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STUDY ON THE GENERATING FAULT AND MECHANISM OF THE *M*5.9 YUMEN EARTHQUAKE ON DEC. 14, 2002, ACCORDING TO THE ACCURATE LOCATING OF THE SEISMIC SEQUENCES USING THE DOUBLE-DIFFERENCE EARTHQUAKE LOCATION ALGORITHM

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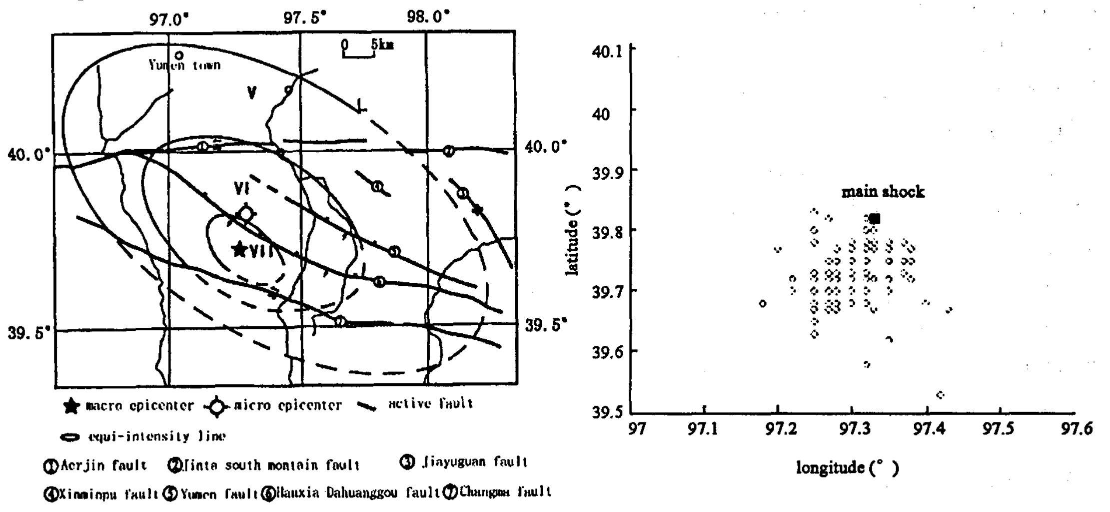
Abstract: The seismic sequence of the *M*5.9 Yumen earthquake on Dec. 14, 2002, are relocated using the double-difference earthquake location algorithm. On this base the generating fault and mechanism are discussed.

Key words: **Double-difference earthquake location algorithm; *M*5.9 Yumen earthquake; Generating fault; Seismic mechanism**

0 Introduction

An earthquake of $M_S = 5.9$ on December 14, 2002, occurred in Yumen city, Gansu province, China. The event is the largest one in continent of China in 2002. It is unsure and exist different understand to the generating fault and the seismic mechanism of this earthquake. The intensity distributing from field investigation, the aftershock distributing (Fig. 1), and the source mechanism (Tab. 1) are disaccord apparently (DONG Zhi-ping et al., 2003)[4]. It is a helpful method using the aftershock distribution having more accurate locations to determine the generating fault and the seismic mechanism of an earthquake.



(a) Intensity distribution (b) Main and aftershocks

Fig. 1 Distribution of intensity and aftershocks of Yumen *M*5.9 earthquake.

Tab. 1 seismic mechanism of Yumen earthquake

nodal plane A			nodal plane B			Axis P		Axis T		Axis N	
strike	dip	Slip	strike	dip	Slip	Azimuth	Elevation	Azimuth	Elevation	Azimuth	Elevation
(1)147°	26°	35°	24°	75°	111°	277°	27°	140°	55°	18°	21°
(2)267°	41°	80°	101°	50°	99°	184°	5°	59°	82°	275°	82°

(1) from Dong Zhiping et al. 2003; (2) from Geological Survey of America

F. Waldhauser (2000) [5] has developed a new method (the double-difference earthquake location algorithm) to relocate the earthquake including the events both in very large region and the territorial area. F. Waldhauser has applied the method to two clusters of earthquake located on the northern Hayward fault, California. There it collapses the diffuse catalog locations into sharp images of seismicity and reveals horizontal lineations of hypocenters that define the narrow regions on the fault where stress is released by brittle failure. YANG Zhi-xian (2003) used the method to relocate 6 496 events in middle – western China, and the results show more fine images of hypocenters.

In this paper the seismic sequence (including the main shock and the aftershocks) of the *M*5.9 Yumen earthquake on December 14, 2002 are relocated using the double – difference earthquake location algorithm.

1 Method and data

The double-difference earthquake location algorithm developed by F. Waldhauser in 2000 is an effective method for relocating earthquakes. This method colligates the virtues of both absolute and relative location. Using the method not only the interevent distance between correlated events that form a single multiplet to the accuracy of the cross – correlation data can be determined but also the determined relative locations of other multiplets and uncorrelated events can be consistent to the accuracy of the absolute travel-time data without using station corrections.

The theory of the double-difference earthquake location algorithm has been specified in detail by F. Waldhauser and not depicted here. We will use the data of the seismic sequence of *M*5.9 Yumen earthquake on December 14, 2002 in Gansu province, west China. For the main shock the data of both the digital network of Gansu and the stations of state base digital network are used. The data from both the stations mentioned above and the temporary digital network on site which is setup after the main shock are used for aftershocks. The station distribution is shown as Fig. 2.

The origin catalogs of 113 events given by the Seismological Bureau of Gansu province are shown in Fig. 1(b), and have no information of depth for most events.

The temporary digital network worked from December 16 to December 26. Because of geographical reason the station distribution around the main shock area is not good. The 93 events recorded by more than 4 stations are used for relocated.

The velocity model used in relocation of the source area is shown as table 2. It is tested time and again in the location using the data of the temporary digital network.

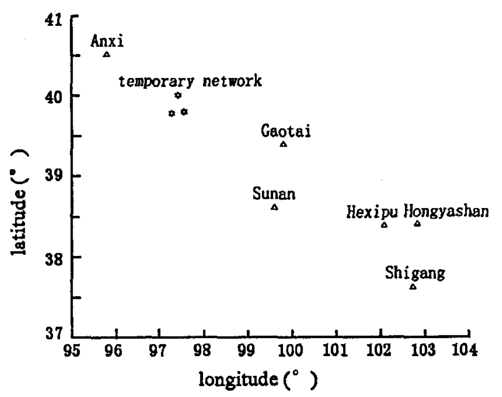


Fig. 2 Distribution of stations used in Yumen earthquake.

2 Results

2.1 The plane distribution of epicenters

Fig. 3 is the map shows the epicenter from relocation and the sketch of main faults.

Tab. 2 The velocity model for relocation*

P wave/[km · s^{-1}]	Thickness/km
4.57	0.0
5.31	1.1
5.45	6.9
5.86	21.0
7.35	51.9

* $Vp/Vs = 1.73$

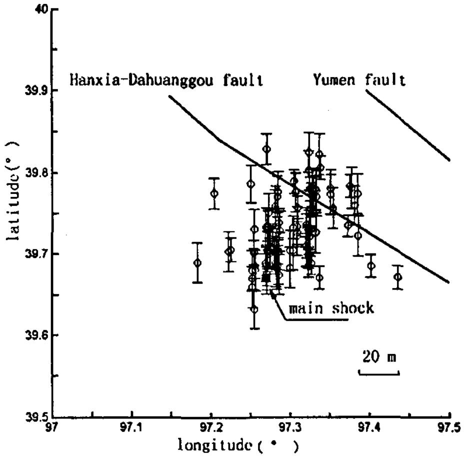


Fig. 3 Epicenters from relocation and the sketch map of the main faults.

The relocated site of the main shock is 39.670°N, 97.272°E with depth 21.3 km, is consistent with the location of macro-epicenter. It is noticed that the epicenter of the main shock is a little far from the original location. The reason is by any possibility that we abnegate the records which having not very good quality in some stations far from the source area and use the data with difference between the travel time of P, S phases obtained by cross – correlation data.

2.2 The depth distribution of aftershocks

Fig. 4 shows the depth distribution of aftershocks and the generating faults. In the figure the horizontal axis is the distance from the epicenter to the location of 97°E, 39.5°N along a line of N 45°E.

2.3 Error of relocation

The error bar of the epicenters and depth are shown in Fig. 3 and Fig. 4 separately. In Fig. 5 the distributions of errors in rms travel – time(a), in plane error(ERH) (b) and in depth error(ERZ) (c) are shown. It is to be seen that the average of RMS, ERH and ERZ are around 0.05 sec., 16m and 23m separately.

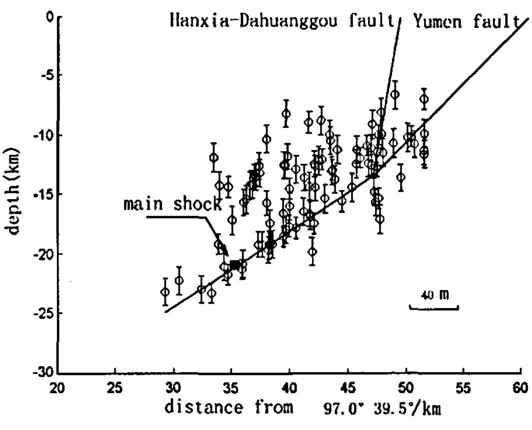
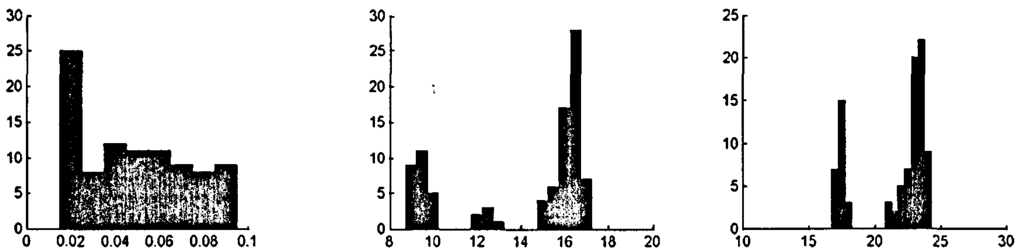


Fig. 4 depth distribution of aftershocks.



(a) rms travel – time/s　(b) ERH/m　(c) ERZ/m

Fig. 5 Error distributions.

3 The generating fault and the seismic mechanism of M5.9 Yumen earthquake

From field review it is primarily confirmed that the macro - epicenter of the main - shock is located at 39.7°N, 97.3°E (Fig.1), and the generating fault is the Hanxia - Dahuanggou fault. According to the results of relocated epicenters the generating fault and seismic mechanism are discussed over again as follows.

3.1 The generating fault

From Fig.4 we can see that the contour line of the aftershock distribution in depth is accordant with the nodal plane A of seismic mechanism of main shock. Considering the Hanxia - Dahuanggou fault to be the only generating fault can not interpret the location of the main shock and the aftershock distribution in depth, we consider that the Yumen fault is concerned with the activity of the main and the after shocks. The Yumen fault is the important part of the northern edge fault of Qilianshan. It is a thrust fault about 70 km long, strike to 310°, dip to SW with 20° ~ 60°, located at north - east of Hanxia - Dahuanggou fault 10 km away (CHEN Wen - bin et al., 1999; CHEN Jie et al., 1998). According to the results of relocation we can consider that Yumen fault extends in depth converging with Hanxia - Dahuanggou fault and is concerned together in seismic energy releasing for the main and aftershocks.

3.2 Generating mechanism

From the discussion mentioned above we would obtain the generating mechanism of the earthquake. The axis P of generating stress is 277° or 184° (Tab.1). The tectonic pressure stress reflected by the mechanism of great earthquakes around the area is NE - SW with predominance direction of 20° ~ 50° (CHEN Yong-ming et al., 1996). We consider that in the action of NEE pressure the joined surface of Yumen and Hanxia - Dahuanggou faults failed at first occurring the main shock with 21km depth, then occured aftershocks releasing residual energy in the northward fault plane from the main shock. The spread range of aftershocks along the fault strike is about 20km, we can estimate the magnitude of the main shock according to the equation (GUO Zeng-jian et al., 1979)

$$M_S = 3.3 + \log L(\mathrm{km})$$

identical $M_S = 6.0$, comparing with $M_S = 5.9$ in the catalog.

4 Conclusions

(1) The relocated earthquake sequence of $M_S = 5.9$ Yumen earthquake on December 14, 2002 using the double-difference earthquake location algorithm has advanced precision.

(2) Based on the results of the epicenters, especially the depths the generating fault, the seismic mechanism is well interpreted.

(3) The results shows that the double - difference earthquake location algorithm is very useful for studying on fine structure of local fault and determining generating fault of moderate - strong earthquakes using the spatial distribution (3-D) of micro - earthquakes.

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基于"双差法"地震精确定位研究2002年12月14日玉门5.9级地震的发震断层和发震机制

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摘　要:利用双差地震定位方法对2002年12月14日玉门5.9级地震主震和余震序列进行了精确定位,在此基础上讨论了本次地震的发震断层和发震机制。

关键词:双差地震定位法;玉门5.9级地震;发震断层;发震机制

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