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Logic Trees for Probabilistic Seismic Hazard Analysis in low Seismological Hazard Zone

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Outline

- What is Logic Tree and Why is it used in PSHA
- Construction of Logic Tree for PSHA in low seismological province(LSP)
- How to build the Logic Tree for LSP
- Conclusions

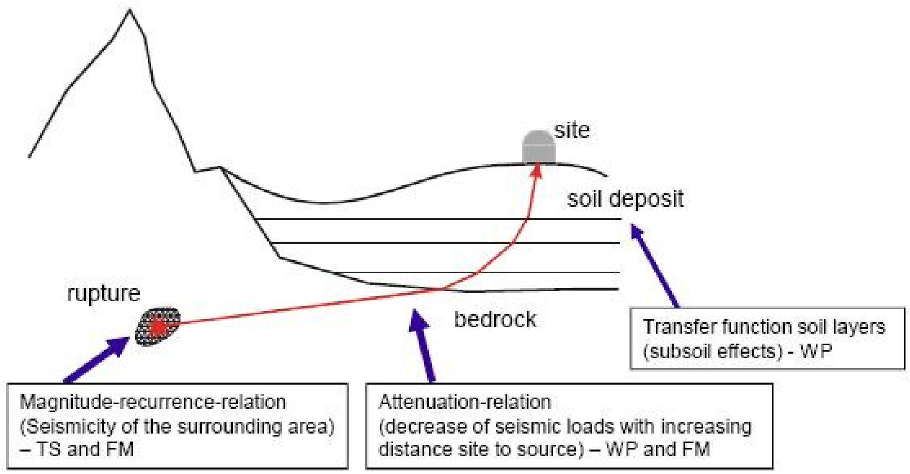
Part One

What is Logic Tree and Why is it used in PSHA

What is Logic Tree

a) R.B.Kulkarni,R.R. Youngs, K.J.Coppersmith(1984)—8th WCEE, first introduced the logic tree in PSHA as a tool to capture and quantify the uncertainties related to PSHA

b) A logic tree in PSHA is described as that all steps in which there are uncertainties to calculate the seismic hazard analysis are separated branches ,each branches are added for each of the choices that the analyst considers feasible, and a normalized weight is assigned to reflect the analyst's **Confidence** in choice of the most correct model or best estimation. The hazard calculation are then performed following all the possible branches.



Why is it used in PSHA

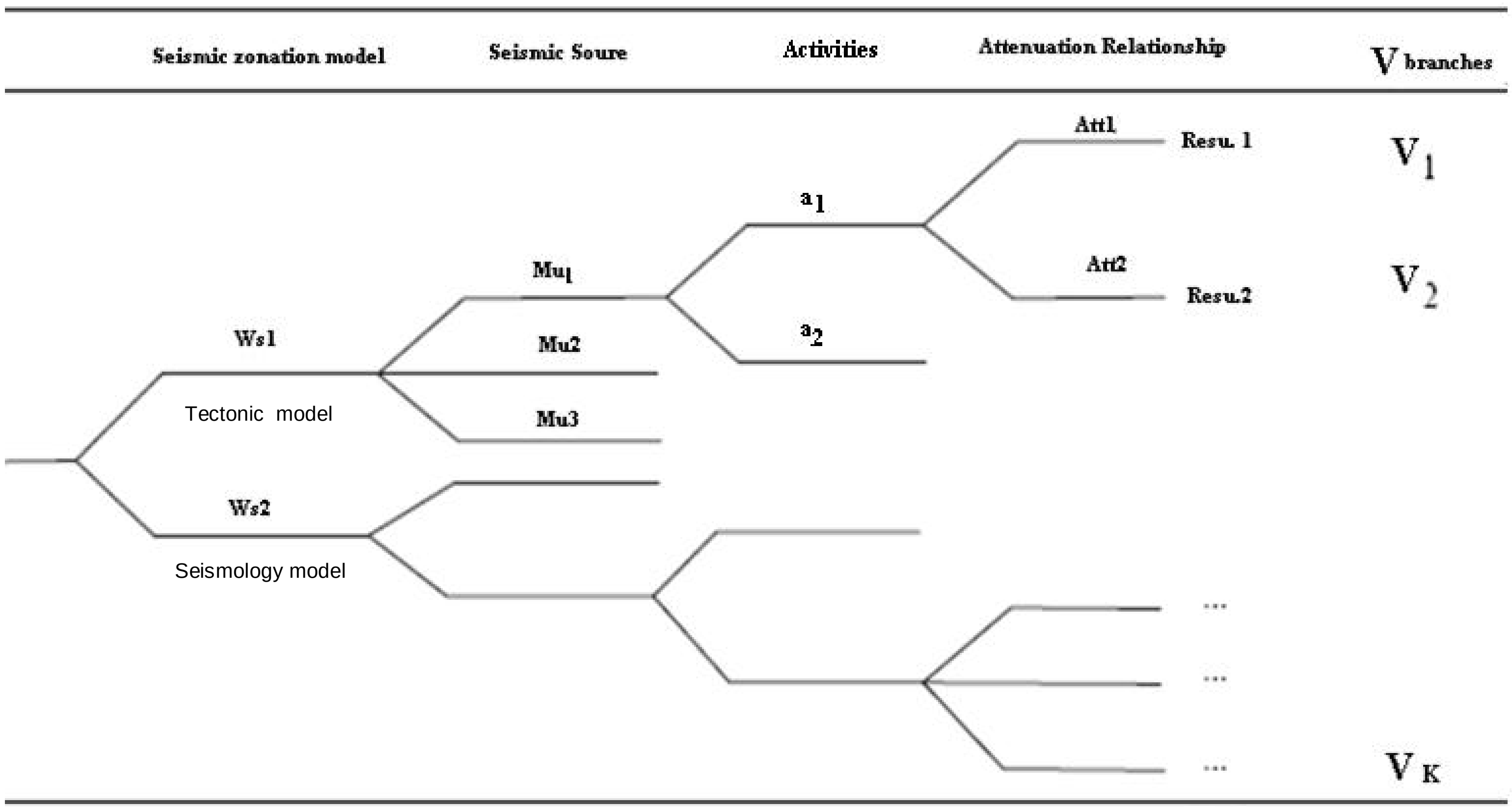
ø Uncertainty in PSHA (R.J.Budnitz,1997, Senior Seismic Hazard Analysis Committee ,SSHAC,1997).)

- epistemic uncertainty: incomplete knowledge (lack of data)
- aleatory uncertainty: inherent randomness of ground motion generation, propagations
- Typical works: 2002 Working Group on California Earthquake Probabilities, Seismic HAzard haRmonization in Europe(SHARE) project 2009

ø PSHA – Logic Tree Methodology

- To estimate the epistemic uncertainty.
- A simple mixture of models (probability distributions).
- Weighting factors based on expert opinions or special approaches

Logic tree in PSHA



$$\sum = 1$$

The hazard calculations are followed all the possible branches through the logic tree, each analysis producing a single hazard curve showing ground motion against annual frequency of exceedance. The weighting of each hazard curve is determined by multiplying the weights along all the component branches.

Part Two

Construction of Logic Tree for PSHA in low seismological province(LSP)

Basic database

- Geology database

--- Continental dynamic, tectonic, , rock and stratum, topography, historic earthquake events, site condition

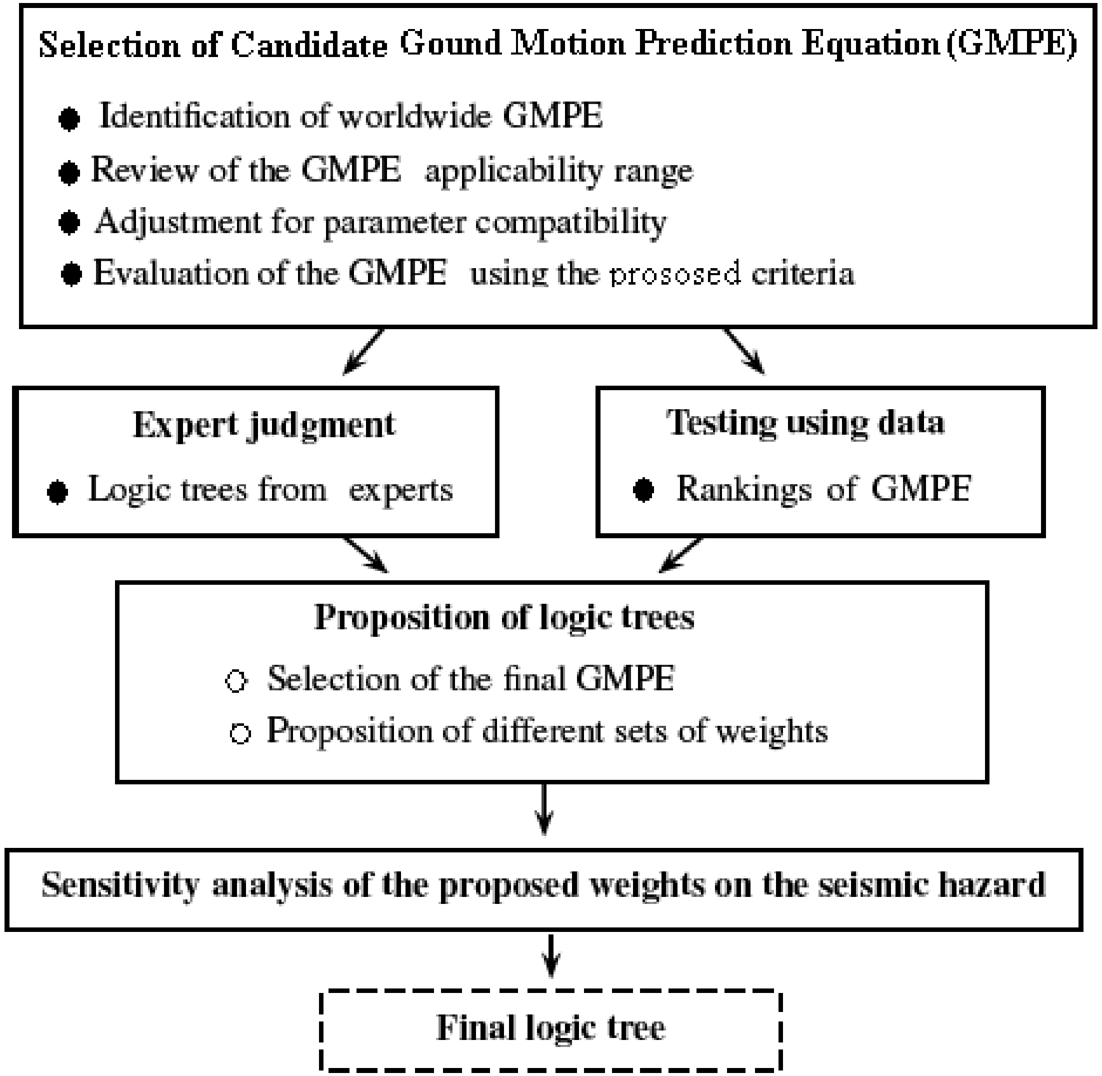
- Analyzing model database

---Seismic source model, Rupture model, Propagation and attenuation model, site response model, etc.

- Expects system database

----Geology, Seismology, Earthquake Engineering, Civil engineering, Mathematics (model, selection and weighting of Logic tree, criterion)

A procedure of Logic tree for GMPE

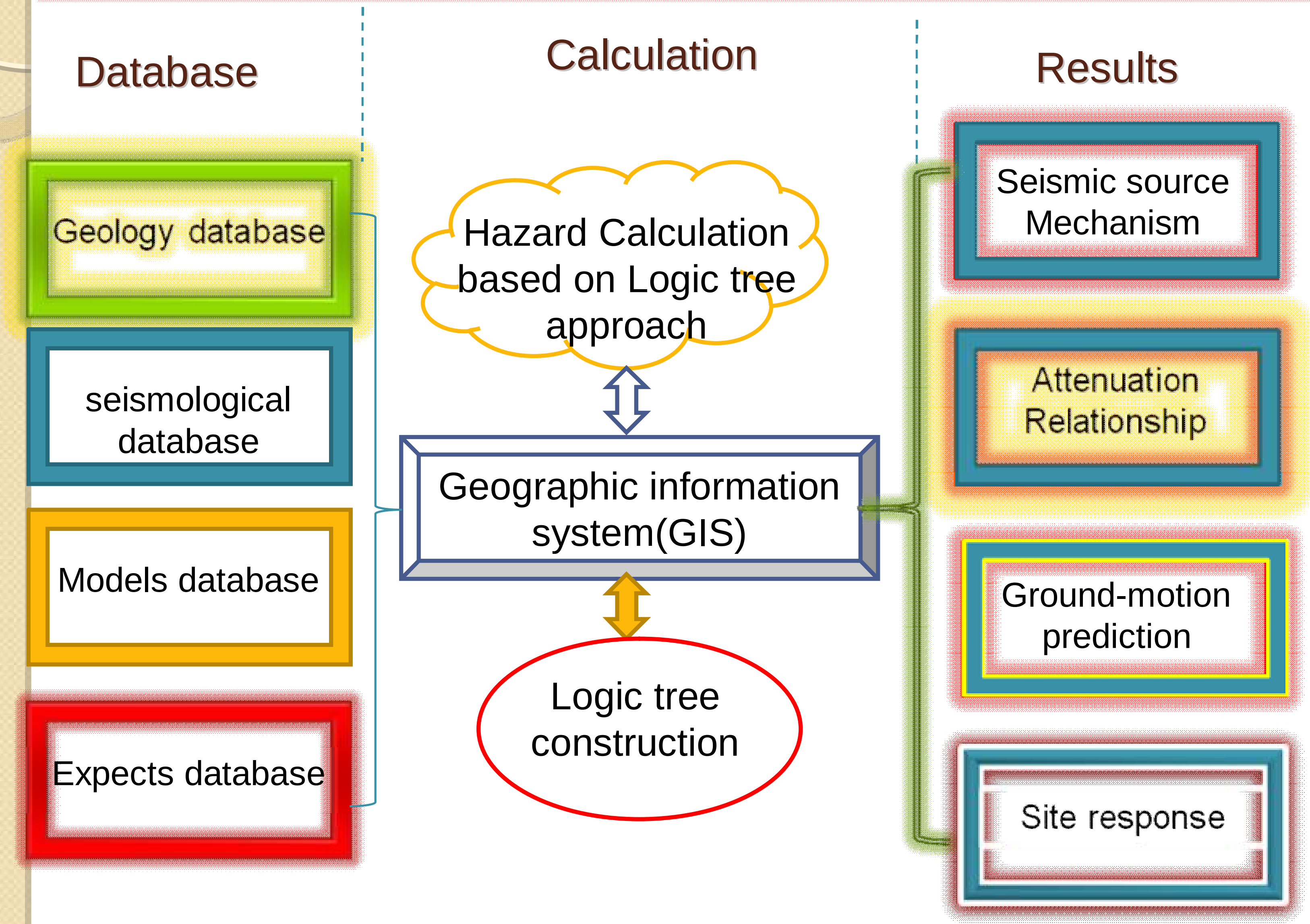


Logic tree setting up procedure for gound motion prediction equations

Part Three

One example of Logic Tree for PSHA
in low seismological province(LT-LSP)

Framework on LT-LSP



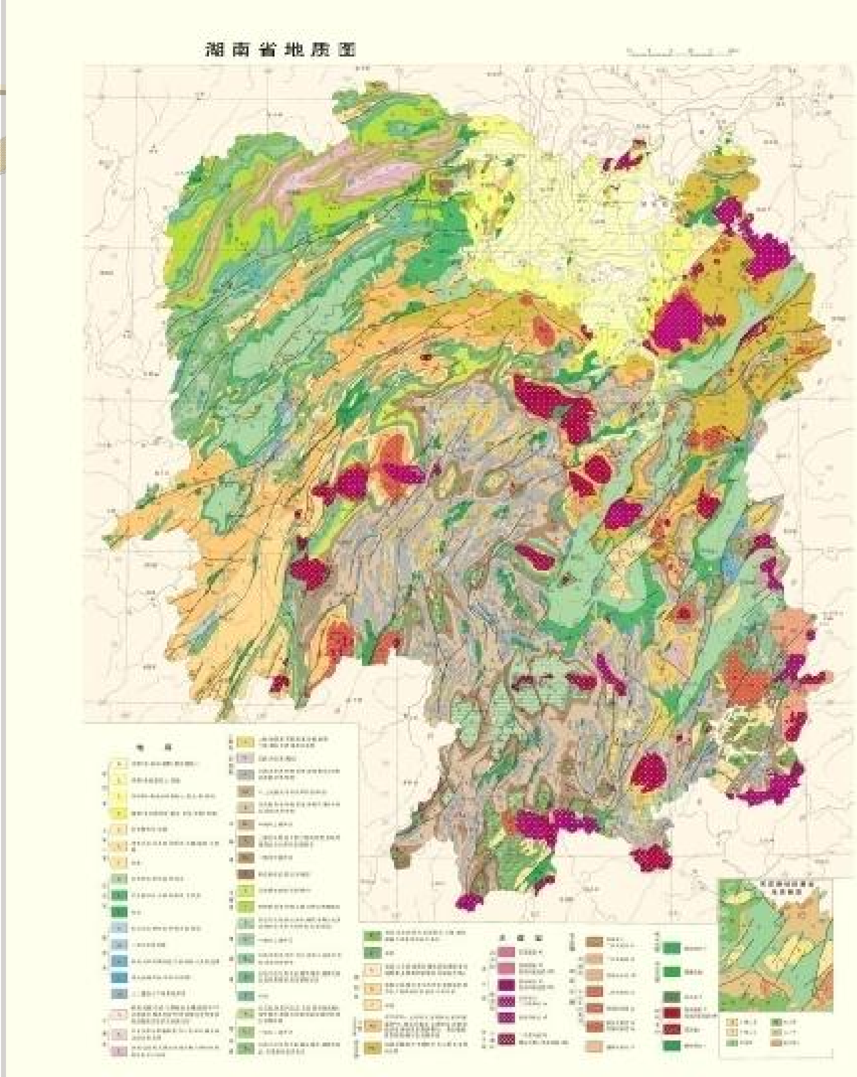
One Illustration of LT-LSP

- Geology database----Continental dynamic, tectonic system, active fault , GPS monitoring......

- Seismological database---Earthquake events(historic and device records), Micro-tremors, M-T, artificial explosion.....

- Models database--- Probability models, Potential seismic source and Seismic Source, GMPE, Site response......

Geology database in GIS



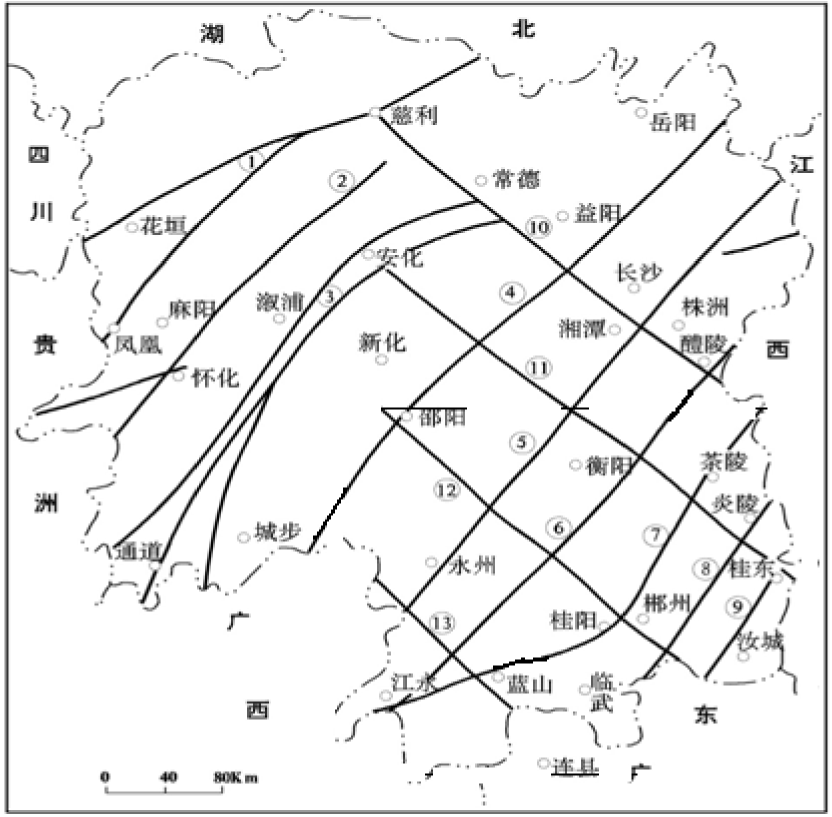
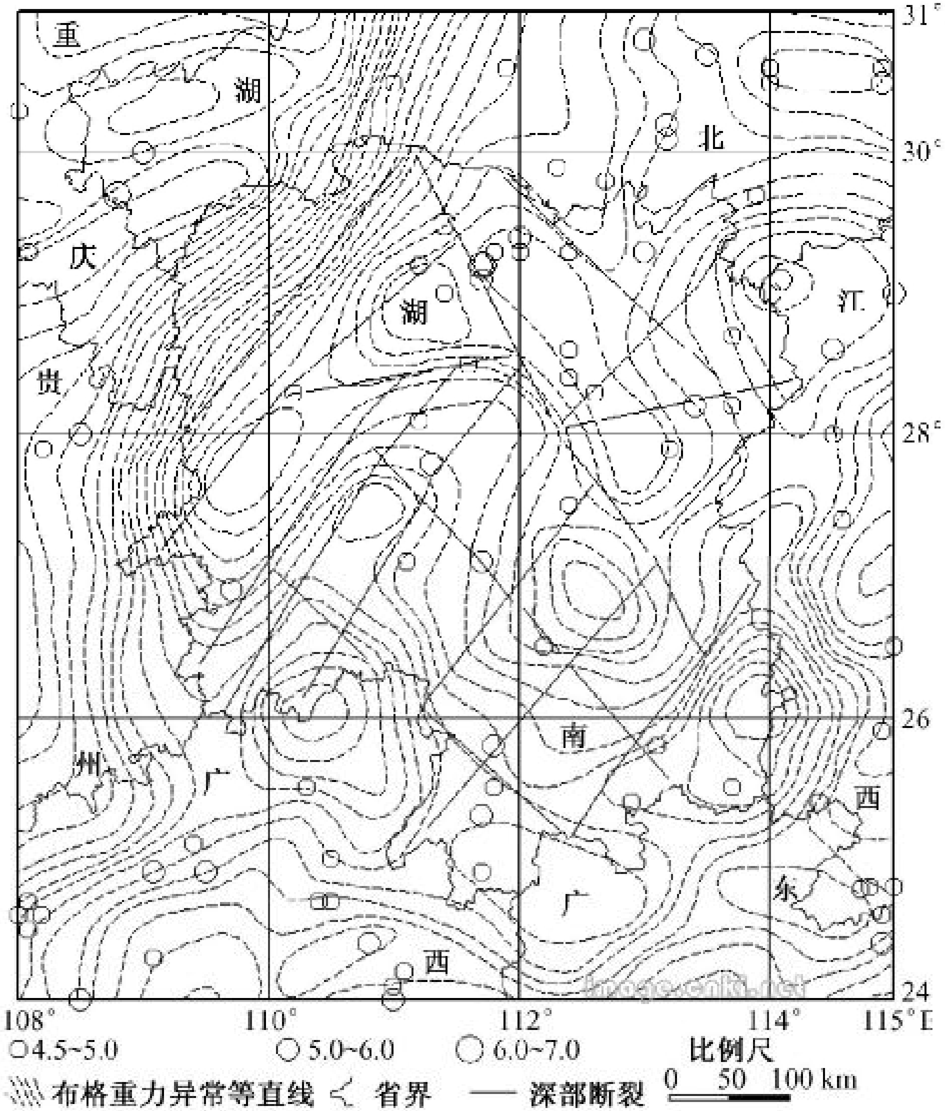
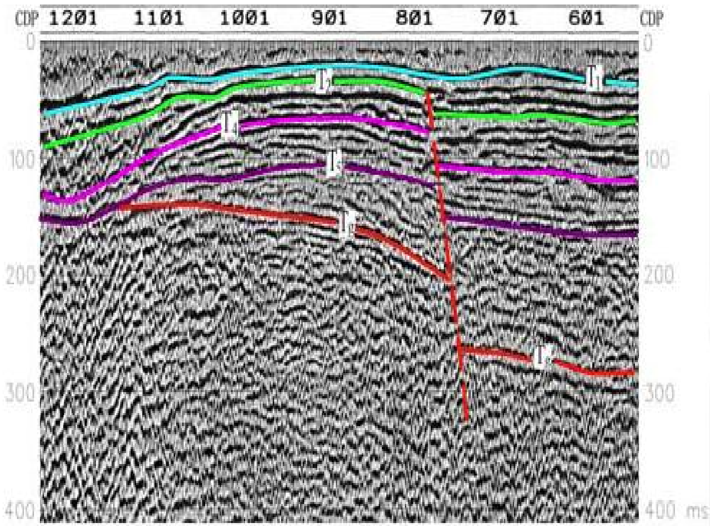


图1–6　湖南省深大断裂分布图

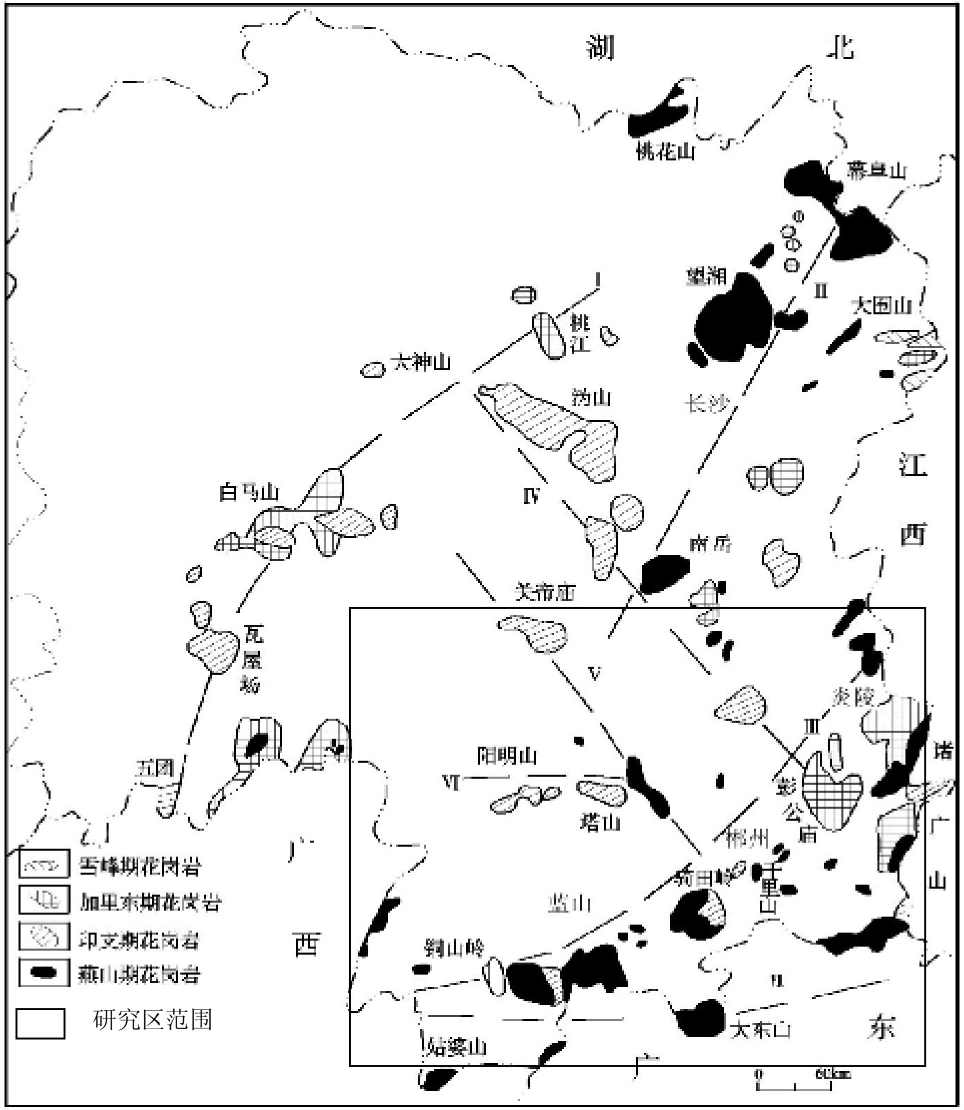
① 慈利—古丈断裂带　② 沅陵—芷江断裂带
③ 安化—通道断裂带　④ 汨罗—新宁断裂带
⑤ 株洲—永州断裂带　⑥ 醴陵—宁远断裂带
⑦ 茶陵—蓝山断裂带　⑧ 炎陵—长城岭断裂带
⑨ 桂东—汝城断裂带　⑩ 慈利—醴陵断裂带
⑪ 安化—桂东断裂带　⑫ 郴州—邵阳断裂带
⑬ 连县—道县断裂带

Bouguer gravity anomaly and deep-fault system





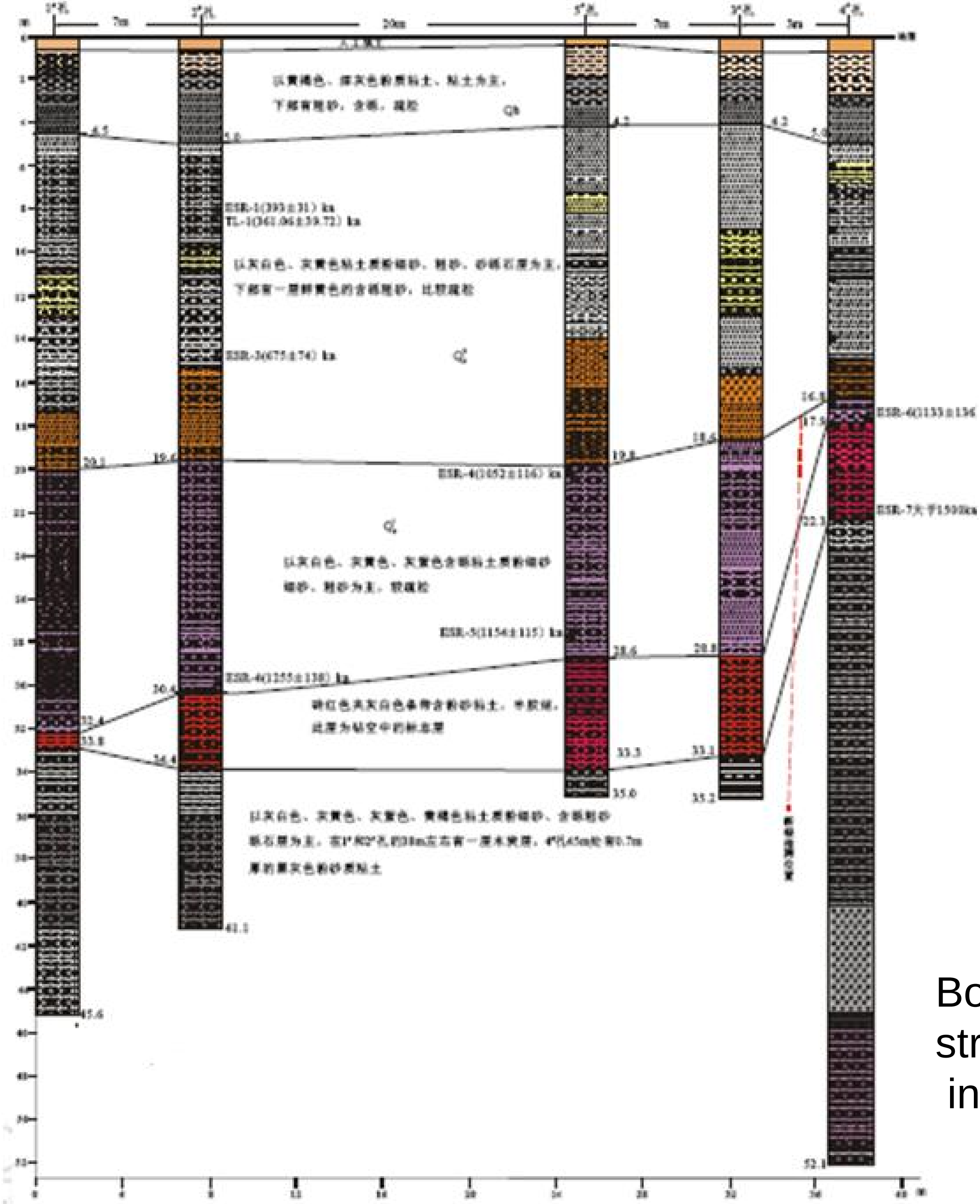
Buried active fault



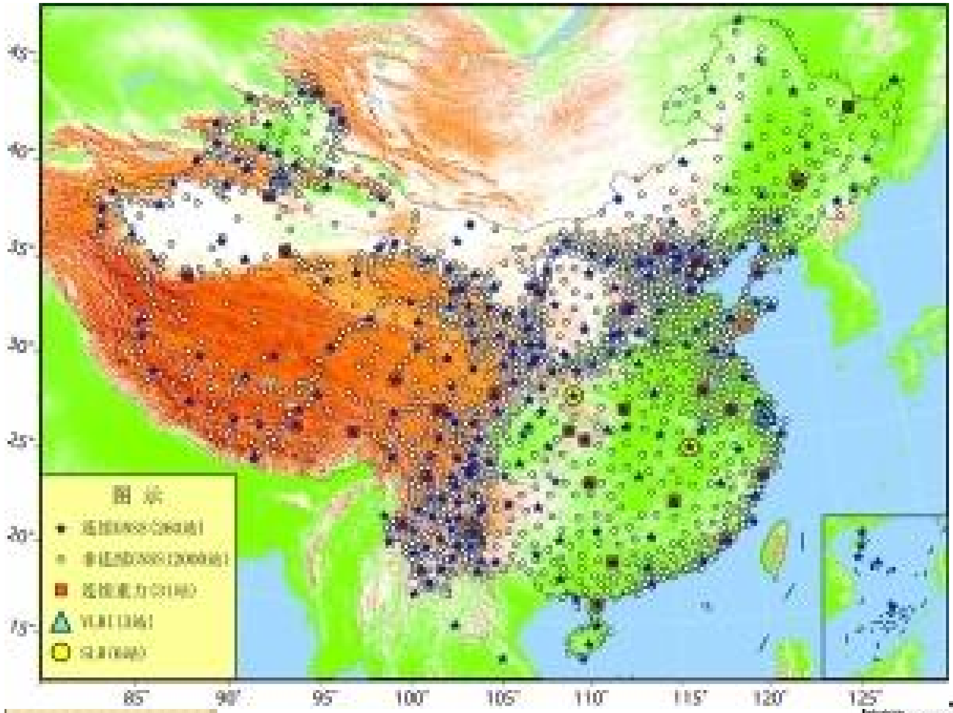
1－ 12　湖南省岩浆岩分布图

Ⅰ.桃江—白马山岩浆带 Ⅱ.幕阜山—南岳岩浆岩带 Ⅲ. 炎－郴－蓝岩浆岩节 Ⅳ. 沩山－彭公庙岩浆岩带 Ⅴ. 关帝庙—骑田岭岩浆岩带 Ⅵ. 阳明山－塔山岩浆岩带 Ⅶ. 姑婆山－诸广山岩浆岩带。

Fault and volcano

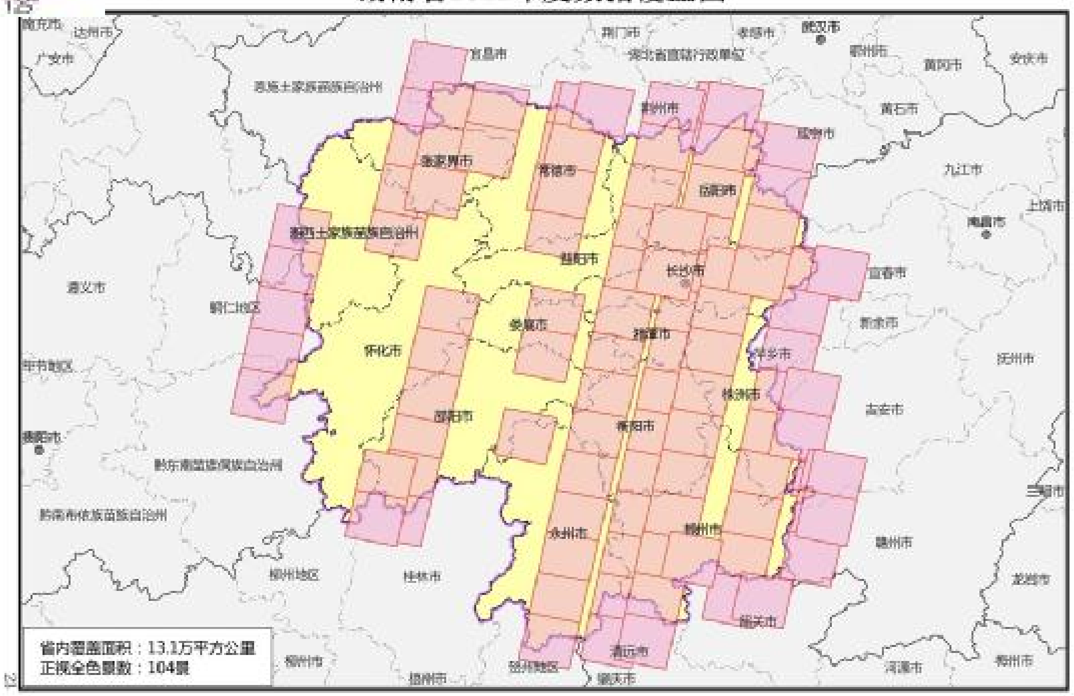


Boring data, stratum profile in active fault

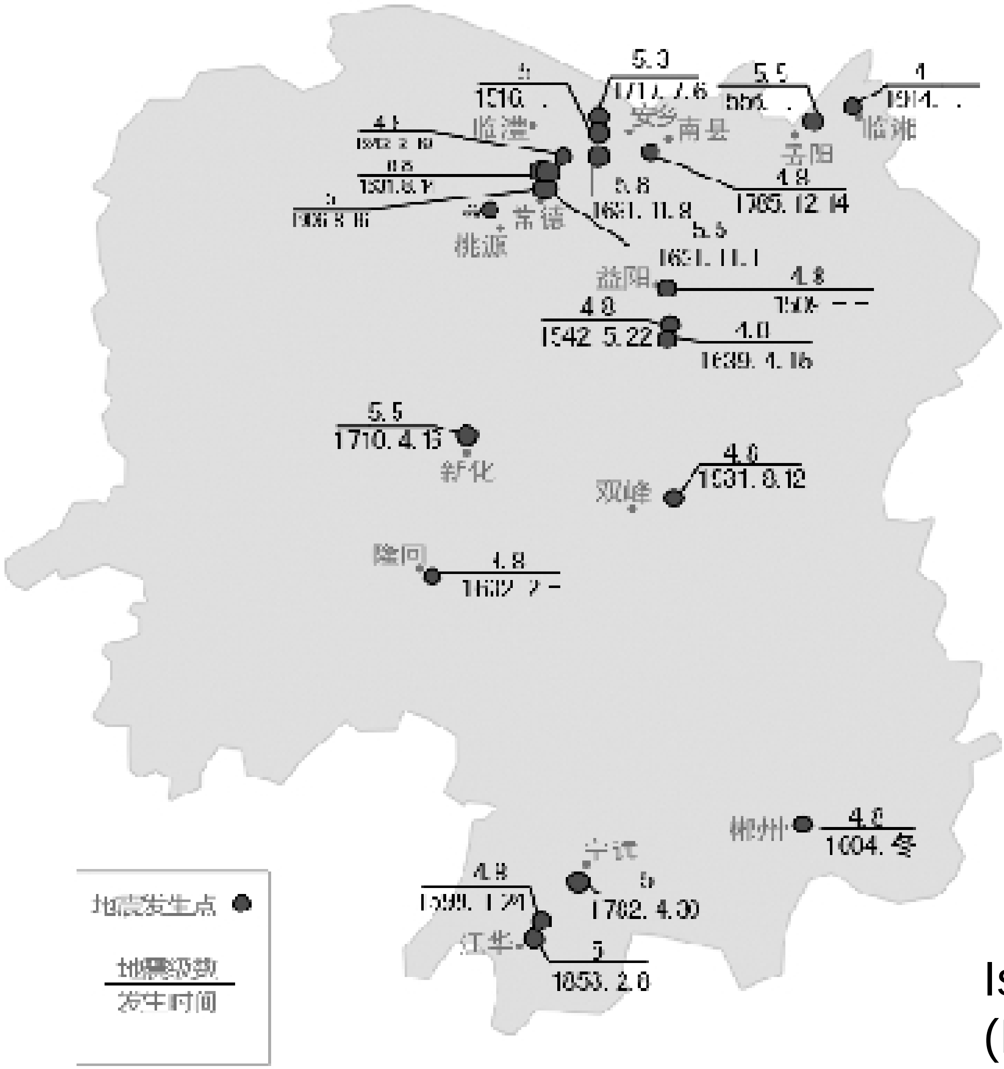


2260 observation stations,
260 consecutive stations

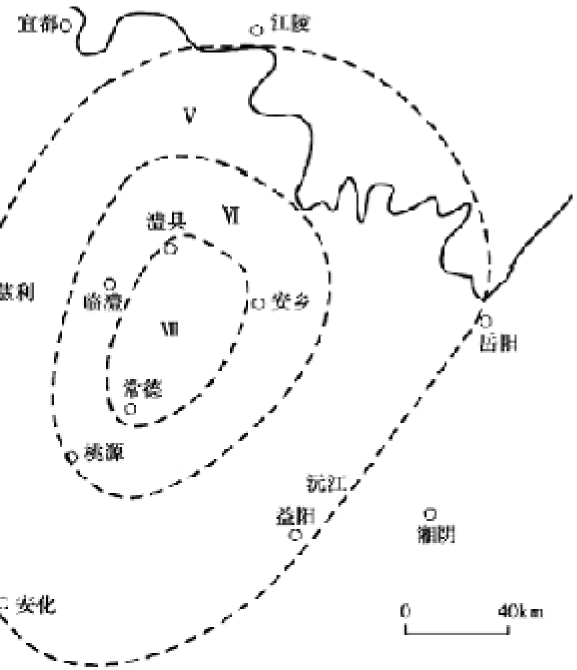
湖南省2012年度数据覆盖图



Seismological database-



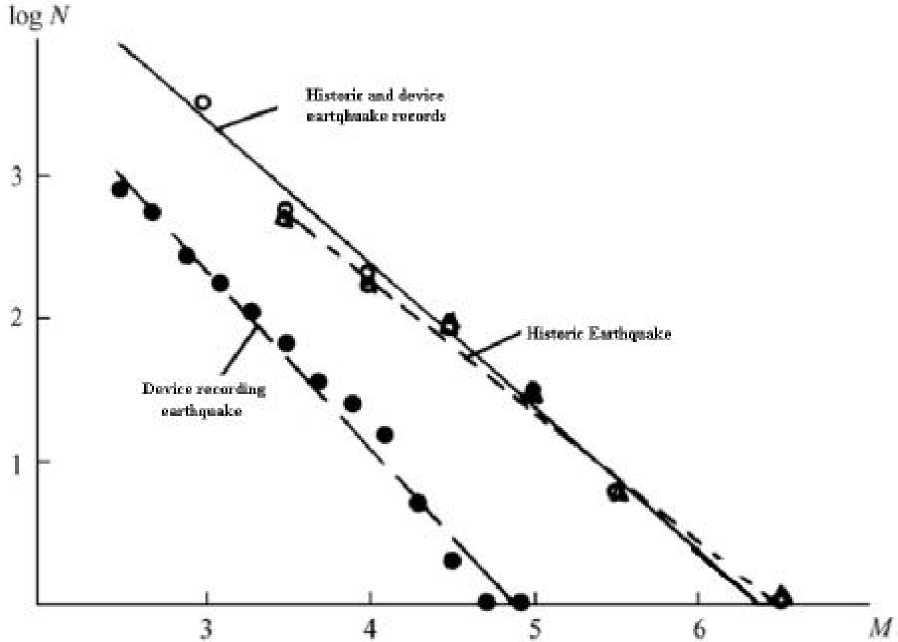
20 earthquake events Ms> 4.7



Isoseismic map
(Ms=6.7,1631, Changde)

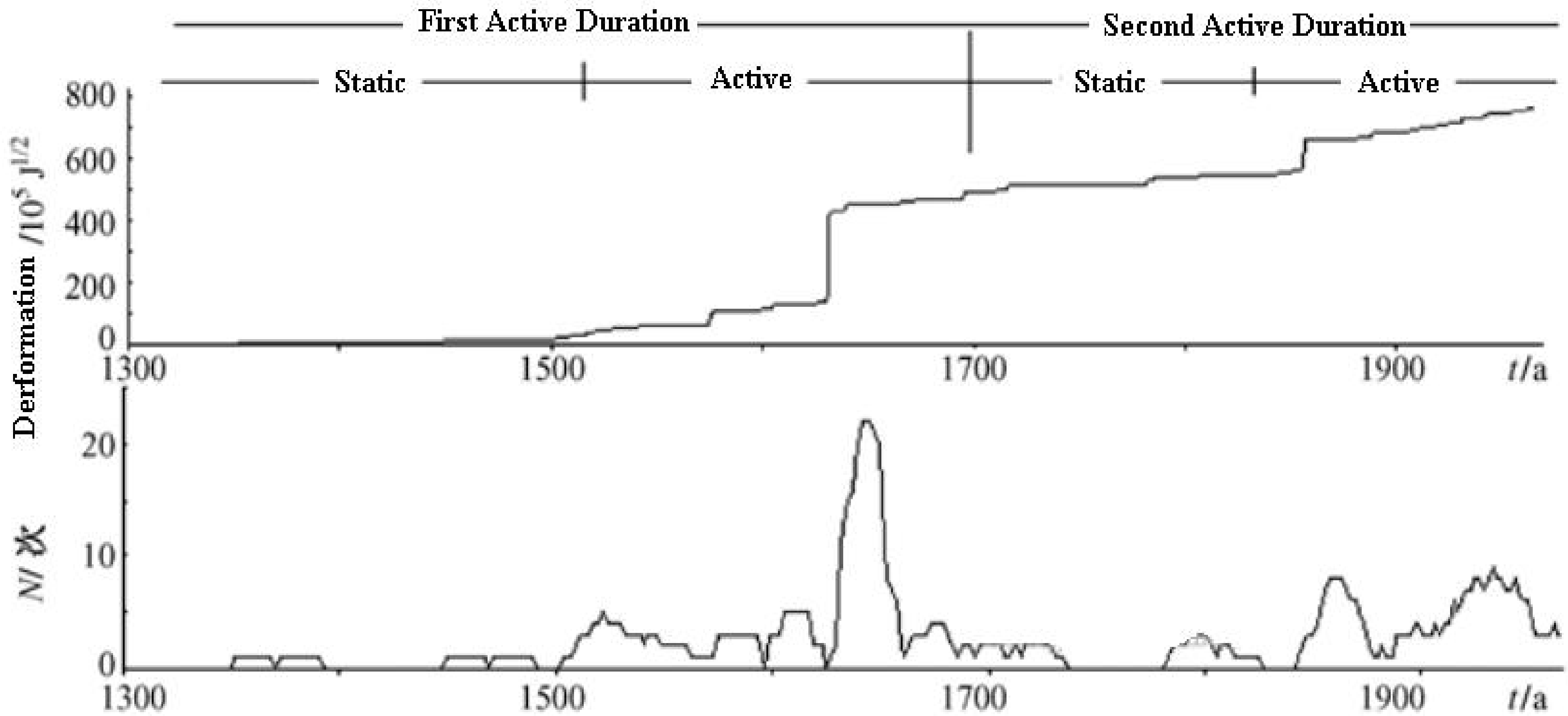
Earthquake events in Hunan Pro.

- Ms<4 147
- 4⩽Ms⩽4.5 43
- >4.5 24



Magnitude and total number based on three datum

Continental deformation and earthquake events



Models database

- Potential seismic source area models

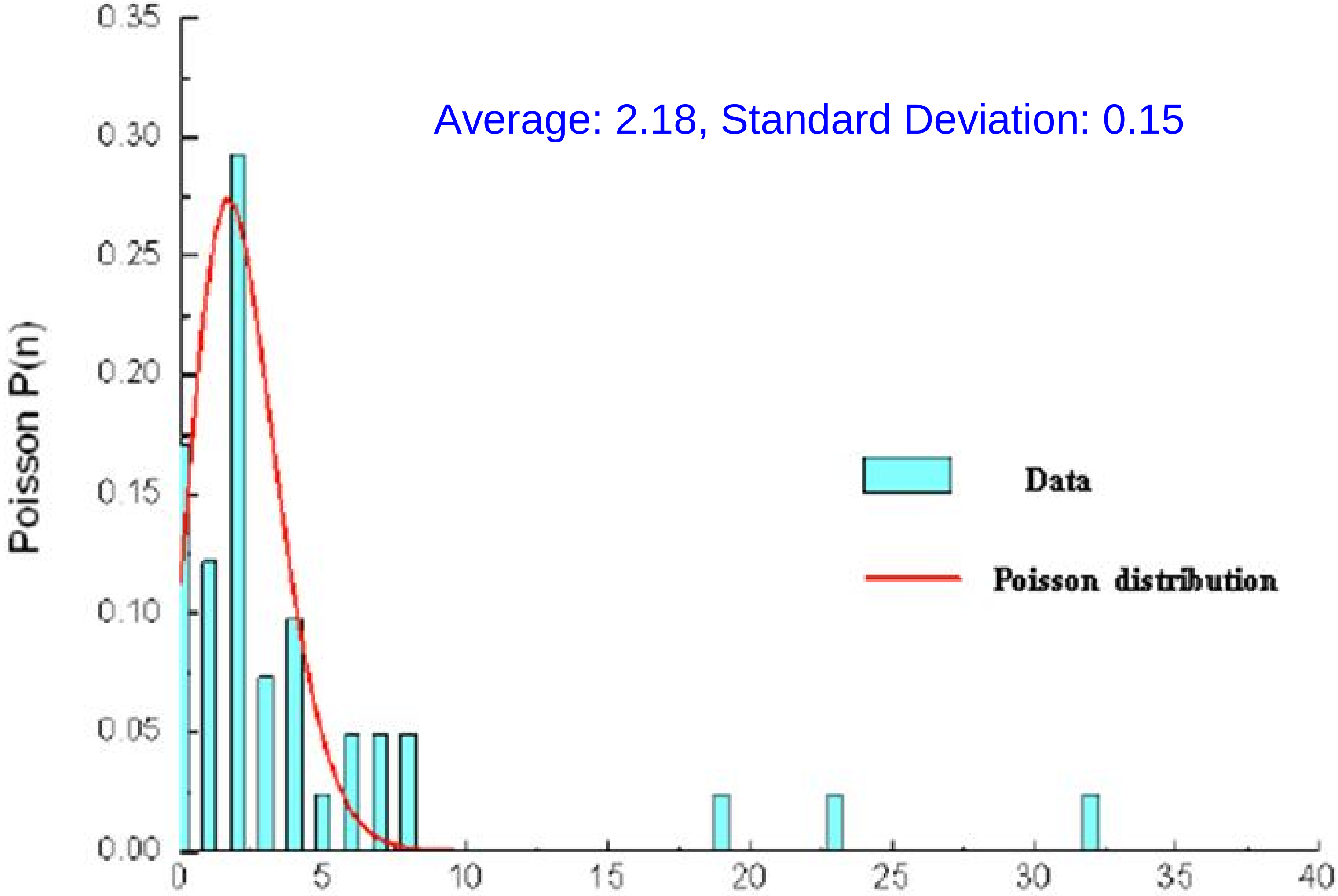
  --- tectonic model, seismological model, Hybrid model

- Earthquake source models—empirical models, New hybrid models(observed data and simulation data), earthquake observed model, etc

- Magnitude distribution models

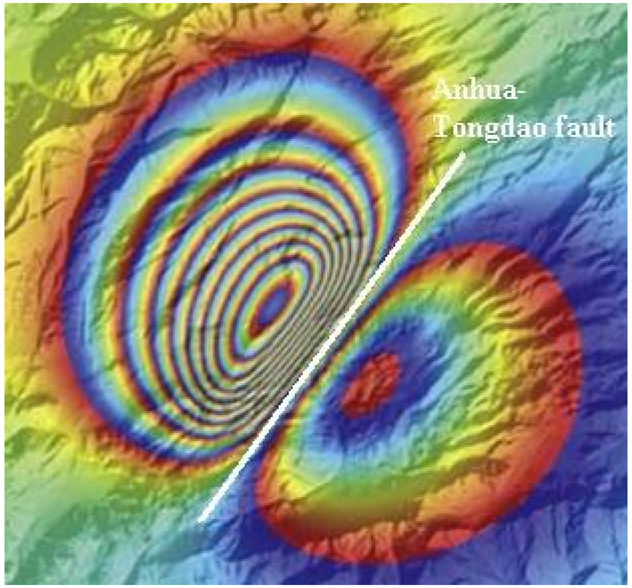
- Ground motion prediction models---Tao, Gao, Chen, Yu, Abrahamson and Silva, Boore, Campbell and Bozorgnia, Chiou and Youngs, Irikura, Si, Kanno, Idriss, Scherbaum, etc.

- Site response models—linear models, nonlinear models

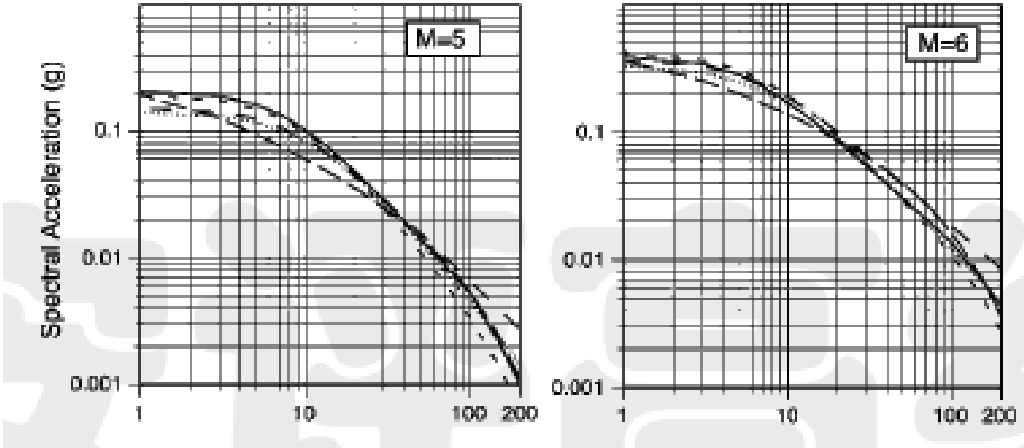


Earthquake events distribution model

Results



fault rupture modeling

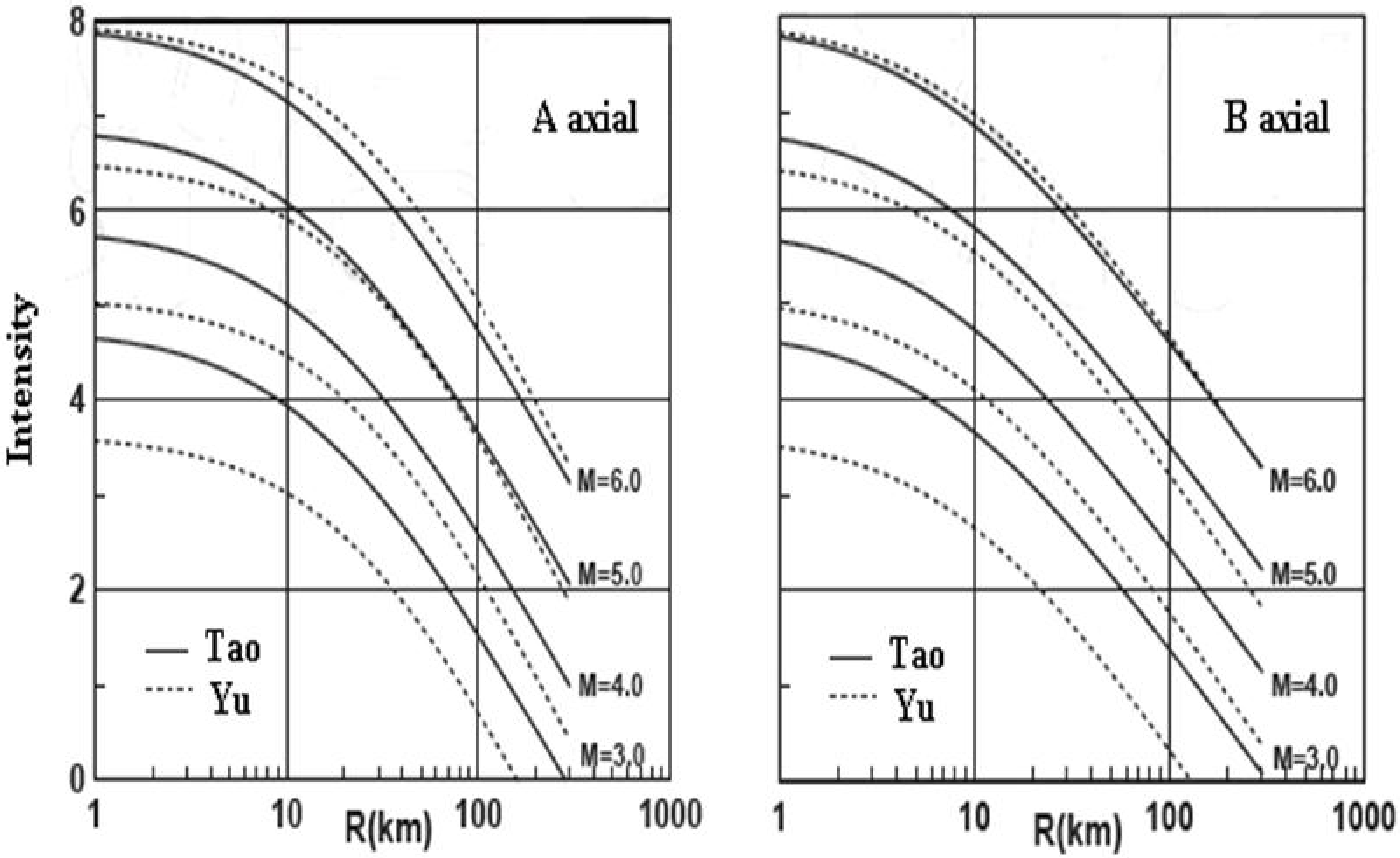


Attenuation Relationship of Spectrum Acc.

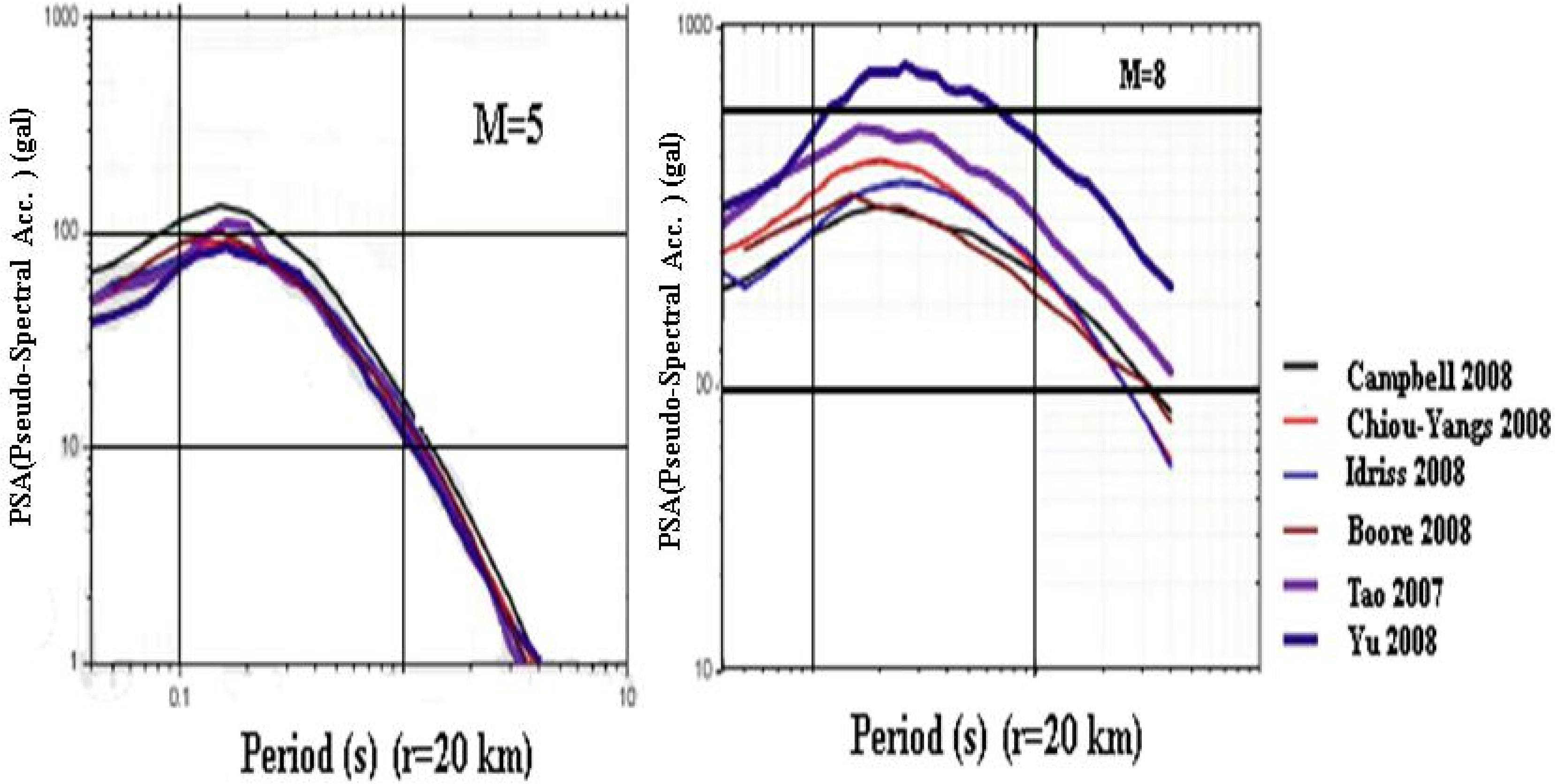
$$I=A+BM+Clg(R+R_0)$$

Zone	A	B	C	R_0	σ	
1	5. 6018	1. 4347	−4. 4899	25	0. 5924	**Western**
	3. 6113	1. 4347	−3. 8477	13	0. 5924	
2	6. 458	1. 2746	−4. 4709	25	0. 6636	**Northern**
	3. 3682	1. 2746	−3. 3119	9	0. 6636	
3	5. 7123	1. 3626	−4. 2903	25	0. 5826	**Eastern**
	3. 6588	1. 3626	−3. 5406	13	0. 5826	
4	5. 841	1. 071	−3. 657	15	0. 5200	**Southern**
	3. 944	1. 071	−2. 845	7	0. 5200	

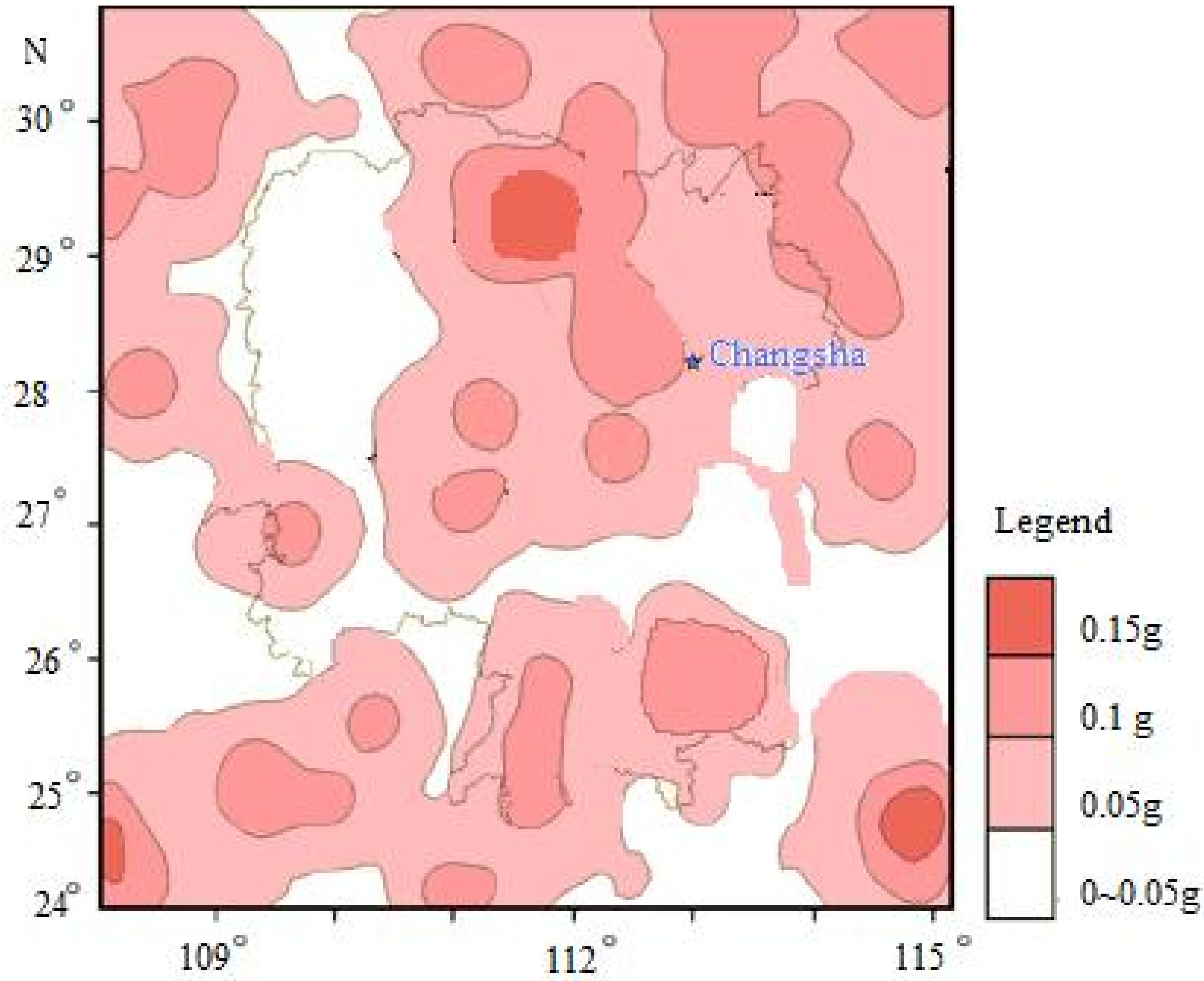
Intensity attenuation model in different division based hybrid data



Intensity attenuation model for different expects



PSA attenuation model for different expects



PGA distribution based on Logic tree methed

Conclusions

- Although it is now common practice to treat uncertainty in seismic hazard analysis with a logic tree approach, there is no standard procedure that describes how the tree should be constructed. Herein, we shared our experience on this subject by presenting the strategy that was adopted to build a logic tree for Low seismological province. As the greater magnitude, the much more uncertainty

- Gathering as much knowledge and Data as possible from independent sources and different methods, and Logic tree method can capture the epistemic uncertainties and do a sensitivity analysis to check the impact on the seismic hazard

- Expects including multidisciplinary are a good way to get and deal with epistemic uncertainties

- GIS is a powerful tool to set up a Logic tree for PSHA

Thanks for your attentions !

Questions and comments ?