

Scenario earthquake- Link of Probabilistic and Deterministic SHA's

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Why combine the two

- Engineering seismic hazard assessment, so called PSHA, is now widely adopted in zoning maps at national, regional and city level in the world.
- In probabilistic seismic hazard assessment, ground motion from earthquake with magnitude in interval M_j and in k^{th} potential area is estimated by means of attenuation relationship.
- The attenuation relation is a kind of simplification, taking magnitude for source mechanism, distance for path of wave propagation, and the source is considered as a point.
- Ground motion at the near field of large earthquake must be overestimated or underestimated, since the energy from a quite large source (rupture plane) is concentrated on a point (hypocenter).

Why combine the two (cont. 1)

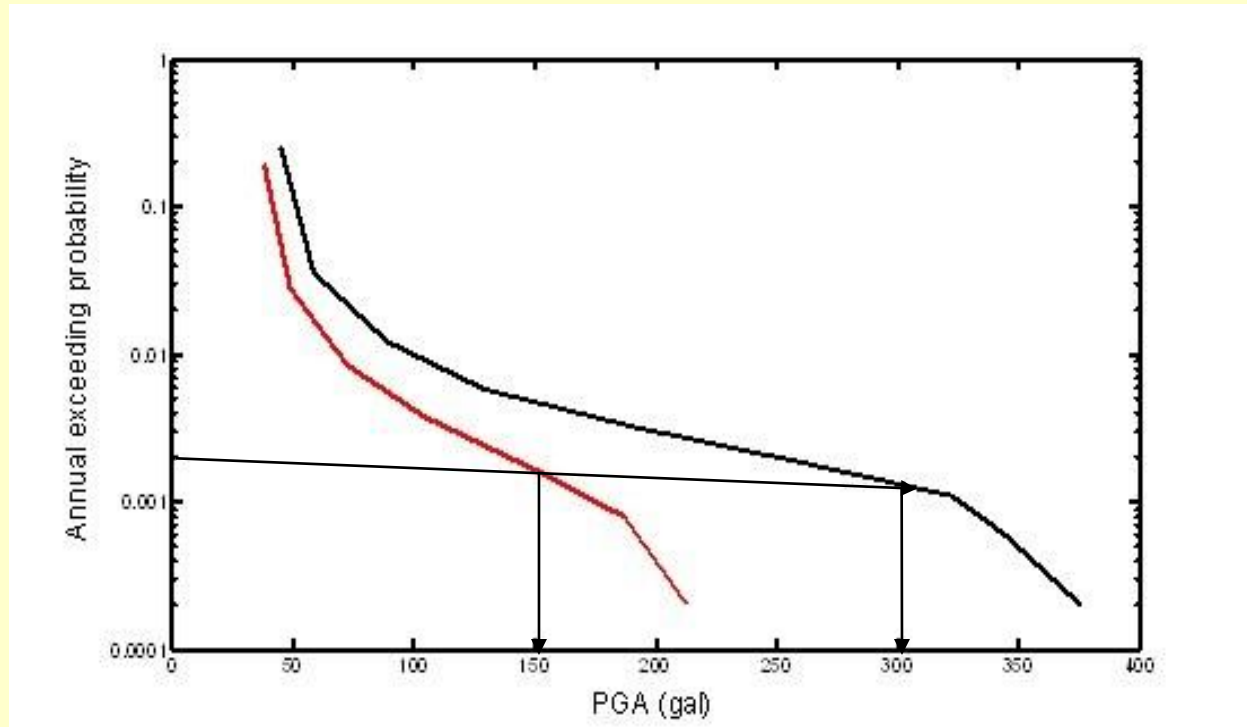
- Strong ground motion at near field is well known complicated since it is governed by the source predominately and the source of large earthquake is quite complicated in general.
- In that case, a rupture plane is needed to characterize the source, for otherwise the ground motion tends to be overestimated, and the near fault effect cannot be simulated.
- Finite fault model is currently adopted in strong ground motion simulation to describe near-fault rupture directivity effect and hanging wall effect which strongly influence the distribution of ground motion amplitudes on rock sites in the near fault region.

Why combine the two (cont. 2)

- A new idea is proposed to combine the two approaches, the key step is how to establish a link between the two.
- Benefit of seismic zoning map is mainly from mitigation of loss and casualty in cities in large earthquake.
- To describe the probabilistic seismic hazard of a city, scenario earthquake is widely adopted, with some strong queries, since the difference between hazard from an earthquake and that from earthquakes with various magnitudes in many areas.

How to build a link

- The way to deal with a scenario earthquake is the key step to build a link between PSHA and DSHA.
- This is seismic hazard curves of a city in case study by PSHA

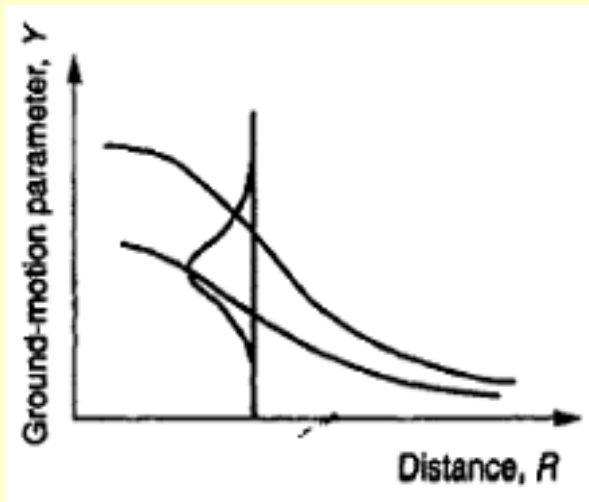


Uncertainty correction of seismic hazard

$$P(Y_C > y) = \int_{-3\sigma}^{3\sigma} P(Y > y \cdot e^{-\varepsilon}) \cdot f(\varepsilon) d\varepsilon$$

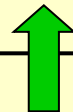


$$\lg Y = C_0 + C_1 M + C_2 M^2 + C_3 \lg(R + C_4 e^{C_5 M}) + C_6 R + \varepsilon$$

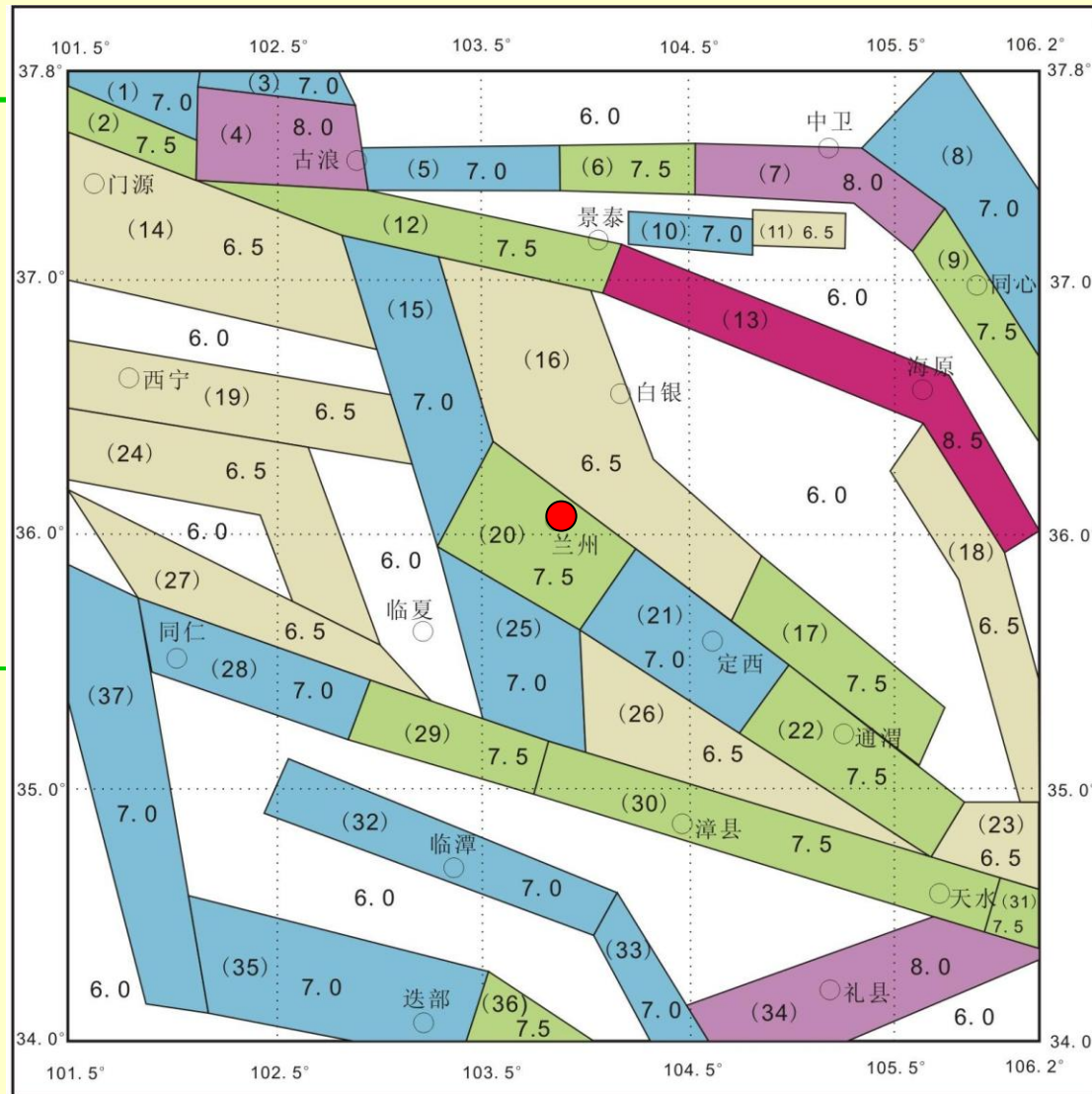


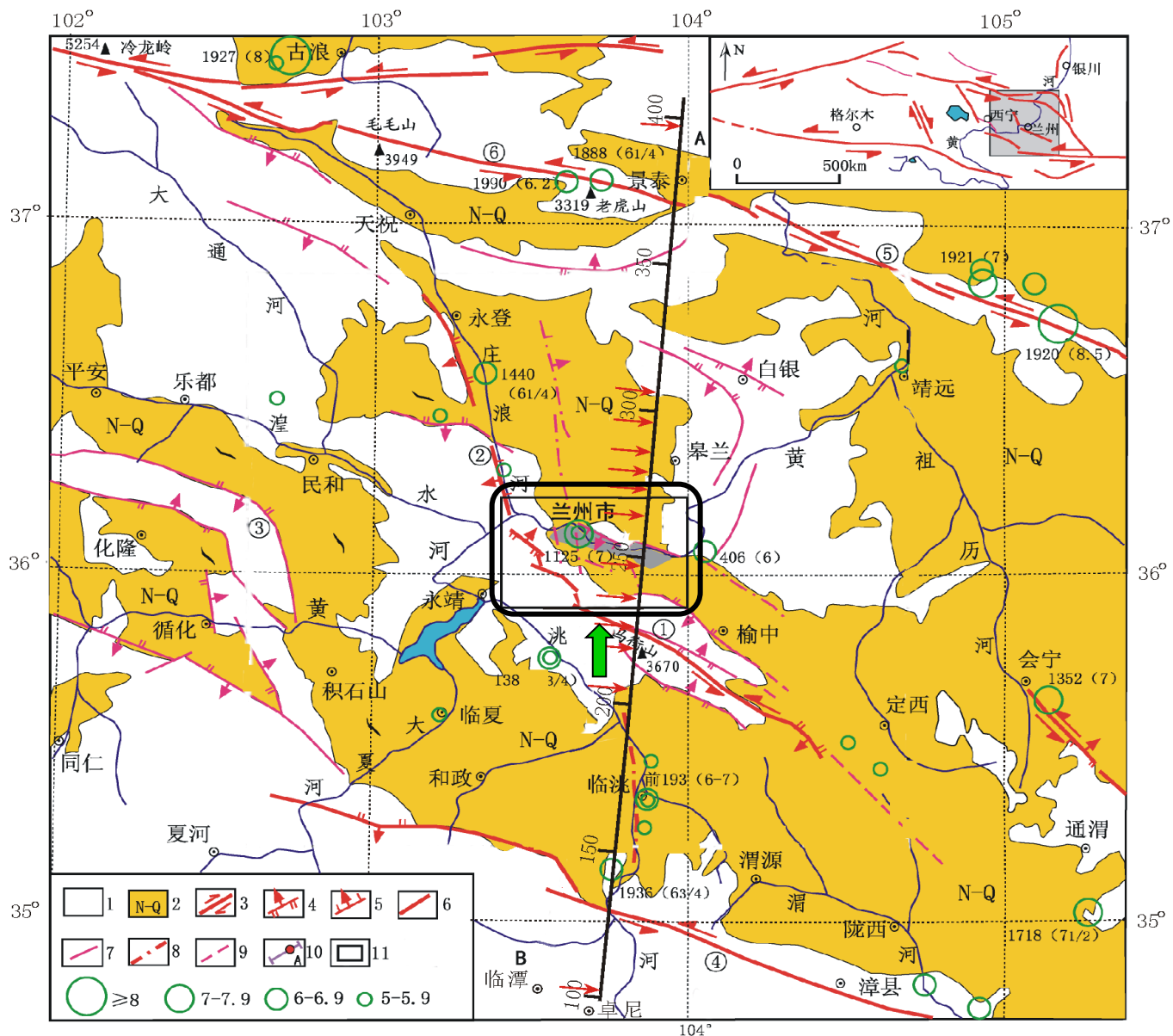
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3	0.0002							
4	0.0058	0.0001						
5	0.0011							
6	0.0165							
7	0.0065							
9	0.0015							
10	0.0017							
12	0.0081							
13	0.0083	0.0018						
14	0.0003							
15	0.0120	0.0024	0.0005	0.0001				
16	0.0121	0.0009	0.0001					
17	0.0060	0.0005						
19	0.0024	0.0000						
20	0.0627	0.0159	0.0068	0.0034	0.0017	0.0008	0.0002	
21	0.0200	0.0027	0.0003					
22	0.0033	0.0001						
24	0.0021	0.0000						
25	0.0210	0.0040	0.0008	0.0002				
26	0.0028							
27	0.0007							
28	0.0025							
29	0.0040	0.0002	0.0000	0.0000				
30	0.0038							
31	0.0006							
32	0.0010							
33	0.0005							
34	0.0066							
36	0.0008							
37	0.0001							

潜源编号	40.00	80.00	120.00	160.00	200.00	250.00
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13	0.0018					
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17	0.0005					
19	0.0000					
20	0.0159	0.0068	0.0034	0.0017	0.0008	0.0002
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22	0.0001					
24	0.0000					
25	0.0040	0.0008	0.0002			
29	0.0002	0.0000	0.0000			

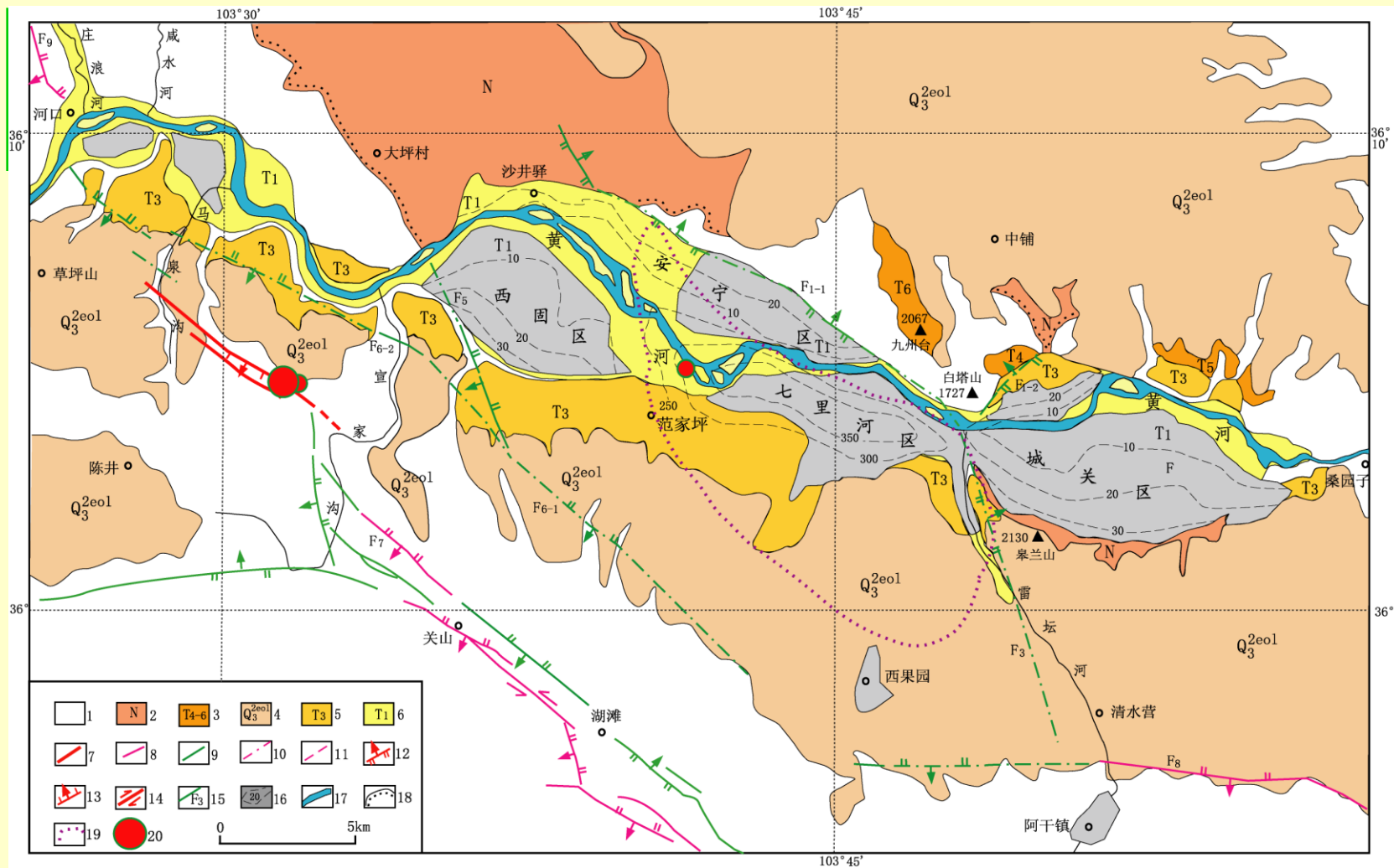


The second Meeting of JRCP, Jeju, Korea, 2012



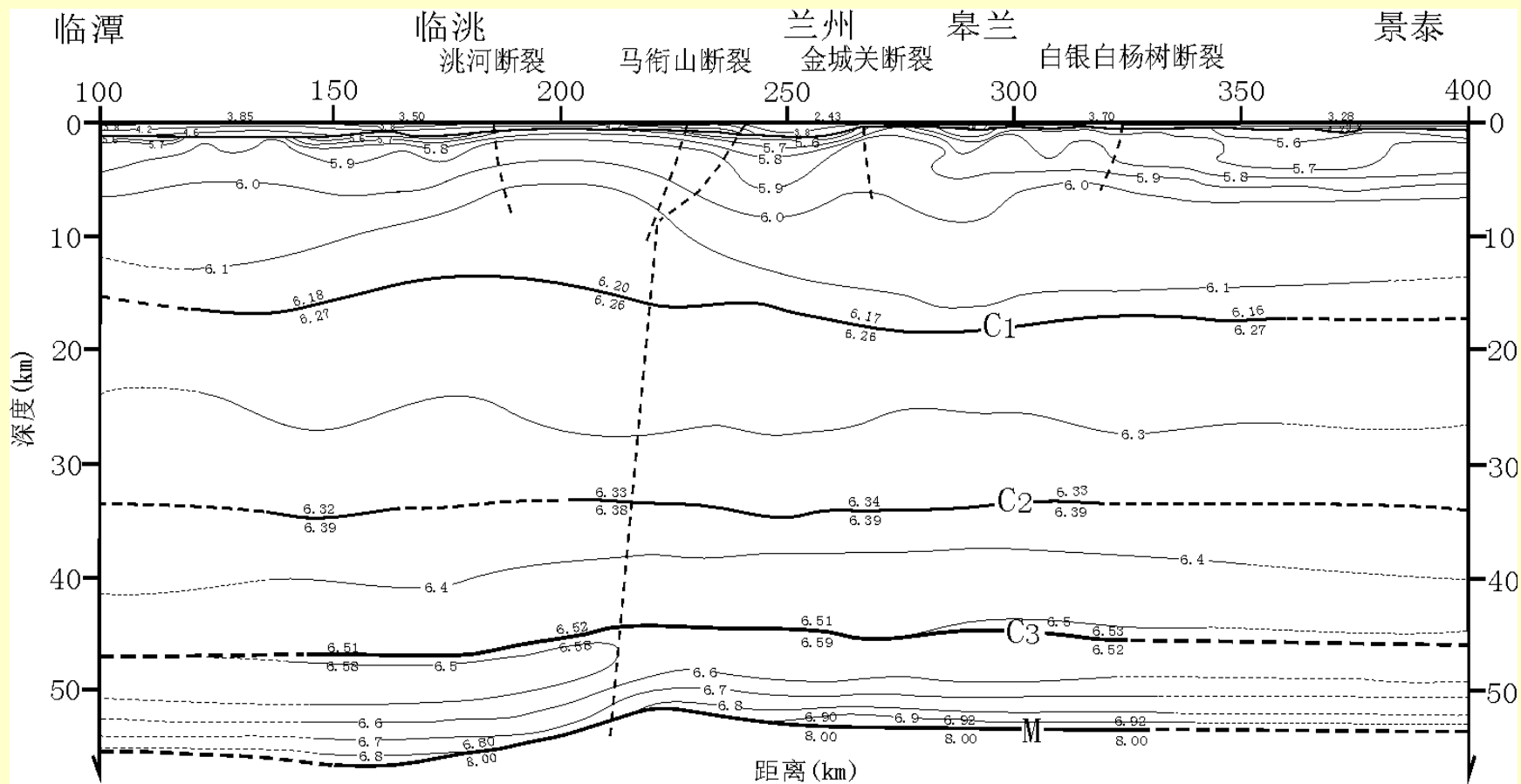


1. 前第三系； 2. N-Q盆地； 3. 走滑断裂； 4. 逆断裂； 5. 正断裂 6. 全新世断裂； 7. 晚更新世断裂；
 8. 隐伏断裂； 9. 推测断裂； 10. 人工地震折射剖面及炮点位置； 11. 兰州市放大图。
 ①马衙山断裂； ②庄浪河断裂； ③拉脊山断裂； ④西秦岭北缘断裂； ⑤海原断裂； ⑥老虎山-毛毛山断裂。



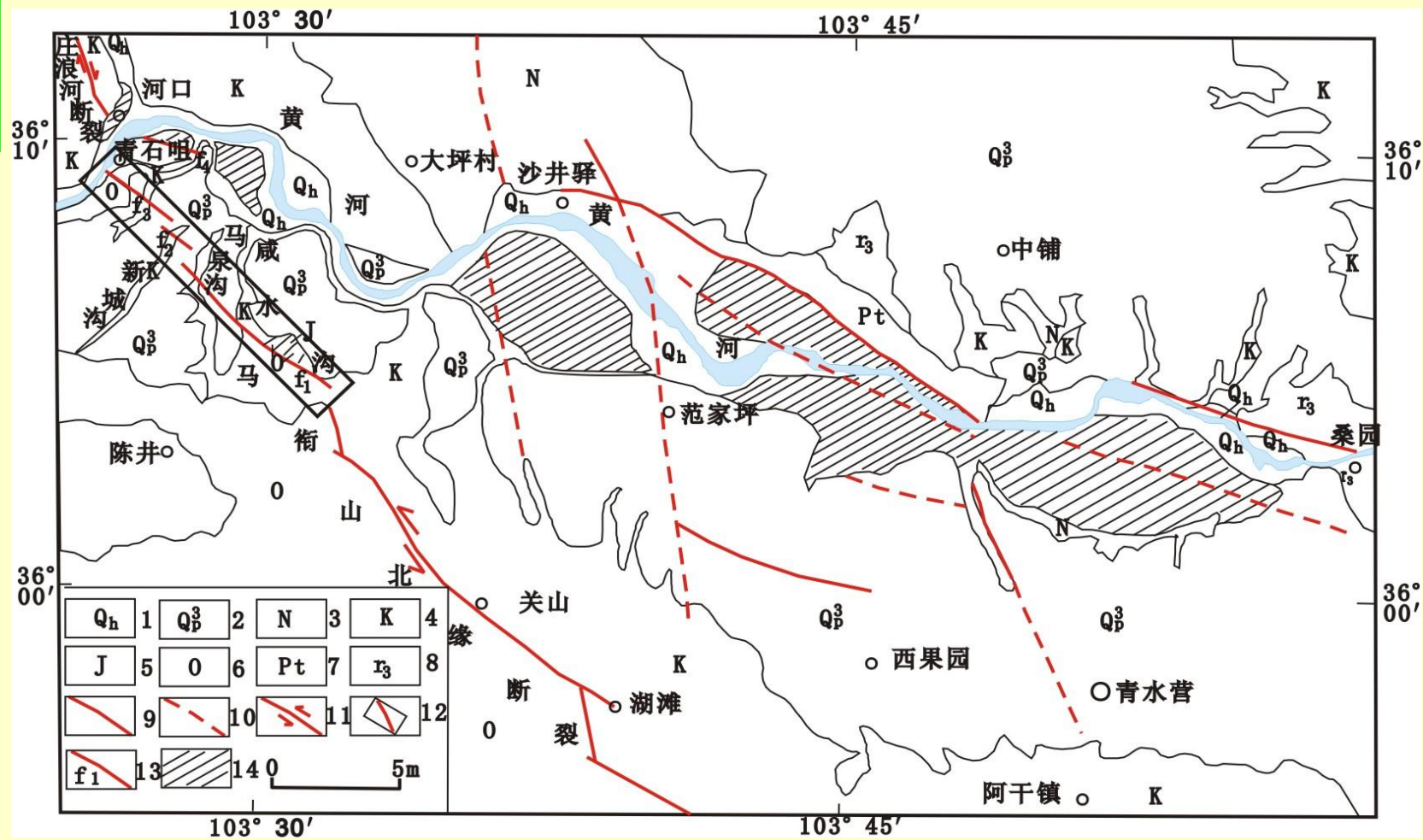
Exceeding Probability	63% in 50 years	10% in 50 years	2% in 50 years
PGA (gal)	59	192	345
Magnitude	5.7	6.5	7.0
Distance (km)	30	21	16
Causative fault	Maxianshan North Fault	Western segment of Maxianshan North Fault	Midele and Eastern segments of Maxianshan North Fault

Parameter	Magnitude 6.5	Mean value
Rupture area S	$\log S = M_w - 4.0$	136 km ²
Rupture width W	$\log W = 0.5 M_w - 2.125$	8 km
Rupture length L	$L = S/W$	17 km
Average slip on the rupture \bar{D}	$\log \bar{D} = 0.5 M_w - 1.45$	146 cm



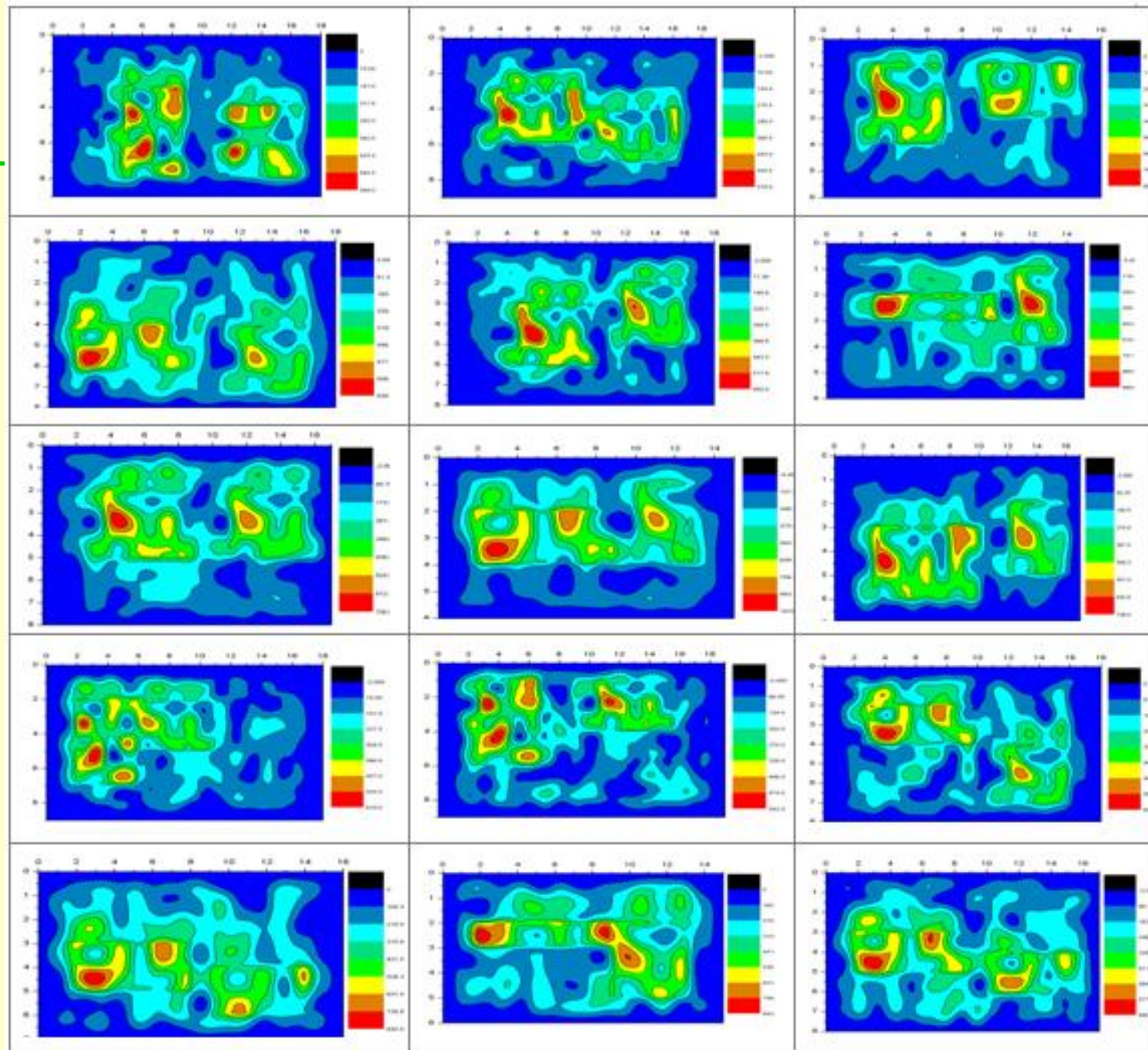
图例 $\frac{6.51}{8.00}$ 地震界面与速度值(km/s) (6.0 速度等值线(km/s) ---推断界面 -C- 壳内界面 -M-莫霍界面 -/- 推测断裂

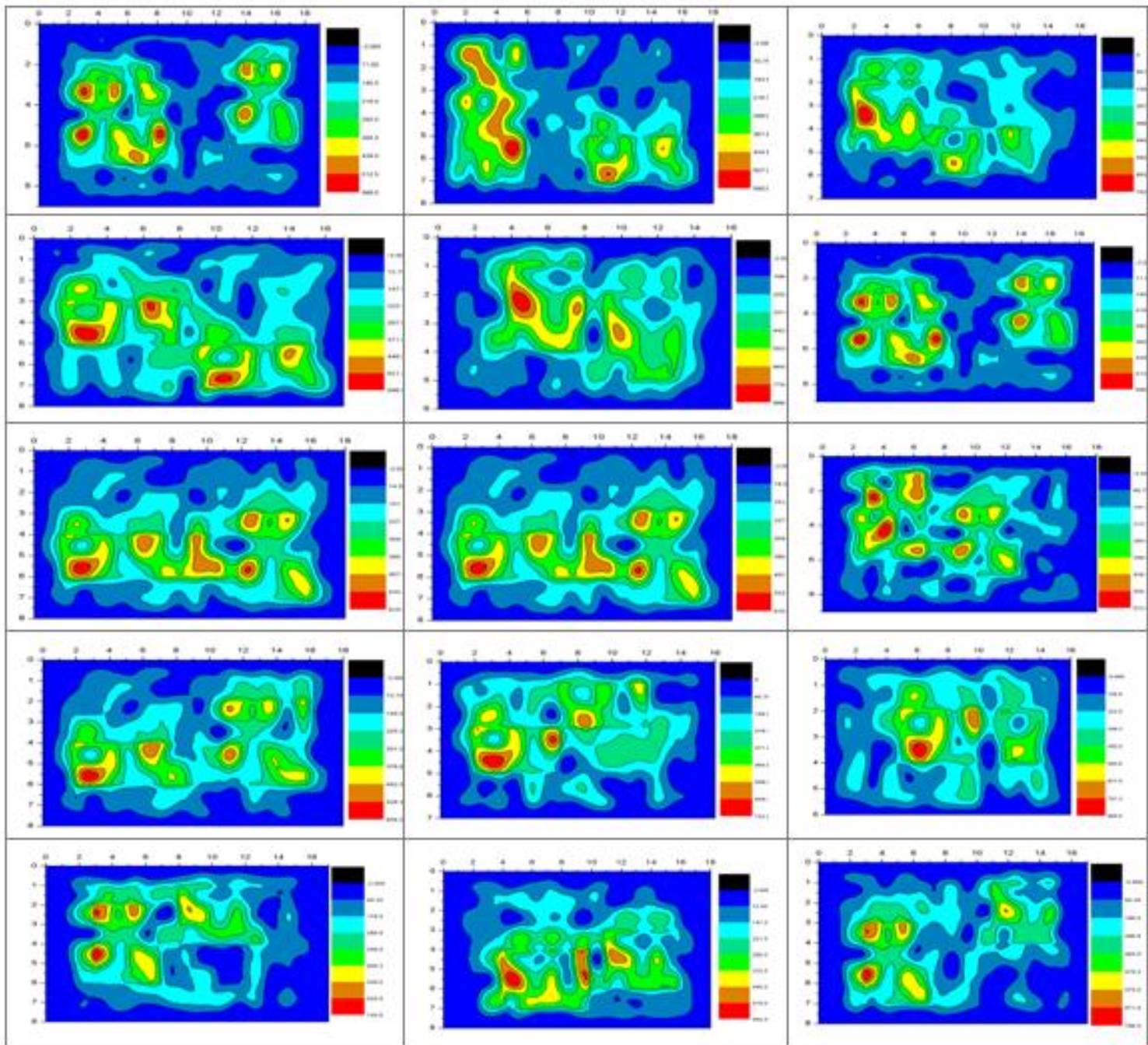
Parameter	Max. Asperity	Other Asperity
Asperity area (km ²)	$\log S_{am} = \log S - 0.92$	$\log S_a = \log S - 0.65$ $S_{ao} = S_a - S_{am}$
Asperity length (km)	$\log L_{am} = 0.5L - 2.31$	$L_{ao} = S_{ao} / W_{ao}$
Asperity width (km)	$W_{am} = S_{am} / L_{am}$	$W_{ao} = \xi_W \sqrt{S_{ao}}$
X coordinate of Asperity center (km)	$\log x_{am} = \log L - 0.72$	$X_{ao} = \xi_X (L - X_2)$
Y coordinate of Asperity center (km)	$\log y_{am} = \log W - 0.28$	$Y_{ao} = \xi_W \times W + W_{ao} / 2$
Average slip of Asperity (cm)	$\log \bar{D}_{am} = \log \bar{D} + 0.39$	$\log \bar{D}_{ao} = M_w + 0.31$

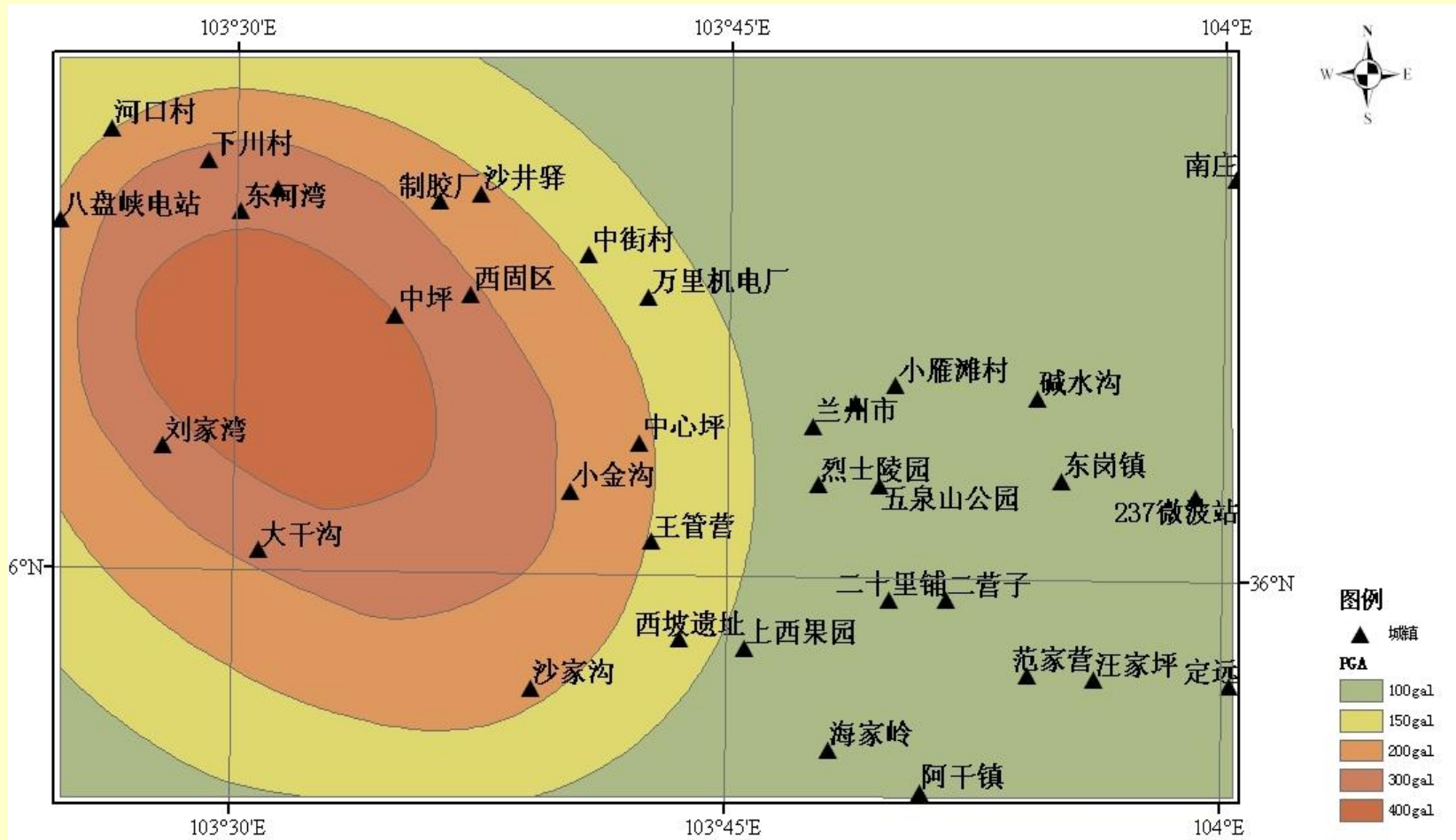


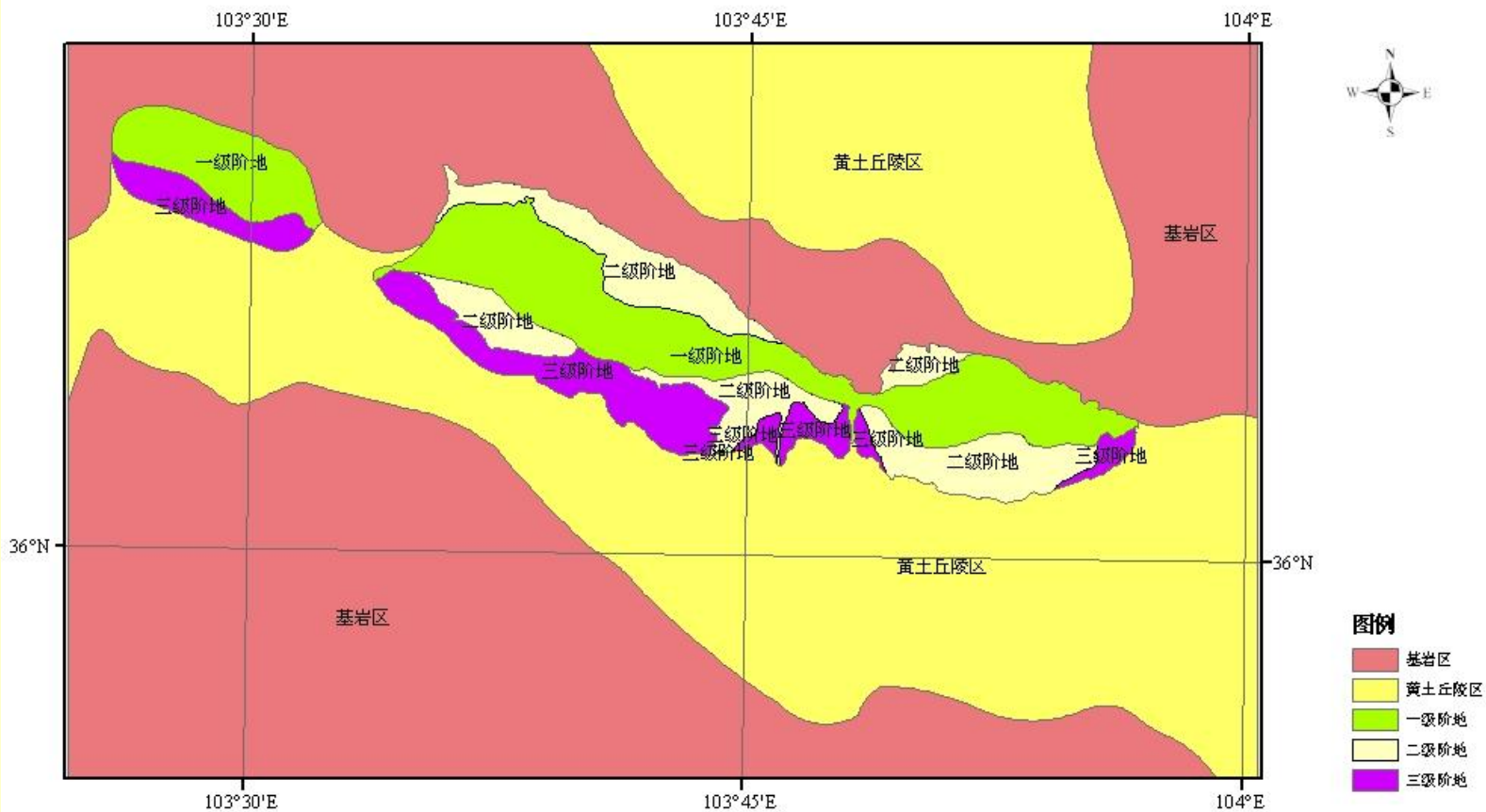
Magnitude 6.5	Mean value
$\log k_{cx} = 1.89 - 0.5M_w$	0.0437
$\log k_{cy} = 2.09 - 0.5M_w$	0.0692

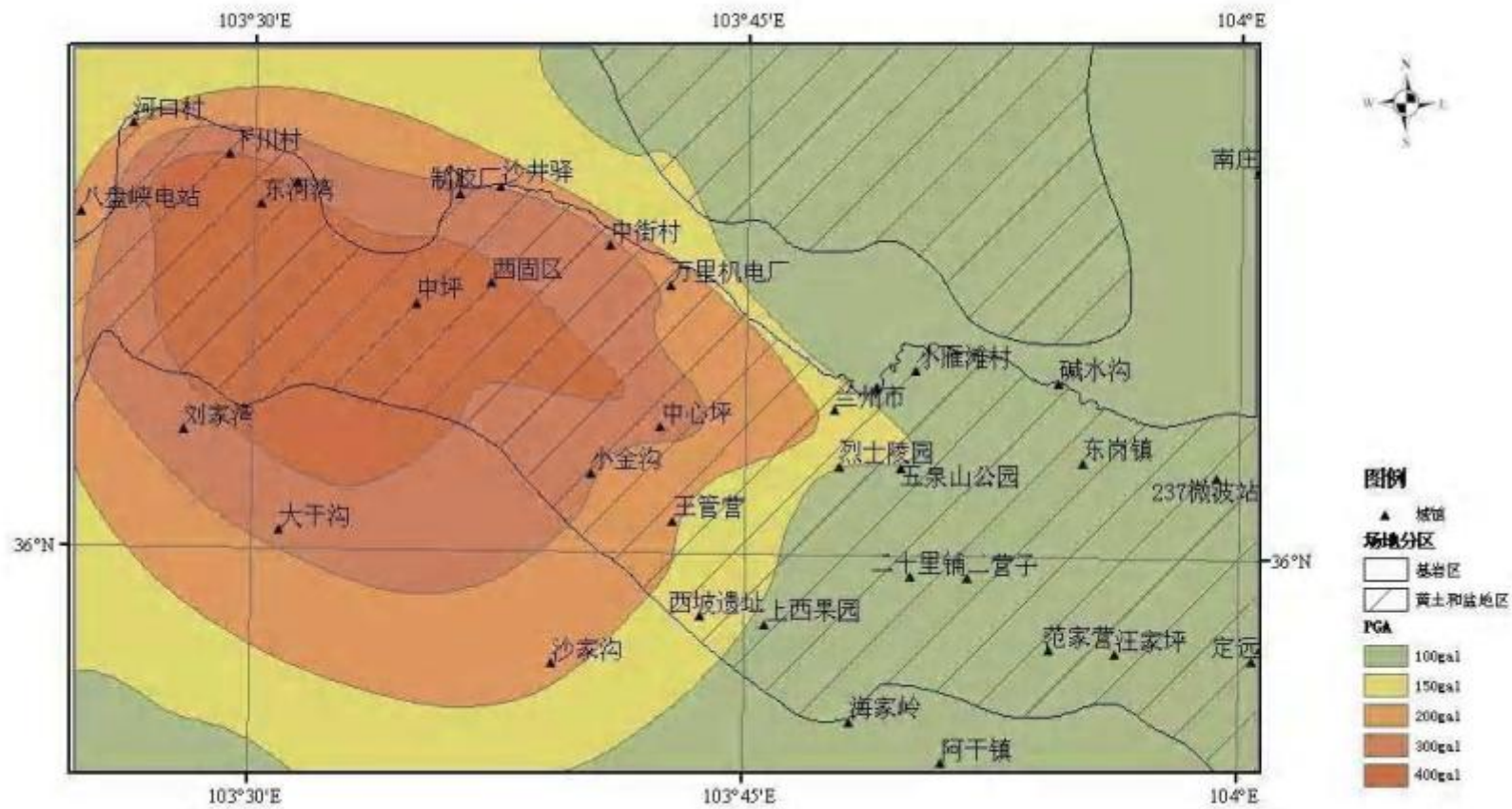
$$D(k_x, k_y) = \frac{\bar{D} \cdot L \cdot W}{\sqrt{1 + \left(\left(\frac{k_x}{k_{cx}} \right)^2 + \left(\frac{k_y}{k_{cy}} \right)^2 \right)^2}} e^{i\Phi(k_x, k_y)}$$

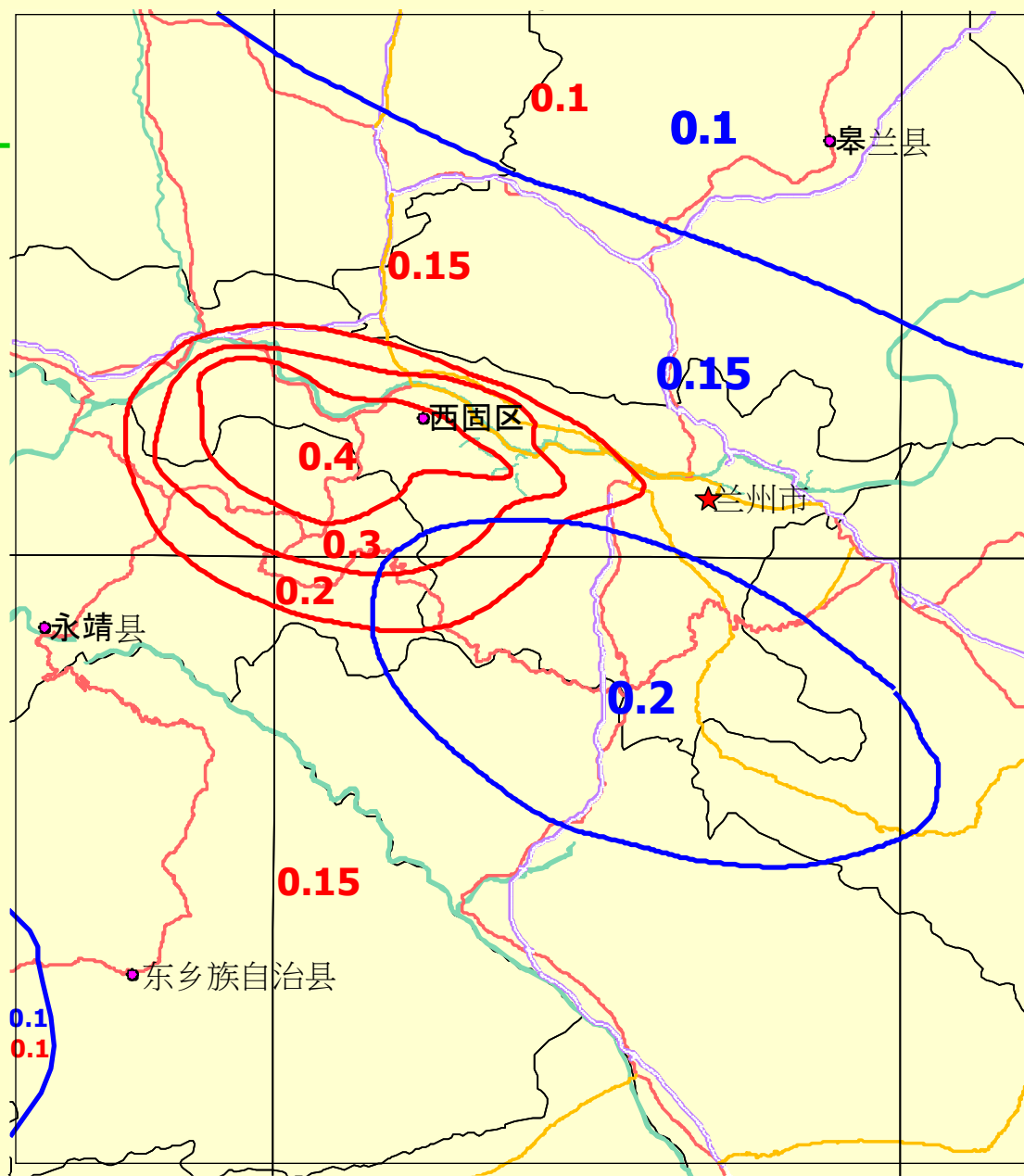


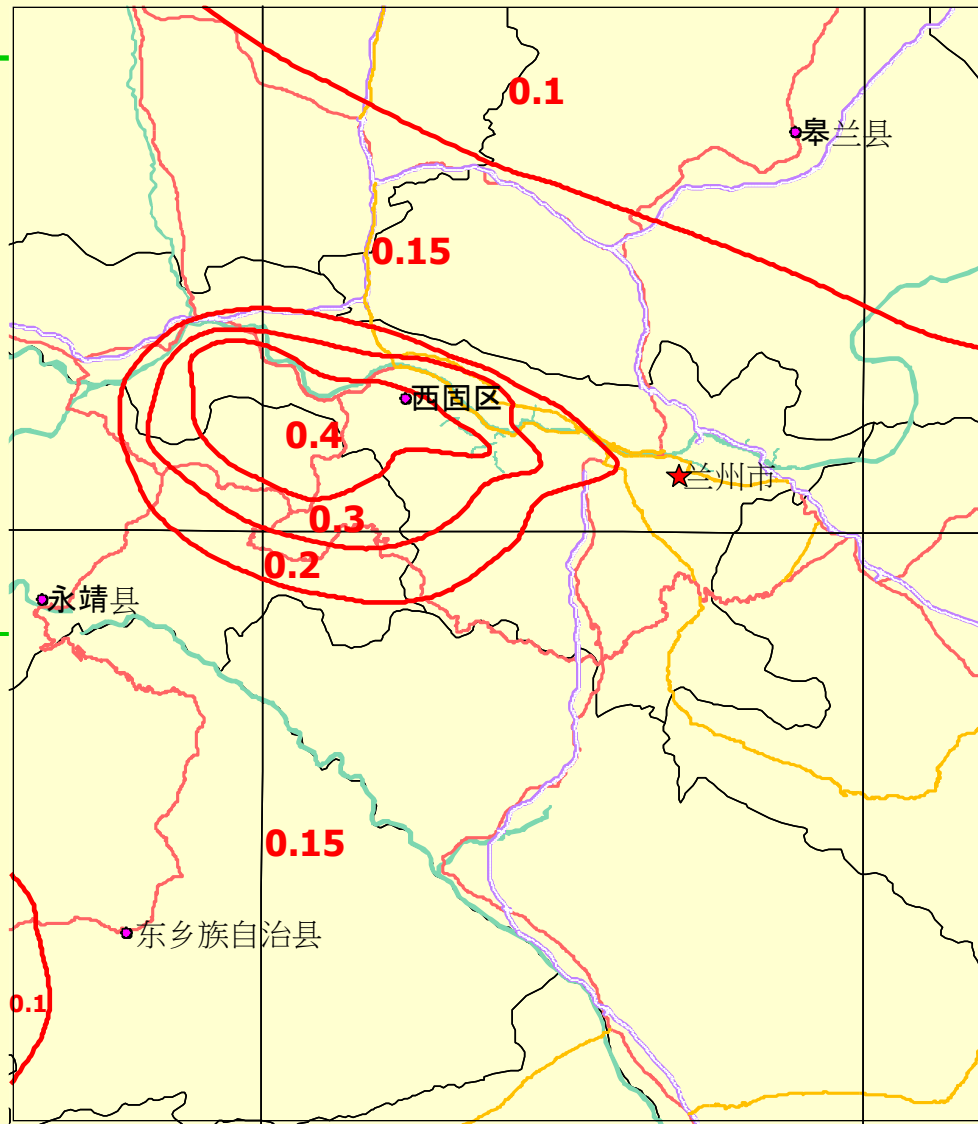












Conclusion

- A new idea is proposed to combine the PSHA and DSHA approaches for the next generation map.
- Scenario earthquake is emphasized as the key step to establish a link between the two.
- From a case study, the detail hazard result by mean attenuation relation is examined, and the most potential source area is acquired for a given exceeding probability.
- A distance range is then fixed from the segmentation of the main active fault in the source area, and the corresponding magnitude is calculated from the PGA by PSHA by the mean attenuation law.
- The magnitude is checked from the upper bond magnitude of the potential area.

Conclusion (cont.1)

- Finite fault source model is built from the checked magnitude with the fault data as much as possible.
- 30 source models are presented to take into account uncertainty on global and local parameters.
- The ground motions at near field are synthesized, and average PGA is assigned to each rock site, and soil site as well by taking site condition into account further.
- The isoseismials constructed from the synthesized motion field is overlaid on that from PSHA, and the two are merged together as the final map by replacing the PSHA result at near field by the synthesized one.

Conclusion (cont.2)

- By this way, the scenario is the maximum confidential, from seismotectonic condition, the corresponding PGA by mean attenuation relation is the same as the PSHA result by the same relation.
- In this meaning, the isoseismals from the scenarion could be considered with that exceeding probabillity of the PSHA result, and can merged with that together.
- The uncertainty on source model has been taken into account, and that on attenuation could also be taken into account by the same way to synthesize more motion fields from each source model with different values of random error term in attenuation law.
- The high intensity area on the map is shifted now westwards reasonably as an improvement.
- The number of synthesis is determined by the stability of the mean PGA.

Thank you!

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Seismic hazard of a city by PSHA

