"Regional Workshop on Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements"
Nuclear Energy Regulatory Agency (BAPETEN), Indonesia
13-17 June2011

Overview of the Japanese siting methodologies against earthquake and tsunami hazards

Jun-ichi UCHIDA

Japan Nuclear Energy Safety Organization (JNES)
Seismic Safety Division

Contents

1-1. Actual practices of Geological, Geotechnical and Seismological survey in NPP siting

Safety Guidelines for Seismic Design on NPP

(a) Government

NSC 2006-59 App1

Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities[1]

NSC Decision No. 2006-D59, Appendix 1
September 19, 2006
The Nuclear Safety Commission of Japan

"Earthquake ground motions with the site specific earthquake source locations"

Japanese safety guidelines for active fault

Recipe for Predicting Strong Ground Motion from Future Large Earthquake

"Earthquake ground motions with no such specific source Locations" (diffuse seismicity)

(b) Nongovernment (Japan Electric Association)

(a) Government

Seismic safety guidelines for active fault (June.20.2008, NSC)

Revised

Guidelines for safety review with regard to geology and ground of site for NPS (Dec.20.2010, NSC)

I. Introduction

II. Definition of technical term

III. Suitable combination of tectonic relief survey, surface geological survey and geophysical survey

1. Survey of active fault around the NPS

1.1 Bibliographic survey, tectonic relief survey, surface geological survey and geophysical survey

1.2. Classification of earthquake, survey of ground and marine

(1) Survey of Inland Earthquake

(2) Survey of Interplate Earthquake

1.3. Identification of active fault for seismic design

2. Survey of geological structure and ground around the NPS

IV. Identification of active fault need to consider for Safety Guidelines for an earthquake-resistant design

V. Assessment of support performance for ground under the building

VI. Phenomenon accompanying an earthquake

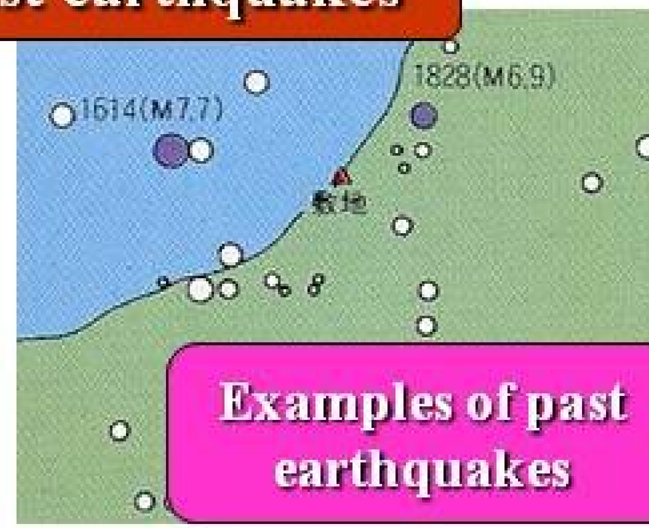
VII. Reliability on survey

VIII. Residual Risk

(a) Government

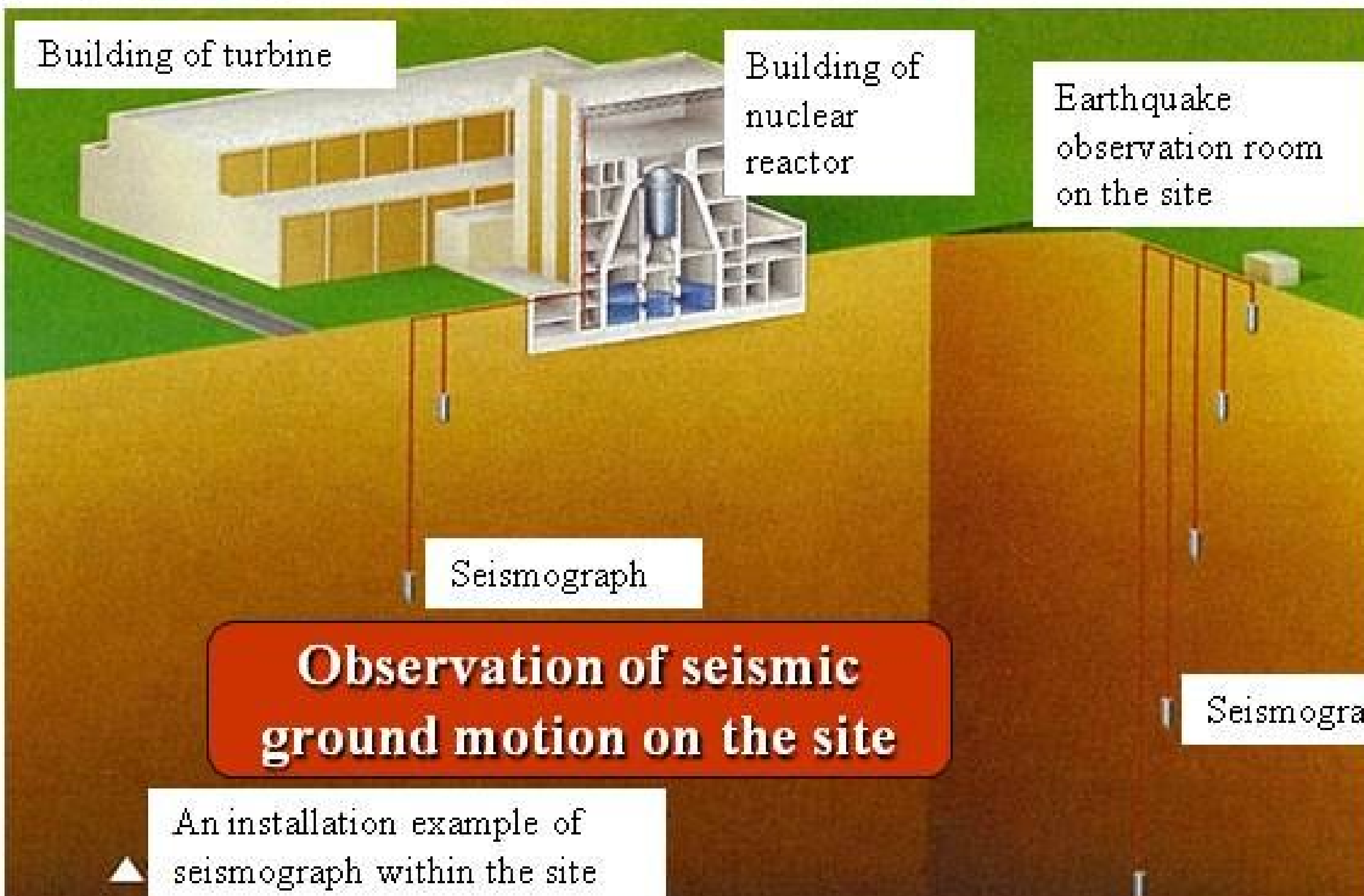
Investigation into past earthquakes


Examples of ancient literatures



Examples of past earthquakes

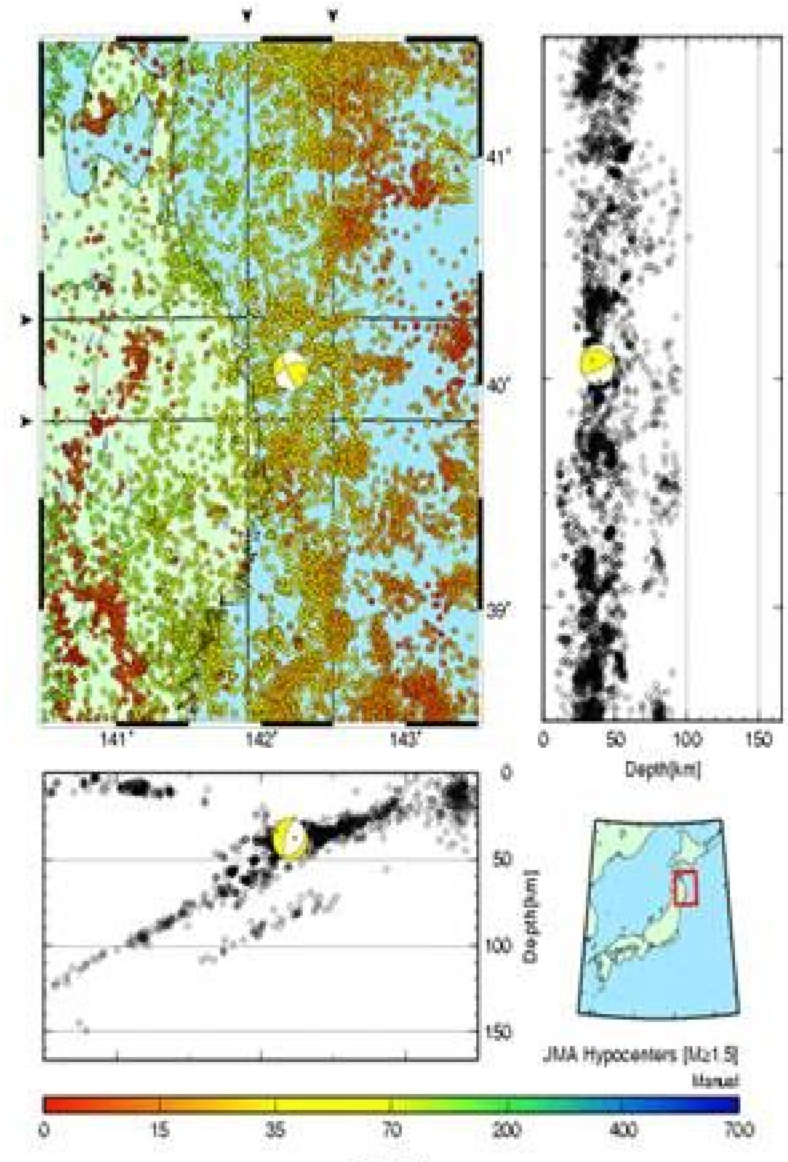
Observation of seismic ground motion on the site



An installation example of seismograph within the site

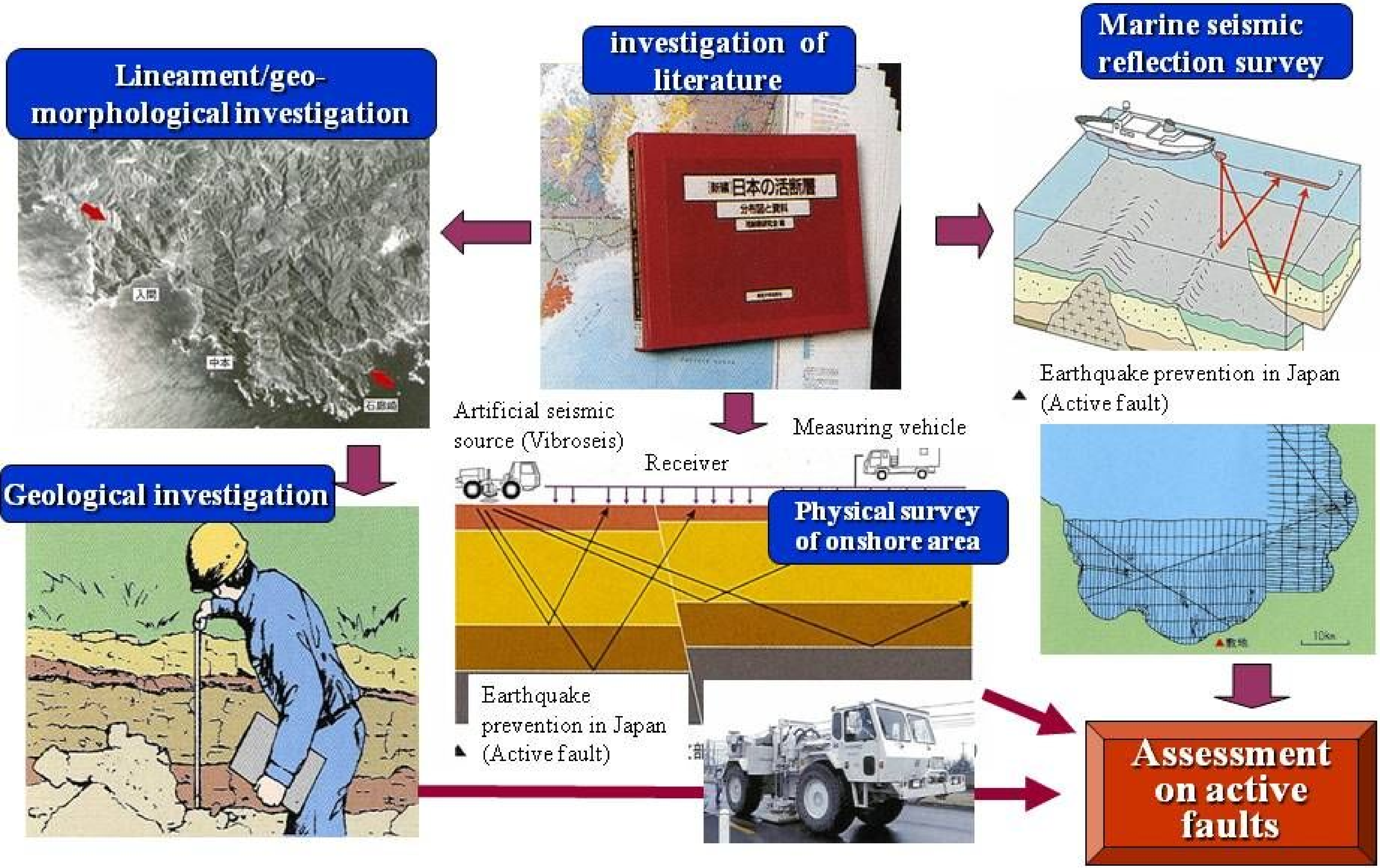
Observation of seismic ground motion outside the site

- Observation of microearthquakes -



Observation records on earthquakes (from web site of National Research Institute for Earth Science & Disaster Prevention)

(a) Government

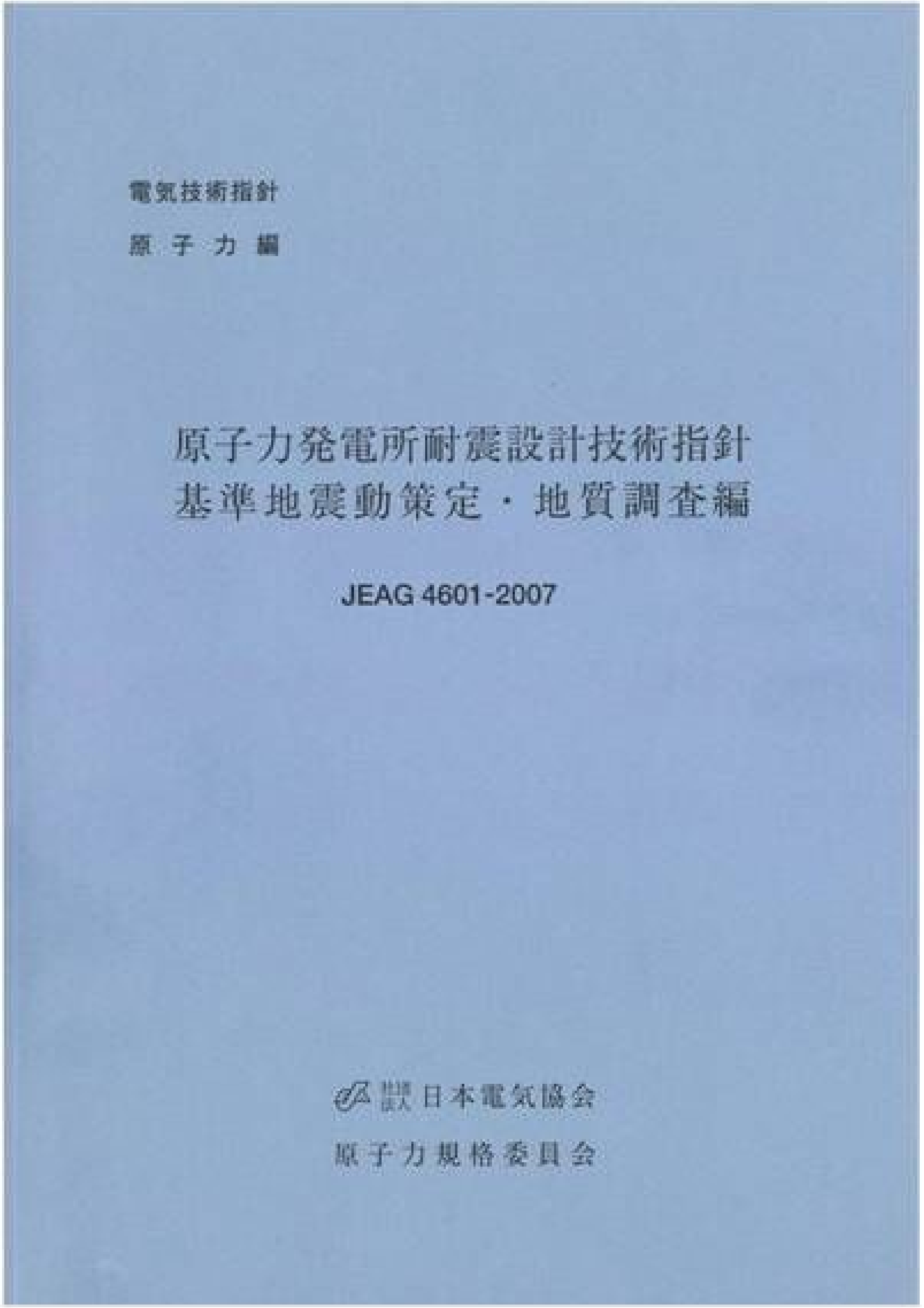


(b) Nongovernment (Japan Electric Association)

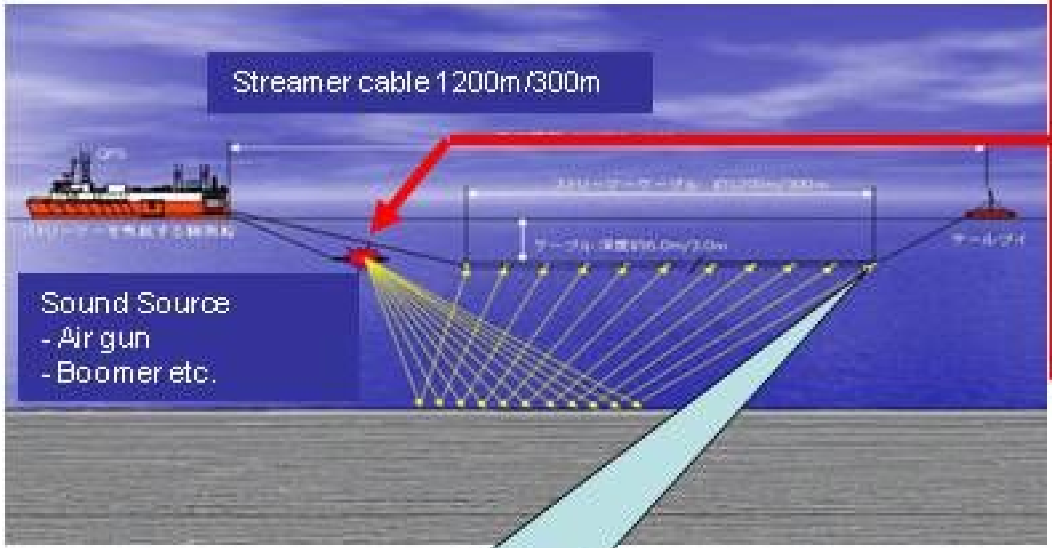
[Contents]

1. Formulation of Design Basis Earthquake Ground Motion
   1.1 Basic Policy
   1.2 Earthquake ground motions with the site specific earthquake source locations
   1.3 Earthquake ground motions with no such specific source locations
   1.4 Formulation of Design Basis Earthquake Ground Motion (Ss)

2. Geological survey
   2.1 Basic Policy
   2.2 Geological survey
   2.3 Classification of ground

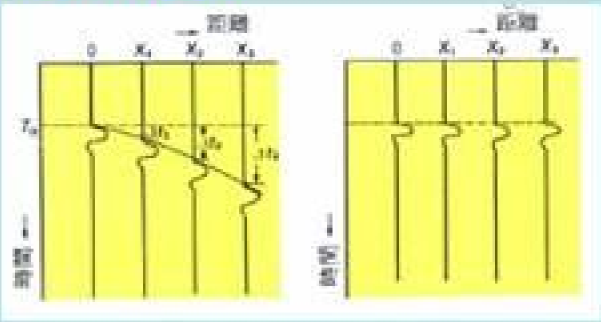


The principle of marine seismic reflection survey

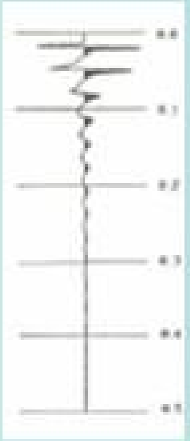


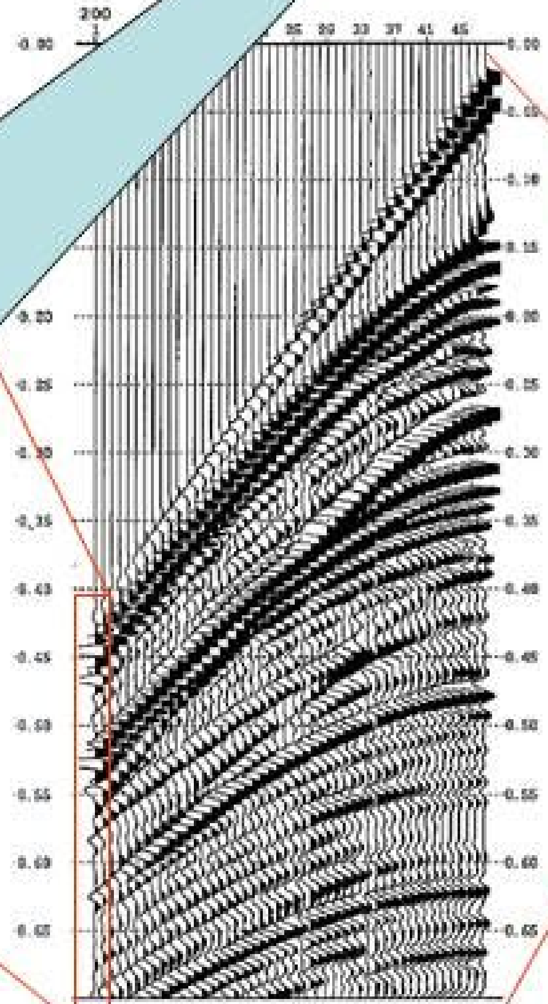
AIST eds.(2006)

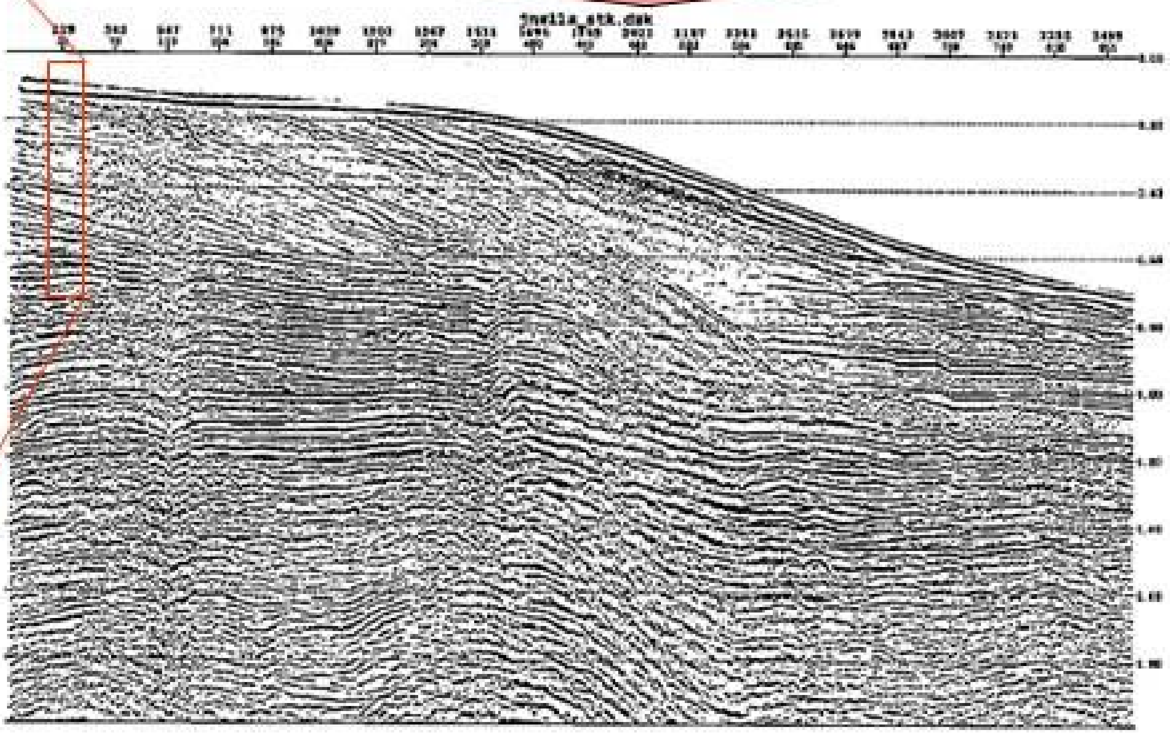
Convert data sets to **SEG-Y format.**
Auto convert can be performed.



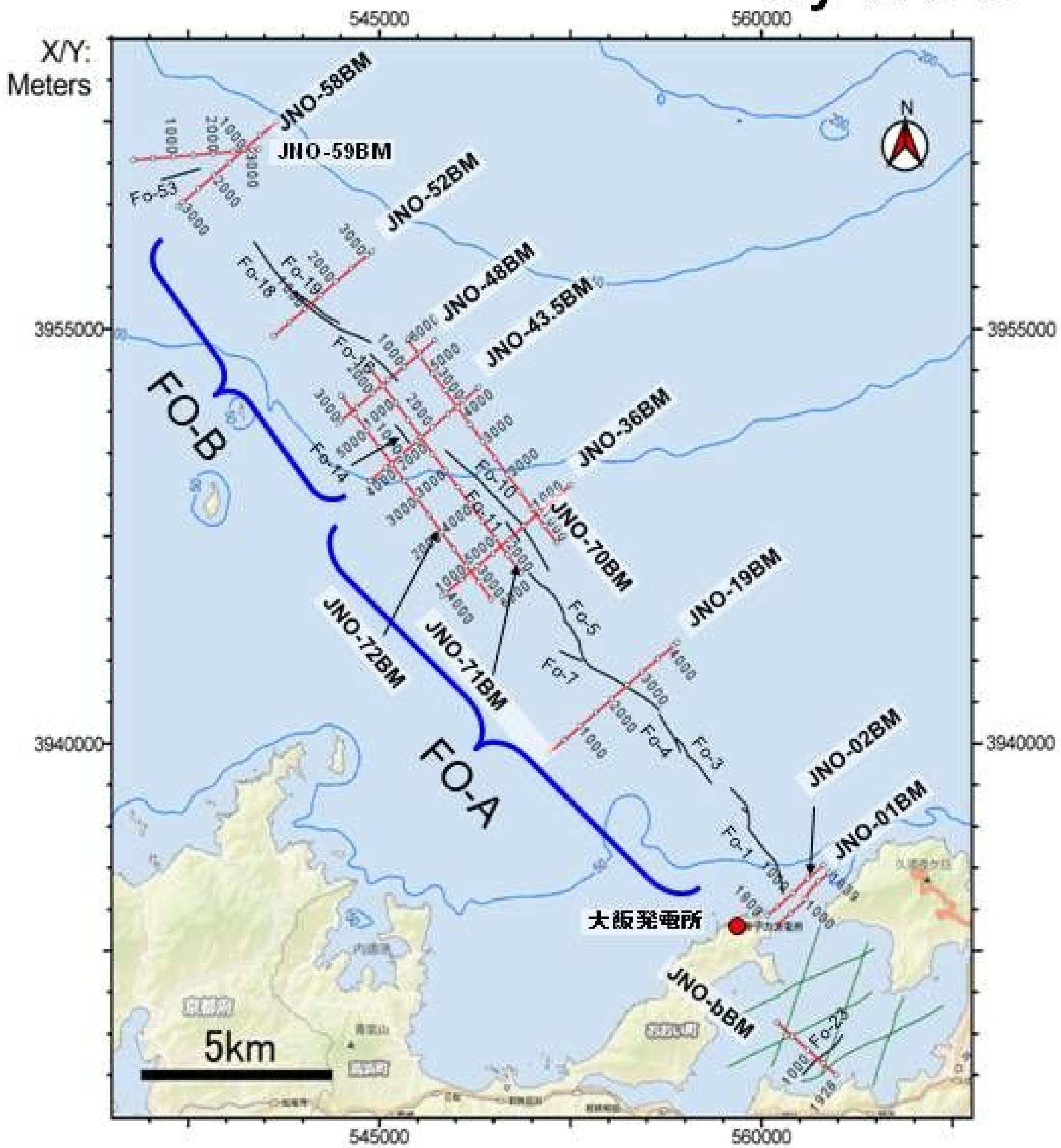
A wave datum







Locations of faults and marine seismic reflection survey by *JNES*



fault
Reflection survey

How find active faults?

Step-1

Collecting fault locations based on detail literature searches

Step-2

Designing location of reflection survey

Step-3

Interpreting active faults based on reflection cross sections

Attention:

Ordinary, interval of reflection surveys is several hundreds meters along fault, those found by detail literature searches.

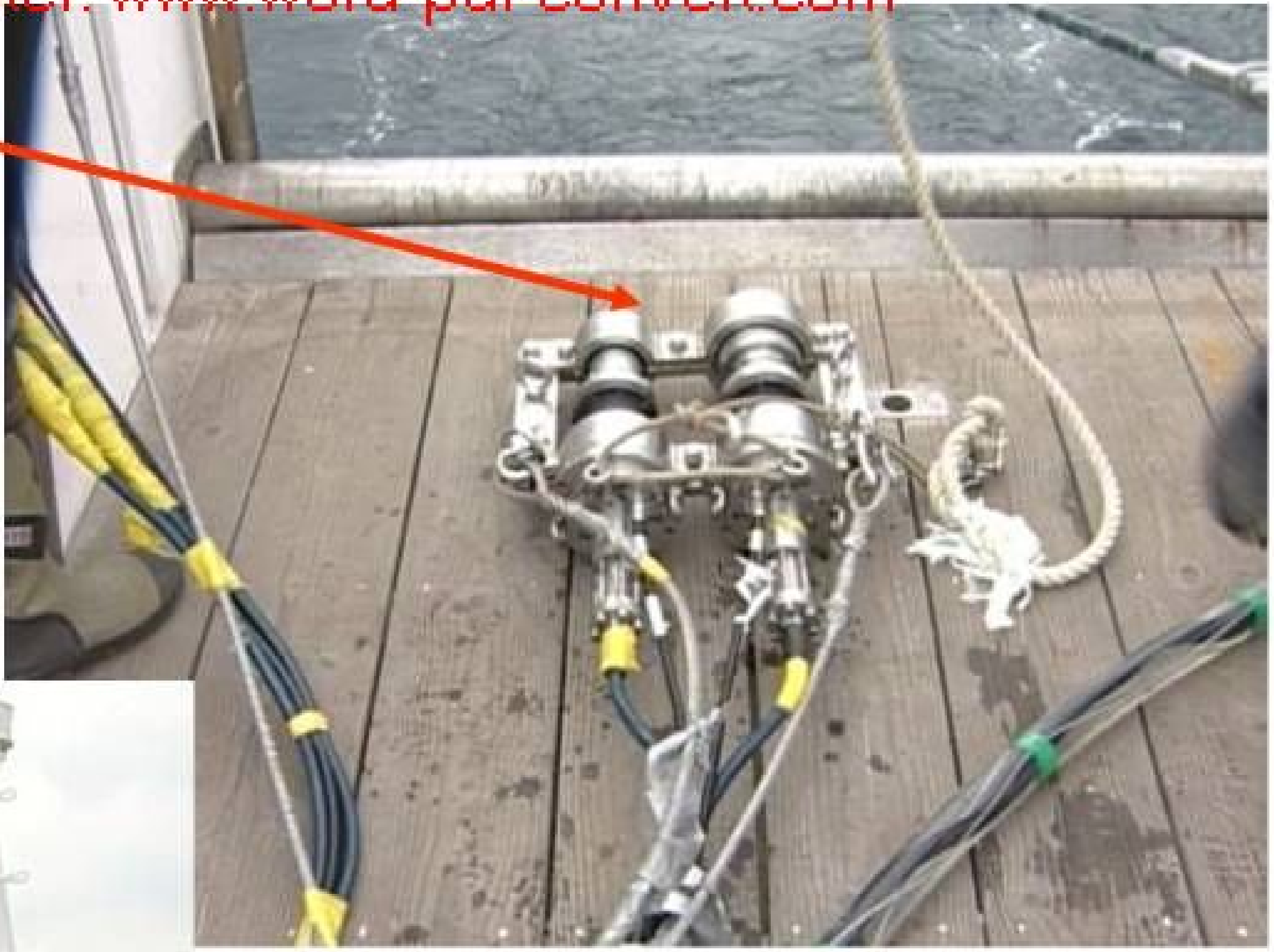
Modified from NSC (Japan) WG2 No. 57-2-1

Marine seismic reflection survey by *JNES*

Streamer cable

Marine seismic reflection survey by *JNES*

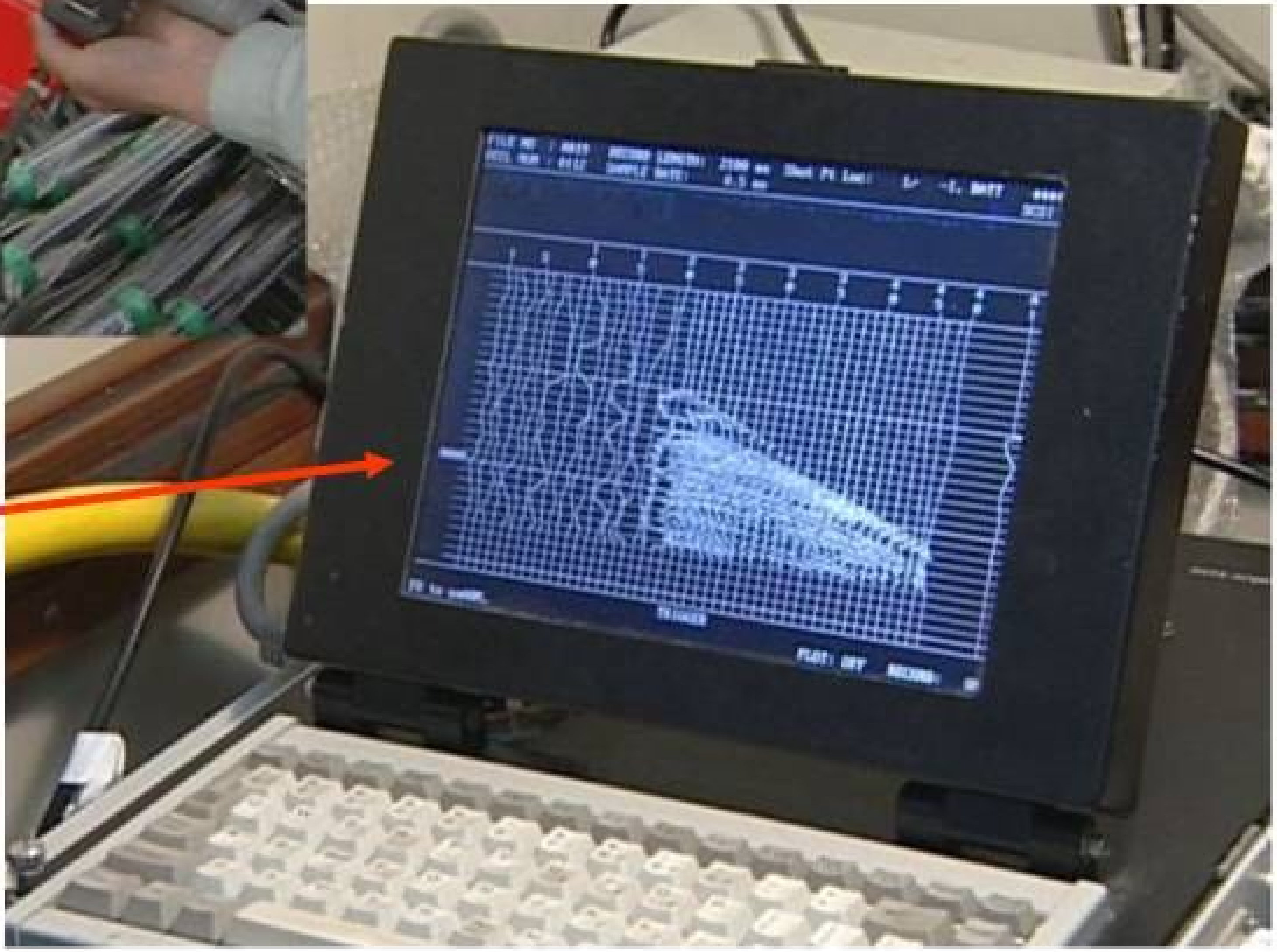
Sound source (Boomer)



Buoy for marking
and floating of sound source

Marine seismic reflection survey by *JNES*

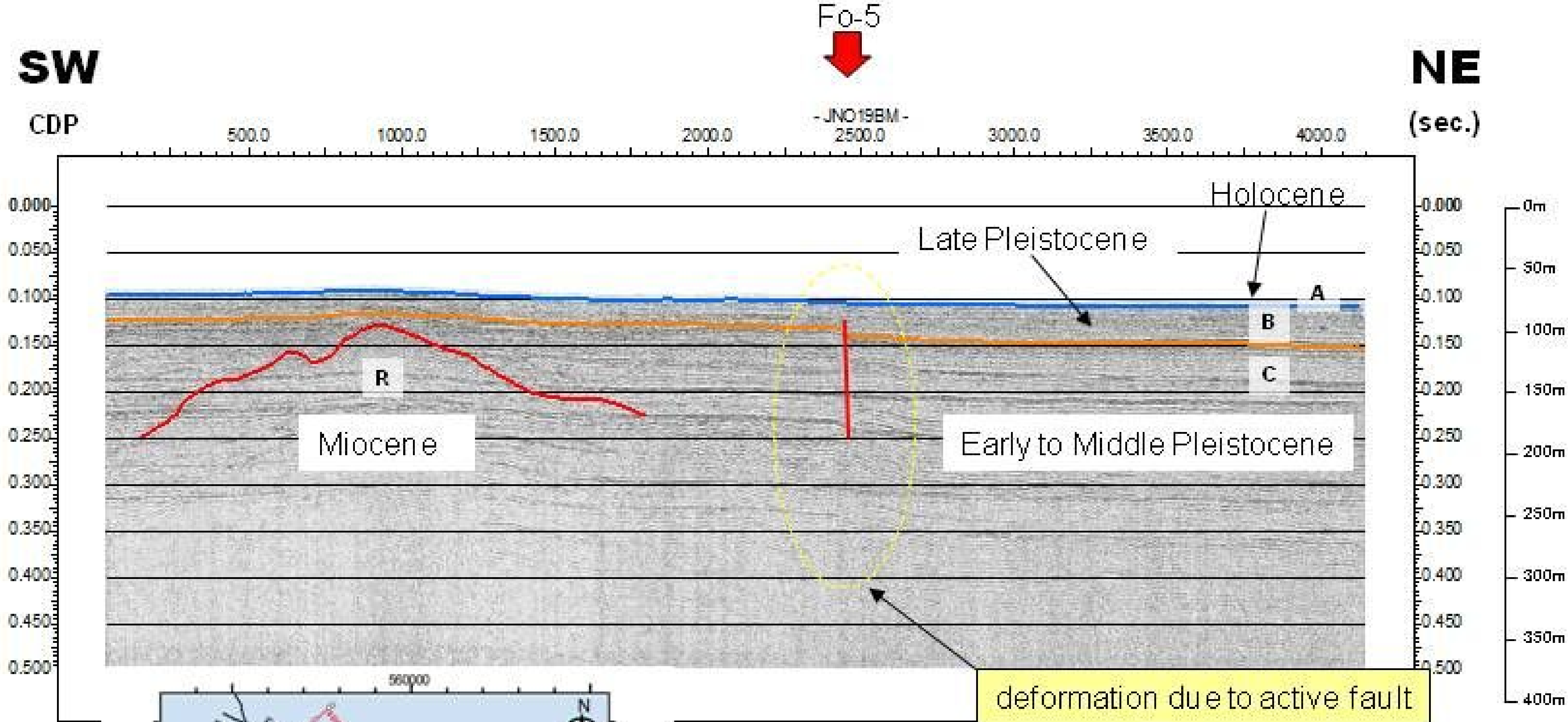
Receiver



Simultaneous monitoring

Example of seismic reflection profiling with active fault

shallow part of marine deposits



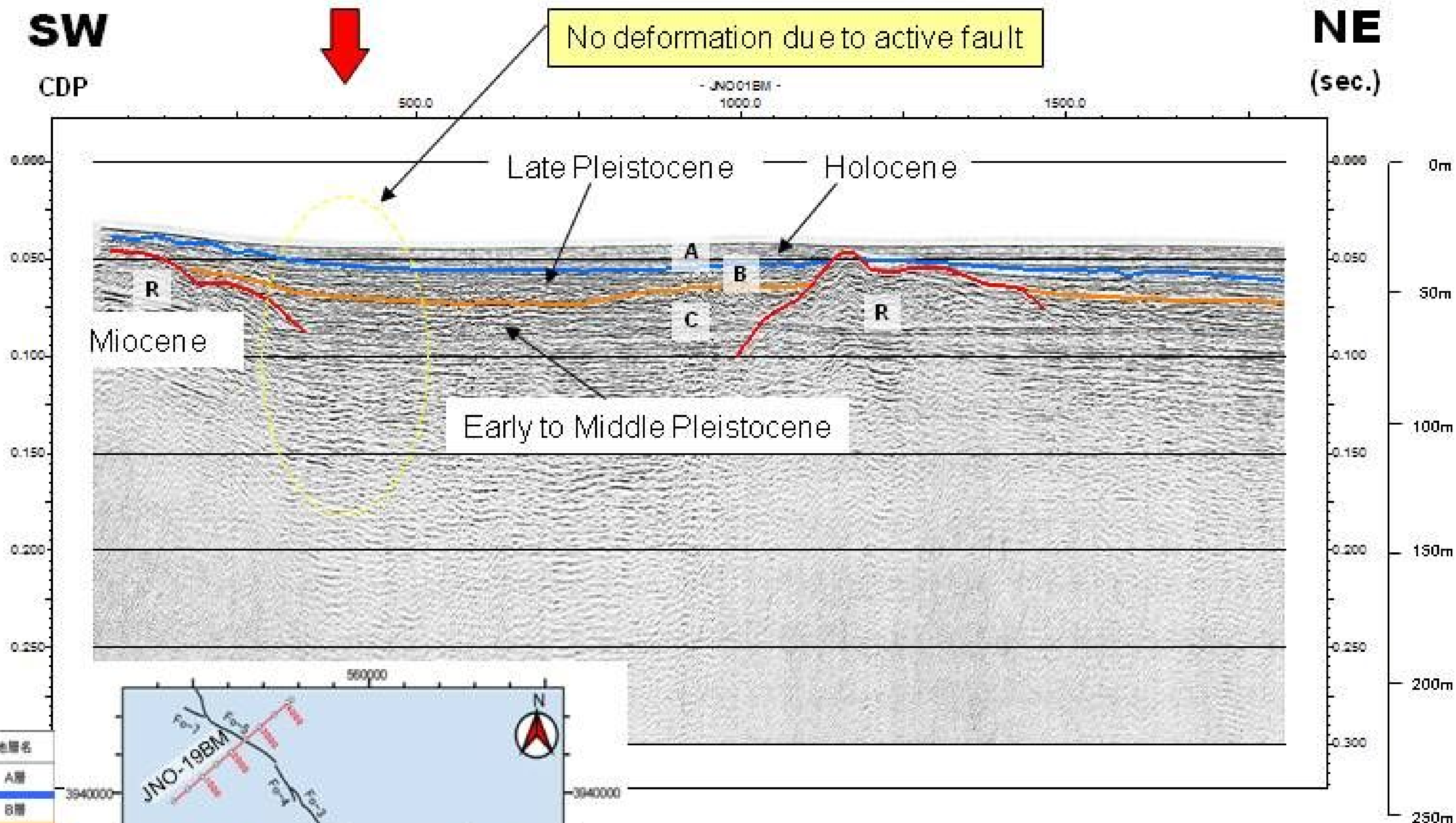
地質時代			地層名
第四紀	完新世		A層
	更新世	後期	B層
		中期	C層
		前期	
新第三紀	鮮新世	後期	
		前期	
	中新世	後期	R層
		中期	
		前期	
先新第三紀			

VE≒6

1km

Modified from NSC (Japan) WG2 No. 57-2-1

Example of seismic reflection profiling without active fault shallow part of marine deposits

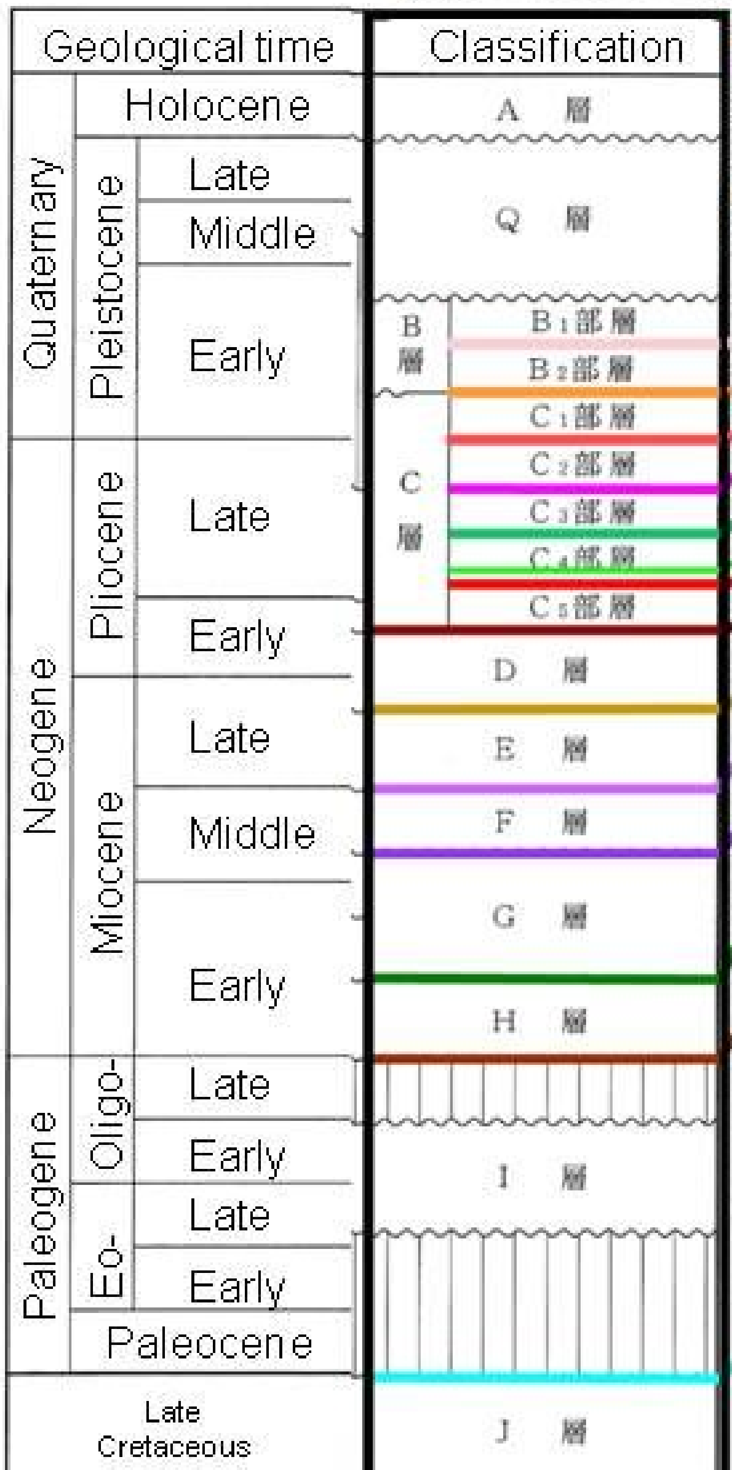


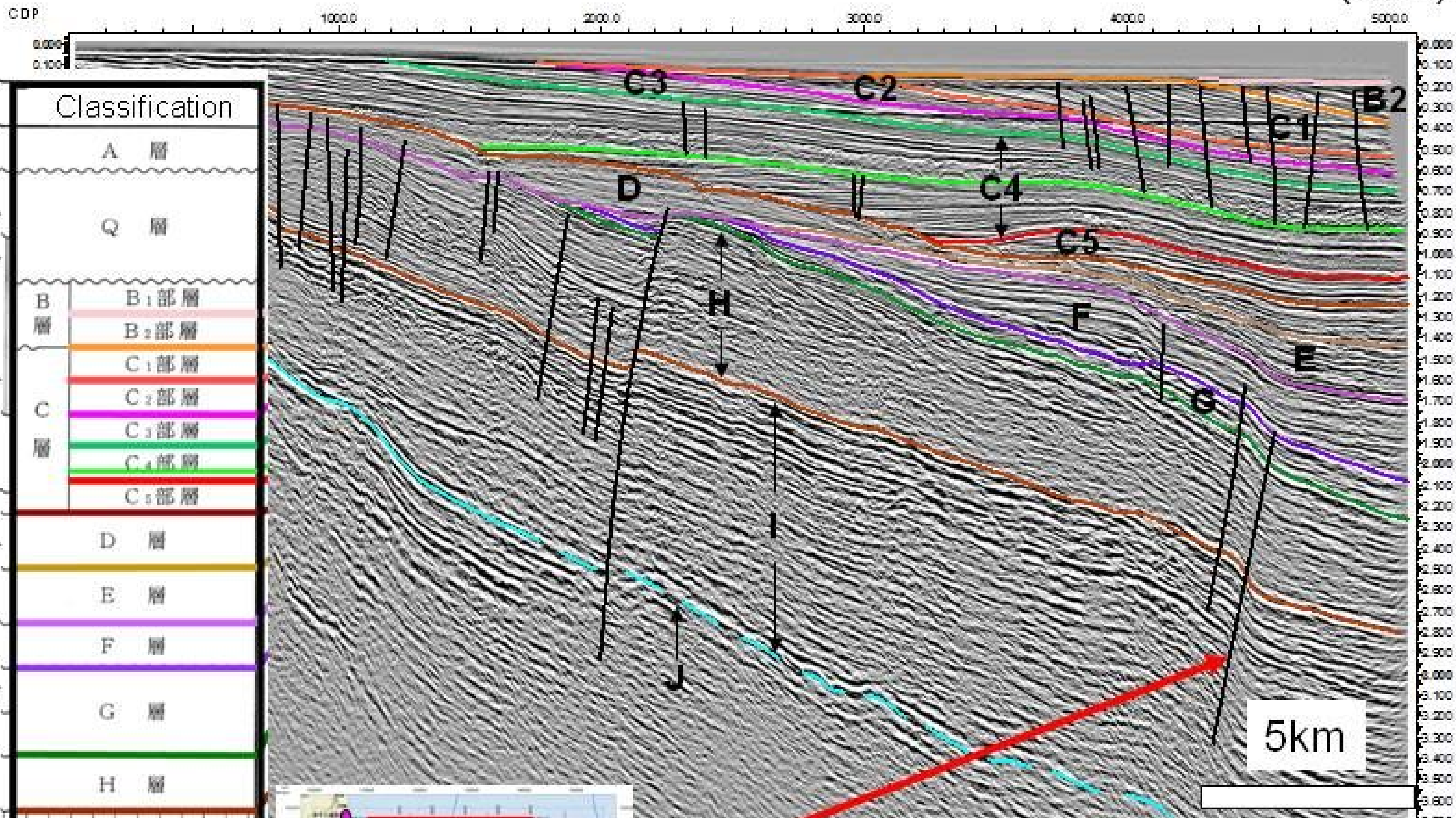
地質時代			地層名
第四紀	完新世		A層
	更新世	後期	B層
		中期	C層
		前期	
新第三紀	鮮新世	後期	
		前期	
	中新世	後期	R層
		中期	
		前期	
先新第三紀			

Modified from NSC (Japan) WG2 No. 57-2-1

Example of seismic reflection profiling without active fault

Intermediate shallow part of marine deposits



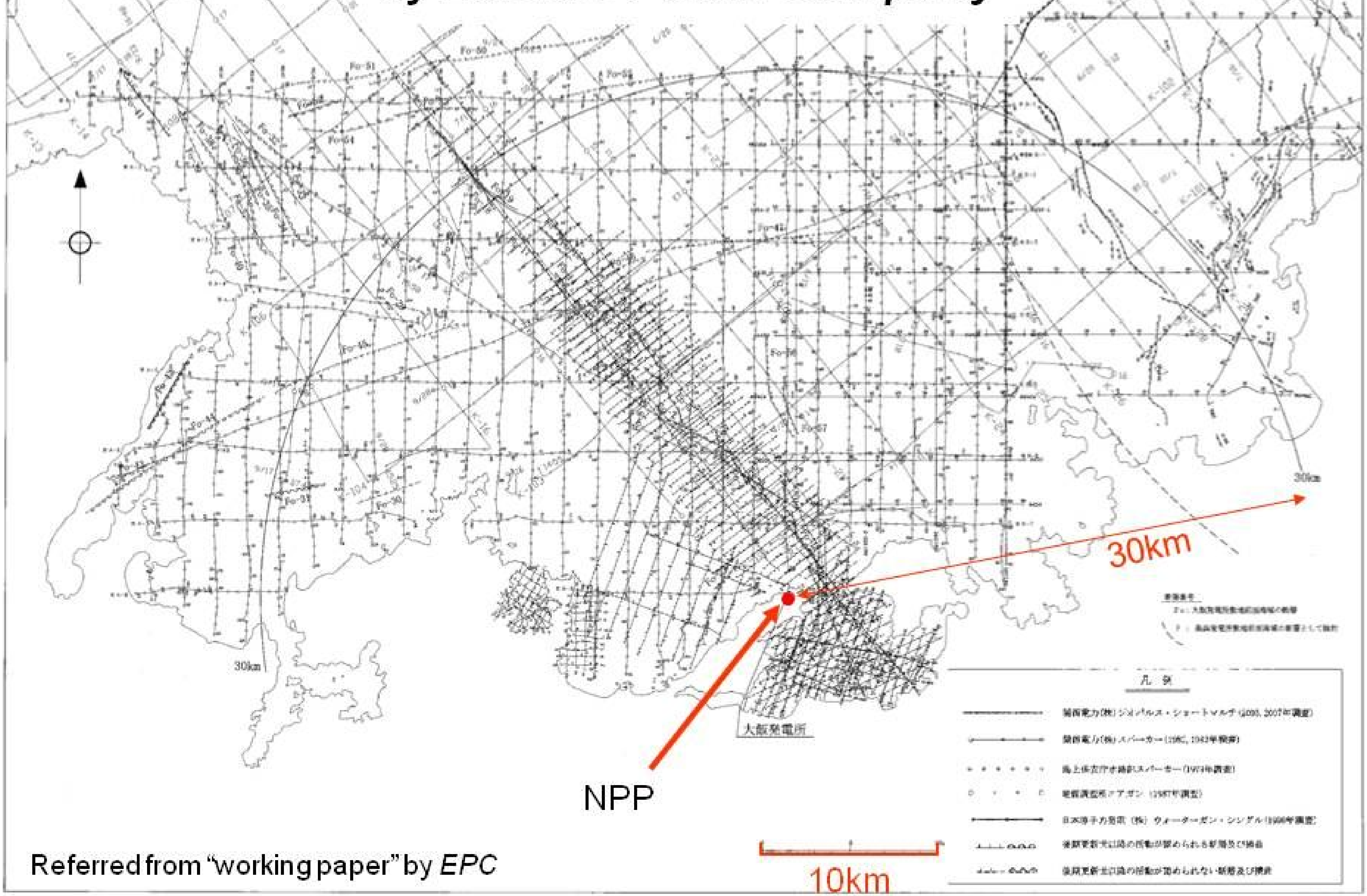


Reverse fault does not influence upper strata than C3 strata.

Because C3 is Late Pliocene strata, this fault has not moved since Latest Pliocene.

Modified from NSC (Japan) WG1 No. 14-1-3

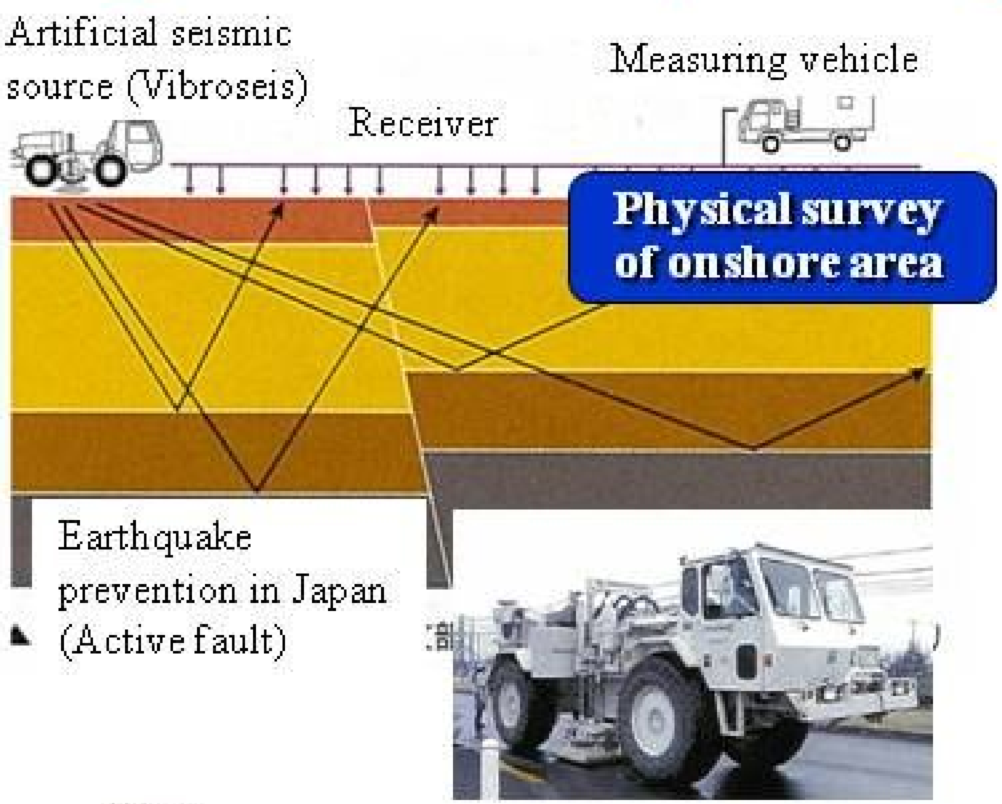
Locations of marine seismic reflection survey by *Electric Power Company*

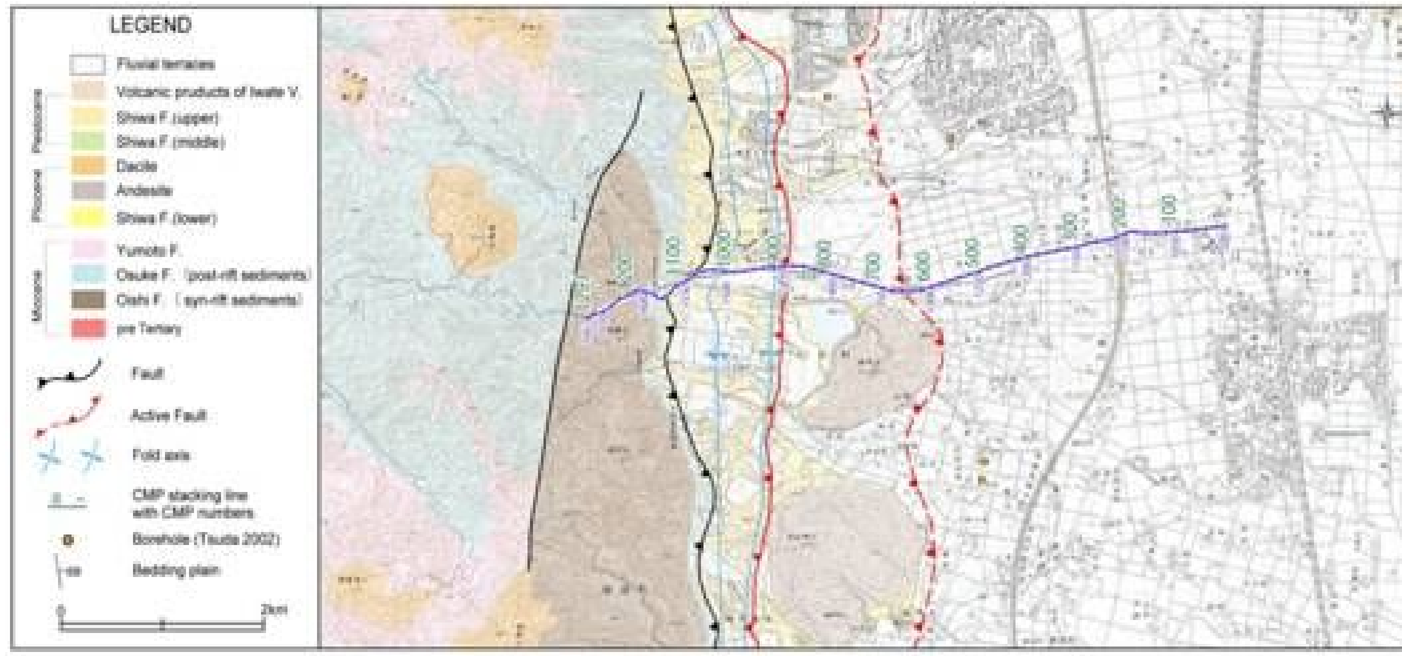


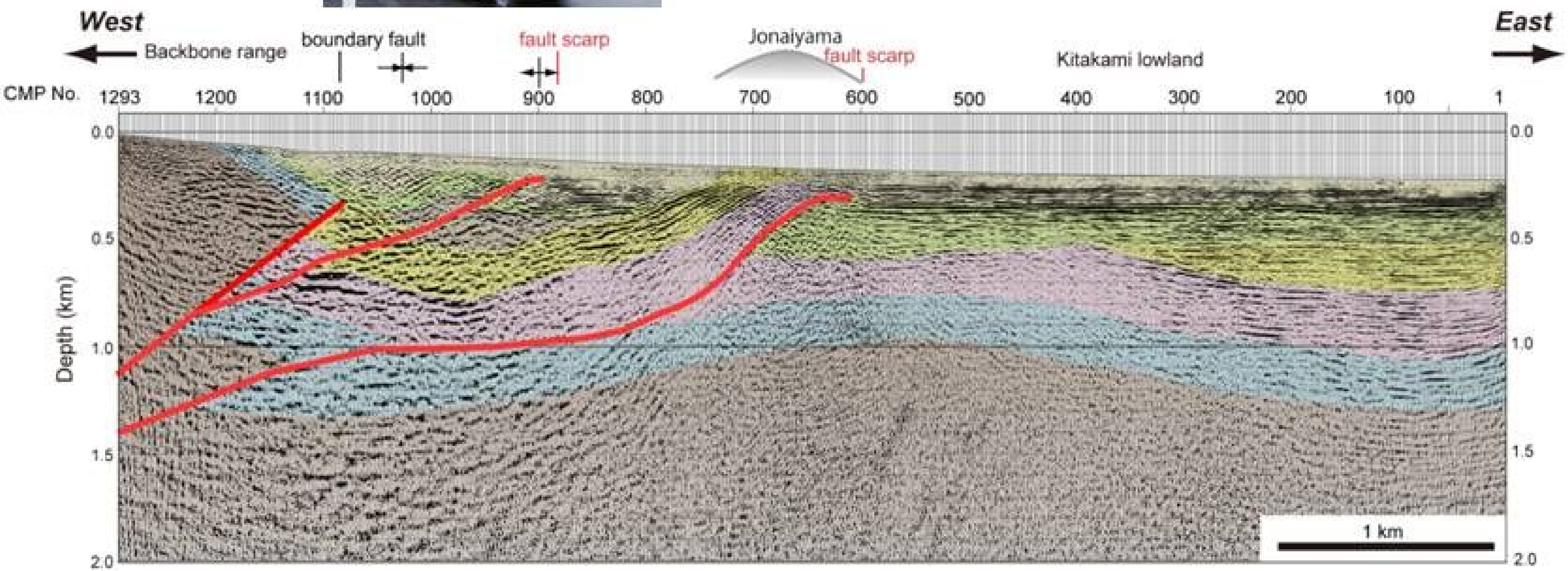
Referred from "working paper" by *EPC*

Example of shallow seismic reflection profiling

Land area







From a part of the study on source fault by JNES, Kagohara et al. (2009)

1-2. Actual practices of seismic strong motion estimation at NPP sites

Hyogo-Ken Nambu Earthquake (1995.1):

↓

- **Nuclear Safety Commission (NSC)** revised
  "Reviewing Guide for Seismic Design of NPP" (2006.9);
  - Require risk assessment due to over design earthquake:
    "**Residual Risk** assessment"

    ↓

  - **Atomic Energy Society** developed

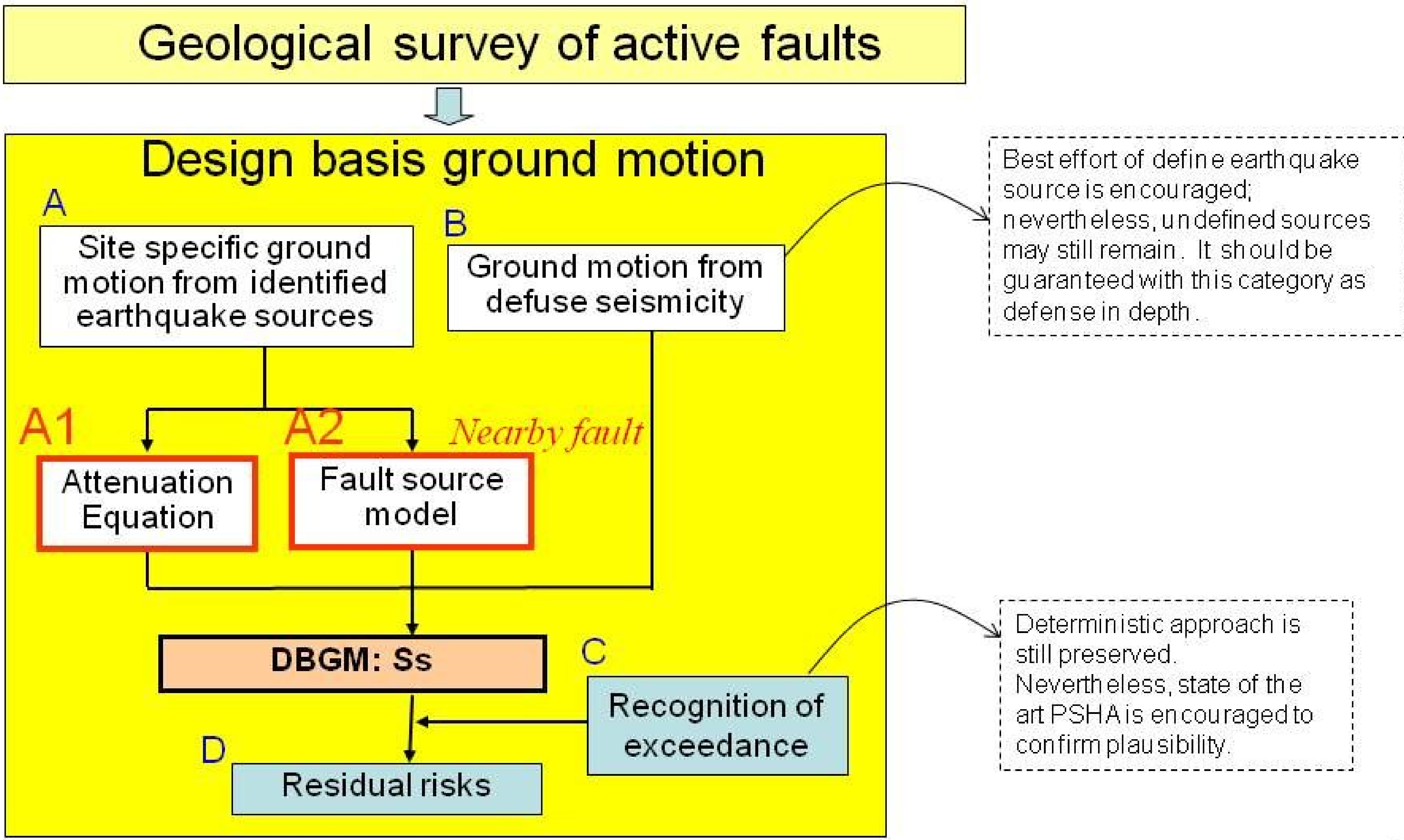
    "Standard procedure for Seismic PSA on NPP" (2007.9)

  - Adopt "**Source model** prediction"

Niigata-Ken Chuets-Oki Earthquake (2007.7)

Kashiwazaki-Kariwa NPP safely shut downed, but lower seismic class facilities were damaged.

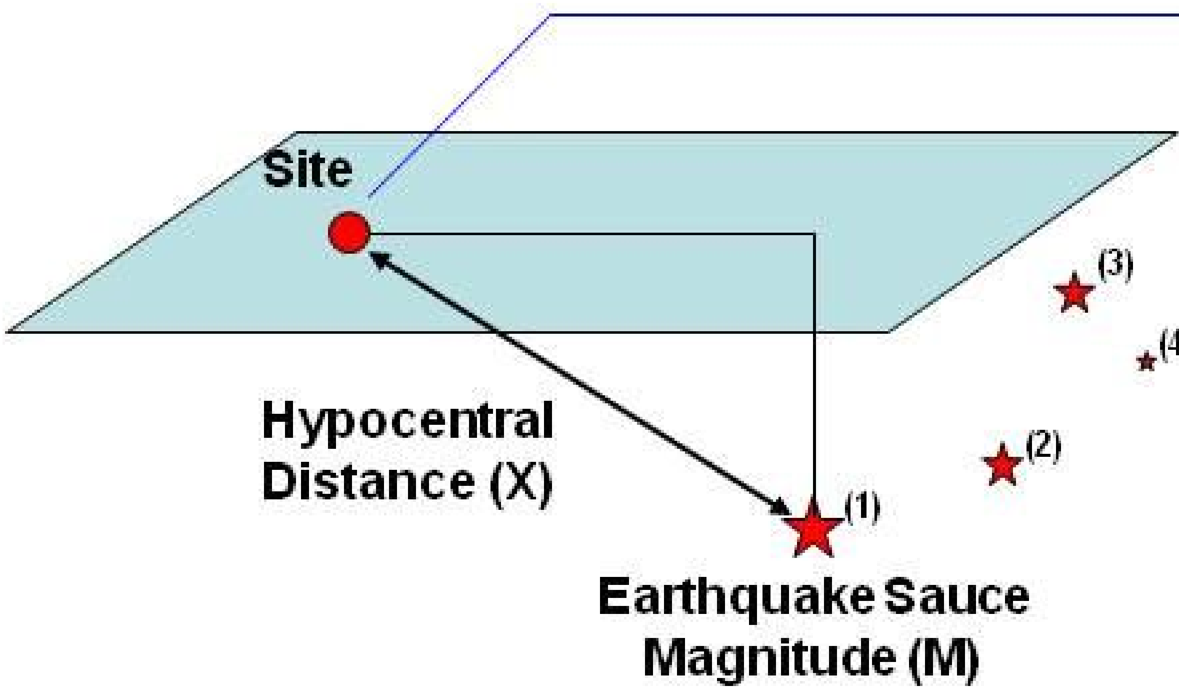
Flow of Seismic ground Motion Re-evaluation According to New Seismic Regulatory Guide



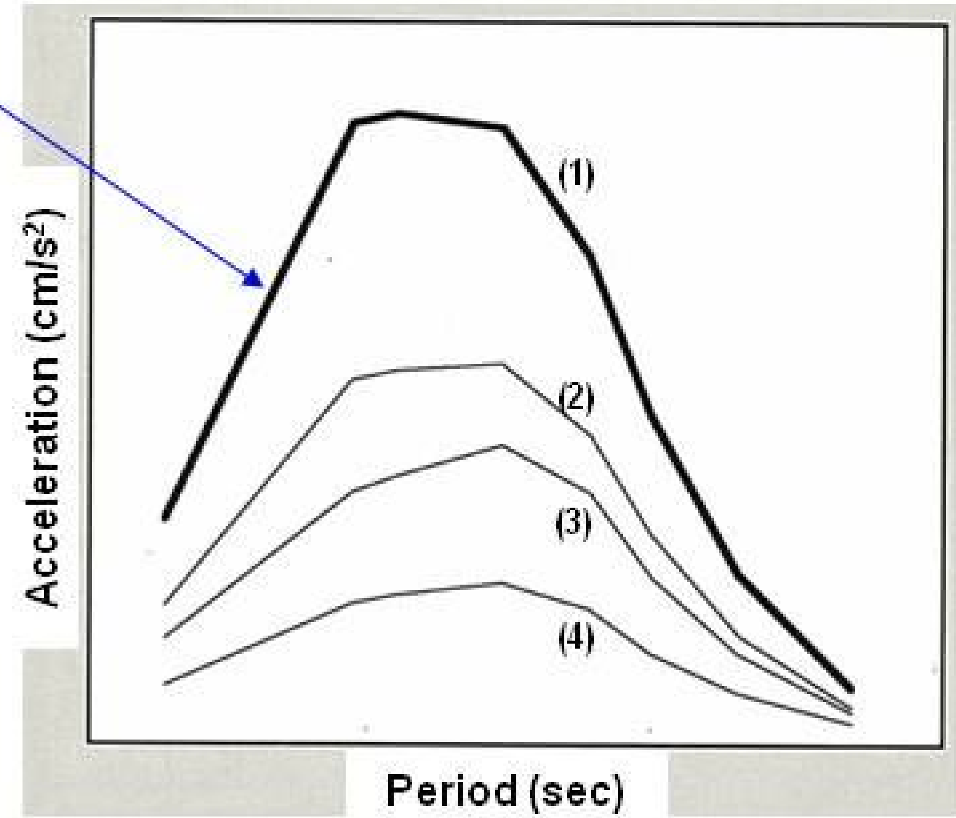
A1 Empirical response spectrum by attenuation equation

Earthquake motion at site can be evaluated by empirical method using available attenuation equation in the region.

- Empirical method is that response spectrum of the site is estimated based on the earthquake magnitude (M) and hypocentral distance (X).
- In case of empirical method, earthquake source is regarded as point source.



Empirical Method



Response Spectrum

A2

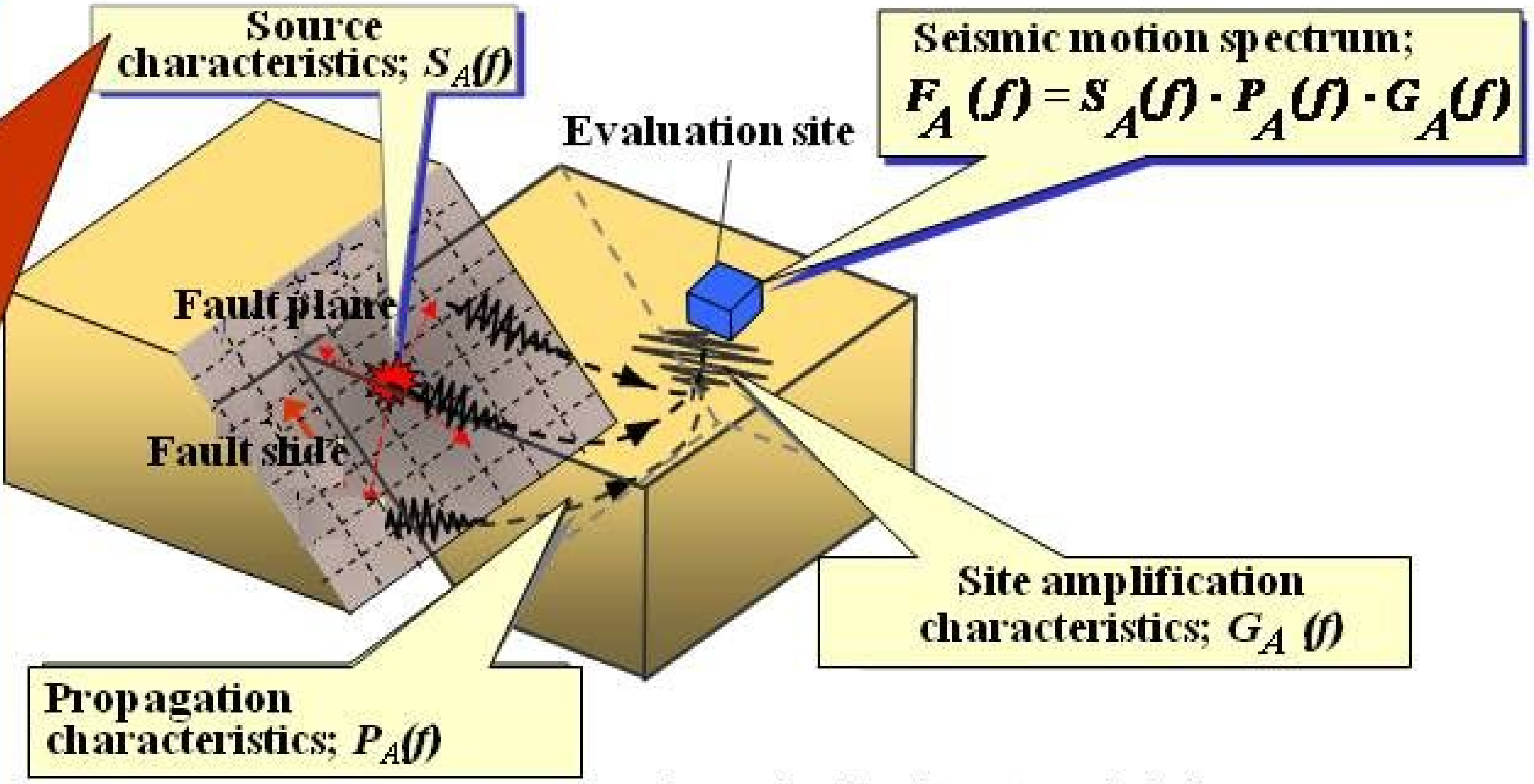
Synthesis of Time-series Waveform by Use of Fault Model

- Fault model is composed of 16 source parameters, and characterized with the source, path and site effects.

O Macroscopic parameters
- Depth of upper fault edge
- Fault length (and linkage with neighboring faults)
- Strike and dip directions of the fault plane, etc.

O Microscopic parameters
- Number of *asperities*
- Rupture initiation point
- Dislocation and stress drop on the *asperity*

etc.



Asperity: Fault rupture is inhomogeneous. High energy was released from the asperity.

- Evaluation of time-series waveforms using fault model
- Fault parameters: set by the IRIKURA's recipe etc.

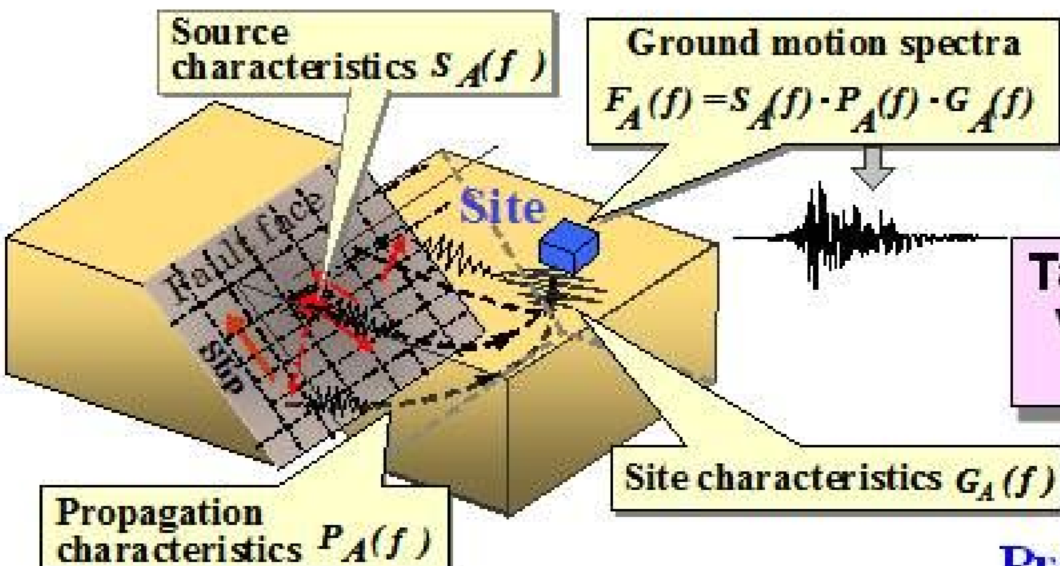
Features of the Methods Using Fault Model / Attenuation Relations

Synthesized motion by Fault model
(Detailed modeling)

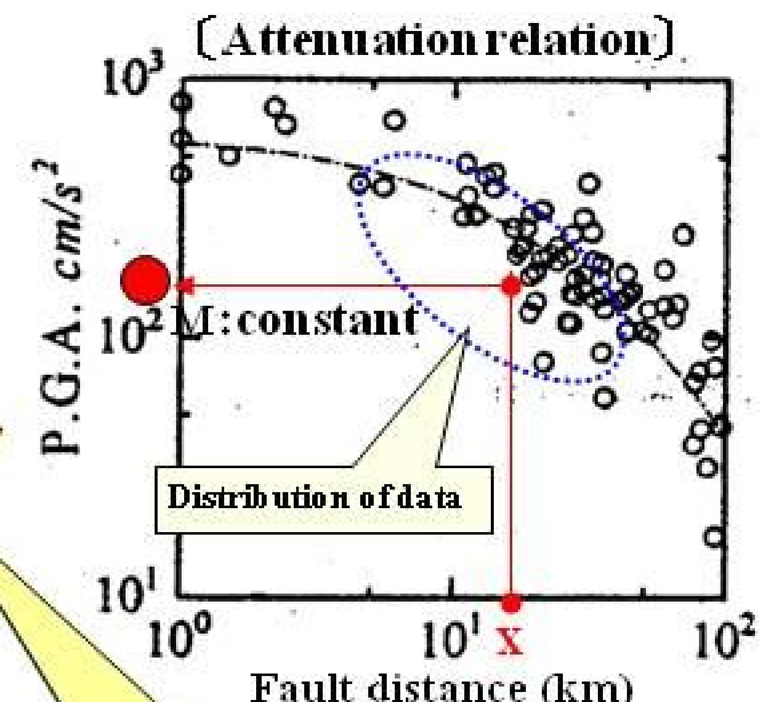
Source characteristics :
Fault area, location of asperity, stress drop, rupture process, directivity, etc.
Propagation characteristics :
Utilizing observed small event records at a site

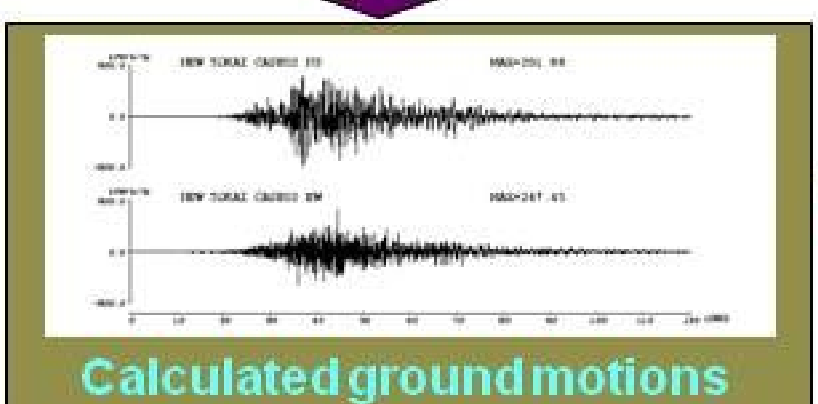
Attenuation equation.
(Conventional modeling)

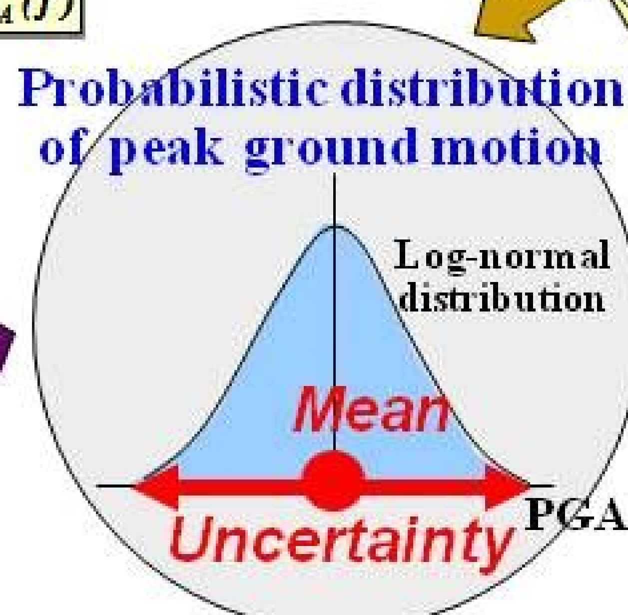
Source characteristics :
Magnitude (M)
Propagation characteristics :
Fault distance (X)



Taking into account variability in each parameter

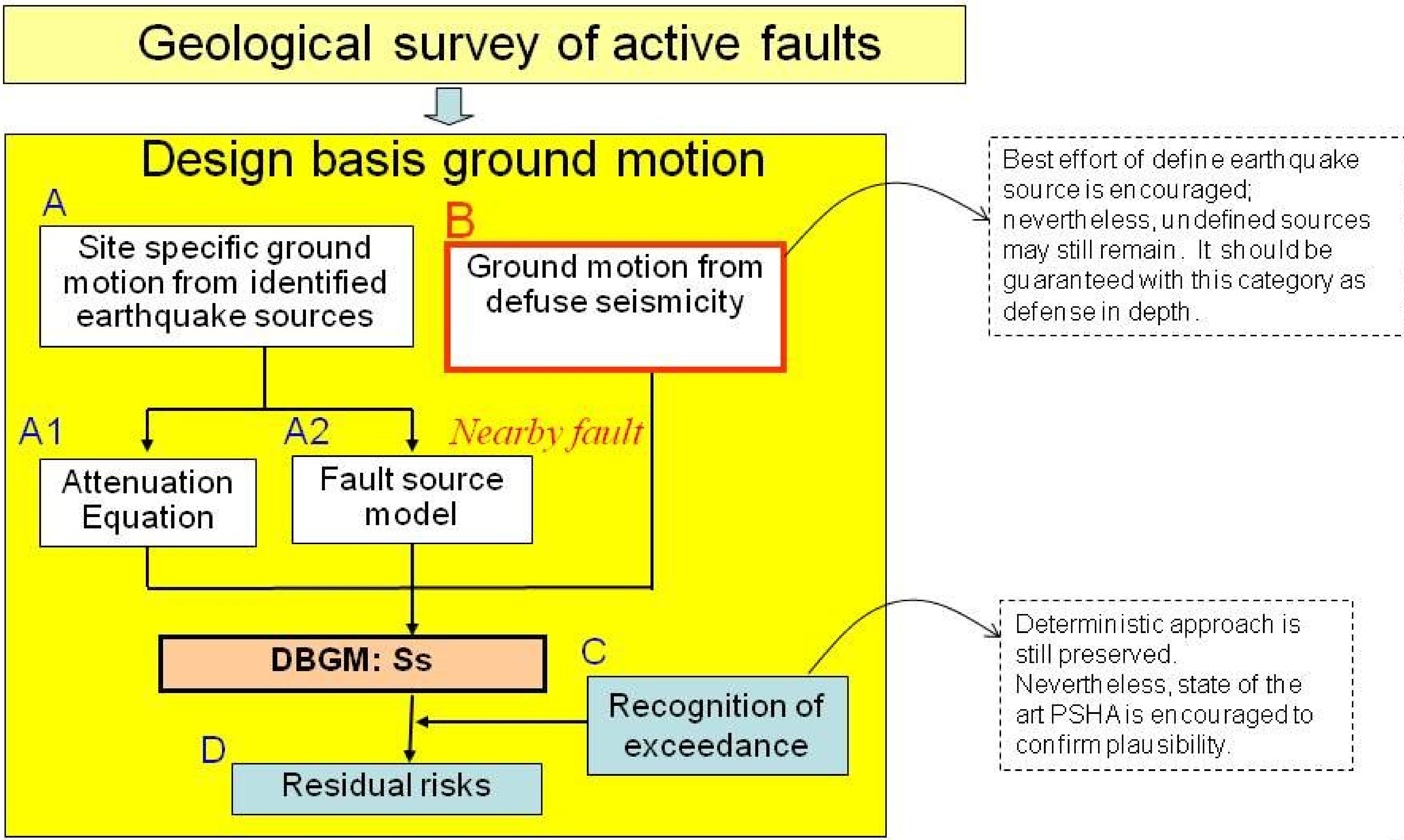






Taking into account deviation around average value (attenuation rel.)

Flow of Seismic ground Motion Re-evaluation According to New Seismic Regulatory Guide



B Defuse seismicity A Identified earthquake sources

■ Short active fault

Surface fault rupture length < Source fault length
Source fault length and width ≒ Seismogenic layer

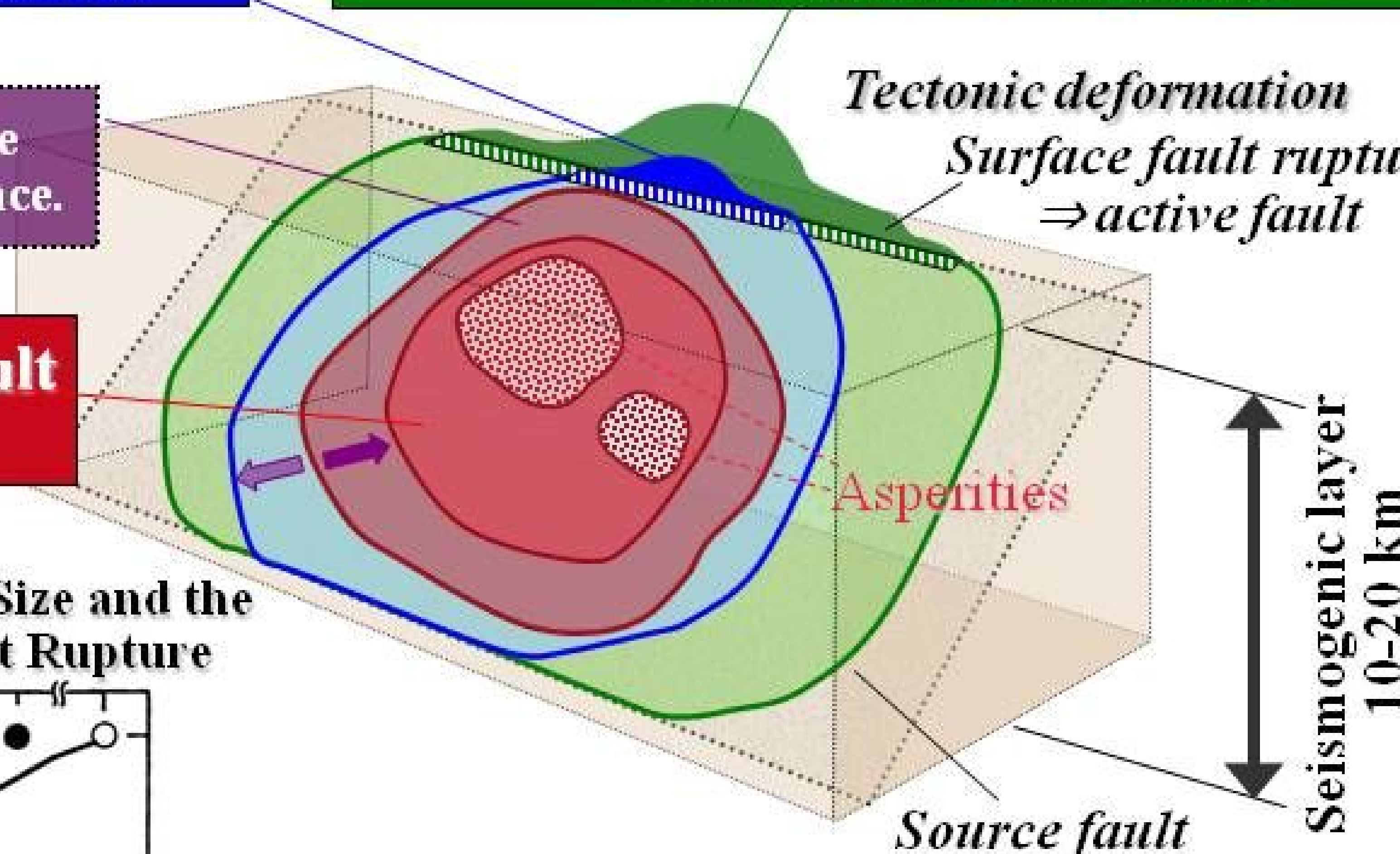
■ Long active fault

Surface fault rupture length ≒ Source fault length
Source fault length ≫ Seismogenic layer

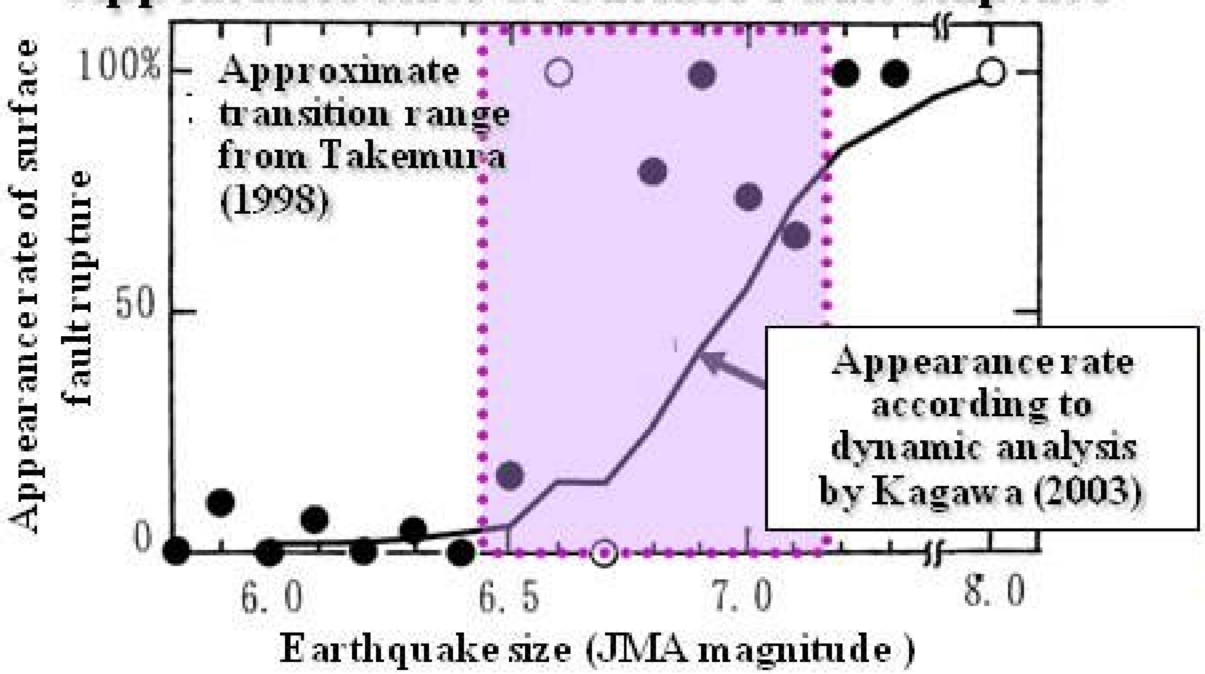
We have to consider the probable faults of upper edge up to the surface.

■ Potential Earthquake Fault

Source fault of inside of seismogenic layer

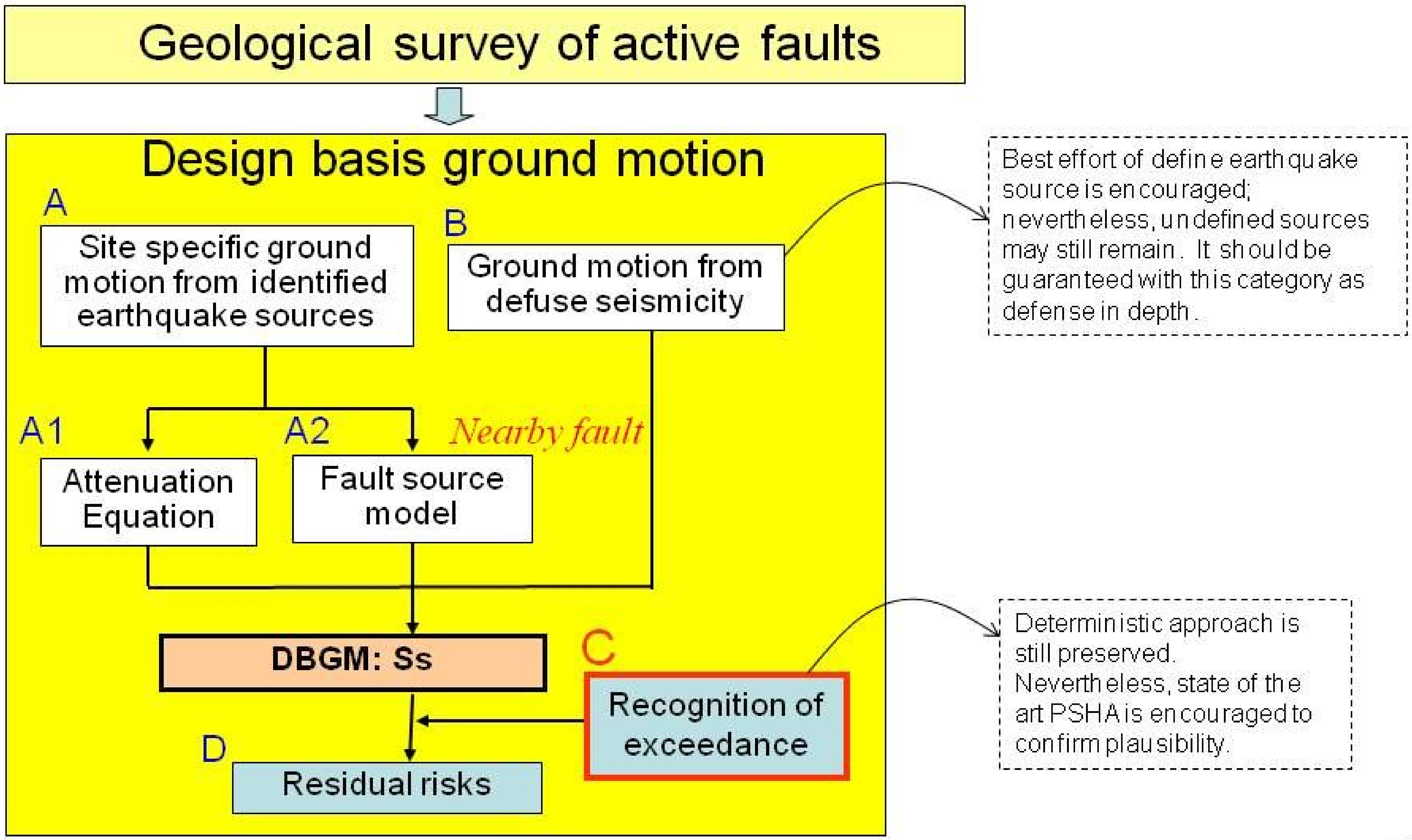


Relationship between Earthquake Size and the Appearance Rate of Surface Fault Rupture



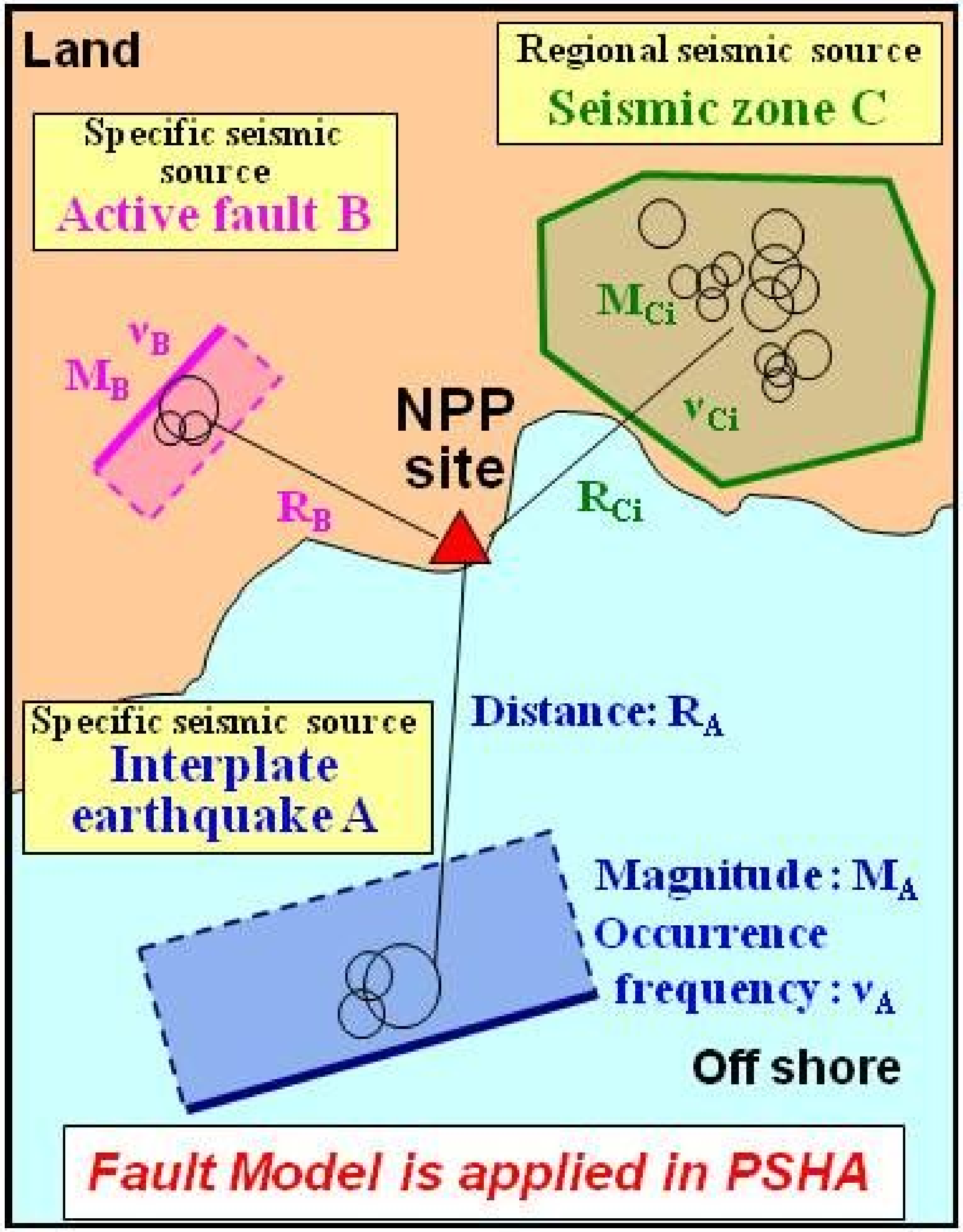
■ Earthquake size should be estimated in the diffuse seismicity. ➔ *Probability* of the surface rupture increases with **M** and **shallow asperity**.

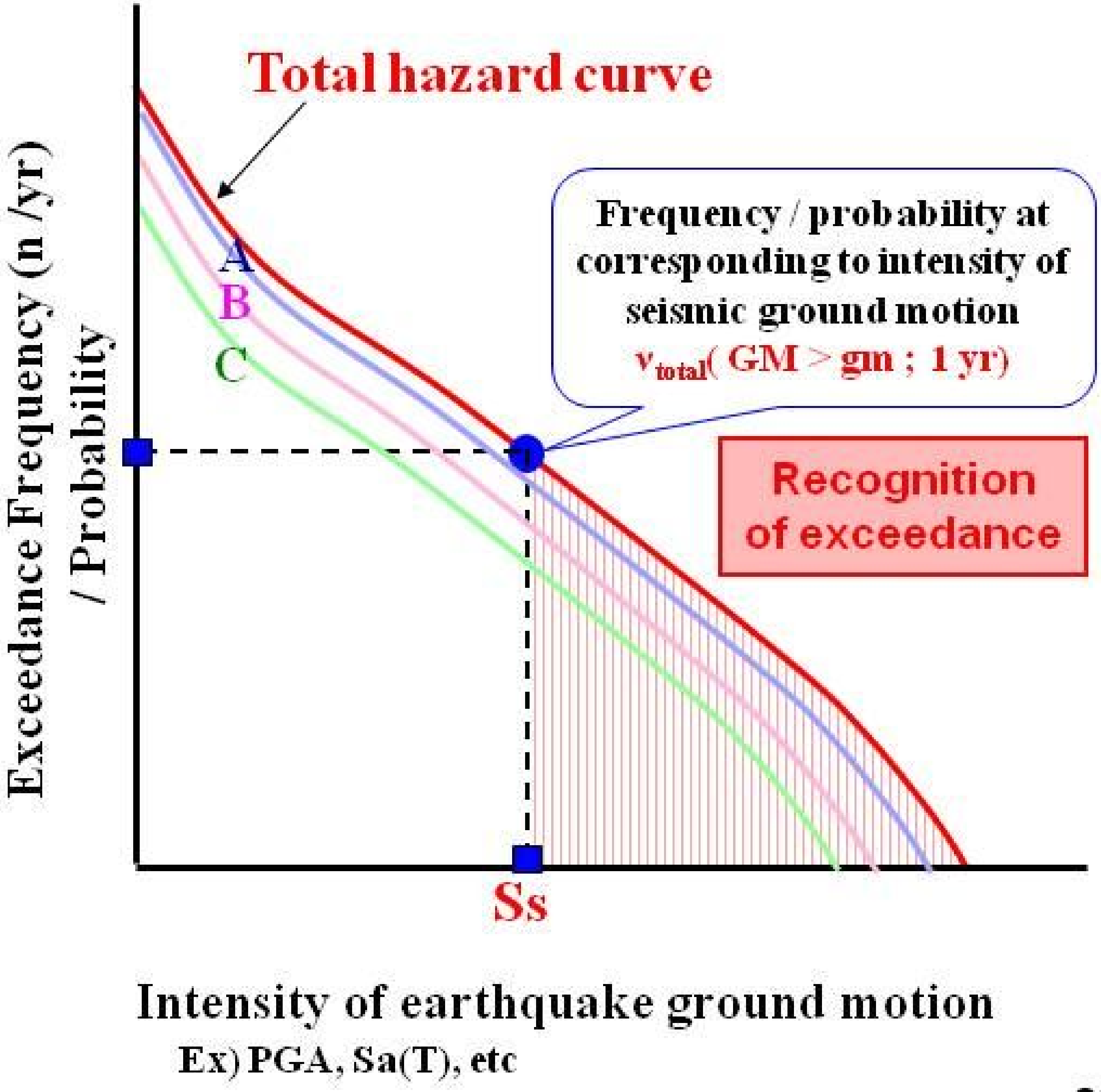
Flow of Seismic ground Motion Re-evaluation According to New Seismic Regulatory Guide



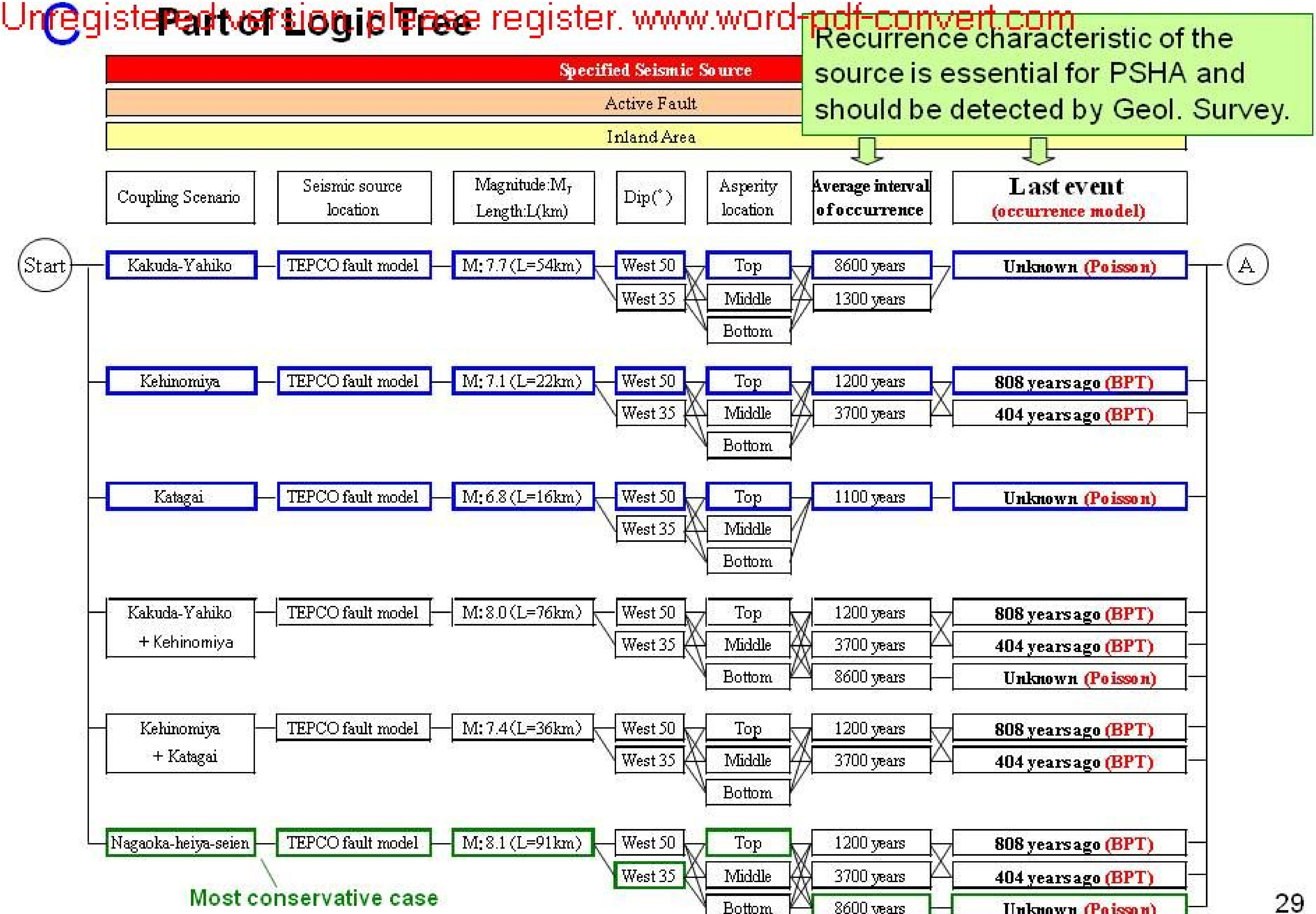
Seismic hazard evaluation method

Seismic hazard is defined as the relationship between the intensity of seismic ground motion and the exceedance frequency / probability at a site.

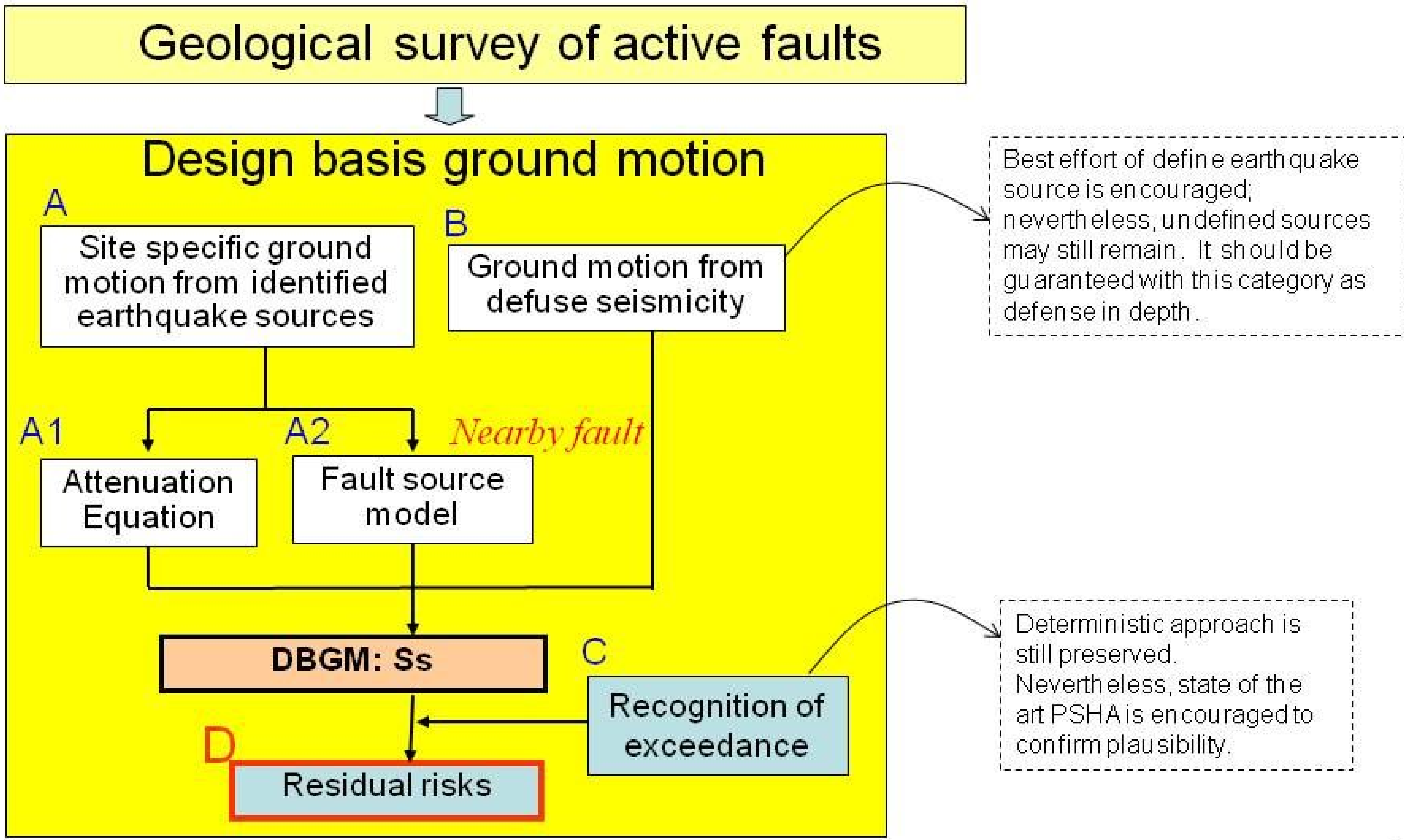


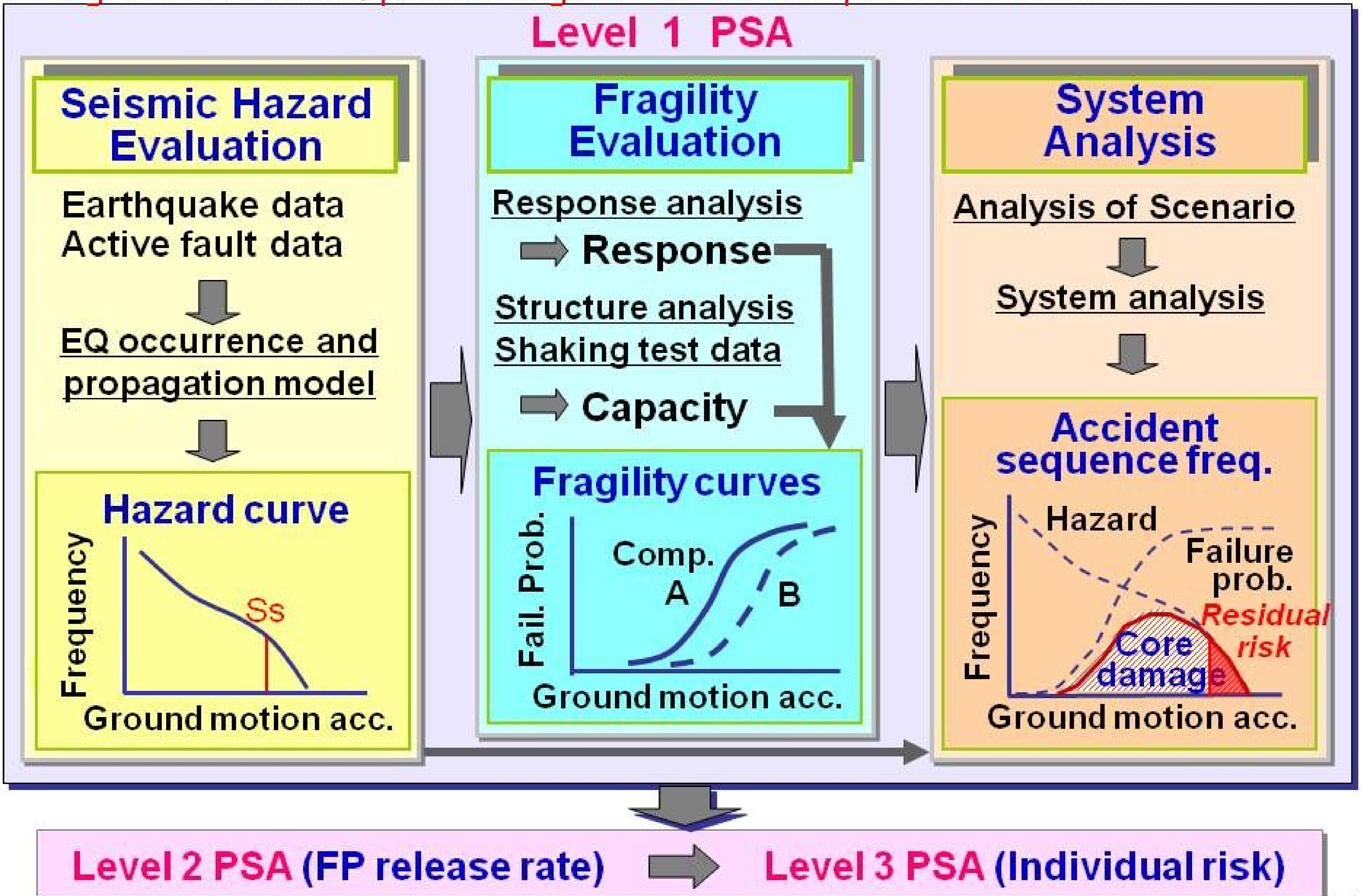


C Part of Logic Tree



Flow of Seismic ground Motion Re-evaluation According to New Seismic Regulatory Guide




Level 1 PSA
Seismic Hazard Evaluation
Earthquake data
Active fault data
EQ occurrence and propagation model
Hazard curve
Frequency
Ss
Ground motion acc.
Fragility Evaluation
Response analysis
Response
Structure analysis
Shaking test data
Capacity
Fragility curves
Fail. Prob.
Comp.
A
B
Ground motion acc.
System Analysis
Analysis of Scenario
System analysis
Accident sequence freq.
Frequency
Hazard
Failure prob.
Residual risk
Core damage
Ground motion acc.
Level 2 PSA (FP release rate)
Level 3 PSA (Individual risk)

More detail in

A standard for Procedure of Seismic Probabilistic Safety Assessment (PSA) for Nuclear Power Plants 2007

The Atomic Energy Society of Japan (AESJ)


AESJ-SC-P006:2007

日本原子力学会標準

原子力発電所の地震を起因とした
確率論的安全評価実施基準：2007

2007年9月

社団法人　日本原子力学会

Since fault model was useful for the estimation of strong motion near fault, it was adopted in IAEA Safety Guide on

Seismic Hazards in Site Evaluation for Nuclear Installations

DS422 → NS-G-3.3

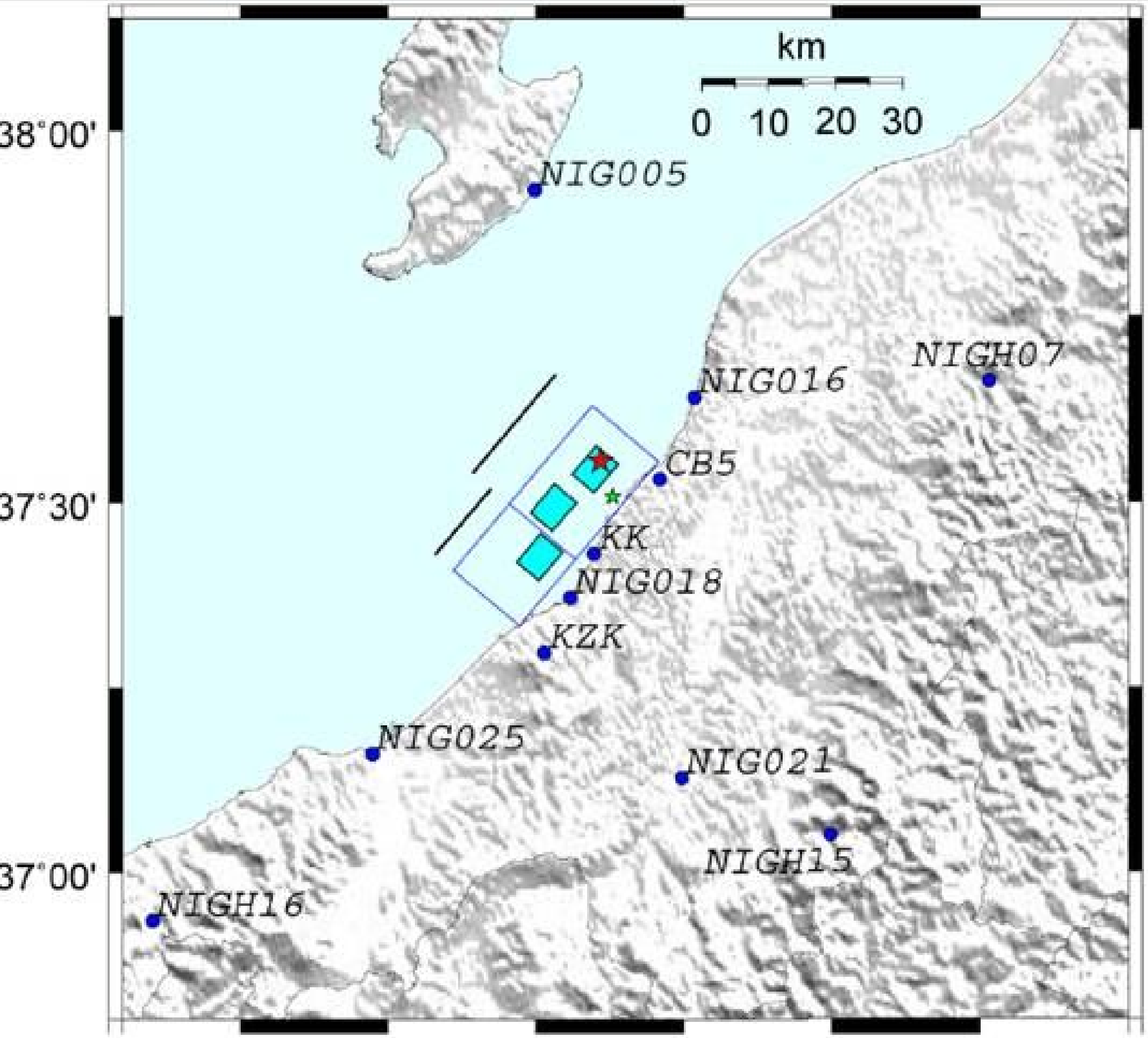
SUBSTANTIAL ISSUES - 3

JAPAN has provided very useful material to be included in the SG regarding the use of source simulation for ground motion prediction models. This represents the current methodology in Japan and can be applied in regions where high quality seismic records are available in large quantities and for nearby faults that can contribute significantly to the seismic hazard.

Secretariat Proposal: In order to reflect this practice the following paragraph has been added to the SG.

". . . 5.12 In seismically active regions where data from ground motion caused by identifiable faults is available in sufficient quantity and detail, simulation of the fault rupture as well as the wave propagation path is a recommended procedure to follow. In cases where nearby faults contribute to the hazard significantly, this procedure may be especially effective. The parameters needed include fault geometry (location, length, width, depth, dip, strike), macro parameters (seismic moment, average dislocation, rupture velocity, average stress drop), micro parameters (rise time, dislocation, stress parameters for finite fault elements) and crustal structure (such as shear wave velocity, density and Q). . . "

Fault model was essential to resolve factor of extreme amplitude.



★ Epicenter ● Observation Sta.

★ Aftershock used as a Green's function

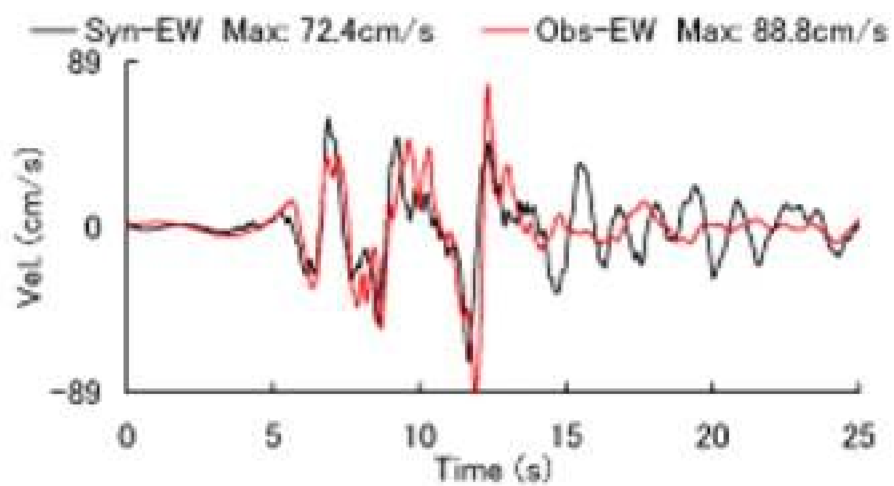
High stress drop about x1.5 times

Micro parameters

	Strike (°)	Dip (°)	Rake (°)	S (km^2)	Mo (Nm)	$\Delta\sigma$ (MPa)
Asp 1	40	40	90	5.6×5.6	1.33×10^{18}	18.4
Asp 2	40	40	90	5.6×5.6	2.00×10^{18}	27.6
Asp 3	40	40	90	5.6×5.6	2.00×10^{18}	27.6

Rupture velocity 2.7km/s

Comparison between synthesized and observed time history at KK1 base



http://www.rri.kyoto-u.ac.jp/jishin/eq/niigata_chuetsuoki_5/chuuetsuoki_20080307.pdf

2. Example of Tsunami Hazards Assessment for NPP

2-1 Objective of crosscheck analysis

- Objective is to support technically for NISA examining the safety report of Electricity Utilities.
- Therefore JNES does crosscheck analysis based on our technical knowledge, using our analysis code, data, etc.

2-2 Points of crosscheck analysis

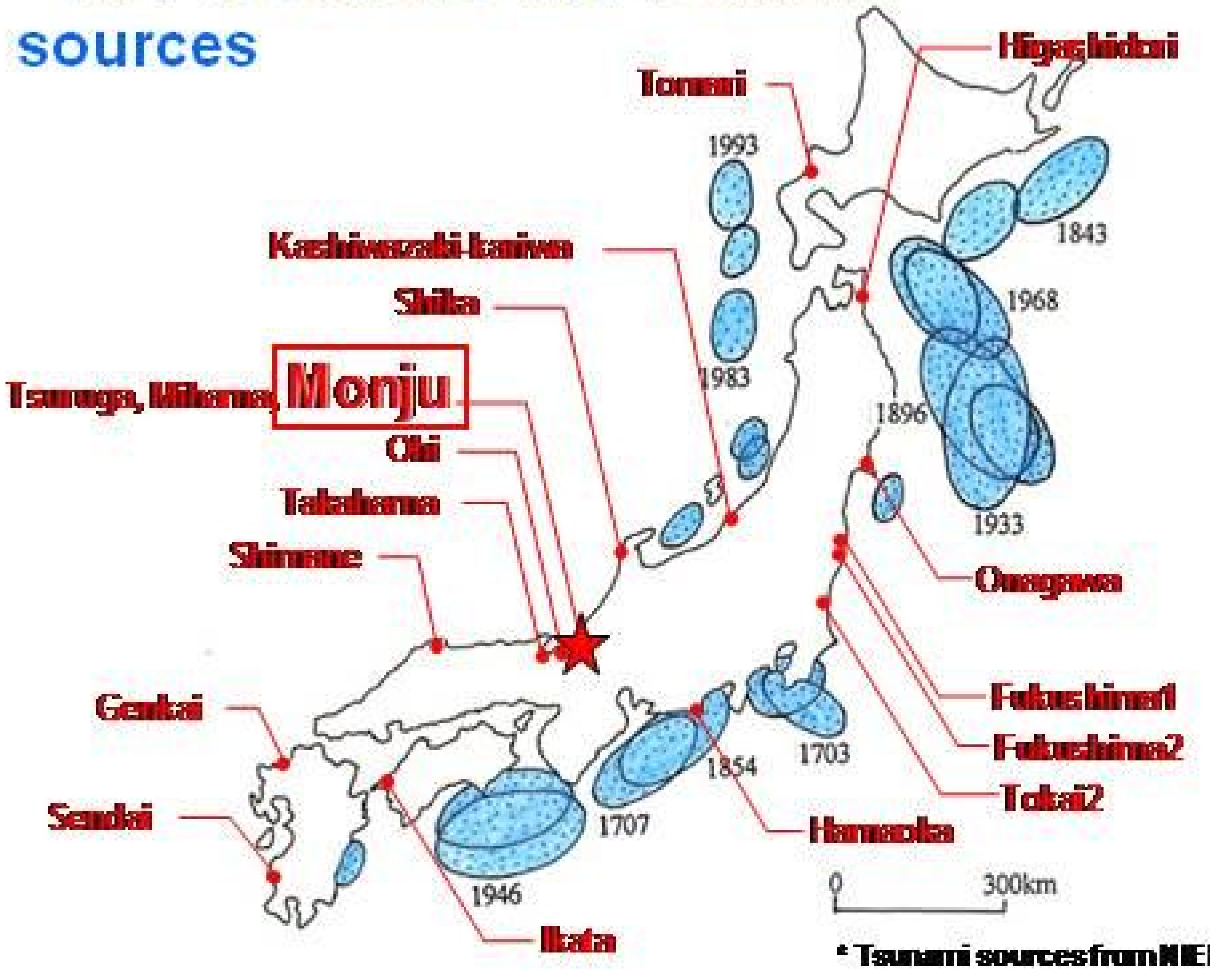
- Setting of analysis condition is independent from electricity utility's one.
- Which is the most influential tsunami source ?
  (view points from tsunami height, deposit height in front of intake facility, etc)
- Is the analysis period enough?
- How long is the grid size of topography model?
- It is necessary to analyze causes if electricity utility's results are different from JNES one.

2-3 Crosscheck analysis for Monju

(0) Outline

- Target Facility – Prototype Fast Breeder Reactor "Monju"
- Electric Utility – Japan Atomic Energy Agency (JAEA)
- Site Location – Fukui Prefecture, Japan

■NPP locations and Tsunami sources



* Tsunami sources from NIED HP

■ Photo of Monju site

*http://www.shiohama.co.jp/example/largescale/detail_a/l_detail_03.html

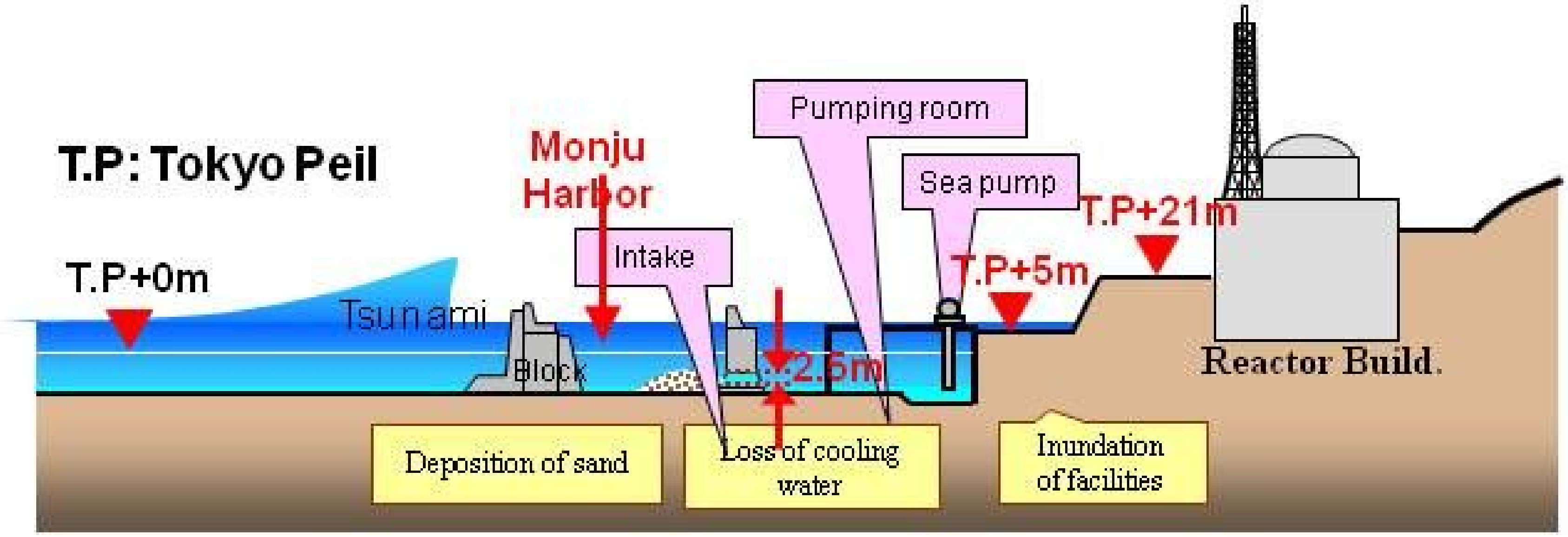
(1) Guideline

"Tsunami Assessment Method for Nuclear Power Plants in Japan" published by JSCE

(2) Safety Criteria

(T.P. : Tokyo Peil)

Accident scenarios	Assessment item	Safety Criteria	
Inundation of important facilities	Max. wave height	Land level (T.P.+5m) + Allowable height of protection wall (0.85m*1)	T.P.+5.8m
Loss of cooling function	Min. wave height*2	Allowable intake water level by sea water pump*2	T.P.-2.9m
	Max. sand height in front of intake	Height of intake mouse	2.5m



*1構造B18-2-4資料を参照し、防水壁(ポリカーボネート板12mm)の許容たわみ量から算定した。

*2事業者による構造Bサブの報告において、自然循環による炉心冷却が可能であると、報告された。

(3) Flow of crosscheck analysis

Verification analysis based on historical tsunami

- Verification of fault model, a numerical system, topography model

↓

Selection of tsunami source

- Setting of tsunami sources
  - Submarine active faults induced tsunami
  - Earthquake induced tsunami that could occur the eastern margin of the Japan Sea
- Selection of dominant tsunami source
  - The max. and min. water level due to tsunami sources are selected
  - Numerical calculation used a rough topography model

↓

Estimation of the max. and min. water levels

- Water levels due to scenario tsunami
  - The max. and min. water levels in front of intake facilities
  - Numerical calculation used a detailed topography model

↓

Estimation of the max. deposition height due to sand move

- Sand deposition height due to scenario tsunami
  - The max. sand deposition height in front of intake facilities
  - Numerical calculation using sand move modeling (Takahashi, etc 1999)

↓

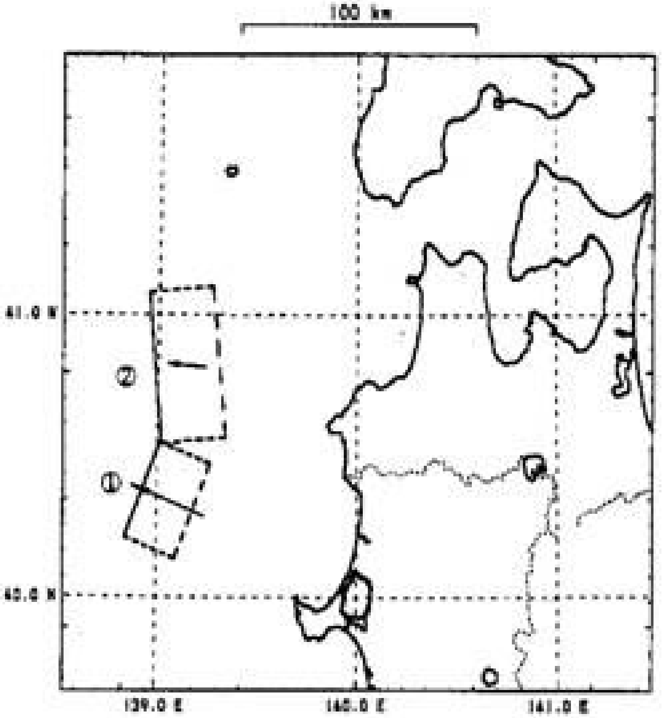
Conclusion of crosscheck

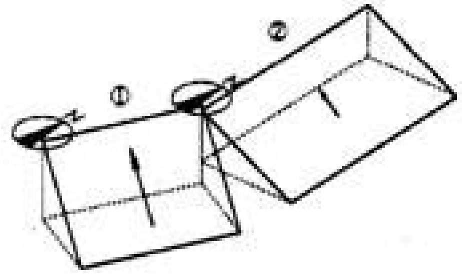
(4) Verification analysis based on historical tsunami

(4a) Target of historical tsunami source

- Nihonkai-chubu earthquake tsunami in 1983
- Fault parameters*1

Segment	Length (km)	Width (km)	Strike (°)	Dip angle (°)	Slip angle (°)	Slip length (m)	Depth (km)
①	40	30	22	40	90	7.6	2
②	60	30	355	25	80	3.05	3

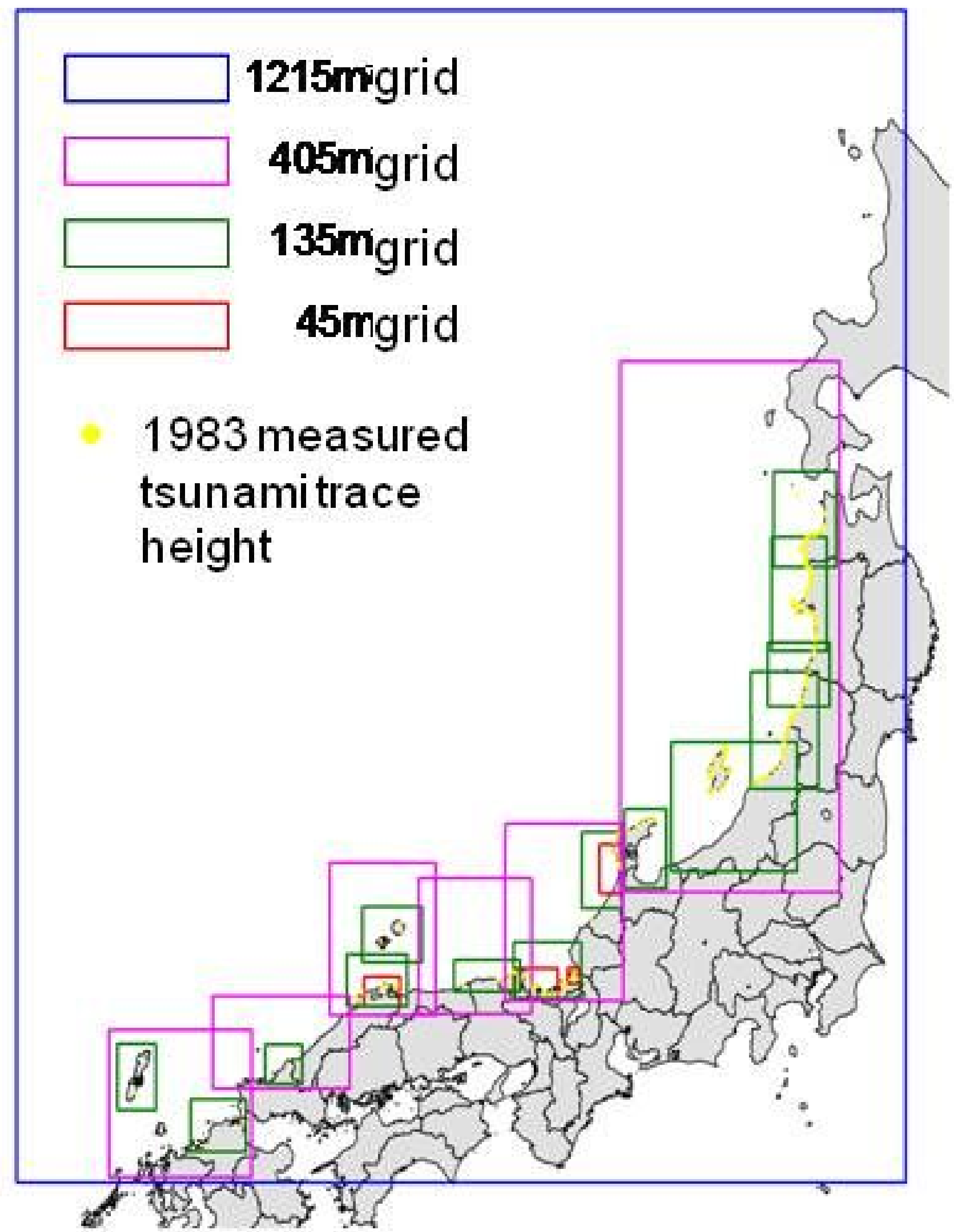




Fault location

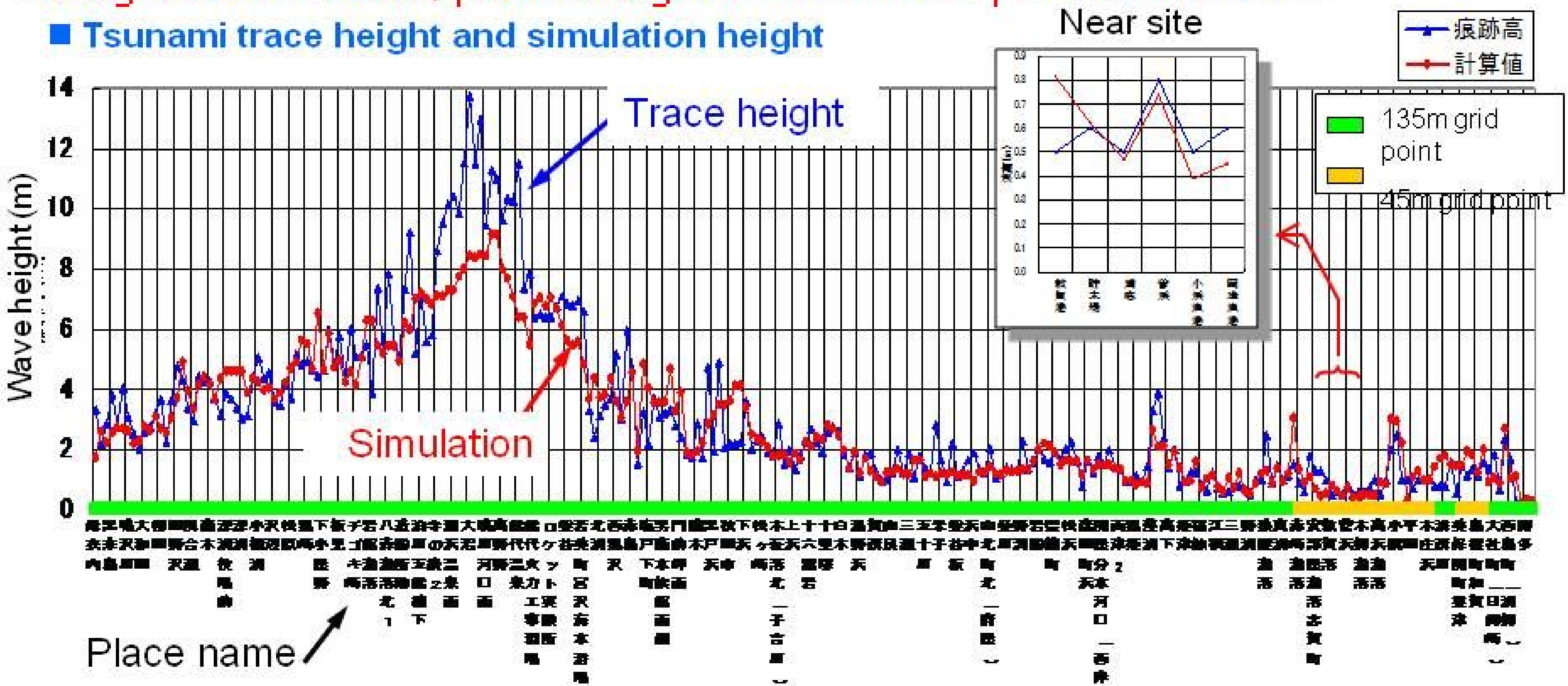
*1 Source: Fault parameter handbook in Japan

(4b) Simulation area and grid size



(4e) Result of verification analysis

■ Tsunami trace height and simulation height



■ Aida's indexes, K and κ

	Wide area	Near site	135m grids	45m grids
Number of trace	266	6	233	33
K	1.01	1.03	1.01	1.05
κ	1.40	1.29	1.37	1.61

Aida's indexes, K and κ in both wide area and near site satisfied the following conditions.

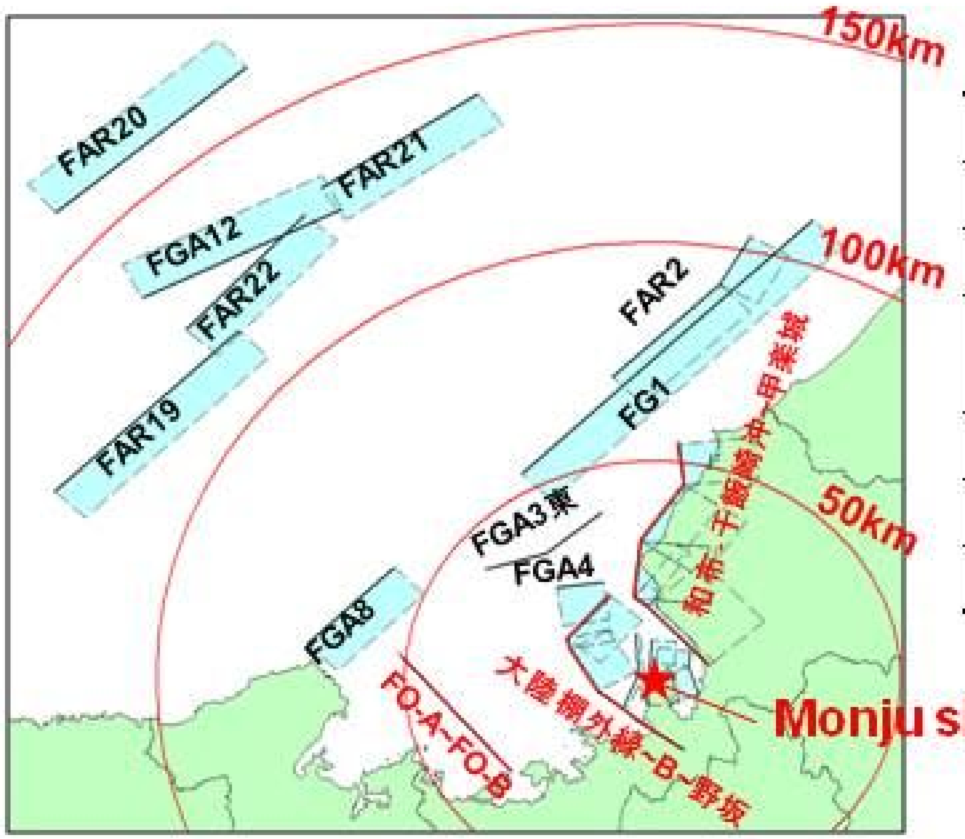
$$0.95 < K < 1.05, \quad \kappa < 1.45$$

Therefore the validity of numerical calculation system was able to be verified.

(5) Selection of tsunami source

(5a) Setting of tsunami sources

■ Submarine active faults induced tsunami



Consideration on simultaneous activity with some segments;

- Tairikudana~B~nosaka Fault
- FO-A~FO-B Fault
- Mera-kareizaki~kaburagi Fault

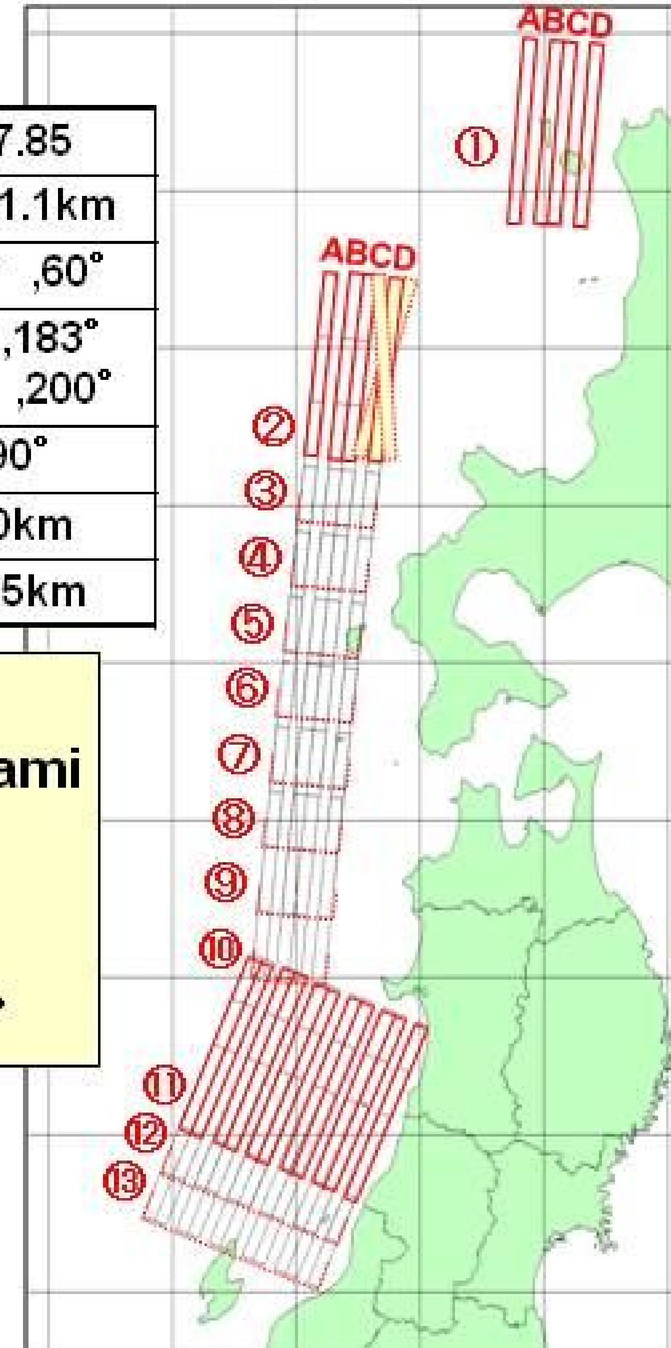
■ Earthquake induced tsunami that could occur the eastern margin of the Japan Sea

Standard fault model
(JSCE2002)

Moment magnitude		7.85
Length		131.1km
Dip angle		30°, 60°
Strike	Hokkaido~Akita	3°, 183°
	Yamagata~Niigata	20°, 200°
Slip angle		90°
Depth of upper edge		0km
Seismogenic layer		15km

Consideration on uncertainties of tsunami source model;

- location : Right fig.
- Strike : standard ± 10°



Location of tsunami sources

(6) Selection of dominant tsunami source

(6a) Method of selection

- The tsunami source estimated max. and min. wave height is selected.
- Numerical simulation is used to estimate wave heights.

(6b) Tsunami modeling

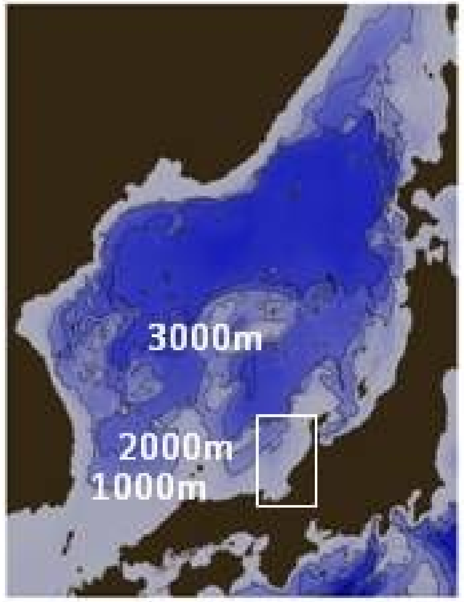
- Goto(1982) method with nonlinear long-wave theory is applied.
- JNES's SANNAMI(+TUNAMI) code is used.

■Analysis conditions of tsunami simulation

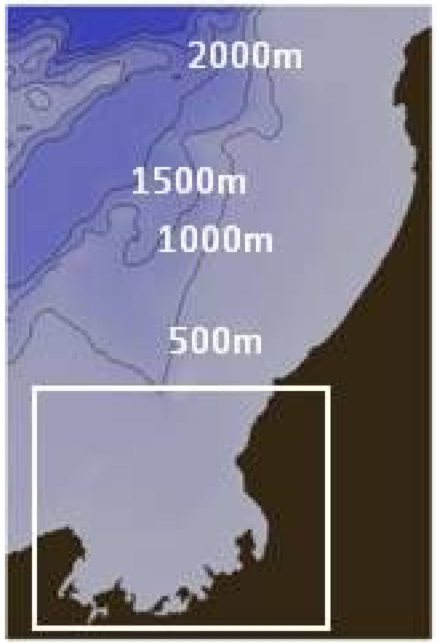
Item	Analysis Conditions (JNES)		
Domain	A	B	C
Grid size (m)	1215	405	135
Time step (s)	1.458	0.486	0.162
Governing equation	Nonlinear long-wave theory		
Onshore boundary condition	Complete reflection		
Friction coefficient	Manning's coefficient of roughness, $n=0.025m^{-1/3}s$		
Horizontal eddy viscosity	Not introduced		
Initial condition	Mansinha and Smylie (1971)		
Simulation time (hour)	Submarine active fault: 5 (h) Eastern margin of the Japan Sea: 10 (h)		

■Computation domains and topography of the sea area

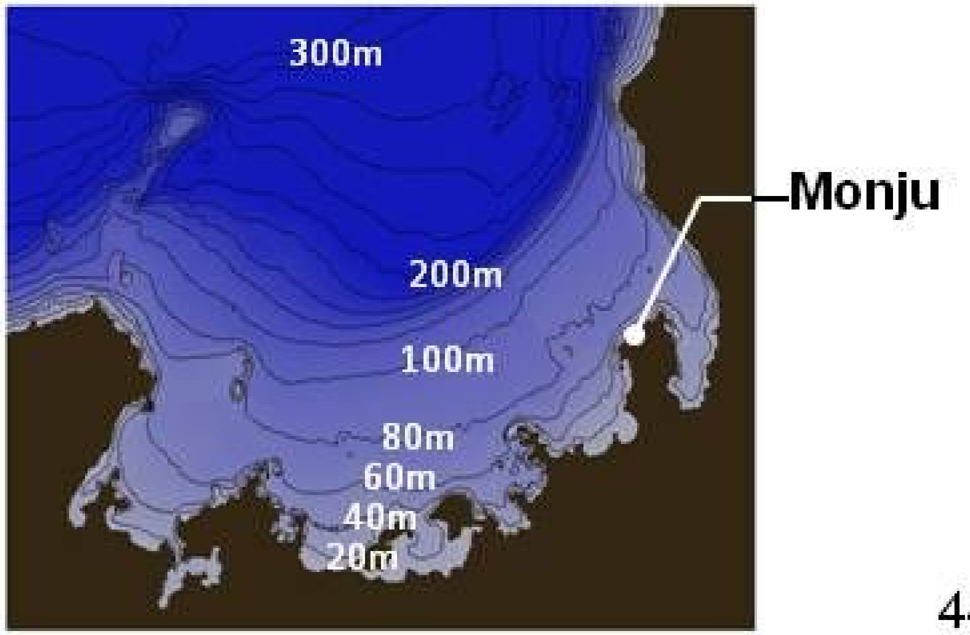
Domain -A



Domain -B



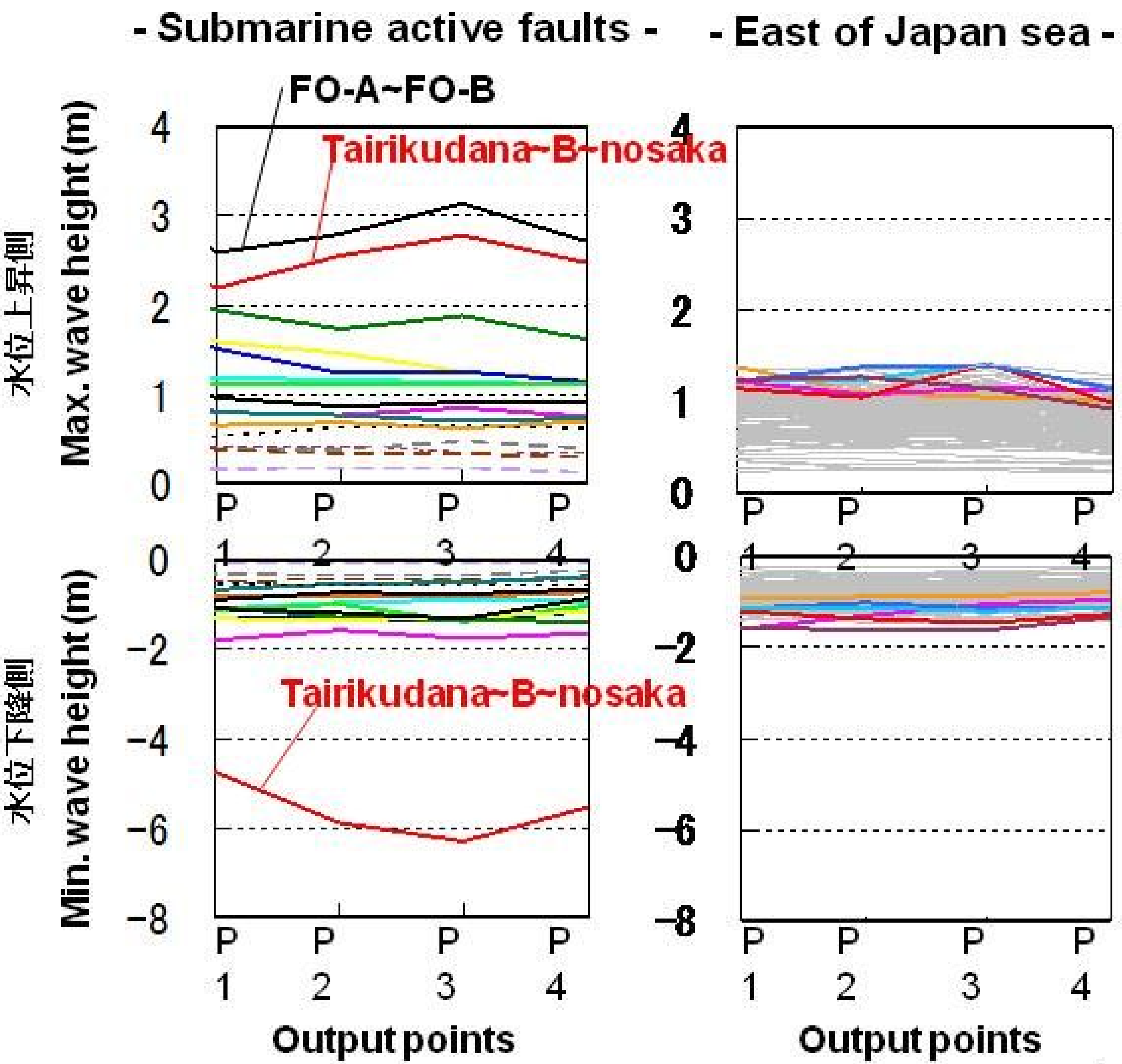
Domain -C



(6c) Results of tsunami simulation

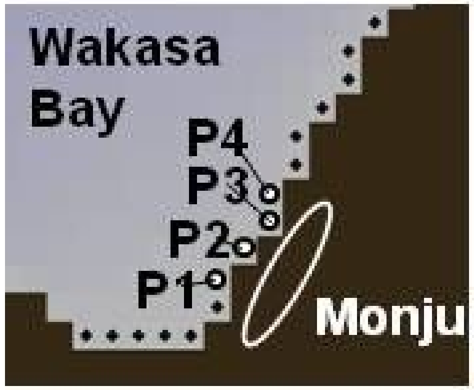
(6d) Result of tsunami source selection

■Max. and Min. wave height at shoreline of Monju site



The following tsunami sources are selected as dominant sources.

- ・Tairikudana ~ B ~ nosaka
- ・FO-A ~ FO-B



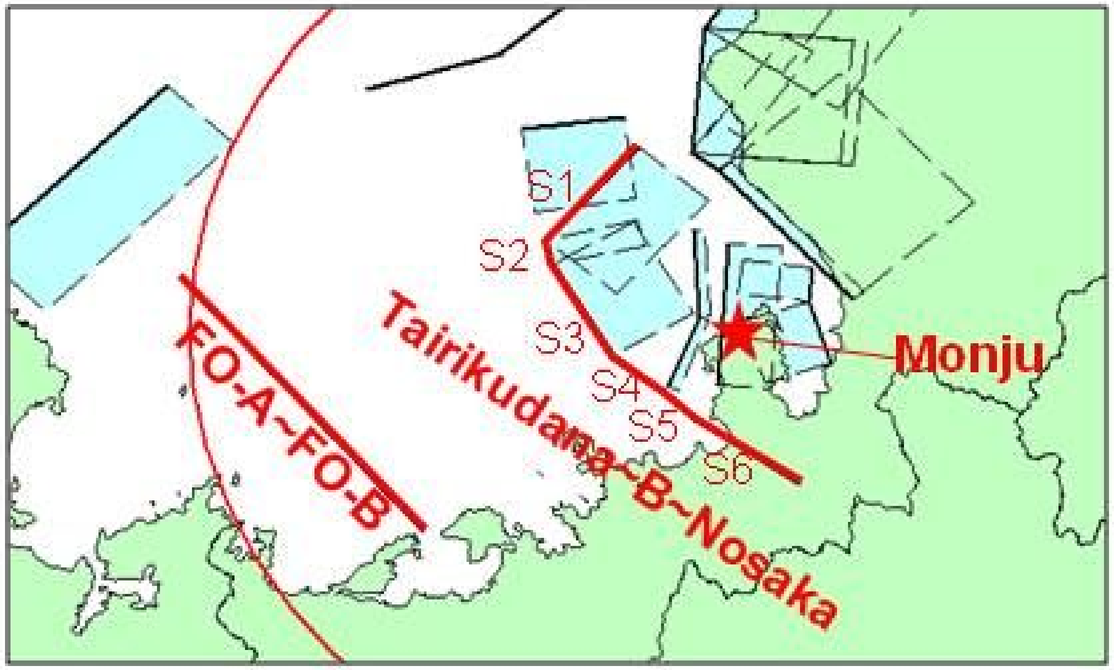
Location of output points

(7) Estimation of the max. and min. water levels

(7a) Target of tsunami sources

Simultaneous activities with;

- **Tairikudana ~ B ~ Nosaka**
- **FO-A ~ FO-B**



Fault parameters of Tairikudana ~ B ~ Nosaka[*1]

Seg. No	L (km)	W (km)	Strike (°)	Dip angle (°)	Slip angle (°)	Slip len. (m)	Depth (km)
S1	12.9	17.3	41.2	60	112.7	3.73	0
S2	2.6	17.3	345.6	60	26.4	3.73	0
S3	11.0	17.3	330.4	60	0.0	3.73	0
S4	7.4	15	309.2	90	0.0	3.73	0
S5	2.7	15	315.6	90	0.0	3.73	0
S6	12.0	15	305.3	90	0.0	3.73	0

*1 合同C21-5資料より

Fault parameters of FO-A ~ FO-B[*2]

L (km)	W (km)	Strike (°)	Dip angle (°)	Slip angle (°)	Slip len. (m)	Depth (km)
34.5	15	140	90	33	2.87	0

*2 原子力安全・保安院より提供を受けた事業者データより

(7b) Tsunami modeling

- **Goto(1982) method with nonlinear long-wave theory is applied.**
- **JNES's SANNAMI(+TUNAMI) code is used.**

■Analysis conditions of tsunami simulation

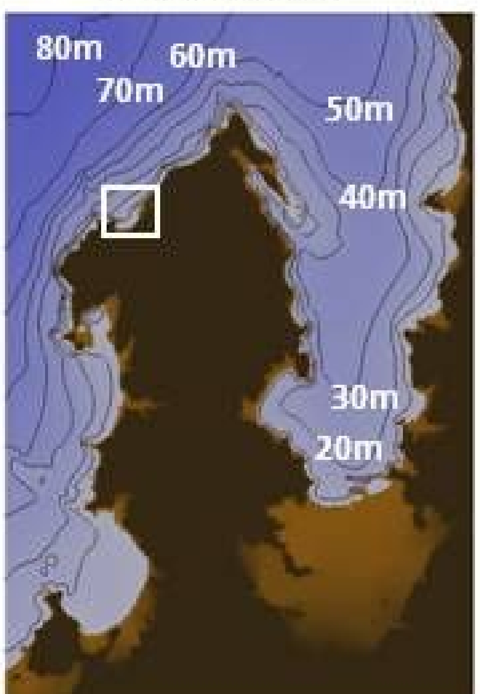
Item	Analysis conditions (JNES)						(Electric Utility)
Domain	A	B	C	D	E	F*1	A ~ I (9 domains)
Grid size (m)	1215	405	135	45	15	5	1600 ~ 6.25m
Time step (s)	1.458	0.486	0.162	0.054	0.018	0.006	0.25
Governing equation	Nonlinear long-wave theory						Nolinear long-wave
Onshore boundary cond.	Complete reflection			**Run-up (Kotani1998)**			**Complete reflection**
Friction coefficient	Manning's coefficient of roughness, $n=0.025m^{-1/3}s$						$n=0.03m^{-1/3}s$
Horizontal eddy viscosty	**Not introduced**						**$10m^2/s$**
Initial condition	Mansinha and Smylie (1971)						Same as the left
Simulation time (hour)	5 (hour)						3 (hour)*2

*1 事業者の深浅測量データからF領域地形モデルを作成した。

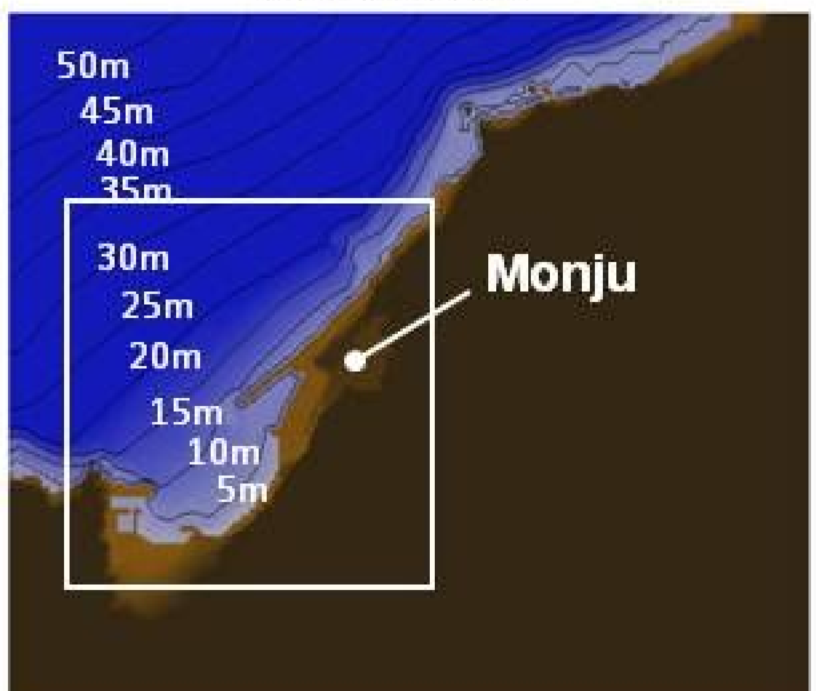
*2 事業者は、地震発生後12時間までの計算を行い3時間以降の最大波の到達がないことを確認している。（合同C23-5資料参照）

■Computation domains and topography of the sea area

Domain -D



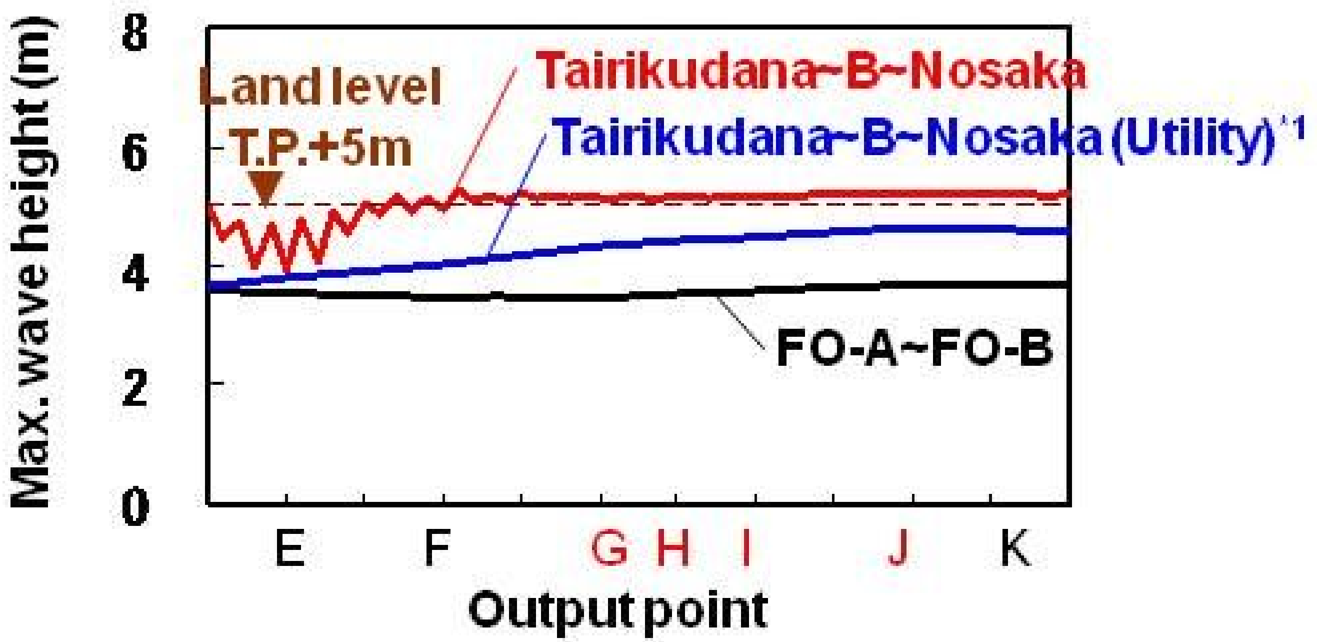
Domain -E

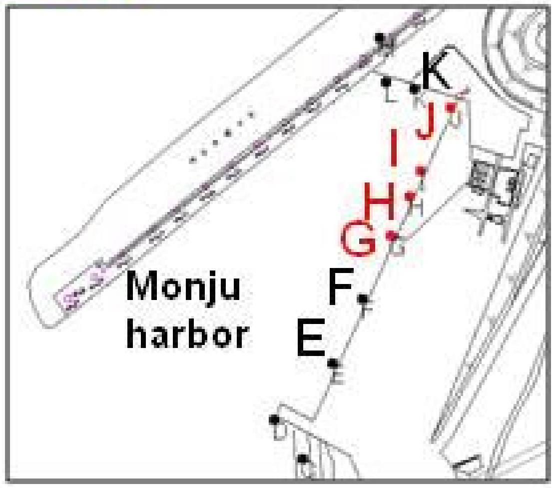


Domain -F

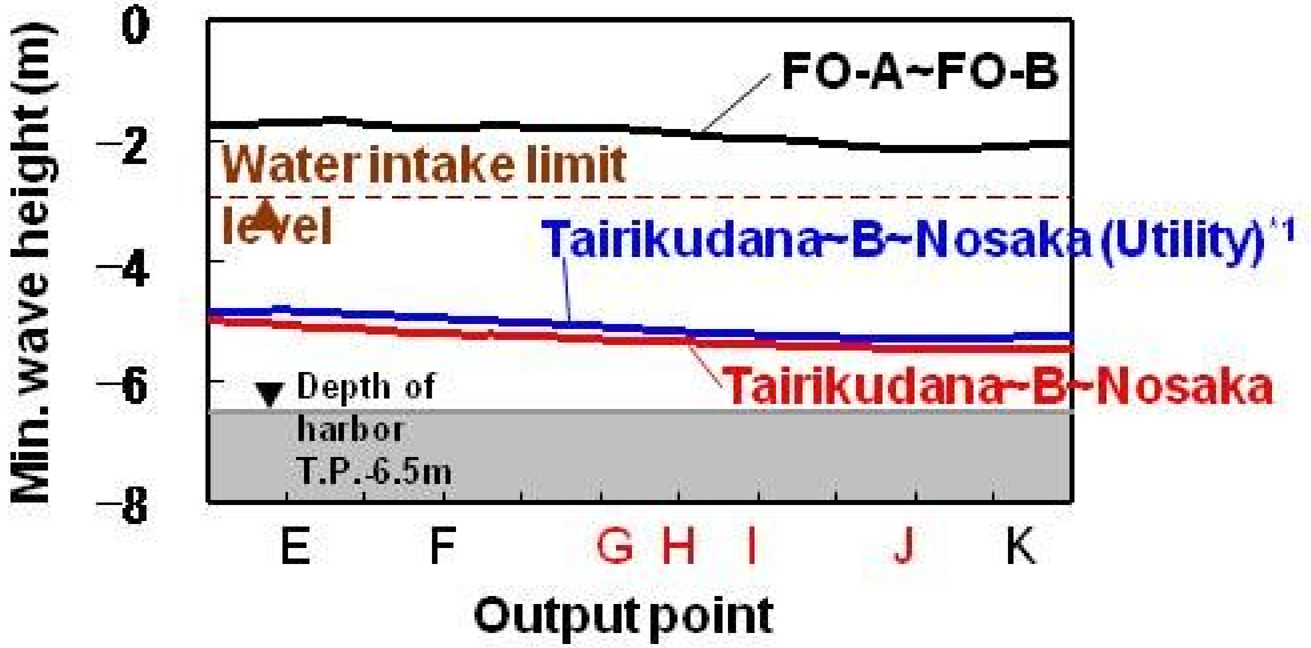
(7e) Results of tsunami simulation

■Max. and Min. wave height in front of the intake facility





Location of output points



- Simultaneous activity of Tairikudana ~ B ~ Nosaka Fault is most influence on the site in both maximum and minimum wave height.
- Max. wave height is beyond the land level.
- Min. wave height is less than the water intake limit level of seawater pump.
- In case of simultaneous activity of Tairikudana ~ B ~ Nosaka Fault, the results of comparison electric utility and JNES are as follows;

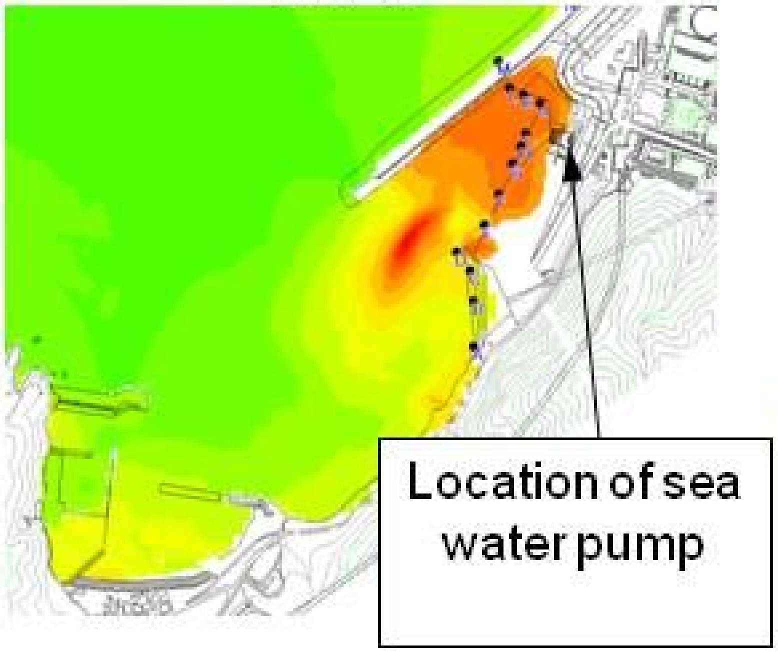
  Max. wave heights have difference of 10%
  Min. wave heights are almost same.

*1 原子力安全･保安院より提供を受けた事業者データより

(7e) Results of tsunami simulation cont.

■ Distribution of Maximum wave height: Tairikudana~B~Nosaka

JNES

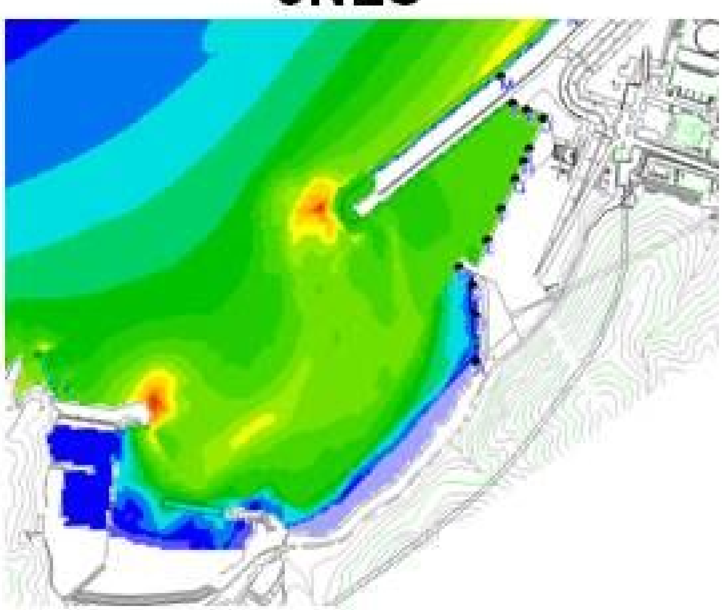


Electric Utility*1

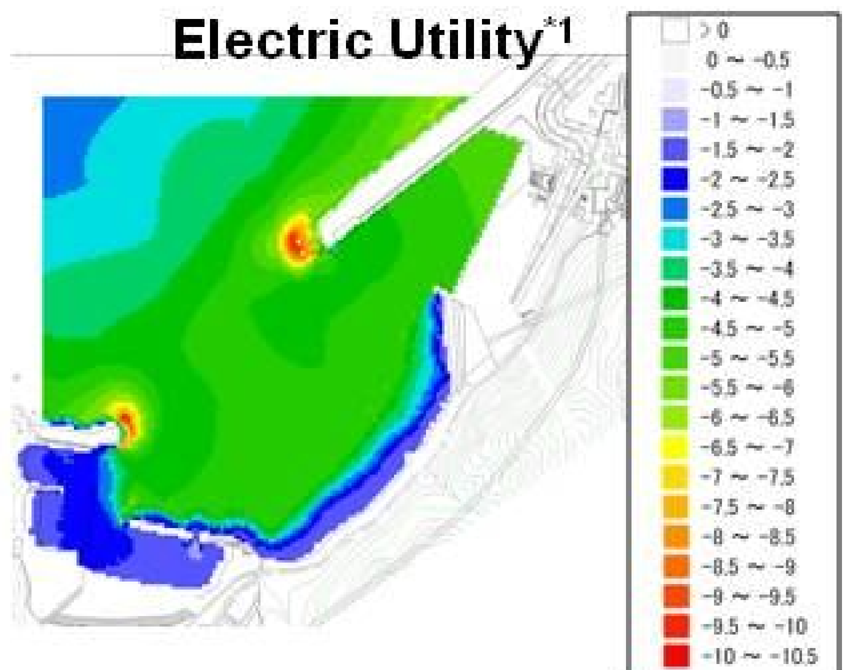
- Result of JNES shows the inundation to the site.
- But the seawater pump is not inundated.

■ Distribution of Minimum wave height: Tairikudana~B~Nosaka

JNES



Electric Utility*1

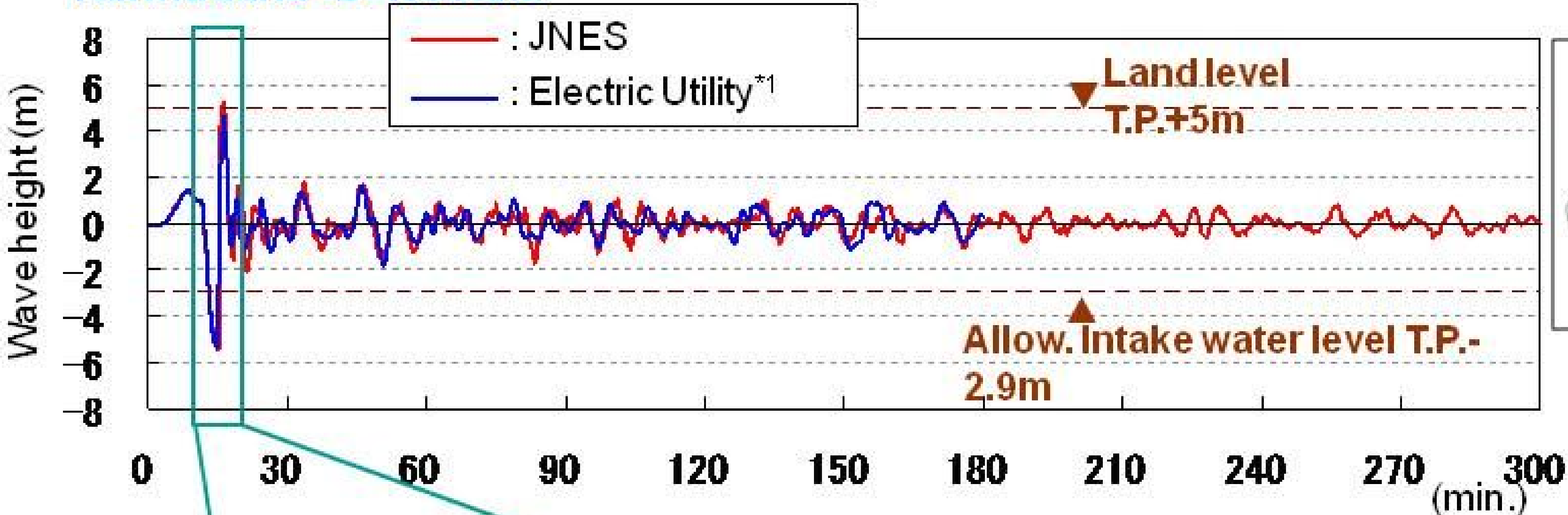


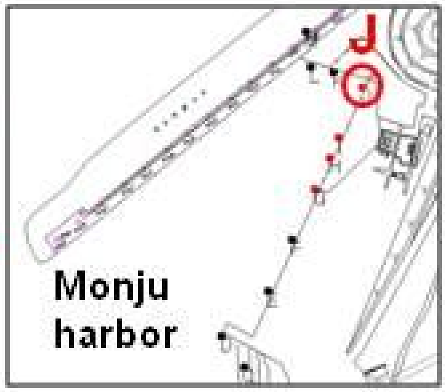
- Results of Utility and JNES are almost same.

*1 原子力安全・保安院より提供を受けた事業者データ

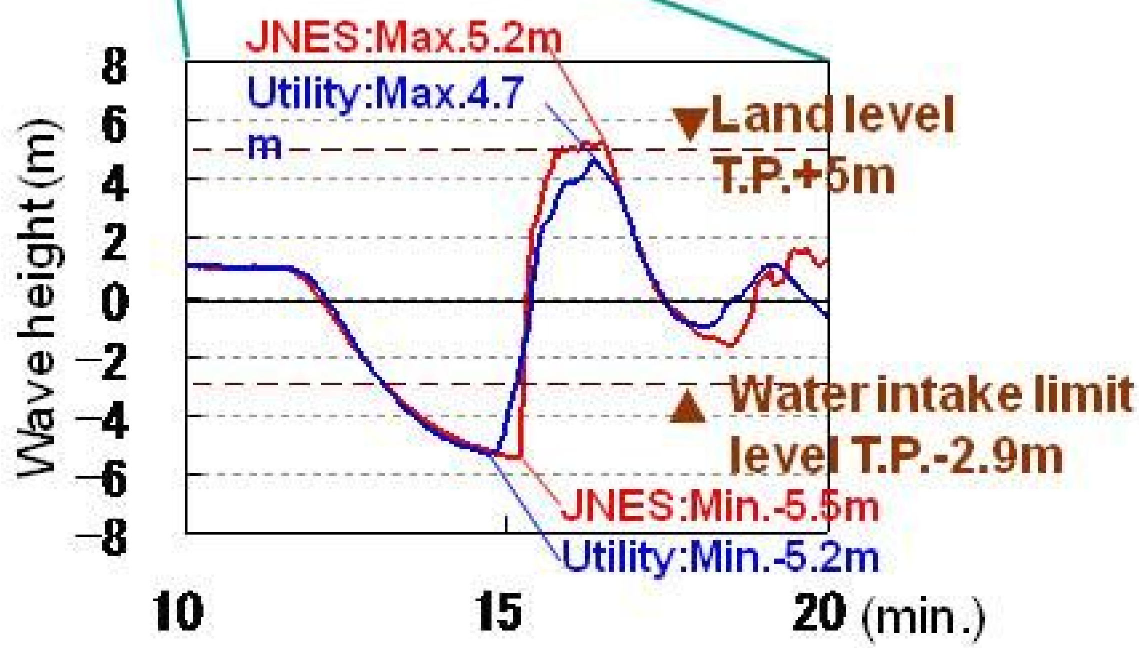
(7e) Results of tsunami simulation cont.

■ Time history of wave height in front of intake facility (Point J): Tairikudana~B~Nosaka





Location of point J



Time history of wave height from 10 min. to 20 min. after the earthquake occurrence

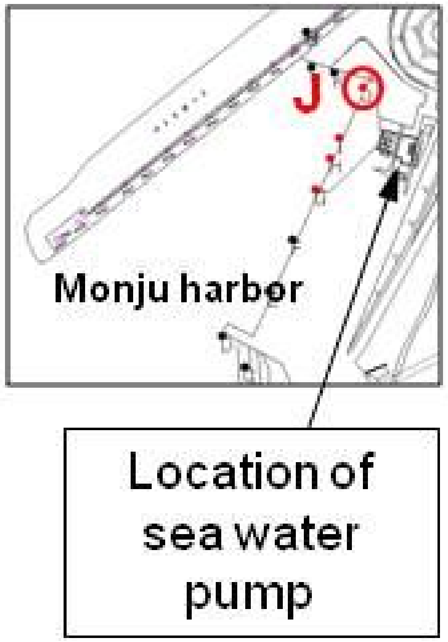
- Results of comparison between utility and JNES are almost same at view point from arrival time and time phase on time history of wave height.
- Max. wave heights have difference of 10%

*1 原子力安全・保安院より提供を受けた事業者データ

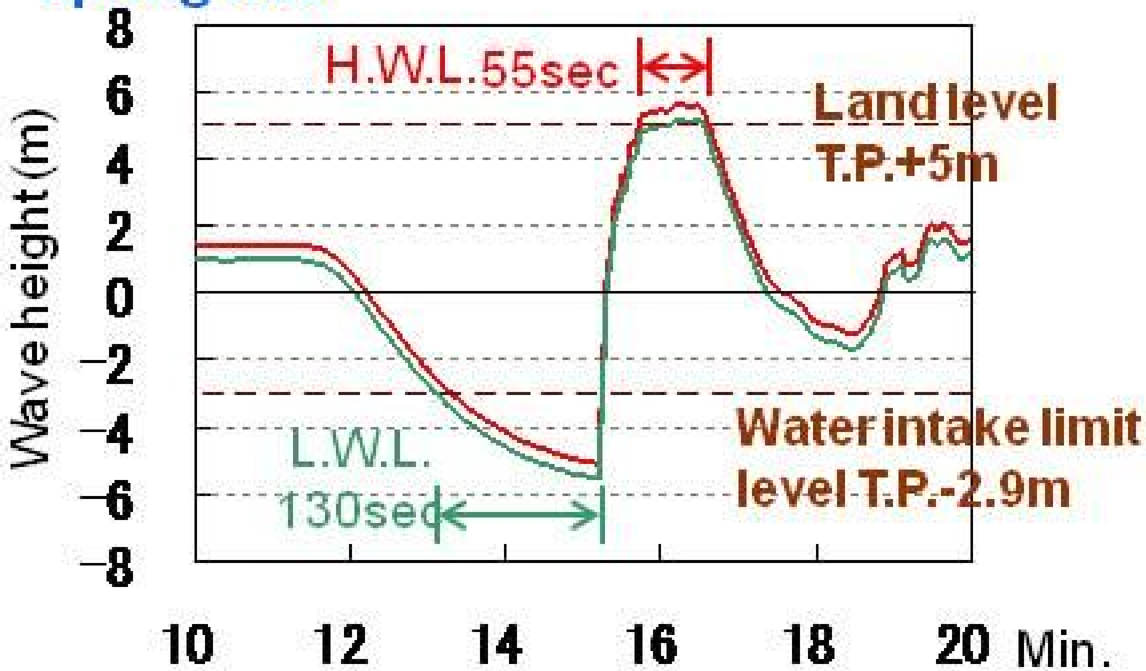
(7d) Estimated results of the max. and min. water levels

■ Estimated result (Most dominant tsunami source: Tairikudana~B~Nosaka)

Item		JNES	Electric Utility	Safety criteria
(1)Max. water level	Calculation (m)	T.P.+5.2 (J)	T.P.+4.7 (J)	–
	High water level (m)	T.P.+0.42	←	–
	Estimated water level (m)	T.P.+5.6	T.P.+5.2	T.P.+5.8
	Duration time (s)	About 55	About 10	–
(2)Min. water level	Calculation (m)	T.P.-5.5 (J)	T.P.-5.2 (J)	–
	Low water level (m)	T.P.-0.03	←	–
	Estimated water level (m)	T.P.-5.5	T.P.-5.2	T.P.-2.9
	Duration time (s)	About 130	About 120	–



■ Time history of wave height in front of intake facility (Point J) considering mean sea level of spring tide



A. Max. water level is T.P.+5.6m, though it is beyond the land level T.P.+5.0m, it satisfies the safety criteria T.P.+5.8m because the seawater pump is not inundated.

Max. wave level of electric utility has difference of 10% from JNES.

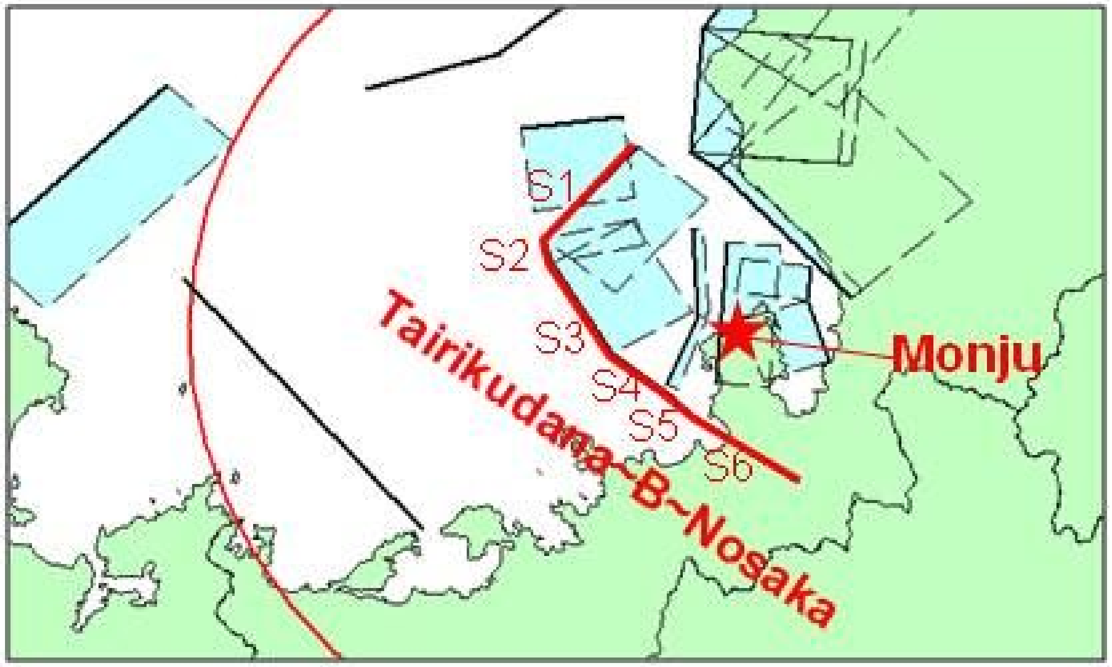
B. Min. water level is T.P.-5.5m, it does not satisfy the safety criteria T.P.-2.9m.

NISA authorized that they were not problem because core cooling by the natural circulation is possible.

(8) Estimation of the max. sand deposition height due to tsunami

(8a) Target of tsunami sources

Simultaneous activity with **Tairikudana ~ B ~ Nosaka Fault** is selected because it shows maximum wave height at Monju site.



(8b) Sediment transport modeling due to tsunami

- Takahashi, etc(1999) method considered with exchange rate between bed load and suspended load layers is applied.
- JNES's SANNAMI(+TUNAMI) code is used.

■Analysis conditions of sediment transport simulation

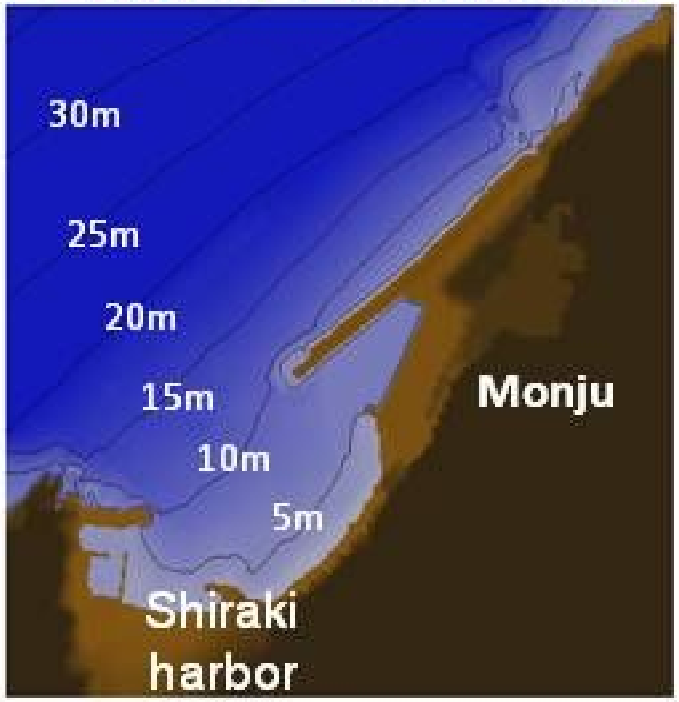
item		Analysis conditions (JNES)						(Electric Utility)
Domain		A	B	C	D	E	F*1	A~I (9 domains)
Grid size (m)		1215	405	135	45	15	5	1600 ~ 6.25m
Time step (s)		1.458	0.486	0.162	0.054	0.018	0.006	0.25
Equation	Water	Nonlinear long-wave theory						A~I: Non. long-wave
	Sediment	–					Takahashi(1999)	C~I: Takahashi(1999)
Onshore boundary condition		Complete reflection						Complete reflection
Friction coefficient		Manning's coefficient of roughness, $n=0.03m^{-1/3}s$						$n=0.03m^{-1/3}s$
Horizontal eddy viscosity		Not introduced						$10m^2/s$
Initial condition		Mansinha and Smylie (1971)						Same as left
Simulation time		3 (hour)						3 (hour)

■Main parameter of sediment transport simulation*2

item		Value
Initial sand layer		∞
Seawater density	g/cm^3	1.0
Dynamic viscosity coefficient	cm^2/s	0.01
Sand density	g/cm^3	2.70
Specific gravity of sand in water		1.7
Diameter of sand particle	mm	0.545
Air porosity		0.4
Settling velocity	cm/s	6.76 (Rubey's Law)
Critical friction velocity	cm/s	0.0
Saturated suspended load concentration	%	1.0
Effect of slope		0.0

*1 事業者の深浅測量データからF領域地形モデルを作成した。

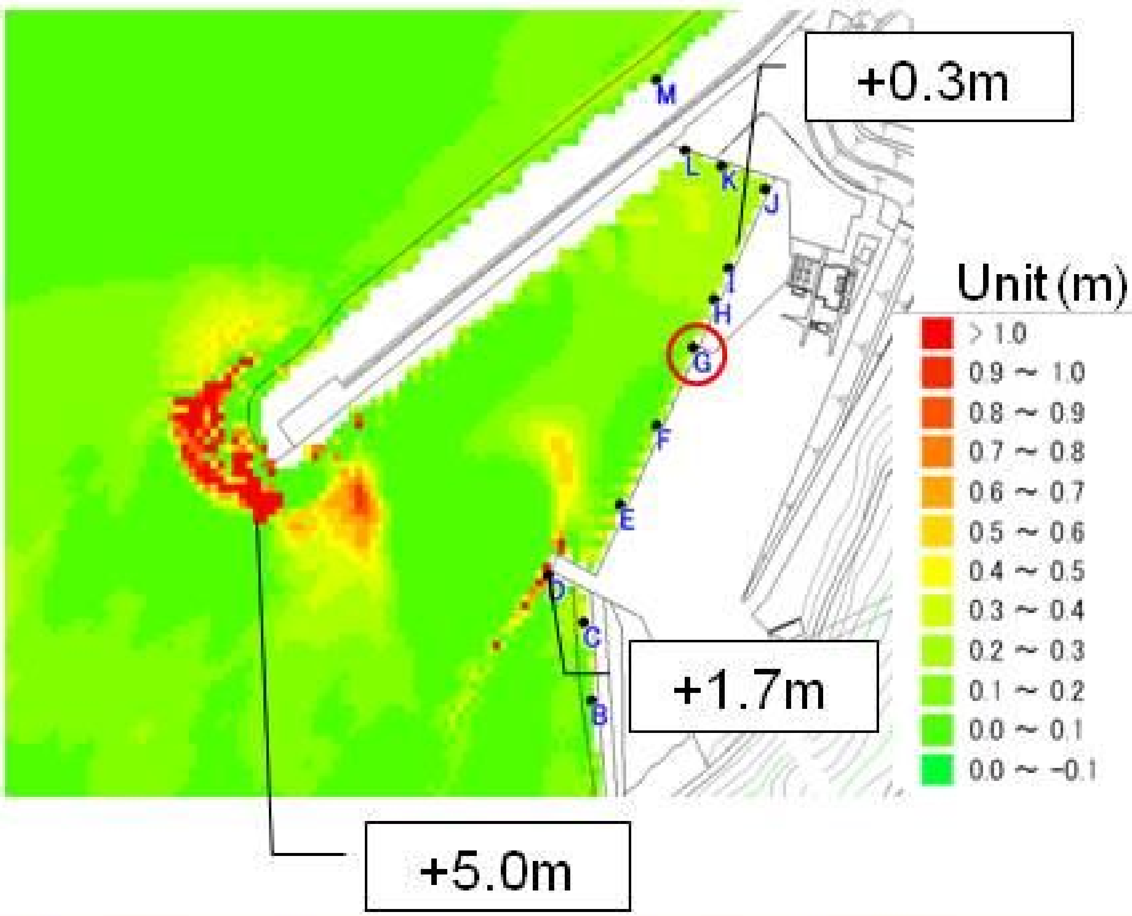
■Computation domain F



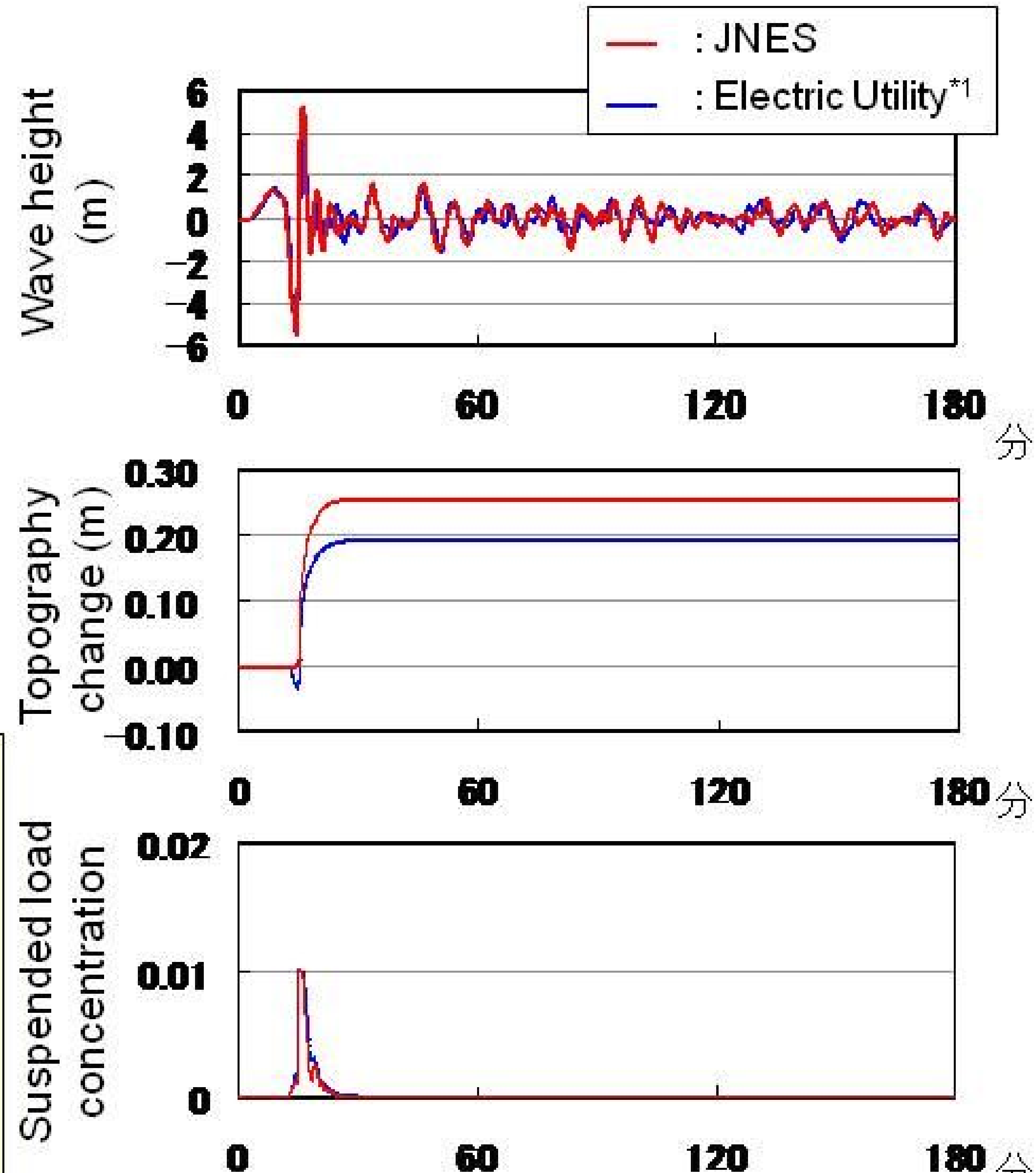
*2 原子力安全・保安院より提供を受けた事業者データ

(8e) Results of sediment transport simulation

■ Distribution of Maximum deposition height



■ Some time histories

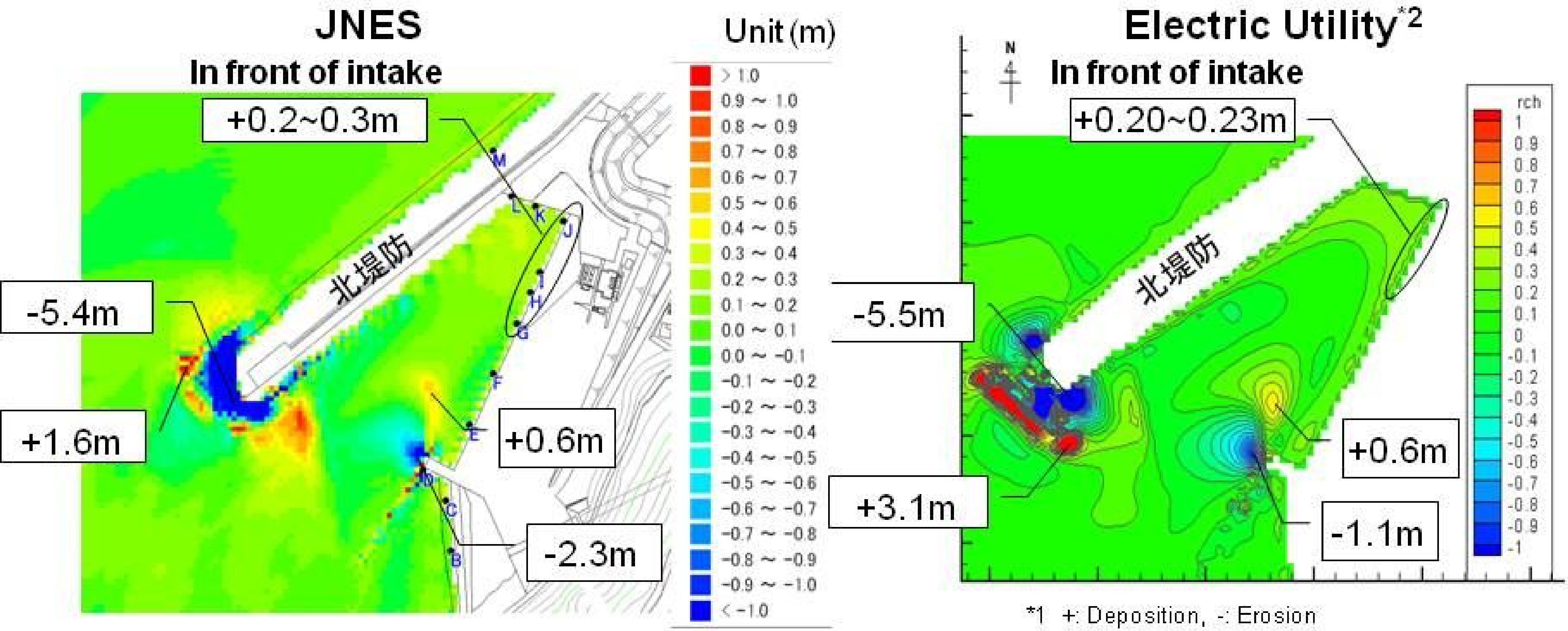


- Max. deposition height in front of intake facility is about 30 cm.
- Topography change almost finish in 30 min. after earthquake occurrence.
- Results of comparison between utility and JNES are almost same at view point from some time histories, wave height, topography change, suspended load concentration.

*1 原子力安全·保安院より提供を受けた事業者データ

(8e) Results of sediment transport simulation, cont.

■ Distribution of topography change after 3 hours



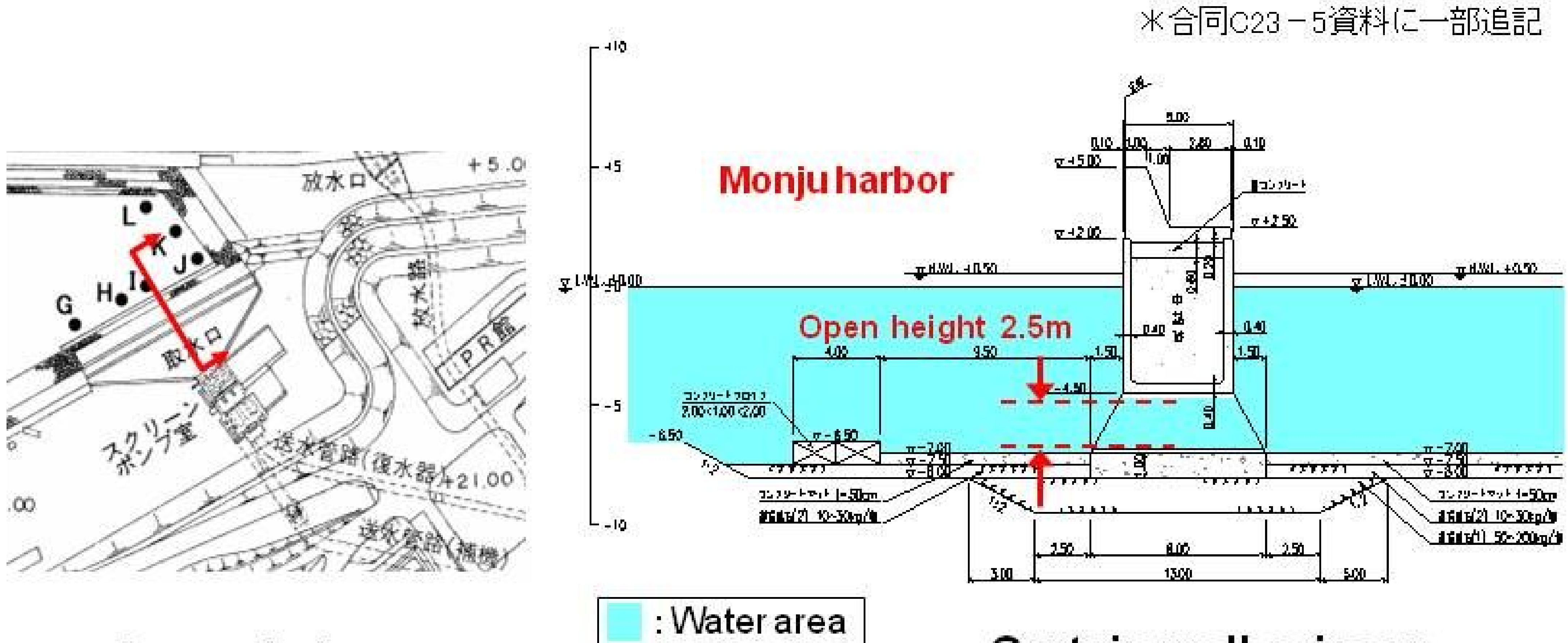
*1 +: Deposition, -: Erosion

*2 原子力安全･保安院より提供を受けた事業者データ

- Result of comparison between utility and JNES are almost same at view point from distribution of topography change around Monju harbor.
- Sand deposition in front of water intake is 20 ~ 30 cm calculated by both utility and JNES.

(8d) Estimated results of the max. sand deposition height due to tsunami

■Details of intake facility



Ground plan

Curtain wall caisson cross section

- Max. sand deposition height is 30 cm, and it satisfies the safety criteria 250 cm.
- Results of comparison between utility 20cm and JNES 30cm are almost same at view point from max. sand deposition height.

Summary 1-1

- In Japan, Government and Nongovernment (Japan Electric Association) *Safety Guidelines for Seismic Design on NPP* are decided on.

- Many precious seismic data are acquired around the NPP sites.

- In Japan, Government and Nongovernment Safety Guidelines are sufficiently applied to assessment for an earthquake-resistant, and new knowledge are incorporated into the assessment. These applications yield rationality and securing transparency for the assessment.

Summary 1-2

- Active faults may exist around future NPP sites.
- Strong ground motion estimation with fault model can contribute significantly to seismic hazard assessment near by the fault.
- Therefore it has been adopted in DS422(NS-G-3.3)/IAEA.
- In order to apply the fault model scheme, input parameters will be desired.
- Seismological and Geological investigations are quite essential to estimate the parameters, as well as, their uncertainties.

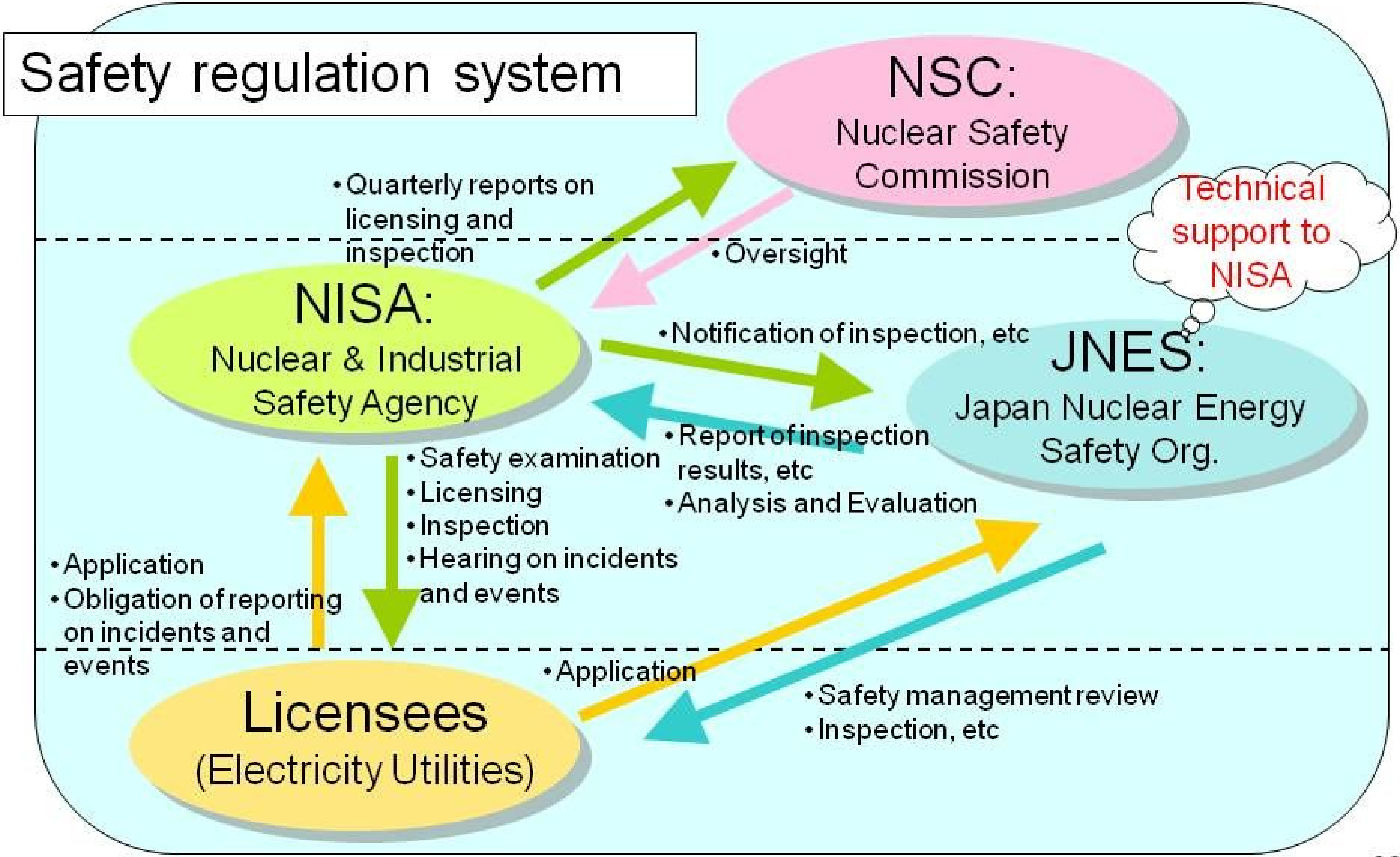
Summary 2

- Example of tsunami hazard assessment crosschecked by JNES were introduced in detail.
- Recent researches to improve tsunami hazard assessment were introduced.

Thank you for your kind attention

Seismic Safety Division
Seismic Test and Research Group
UCHIDA Jun-ichi

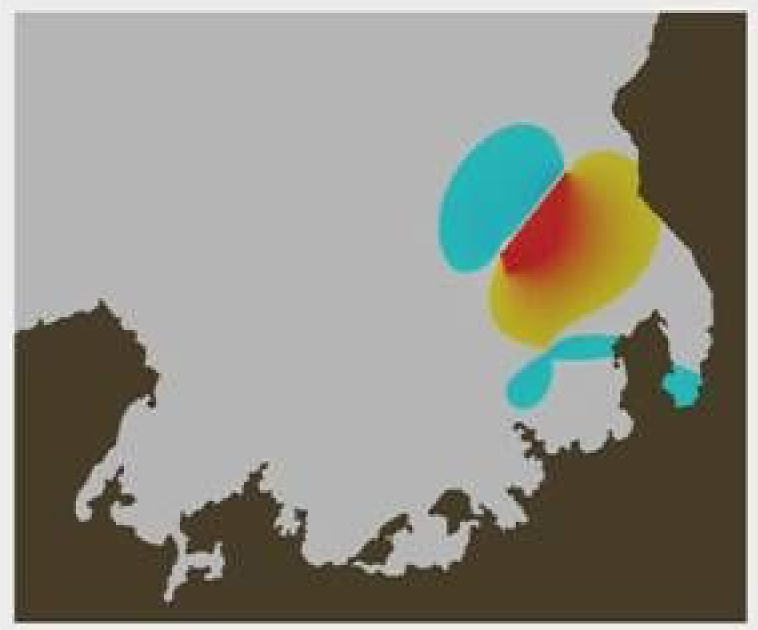
2-1 Role of JNES in safety regulation system



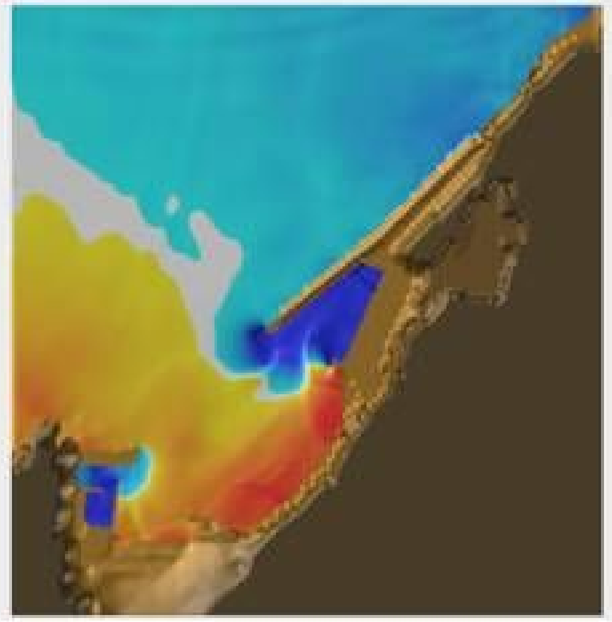
(9) Animation of tsunami and sediment transport

Tsunami propagation

- Large area (Domain - B)

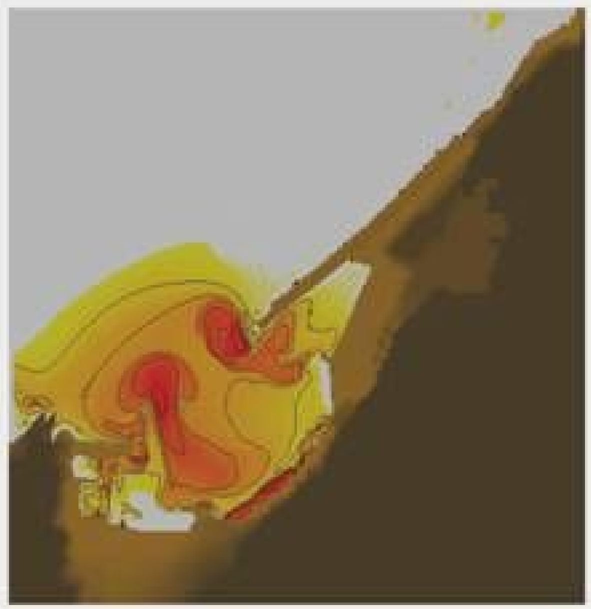


- Near site area (Domain – F)



Sediment transport

- Suspended load layer (Domain - F)



- Topography change (Domain - F)