中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

Strong Motion, Damage, and Loss of Wenchuan Earthquake

Zifa Wang
Institute of Engineering Mechanics, China Earthquake Administration

August 18, 2008

Acknowledgement

This presentation uses a number of pictures and loss numbers aggregated based on the efforts of CEA field team after the earthquake, particularly from members of IEM. The numbers presented here are preliminary and the opinions expressed here are the personal ones of the presenting author and they do not necessarily reflect those of IEM and CEA.

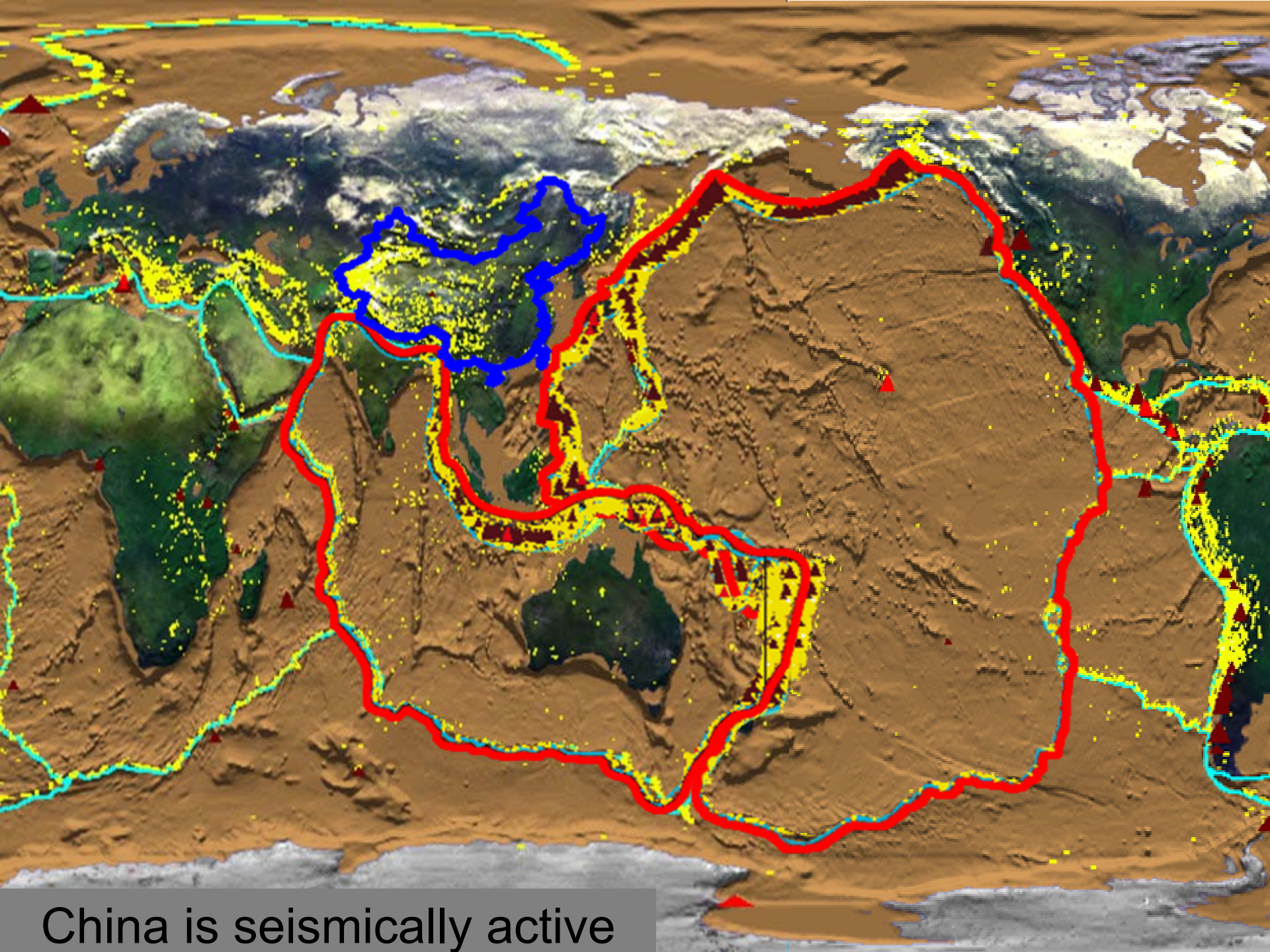
中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

Contents

- Historical Earthquakes in China
- Strong Motion
- Damage
- Response and Reconstruction Efforts
- Loss Estimation

中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

1□Historical Earthquakes in China


China is seismically active

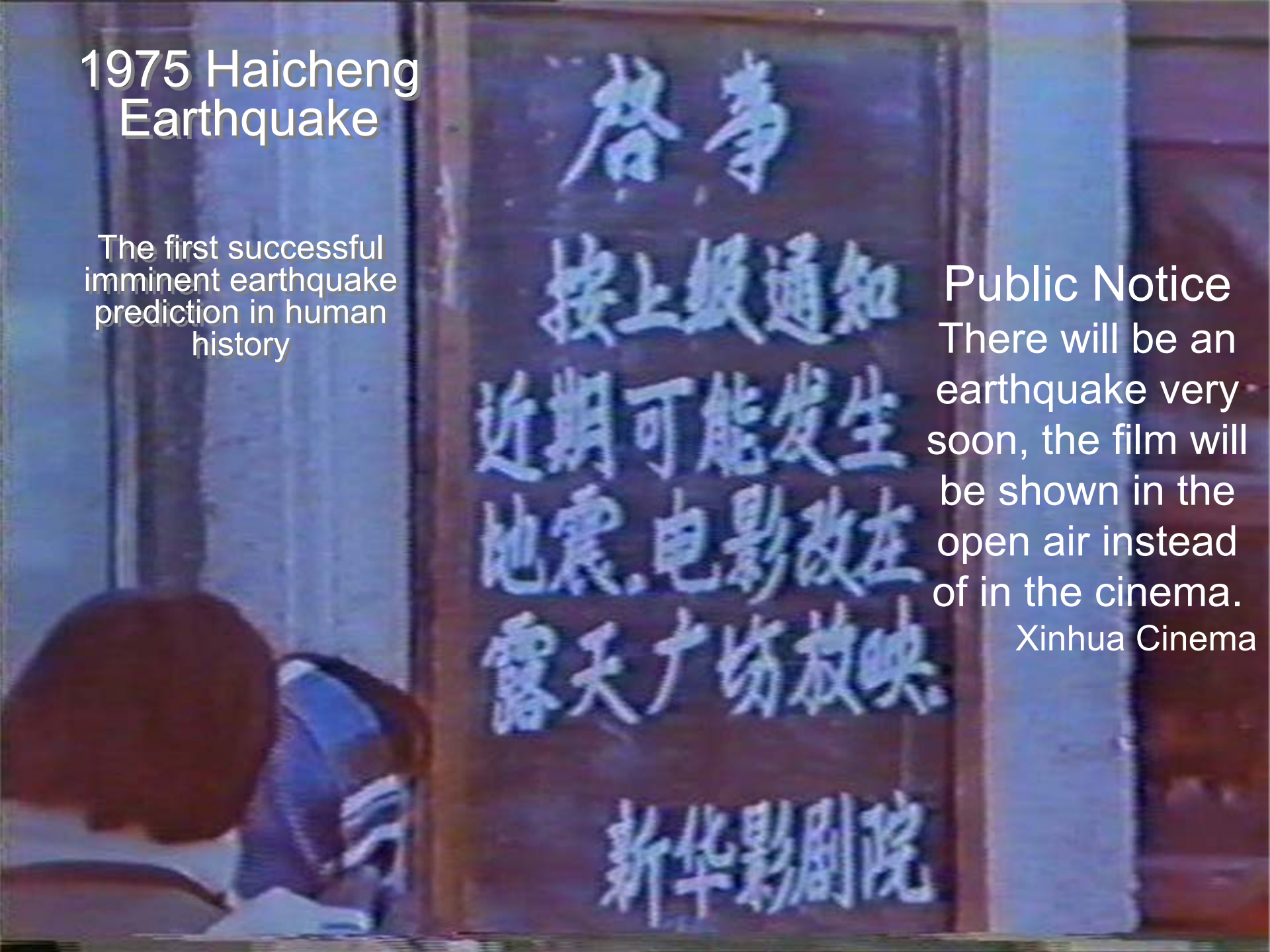
The Distribution of China Seismic Belt

Strong Earthquakes in the History of China

No.	Time	Location	M	Death
1	1303	Shanxi	8	200,000
2	1411	Tibet	8	
3	1556	Shaanxi	8.5	830,000
4	1654	Gansu	8	31,000
5	1668	Shandong	8.5	50 , 000
6	1679	Hebei	8	45,000
7	1739	Ningxia	8	50,000
8	1812	Xinjiang	8	58
9	1833	Tibet	8	5
10	1833	Yunnan	8	6,707
11	1879	Gansu	8	30,000
12	1902	Xinjiang	8.3	5,650
13	1920	Taiwan	8	5
14	**1920**	**Ningxia**	**8.5**	235,000
15	1927	Gansu	8	40,000
16	1931	Xinjiang	8	300
17	1950	Tibet	8.6	3,300
18	1951	Tibet	8	
19	**1976**	**Tangshan**	**7.8**	**242,000**
20	**2008**	**Wenchuan**	**8.0**	**69,000+**

1975 Haicheng Earthquake

The first successful imminent earthquake prediction in human history



Public Notice

There will be an earthquake very soon, the film will be shown in the open air instead of in the cinema.

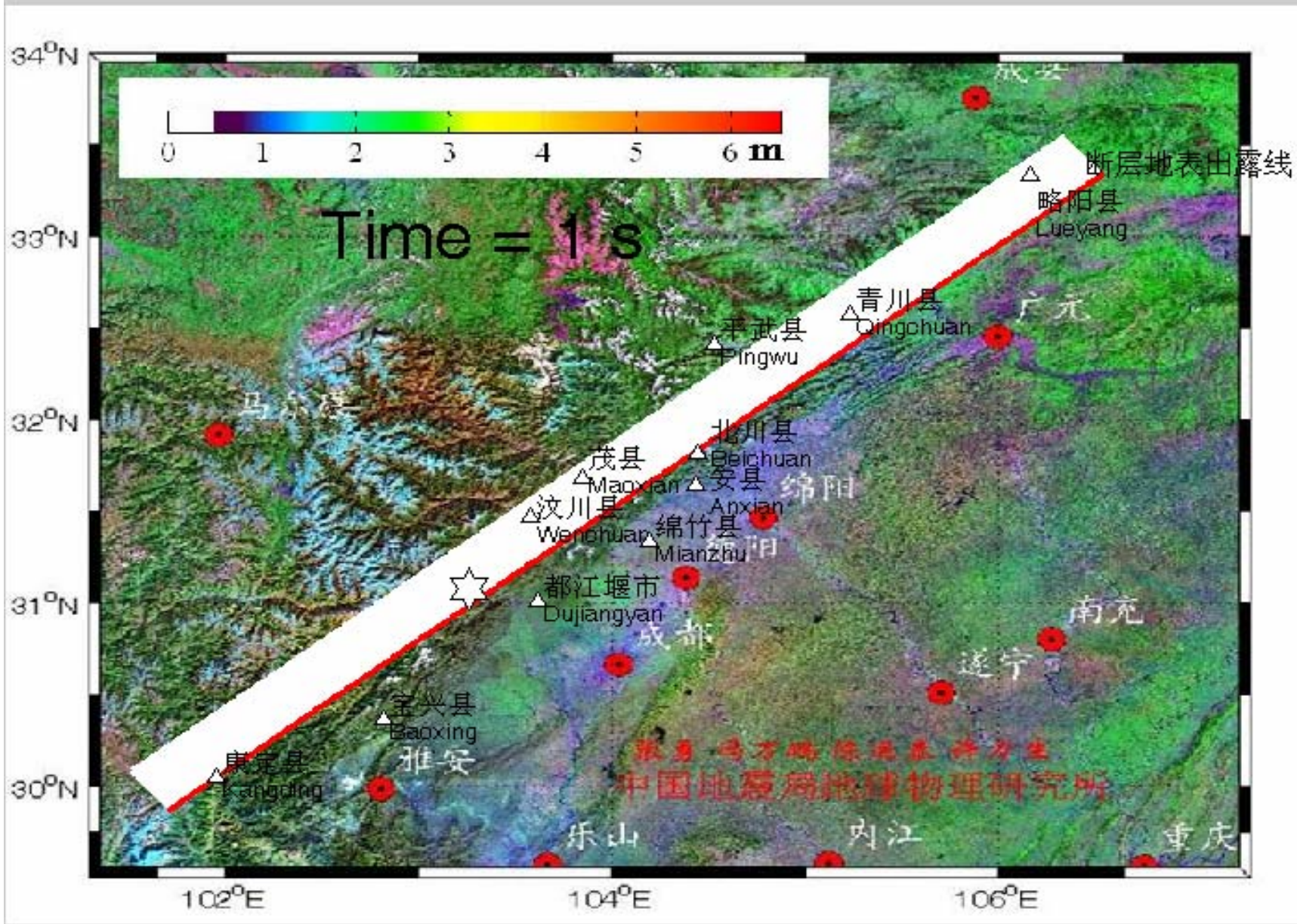
Xinhua Cinema

The 1976 Tangshan Earthquake

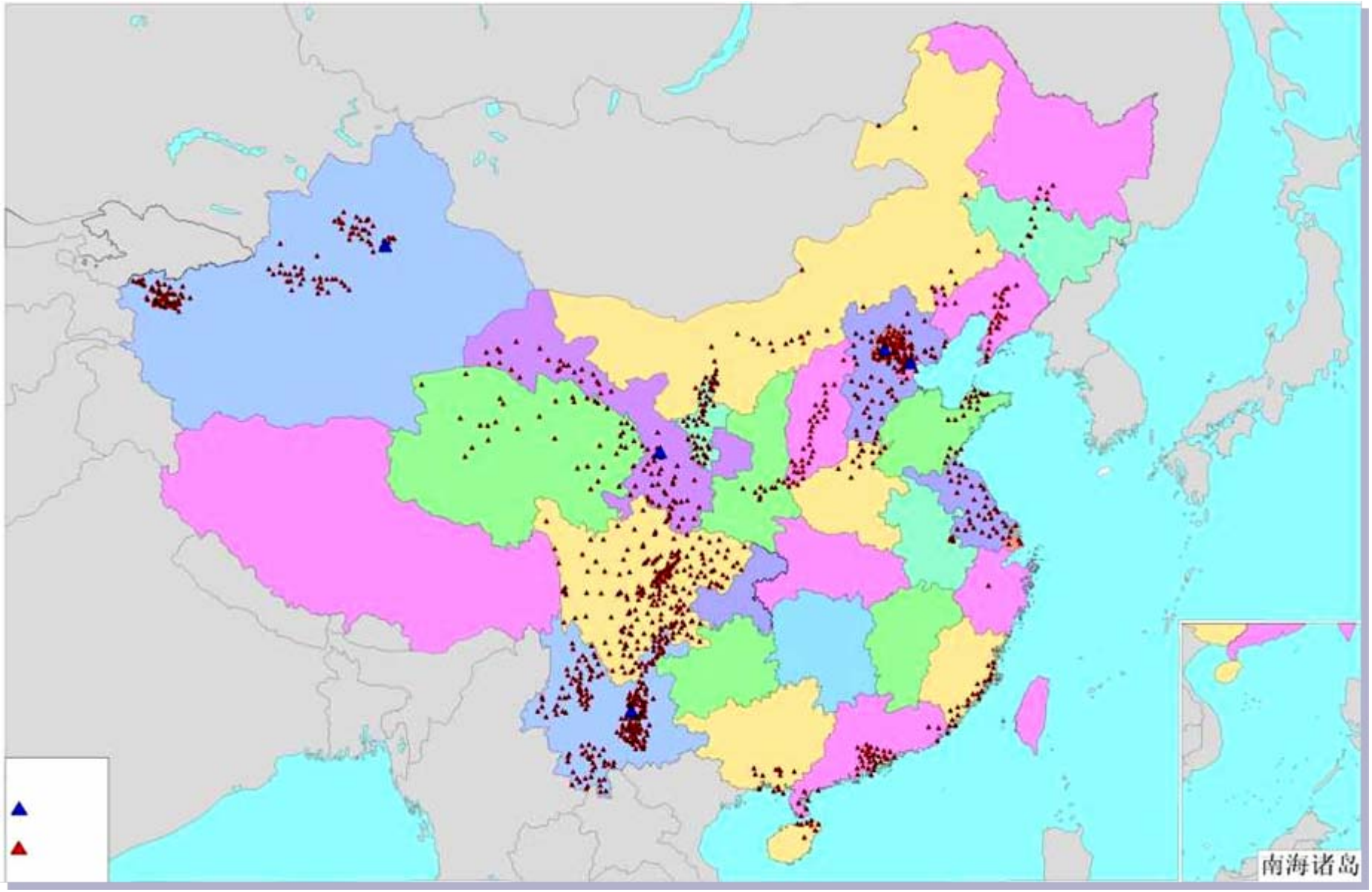
2□Strong Motion

Earthquake Parameters

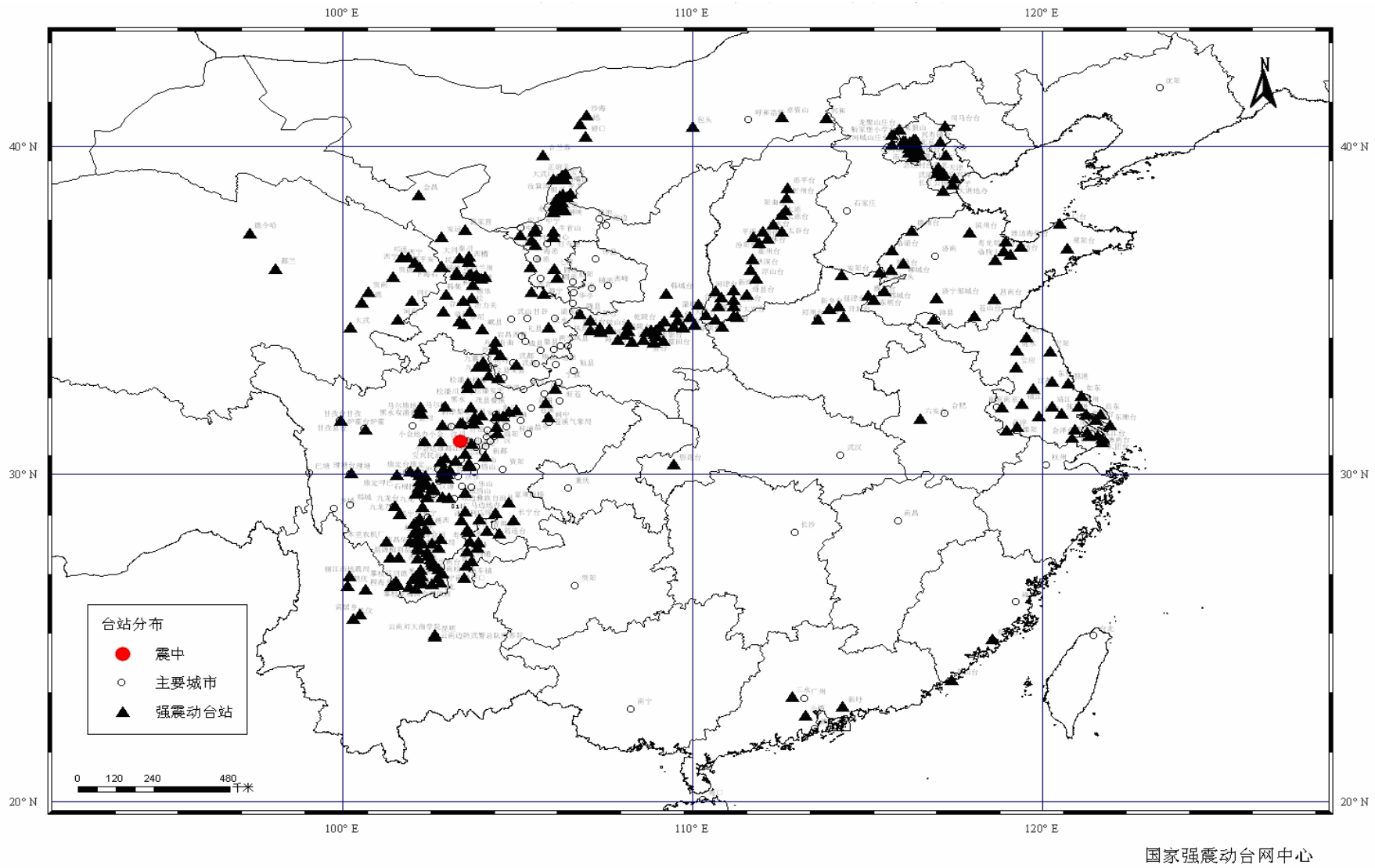
- Time：at 14：28：01, May 12, 2008
- Location：Wenchuan (31.0, 103.4)
- Magnitude：8.0 (Ms)
- Depth：19km
- Death：69，197 (July 10th, 2008)
- Missing: 18，377
- Injury：374，176
- Loss: ~ 1 trillion rmb (150b usd)?



The Earthtquake Rupture Process
(IGS)



Newly completed strong motion observation network
（2000+ nationwide，211 in Sichuan Provicne)

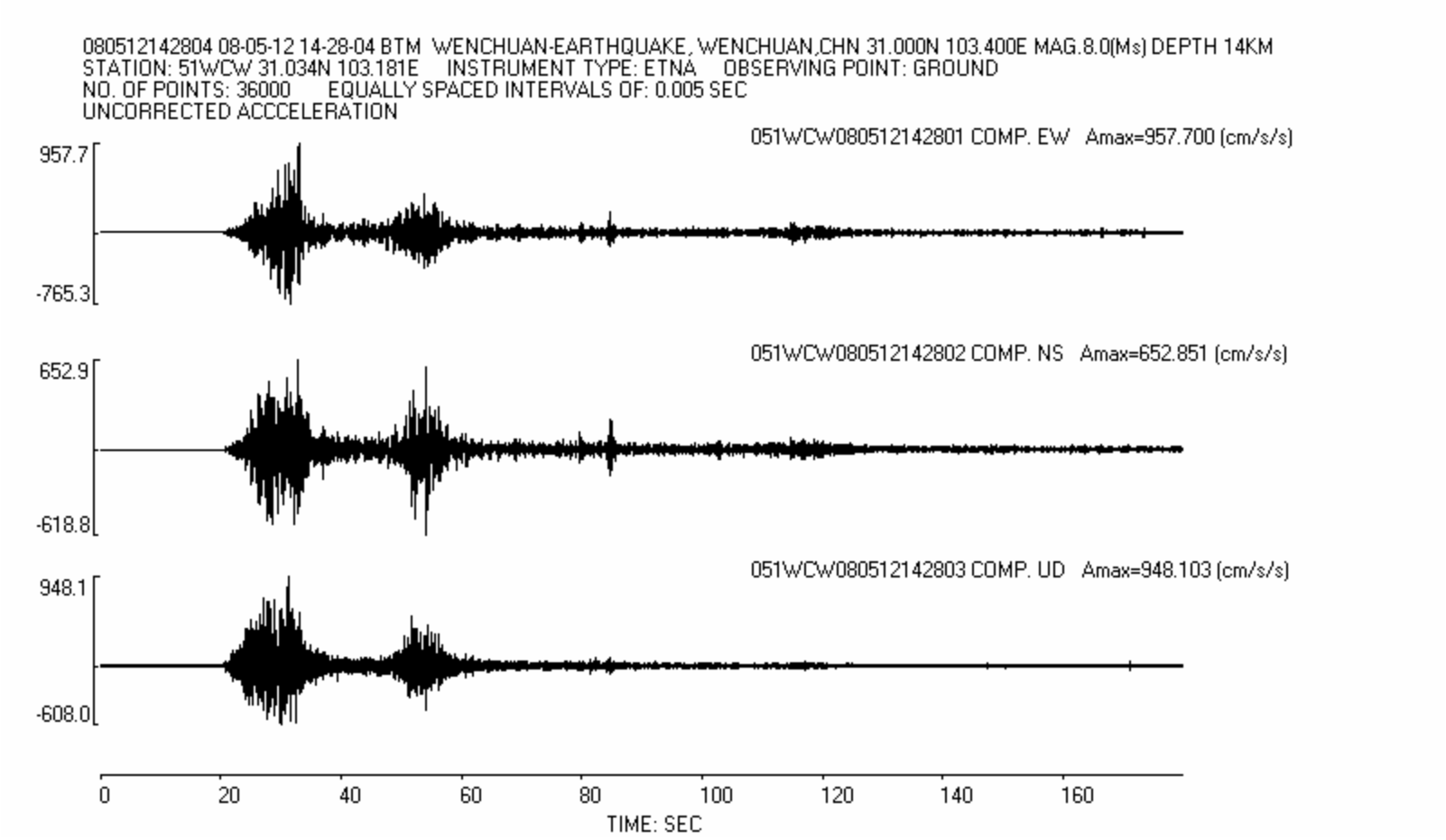


Stations which recorded the Wenchuan Earthquake

2008-8-25

Summary of strong motion observation

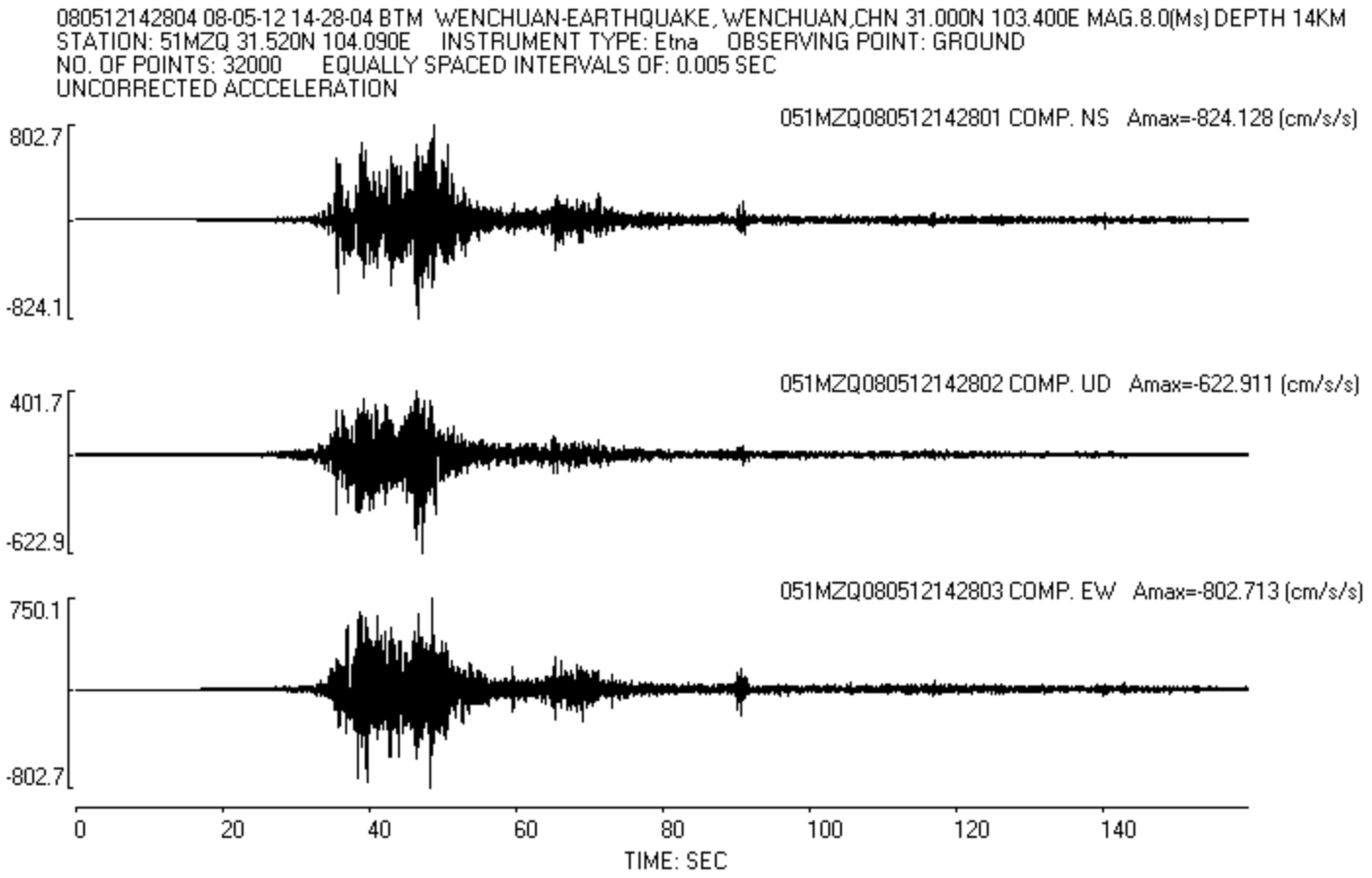
- 398 stations, 1191 records
- 19 stations within 100km from the epicenter, 34 stations within 200-300km from the epicenter
- 12 stations within 20km from the fault, 11 within 20-50km from the fault, 22 within 50-100km from the fault;
- 120 records with PGA over 100gal;
- Closest fault distance is 0.74km at Qingping Station, with a PGA of 824.1gal
- Closest epicenter distance is 22.2km at Wolong, with a PGA of 956.7gal and 1.09km fault distance.



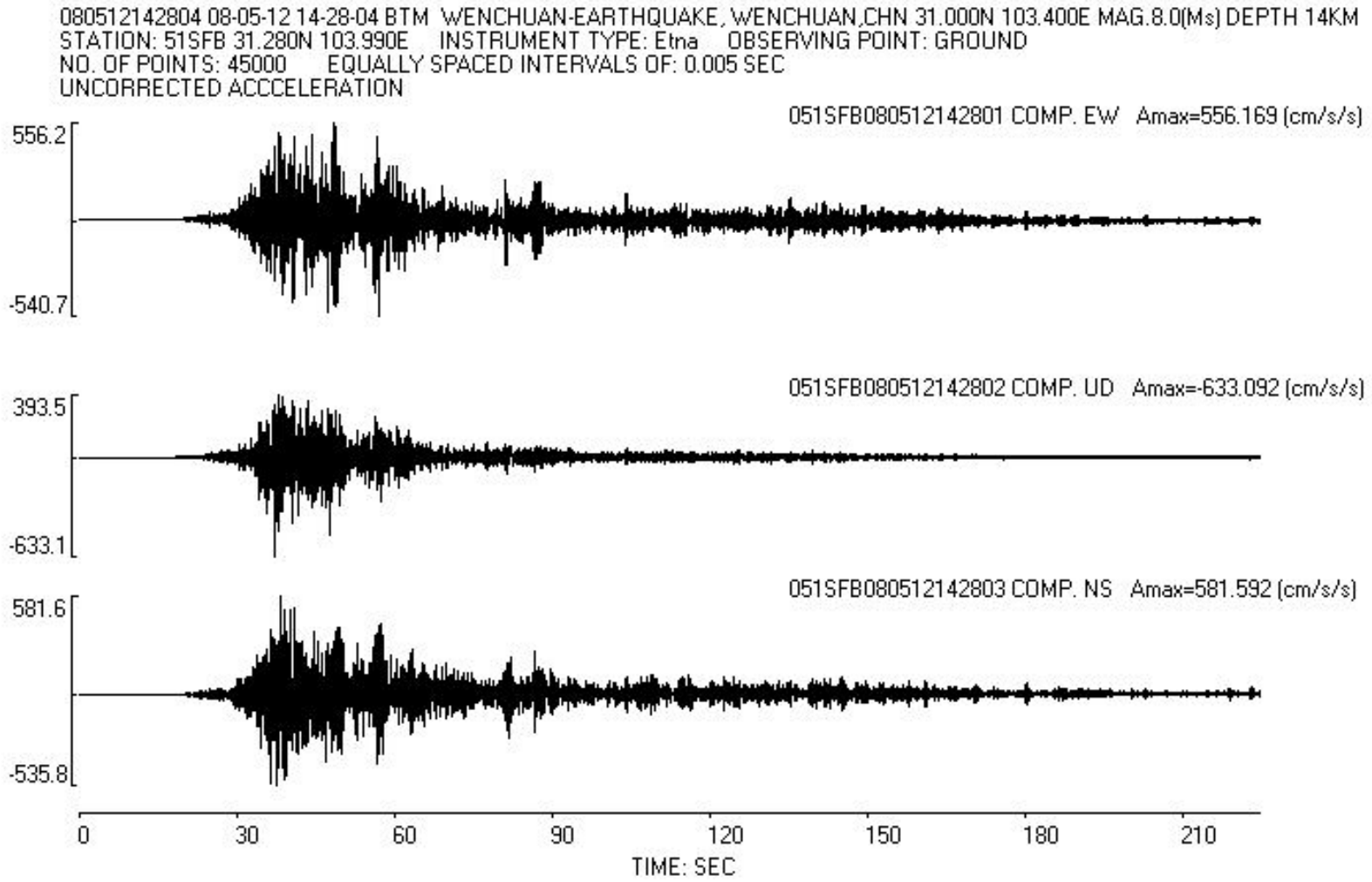
Wolong Station (22.2km epicenter distance, 1.09 fault distance)

中国地震局工程力学研究所

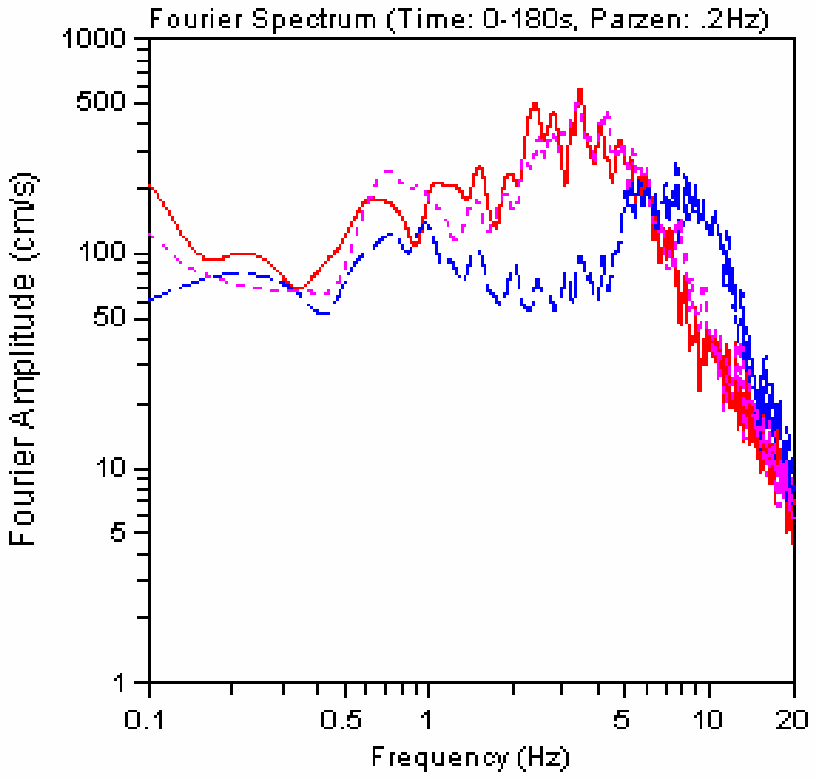
Institute of Engineering Mechanics,China Earthquake Administration

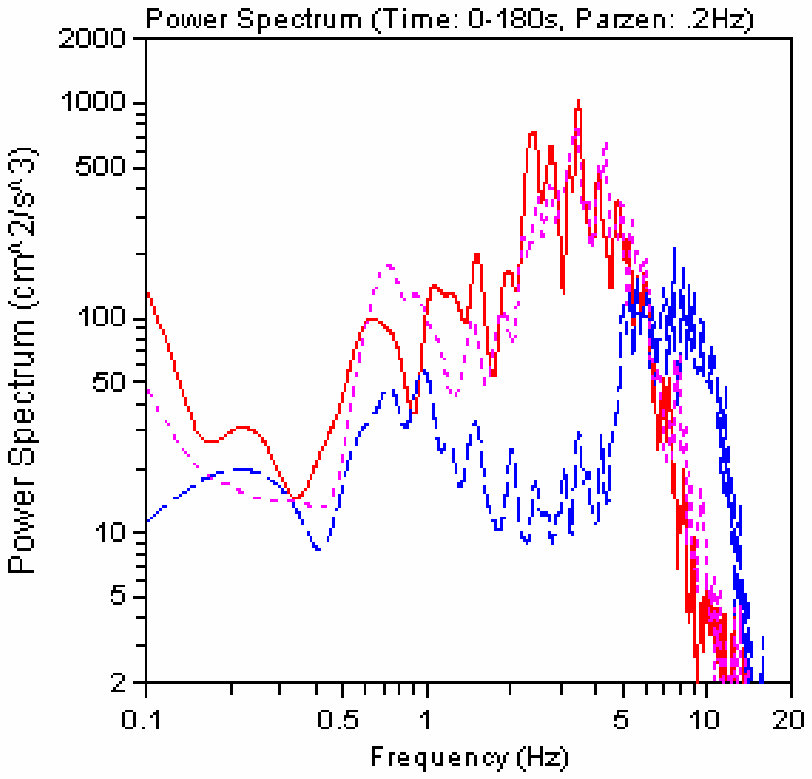


Qingping, Mianzhu Station□epicenter distance: 87.5km, fault distance: 0.74km)



Bajiao, Shifang City (~150km epicenter distance, ~75km fault distance)

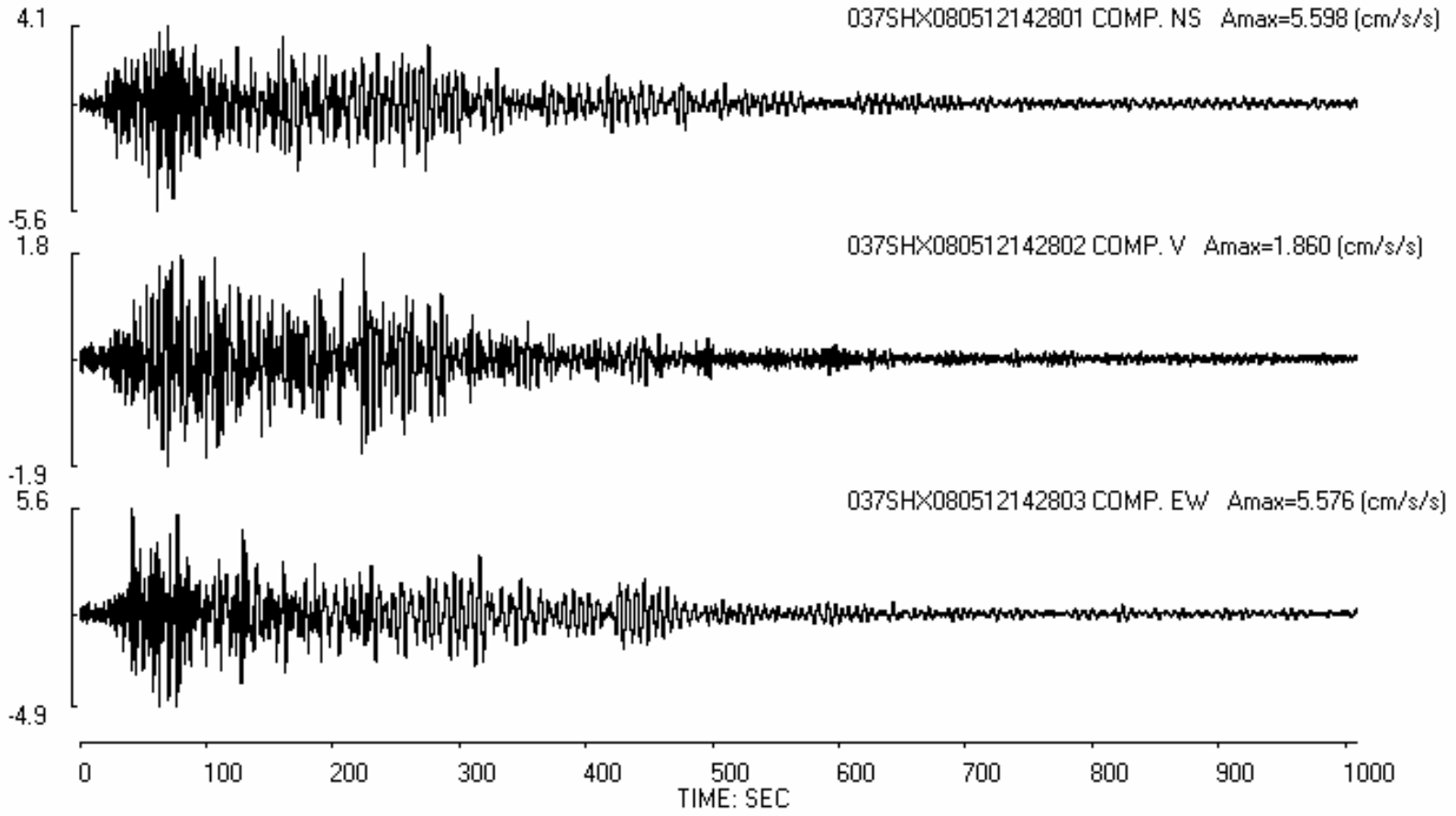




Fourier and Power Spectrum at Bajiao, Shifang City

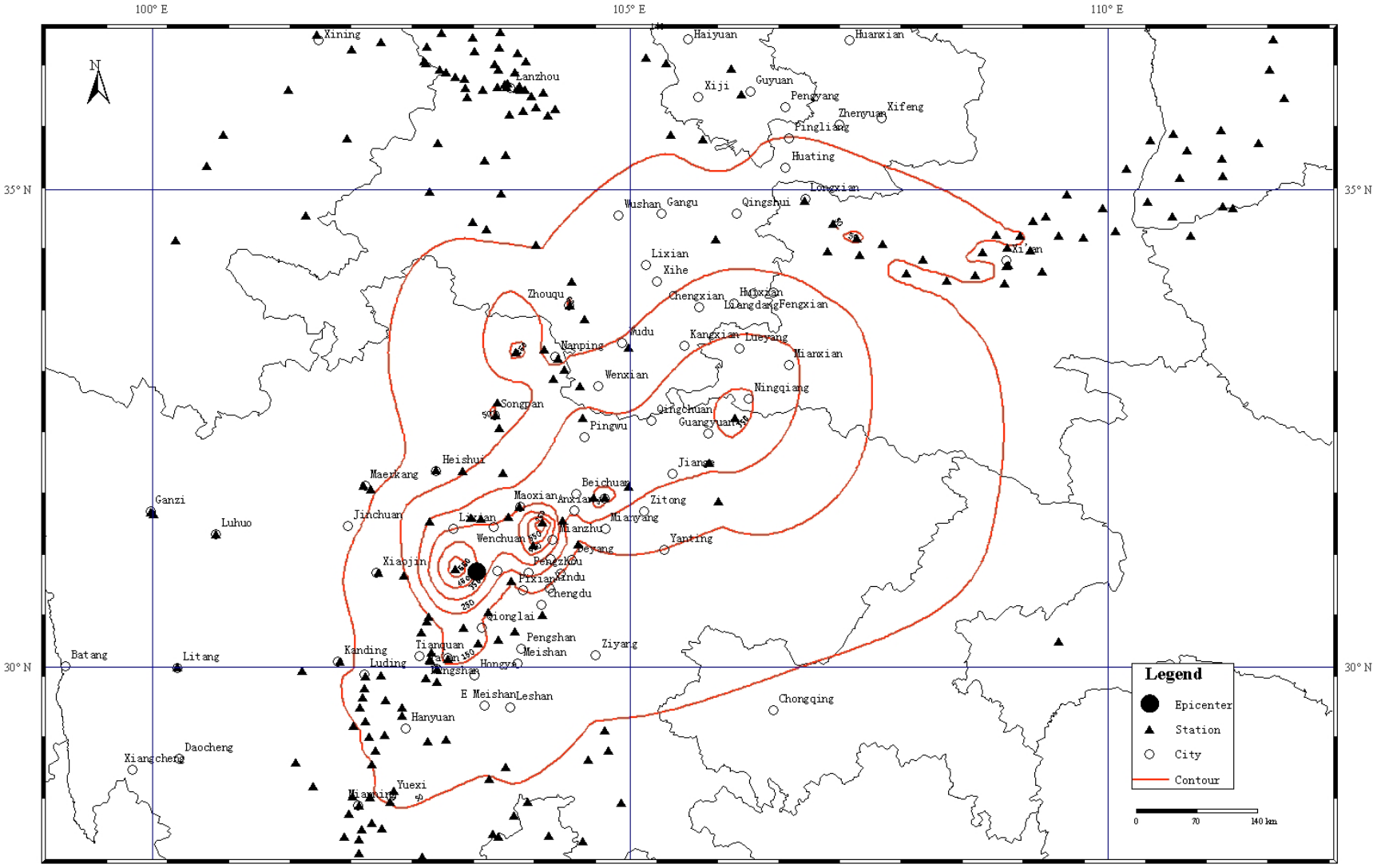
中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

080512142804 08-05-12 14-28-04 BTM WENCHUAN-EARTHQUAKE, WENCHUAN,CHN 31.000N 103.400E MAG.8.0(Ms) DEPTH 14KM
STATION: 37SHX 36.240N 115.690E INSTRUMENT TYPE: Etna OBSERVING POINT: GROUND
NO. OF POINTS: 202000 EQUALLY SPACED INTERVALS OF: 0.005 SEC
UNCORRECTED ACCCELERATION



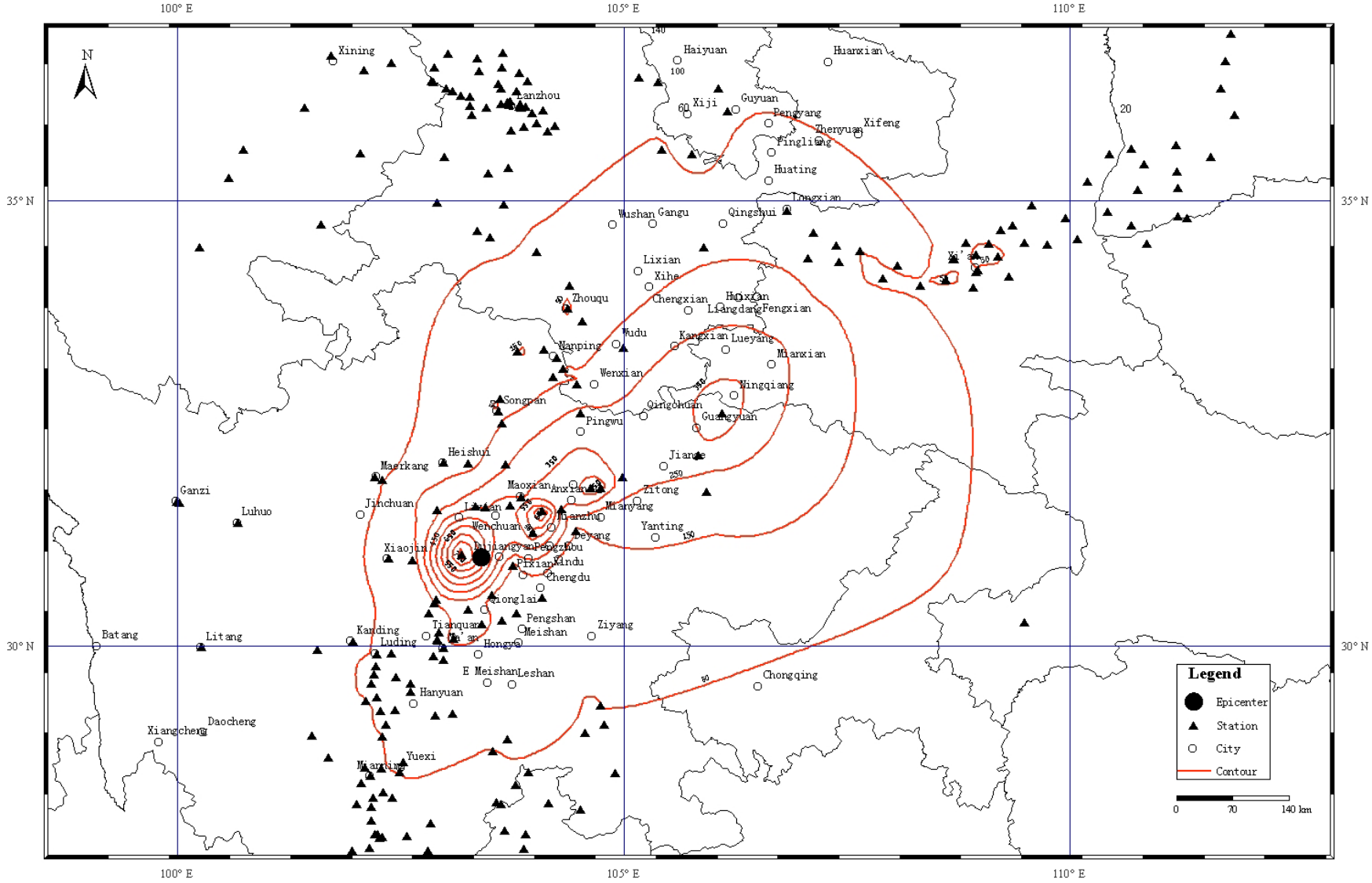
□□□□□□□□□□□□□□□□(□□□)

Ms 8.0 Wenchuan earthquake Peak Ground Acceleration(North-South) contour map



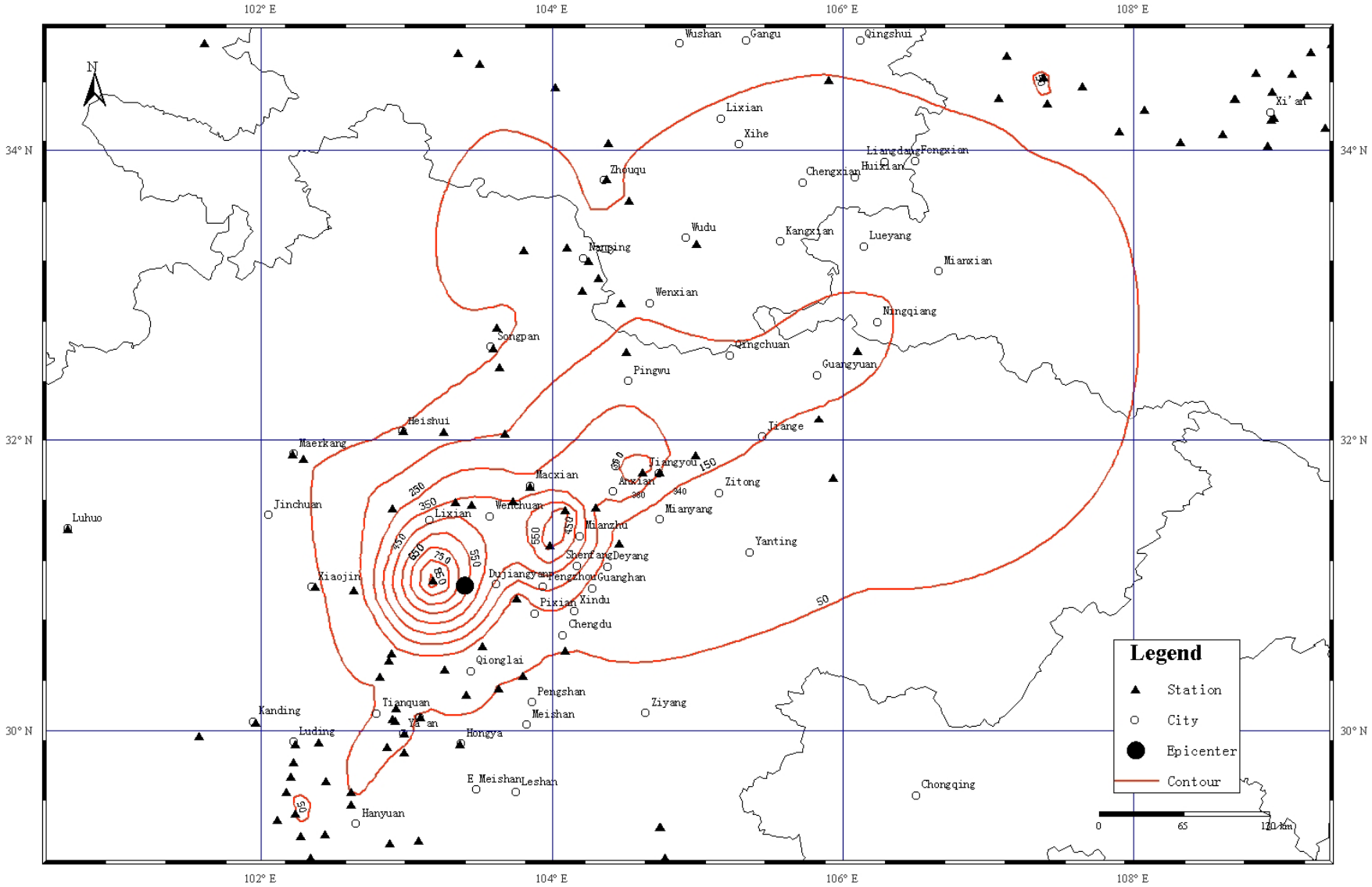
China Strong Motion Net Center

Ms 8.0 Wenchuan earthquake Peak Ground Acceleration (East-West) contour map



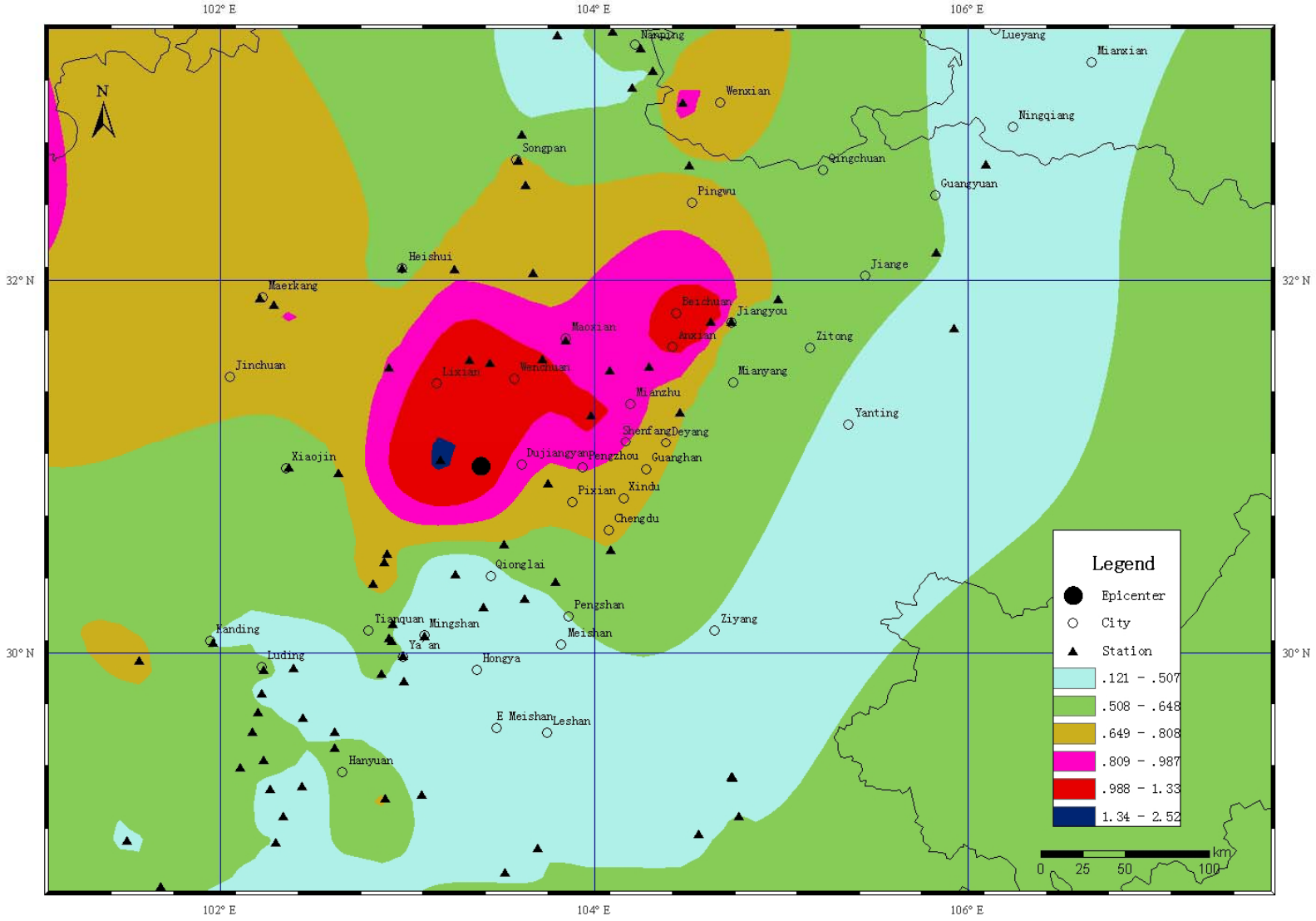
China Strong Motion Net Center

Ms 8.0 Wenchuan earthquake Peak Ground Acceleration (Veritical) contour map



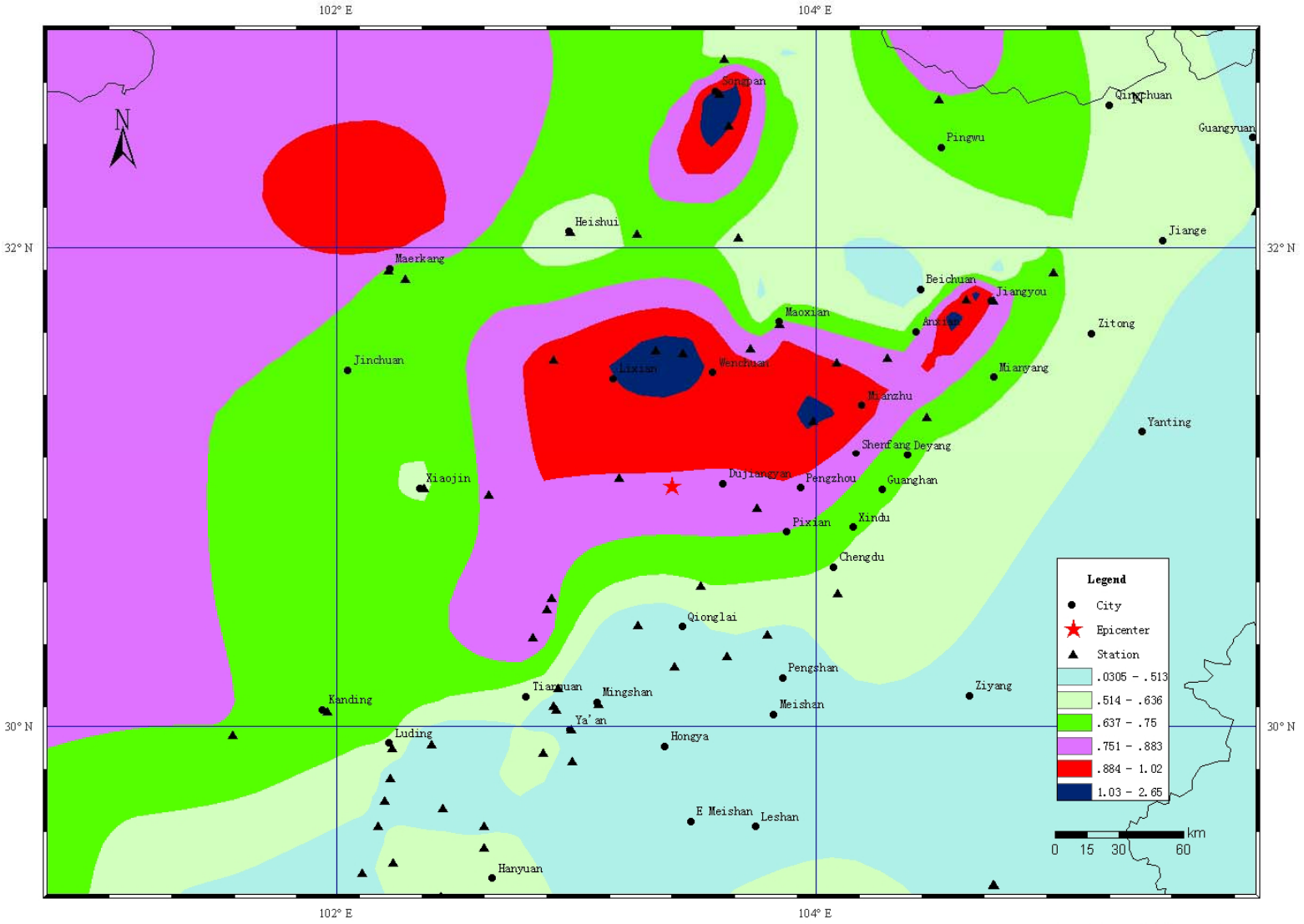
China Strong Motion Net Center

Ms 8.0 Wenchuan earthquake PGA(V)/PGA(NS) distribution



China Strong Motion Net Center

Wenchuan earthquake PGA(V)/PGA(EW) distribution



China Strong Motion Net Center


□□□□□□PGA□□□
□□□□EW287gal
□□□□NS519gal
□□□□EW421gal
□□□□UD357gal
□□□□NS289gal
□□□□EW824gal
□□□□EW957gal
□□□□UD633gal
北川羌族自治县
江油市
茂县
安县
游仙区
绵阳市
绵竹市
罗江县
德阳市
旌阳区
什邡市
中江县
汶川县
理县
都江堰市
彭州市

3□Damage

3.1 Structural Damage in a variety of forms

Typical damage for a brick structure

Damage to a dorm in Tumen Middle School in Mianzhu City

Tilted building toward right

Complete destruction to buildings in the remote villages

Collapse of an 8-story building in Beichuan County

Damage to a 2-story building in Beichuan County

Crushed bottom 2 stories and
rotation of the building in Dujiangyan
City

Complete destruction to school buildings in Hanwang town in Mianzhu

Collapse of the 1st story in a dorm building of Xuankou Middle School at Yingxiu town of Wenchuan County

Collapse of classroom building in Xuankou Middle School of Yingxiu Town in Wenchuan County

Damage to a classroom building at
Jiuyuan Middle School in Dujiangyan City

A Standing structure in Hongbai town of Shifang City

ministration

Minor damage to an office building for Beichuan Tea Manufacturer in Beichuan County

Bailuzhen Middle School in Pengzhou

中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

3.2 Damage to lifelines

3.2.1 Damage to road and bridges

Damage To Road Network

- 14 days after the earthquake, all roads to county center were repaired.
- By June 14, all roads to 248 out of 254 towns were repaired.

Damage to a bridge in Beichuan County

Sliding of the bridge decks in Beichuan County

Collapse of Baihua Bridge toward Yingxiu

Damage to the roads to Yingxiu

Collapse of small bridges deep in the mountains near Hongbai town

Damage to the pillar of Huilan Bridge in Mianzhu City

Damage to a bridge in Mianchi Town

Road damage due to
landslide near Yingxiu

3.2.2 Damage to water system

Damage overview

- Damage
  - water plant:8426
  - pipeline:47642.5km
- By May 31st, 4080 plants were restored, and 21876km pipeline were repaired (less than 20 days)

Damage to water system in Pengzhou city

究所

hquake Administration

Typical Damage types

Damage to Pipe Joint

Damage to PVC pipeline

3.2.3 Damage to electric system

Damage to electric system

(Sichuan province)

	Type	Total	Damaged
500kV	Station	18	1
	Line	41	4
220kV	Station	94	13
	Line	337	46
110kV	Station	351	66
	Line	796	118
35kV	Station	351	91
	Line	603	106
10kV	City net	5473	795
	Rural net	5876	1700

Destruction to Ertaishan Station (220kV, near epicenter)

Restoration of partially damaged electric system
(Sichuan province)

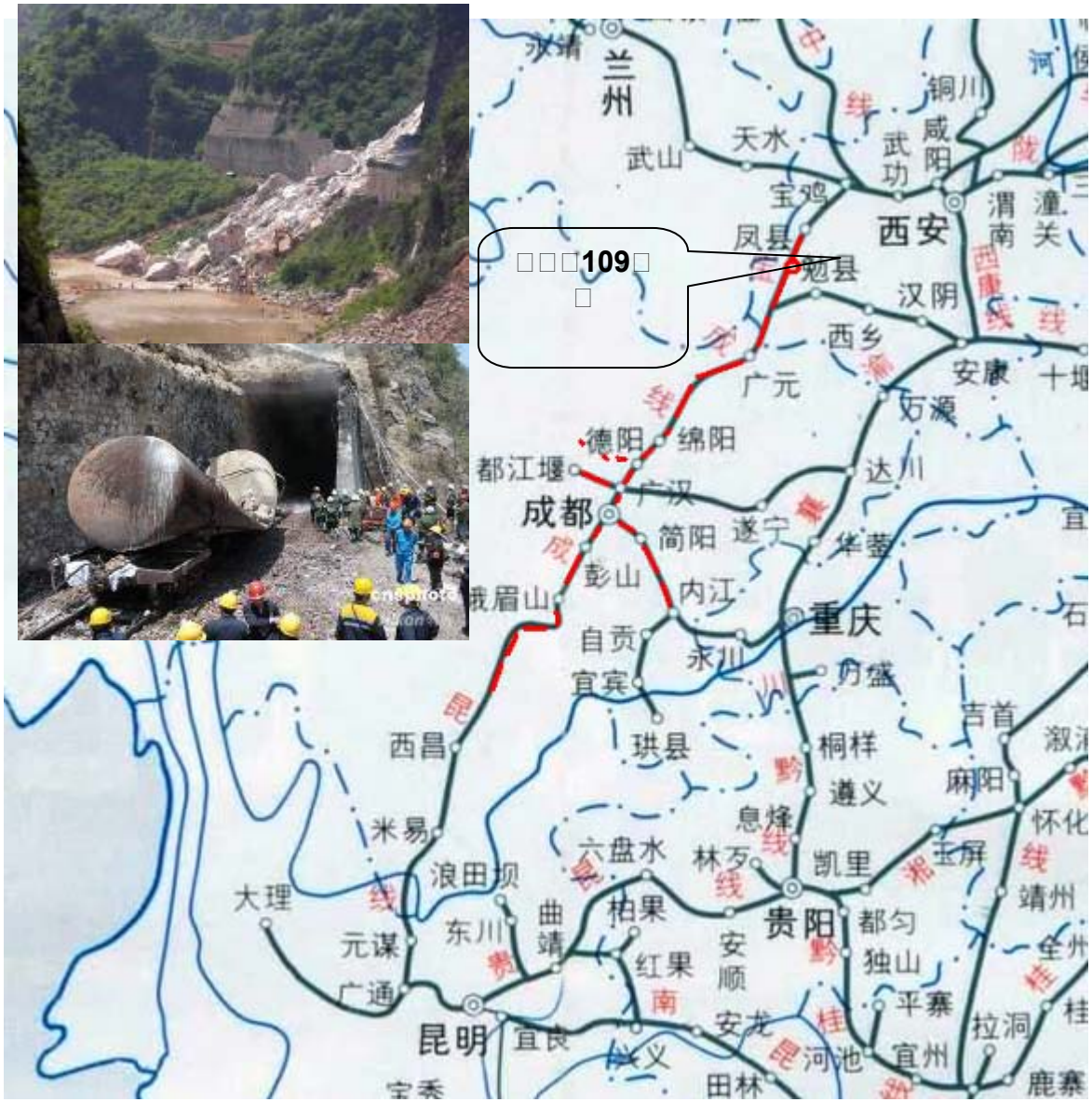
- **By June 10, 155 out of 171 35kv or above power stations were repaired and service was restored**
- **2607 of 2769 10kv line were repaired**
- **Electricity service was fully restored**

Restoration of partially damaged electric system

(Sichuan province)

Out of the 17 completely demolished stations, 220kv Anxian, 220kv Dakang, 110kv Xiaoba, 110kv Yuanmenba and 35kv Jujiaya are to be rebuilt. They are all scheduled to put into service by August 31, 2008

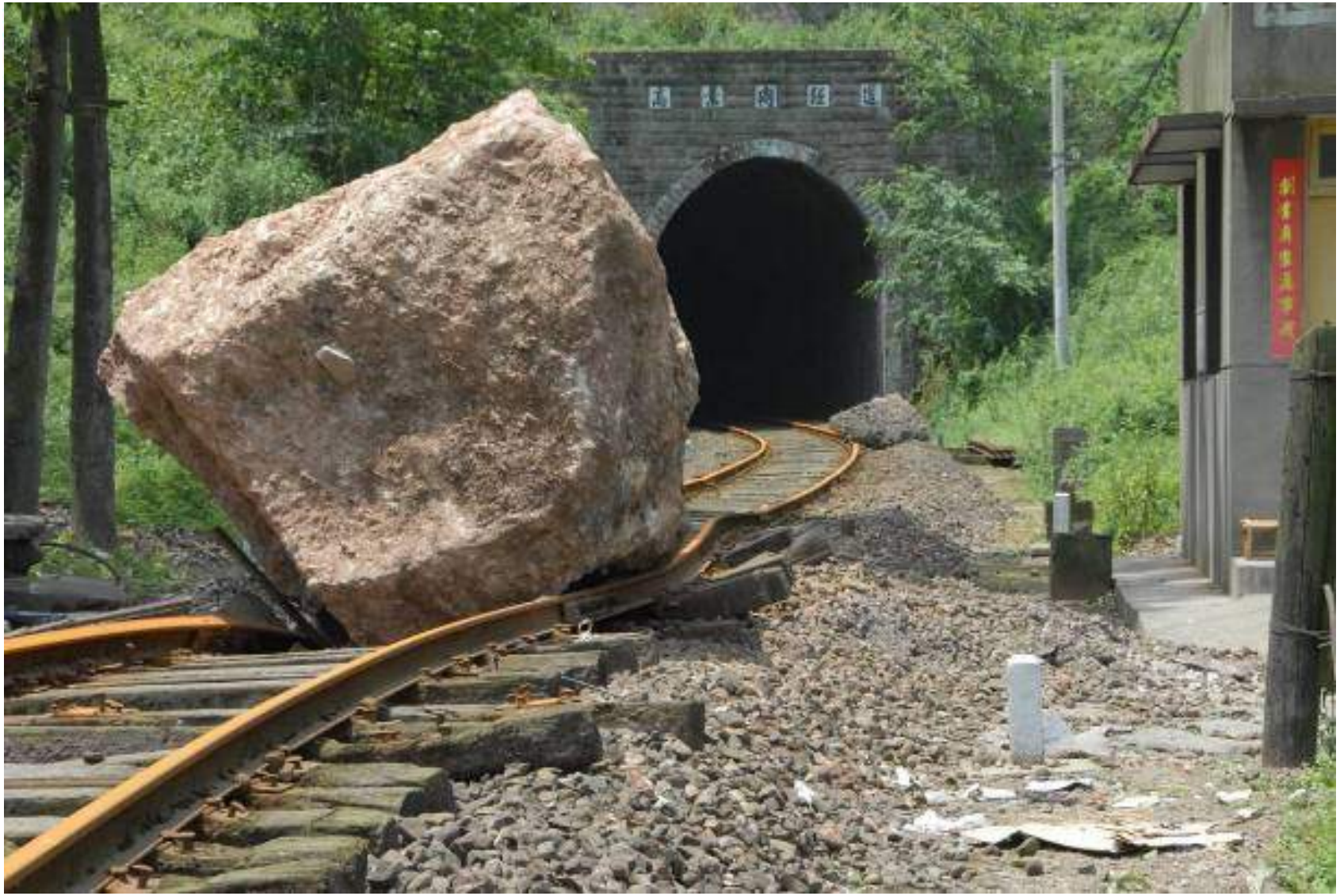
3.2.4 Damage to railroads



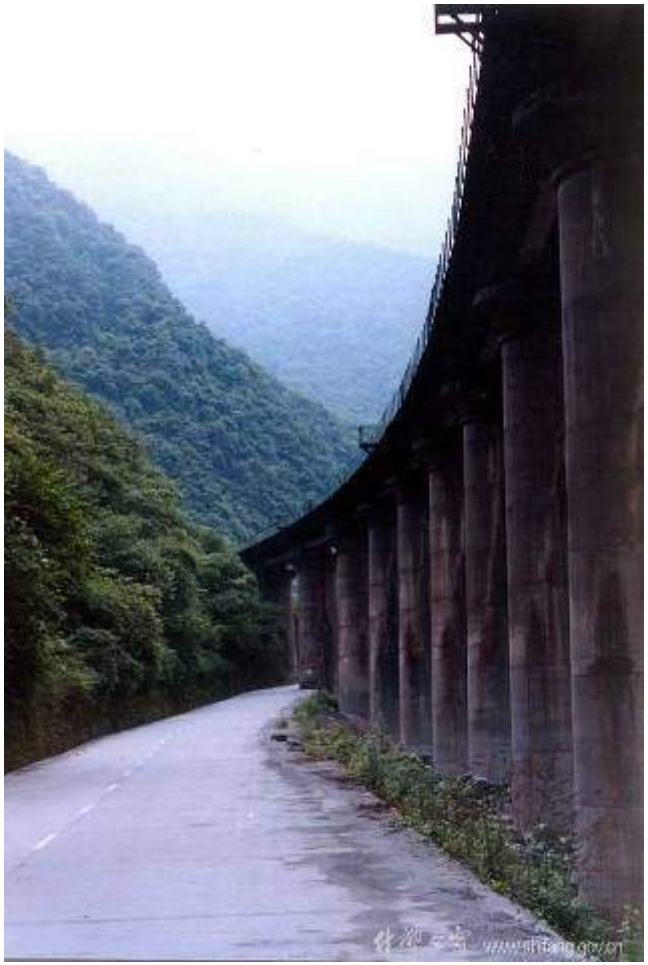
- Damage to rails
  - Baoji-Chengdu line 4 locations, Chengdu-Kunming line 4 locations, and Chengdu-Chongqing 7 locations
- Damage to Stations
- May 24, all major lines were repaired and service was restored

Damage to Railroads

Damage to train tracks on a bridge near Yinghua town



Damage due to rolling stones (Shifang City)



Same bridge before the earthquake

Damage to Macaotan railway bridge near Hongbai town

3.3 Geotechnical damage

Landslide on the left side of
Beichuan County

Rolling stones on the right side in Beichuan County (Beichuan Middle School new site□

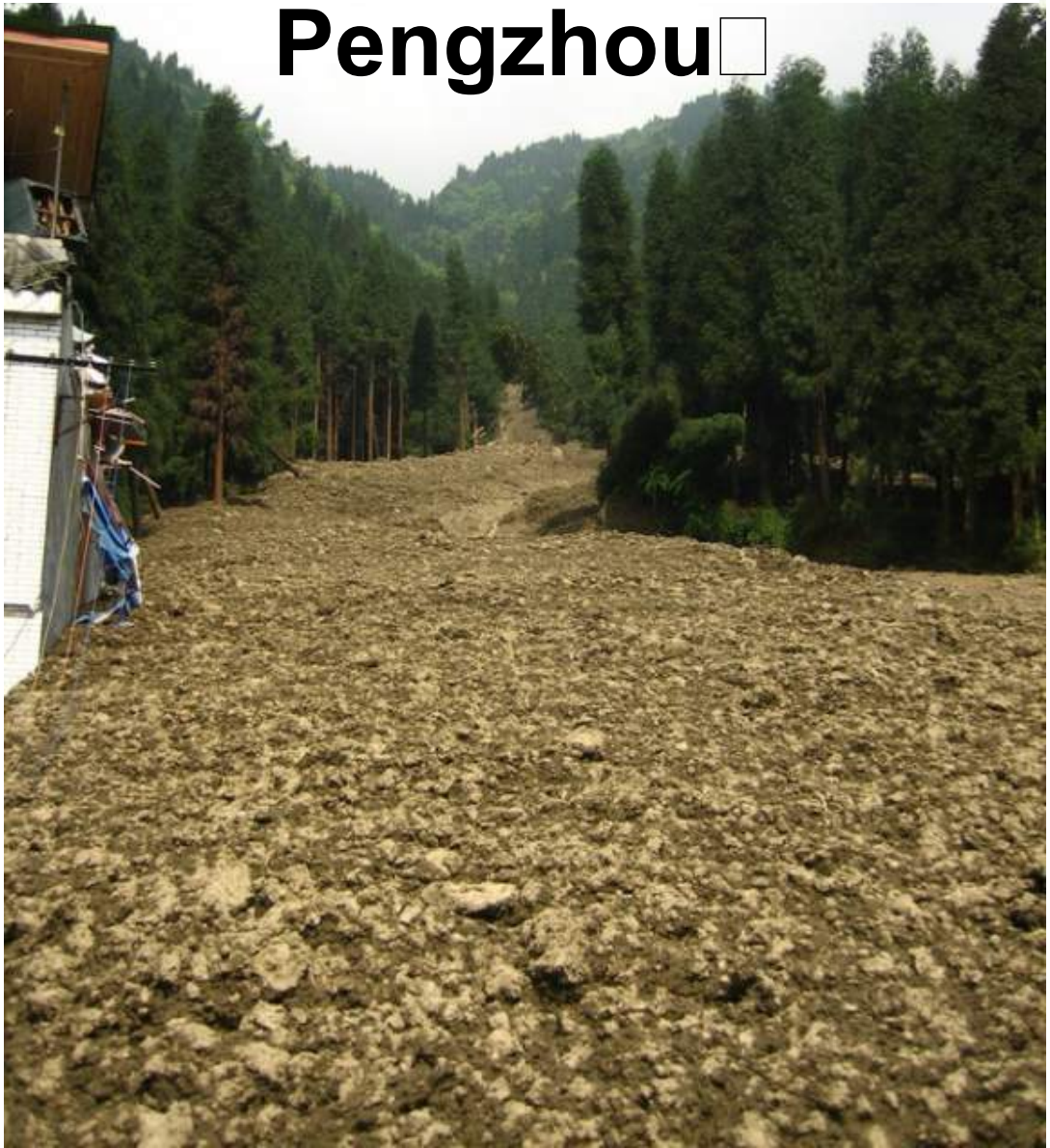
Rolling stones in Gaochuan, Anxian County

Liquefactio

Liquefaction in Pixian

Quake Lake at Tangjiashan

Mudslide □Jiufengshan, Pengzhou□



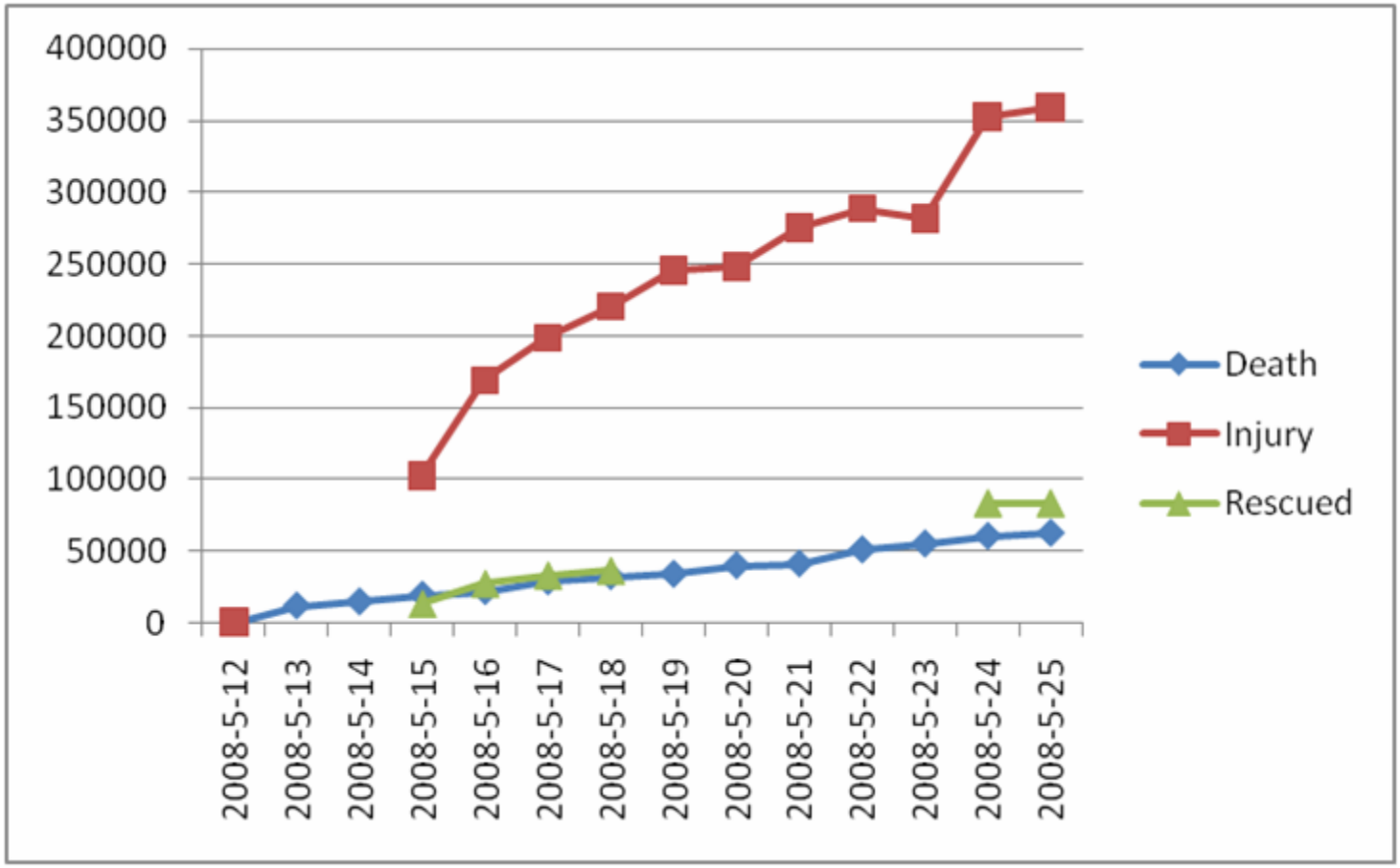
Fault Rupture near Beichuan
County

Rupture along a road to Beichuan County

Fault Rupture in Pingtong town in Pingwu County

中国地震局工程力学研究所
Institute of Engineering Mechanics,China Earthquake Administration

4. Response and Reconstruction



Daily number of death, injury and rescued

Emergency response personnel seen everywhere

Tents were set up everywhere

Water and food quickly delivered to rural areas

Water supply response, restored < 20days

□□□□□□□□□

□□□□□□□

□□□□□□□□□□□□□

□□□□□□□□□

Emergency response

- Merit of a centralized government
- Medical, mental help
- Supply for daily life needs
- Monetary help

Reconstruction

- National committee
- National guidelines
- Financial support
- Engineering support
- Local plans
- Execution: 3 years of reconstruction, 5 years of improvement

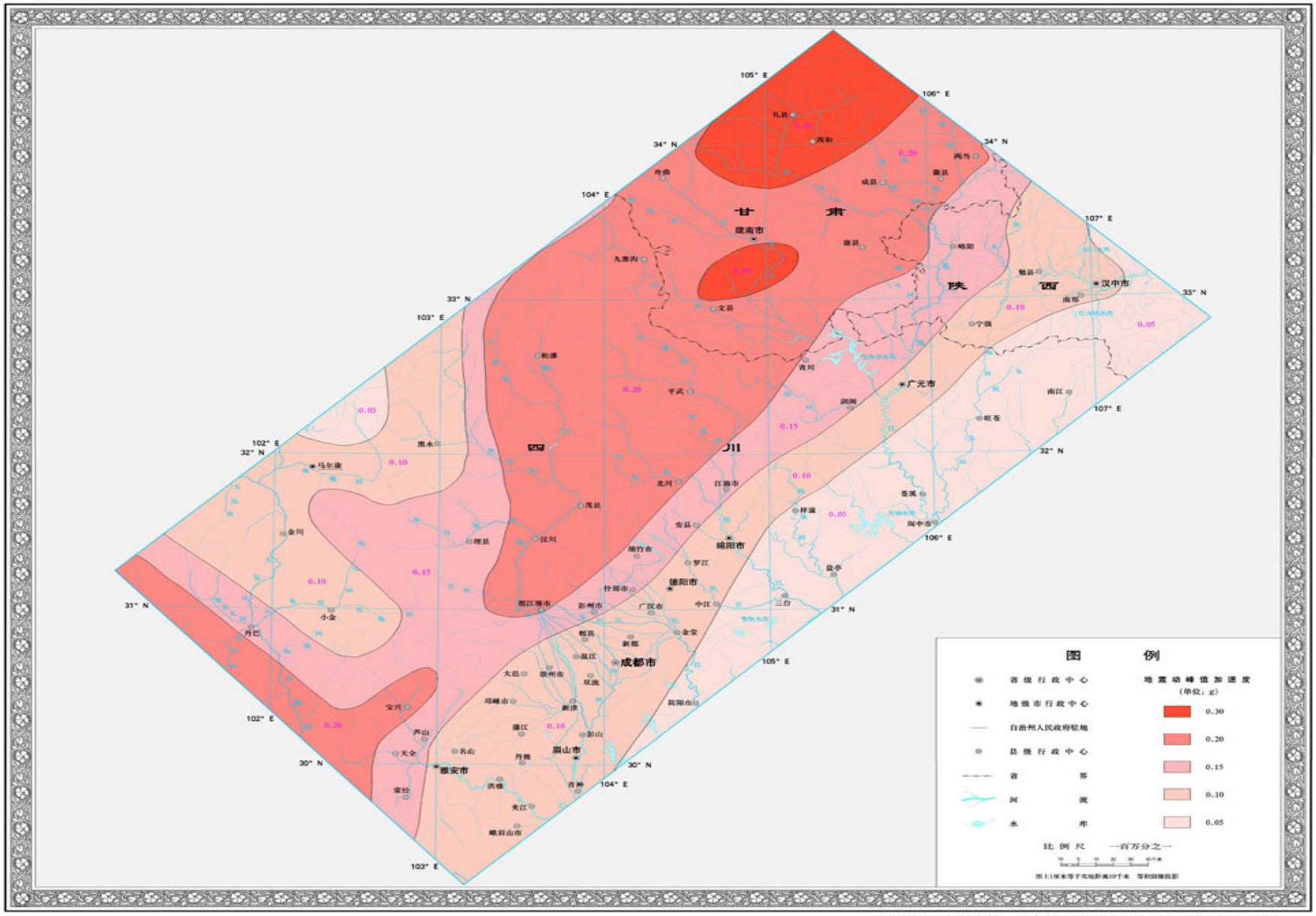
Building evaluation

- No damage: inhabitable
- Slight damage: inhabitable with possible future retrofitting
- Medium damage: repair
- Heavy damage: rebuild
- Collapse: rebuild

Relationship of design earthquake with different level and average return period(suggested)

Type of Buildings	Basic Design Period/a	Design Earthquake	Exceeding Probability within Basic Design Period	Average Return Period (TR/A)
A	200	Frequently Occurred	0.63	200
		Occasionally Occurred	0.10	1900
		Rare Occurred	0.05	3900
B	100	Frequently Occurred	0.63	100
		Occasionally Occurred	0.10	950
		Rare Occurred	0.05	1950
C	50	Frequently Occurred	0.63	50
		Occasionally Occurred	0.10	475
		Rare Occurred	0.05	975
D	40	Frequently Occurred	0.63	30
		Occasionally Occurred	0.10	285
		Rare Occurred	0.05	585

Modified PGA Zonation
(change building type for schools)

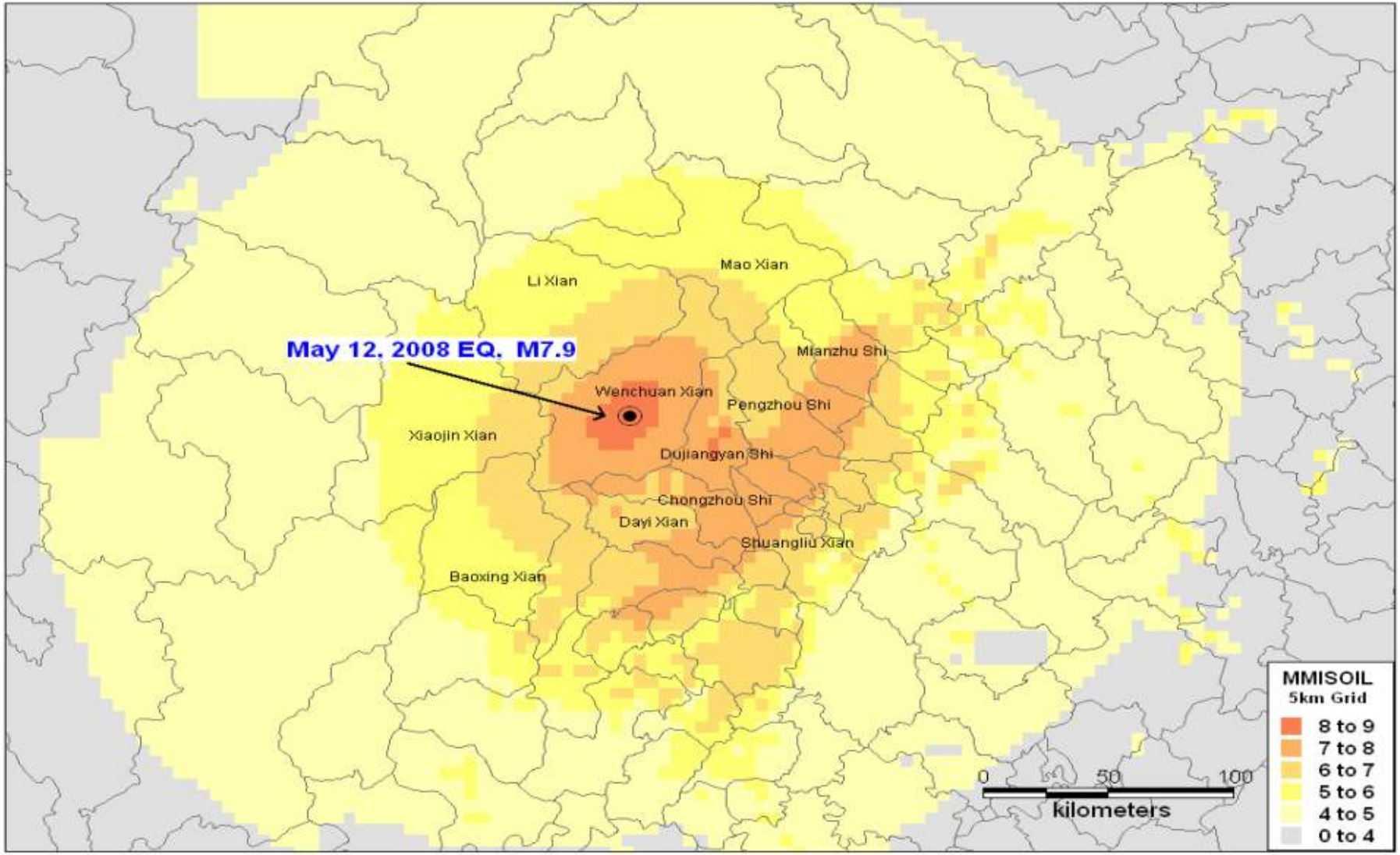


Financial support

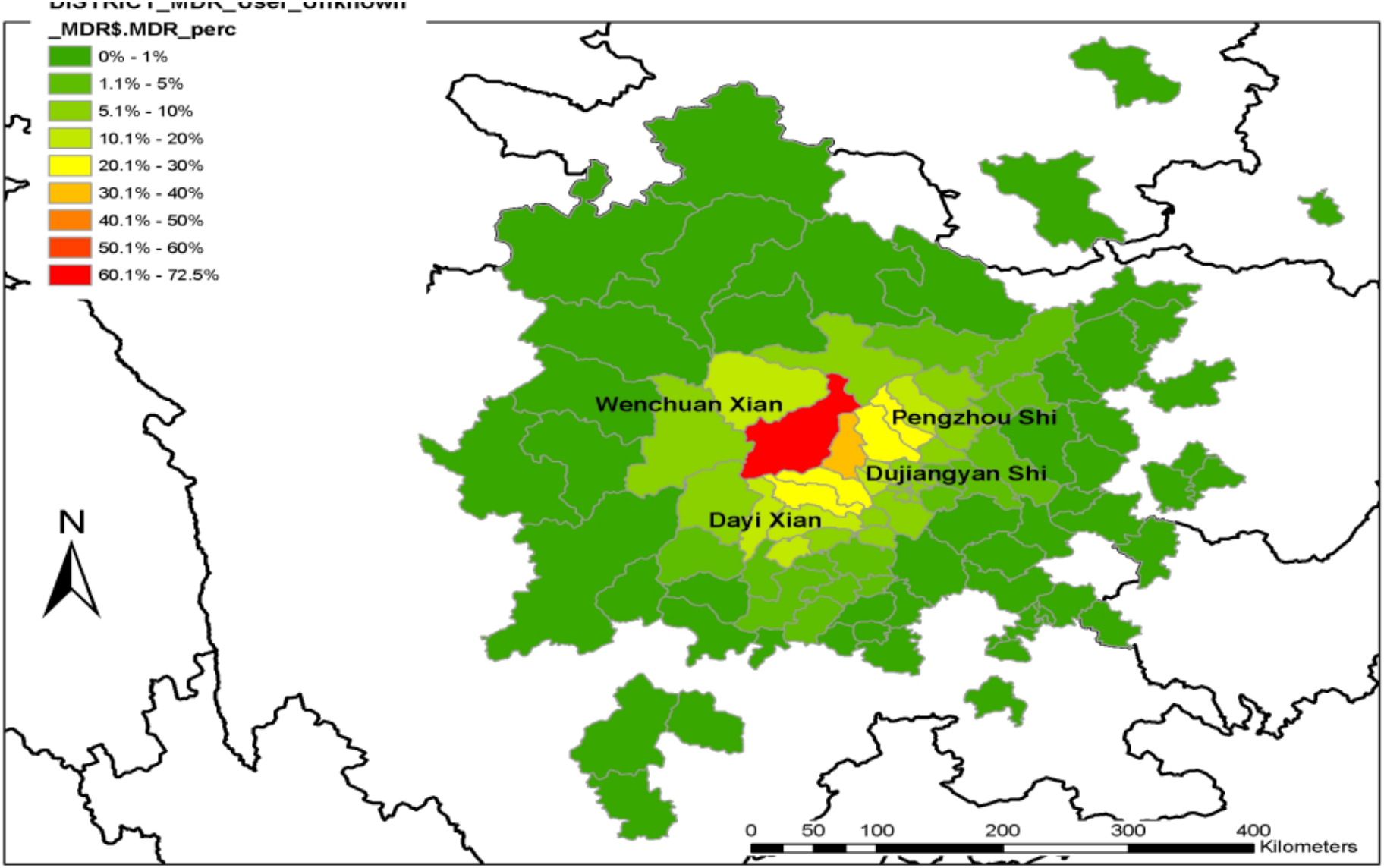
- Central government: 70b
- Local government: ~30b
- Donations: ~ 50b

Total: 150b RMB, 20+b USD for 2008

5□Loss estimate

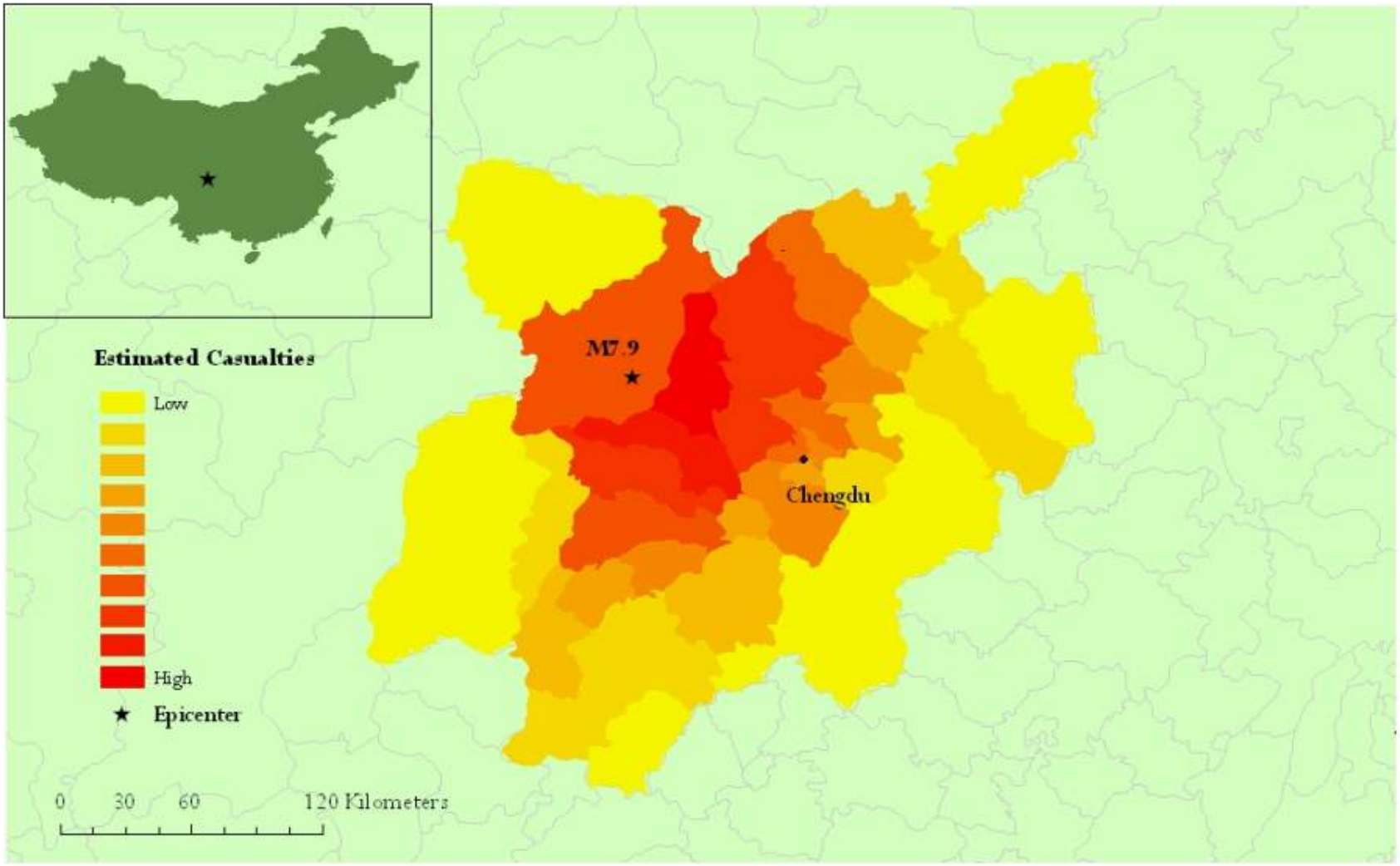


Estimated intensity right after the event with a point source

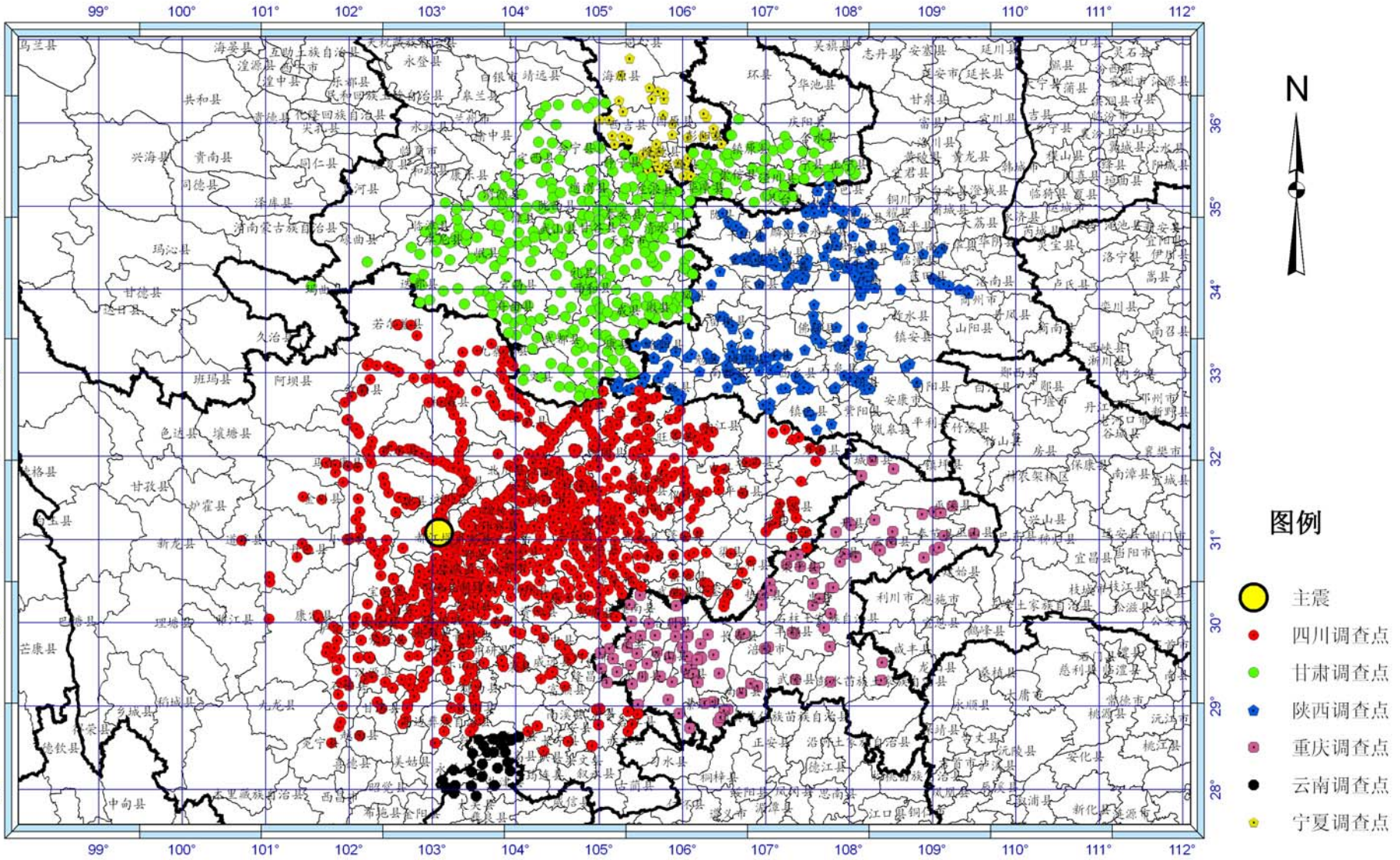


Damage ratio distribution

Total loss: 983 b (building only)

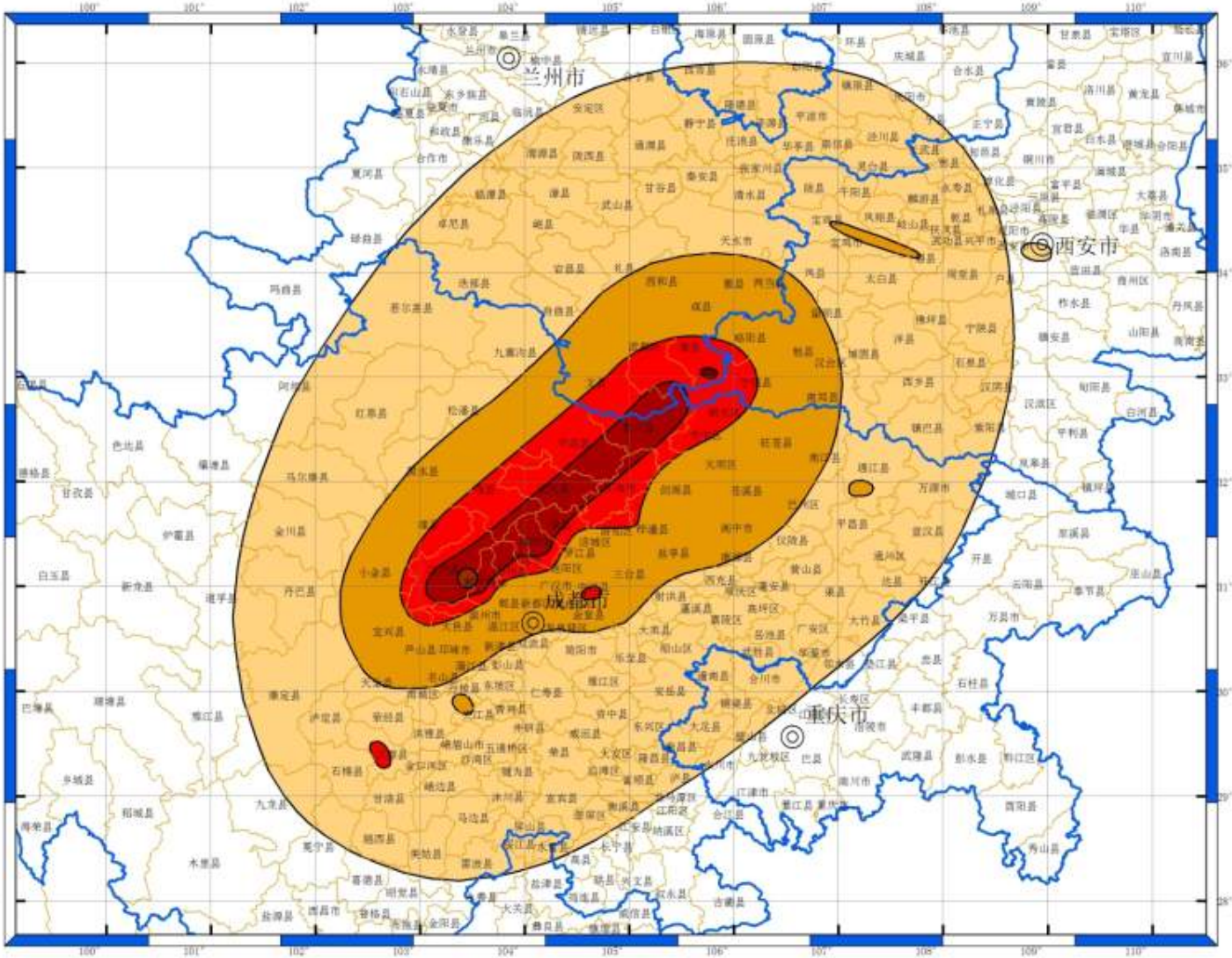


RMS/IEM casualty estimate: 18,000~33,000 (building only, this number helped the government making decisions to dispatch more troops)



Distribution of field survey locations

汶川8.0级地震灾害分区图



N

图例

极灾区

严重灾区

重灾区

受灾区

Concluding remarks

- We know little about earthquakes
- Effectiveness of seismic design
- Economically effective structures for rural areas
- Design earthquakes for public facilities
- Importance of lifeline systems
- Wide spread issue with geotechnical failures
- Risk diversification