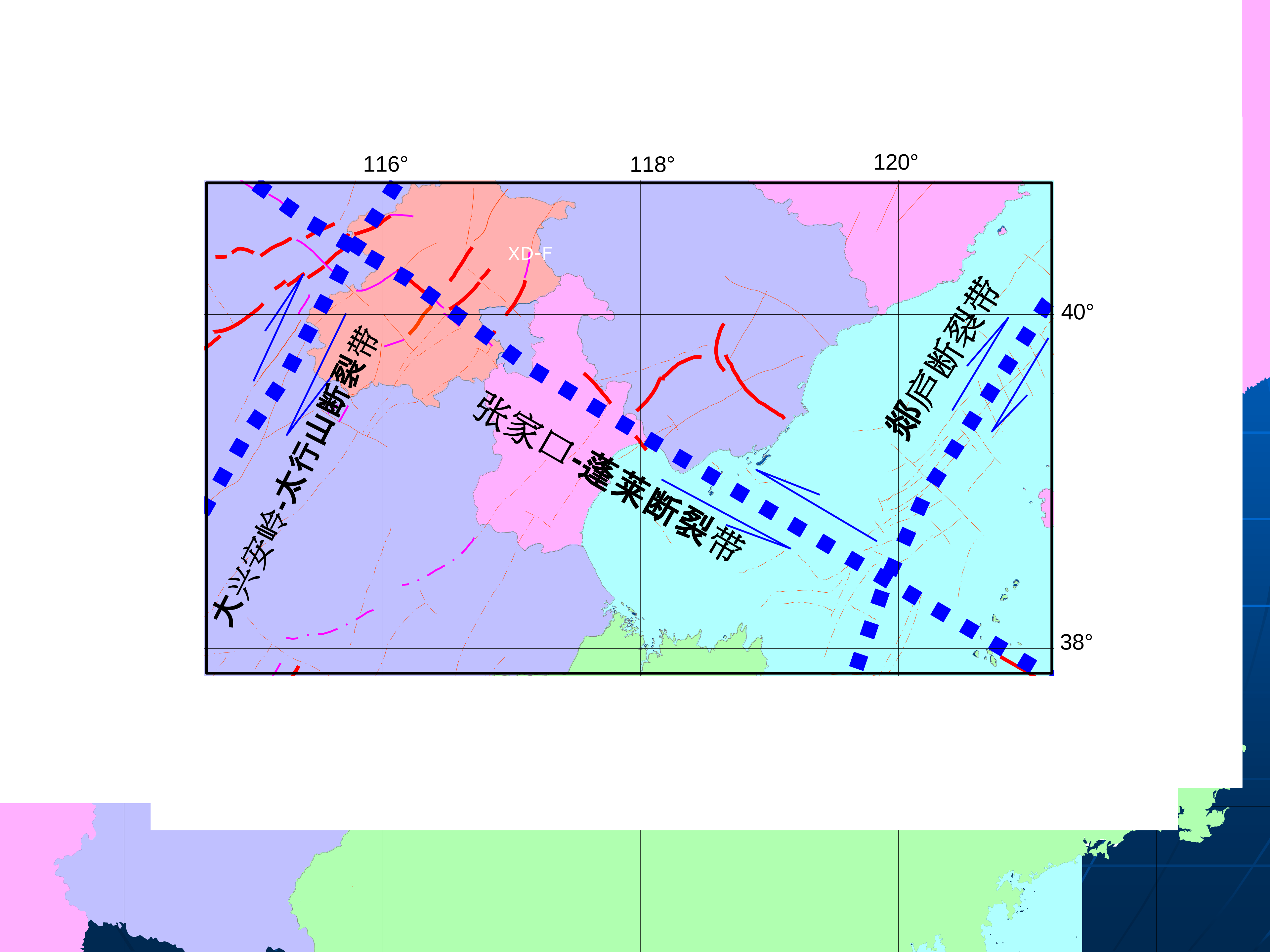
Seismic hazard on an active fault
-- Xiadian fault

Institute of Mechanics Engineering ,
China Earthquake Administration

Zhao Jisheng

1 Introduction

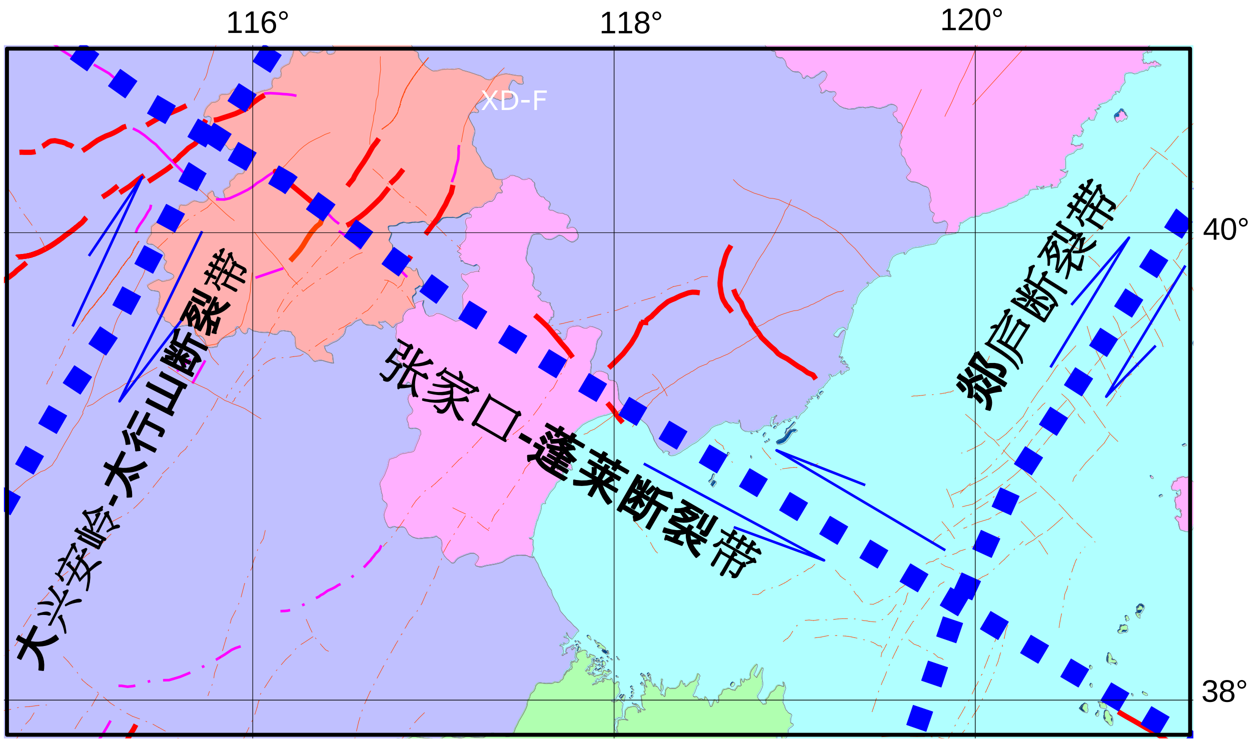
- With major infrastructure projects are constructed in recent years , for example, the south-to-north water transfer project, west to east gas pipeline project and some large span bridges, they inevitably can pass through some active faults with strong activity.
- Here, we focus on estimation of surface dislocation induced by strong earthquake on an active fault in 100 years, to ensure the safety of their service life.
- Seismic hazard of an active fault is a basis to choice route line of the major projects, seismic design measures.
- An example: Xiadian Fault (XD-F)



116°
118°
120°
40°
38°
XD-F
大兴安岭-太行山断裂带
张家口-蓬莱断裂带
郯庐断裂带

The neo-tectonic characteristics

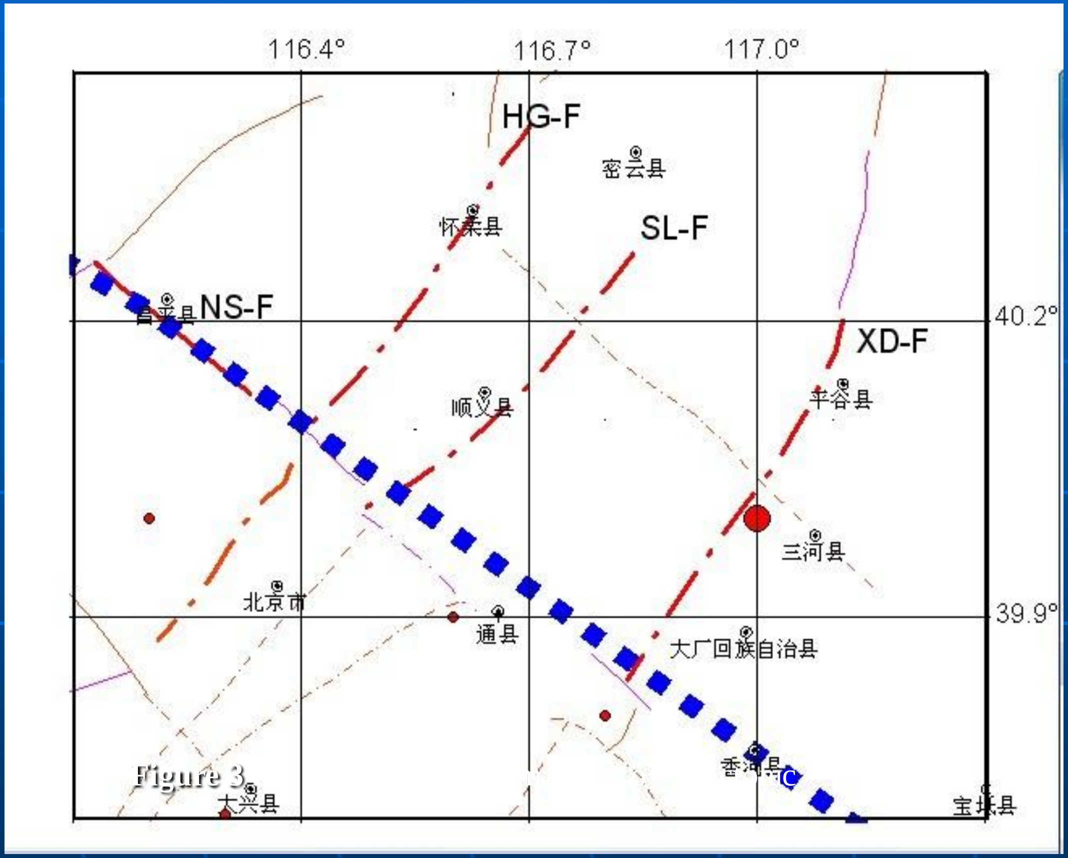
Most part segment of XD-F located in the north China plain fault block, the other in Yanshan fault block. On the secondly stege, it located on the boundary of Daxin uplift block and Jizhong depression block, where a disastrous earthquake Ms8 took place in 1679.



fa

considered the width of fault zones. XD-F and several faults in parallel are almost orthogonal to Zhangjiakou-Penglai fault zone.

➢The fault system feature -Small scale

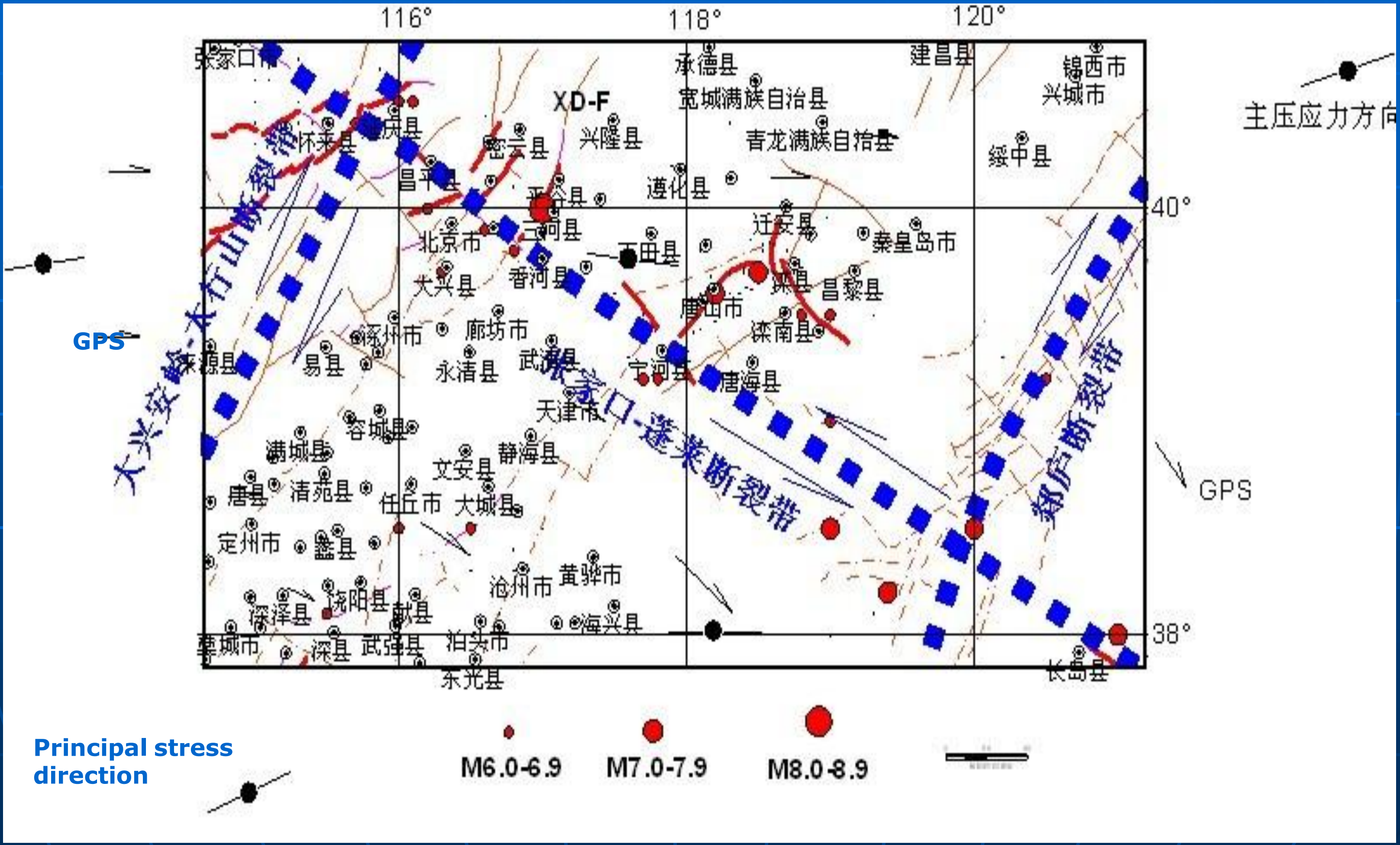


In small area, XD-F, SL-F and HG-F are almost orthogonal to Nankou-Sunhe fault(NS-F).

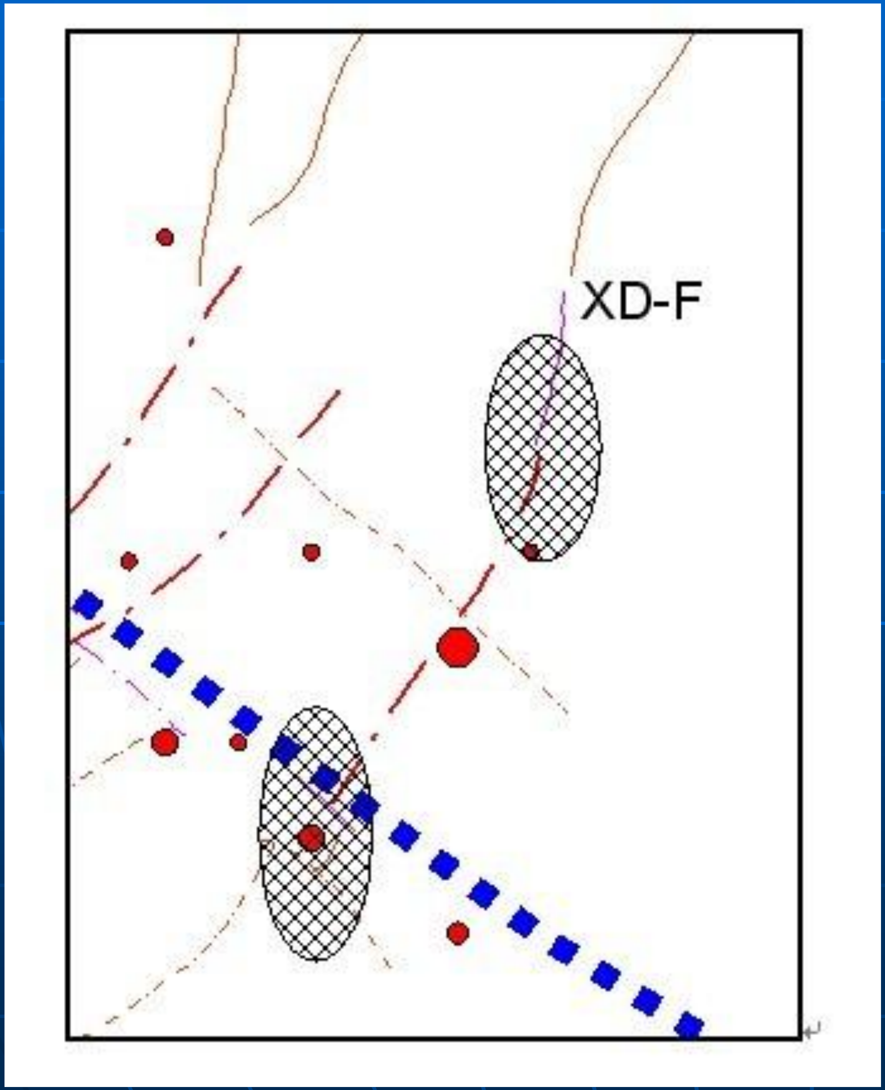
NS-F is a blind fault, which control Machikou-Shahe depression boundary. Starting from Nankou along SE direction to Sunhe, length is about 58km. Trench survey showed, it is a Holocene Active fault.

XD-F can be divided into 4 different activities of the fault segment. The Xiadian segment is a Holocene fault about 28km, which controlled the boundary of Dachang basin.

➢GPS and tectonic stress direction



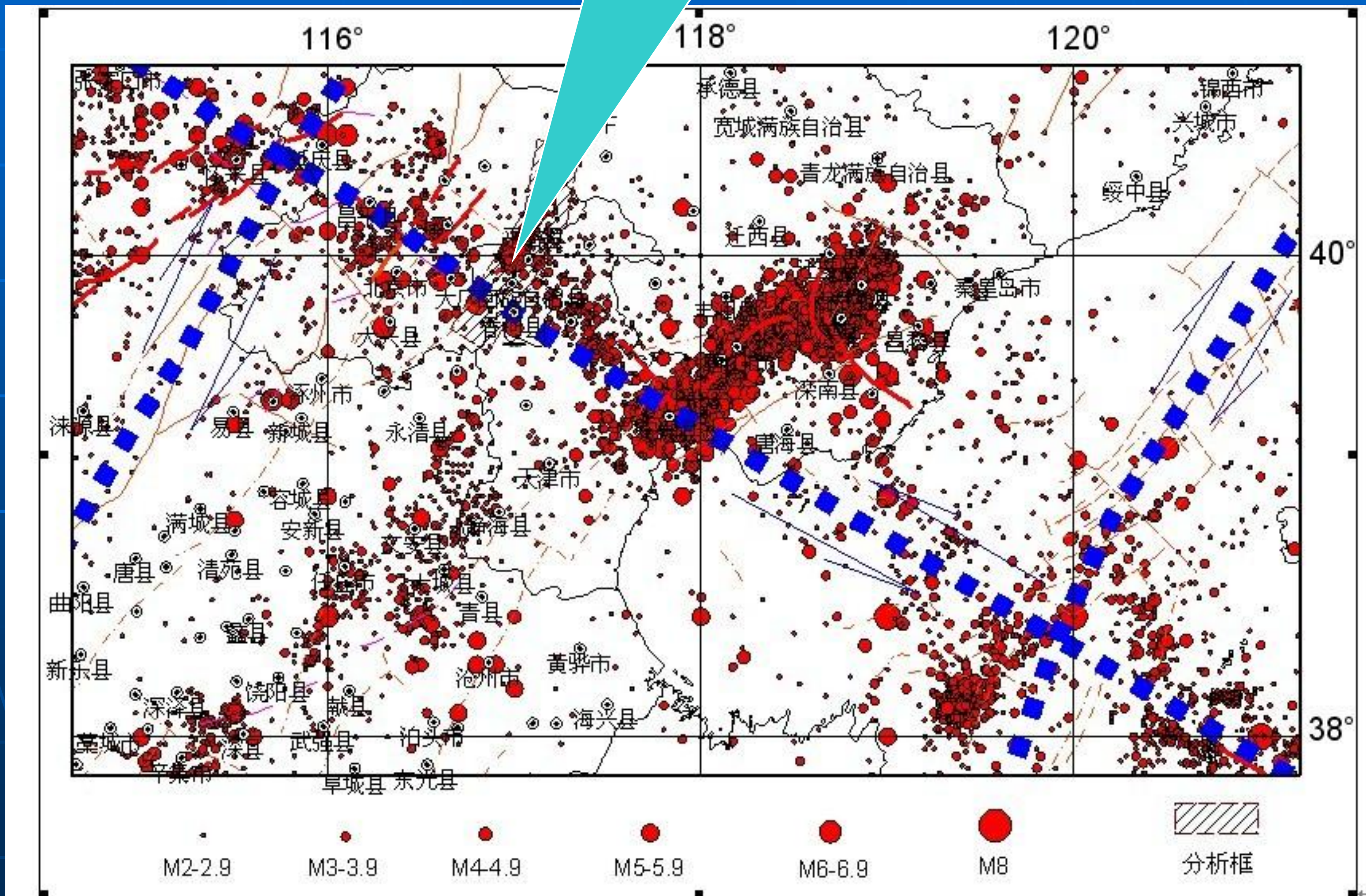
➢Dangerous area



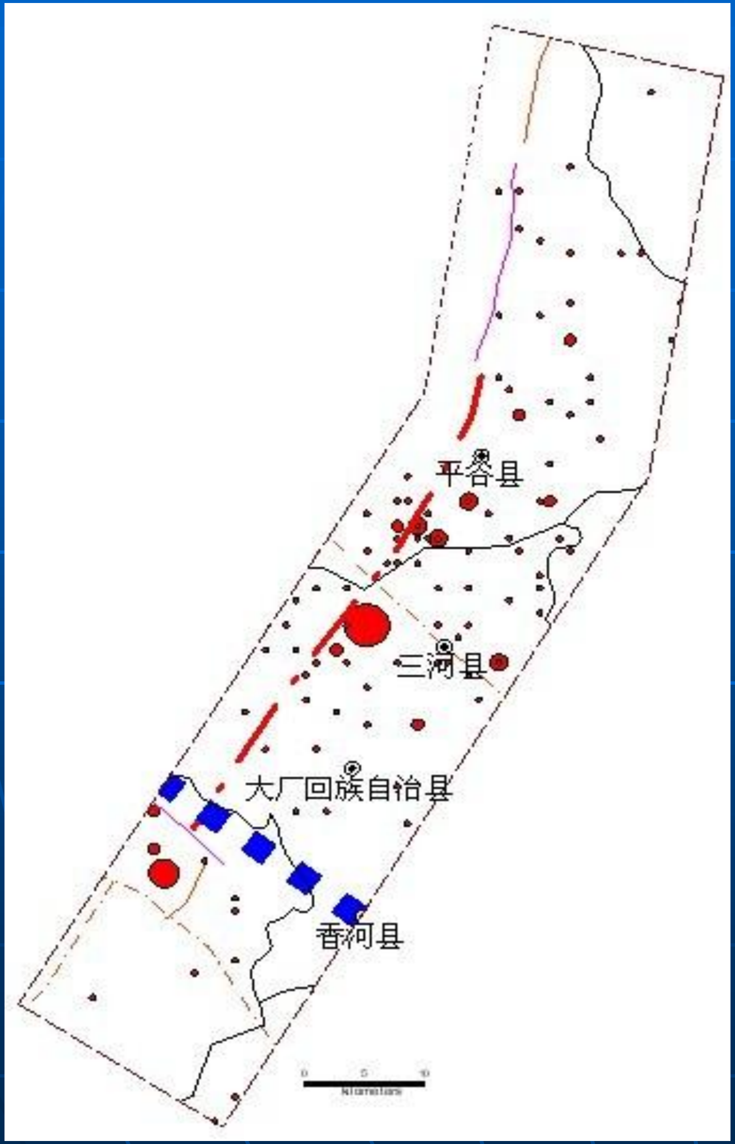
The application of GPS, tectonic stress field, mechanics parameters of Rock, soil and the fault fracture zone, we can use numerical fine-analysis method, or the coarse blocks analysis method, give some positions of stress changed Significantly, where may be an earthquake take place

3 The earthquake sequence

region of interest



➢Earthquake record on the XD-fault



Distribution of earthquakes on XD-fault

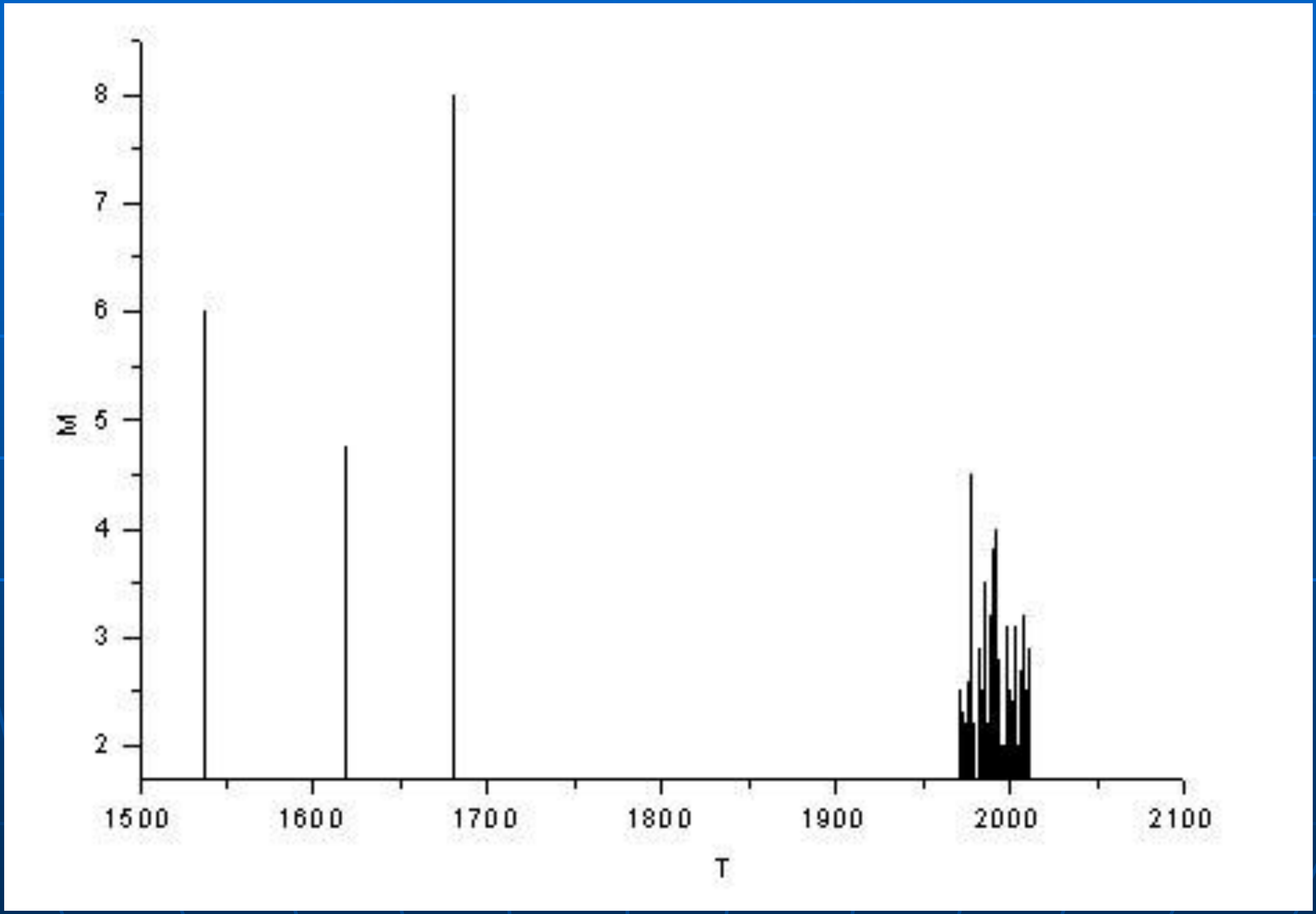
-- Earthquake catalogue M≥4.7 since the beginning of the history

-- Earthquake catalogue 2.0≤Ms≤4.6 1970～2011.10

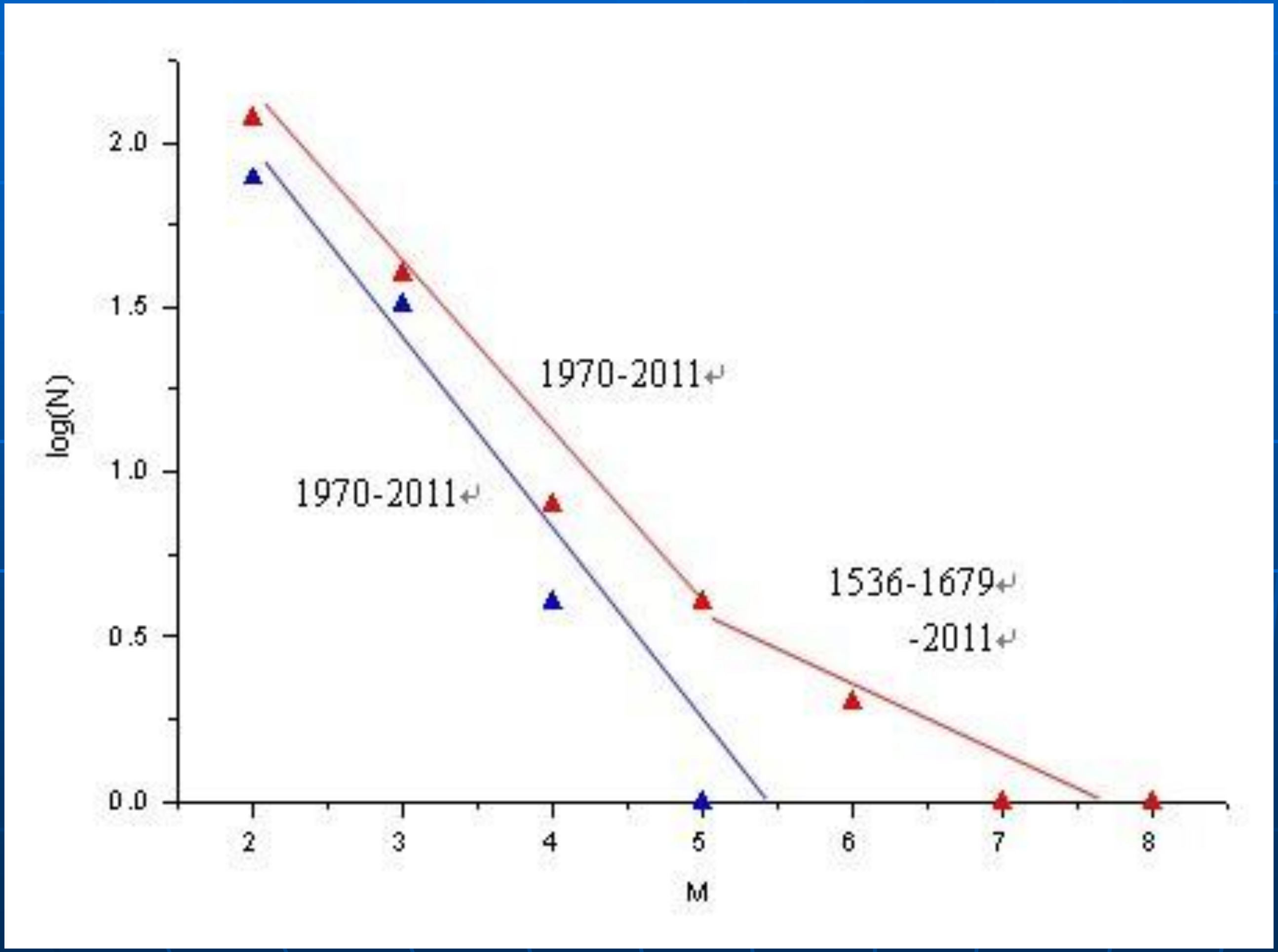
The earthquake records of XD-fault

Magnitude interval	Number of earthquake
2-2.9	106
3-3.9	8
4-4.9	4
5-5.9	0
6-6.9	1
7-7.9	0
8-8.9	1

➢Temporal distribution of earthquake on the XD-fault



➢Magnitude-frequency relation of earthquakes on the XD-fault

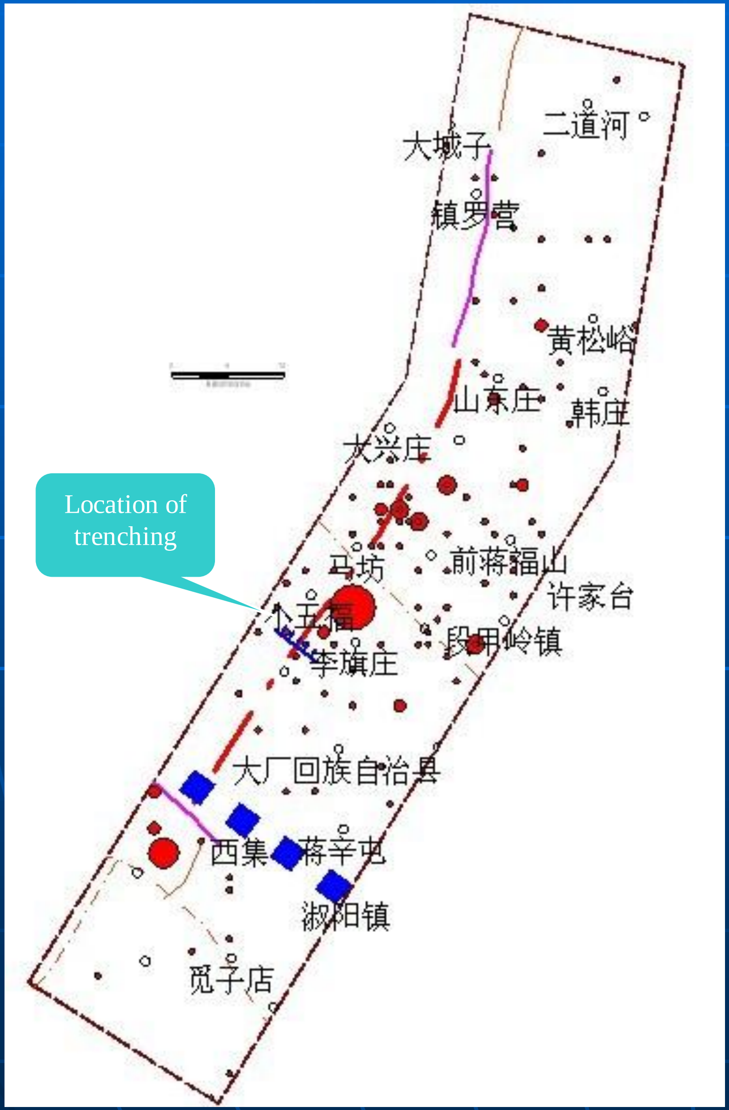


Comparison diagrams of GR relation

So short a time earthquake record;

So limited the number of earthquakes.

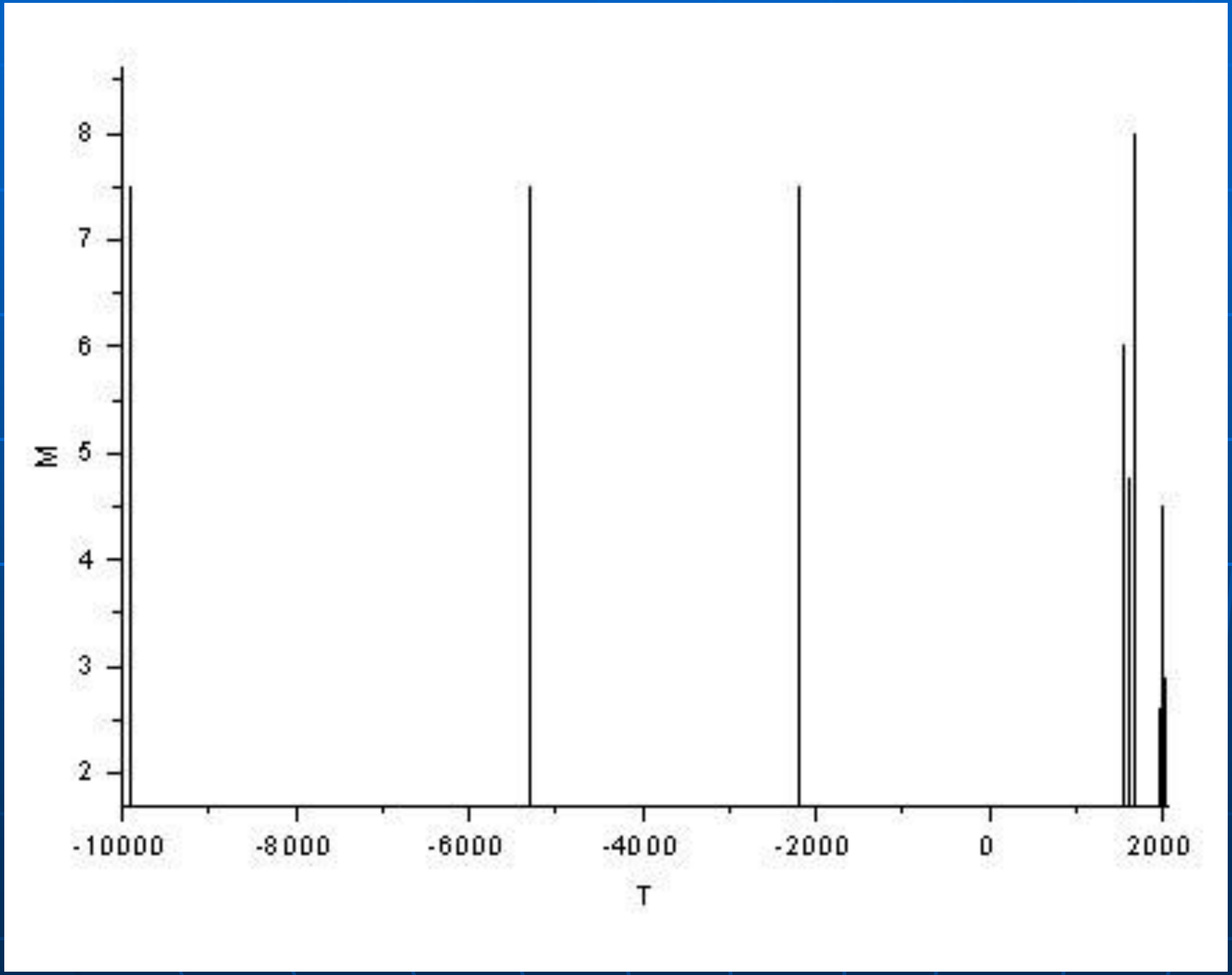
➢The paleo-earthquakes on the XD-fault



Distribution of paleo-earthquakes on XD-fault

Xiang Hongfa (1988), Ran Yongkang (1998) had been excavated trench of the fault characteristics to chick paleo-earthquakes. Xu Xiwei (2002) used the drilling data, by using the successive limit method to get 4 paleoseismic events on XD-F in period of Holocene. They are 1679 (Sanhe-Pingu earthquake), (4.2+0.37) Ka, (7.3+0.3) Ka and (11.9+2.2) Ka, recurrence interval of about 3.1-4.6ka. The corresponding magnitude 7.55, 7.45, 7.32, 8.

➢Temporal distribution with paleo-earthquakes on the XD-F



There existed an interval of characteristics earthquake, but the record is incomplete in any one interval.

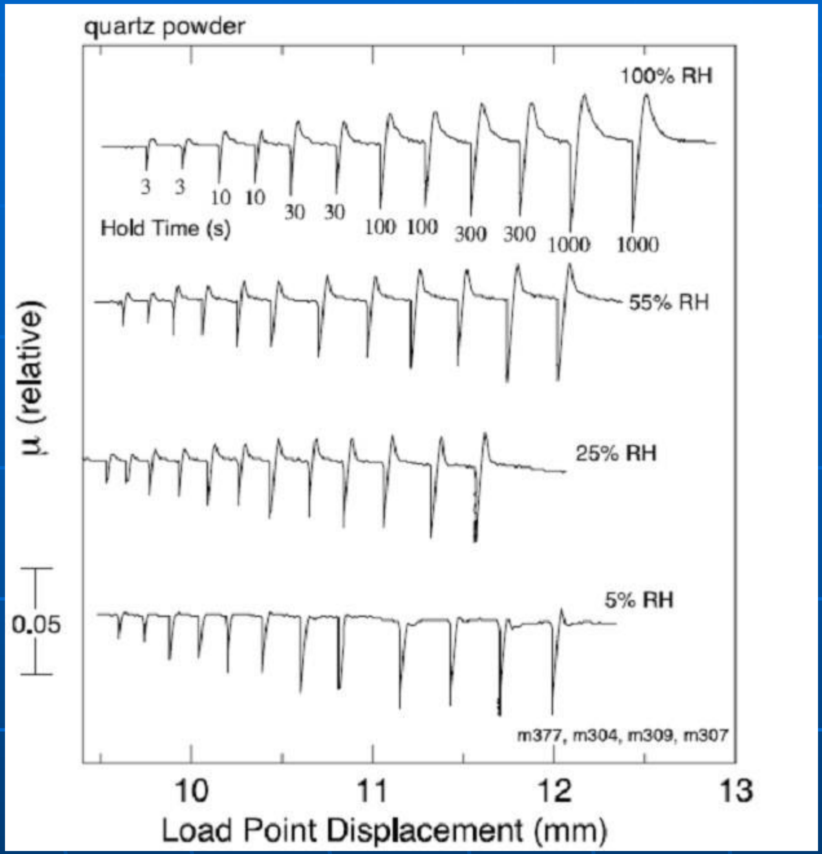
4 Assessment of seismic hazard on XD-F

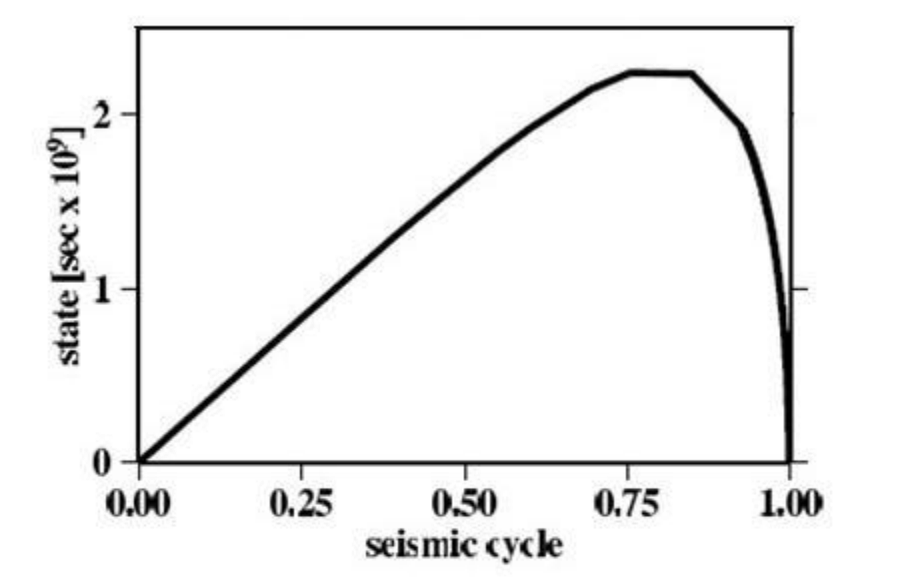
--On the XD-fault earthquake recurrence model is quasi-periodically recurrence.

--The trench information verify that strong earthquake interval is 3.1-4.6ka.

$$\mu = \mu_0 + a \ln\left(\frac{V}{V_0}\right) + b \ln\left(\frac{V_0\theta}{D_c}\right),$$

$$\frac{d\theta}{dt} = 1 - \frac{V\theta}{D_c},$$





--Using state variable of rate and state dependent friction law in XD-F,its interval is the average 0.85-0.95 times.

➢The characteristic earthquake model

--Characteristic earthquake with a magnitude of 7.5, at intervals of 3450 * 0.85 = 3000 years.

--1679 Ms8 earthquake elapsing time is 332 years, the next 100 years Xiadian fault will not 7.5 earthquake occurred.

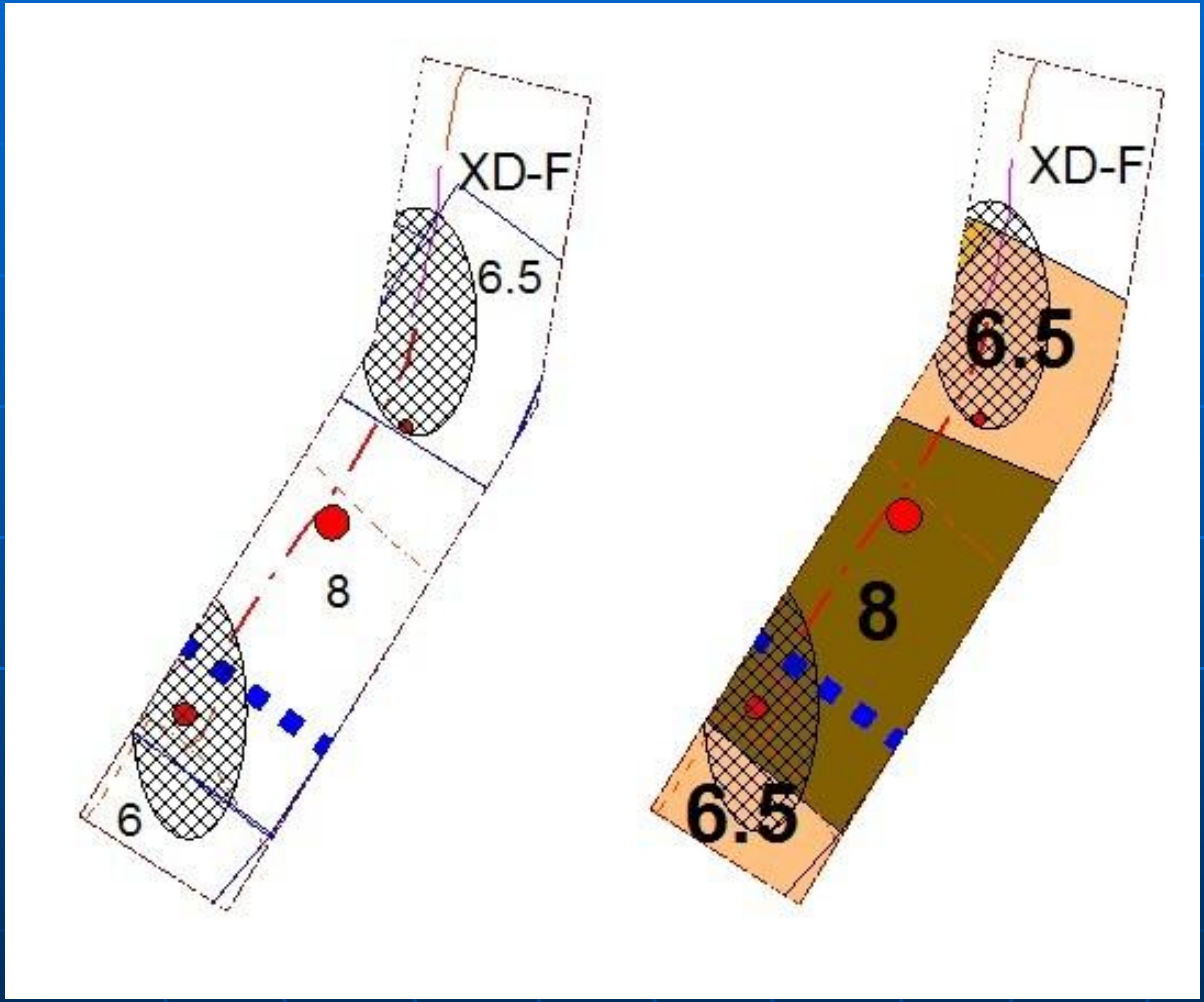
➢The model of Gutenberg-Richter model

Earthquake catalogue M≥4.5 since the first record in the history

Time(Beijing time)	Magnitude	Depth /km	Latitude	Longitude
1536.919	6		39.8	116.8
1618.708	4.75		40.1	117.1
1679.756	8		40.0	117.0
1977.178	4.5	15	39.97	117.13

Defect: Because of statistical range is small (we defined) and earthquake recorded time history is short.

➢Strain energy accumulation model base on characteristic earthquake quasi-period

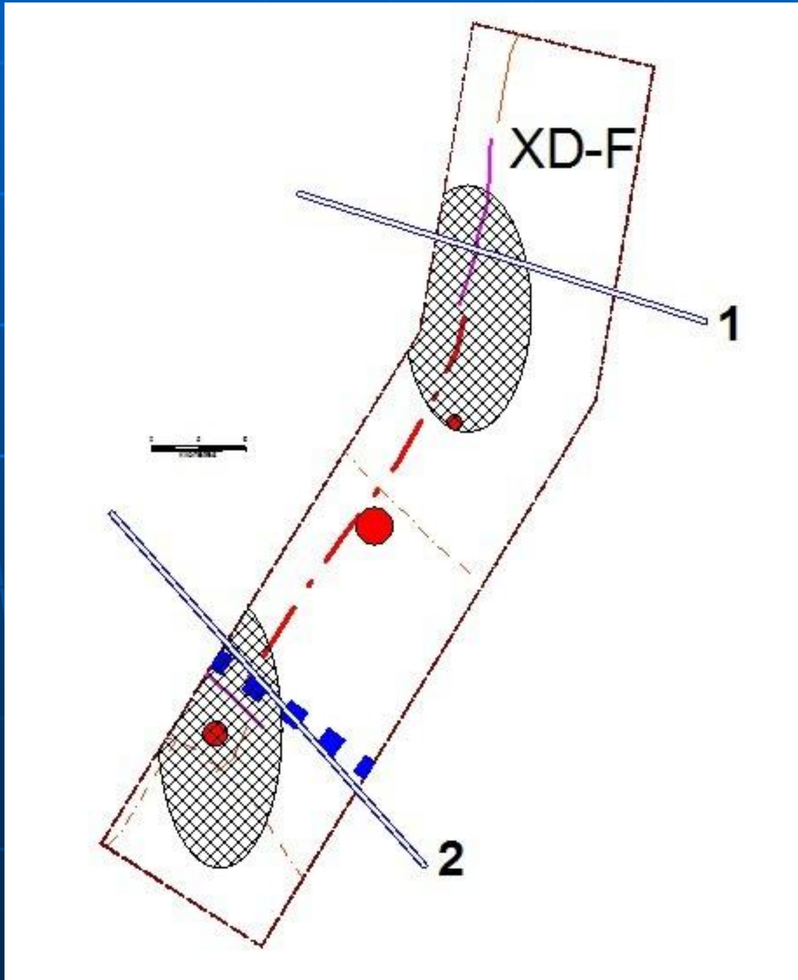


Comparison diagrams of zonation map

Characteristic earthquake on XD-F is Ms7.5, intervals is about 3000 years.

1679's earthquake elapsing time is 332 years,
The next 100 years (i.e. passing time of 432 years) the maximum earthquake on XD-F Will be Ms6.4, according to the strain energy accumulation mode spacing.

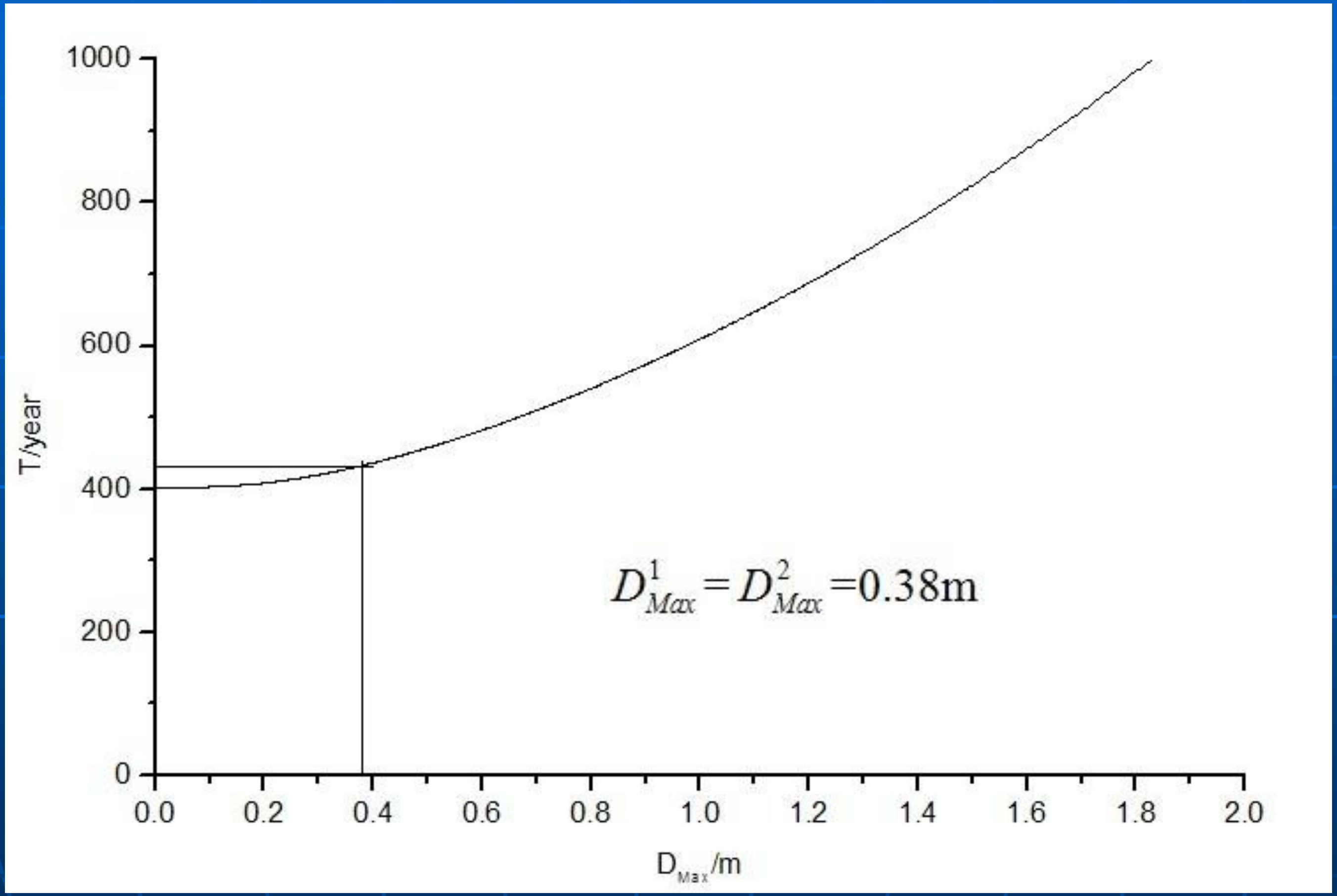
5 Estimation of surface rupture induced by earthquake on XD-F in the next 100 years



Strain energy accumulation model base on characteristic earthquake quasi-period (A step memory model) used, Assume epicenter in the fault is random distribution, elapsed time is t0 = 432 years, pipelines location 1, 2 crossing the fault larger than the dislocation of D annual exceeding probability p (d) is

$$p(d,t|t_0) = n(t|t_0)\cdot\lambda\cdot\xi\frac{L_R(m)}{L(m)}\cdot P[D_{site}(x_0) > d_{\max}|m]$$

$$\begin{cases} \xi = \kappa, & if\,(x_1 - x_0) \geq L(m) \\ \xi = \dfrac{L(m)+(x_1-x_0)}{2L(m)}\kappa, & if\,(x_1 - x_0) < L(m) \end{cases}$$



1000
800
600
400
200
0
T/year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
D_{Max}/m
$D_{Max}^{1} = D_{Max}^{2}$ =0.38m

well's statistical relation

$$\log(D_{Max}) = -5.90 + 0.89M$$

$$D_{Max}^{1} = D_{Max}^{2} = 0.62\text{m}$$

Dengqidong's statistical relation

$$\log(D_{Max}) = -11.071 + 1.447M$$

$$D_{Max}^{1} = D_{Max}^{2} = 0.016\text{m}$$

6 Conclusion

Using data of geological region around XD-F, GPS, tectonic stress field, we can find some dangerous areas where an earthquake would be taken place.

Because we confined statistical area is small, the number of Earthquake is limited, paleo-earthquake trench exploration is needed.

Characteristic earthquake model, Gutenberg-Richter model, and Strain energy accumulation model based on characteristic earthquake quasi-period can be adopted in the seismic hazard assessment from the characteristics of fault. XD-F belongs the third.

Surface rupture from earthquake on XD-F is evaluated in the next 100 years.

Thank you

questions and suggestions?