GEODESY AND GEODYNAMICS 2015, VOL 6 NO 3, 210–219

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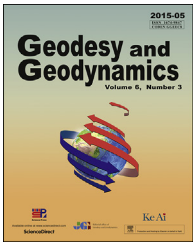
http://www.jgg09.com/jweb_ddcl_en/EN/volumn/home.shtml



Cognitions and questions regarding crustal deformation and location forecasts of strong earthquakes

Wei Wenxin[a], *Jiang Zaisen*[a,*], *Wu Yanqiang*[b]

[a] *Institute of Earthquake Science, China Earthquake Administration, Beijing 100036, China*
[b] *First Crust Deformation Monitoring and Application Center, China Earthquake Administration, Tianjin 300180, China*

ARTICLE INFO

Article history:
Received 4 February 2015
Accepted 14 March 2015
Available online 29 May 2015

Keywords:
Global Positioning System (GPS)
Active fault
Focal mechanism
Elastic rebound
Earthquake preparation
Dynamic characteristics of deformation field
Strain rate field
Spatial-temporal process

ABSTRACT

Using Global Positioning System(GPS) data to analyze the earthquake preparation characteristics of the Kunlun Ms8.1 and the Wenchuan Ms8.0 earthquakes, we review the main research developments of earthquake forecasting and the mechanisms of earthquake preparation using crustal deformation data from recent periods, and discuss the similarities and differences in the scientific approaches adopted by the Chinese and foreign scholars. We then analyze the deformation characteristics of earthquake preparation, with respect to slip and dip-slip faults. Our results show that, in order to understand the relationship between crustal deformation and earthquake preparation, research focus should be expanded from fault-scale to larger scale regions. Furthermore, the dynamic deformation characteristics associated with earthquake preparation must be considered as a multiscale, spatial-temporal process, in order to obtain the necessary criteria for strong earthquake forecasts.

1. Introduction

The application of Global Positioning System (GPS) equispaced Earth observation technology is facilitating a greatly increased ability to monitor large- and mid-scale crustal deformations, which further enables us to study the development and occurrence processes of strong earthquakes from the large-scale, and to the mesoscale and fault scale of developing earthquakes. For over 10 years, beginning with the establishment and operation of the Crustal Movement Observation Network of China (CMONOC) in 1998, the China mainland has suffered from the Kunlun Mountain Pass West Ms8.1 earthquake in 2001 and the Wenchuan Ms8.0

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* *Corresponding author.*
E-mail address: jiangzaisen@126.com (Jiang Z.).
Peer review under responsibility of Institute of Seismology, China Earthquake Administration.

Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.geog.2015.03.006

earthquake in 2008. In particular, any "premonitions" about the impending occurrence of the Wenchuan earthquake and the great calamity it would bring were not obvious, and were clearly beyond the existing capabilities of seismologists. Allusions to the characteristic faulting rate of the Longmen Mountain fault zone being low, as reflected by the GPS observation, led one observer to suggest that the GPS observation result had misled our scientific understanding. In this paper, we analyze the characteristics of crustal deformation at different scales and propose the processes of development and occurrence of the Kunlun Mountain Pass West earthquake and the Wenchuan earthquake that were reflected by the GPS observation. We also combine our analysis with a review of our basic understanding of crustal deformation in the earthquake development process over the past decades. We discuss and extract some knowledge on the analysis of the dynamic characteristics of the crustal deformation of developing earthquake from a multi-spatial-temporal scale and propose some research ideas.

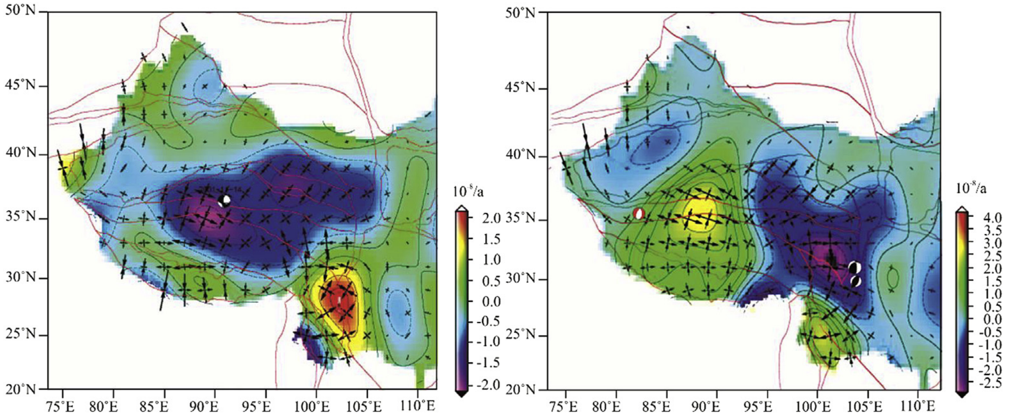
2. Dynamic characteristics of crustal deformation in the development and occurrence processes of violent earthquakes

(1) Characteristics of crustal deformation in the development and occurrence processes of the Kunlun Mountain Pass West Ms8.1 earthquake

On November 14, 2001, the Kunlun Mountain Pass West Ms8.1 earthquake took place. Because this earthquake occurred in a depopulated zone in the middle of the Qinghai–Tibet Plate, it did not result in a severe human disaster. However, it was the largest earthquake in the past 50 years in China mainland. The CMONOC (which includes a regional network of 1000 stations, a basic network of 81 stations, and a fiducial network of 26 stations) [1] was established in 1998, and began conducting comprehensive observations over the GPS regional network in 1999. To judge earthquake tendencies by applying GPS observation for reference support, the academician Ma Zongjin presented a special report for the 2001 annual earthquake tendency conference, launched in December 2000, on behalf of the CMONOC [1]. According to Ma's report, the second shearing strain rate parameter of the strain rate field, as computed by China mainland's GPS data for the 1993–2000 period, shows a large-scale negative value region inside the Qinghai–Tibet Plate. Most of the fracture zone of the Kunlun Mountain Pass West Ms8.1 earthquake that occurred on November 14, 2001 fell into the northeast edge of the extreme value region of the large-scale negative value region of the second shearing strain rate (Fig. 1). The negative high value region of the second shearing strain rate indicates a deformation rate that occurred close to the east and west, and then revolved and sheared towards the left, or close to the south and north, and continued to revolve and shear toward the right in this area. This pattern accords with that of the Kunlun Mountain Pass West Ms8.1 earthquake's East Kunlun fault zone, which was close to the east and west, and revolved, sheared, and ruptured towards the left. An understanding has thus been reached that violent earthquakes may occur at the edges of high value shearing strain rate regions, which is consistent with our understanding of tectonic deformation. [2,3]

According to the principal strain distribution diagram of the strain field, as calculated using GPS data, the value of the principal stretching strain rate (i.e., the maximum principal strain rate) that occurred in the northwest area of the Kunlun Mountain Pass West earthquake was slightly larger than the strain rate of the principal pressing strain rate (i.e., the minimum principal strain rate) in the north and east. In other words, this earthquake occurred in a region in which the surface strain rate was slightly stretching. [4] This crustal deformation characteristic would have been beneficial for the full release of the strain close to the east and west, and its revolving and rupture toward the left during the process of the violent earthquake, This contributes to our understanding of the phenomenon that suggests that the rupture scale of this Ms8.0 earthquake was obviously too long (reaching a length of 426 km) and the strength of the aftershock was relatively lower (no earthquake with a magnitude of more than 6.0).

We processed the basic network data (81 stations) of the CMONOC, and adopted changes in the 1998–2006 base line



a–The second shear strain rate during 1999–2001 b– The East-West strain rate during 1999–2007

2×10^{-8}/a Principal strain rate; Epicentral location and focal mechanism solution: Active block boundary

Fig. 1 – Field distribution of strain rate in Midwestern China.