GRUPPO NAZIONALE DI GEOFISICA DELLA TERRA SOLIDA

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Palazzo della Regione

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CHARACTERISATION OF HILLSLOPE SEISMIC RESPONSE IN THE QIAOZHUAN AREA (SICHUAN - CHINA) THROUGH THE DATA OF A TEMPORARY ACCELEROMETER ARRAY

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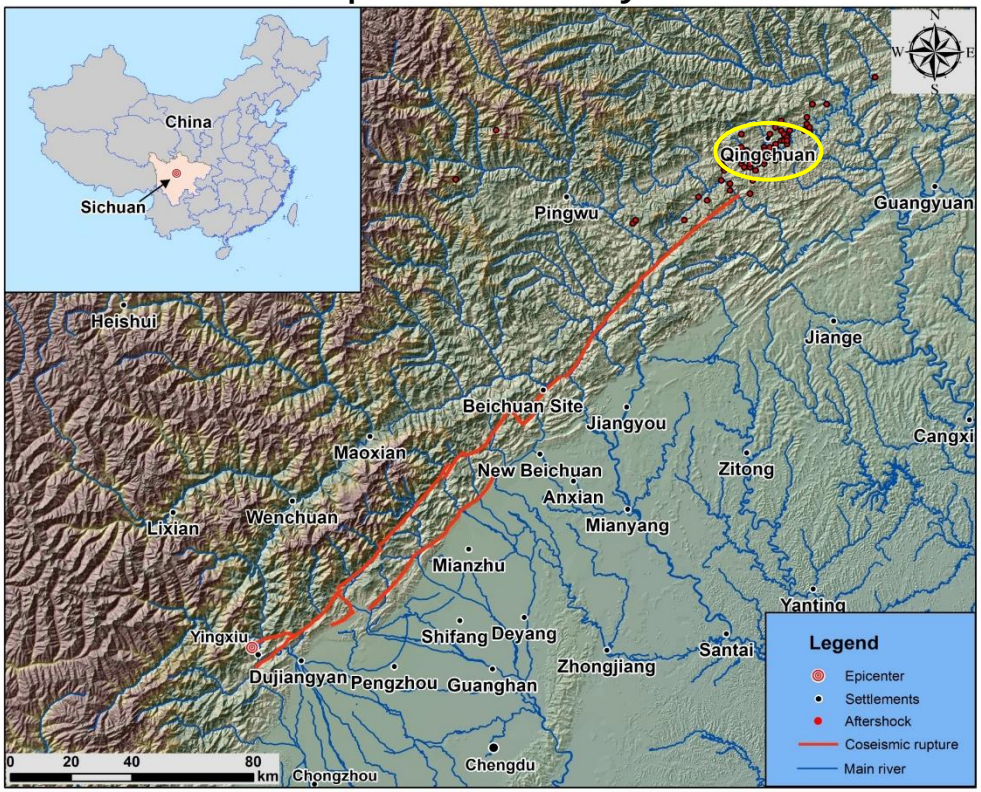
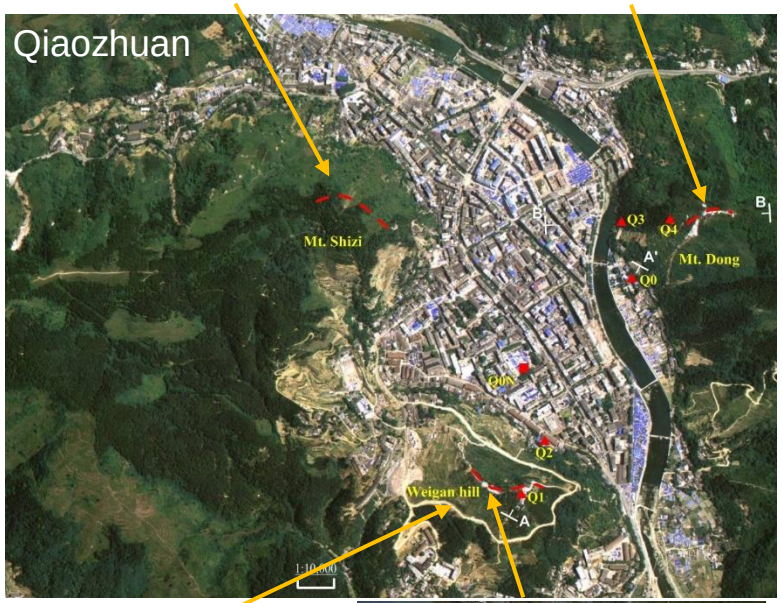
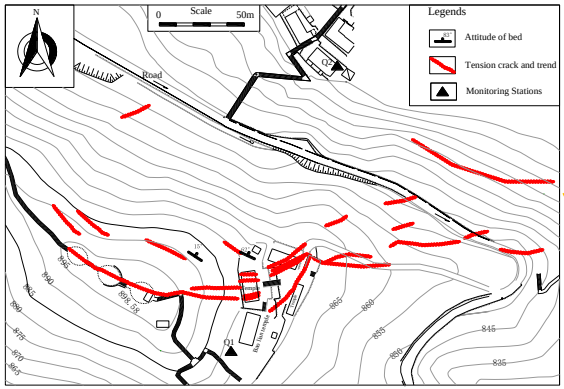
Introduction

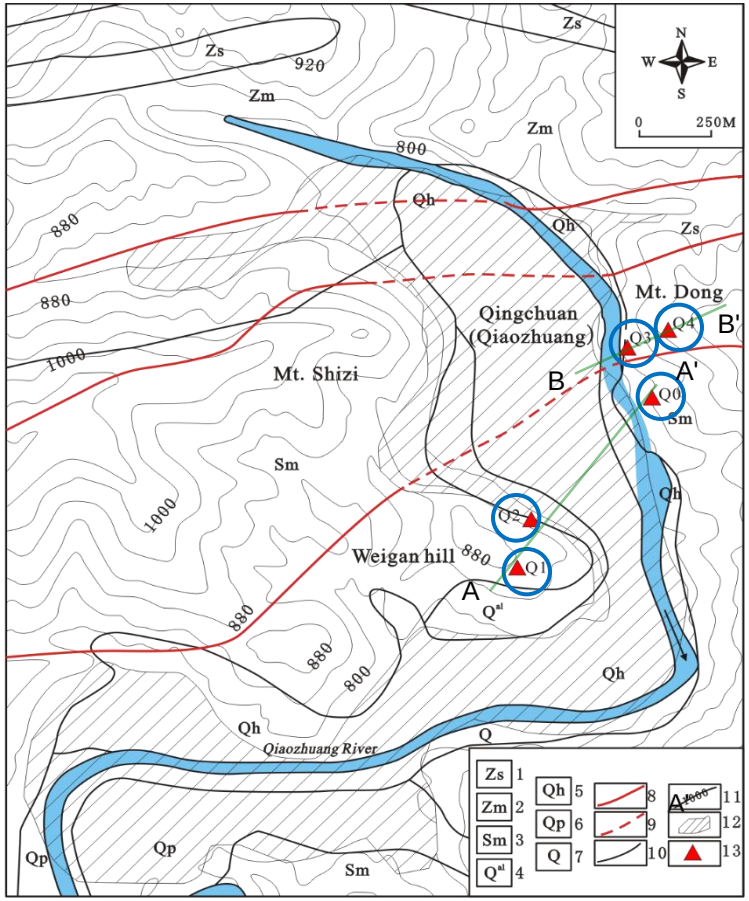
Wenchuan earthquake: 12 May 2008 – Mw 7.9

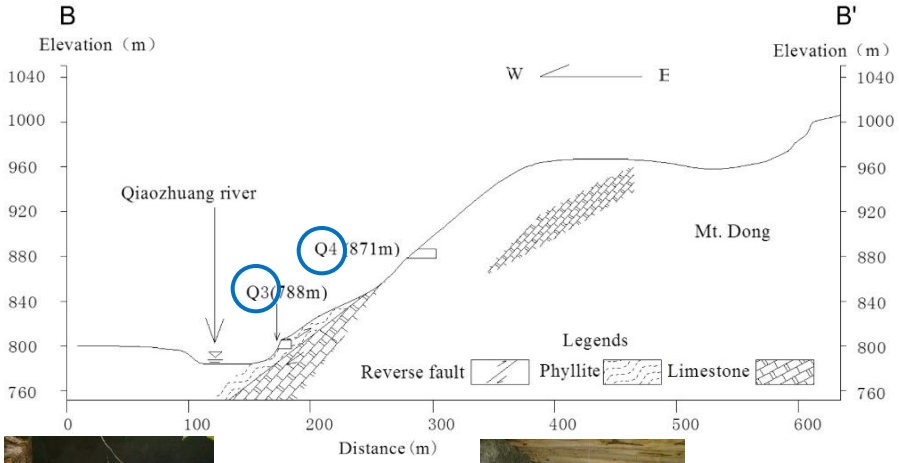


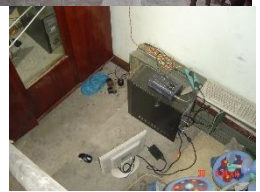


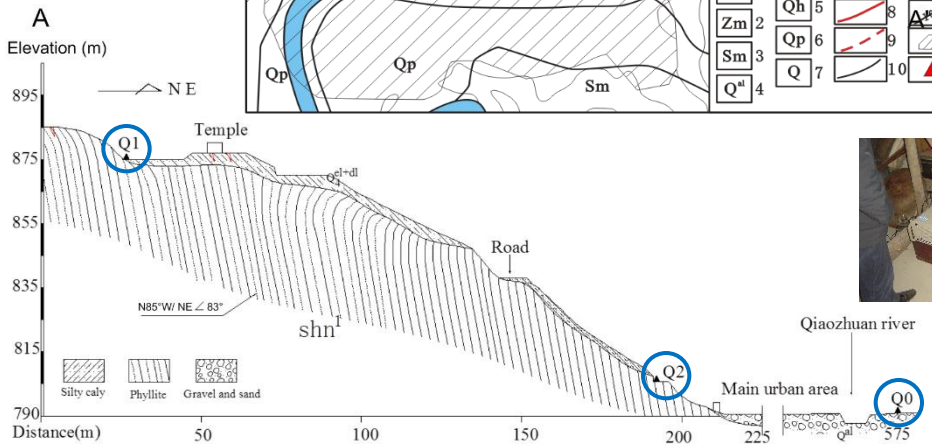


Study area


N
W
E
S
0
250M
Zs
Zm
920
800
880
1000
Qh
Mt. Dong
Qingchuan
(Qiaozhuang)
Mt. Shizi
Sm
Weigan hill
Q0
Q1
Q2
Q3
Q4
A
A'
B
B'
Qiaozhuang River
Q
Qp
Zs 1
Zm 2
Sm 3
Qal 4
Qh 5
Qp 6
Q 7
8
9
10
11
12
13


B
B'
Elevation (m)
W
E
Qiaozhuang river
Q4 (871m)
Q3 (788m)
Mt. Dong
Legends
Reverse fault
Phyllite
Limestone
Distance (m)
1040
1000
960
920
880
840
800
760
0
100
200
300
400
500
600




A
Elevation (m)
N E
895
875
855
835
815
790
Q1
Temple
Road
N85°W/ NE∠83°
shn
Q2
Qiaozhuan river
Main urban area
Q0
Silty caly
Phyllite
Gravel and sand
Distance(m)
50
100
150
200
225
575

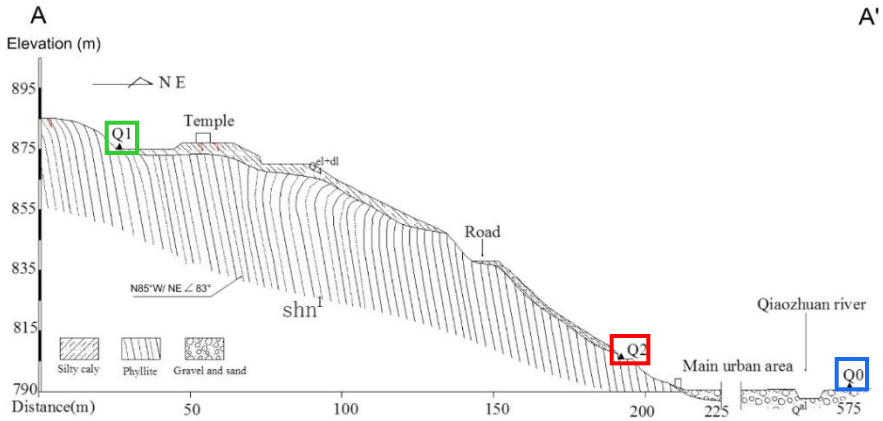
PGA relative amplification

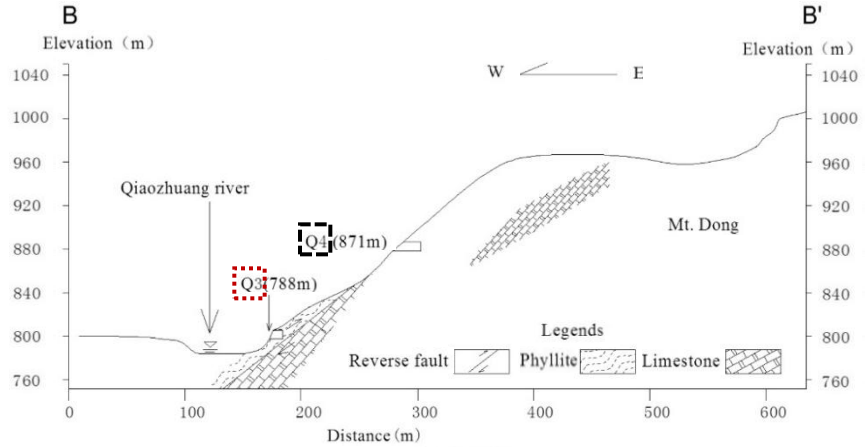
Relationship PGA vs magnitude-distance

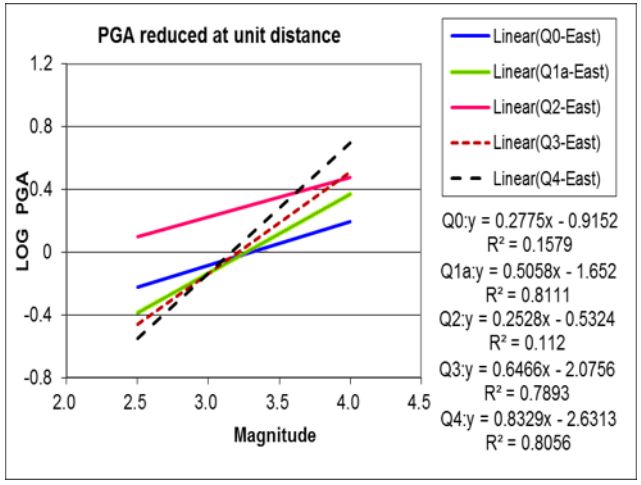
$$\log PGA = a + b \cdot M - \log\sqrt{D^2 + h^2}$$

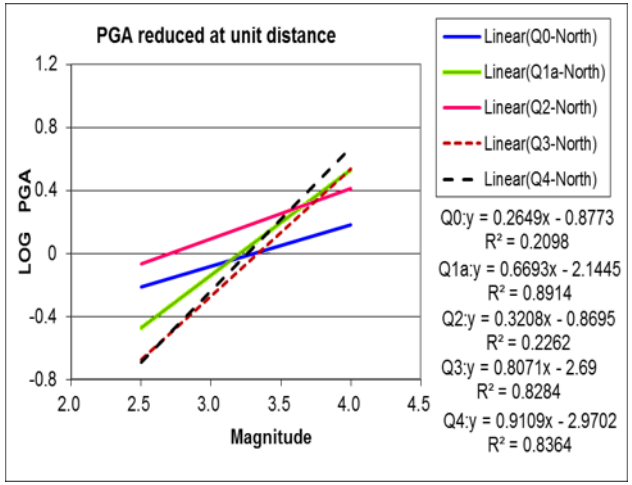
$$\log PGA_r = \log PGA + \log\sqrt{D^2 + h^2} = a + b \cdot M$$

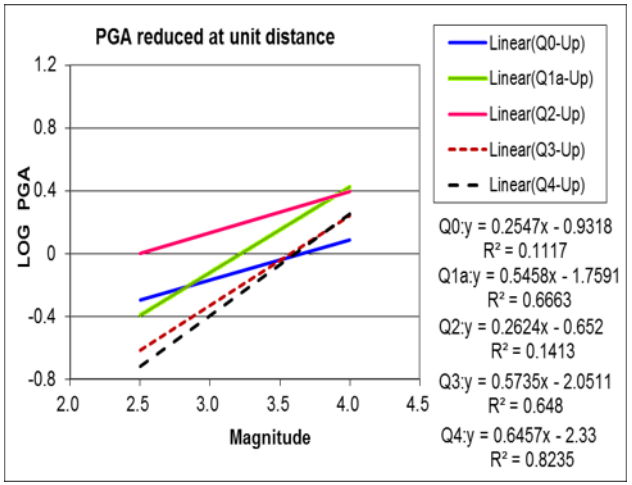
M = magnitude,
D = epicentral distance
h = depth.











Arias intensity polar diagrams

Arias intensity tensor

Components

$$I_{ij} = \frac{\pi}{2g} \int_{t_i}^{t_f} a_i(t) \cdot a_j(t)\, dt \qquad i, j = 1,2,3$$

Energy in a generic direction

$$I_\theta = \sum_{i=1,3} \sum_{j=1,3} I_{ij} \cdot \theta_i \cdot \theta_j$$

Energy in a generic horizontal direction

$$I_\alpha = I_e \cdot \sin^2 \alpha + I_n \cdot \cos^2 \alpha + I_{en} \cdot \sin 2\alpha$$

Maximum/minimum directions

$$\tan 2\alpha = \frac{2 I_{en}}{I_n - I_e}$$

Average normalised Arias intensity at a site

$$I^*_\alpha = \frac{1}{N}\left[\sum_{i=1,N} \frac{I_{ei}}{I_{\alpha M i}} \cdot \sin^2 \alpha + \sum_{i=1,N} \frac{I_{ei}}{I_{\alpha M i}} \cdot \cos^2 \alpha + \sum_{i=1,N} \frac{I_{en i}}{I_{\alpha M i}} \cdot \sin 2\alpha \right] = \bar{I}_e \cdot \sin^2 \alpha + \bar{I}_n \cdot \cos^2 \alpha + \bar{I}_{en} \cdot \sin 2\alpha$$

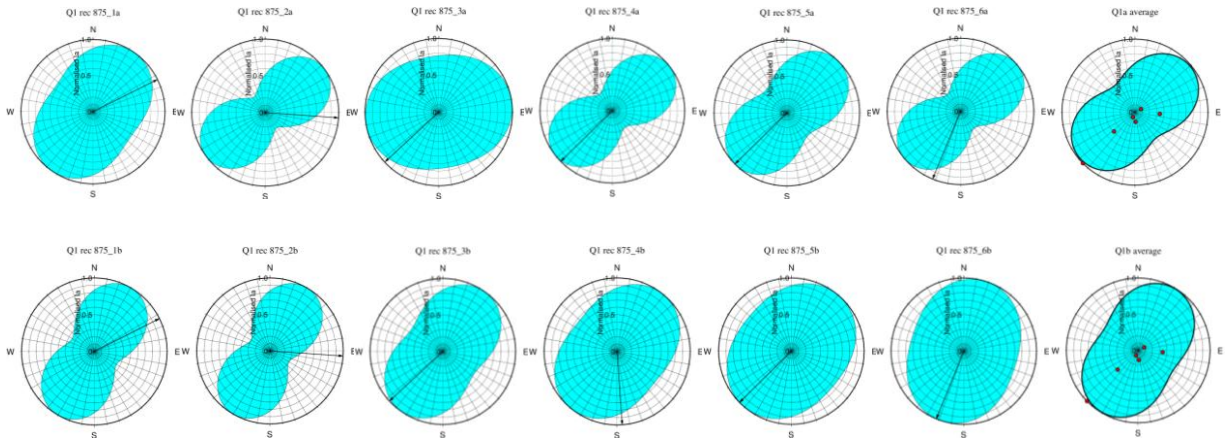
Maximum/minimum directions

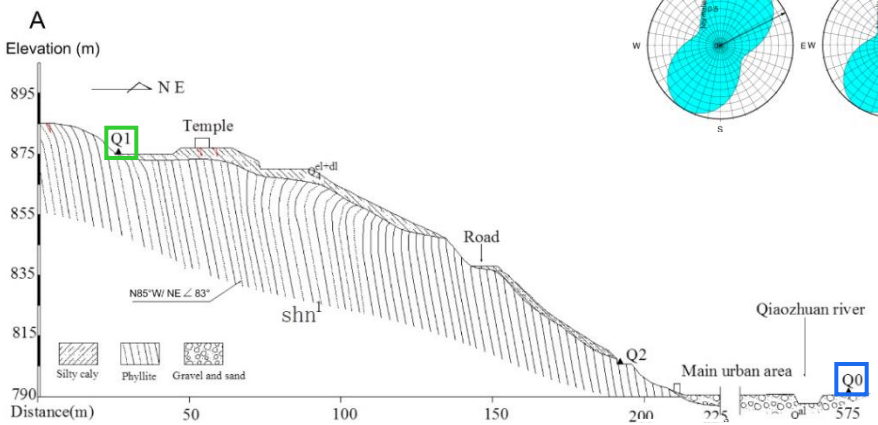
$$\tan 2\alpha'_{\max/\min} = \frac{2 \bar{I}_{en}}{\left(\bar{I}_n - \bar{I}_e\right)}$$

Arias intensity polar diagrams

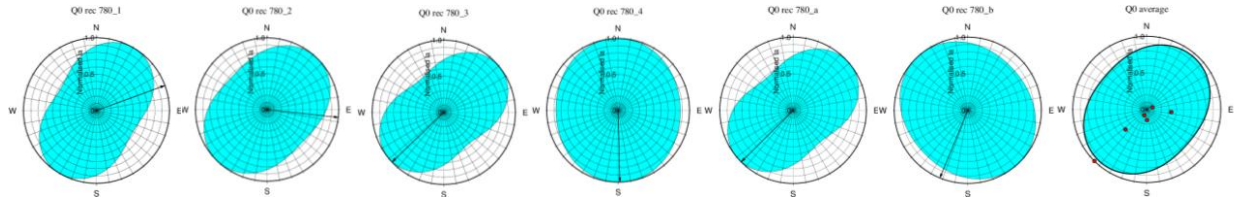
Weigan hill

Q1





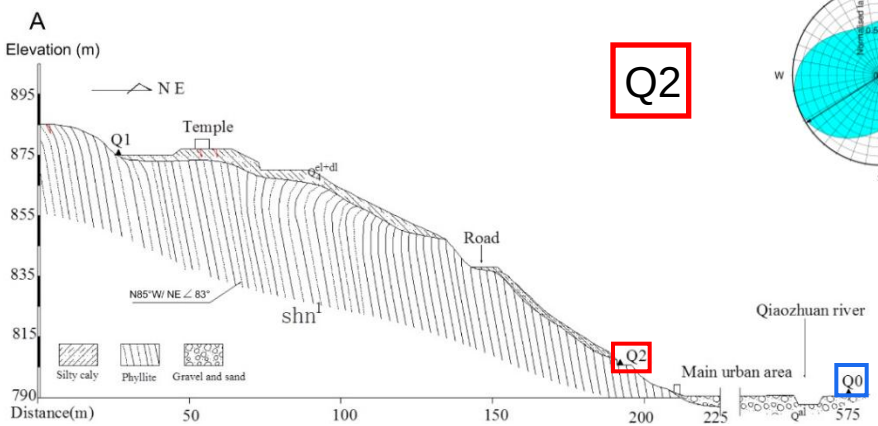
Q0



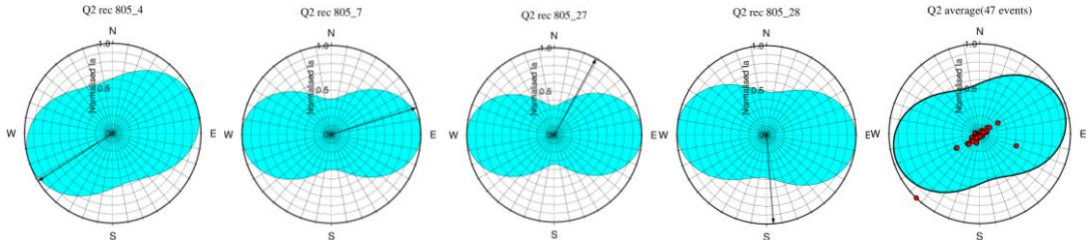
07/04/09-ML3.4	30/04/09-ML2.8	30/04/09-ML3.4	06/05/09-ML3.1	01/05/09-Ms4.0	01/05/09-ML2.5	Average
Dist=4.72	Dist=17.36	Dist=19.79	Dist=6.79	Dist=50.76	Dist=3.72	

Arias intensity polar diagrams

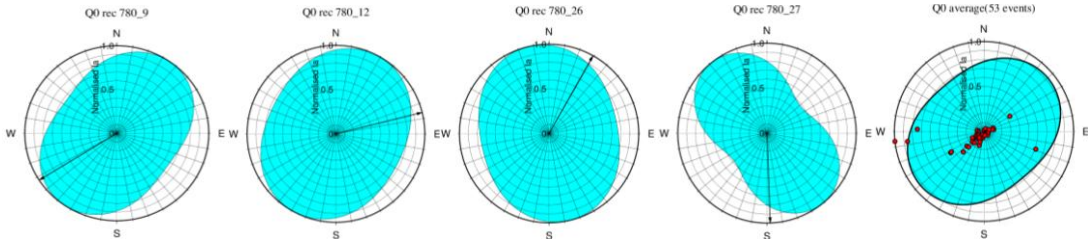
Weigan hill



Q2



Q0

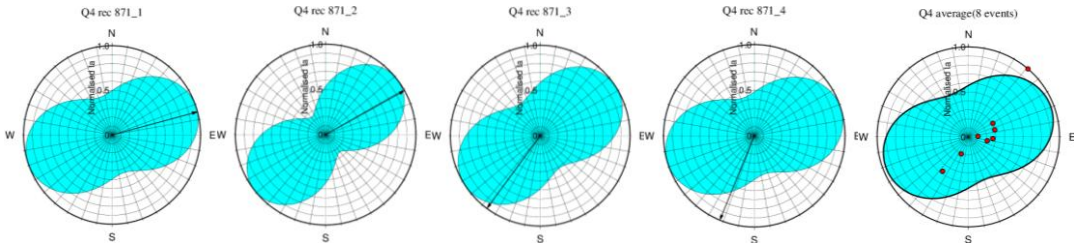


14/05/09-Ms4.4	17/05/09-M_L2.5	04/06/09-M_L2.7	04/06/09-M_L2.8	Average
Dist=52.55	Dist=6.44	Dist=4.93	Dist=4.58	

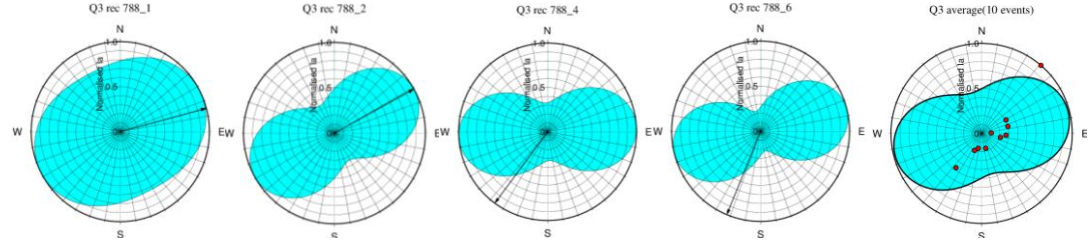
Arias intensity polar diagrams

Weigan hill

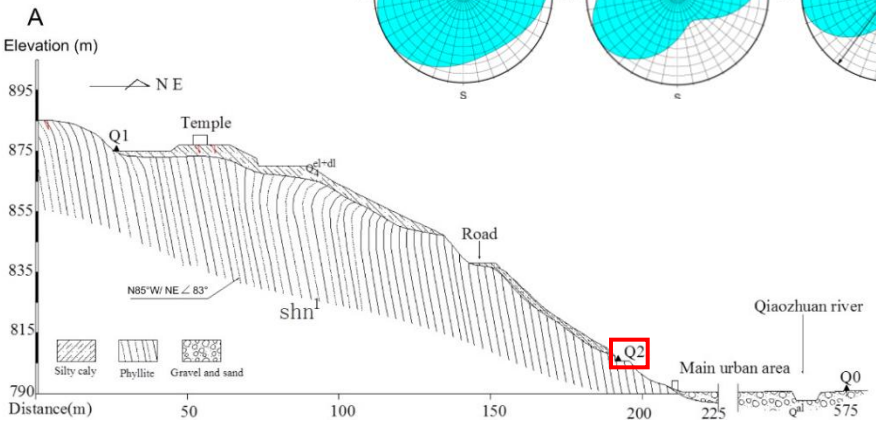
Mount Dong

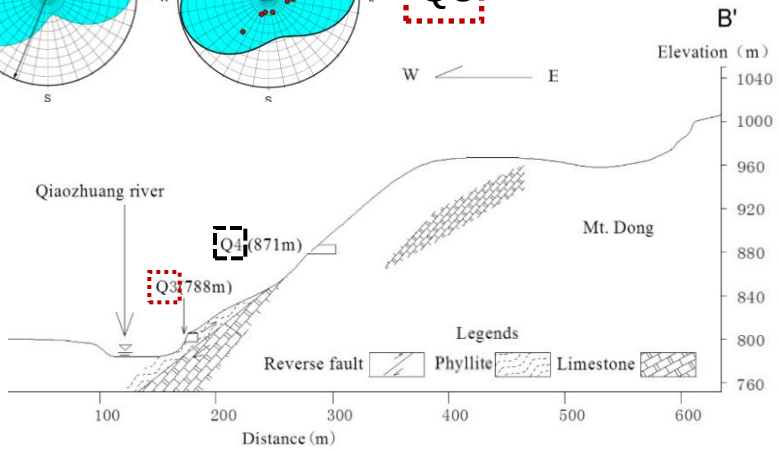


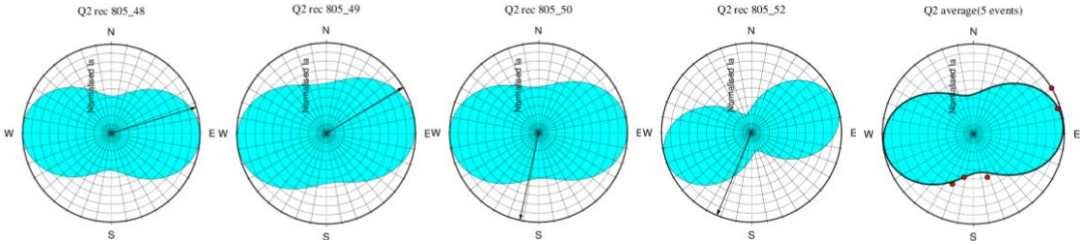
Q4



Q3





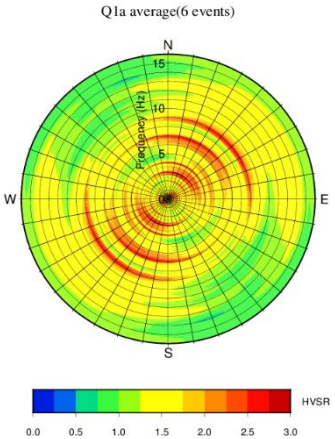


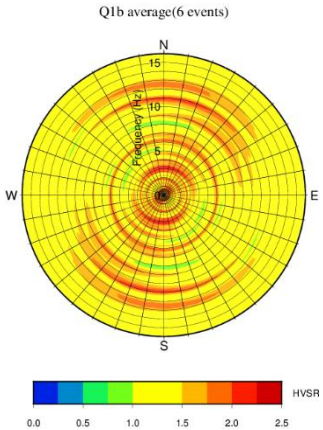
Q2

10/08/09-ML2.5	12/12/09-ML3.4	16/08/09-ML3.2	23/08/09-ML2.6	Average
Dist=14.25	Dist=14.78	Dist=21.01	Dist=8.54	

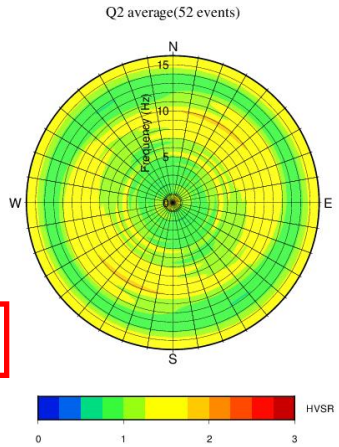
HVSR

Weigan hill





Q1



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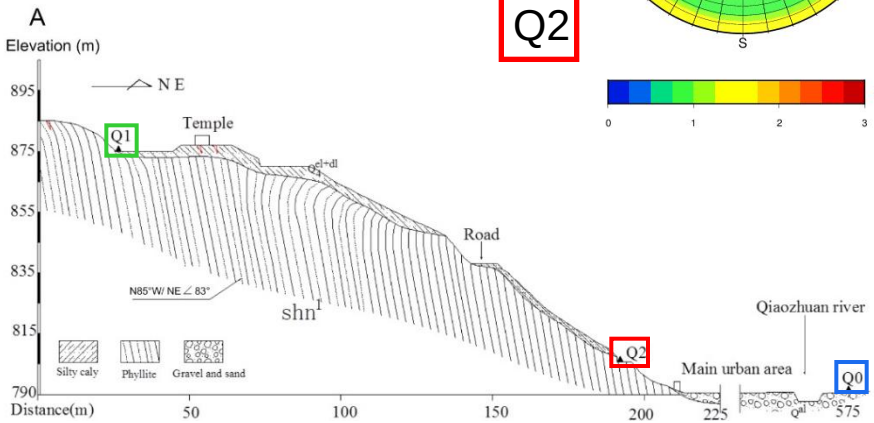

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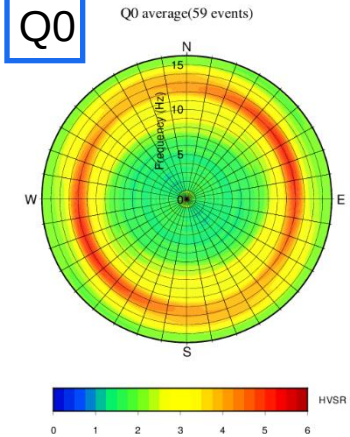
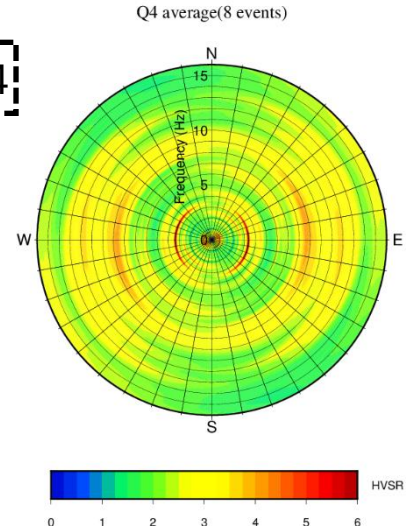


HVSR

Mount Dong

Q4



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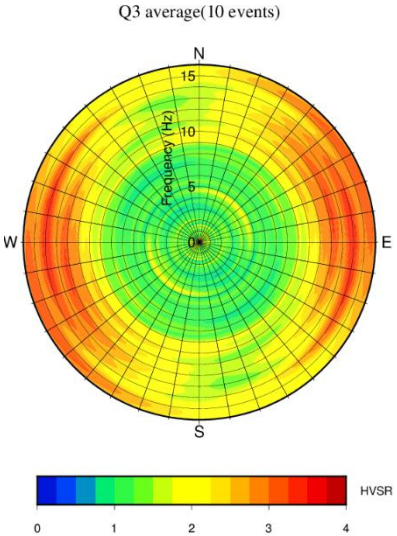
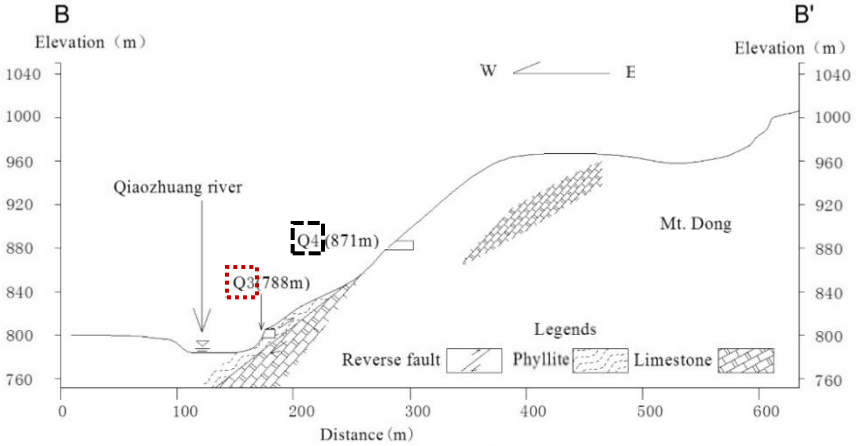
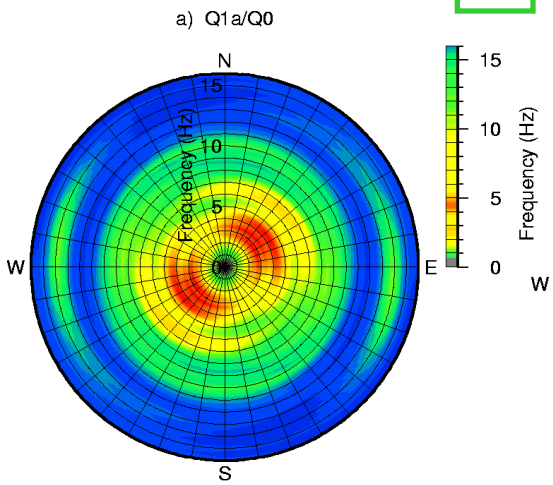


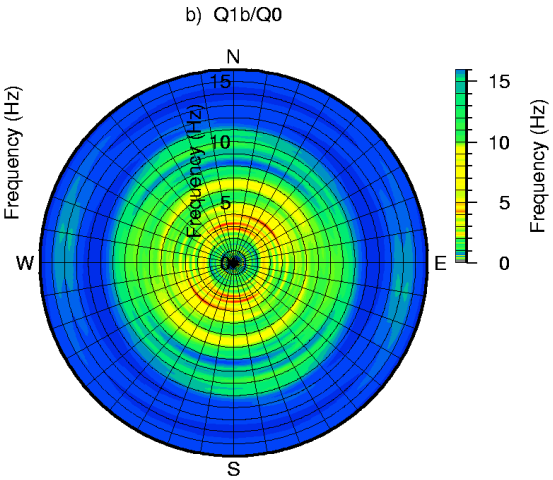


SSR

Weigan hill

Q1





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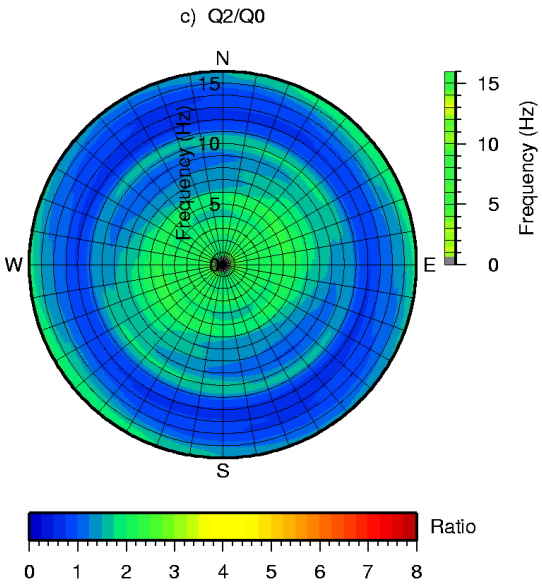
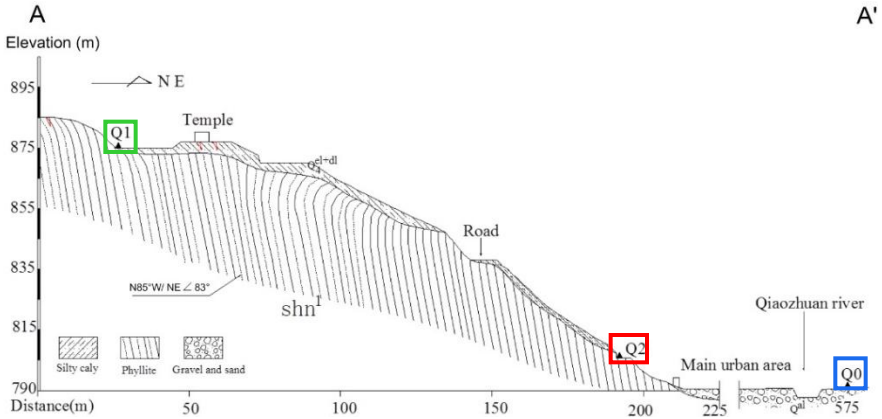




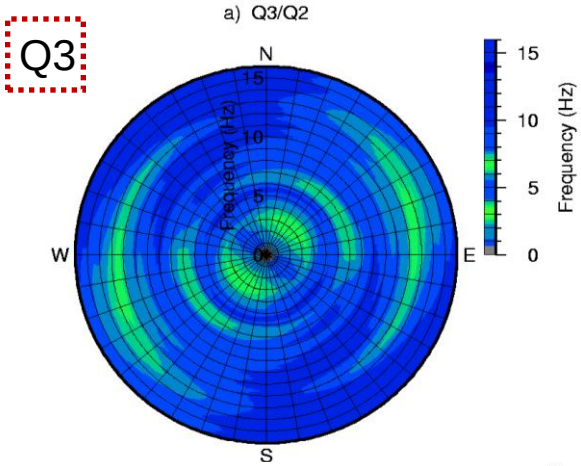
Reference

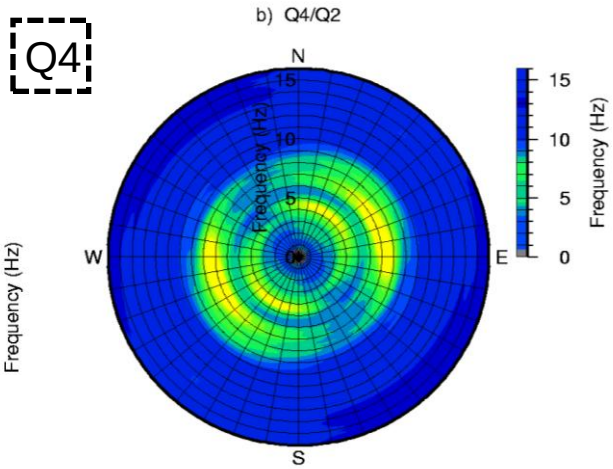
Q0

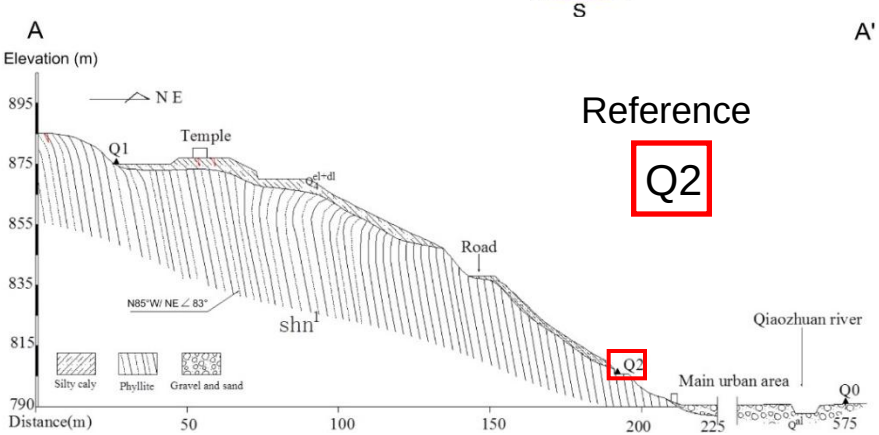
SSR

Weigan hill

Mount Dong

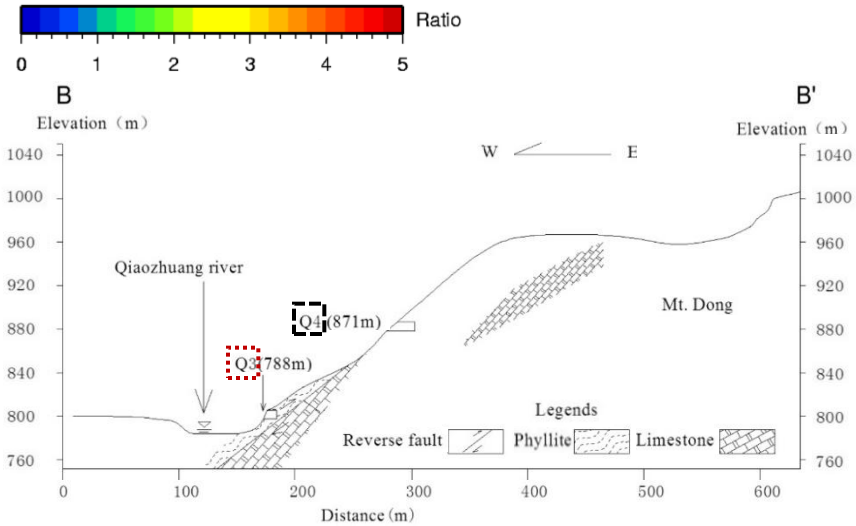






Reference

Q2



CONCLUSIONS

- The use of different kinds of analysis (PGA reduced to unit distance, directional variation of Arias intensity, HVSR and SSR) of “weak motion” data recorded by a temporary network can provide useful insight into site dynamic response.

- Among the employed techniques, HVSR gave problematic results, not always consistent with those of the other methods, possibly as effect of anomalous site response affecting the vertical ground motion as consequence of the local geological setting.

- The comparative analysis of 2008 Wenchuan earthquake sequence data at five Qiaozhuan (Sichuan - China) sites pointed out directional amplification affecting two hills characterized by maxima transversal (Weigan hill) or sub-parallel (Mount Dong) to reliefs elongation.

- Although the presence of amplification increasing with altitude suggests the occurrence of topographic effects, amplification factors indicate a major role played by geological structural characteristics.

Luo et al., 2014, Engineering Geology, 183, 193-207,
http://dx.doi.org/10.1016/j.enggeo.2014.10.015