Characteristics of the seismic source stress field in the joint region of Xianshuihe, Longmenshan and An’ninghe faults*

LONG Si-sheng (龙思盛) ZHAO Zhu (赵 珠)
Seismological Bureau of Sichuan Province, Chengdu 610041, China

Abstract

Twenty-two earthquakes ($M_L=2.2$–$3.7$) in the joint region of Xianshuihe, Longmenshan and An’ninghe faults are studied in this paper. The source mechanism solutions of these events are obtained using P-wave first motion method, and the characteristics of the source stress field and rupture in the joint region are summarized preliminarily with some results of other researchers. Being strongly extruded by the approximately horizontal regional stress with the direction from north-west to south-east and the effect of the complex tectonics in the region, the source stress field has complex and variable characteristics. The earthquakes mainly show normal or strike-slip faults in Yajiang, North-triangle and west of Chengdu-block areas, indicating that the vertical forces have been playing an important role in the source stress fields, while the earthquakes mainly show reverse or strike-slip faults in Baoping-Tianquan area, with the horizontal components of the principal pressure stress axes identical to the south-west direction to which the shallow mass is moving. We think that the manifold combinations of earthquake faults are the micro-mechanism based upon which the large regional shallow crust mass has been moving continually.

Key words: source mechanism solution; source stress field; earthquake fault; mass movement

CLC number: P315.2 Document code: A

Introduction

Sichuan region is one of the extruded and connected parts between the Qinghai-Xizang (Tibet) Plateau and Yangtze block. And the joint region of Xianshuihe, Longmenshan and An’ninghe faults reflects the structure characteristics formed by the Qinghai-Xizang Plateau's extruding to Yangtze block and the Sichuan basin evolutionary process as fore-land basin. The researches on seismic activity in Sichuan region were mainly around Xianshuihe, Longmenshan and An’ninghe faults separately in the past, and the special works about the joint region of the three large faults are rare up to now. After long geologic development periods, the present joint region is composed of Ganzi-Aba, Longmenshan and Chengdu block, which are extruding and colliding together now. The Longmenshan, Xianshuihe and An’ninghe faults are main faults dividing tectonic regions. The faults are multitudinous and the geologic structure is complex. Earthquakes occur frequently. The characters of the seismo-geological condition, the regional tectonic stress field, the seismic activity and the rupture feature appear also to be very complex in the joint region. Based on the earthquake focal mechanism solutions obtained from P-wave first motion analysis, this paper studies

* Received date: 1999-12-05; revised and accepted date: 2000-03-15.

本文英文审校：许忠准
the stress field and earthquake faulting features in the three faults joint region. This is not only a supplement of the works on Sichuan basin development, the seismic activity in Sichuan and Qinghai-Xizang Plateau's extrusion onto the Yangtze block, but also useful to the study on the complex upper crust structure in other fault joint region.

1 Data processing

The studied region in this paper is the joint region of the three large faults, i.e., Longmenshan, Xianshuihe and An'ninghe faults, 29°20'~30°45'N, 101°00'~103°25'E. It is called "the joint region" in this paper. The triangular area between Xianshuihe and Longmenshan faults in the joint region is simply called as "North-triangle area" (Figure 1). Based on The Seismic Catalogue of Sichuan Seismic Network, 22 events in the joint region occurred recently (1998-01-01~1999-03-31) are selected. They have the magnitude $M_L=2.2$~3.7 and more station (23-40 stations) recordings. These events mainly locate near the faults and part of them distribute in the joint region. They can reflect the change of source stress field and the faulting feature in the joint region.

Although the selected events have the location precision in first or second grade, yet their epicentral location errors are "less than 5 km" or "5~15 km", and their focal depths dispersively locate in 0~33 km range or are not given. Before working on earthquake focal mechanism solutions, we checked all relevant seismograms and measured the P-wave first motion polarities and times, than we redetermined epicentral location, focal depths and original times of the selected events and obtained more accurate results. The travel-time residuals are all less than 0.1 s (0.05~0.9 s). We initially estimate that the epicentral location (including focal depth) precisions are less than 0.6 km when taking the average velocity 6.0 km/s in the upper crust. These focal depths are mainly in the 0.7~19 km upper crust. This is identical with the results obtained before by us in the nearby area of the joint region (ZHAO, et al, 1997). The accurate source locations, especially the improved focal depths, are the basis on which we further obtain the exact and reliable source mechanism solutions.

A nonlinear location method with an excellent mathematics property has been used in the accurate seismic location. The basic technique is the average reference time and the superior algorithm. This technique has been used in many subjects of research (ZHAO, et al, 1997, 1999). Its good convergence, stability and generality have been documented in research practice. Here we do not introduce it in detail. The velocity model used in event location is taken from ZHAO, et al (1997).

2 Focal mechanism solution

P-wave first motion method is used to obtain the focal mechanism solutions in this paper. Because the joint region is well covered by the Sichuan seismic network, we can obtain better event locations and better focal mechanism solutions. About 30 station recordings are used for an $M_L≥3.0$ earthquake, all of them are near-earthquake having more clear seismic phases and more exact first motions. The vertical displacement records of 35 man-maintained and 6 telemetered stations have been used in this paper. Based on the location results, the azimuth between every event and every station, the take-off angles of Pg are calculated, the take-off angles of P* and Pn are computed according to the average velocities 5.8 km/s in upper crust, 6.44 km/s in lower crust and 7.8 km/s in uppermost mantle; the phase of P-wave first motion is determined based on "the travel-time table in Sichuan region" (Department of Scientific Programming and Earthquake Monitoring, State Seismological Bureau, 1989), and the focal mechanism solutions are made on