Seismic issues in Japan

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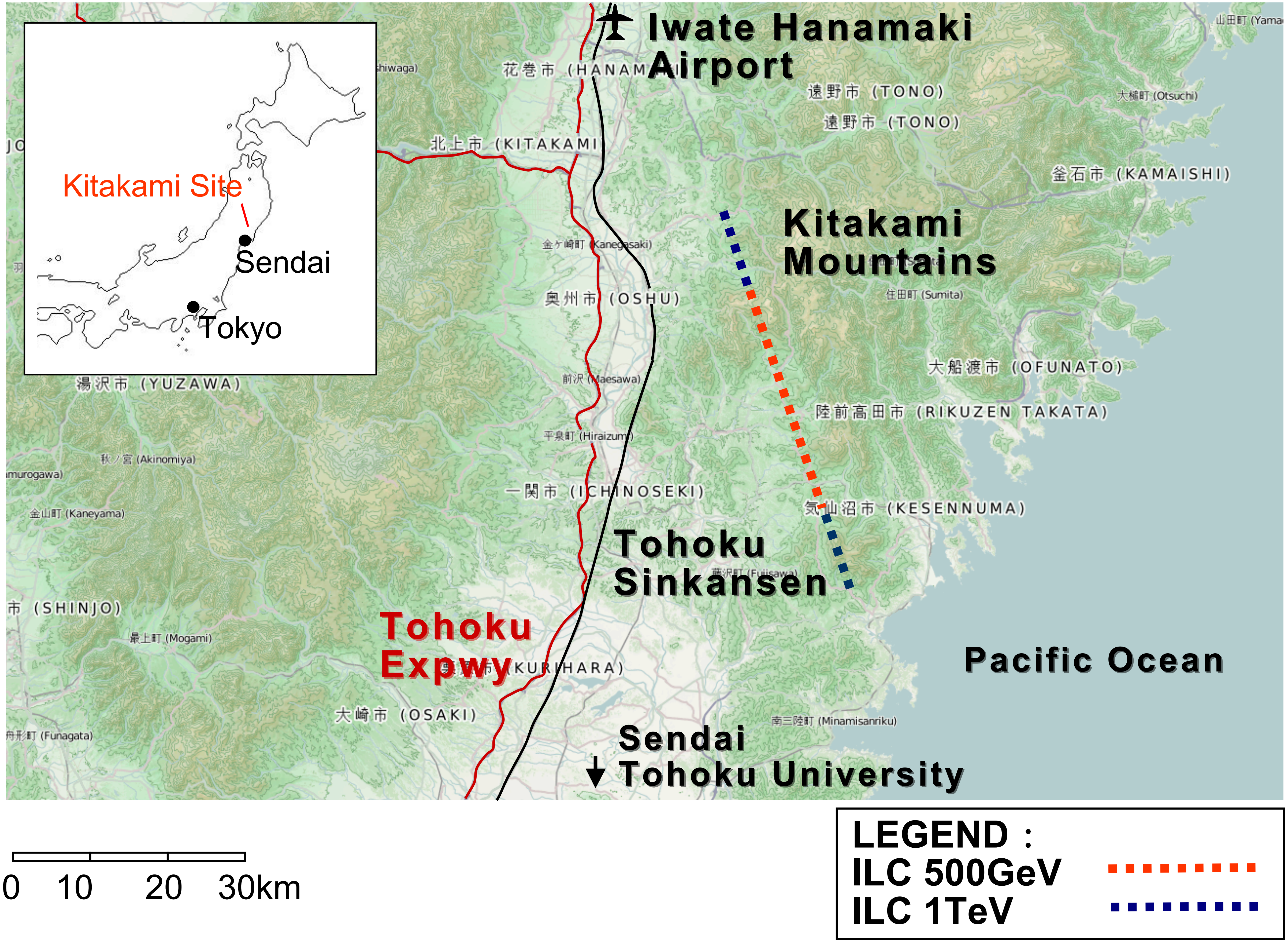
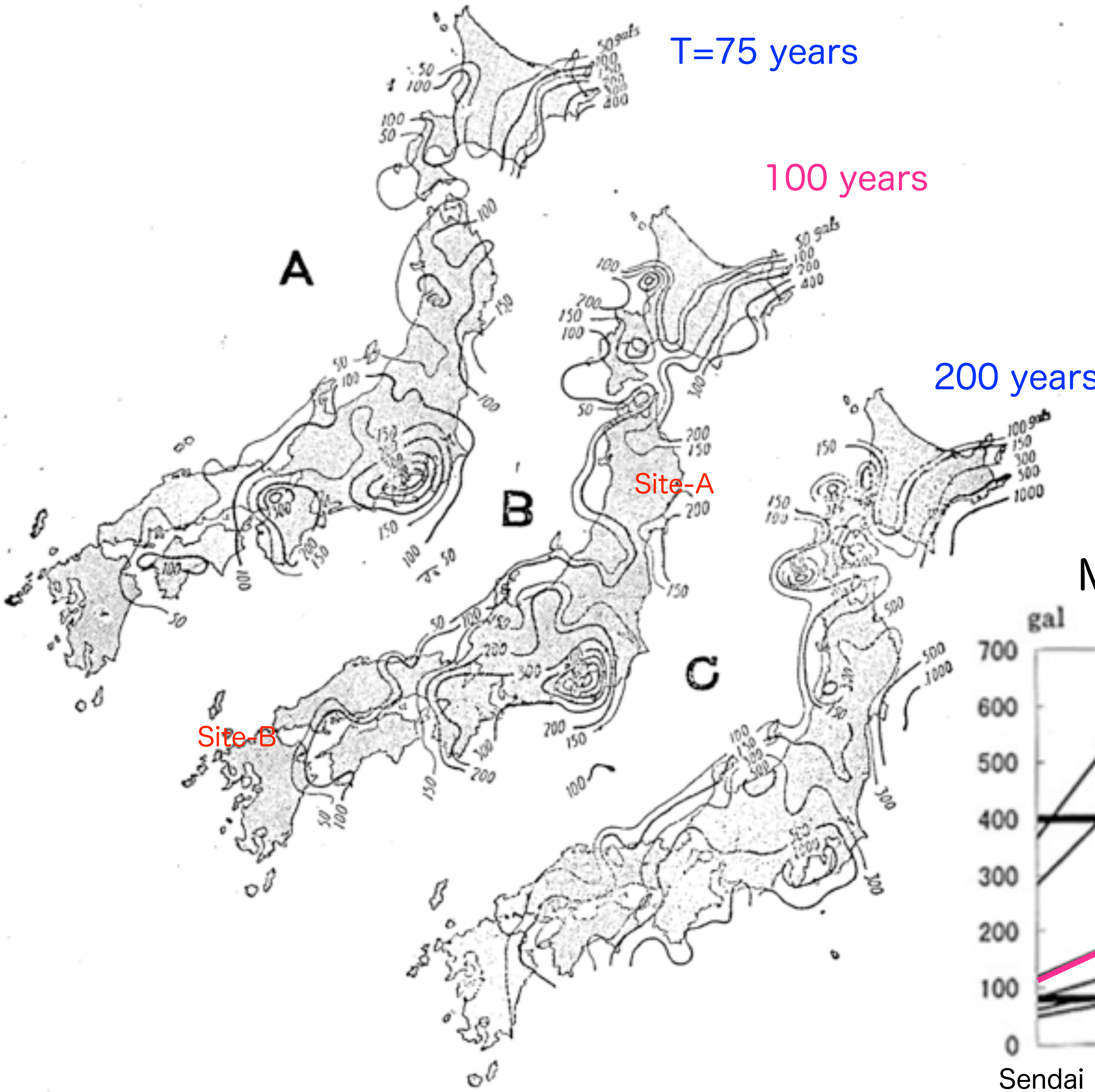
ILD workshop, Cracow, 24-26 September 2013

Site A : Kitakami in Japan

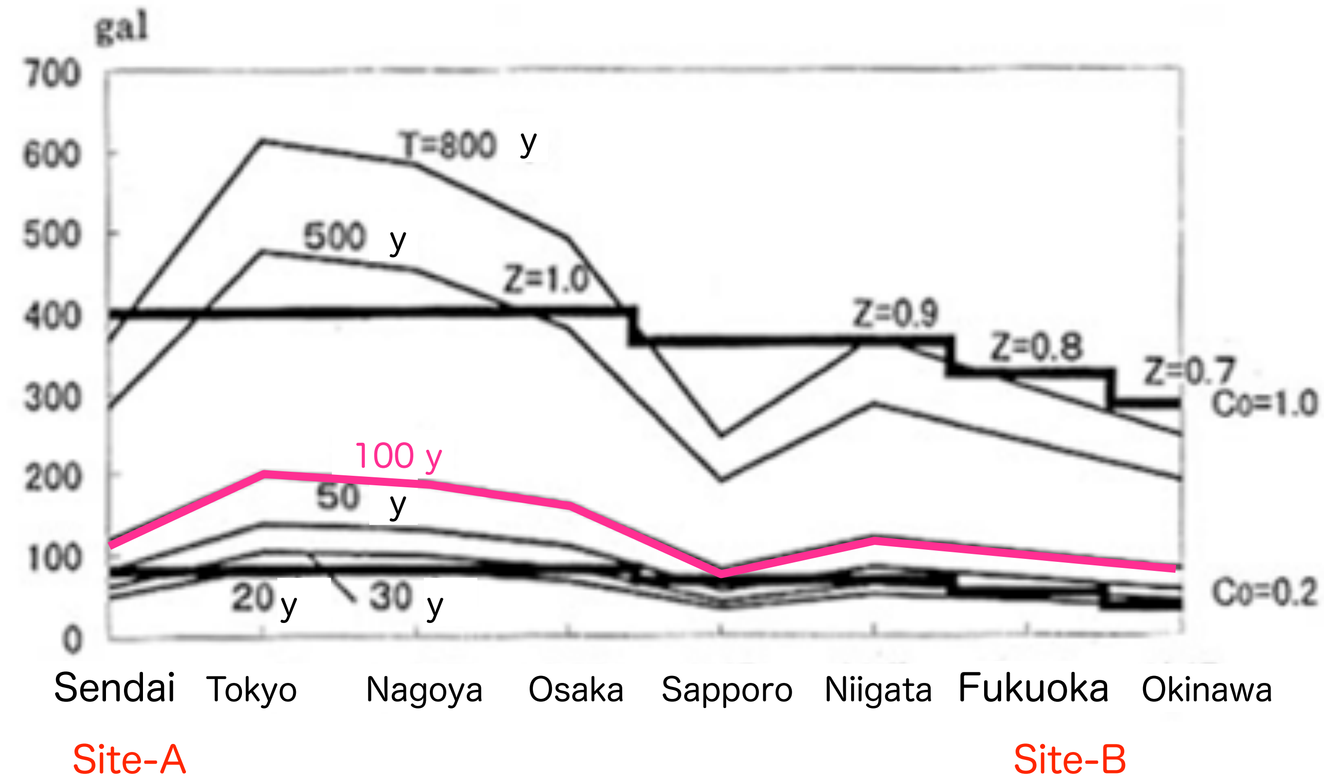


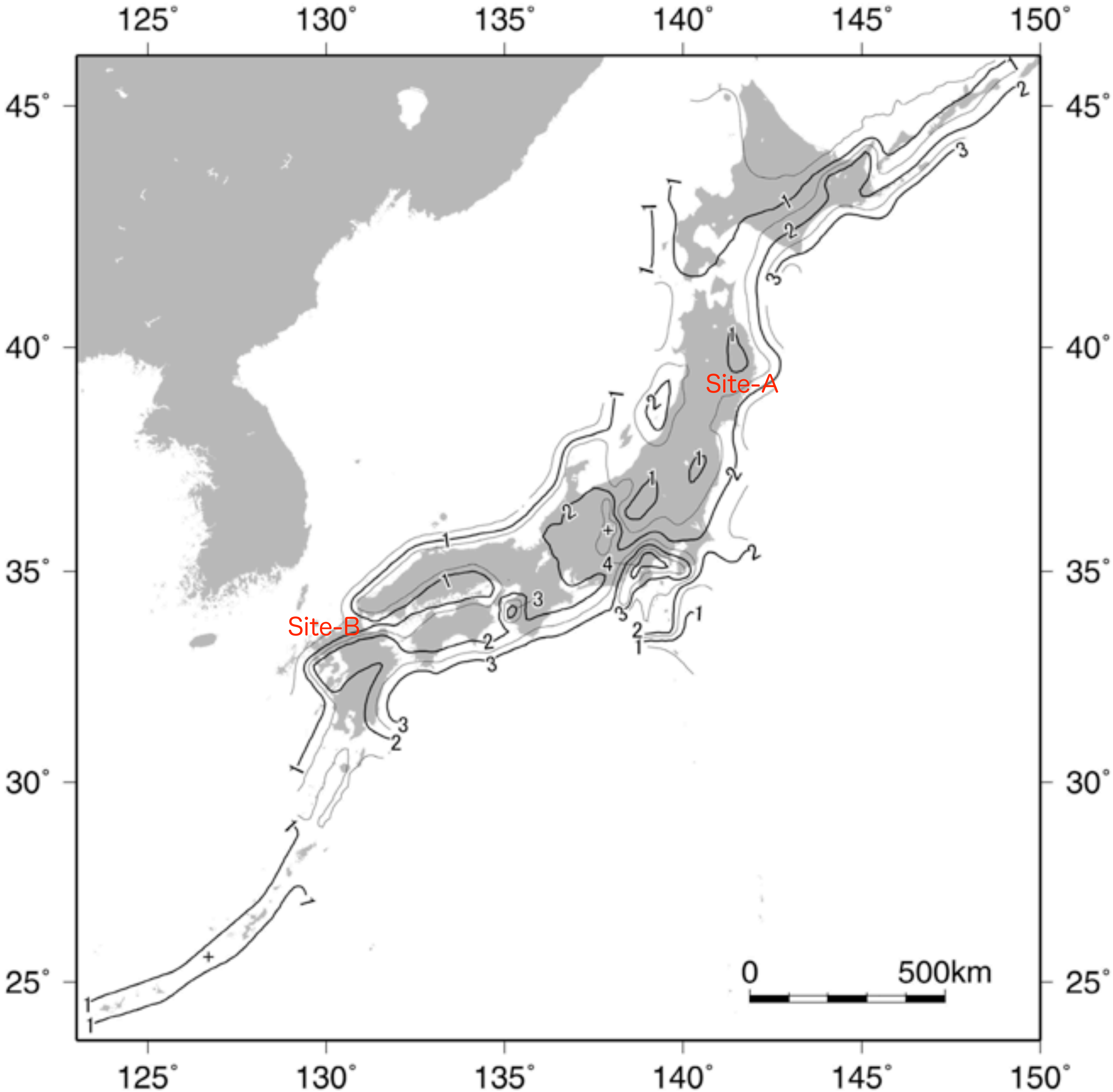
Seismic Hazard Map in Japan : Maximum acceleration (gal) in recurrence intervals of earthquake

Kawasumi map : based on earthquakes from 679 to 1,948 in Japan



Max. acceleration in cities, Japan



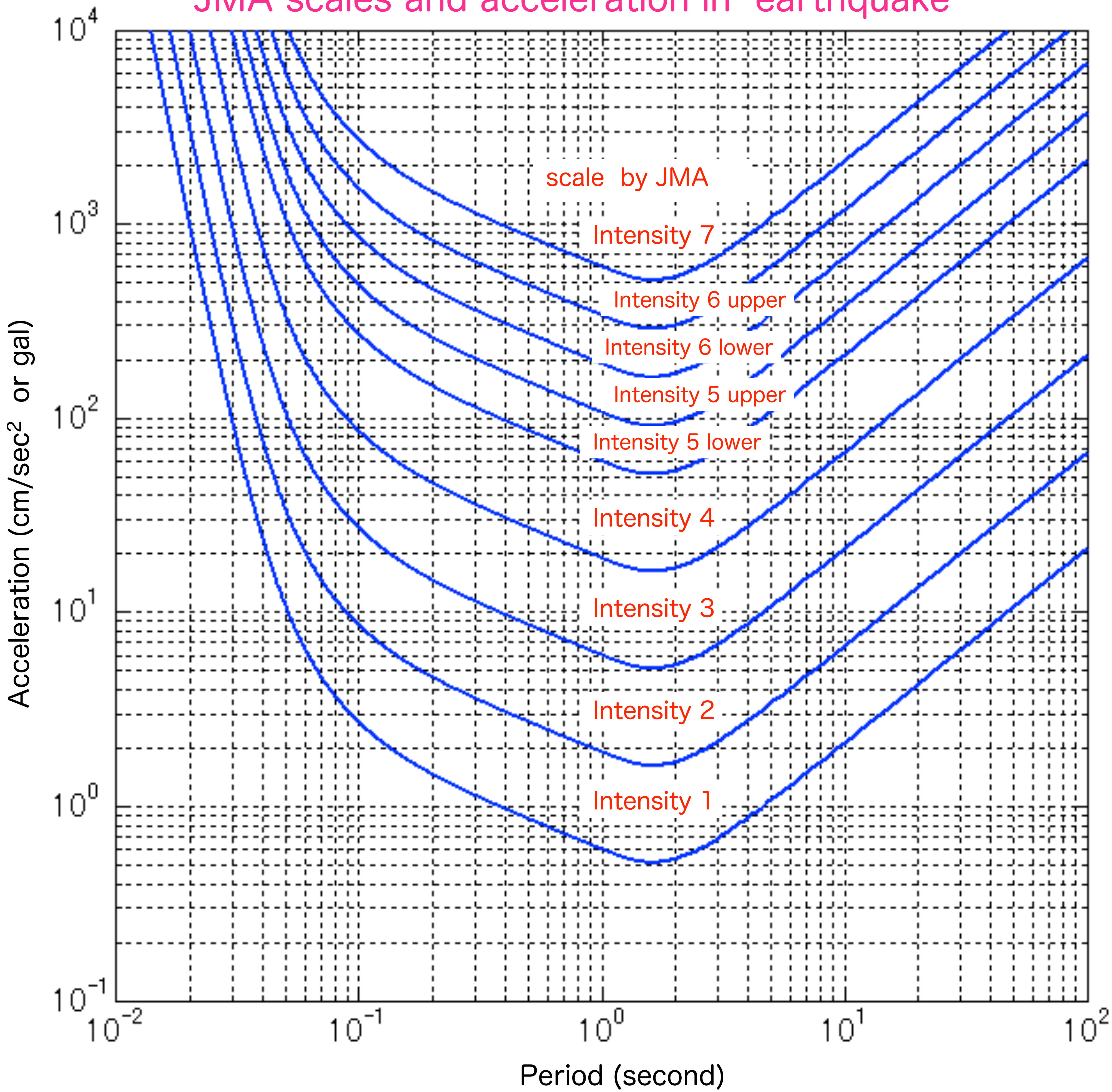


Basic peak acceleration a_0 (m/s^2) at the surface of the engineering bedrock for a return period of 100 years. "+" indicates that the value in that area is greater than that of the adjacent area
AIJ Recommendations for Loads on Buildings, 2006

JMA (Japan Meteorological Agency)				http://www.jma.go.jp/jma/kishou/know/shindo/explane.html	
Scale(m)	gal JMA lower end	Acc(cm/s^2) $0.45 \times 10^{0.5m}$	People	Indoor Situations	Outdoor Situations
0			Imperceptible to people.		
1	0.8	1.4	Felt by only some people in the building.		
2	2.5	4.5	Felt by most people in the building. Some people awake.	Hanging objects such as lamps swing slightly.	
3	8	14	Felt by most people in the building. Some people are frightened.	Dishes in a cupboard rattle occasionally.	Electric wires swing slightly.
2012.12.7 (M7.3)@Tsukuba 4	25	45	Many people are frightened. Some people try to escape from danger. Most sleeping people awake.	Hanging objects swing considerably and dishes in a cupboard rattle. Unstable ornaments fall occasionally.	Electric wires swing considerably. People walking on a street and some people driving automobiles notice the tremor.
5-Lower	80	142	Most people try to escape from a danger. Some people find it difficult to move.	Hanging objects swing violently. Most Unstable ornaments fall. Occasionally, dishes in a cupboard and books on a bookshelf fall and furniture moves.	People notice electric-light poles swing. occasionally, windowpanes are broken and fall, un-reinforced concrete-block walls collapse, and roads suffer damage.
5-Upper		253	Many people are considerably frightened and find it difficult to move.	Most dishes in a cupboard and most books on a bookshelf fall. Occasionally, a TV set on a rack falls, heavy furniture such as a chest of drawers falls, sliding doors slip out of their groove and the deformation of a door frame makes it impossible to open the door.	In many cases , un-reinforced concrete-block walls collapse and tombstones overturn. Many automobiles stop because it becomes difficult to drive. Occasionally, poorly-installed vending machines fall.
2011.3.11 (M9.0)@Tsukuba 6-Lower	250	450	Difficult to keep standing.	A lot of heavy and unfixed furniture moves and falls. It is impossible to open the door in many cases.	In some buildings, wall tiles and windowpanes are damaged and fall.
6-Upper	400	800	Impossible to keep standing and to move without crawling.	Most heavy and unfixed furniture moves and falls. Occasionally, sliding doors are thrown from their groove.	In many buildings, wall tiles and windowpanes are damaged and fall. Most un-reinforced concrete-block walls collapse.
7		1423	Thrown by the shaking and impossible to move at will.	Most furniture moves to a large extent and some jumps up.	In most buildings, wall tiles and windowpanes are damaged and fall. In some cases, reinforced concrete-block walls collapse.

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK

JMA scales and acceleration in earthquake



International Standard
Based for Design of Structures - Seismic Actions on Structures

ISO3010 2001

International Organization for Standardization

a) (ultimate limit state: ULS) The structure should not collapse nor experience other similar forms of structural failure due to severe earthquake ground motions that could occur at the site .

b) (serviceability limit state: SLS) The structure should withstand moderate earthquake ground motions which may be expected to occur at the site during the service life of the structure with damage within accepted limits.

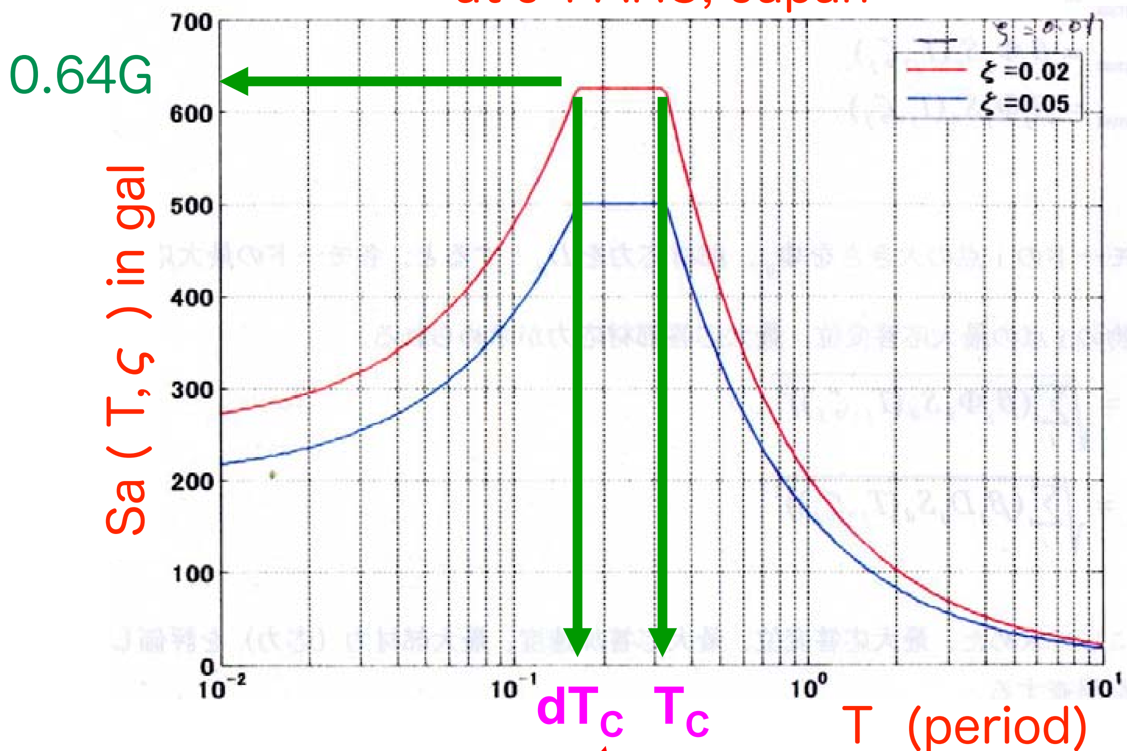
In both cases, the seismic force can be the maximum acceleration of earthquakes in the recurrence intervals of 100 years.

The ISO 3010 is expected to be used as a raw material for new national regulations or as a guideline for revising existing national regulations.

Seismic Analysis with the class-1 geology (hard soil)

following the guideline of construction loads by Architectural Institute of Japan

Example： Acceleration Response Spectrum at J-PARC, Japan



$0 \le T \le dT_C$

$$S_a = \left(1 + \frac{f_A - 1}{d} \cdot \frac{T}{T_C}\right) \cdot F_h \cdot G_A \cdot R_A \cdot A_0$$

$dT_C \le T \le T_C$

$$S_a = f_A F_h \cdot G_A \cdot R_A \cdot A_0$$

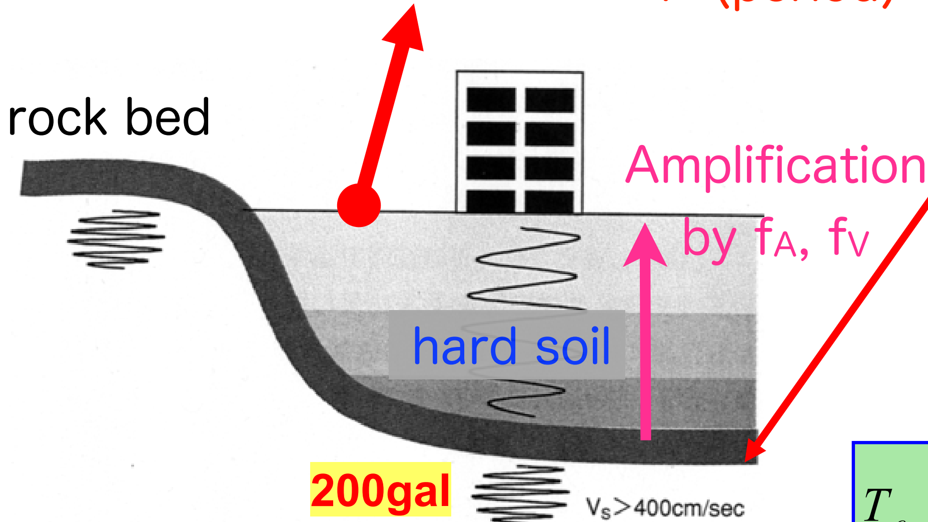
$T_C \le T$: Velo = const.

$$S_a = \frac{2\pi \cdot f_V \cdot F_h \cdot G_V \cdot R_V \cdot V_0}{T}$$

hard soil

$$A_0 = 15 V_0$$

A_0=200gal: *representative value of earthquake*



In case of hard soil,

f_A=2.5, f_V=2.0, d=0.5, R_A=1.0, R_V=1.0,
G_A=1.0, G_V=1.0, T_C=0.33

$$F_h = \frac{1.5}{1 + 10\varsigma}$$

ζ(Damping ratio) =0.02 → F_h=1.25

Steel structure： ς =0.02

$$T_c = \frac{2\pi f_V \cdot G_V \cdot R_V \cdot V_0}{f_A \cdot G_A \cdot R_A \cdot A_0} = \frac{2\pi \cdot 2 \cdot 1 \cdot 1 \cdot A_0/15}{2.5 \cdot 1 \cdot 1 \cdot A_0} = 0.33 \text{ sec}$$

$dT_C \le T \le T_C$

$$S_a = f_A F_h \cdot G_A \cdot R_A \cdot A_0 = 2.5 \cdot 1.25 \cdot 1.0 \cdot 1.0 \cdot 200 = 625\ (gal)$$

T_c=0.33sec= *3Hz*

dT_c=0.16sec= *6.3Hz*

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK

Site-dependent parameters in seismic analysis

f_A (2.5 hard): ratio of $G_A R_A A_0$ of $S_a(T, \varsigma=0.02$ for steel structure) in $dT_c<T<T_c$, amplification factor

f_v (2.0 hard): ratio of $G_v R_v V_0$ of $S_v(T, \varsigma) = S_a(T, \varsigma)T/2\pi$ in $T_c<T$, amplification factor

d (0.5 hard): dT_c/T_c, ratio of lower bound of period (dT_c) relative to the upper one (T_c=0.33sec hard) in the constant $S_a(T, \varsigma)$

F_h (1.25 hard): Correction factor of damping constant, $1.5/(1+10\varsigma)$, $F_h=1$ for $\varsigma=0.05$ (ferroconcrete)

A_0 (200 at J-PARC hard): Basic maximum acceleration of ground motion

V_0 ($A_0/15$ hard) : Basic maximum velocity of ground motion

R_A (1.0 hard): conversion coefficient of recurrence intervals (std:100y) of the maximum acceleration

R_v (1.0 hard) : conversion coefficient of recurrence intervals (std:100y) of the maximum velocity

G_A (1.0 hard): site-dependent correction factor of the maximum acceleration

G_v (1.0 hard): site-dependent correction factor of the maximum velocity

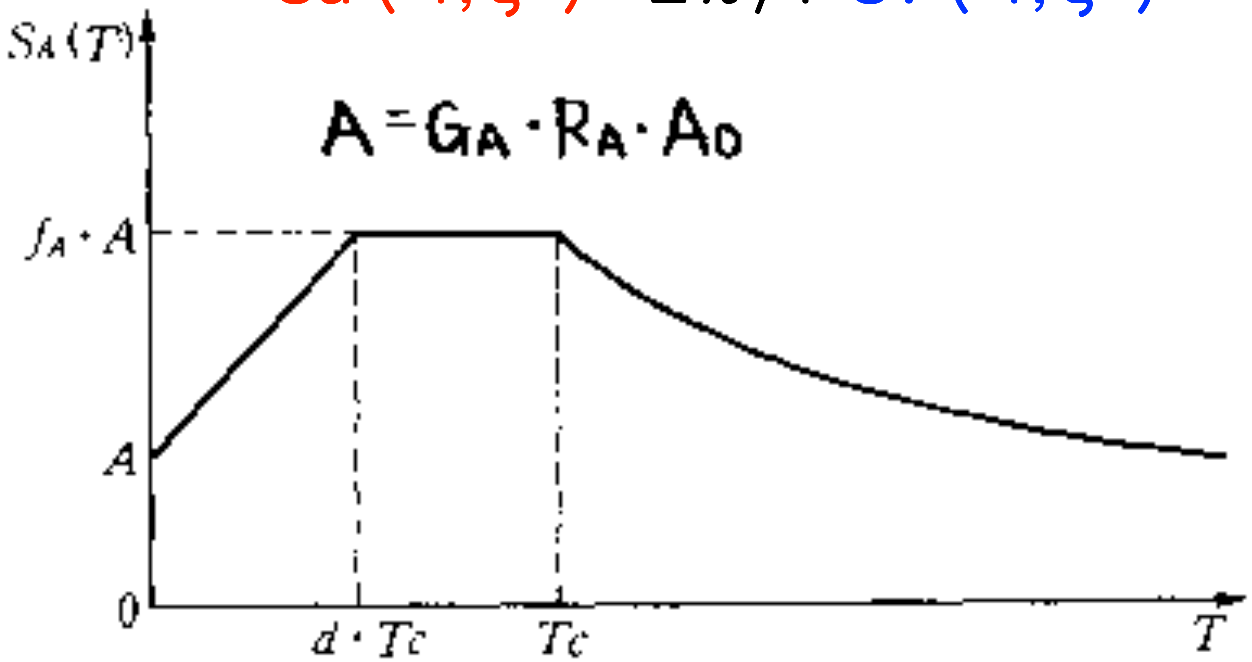
Natural vibration analysis of structures

Calculation of natural frequencies, own natural periods, natural angular frequencies, natural vibration modes, impulse constants, effective masses then,

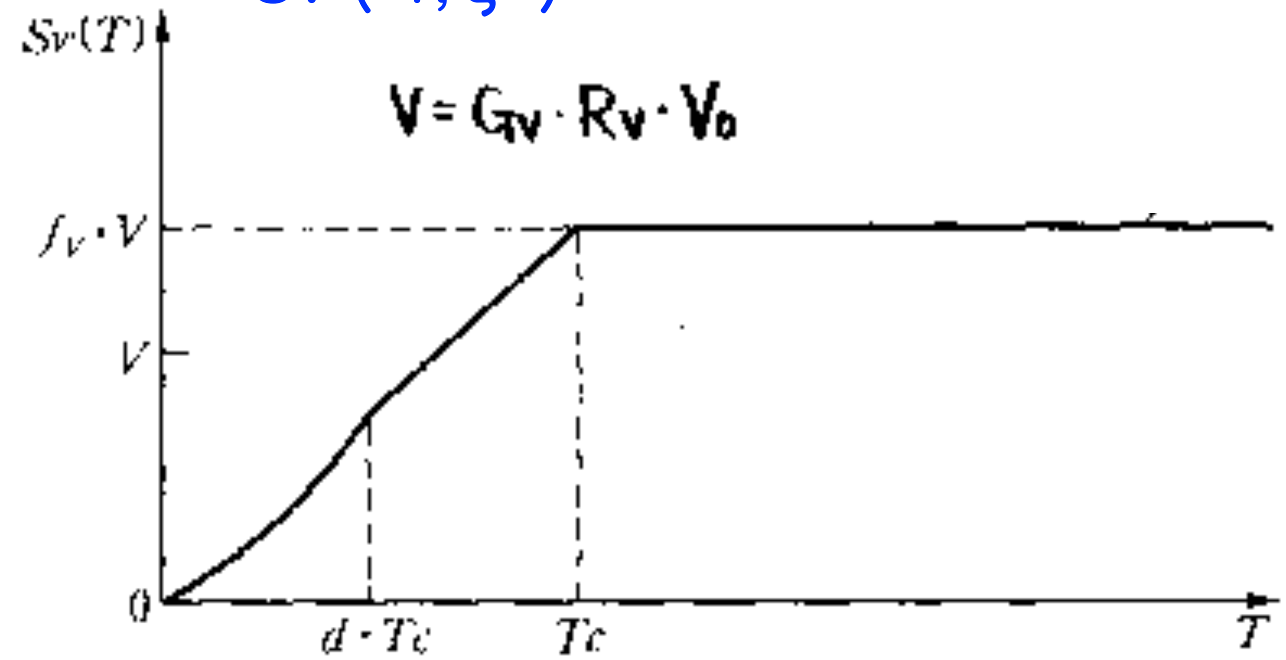
Estimation of maximum displacement, maximum response acceleration, and maximum stress to be reviewed if it is less than the allowable stress.

Acceleration and Velocity Response Spectrum

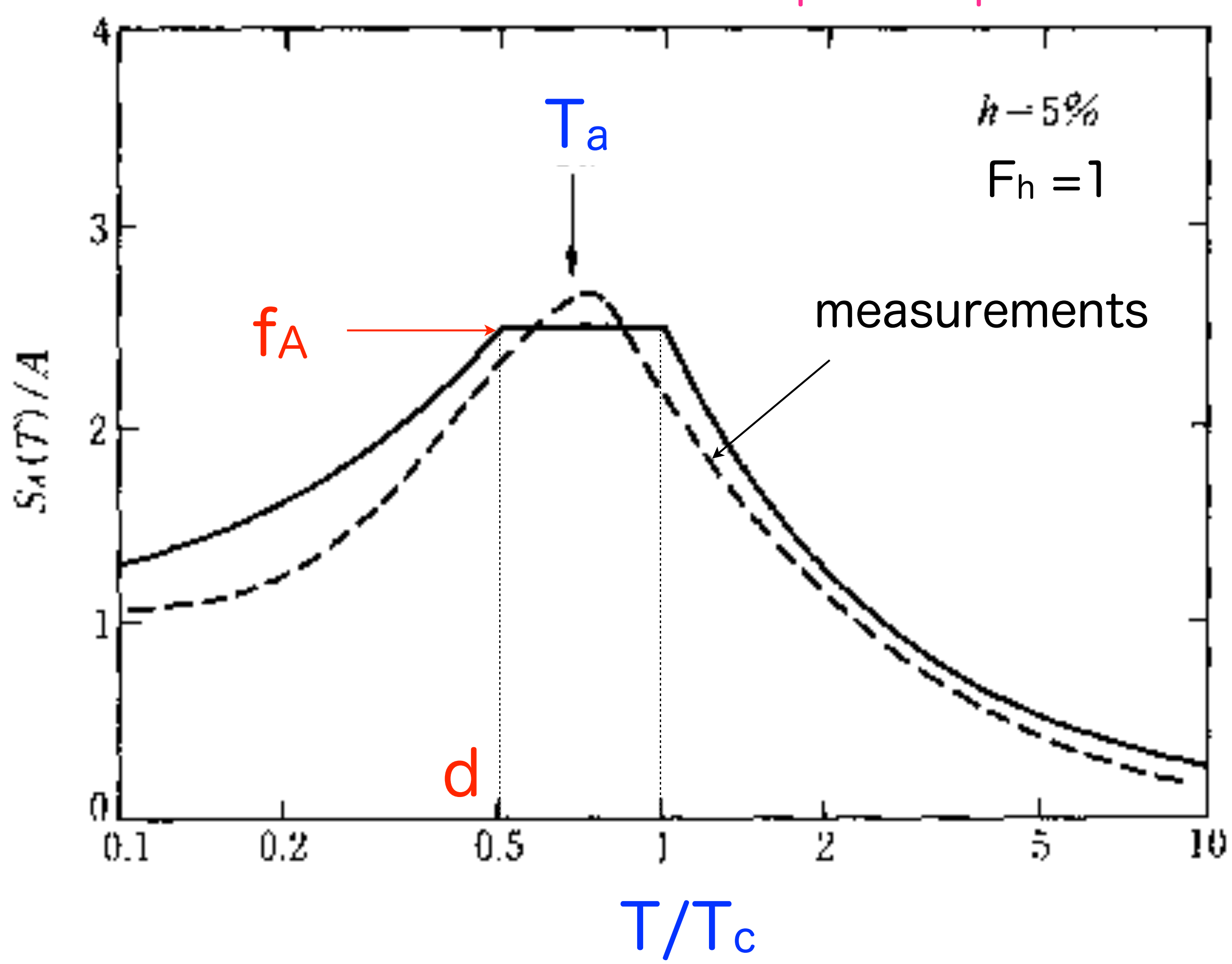
Sa (T, ς) ~2π/T Sv (T, ς)



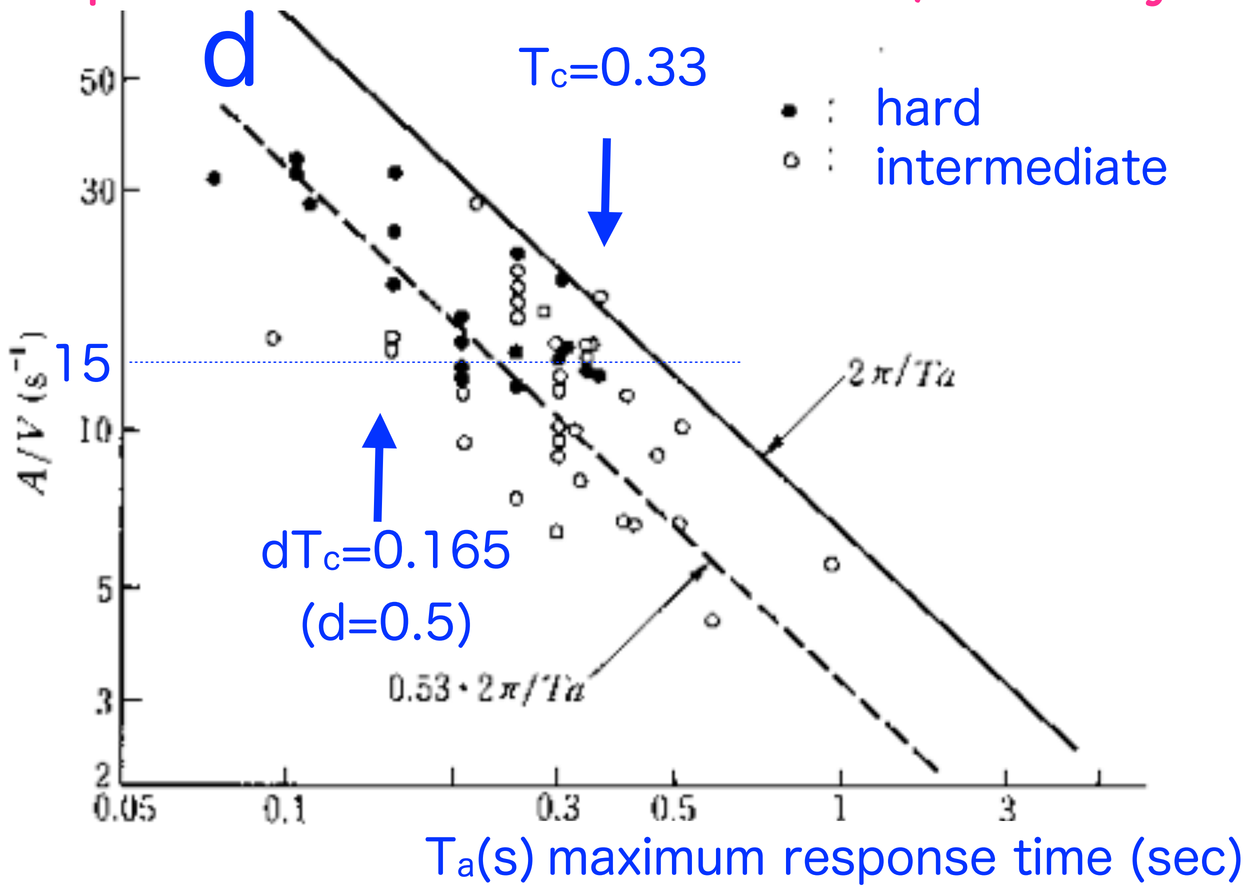
Sv (T, ς)



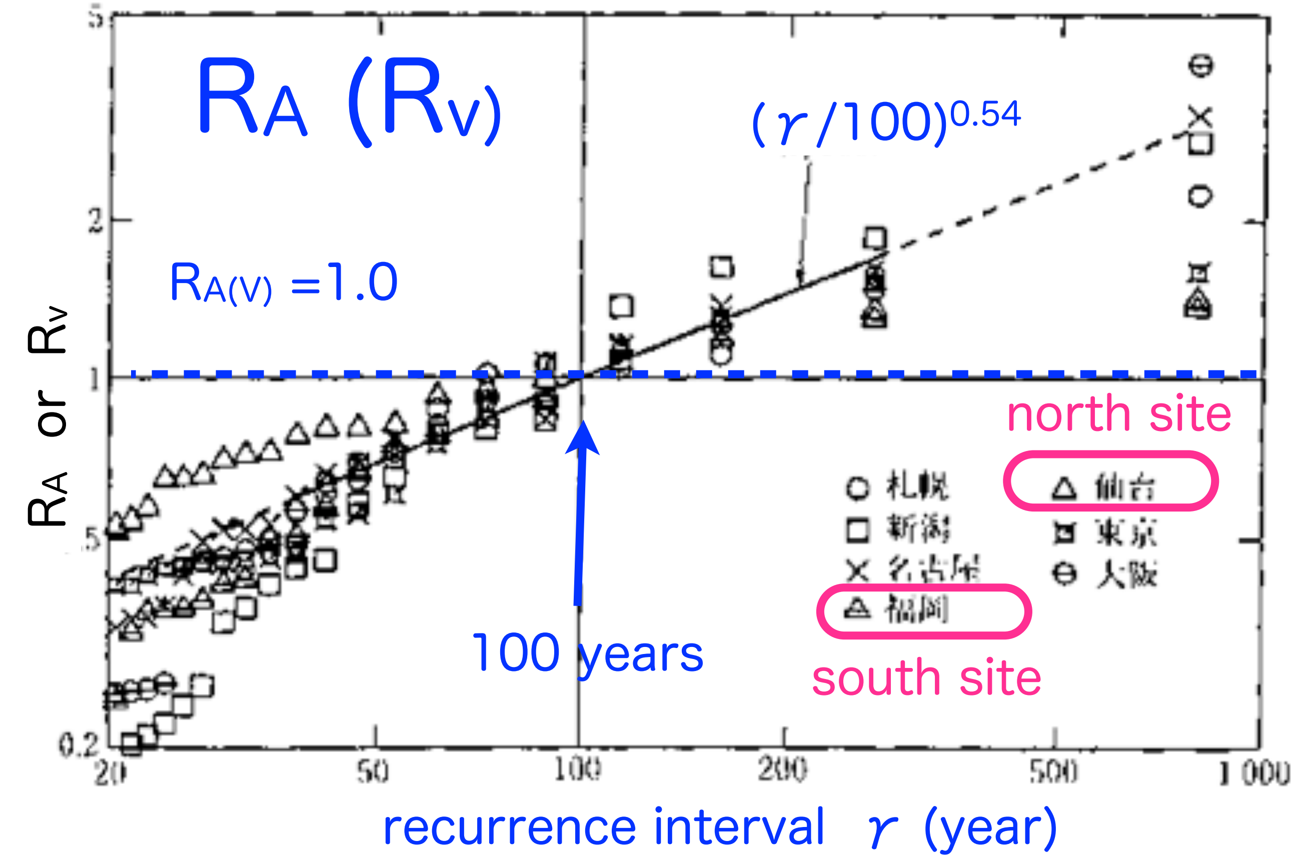
Normalized acceleration response spectrum



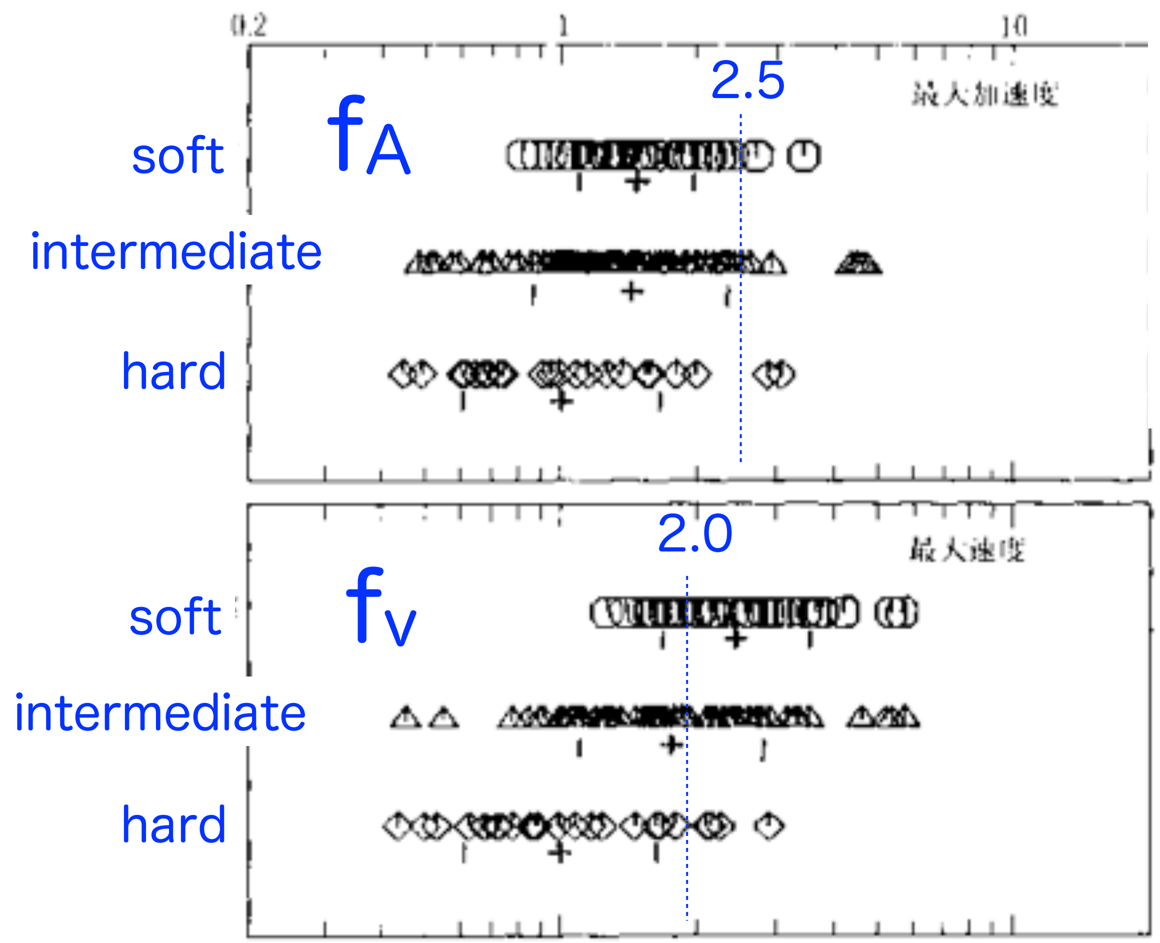
Response time of acceleration/velocity



Conversion coefficients(recurrence intervals)

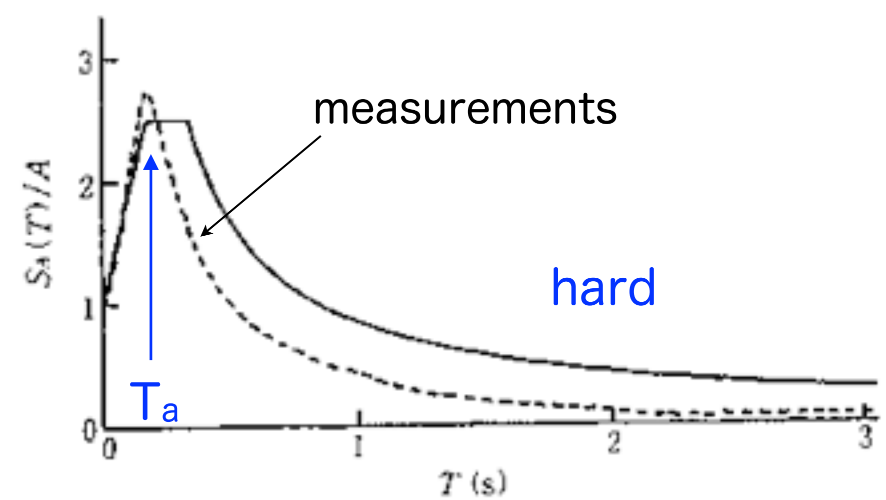


Amplification (千葉県東方沖地震,1987)



G_A, G_V, T_c in various soil(geology)

地　盤　種　別	G_A	G_V	T_c (s)	soil
第 I 種：標準地盤（堅固な地盤）	1.0	1.0	0.33	hard
第 II 種：緩い洪積地盤または締った沖積地盤	1.2	2.0	0.56	inter-mediate
第 III 種：軟弱地盤	1.2	3.0	0.84	soft



Normalized acceleration response spectrum

2011.3.11
M9.0

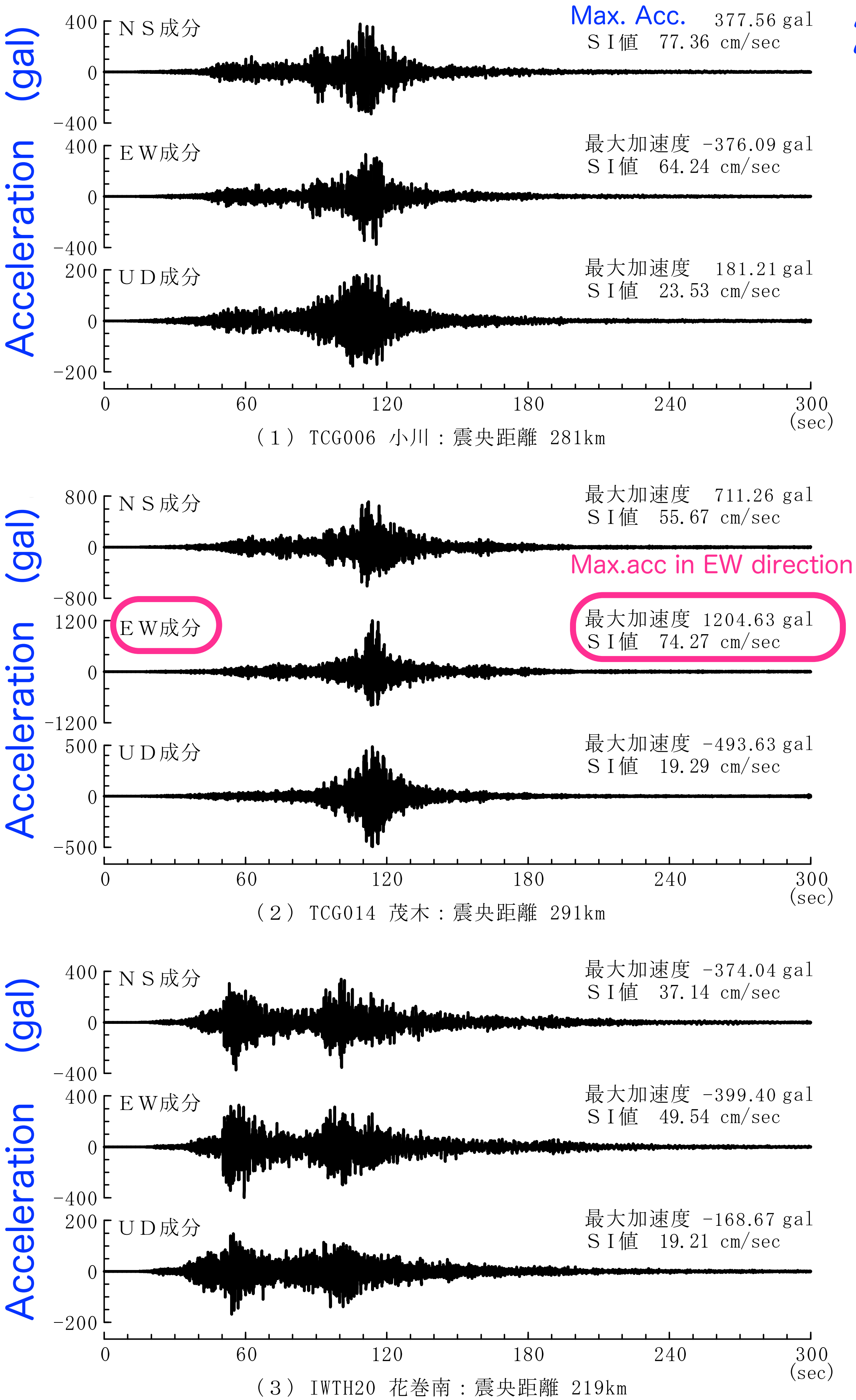


図 ー (2) 2011.03.11 14:47 東北地方太平洋沖地震(M9.0, 深さ24km)の加速度波形(防災科学技術研究所K-NET,KiK-netによる) I 種地盤

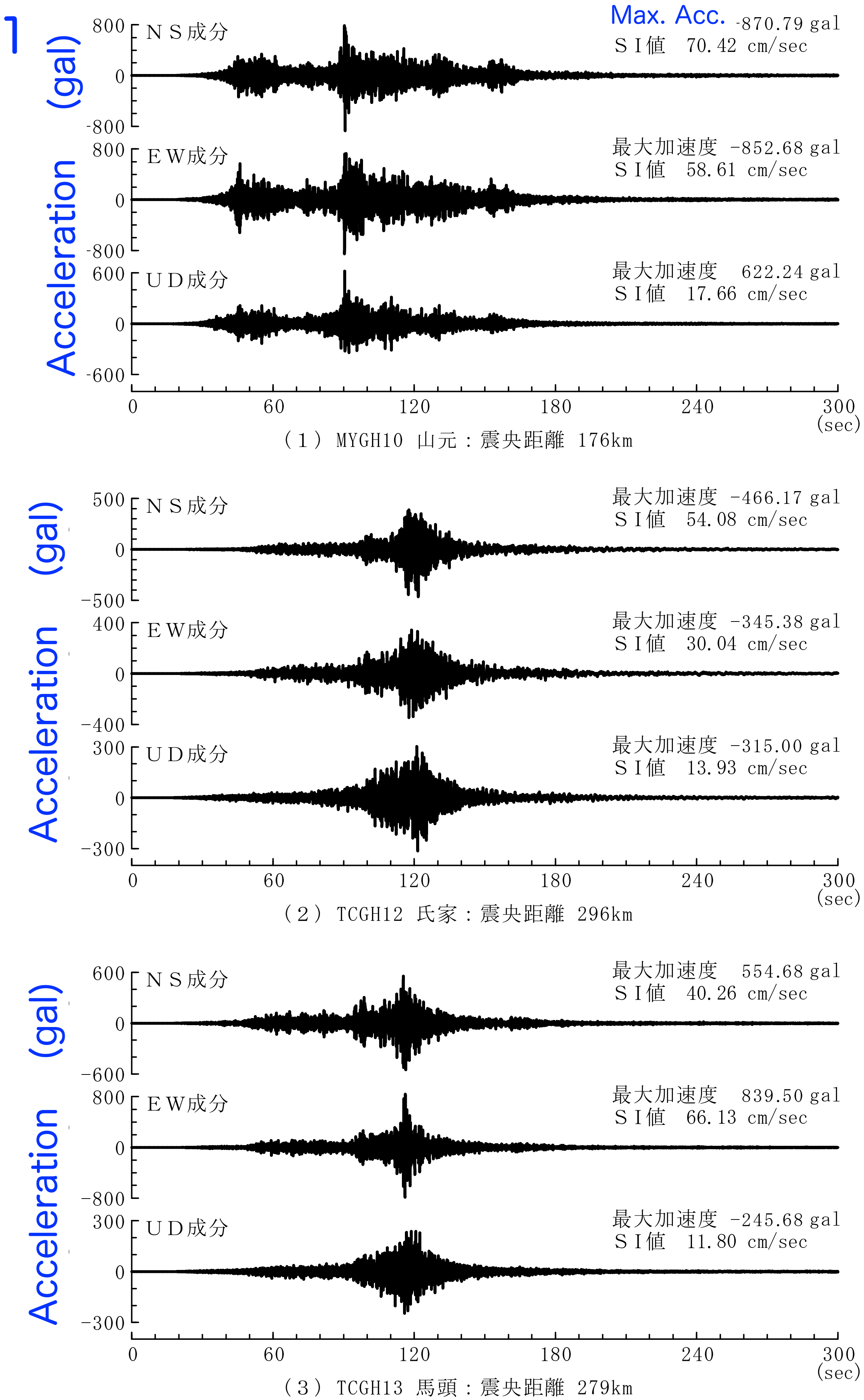
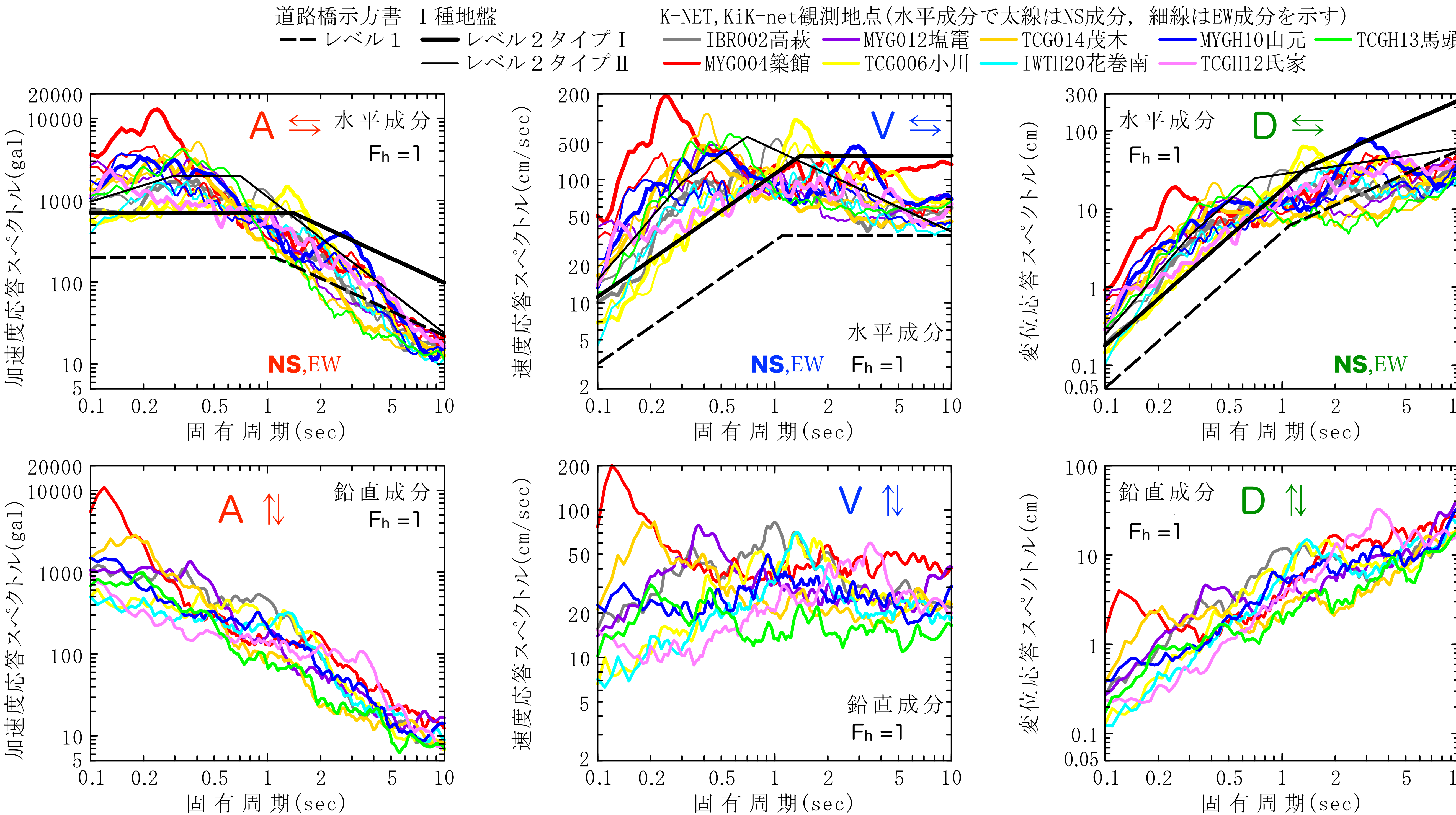


図 ー (3) 2011.03.11 14:47 東北地方太平洋沖地震(M9.0, 深さ24km)の加速度波形(防災科学技術研究所K-NET,KiK-netによる) I 種地盤

Acceleration/Velocity/Displacement Response Spectrum

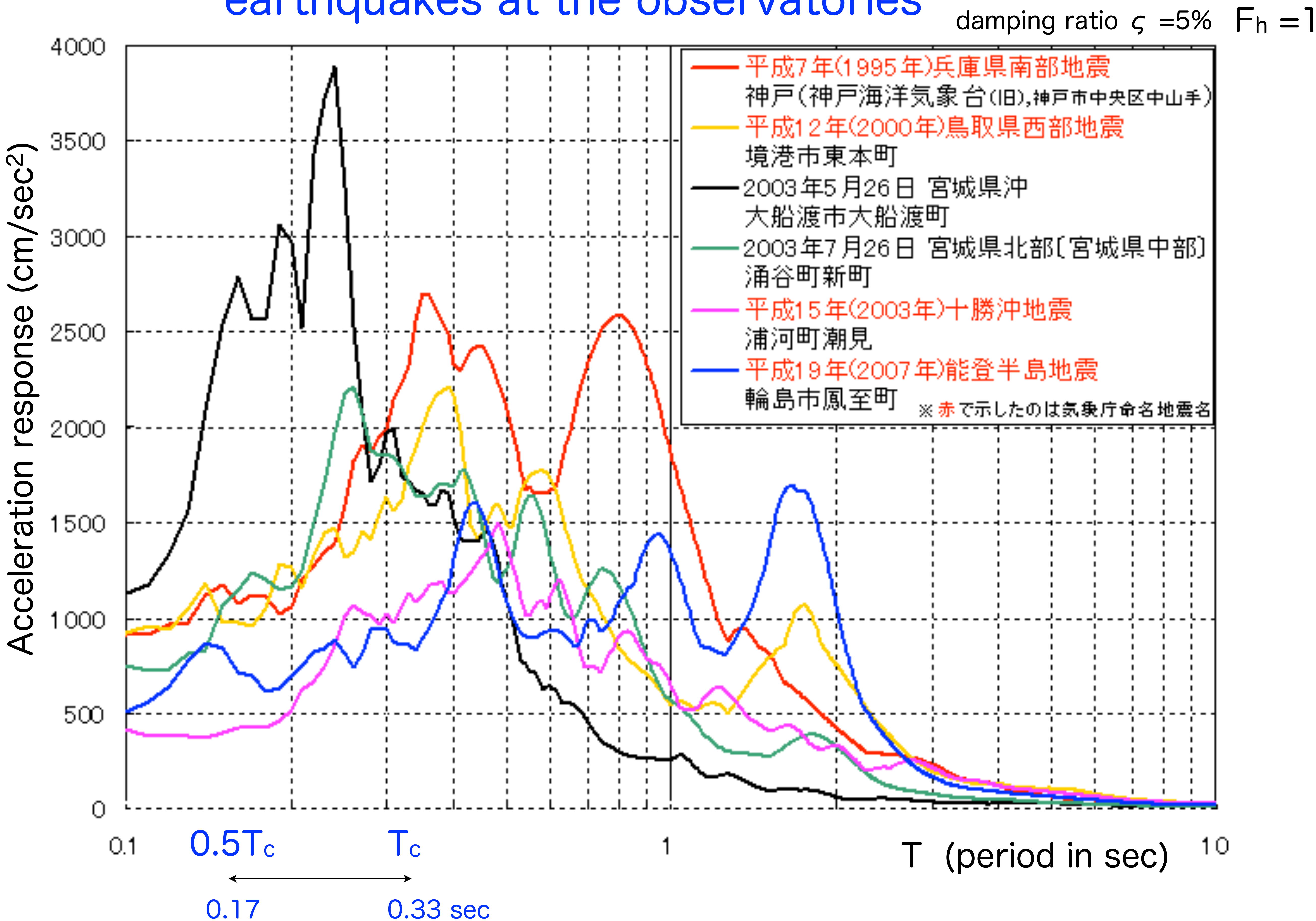
2011.3.11 M9.0 24m in depth



（1）加速度応答スペクトル　（2）速度応答スペクトル　（3）変位応答スペクトル

Acceleration : shear force　Velocity : kinetic energy　Displacement : strain

Acceleration Response Spectrum of various earthquakes at the observatories

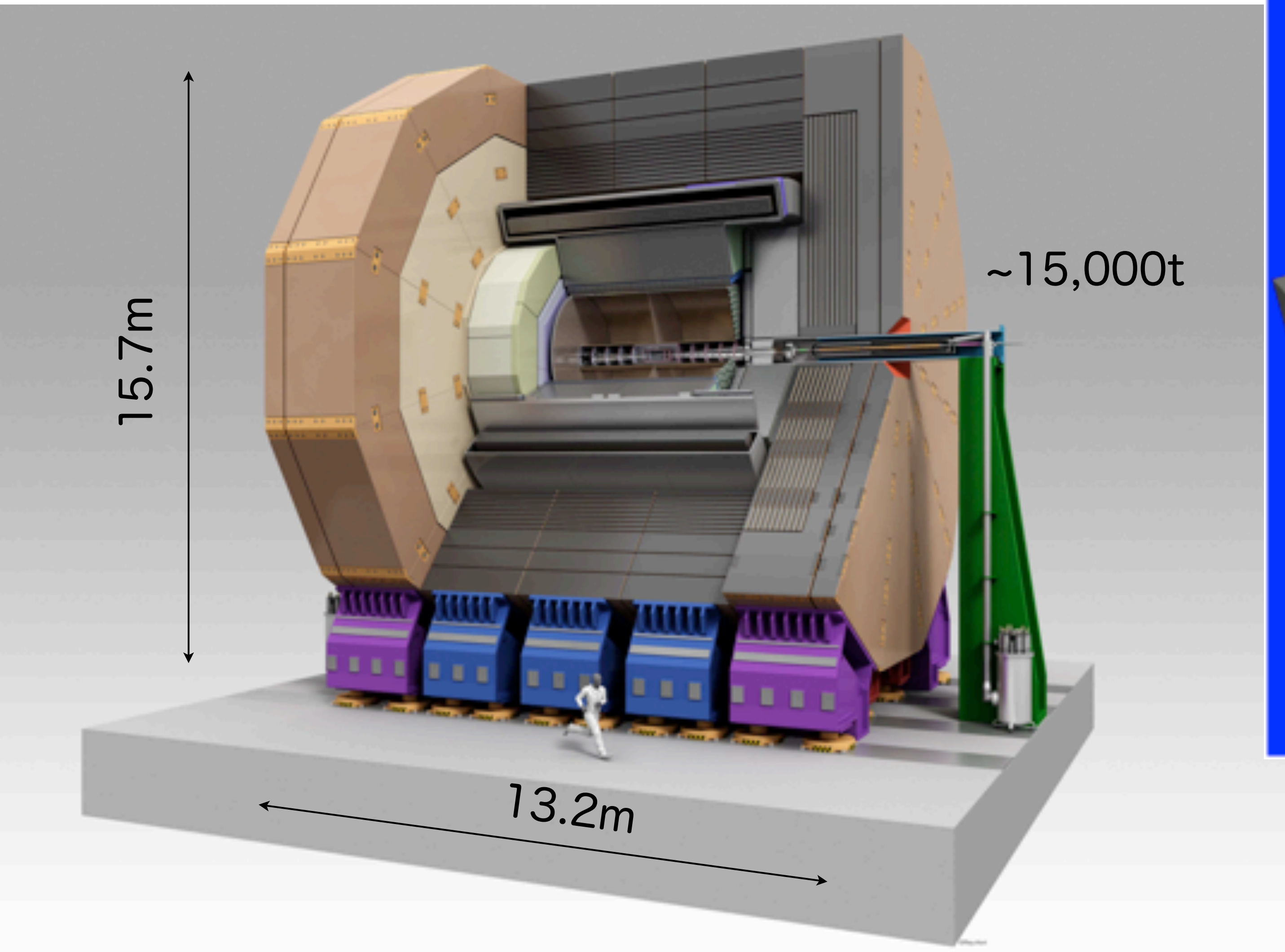


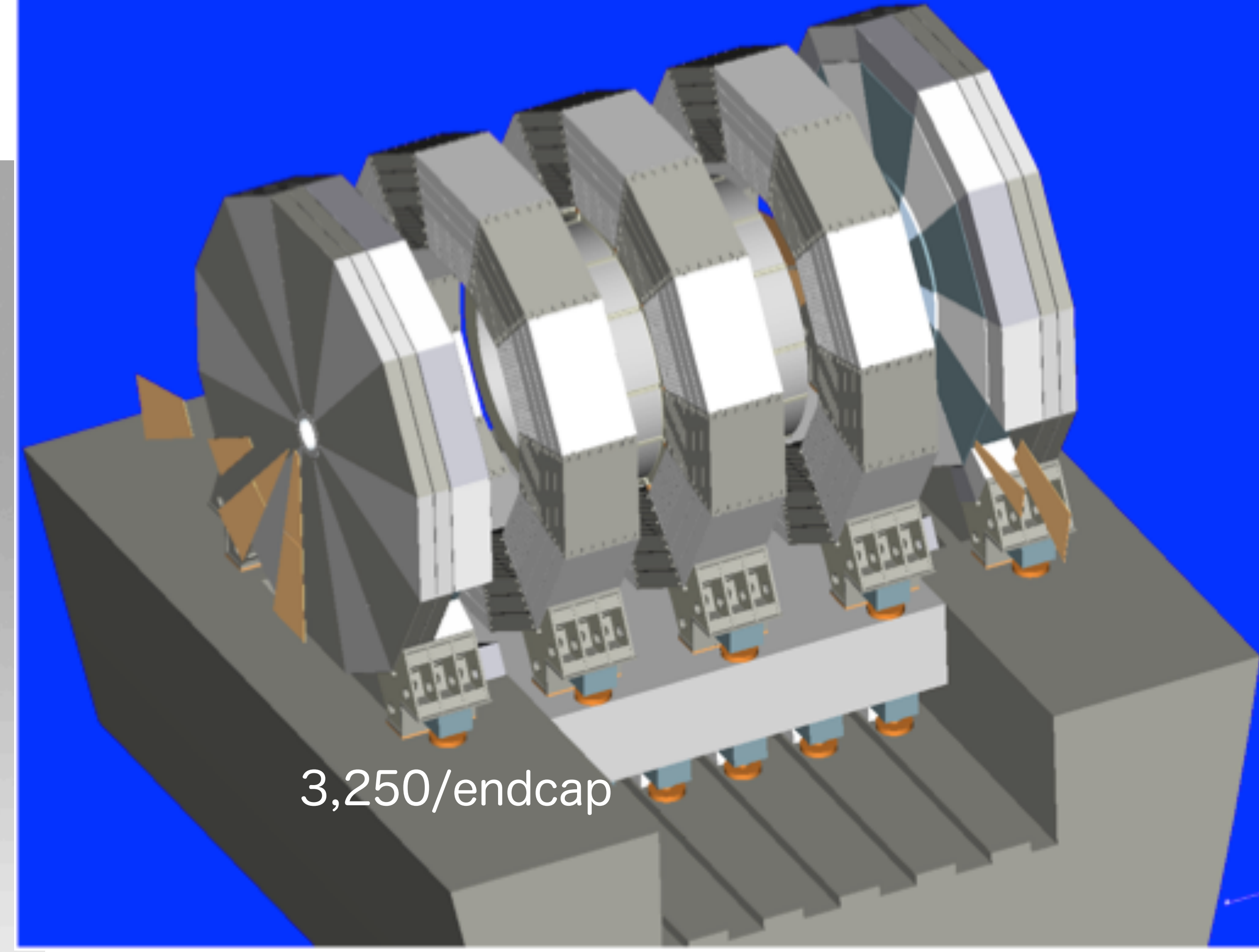
Material Strength and Allowable stress

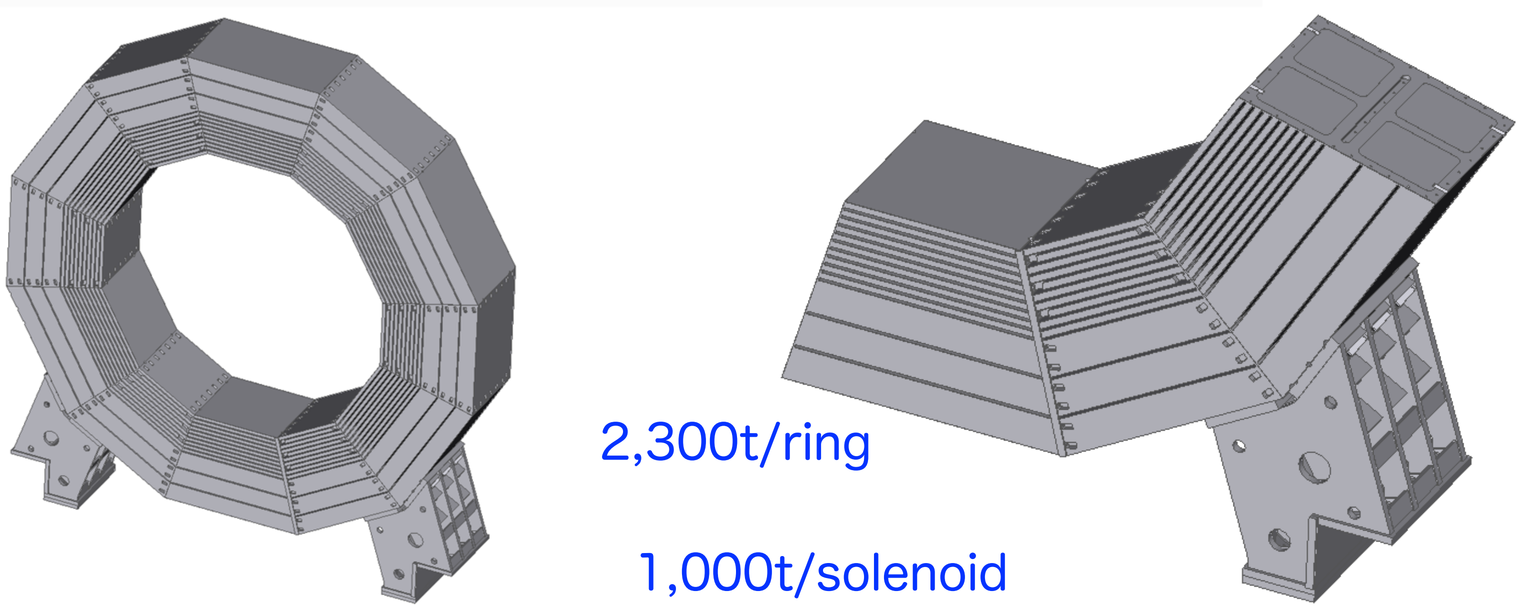
	Material		Steel	Aluminum	Stainless
			SS400	AC4C－T5	SUS304
Material strength	Tensile (σu)	N/mm2 (=MPa)	400	137	520
	Yeild (σy)	N/mm2	205	108	205
	F -1	F-1＝σy	205	108	205
	F-2	F-2=0.7*σu	280	96	364
	F	Smaller value	205	108	205
Material Allowable Stress	Allowable stress(MPa)				
	Tension	ft＝F/1.5	137	72	137
	Shearing	fs＝F/(1.5√3)	79	42	79
	Bending	fb＝F/1.3	158	83	158
	Hertz stress	fp＝F/1.1	186	98	186
	Bolt(Tension)	ft＝F/2	103	54	103
	Bolt(Shear)	fs＝F/(1.5√3)	79	42	79
	Bolt(Hertz)	fp＝1.25F	256	135	256
	Roller	fp＝1.9F	390	205	390
	Welding(PT)	fs＝F/(1.5√3)	79	42	79
	Welding(No PT)	fs＝0.45F/(1.5√3)	36	19	36
			237@Bend		
	Earthquake	(Above)x1.5	(=158x1.5)		

H. Yamaoka, "Magnet seismic analysis", 10 July, 2007, KEK

ILD Detector in TDR



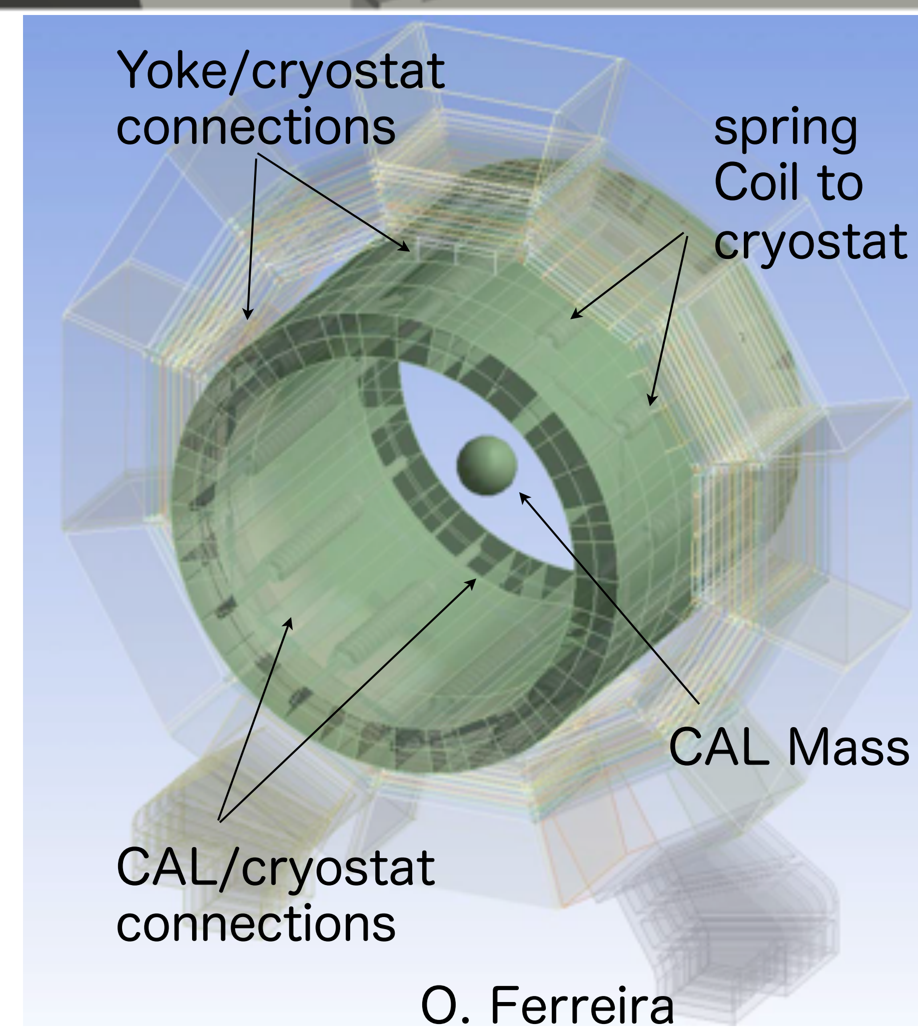




2,300t/ring

1,000t/solenoid

Figure 2.6.2: The yoke barrel design: general view of one barrel ring (left) and detailed view of a sector with one supporting foot (right)



Summary on seismic issues

1. Earthquake protection will follow the ISO3010;

   uses analysis with acceleration response spectrum

2. Earthquake model at Kitakami site :

   150 gal (100 years) as earthquake representative

   , where flat period between 0.17 to 0.34sec (dT_c - T_c)

   the amplification factor(f_A) of less than 2.5

3. We would like to analyze ILD earthquake protection.

   - Rigidness of ILD detector
   - Isolation method with respect to the platform
     and detailed layout needed