

Chen Yong  
David C. Booth

# The Wenchuan Earthquake of 2008

Anatomy of a Disaster



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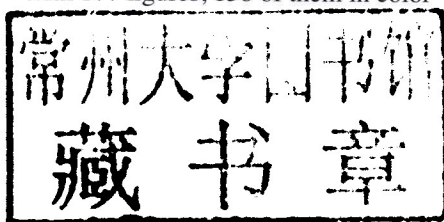
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**Anatomy of a Disaster**

With 177 figures, 158 of them in color



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*Authors*

Prof. Chen Yong  
China Earthquake Administration  
63 Fuxing Road  
Haidian District  
Beijing 100036  
China  
E-mail: yongchen@seis.ac.cn

Dr. David C. Booth  
British Geological Survey  
Murchison House  
West Mains Road  
Edinburgh EH9 3LA  
UK  
E-mail: dcb@bgs.ac.uk

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## Preface

China is the most populated country on the planet, and also one of the most earthquake-prone. Its history of large and devastating earthquakes, coupled with a long tradition of seismological research, gives it a special place in seismology. Most seismologists would agree that the most significant Chinese earthquakes in recent history are the 1976 Tangshan and 2008 Wenchuan earthquakes. There are many differences between them in terms of location, size, tectonics, casualties, damage, and relief operations. However, the outstanding difference is that, in contrast to the Tangshan disaster, the immensity of the Wenchuan disaster was quickly and widely communicated to the Chinese people and the rest of the world. Fast, open communication of the effects of the earthquake, was implemented for the first time for a major Chinese earthquake disaster. This generated an equally swift and direct response within China and the world, which massively assisted the relief efforts. It has also made possible the speedy publication of this book, giving a unique Chinese perspective on the effects of the earthquake, and the lessons learned.

With a magnitude of  $M_s 8.0$ , the Wenchuan earthquake is classified as one of the “great earthquakes”, which are potentially the most destructive. Unfortunately, since it occurred at shallow depth close to a highly populated area containing many old and poorly constructed buildings, and mountains prone to landslides, its potential for death and destruction was fully realized. To convey the enormity of the earthquake, and show how many lessons are to be learned from the damage to buildings, infrastructure, transport and communication systems, we begin by describing the effects which the powerful seismic waves inflicted on Wenchuan and the surrounding regions. It is probably fortunate that the reader can only get a hint of the thousands of tragedies behind these

words and pictures.

Having seen what happened, the next important question is “Why?” Seismologists and engineers must get an understanding of the mechanism of the earthquake, the nature and size of the seismic waves and the ground accelerations they produced, as well as the tectonic movements that generated it, so that the seismic hazard affecting new buildings in Wenchuan and other areas of China can be better assessed and guarded against. China’s turbulent tectonic history is certain to continue, with inexorable thrusting and folding of the Earth’s crust as India is pushed into Eurasia. We show how the seismic characteristics of the Wenchuan and other earthquakes are monitored, analysed, and used to improve our knowledge of the relevant seismological and tectonic processes.

At the time of the 1976 Tangshan earthquake, through their successful prediction of the 1975 Haicheng earthquake, Chinese seismologists had given the world hope that earthquake prediction might be possible. However, the Tangshan earthquake was not predicted, and neither was the Wenchuan earthquake. Since 1976, decades of research worldwide and the continuing absence of valid predictions of time, place and size (which can not be attributed to chance alone) have demonstrated that the prediction problem is currently insoluble. We describe research on earthquake prediction at Wenchuan, provide a historic perspective on the development of earthquake prediction research in China, and give an indication of its challenges and future direction.

For the foreseeable future, mitigation of seismic risk does not involve prediction, but only the correct assessment of seismic hazard, and appropriate measures for reduction in the vulnerability of buildings and infrastructure. There is no doubt that the effects of the earthquake could have been considerably mitigated if the seismic hazard had been fully recognized, strengthening had been applied to rural buildings as well as urban ones, and public buildings had been given particular attention. You will see a history of seismic hazard research leading the development of better building codes. Sadly, neither had been properly applied in the Wenchuan area. The post-Wenchuan proposals for better risk management as described here, now mandatory and in practice only months after the earthquake, define mitigation practices to be adopted throughout China. When properly implemented, it is these procedures

that will save future generations in the earthquake-prone regions of China.

The Wenchuan earthquake caused an unusually high number of deaths from numerous secondary disasters due to its proximity to the mountainous region of Longmenshan. These were caused by landslides, rock falls, mudflows, etc., and their effects on remote villages and transportation systems are discussed throughout the book. Dams, both artificial and landslide-induced, threatened flooding where they to give way. There are many dams in the mountain valleys and some scientists suggested that the Wenchuan earthquake was triggered by the Zipingpu dam and reservoir; this theory is examined in detail.

The exceptionally severe ground shaking and the relatively small proportion of properly strengthened buildings, in a highly populated and mountainous area, caused thousands of buildings to collapse, and posed an enormous challenge to rescuers. The immediate, open and widely broadcast reports and film footage of the scale of the disaster generated an unprecedented response from China and the rest of the world. China's disaster relief acquired many new characteristics, backed by top-level management, such as a people-first open-information approach, and numerous teams of volunteers, offering financial, medical, psychological aids, both from within China and abroad. These new features are described and assessed; they show how the disaster response has made a positive contribution to the health and vitality of Chinese scientific research and social care, and the cohesion and compassion of its people.

The policy of open communication adopted by the Chinese Government when facing natural disaster, has allowed us to describe, assess, and form conclusions on the effects of the Wenchuan earthquake, and to record them here for speedy publication. We have used data, documents and photographs which could not have been released so quickly as in the previous earthquake disasters in China. We hope that geophysicists (particularly seismologists), engineers, social scientists, administrators, and all those who were touched in any way by the devastating Wenchuan earthquake, will find something new and significant in this book.

Chen Yong  
David C. Booth  
April 2011

## Acknowledgements

In 1976, over 240,000 people were killed in the magnitude 7.8 Tangshan earthquake, one of the most devastating earthquakes occurring in mainland China in the 20th century. After the earthquake, Professor Teng-fong Wong, his wife, my colleagues and I wrote a book entitled “The Great Tangshan Earthquake of 1976: An Anatomy of Disaster”. The book which was published in English by a British publisher, Pergamon Press, was frequently used by many foreign scholars to understand the earthquakes and earthquake related work in China.

In 2008, a magnitude 8.0 earthquake stroke Sichuan, China, resulting in more than 70,000 casualties and about 1.5 trillion direct economic loss. It was the most destructive, most largely affected, and hardest rescue work involved for an earthquake in China since the 1976 Tangshan earthquake. China and the whole world were shocked by this earthquake disaster. Professor Teng-fong Wong and his wife suggested me to write a book and, as a lesson and experience, objectively tell the most comprehensive information and work experience about this earthquake to the people who care about the earthquakes and earthquake hazard. They also emphasized that tremendous changes had taken place in China during the three decades from the 1976 Tangshan earthquake to the 2008 Wenchuan earthquake. By comparing events in these two large earthquakes, it could show how the Chinese societies have evolved, how the Chinese government and people handled differently these kinds of natural disaster, and how after-earthquake rescue work has been improved. Although Professor Wong and his wife could not join me in the writing of this book because of other commitments, their suggestions were the driving force for writing this book. Here, I express my sincere thanks to them.

This book covers a variety of topics, including seismology, civil engineering, earthquake prediction, management science, humanities and economics, therefore extensive data collection was critical. I must first express my sincere gratitude to the China Earthquake Administration (CEA). This book could not have been written without the support from the CEA's collections of precious and comprehensive data and images, e.g. great Wenchuan earthquake image library, on-the-spot records of great Wenchuan earthquake rescue, and great Wenchuan earthquake scientific survey report. I thank the CEA for the permission of using these data and images. All the data, information and images with no mentioned reference in this book were from the CEA image and data libraries mentioned above.

Many colleagues and friends have helped me. For taking a better picture, they went to the Wenchuan earthquake scene many times. These people include Lu Ming, Guo Xun, Huang Runqiu, Xu Qiang, Liu Ruifeng, Yin Guanghui, Guo Huadong, Gong Jianya. Thanks also go to many more colleagues and friends who I cannot mention here one by one for their help and support. I will remember and thank them from the bottom of my heart.

I also thank my co-author, David C. Booth. He is a senior seismologist in the British Geological Survey, who has long been engaged in the studies of global seismology. He helped polish the English version of this book. More importantly, he used the internationalized language and could objectively appraise the seismological studies in China.

We would like to thank many authors of books and research papers, since a significant proportion of the present book was based on their work. We are also grateful to following people for providing background information and draft assistance, Zhang Wei, Dou Aixia, Chen Qifu, Wang Xiaoqing, Liu Jifu and Shi Peijun, without their help, publication of this book would not be possible.

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April 2011

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# The Wenchuan earthquake

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The Wenchuan earthquake was the most destructive earthquake in China, with the widest zone of influence and the most serious disaster-induced losses, since the founding of the People's Republic in 1949. Measured at  $M_s 8.0$  in magnitude, and XI on the Modified Mercalli Intensity (MMI) scale of felt effects, the earthquake also caused severe secondary disasters such as landslides, mud-rock flows, barrier lakes, etc (Figure 1.1).

1. The earthquake caused large loss of life.

On 25 August 2008, it was estimated that there were 69,226 people killed, 374,643 injured, and 17,923 missing.

2. Numerous urban and rural buildings were devastated. Some towns, including Beichuan, Yingxiu, and a vast number of villages were razed to the ground.

**Figure 1.1** Under the combination of strong ground motion, surface rupture and giant landslides, Beichuan County suffered severe damage: more than 80% of buildings collapsed.