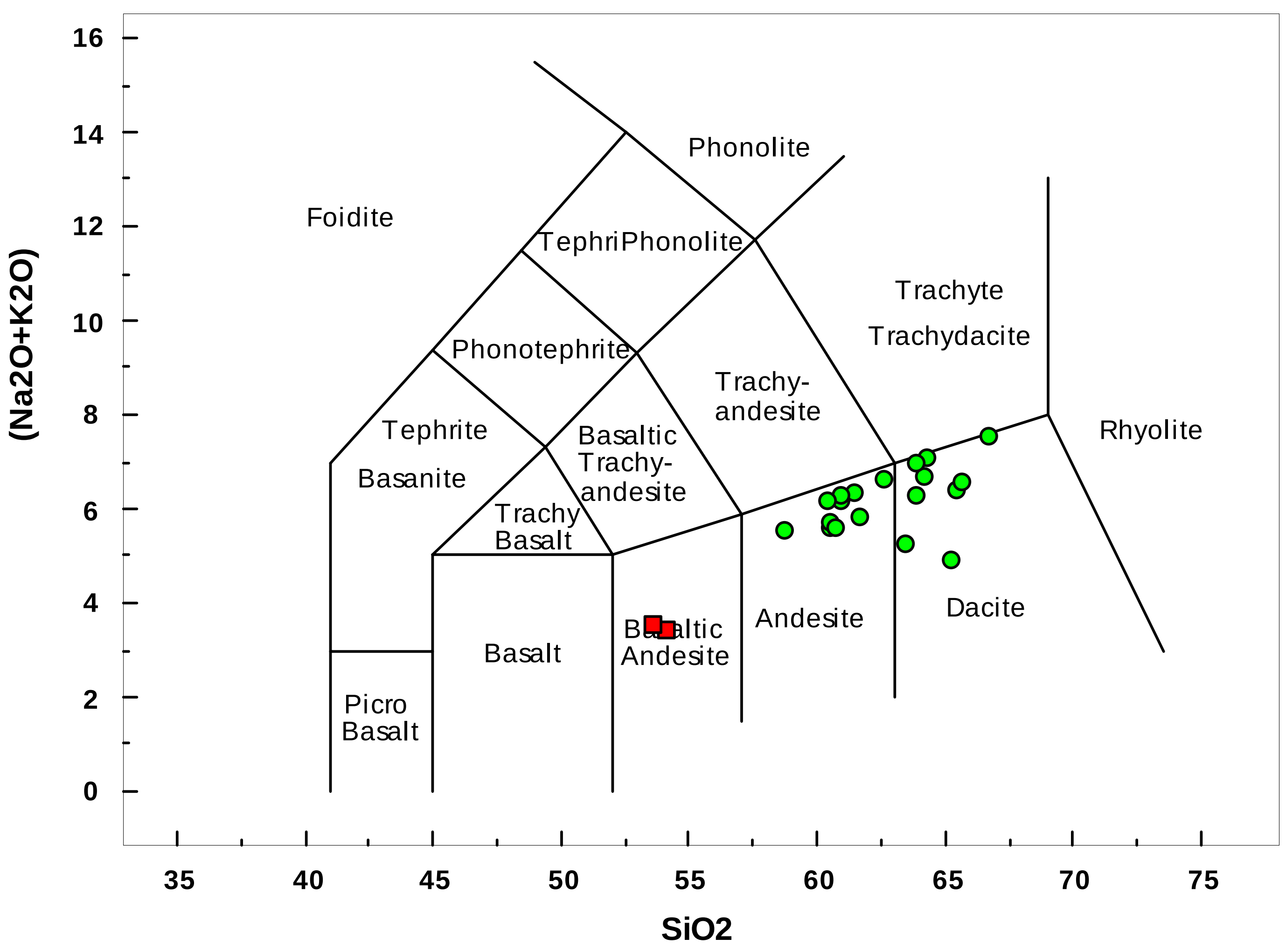


Diagram of Volcanic Rock Classification in Banten Region Based on Geochemical Analysis (diagram Le Maitre et.al., 1989 in Rolinson, 1993)

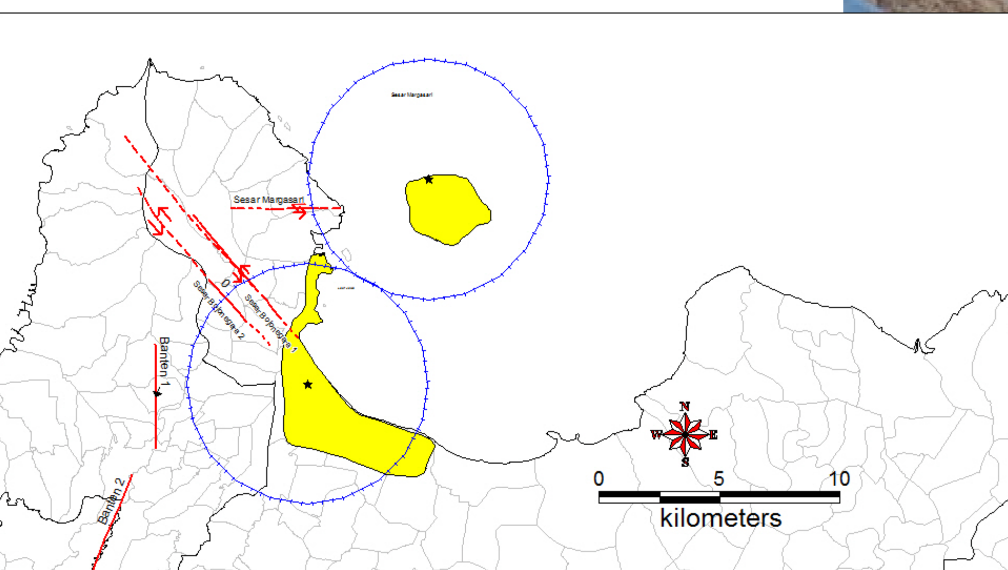


7 Conclusion and Recommendation

TRENCHING/EXCAVATION
(taken from Mr. Fukushima Presentation, Indonesia, 2008)

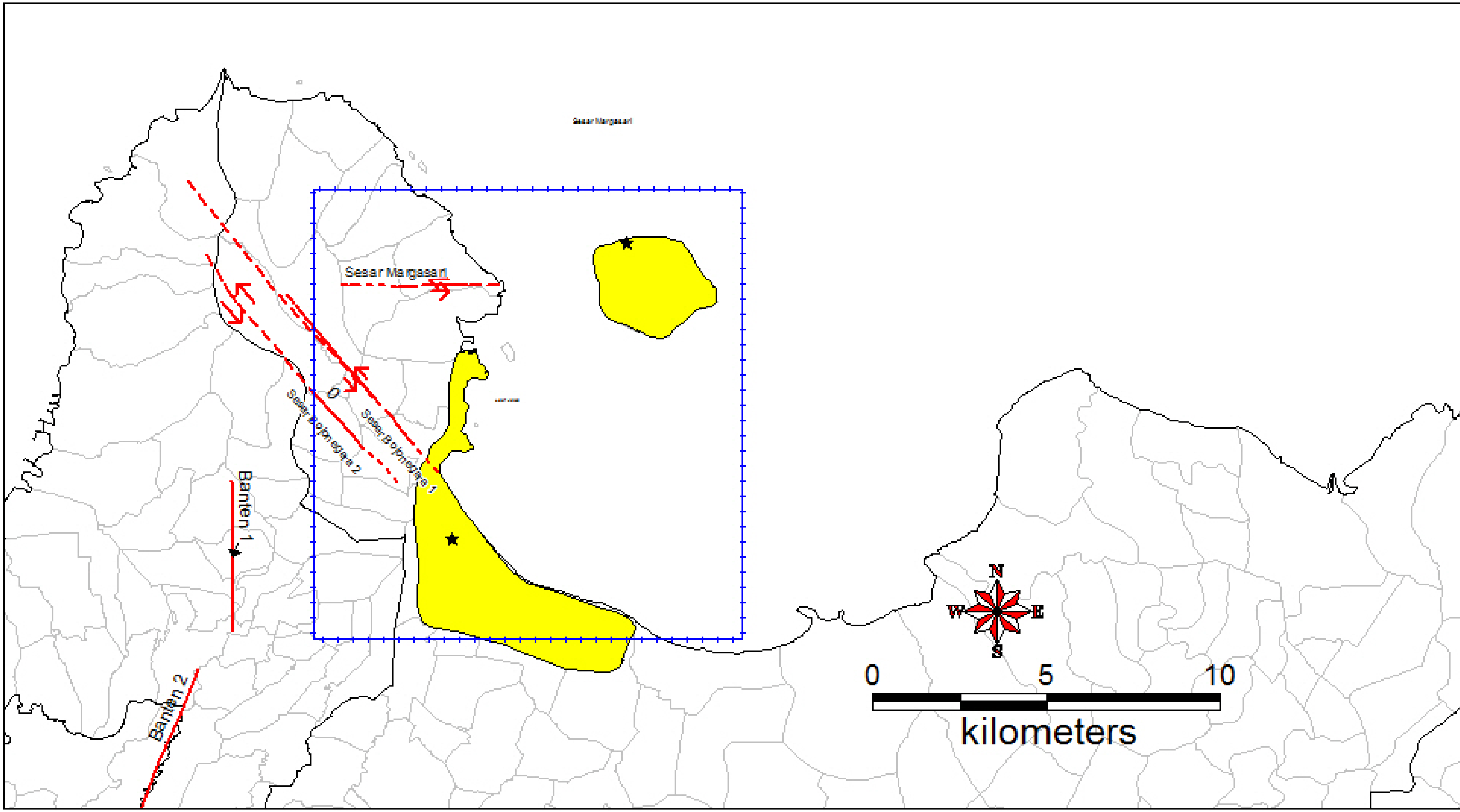
Stratum layers around the active faults are directly observed by excavation for surveying which layers are crossed by the fault displacements. This survey helps knowing the locations, shapes and degrees of activities of the active faults.

Trenching will be perform at supposed capable fault in the site vicinity (5 km): Bojonegara dan Margasari Fault



Trench excavation survey
(Sanageyama Faults, Aichi)

SEISMIC REFLECTION 2-D PLANNING



Volcanic Hazard Assessment

- Volcano-Geological mapping in detail
- Volcano-stratigraphy mapping
- Probabilistic assessment: Age dating, petrography and geochemical analysis
- Deterministic assessment


Thank You