Three-dimensional $Q$ structure in Jiashi earthquake region of Xinjiang*

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Abstract

3-D S-wave $Q$ structure in Jiashi earthquake region is inverted based on the attenuation of seismic waves recorded from earthquakes in this region in 1998 by the Research Center of Exploration Geophysics (RCEG), CSB, and a rough configuration of deep crustal faults in the earthquake region is presented. First, amplitude spectra of S-waves are extracted from 450 carefully-chosen earthquake records, called observed amplitude spectra. Then, after instrumental and site effect correction, theoretical amplitude spectra are made to fit observed amplitude spectra with nonlinear damped least-squares method to get the observed travel time over $Q$, provided that earthquake sources conform to Brune’s disk dislocation model. Finally, by 3-D ray tracing method, theoretical travel time over $Q$ is made to fit observed travel time over $Q$ with nonlinear damped least-squares method. In the course of fitting, the velocity model, which is obtained by 3-D travel time tomography, remains unchanged, while only $Q$ model is modified. When fitting came to the given accuracy, the ultimate $Q$ model is obtained. The result shows that an NE-trending low $Q$ zone exists at the depths of 10–18 km, and an NW-trending low $Q$ zone exists at the depths of 12–18 km. These roughly coincide with the NE-trending and the NW-trending low velocity zones revealed by other scientists. The difference is that the low $Q$ zones have a wider range than the low velocity zones.

Key words: 3-D $Q$ structure; seismic wave attenuation; deep fault; spectral analysis

CLC number: P135.3  Document code: A

Introduction

It is well known that the occurrence of moderate and strong earthquakes and the distribution of seismically active belts are most directly related to deep crustal faults. Therefore, studying geometrical spreading and physical state of medium of deep crustal faults has always been a major subject in earthquake science. It is not only of great significance to the understanding of deep structural background and seismogenic mechanism of strong earthquakes, but also of great help to seismic hazard estimation and prevention. The intensity anomaly of Jiji, Taiwan, earthquake and the Los Angeles earthquake indicates clearly that the damage degree of strong earthquakes is directly related to fault positions. Therefore, determining the exact positions of faults has become a key problem in urban seismic hazard prevention and mitigation.

So far, study on deep crustal faults has mainly been confined to surface and shallow explora-
tions with geological techniques, by which geometrical parameters and physical state of faults in the deep crust are deduced on the basis of shallow geological data. This method of determining deep state according to shallow information may produce some results, but indirect after all. In order to get an overall picture of faults, the fault parameters and physical properties must be inverted by using deep information directly with the aid of modern geophysical techniques. In recent years, with the constant improvement of digital seismographs and with the rapid development of data processing techniques, seismic tomography has been widely used in study on the deep crust. It has become an urgent task for us to implement tomography of faults by combining seismic tomography with the study of deep crustal faults. By comparison, tomography of faults seems more difficult, but the results will be of greater scientific value.

In 1997, a series of strong earthquakes occurred in Jiashi of Xinjiang region. In a short period, i.e. from January to April of 1997, seven $M_S \geq 6.0$ earthquakes occurred successively in this area. Altogether 9 earthquakes with $M_S = 6.1$-$6.8$ have occurred in Jiashi, including two in 1998, these earthquakes are distributed in an NE-orienting zone and an NW-orienting zone (Figure 1).

![Figure 1 Geological structure and epicenter distribution of Jiashi earthquake region in Xinjiang](image)

The RCEG set up a mobile seismic observation network in May of 1998 to record aftershocks. The network consisted of 20 DAS-1 digital seismometers with station spacing of 5~10 km. It recorded more than 1 000 aftershocks in less than two months.

The DAS-1 digital seismograph used in the network was designed and produced by the RCEG (YUAN, et al, 1999). It has three components, an automatic trigger function and uses GPS for time correction. The sampling rate used in this observation is 100 samples per second. The frequency band of the seismograph is 4~40 Hz with a rather flat response.

The Jiashi earthquake region is located at the northwest of Tarim basin. So far, no fault has