Seismic Hazard Assessment in China

——Introduction of Seismic Zonation Map of China

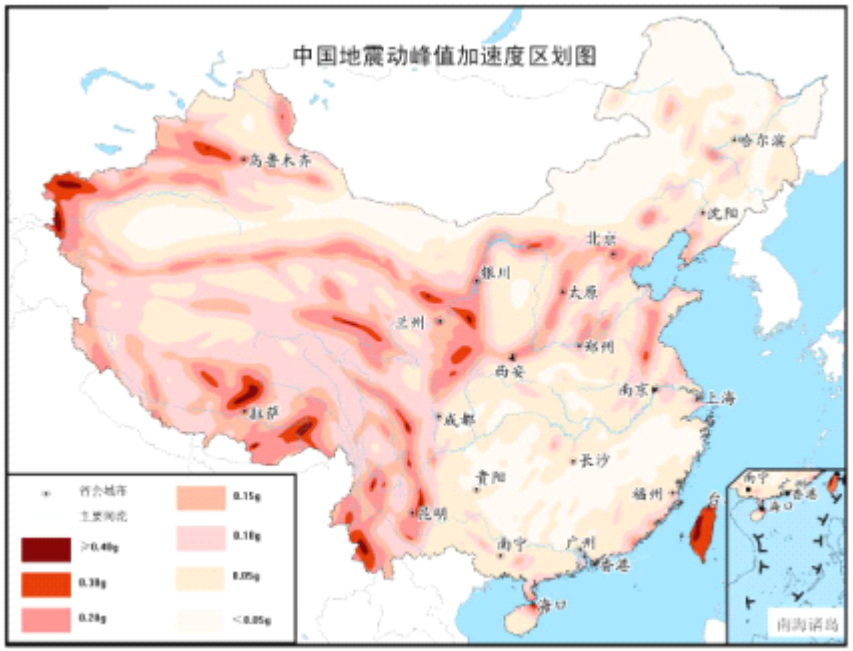
Xiaojun LI

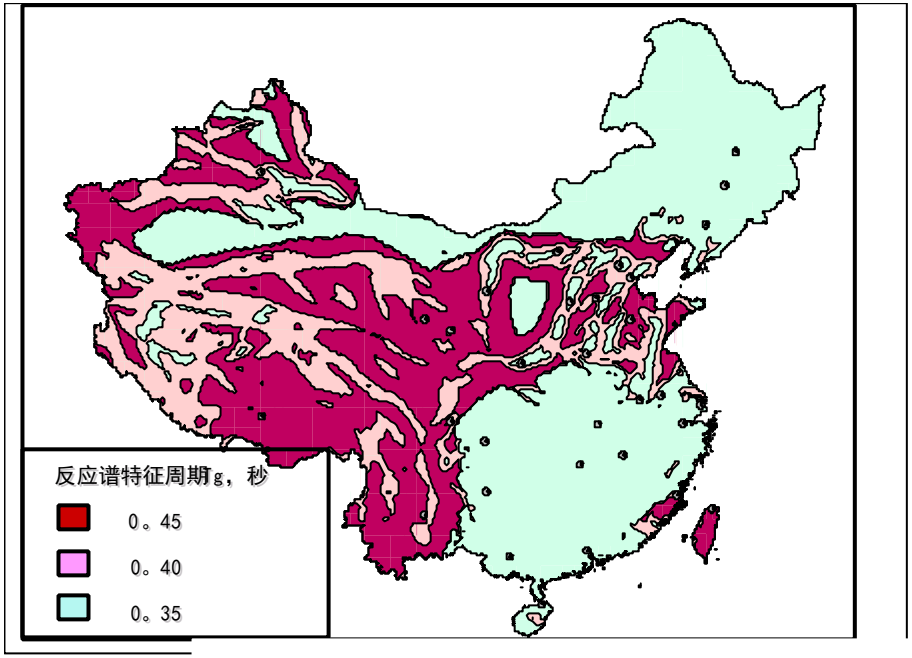
Institute of Geophysics,
China Earthquake Administration

Harbin 2011.11

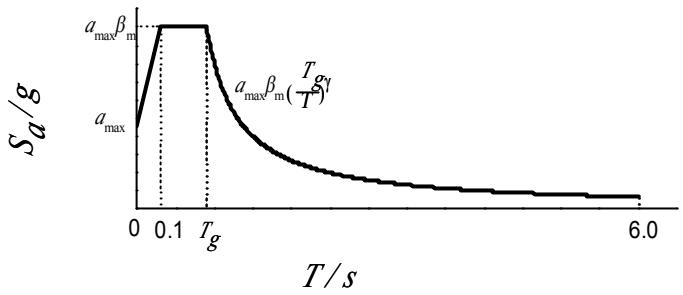
Current Seismic Zonation Map of China

- is the fourth generation map, and issued in 2001
- includes PGA zonation map and Tg zonation map
- and a table for adjustment of Tg with site types





Characteristic period Tg（s）		Site Types			
		I	II	III	IV
Tg Zone	1 zone	0.25	0.35	0.45	0.65
	2 zone	0.30	0.40	0.55	0.75
	3 zone	0.35	0.45	0.65	0.90



New Generation
Seismic Zonation Map of China

The fifth generation map

is being compiled
and will be issued in 2012 ?

Outlines of Presentation

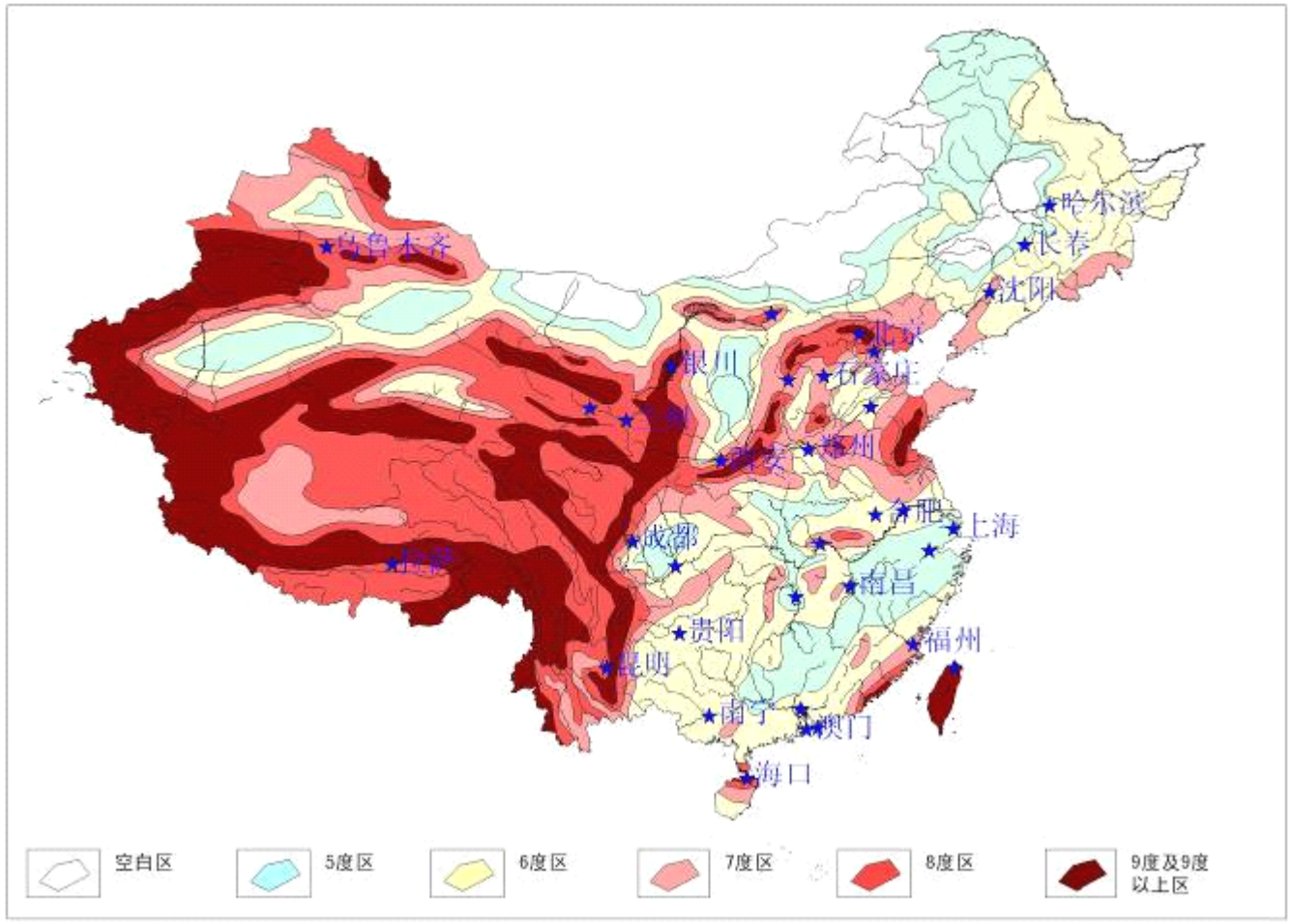
1. Development of Seismic Zonation Map of China
2. The feature of 5G Seismic Zonation Map
3. Compiling of 5G Seismic Zonation Map
4. Consideration of site condition in seismic zonation maps

Outlines of Presentation

1. **Development of Seismic Zonation Map of China**
2. **The feature of 5G Seismic Zonation Map**
3. **Compiling of 5G Seismic Zonation Map**
4. **Consideration of site condition in seismic zonation maps**

Seismic Intensity Zonation Map of China

——first generation map， issued in 1957



Distribution of the seismic intensity

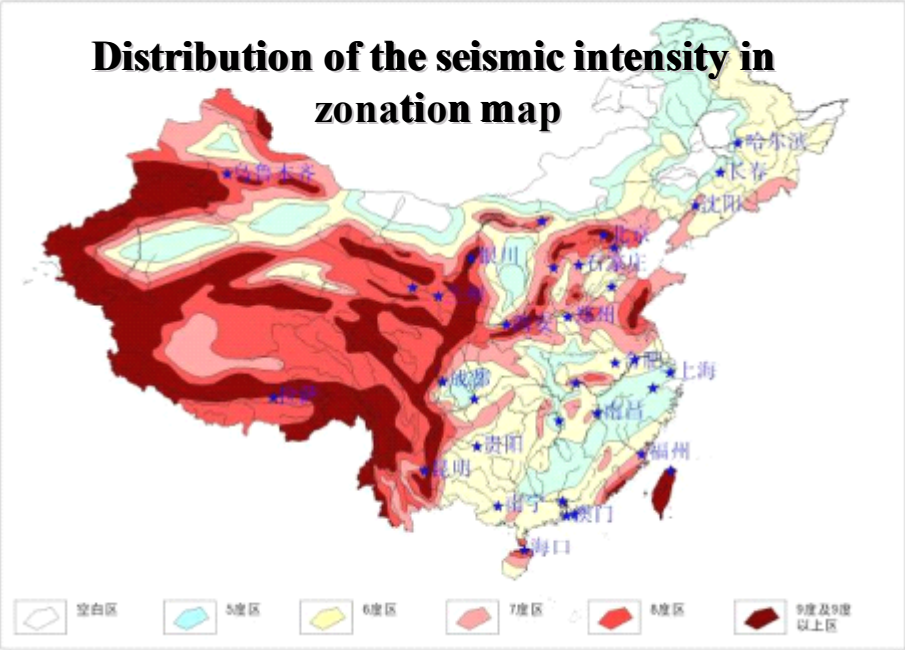
Seismic Intensity Zonation Map of China (1957)

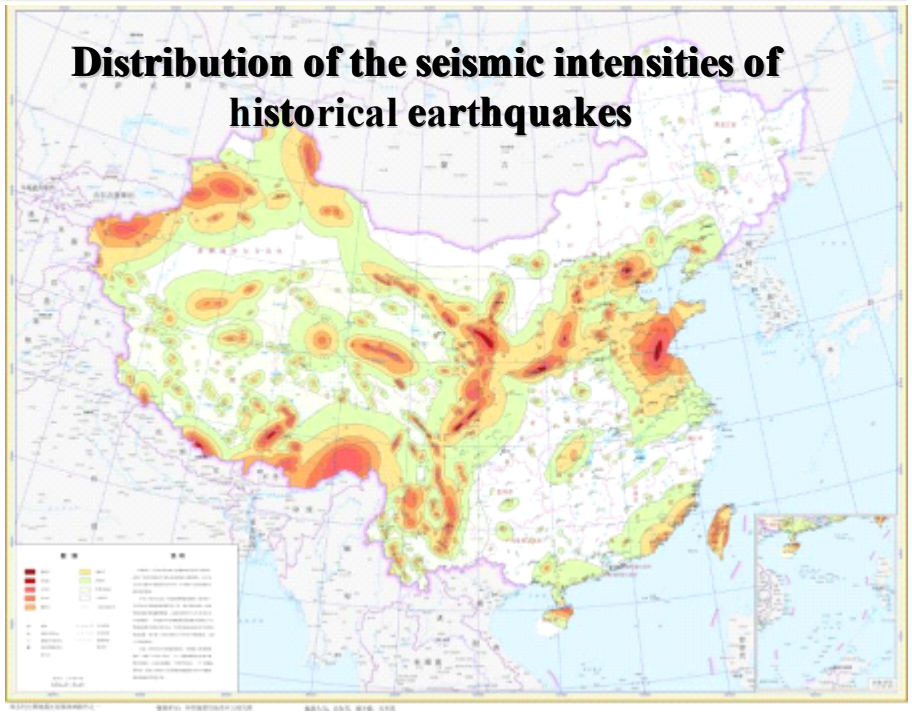
Principle and Method

- **Two regulations were taken to determine future earthquakes and its effect on seismic intensity:**

1. **Historical earthquake recurrence regulation**
2. **Geological structure analog regulation**

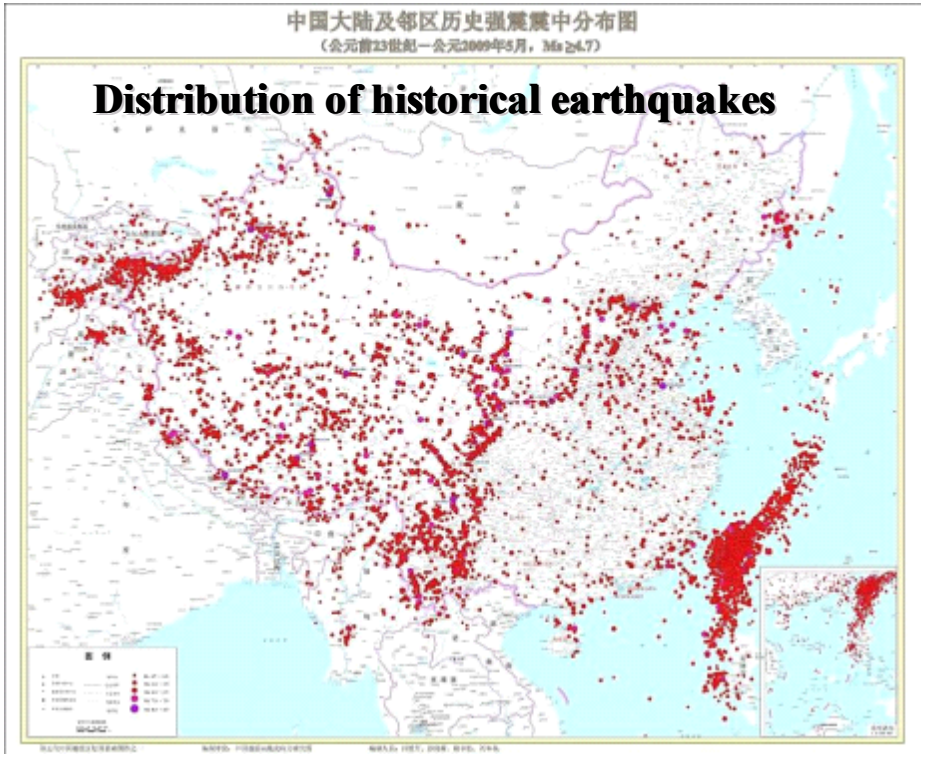
- **In compiling of the zonation map,**
  - **the geological method was used to consider the seismic hazard in the region where no strong earthquake occurred**
  - **but the earthquake recurrence interval was not considered**
- **The map was disused after a short period in practical application**





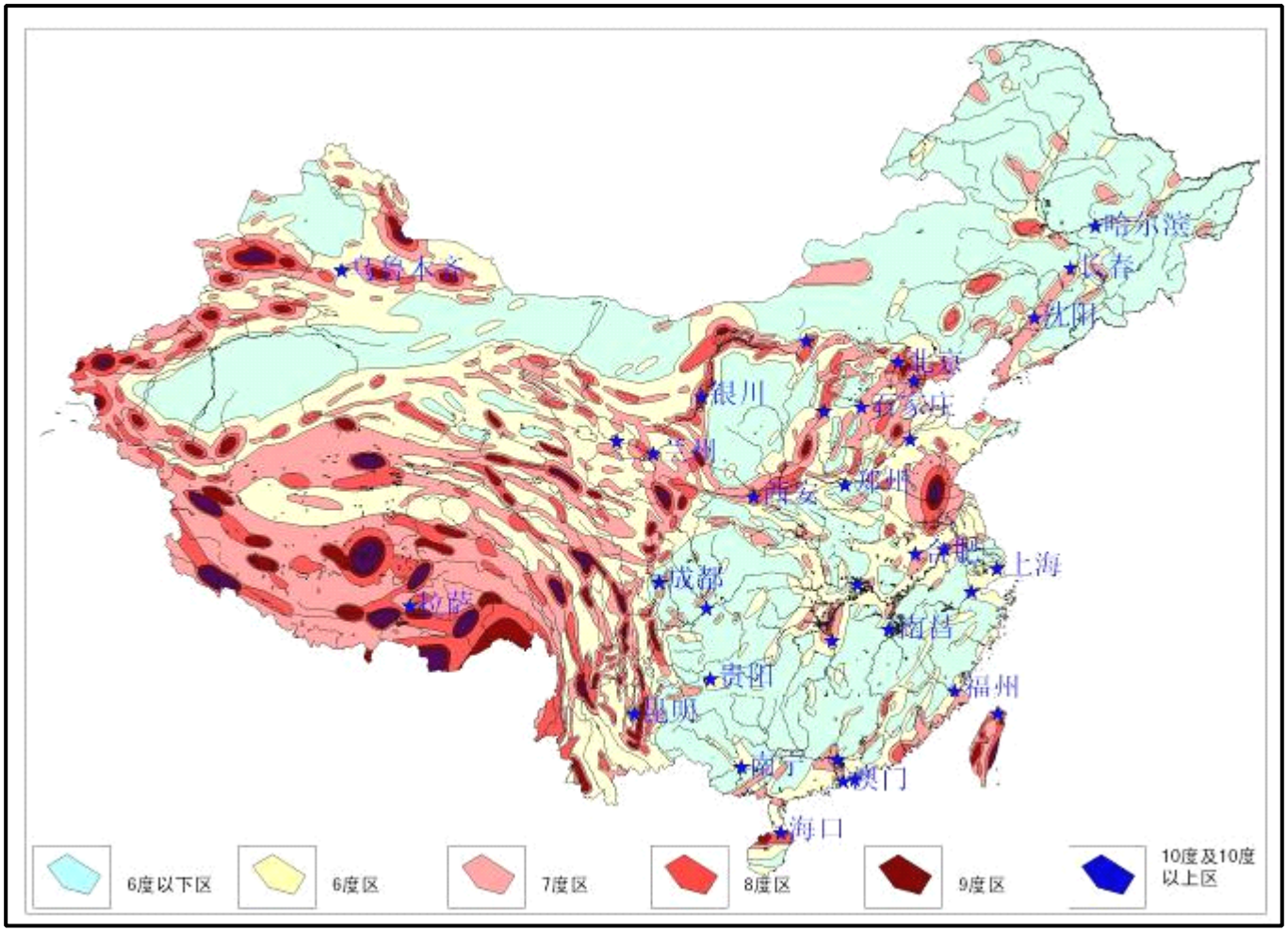
➢ **A clear difference between the two map, which is due to the geological structure analog regulation used**

➢ **larger area with high SI ≥ 9**



Seismic Intensity Zonation Map of China

——second generation map, issued in 1977



Distribution of the seismic intensity

Seismic Intensity Zonation Map of China (1977)

Principle and Method

- **Two regulations were also adopted:**

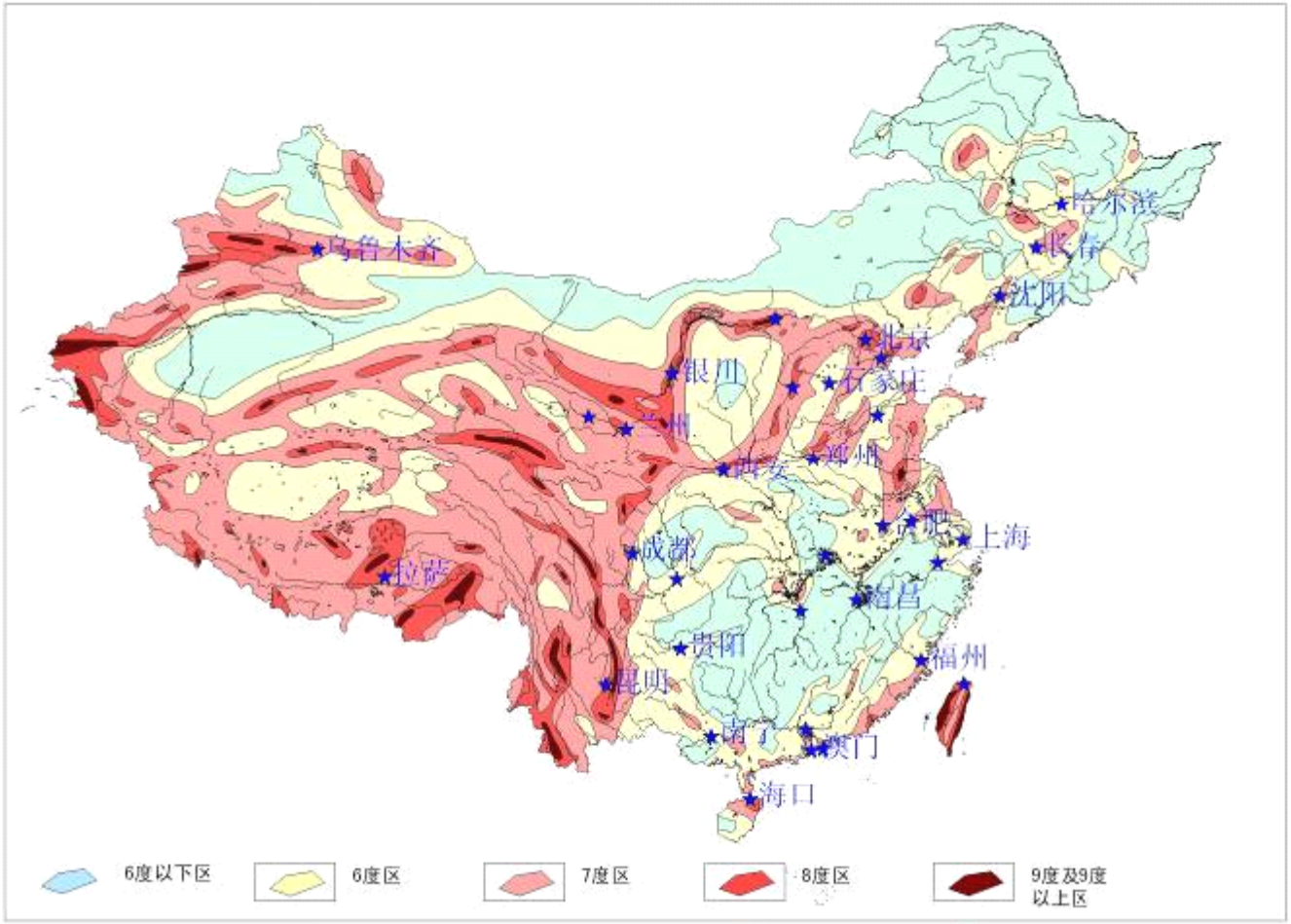
1. **Historical earthquake recurrence regulation**
2. **Geological structure analog regulation**

- **What is the progress in second zonation map?**

1. **The earthquake recurrence interval was considered**
2. **Seismic belts were divided , through the tendency of earthquake recurrence analyzed in the coming 100 years**
3. **The framework and method were proposed for seismic hazard analysis in China**

Seismic Intensity Zonation Map of China

——third generation map, issued in 1990



Distribution of the seismic intensity

Seismic Intensity Zonation Map of China (1990)

Principle and Method

- **Two (modified) regulations were adopted:**

  In the historical earthquake recurrence regulation: take into consideration of upper magnitude and activity parameters of seismic potential sources

- **The progress in the third zonation map is:**

1. **The earthquake recurrence interval was considered with probability method**
2. **The spatial and temporal heterogeneity of seismic activities were considered**
3. **The method of probabilistic seismic hazard analysis was adopted in calculating the predicted seismic intensity with exceeding probability in 50 years**

Seismic Intensity Zonation Map of China (1990)

Principle and Method

- **In compiling this zonation map:**

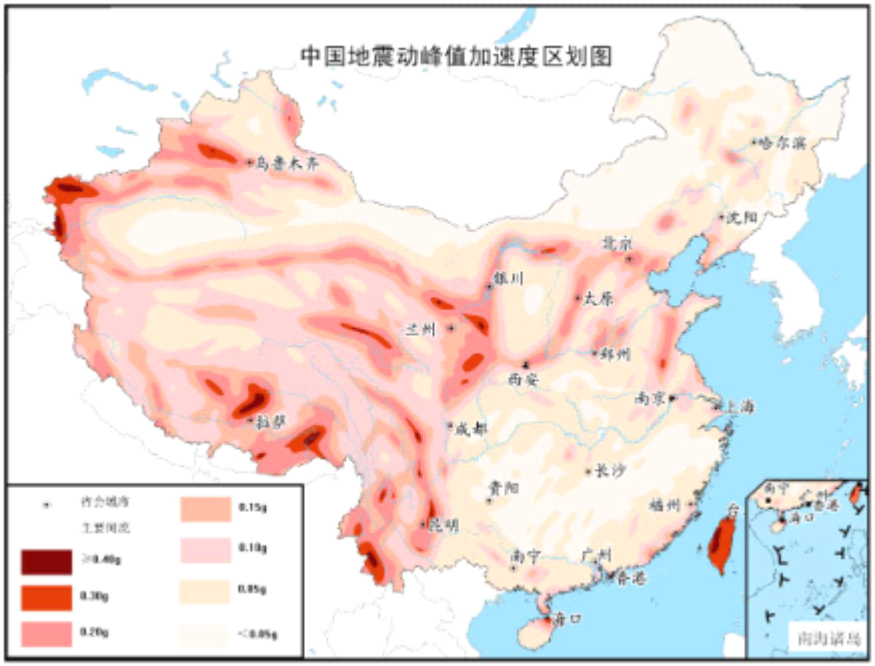
1. **The main work was to provide the seismic intensity zonation map of China with exceeding probability in 50 years**
2. **And also a testing peak ground acceleration zonation map in some region of China was obtained, which was helpful for next generation map**

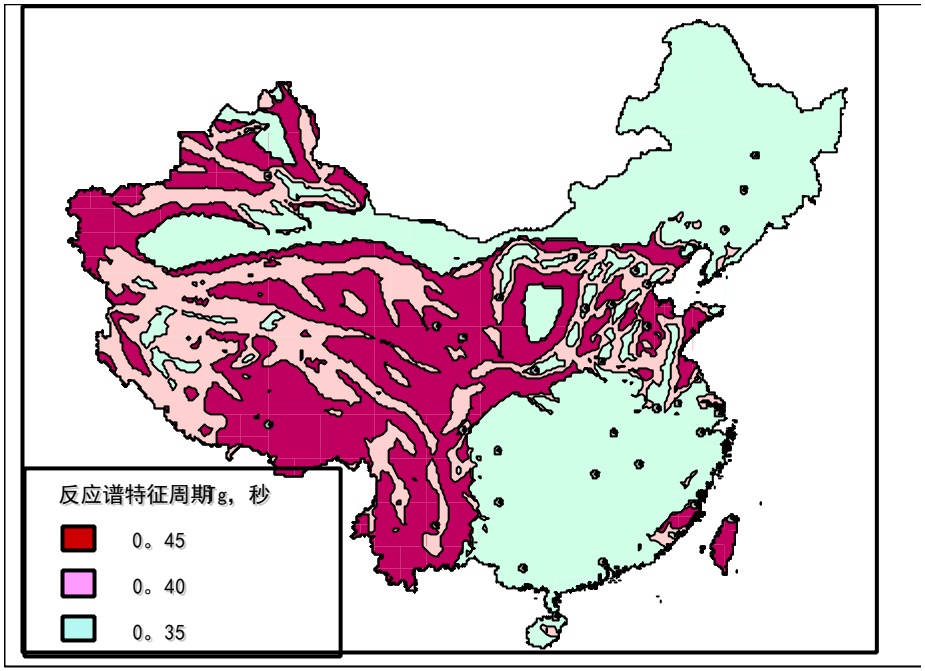
Seismic Ground Motion Parameter Zonation Map of China

——fourth generation map， issued in 2001

It include two maps and one table

Two maps： peak ground acceleration map and spectral characteristic period map



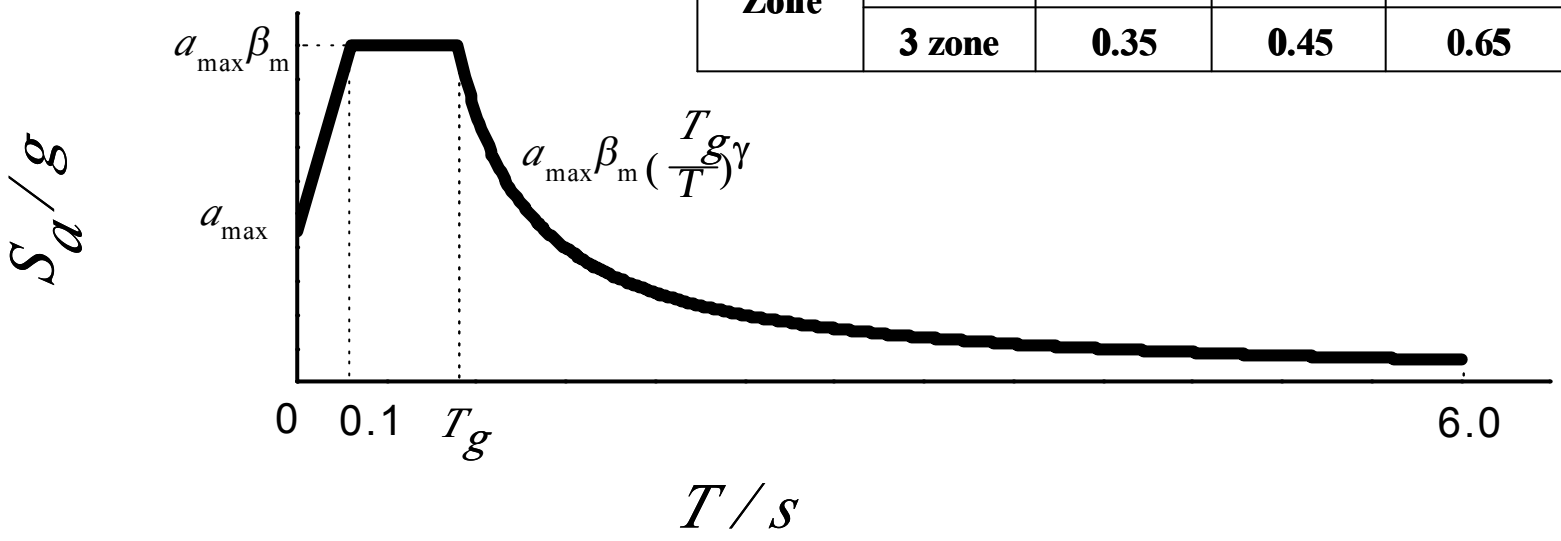


Seismic Ground Motion Parameter Zonation Map of China

——fourth generation map, issued in 2001

One table: for adjustment of spectral characteristic period Tg with site types

Characteristic period Tg (s)		Site Types			
		I	II	III	IV
Tg Zone	1 zone	0.25	0.35	0.45	0.65
	2 zone	0.30	0.40	0.55	0.75
	3 zone	0.35	0.45	0.65	0.90



Seismic Ground Motion Parameter Zonation Map of China (2001)

- **In the fourth map:**

1. **The seismic intensity was replaced with ground motion parameters PGA and Tg**
2. **Multi-schemes of seismic potential source division were adopted to consider the uncertainty of seismic activities**
3. **The site condition effect on spectral characteristic period Tg was considered**

Outlines of Presentation

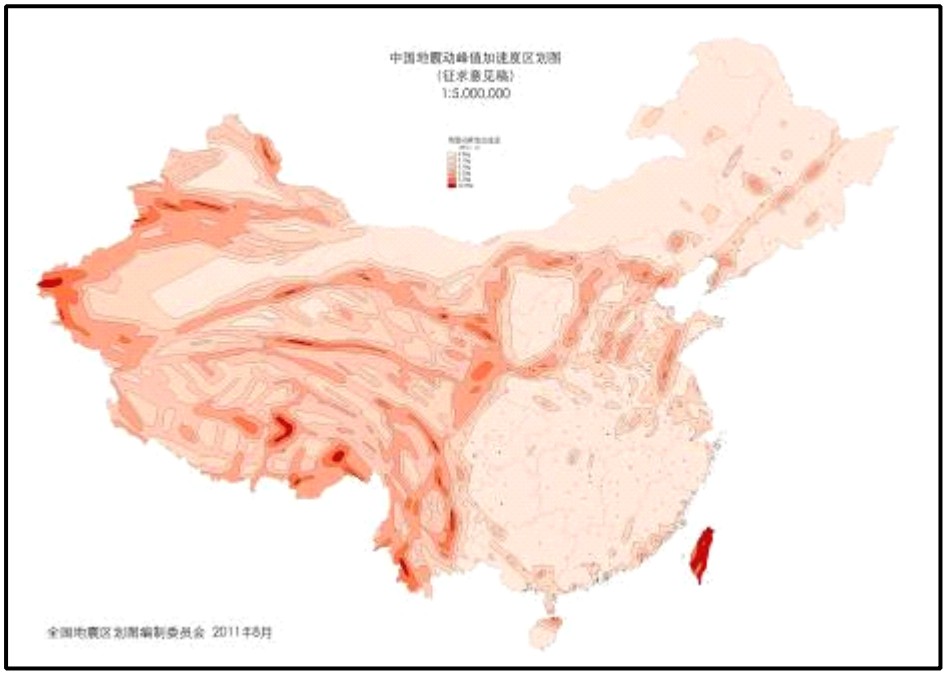
1. Development of Seismic Zonation Map of China
2. The feature of 5G Seismic Zonation Map
3. Compiling of 5G Seismic Zonation Map
4. Consideration of site condition in seismic zonation maps

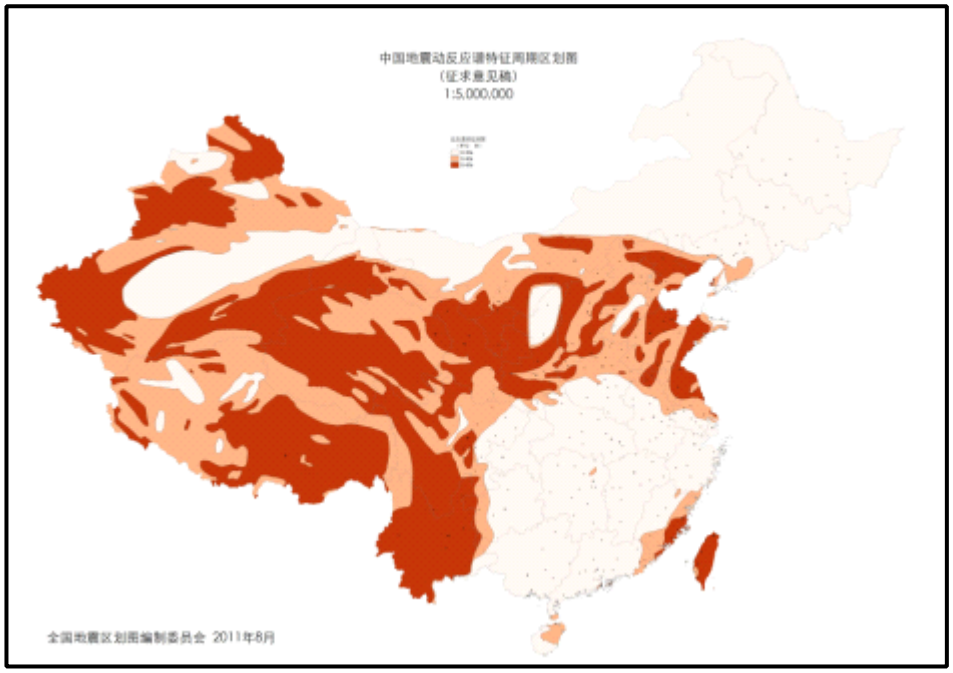
Seismic Ground Motion Parameter Zonation Map of China

——fifth generation map, issued in 2012?

It include two maps and two tables

Two maps: peak ground acceleration map and spectral characteristic period map





Seismic Ground Motion Parameter Zonation Map of China

——fifth generation map, issued in 2012?

Two tables: for adjustment of peak ground acceleration and spectral characteristic period Tg with site types

Site types	*PGA*(g) for site type II					
	≤0.05	0.10	0.15	0.20	0.30	≥0.40
I_0	0.64	0.68	0.70	0.75	0.85	0.90
I_1	0.80	0.82	0.83	0.85	0.95	1.00
II	1.00	1.00	1.00	1.00	1.00	1.00
III	1.30	1.25	1.15	1.00	1.00	1.00
IV	1.25	1.20	1.10	1.00	0.95	0.90

Tg（s）	Site types				
	I_0	I_1	II	III	IV
1 zone	0.20	0.25	0.35	0.45	0.65
2 zone	0.25	0.30	0.40	0.55	0.75
3 zone	0.30	0.35	0.45	0.65	0.90

Seismic Ground Motion pParameter Zonation Map of China (2012?)

- **The advanced points of the zonation map are:**

1. **Paying close attention to dividing the seismic potential source areas with high upper magnitude**
2. **Using different ground motion attenuation relations for different spatial regions and regions with different seismic activities**
3. **Considering the contribution of the calculating value with different exceeding probabilities on compiling the zonation map**
4. **Considering the site condition effect on both peak ground acceleration PGA and spectral characteristic period Tg**

Outlines of Presentation

1. Development of Seismic Zonation Map of China
2. The feature of 5G Seismic Zonation Map
3. Compiling of 5G Seismic Zonation Map
4. Consideration of site condition in seismic zonation map

New Seismic Ground Motion Parameter Zonation Map of China (2012?)

Six working teams for compiling map:

- **Group 1: Seismotectonic environment and related foundation maps**
- **Group 2: Seismic zone and potential seismic source**
- **Group 3: Seismic activity parameter**
- **Group 4: Ground motion attenution relations**
- **Group 5: Site effect on ground mtion**
- **Group 6: Zonation map compiling**

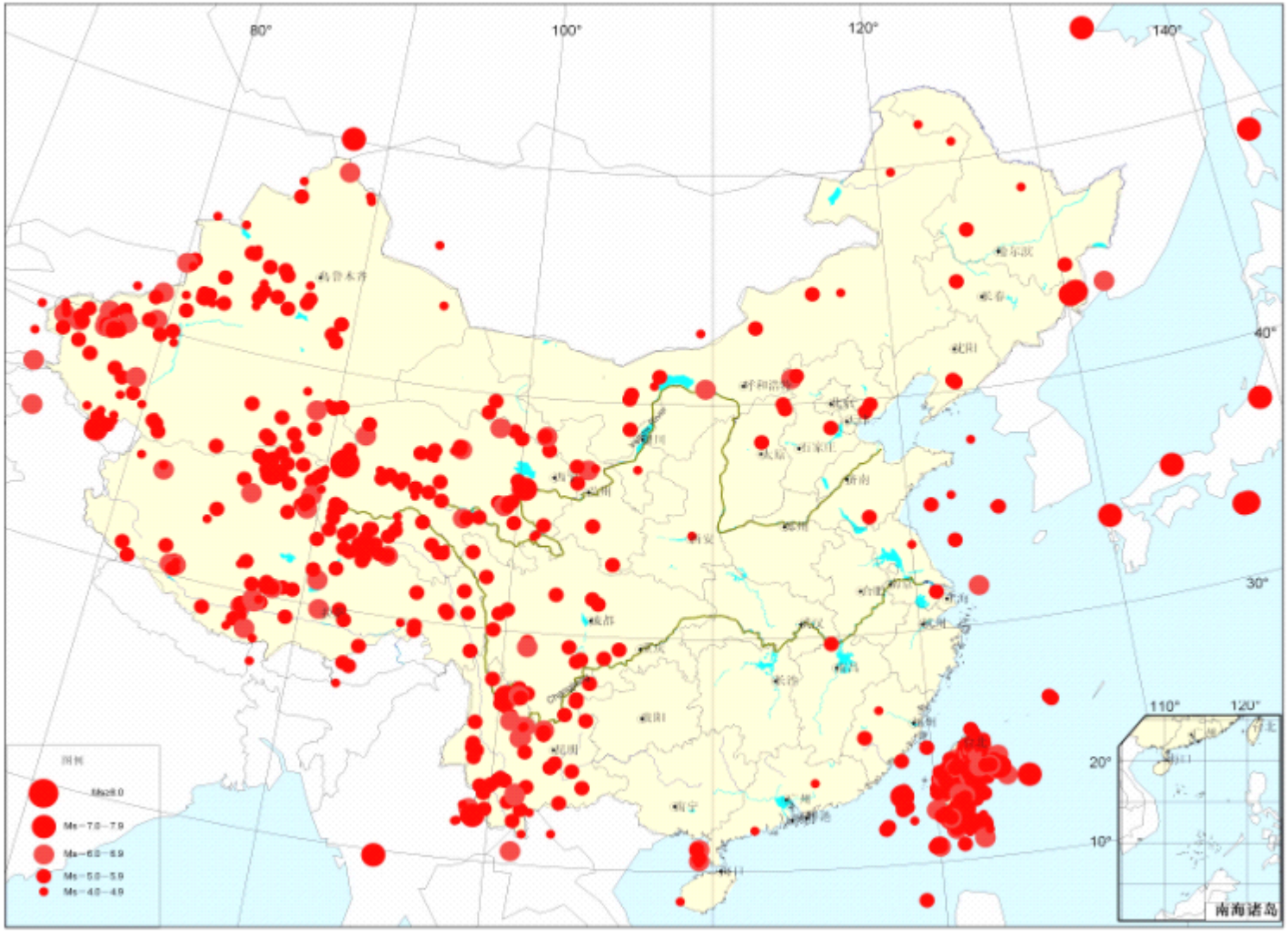
New Seismic Ground Motion Parameter Zonation Map of China (2012?)

1. Working team 1

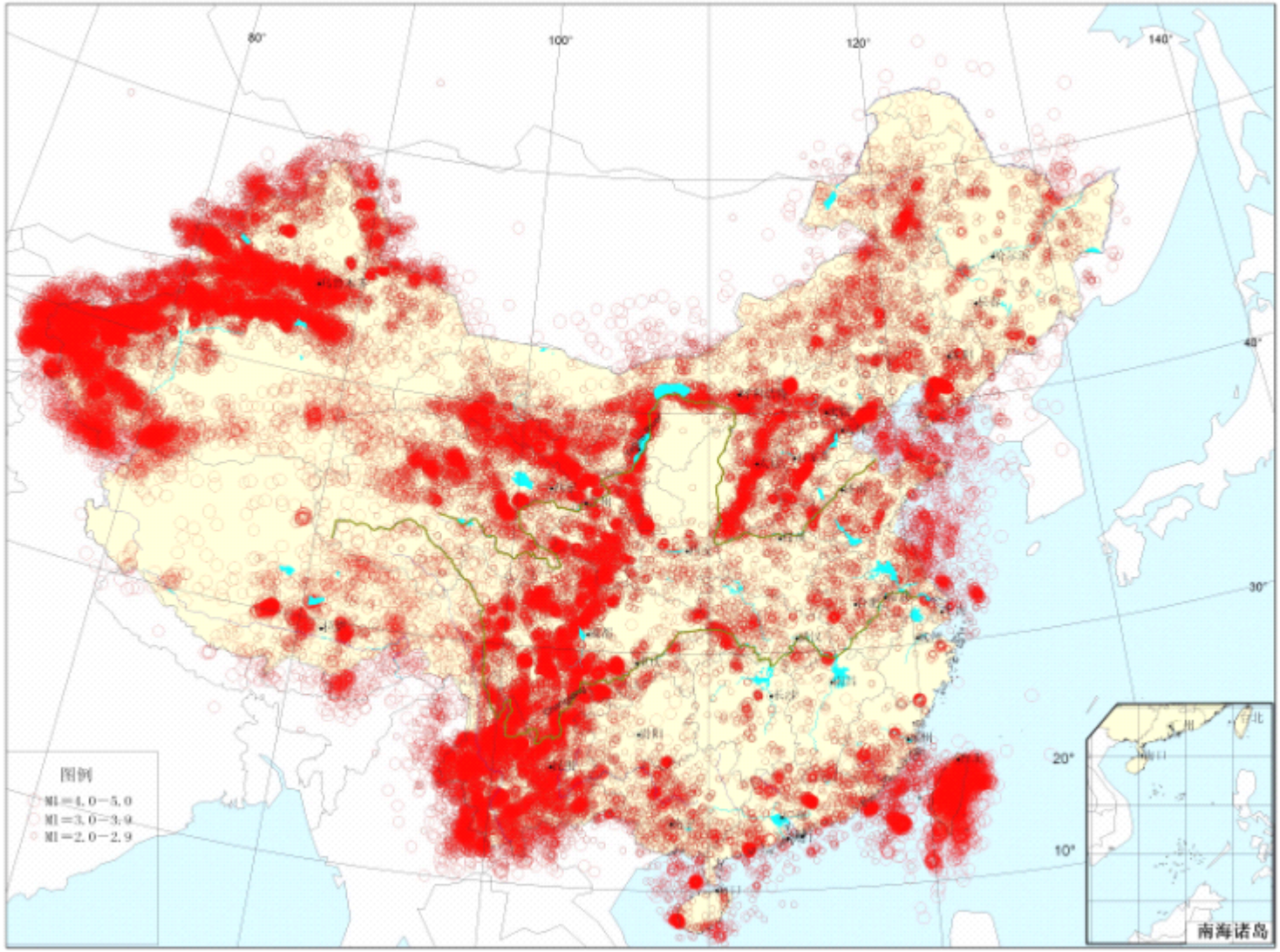
- Collecting the investigating and research materials
- Compiling the related foundation maps

Epicentral distribution of earthquakes in 1990－2007

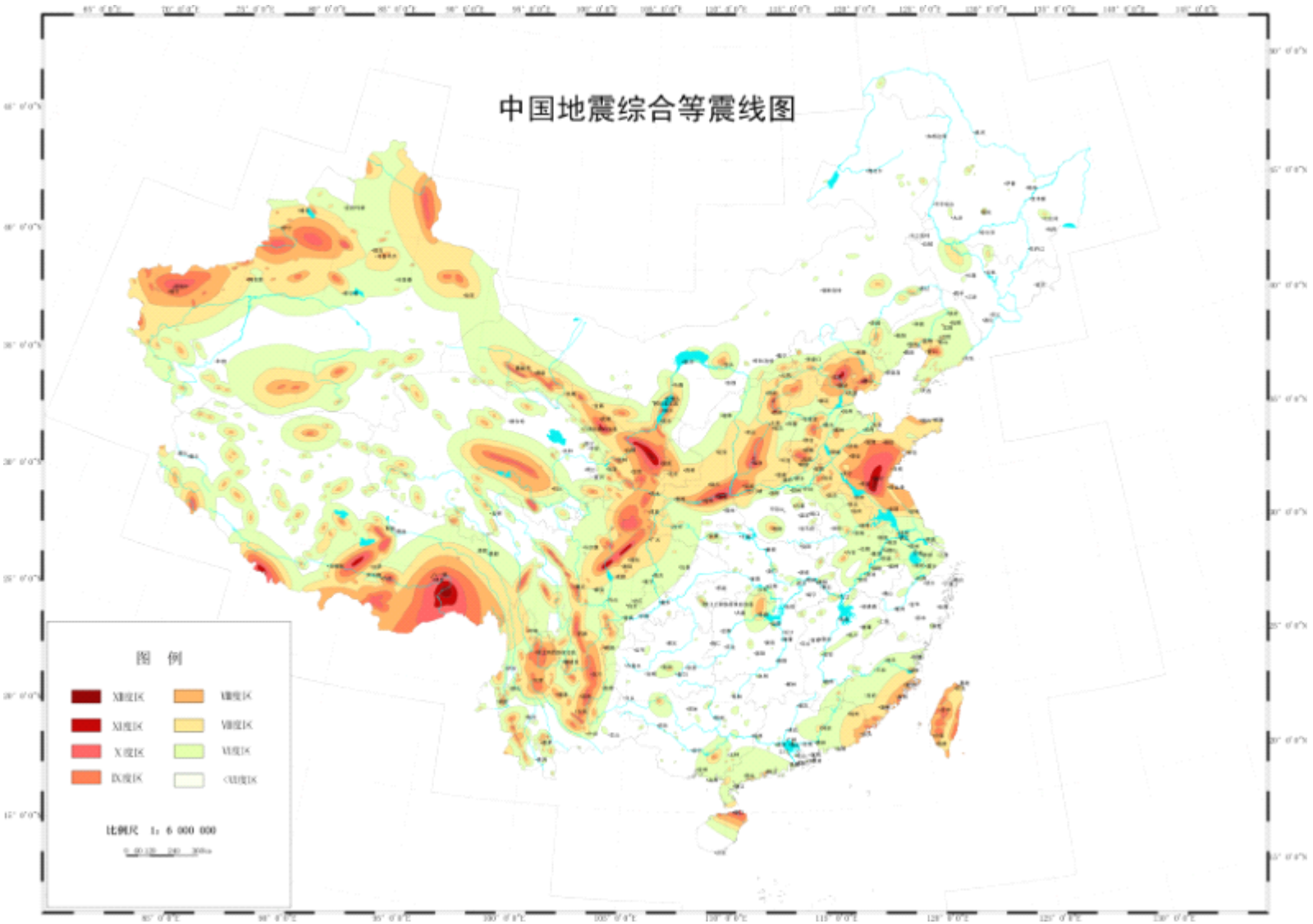
M≥4. 7



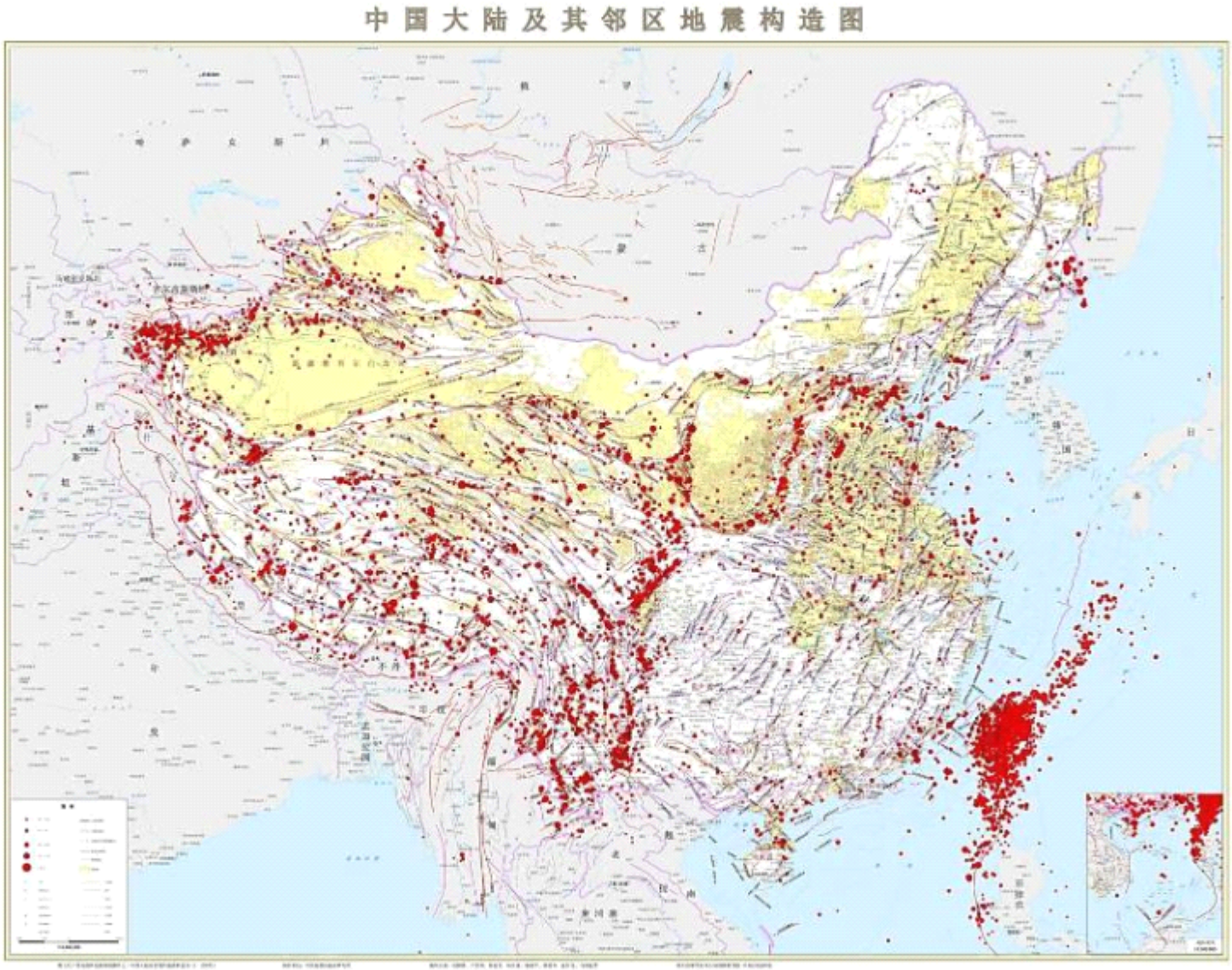
Epicentral distribution of earthquakes in 1990－2007
2.0≤M≤5.0



Comprehensive isoseismal map in China



Seismotectonic map in China and adjacent areas



New Seismic Ground Motion Parameter Zonation Map of China (2012?)

2. Working team 2

- Modifying division scheme of the seismic belts
- Compiling the new division scheme of the potential seismic sources based on the division scheme for the 4th generation map

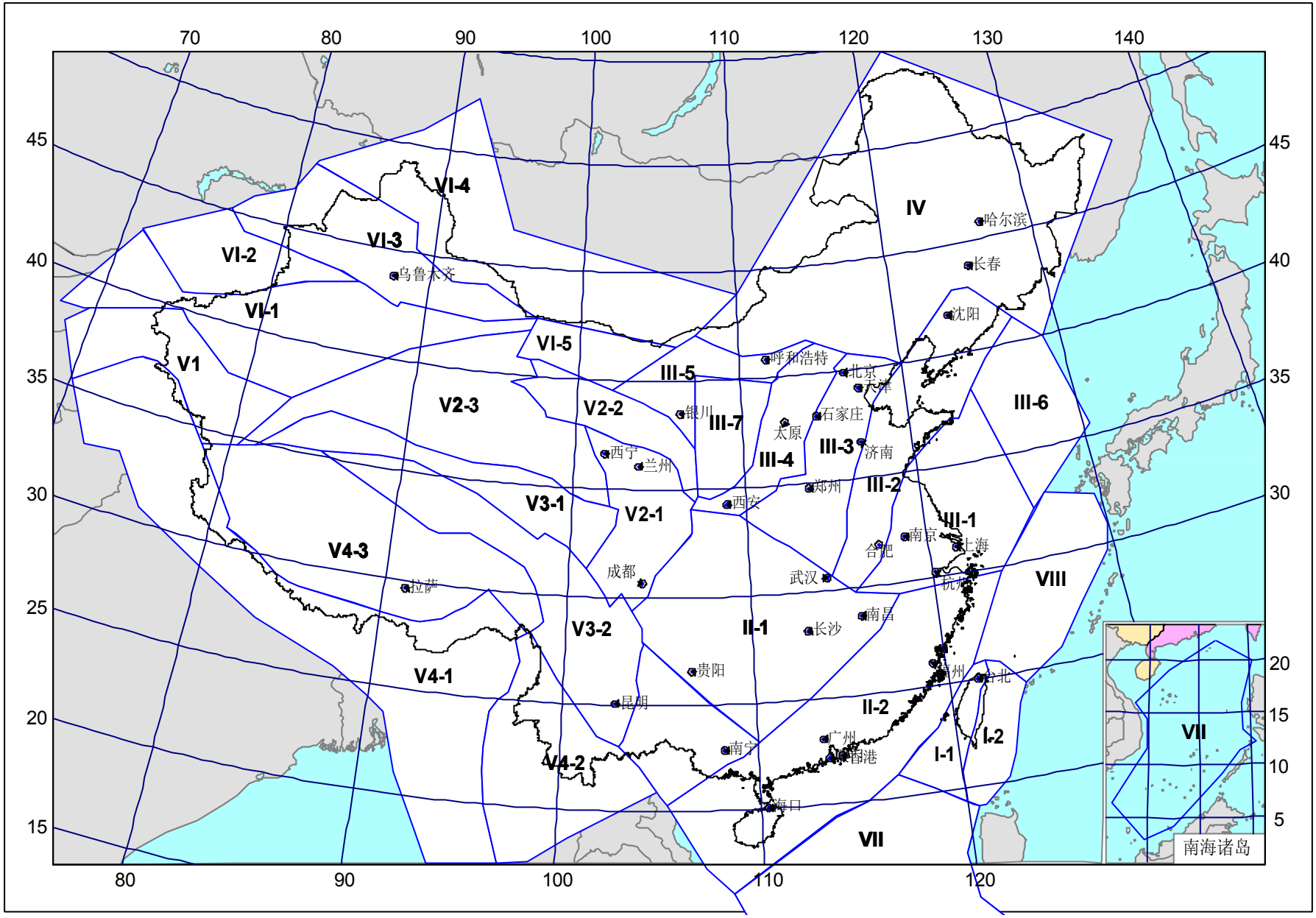
New Seismic Ground Motion Parameter Zonation Map of China (2012?)

2. Working team 3

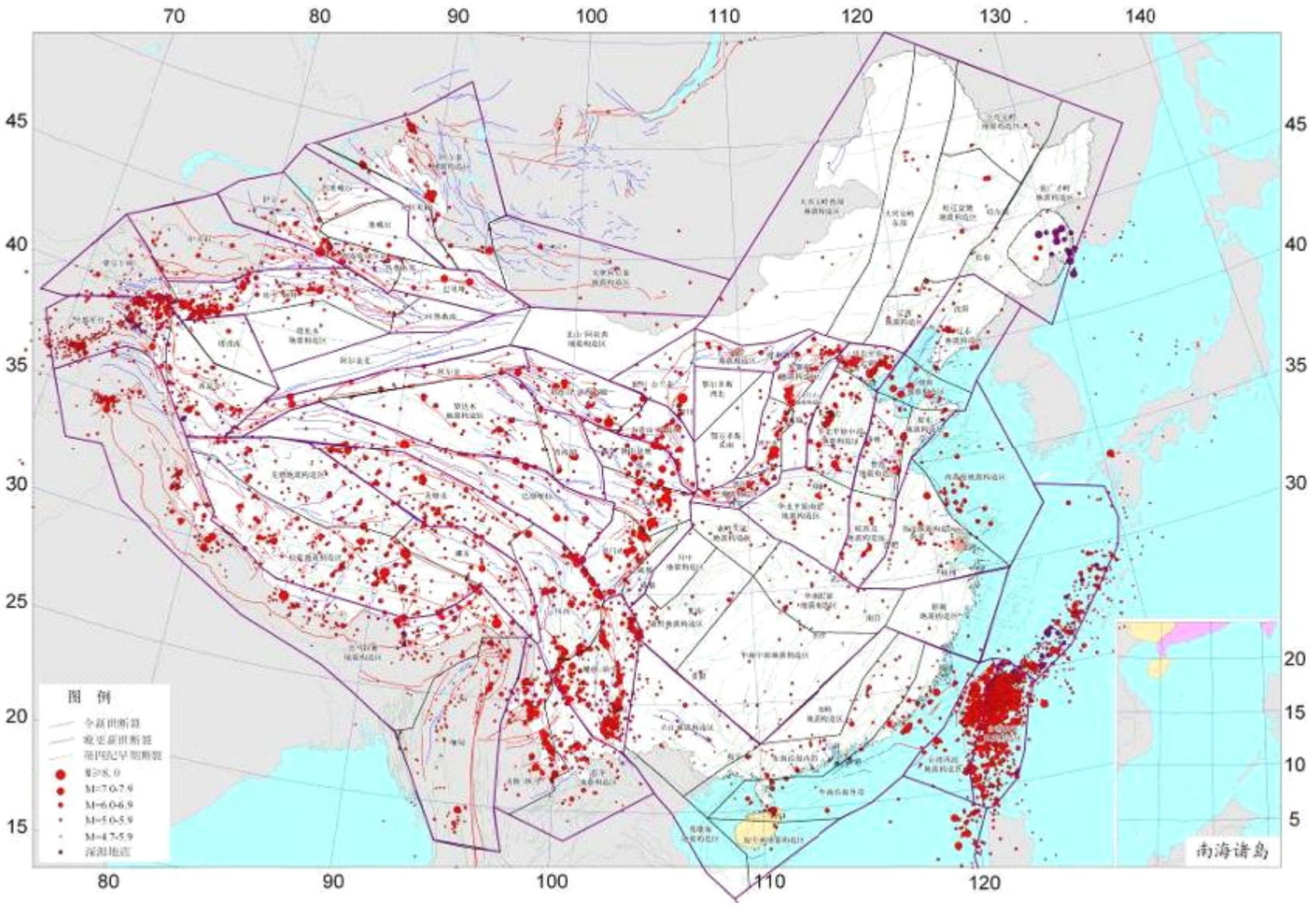
- **Extending two-step scheme of potential seismic source to three-step scheme**

1. **Seismic zones divided—>seismotectonic zones divided —>potential seismic sources divided**
2. **Add a step— seismotectonic zone divided as the controlling part between seismic zone and potential seismic source**

Seismic zones in China and adjacent areas

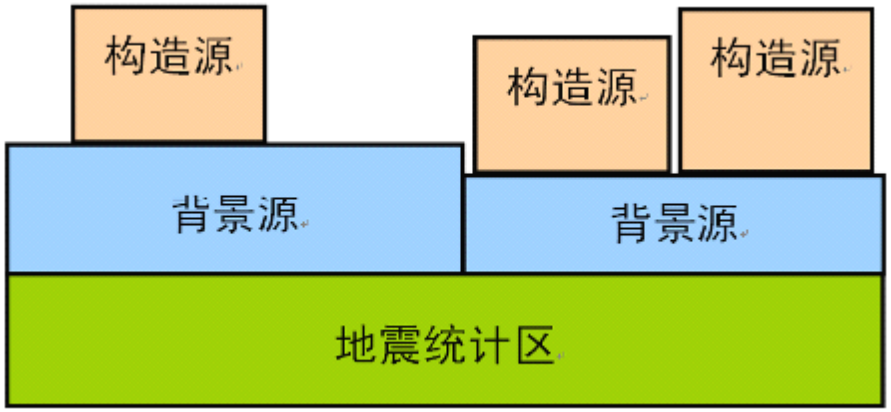


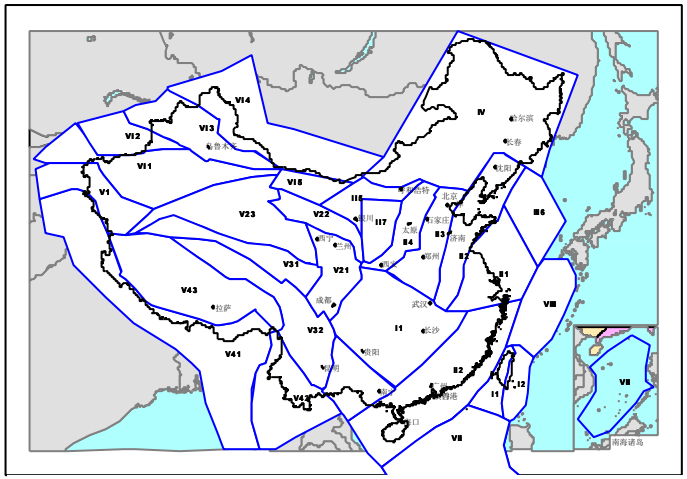
Seismotectonic zones in China and adjacent areas

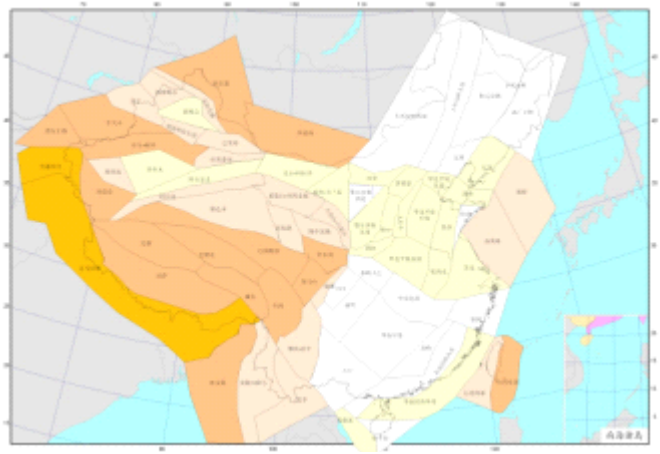


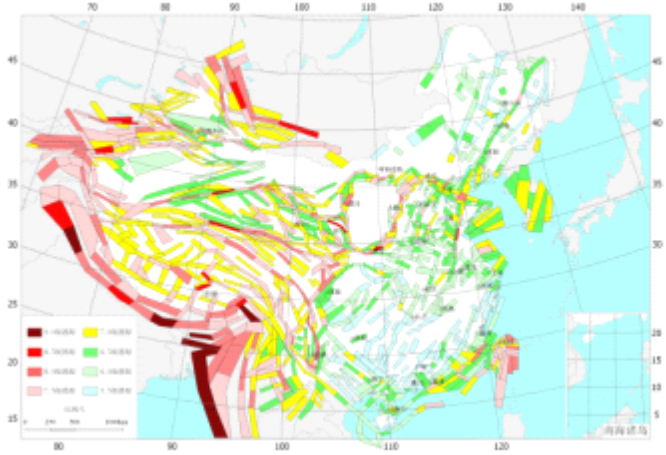
Three-step scheme of potential seismic sources used:

- **29 statistical zones （for seismic zones）**
- **77 background sources （for seismotectonic zones）**
- **1199 seismotectonic sources （for active faults）**





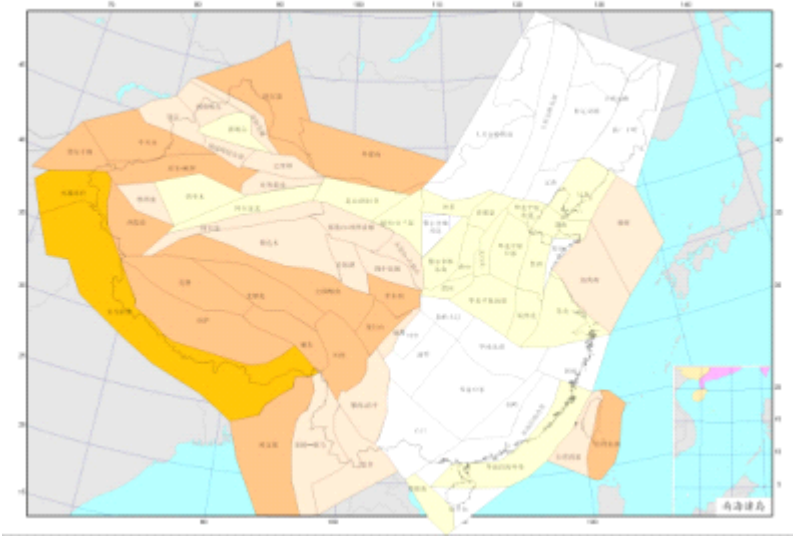


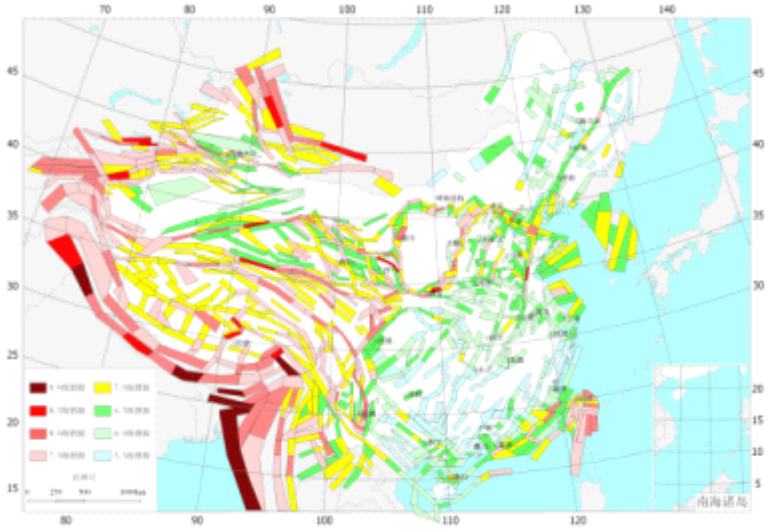


New Seismic Ground Motion Parameter Zonation Map of China (2012?)

3. Working team 3

- Determinating seismic activity parameters of
  - statistical zones
  - background sources
  - seismotectonic sources





New Seismic Ground Motion Parameter Zonation Map of China (2012?)

4. Working team 4

For ground motion attenuation relation

- **Factors considered:**

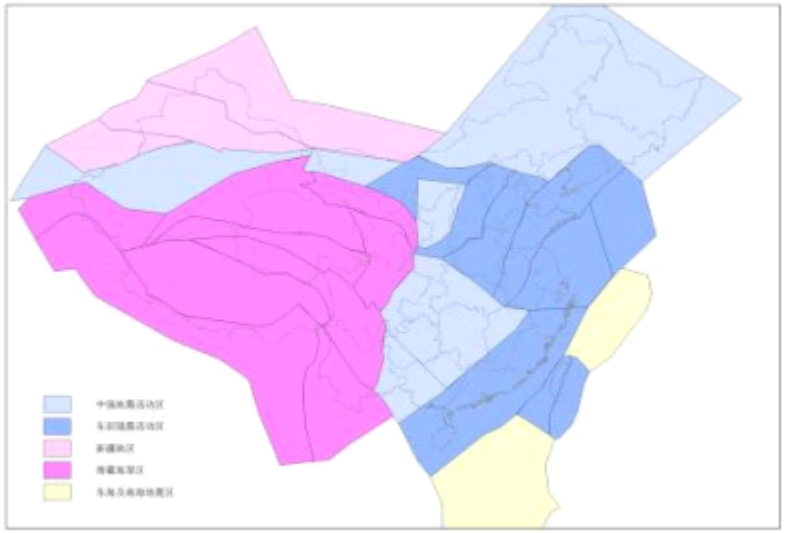
1. Great earthquake region or Small-moderate earthquake region
2. Strong seismic activity region or weak seismic activity region

- **Four attenuation zones**

1. Strong earthquake region in east China（1）
2. Strong earthquake region in west China

   Xinjiang region（2)

   Qing-zang-chuan-dian region（3）
3. Small-moderate earthquake region（4）

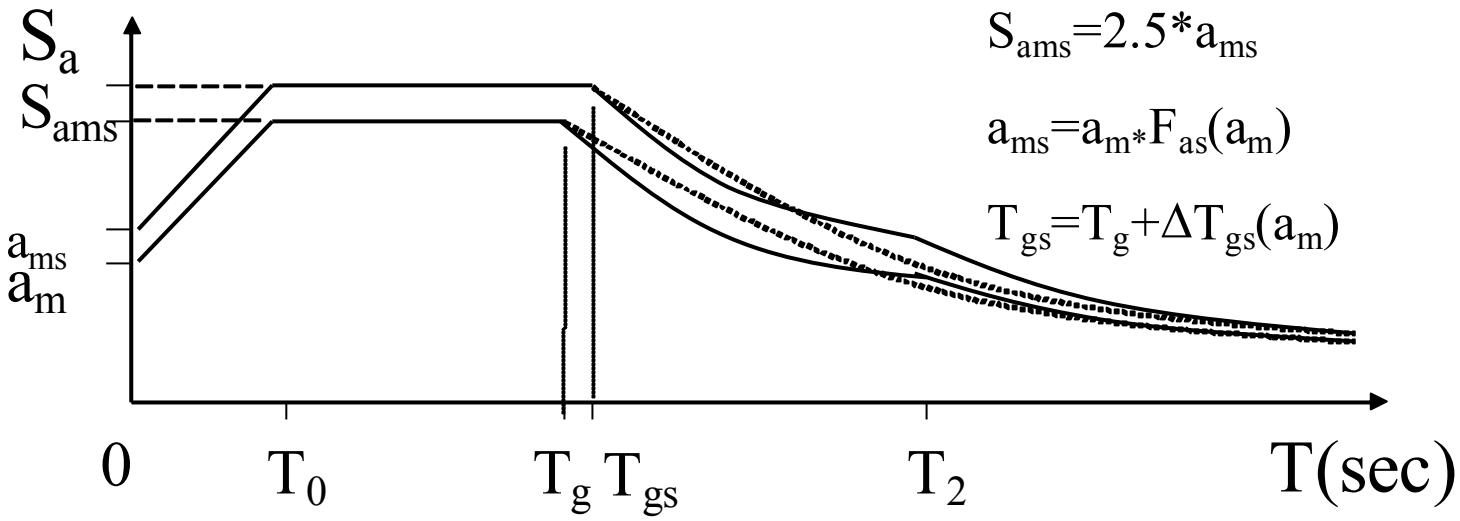


New Seismic Ground Motion Parameter Zonation Map of China (2012?)

5. Working team 5

- **Two-parameter adjustment way used**

1. **Peak ground acceleration adjusted with site types**
2. **Spectral characteristic period adjusted with site types**



Adjustment coefficients for peak ground acceleration

Site types	*PGA*(g) for site type II					
	≤0.05	0.10	0.15	0.20	0.30	≥0.40
I_0	0.64	0.68	0.70	0.75	0.85	0.90
I_1	0.80	0.82	0.83	0.85	0.95	1.00
II	1.00	1.00	1.00	1.00	1.00	1.00
III	1.30	1.25	1.15	1.00	1.00	1.00
IV	1.25	1.20	1.10	1.00	0.95	0.90

Adjustment values for spectral characteristic period

Tg	Site types				
	I_0	I_1	II	III	IV
1 zone	0.20	0.25	0.35	0.45	0.65
2 zone	0.25	0.30	0.40	0.55	0.75
3 zone	0.30	0.35	0.45	0.65	0.90

New Seismic Ground Motion Parameter Zonation Map of China (2012?)

6. Working team 6

For compiling of the zonation map

- Considering the peak ground accelerations with different exceeding probabilities, and defining

1. Special strong earthquake: 0.5% exceeding probability in 50 years
2. Strong earthquake: 2% exceeding probability in 50 years
3. moderate earthquake: 10% exceeding probability in 50 years
4. Small earthquake: 63% exceeding probability in 50 years

New Seismic Ground Motion Parameter Zonation Map of China (2012?)

Calculating results show

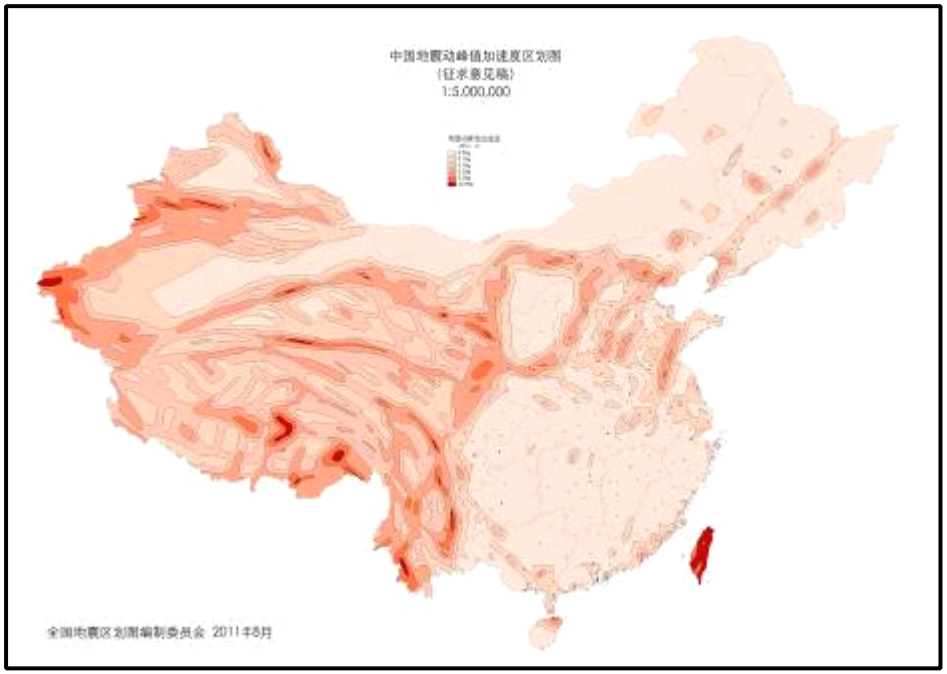
- K1：SSE/ME（PGA） 2.7～3.1
- K2：STE/ME（PGA） 1.8～2.0
- K3：SME/ME（PGA） 1/2.8～1/3.0

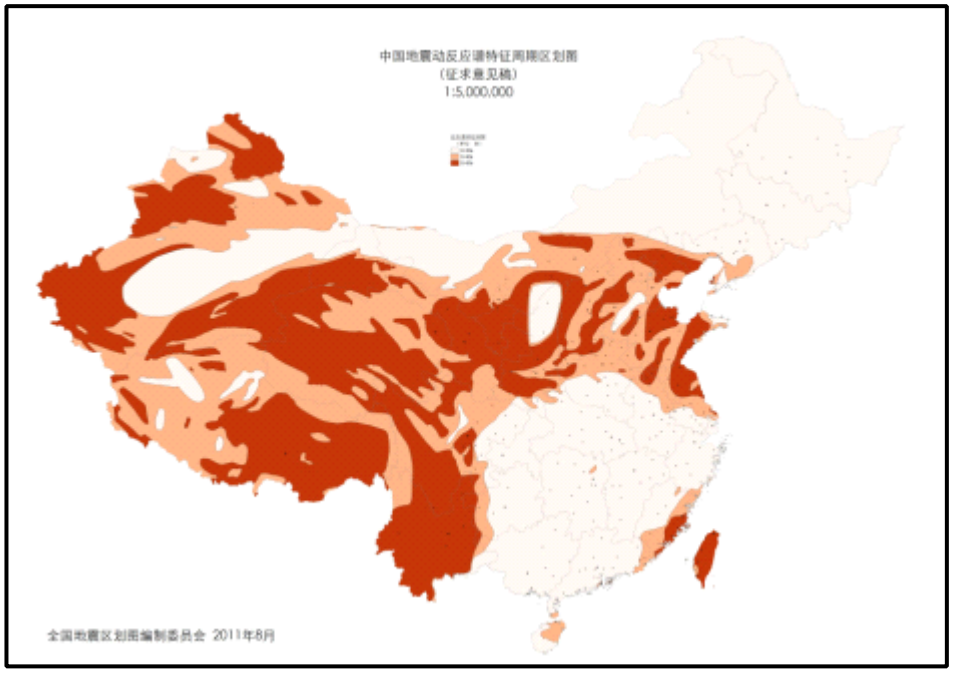
- For the zonation map compiling,

PGA＝Max (PGA10%/50Y,PGA2%/50Y/1.9)

Tg＝2π×(PGA10%/50Y/PGV10%/50Y)

peak ground acceleration map and spectral characteristic period map





Outlines of Presentation

1. Development of Seismic Zonation Map of China
2. The feature of 5G Seismic Zonation Map
3. Compiling of 5G Seismic Zonation Map
4. Consideration of site condition in seismic zonation maps

Consideration of site condition in seismic zonation maps

1. In first, second and third generation maps （1957,1977,1990）

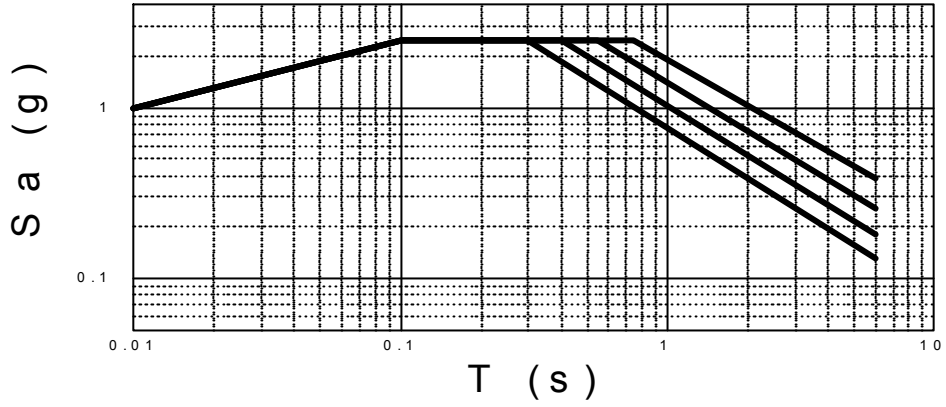
- The site effect was not considered

Consideration of site condition in seismic zonation maps

2. In fourth generation maps（2001）

- The site effect was considered on the spectral characteristic period

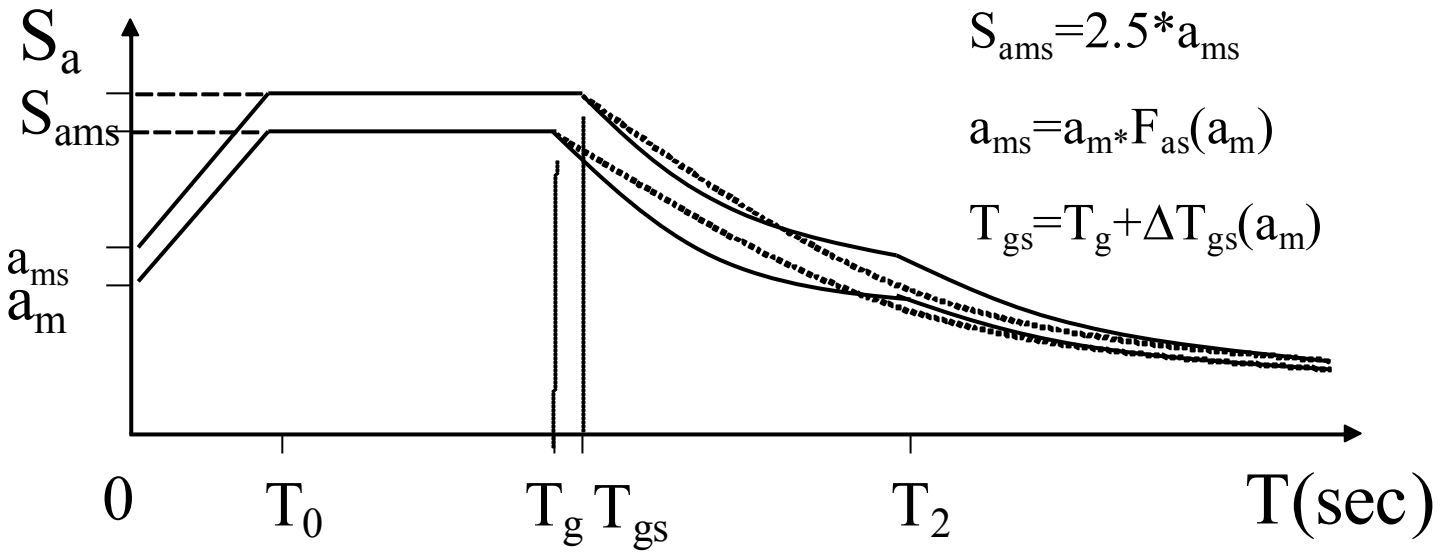
Tg（s）	Site types			
	I	II	III	IV
1 zone	0.25	0.35	0.45	0.65
2 zone	0.30	0.40	0.55	0.75
3 zone	0.35	0.45	0.65	0.90



Consideration of site condition in seismic zonation maps

3. In fifth generation maps（2012?）

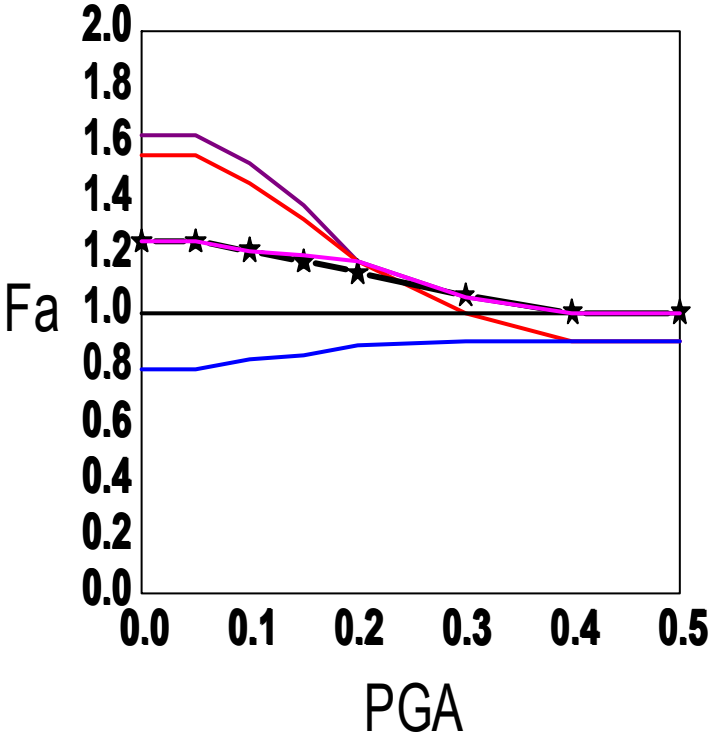
- **The site effect was considered on both the peak ground acceleration and the spectral characteristic period**



Consideration of site condition in seismic zonation maps

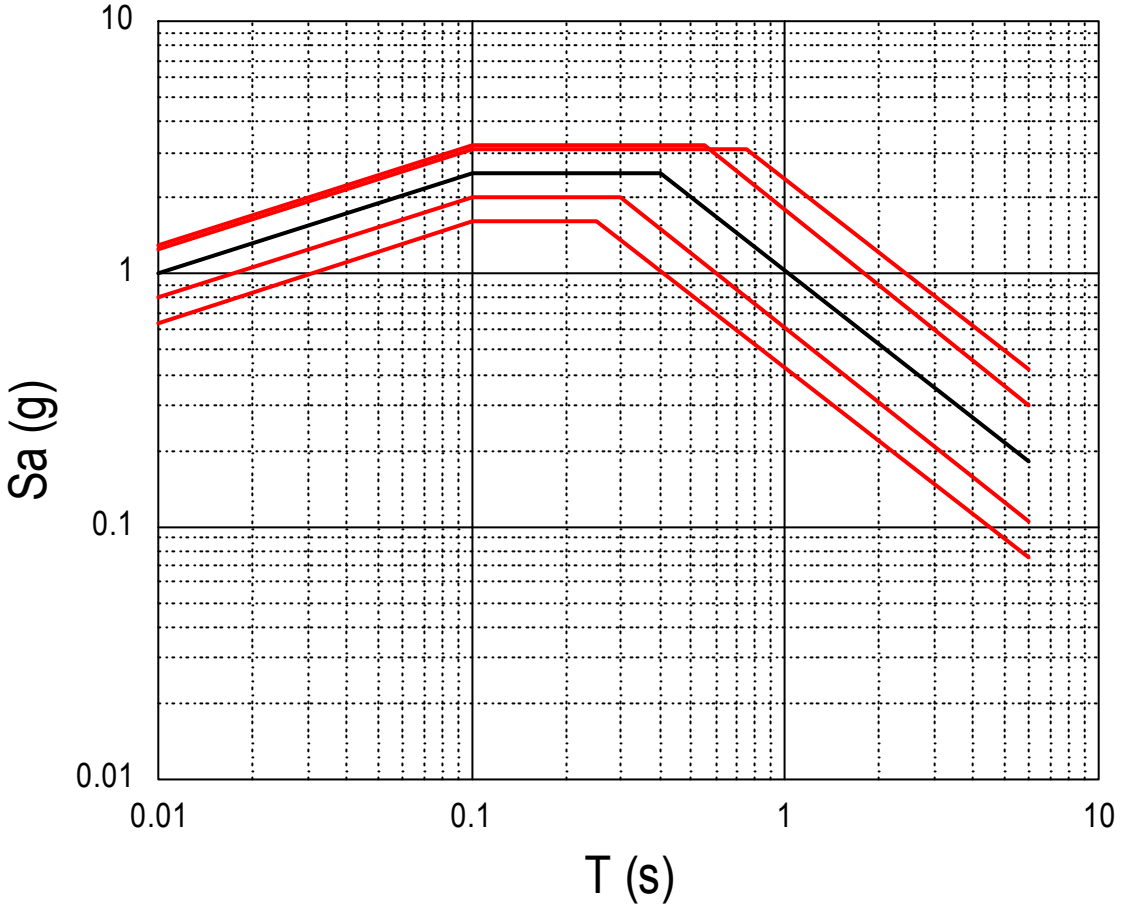
3. In fifth generation maps（2012?）

Site types	*PGA*(g) for site type II					
	≤0.05	0.10	0.15	0.20	0.30	≥0.40
I_0	0.64	0.68	0.70	0.75	0.85	0.90
I_1	0.80	0.82	0.83	0.85	0.95	1.00
II	1.00	1.00	1.00	1.00	1.00	1.00
III	1.30	1.25	1.15	1.00	1.00	1.00
IV	1.25	1.20	1.10	1.00	0.95	0.90



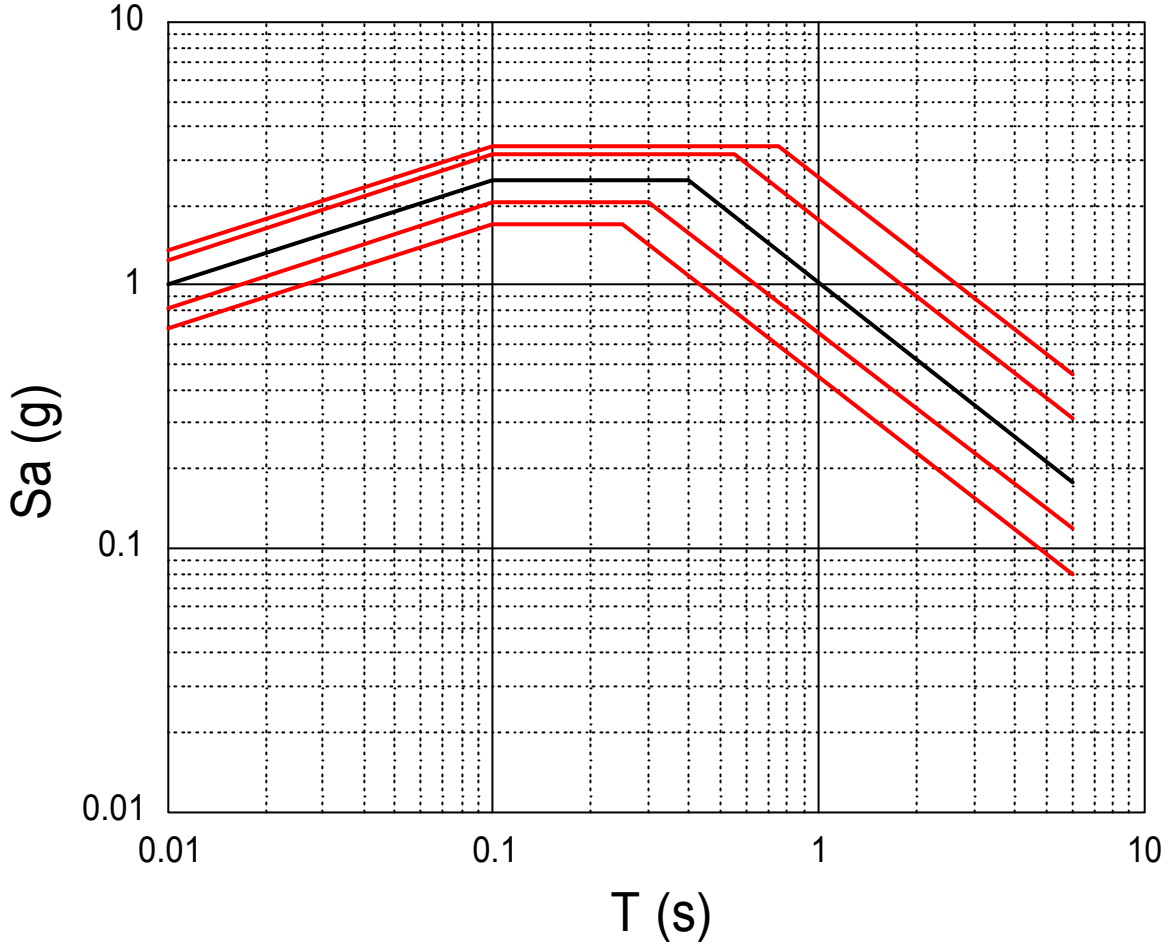
3. In fifth generation maps（2012?）

≤0.05g



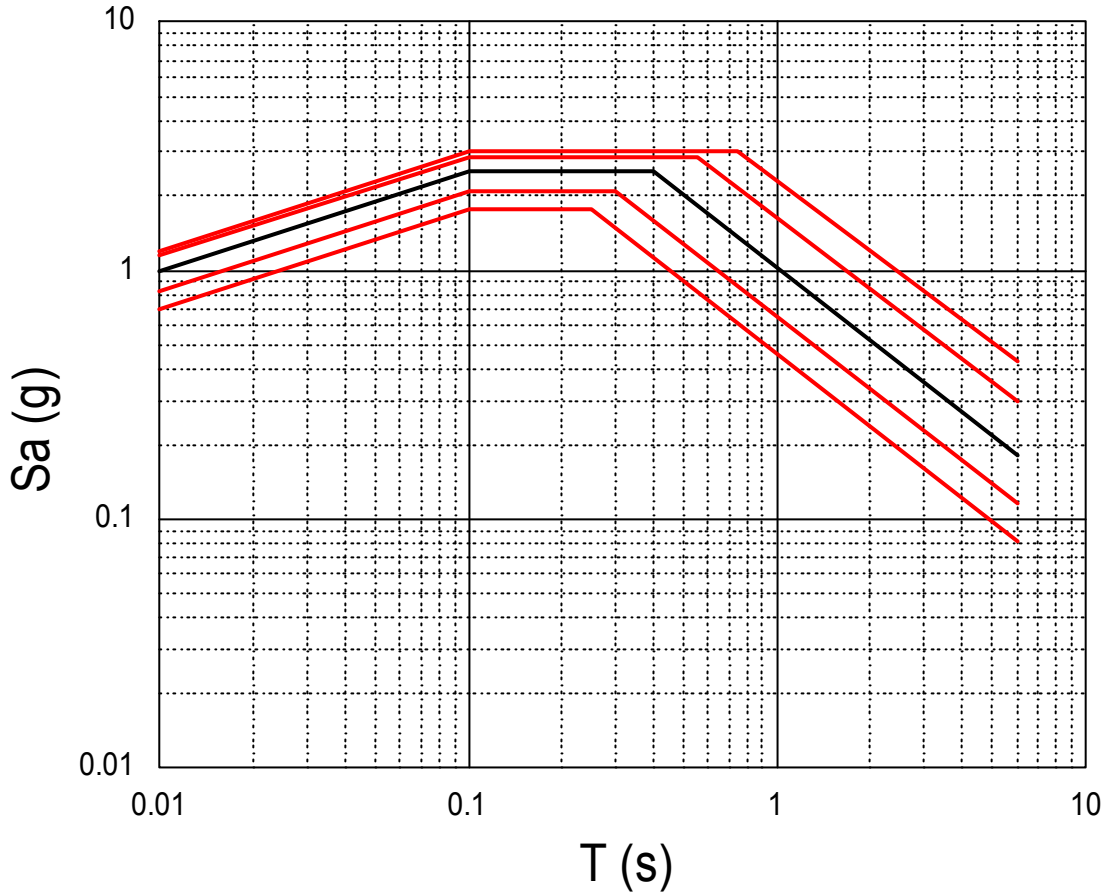
3. In fifth generation maps（2012?）

0.10g



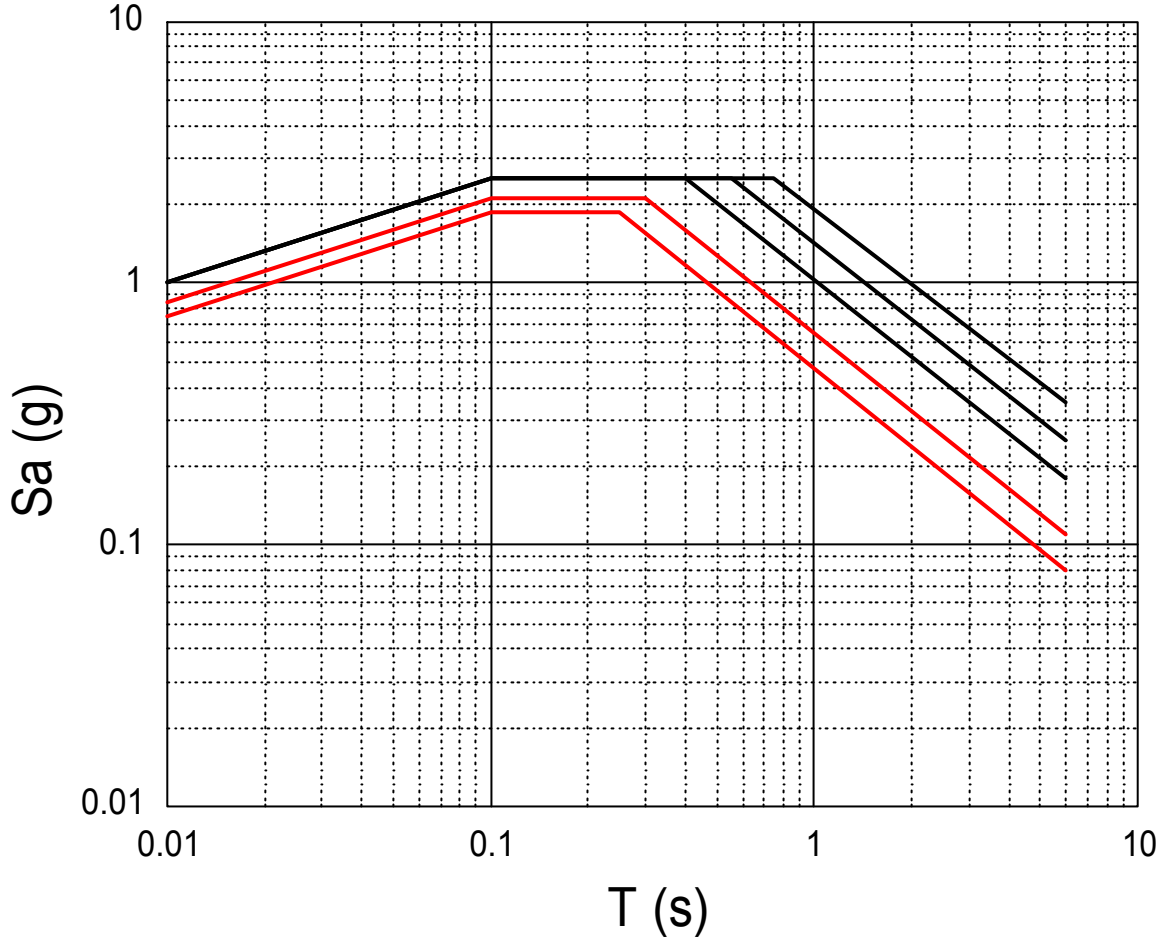
3. In fifth generation maps（2012?）

0.15g



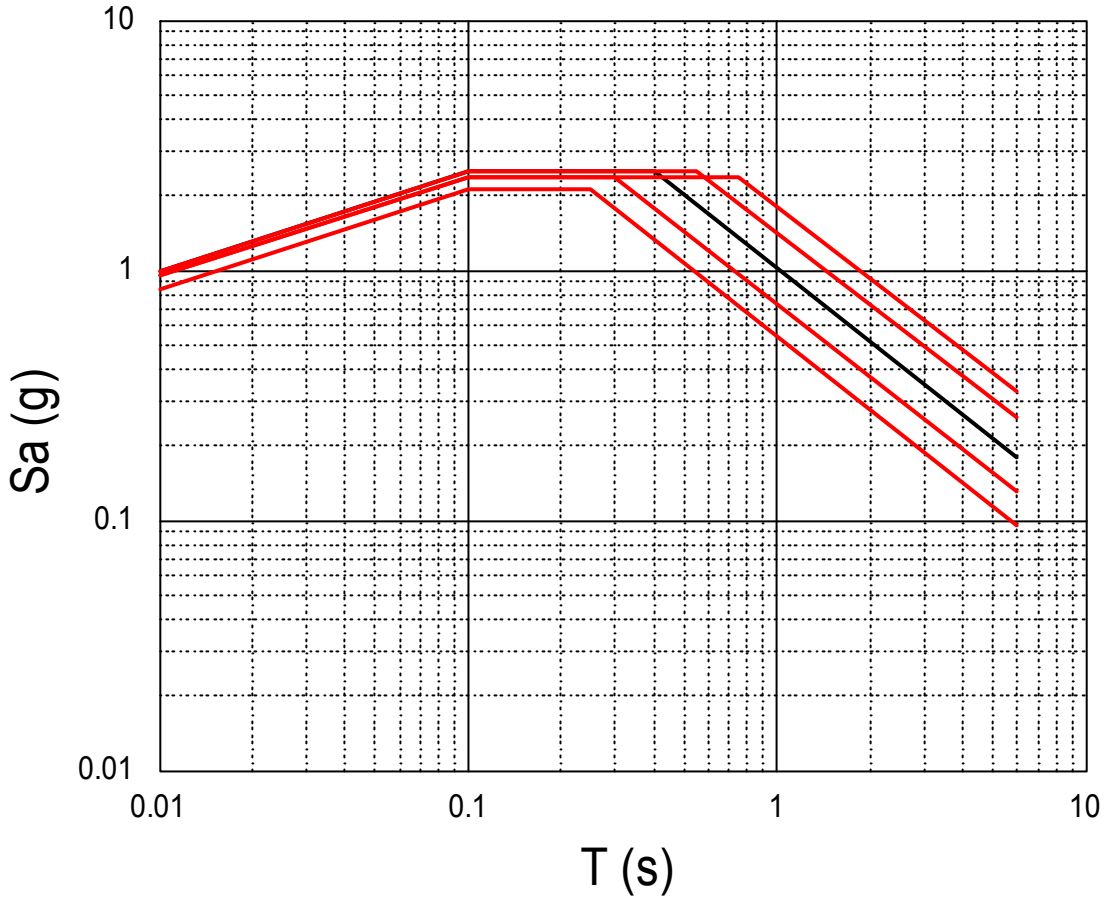
3. In fifth generation maps（2012?）

0.20g



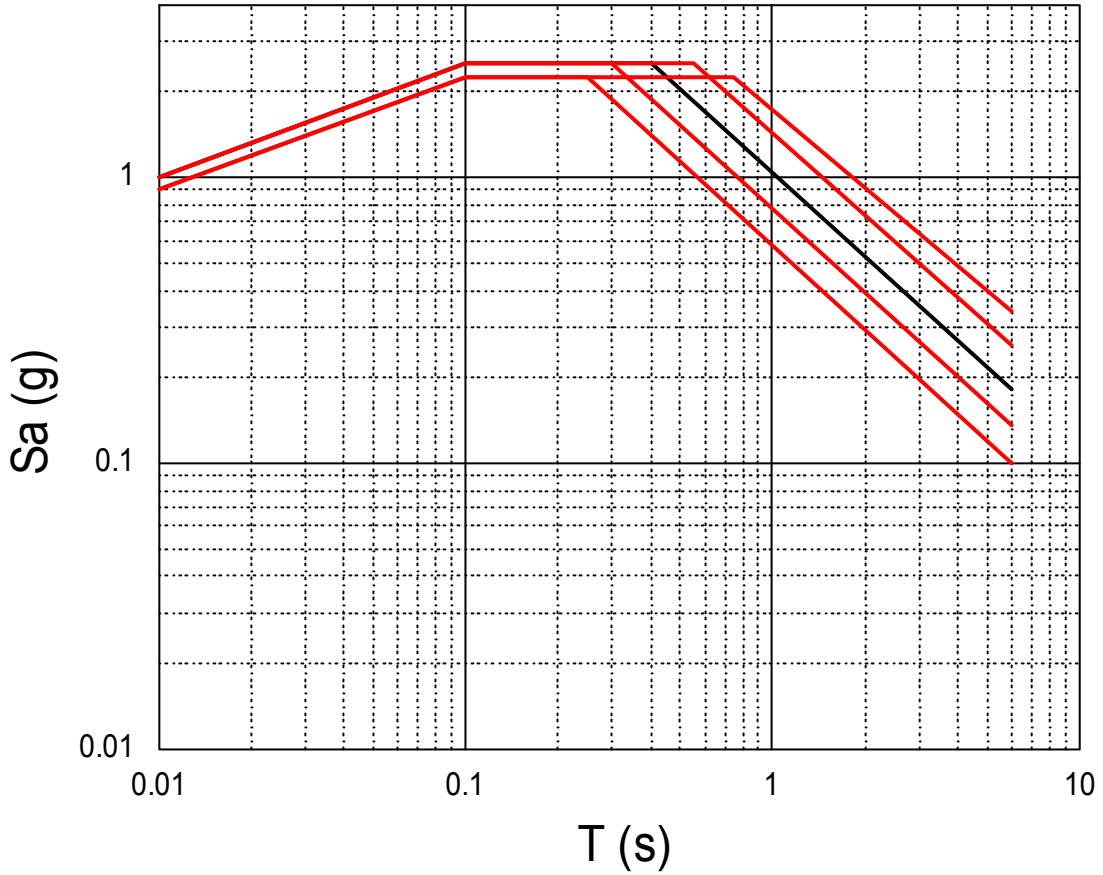
3. In fifth generation maps（2012?）

0.30g



3. In fifth generation maps（2012?）

≥0.40g

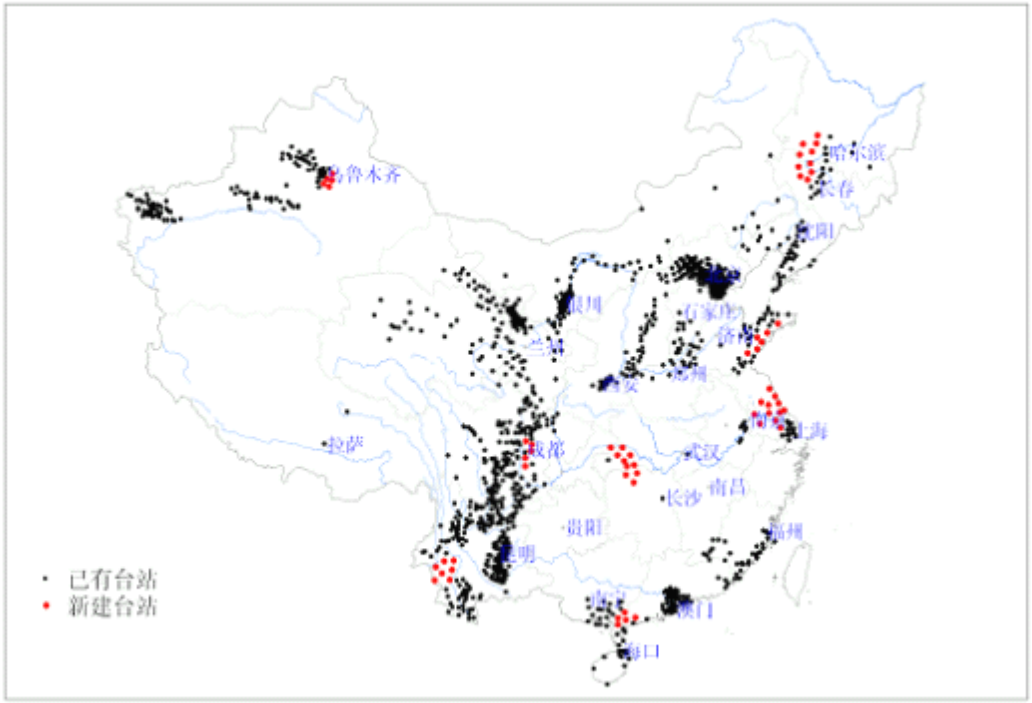


Some Ideas for Next Generation Seismic Zonation Map of China

The sixth generation map

Some Ideas for Next Generation Seismic Zoning Map of China

1. **Ground motion attenuation relations should be obtained based on the ground motion records from different zones in China**



Some Ideas for Next Generation Seismic Zoning Map of China

2. **Ground motion parameter zonation maps with different exceeding probabilities should be compiled**
3. **Is possible to compile the ground motion velocity and displacement zonation map?**

Thanks !