The features of multiple fractures associated with the great Haiyuan 8.5 magnitude earthquake of 1920

Wenlin Huan, Min Ge and Xiangdong Chang

Abstract

It is deduced on the basis of field investigation that the total length of the stratigraphic fault associated with the great Haiyuan 8.5 magnitude earthquake of 1920 was 225 km. This fault was formed by 6 secondary faults with different geometric parameters, which align regularly in an echelon arrangement. Each secondary fault can be divided into three segments with different characteristics of deformation where the middle segment was mainly of the horizontal strike-slip fault while another two segments the vertical deformation as shown by the features of reverse or normal faults. It is also shown by the data of vertical and horizontal displacements that the horizontal displacement approached a maximum at the middle segment for each secondary fault and gradually decreased toward and finally disappeared at both ends of each segment while in contrast the vertical displacement was minimum at the middle and became large at both ends of the segment. The feature of the multiple peaks appeared in the deformation as shown by the earthquake displacements along the whole fault. This feature indicates that the 6 secondary faults associated with the great Haiyuan earthquake were the horizontal interrupted planes (i.e., dislocation surface) which were independent on each other, and hence each dislocation surface may represent an independent secondary fracture event of the earthquake. We thus think that the 6 relatively independent secondary events which occurred successfully might result in the great 8.5 magnitude Haiyuan earthquake.

Key words: earthquake fault, earthquake deformation belt, dislocation surface, multiple fracture, fracturing—barrier.

Introduction

The great Haiyuan 8.5 magnitude earthquake of December 16, 1920 as the largest intraplate earthquake in recent years in China has interested many geoscientists at home and abroad (Miyamura, 1965; Zeng and Shi, 1978; Xie, 1924; Song et al., 1983; Close and Mccormic, 1922; Wan et al., 1987; Luo, 1980). In collaboration with Zicheng Wan, Jizhang Chai and others from the Seismological Bureau of Ningxia we also made a field investigation on the surface deformation and earthquake faults associated with the earthquake from 1982 to 1984 (Lanzhou Institute of Seismology, Seis, SSB and Seismological Brigade of Ningxia, 1980; Ding, 1982; Wyss and Brune, 1976; Weng, 1921).

The great Haiyuan earthquake of 1920 resulted in a large scale and a wide extent of surface deformation. Fortunately most remains and traces of the earthquake deformation have been retained properly because this earthquake took place in a remote area on the loess plateau of NW China. Taking the above—mentioned advantage we have fully used the data of remote sensing. In other words, a thorough study has been made of the earthquake deformation belt from different elevations and views, i.e., through field investigation, measuring and mapping on the field as well as interpretation of the aerial and the satellite photography. The map showing distribution of the earthquake deformation and

earthquake fault belt was completed (Huan et al., 1987). The mechanical features of various earthquake deformation as well as the mechanical characteristics at different segments of the earthquake faults were also studied. We have obtained the data of displacements of the earthquake faults at 245 sites. This information provides evidences to the study on the feature of surface displacements due to the great Haiyuan earthquake.

Many large earthquakes were resulted in by multiple independent secondary events occurring successively, which is known as the multiplicity of a large earthquake. This phenomenon was discovered by some authors through the analysis of seismic waves (Umesh, 1970; Wyss and Brune, 1967; Miyamura, 1965; Zeng and Shi, 1978). The features of surface displacement of the great Haiyuan earthquake indicates the existence of the multiplicity for the displacements at the seismic source. An attempt has thus been made in the present study to investigate the feature of the fracture in the seismic source through much the information concerning displacements at the seismic source obtained by the field investigation of the Haiyuan earthquake faults.

**General situation of the earthquake faults distribution for the great Haiyuan earthquake**

Many phenomena showing ground deformation due to vertical and horizontal movements have been retained in a considerably large area. On the whole the Haiyuan earthquake deformation consisted of two parts; i.e., first, the earthquake faults belt which was mainly of sinistors horizontal shear movement, and second, the surface landslip—collapsing area at western Liupan mountain, which was mainly of vertical movement. The faults discussed in the present study are those ones which directly reflect the displacements at the seismic source. The landslip—collapsing area is located at the SW—side of the eastern terminal of the earthquake fault. It was possibly due to the vertical deformation caused by a secondary stress field at the end of the fault during its horizontal strike—slip movement.

![Figure 1 Distribution of earthquake faults associated with the great 8.5 magnitude Haiyuan earthquake of 1920.](image-url)