

云南强震活动

与预测方法研究

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序

云南是中国大陆强震活动最频繁的地区之一，根据 1900 年以来百年的地震活动统计，平均每年累积地震能量释放相当于一次 7 级地震释放的能量，在时间序列上，平均每年发生 3 次 5 级地震，3 年发生 2 次 6 级地震，8 年发生 1 次 7 级地震；在空间分布上，以红河深大断裂为界，把云南分为东西部地区，则强震活跃期有东西交替活动的现象，平静期和活跃期时间间隔均为 10 年左右。云南强震活动在时间和空间方面所表现出的这些明显特征，对分析研究与预测强震活动趋势具有十分重要的参考指导作用。

在现代文明社会进步及全球经济快速发展过程中，发生在中国、日本、美国、伊朗以及印度等国的若干次破坏性大地震，造成了一次次惨重的人员伤亡和巨大的经济损失，引起了世界各国政府对地震灾害的高度重视。特别是 2004 年 12 月 26 日在南亚的印尼北苏门答腊近海发生一次 $M 9.0$ 的巨大地震，并引起了印度洋巨大海啸。由这次地震及其引起的海啸造成 30 万人的死亡和无法估量的经济损失，震惊了全世界。云南由于频繁的破坏性地震发生，也是我国遭受地震灾害的重灾区，从 1970 年通海 7.8 级大地震发生至今的 30 多年，地震夺去近 2 万人的生命，由震灾造成的直接经济损失高达数百亿元人民币，仅从 1993 年至 2003 年期间，云南由中等破坏性地震灾害造成的经济损失占全国地震灾害经济损失 170 多亿元人民币的一半左右。

地震预测预报是全世界关心的问题，同时也是世界性的科学难题，出自对社会减轻自然灾害的责任感和对地震科学的追求，中国地震科学家对地震预报开展了长期不懈的探索研究与预报实践，取得了引人注目的成果，但离科学地预报仍然还有相当长的距离。地震预报是一门以观测为基础的研究学科，地震预报要取得根本性突破，必须要有新的观测资料，新的分析研究思路，尤其是需要观测到与孕震过程密切相关的诸如力源作用、介质信息、传播衰减等前兆异常物理量，也就是说，对于地震学和地震预测科学，提供可靠、真实、客观和科学的信息量是最重要、最基础的条件，如果缺乏或不足，企图通过数学物理技巧、计算机处理或图像显示等方法解决地震预报科学难题，都是不现实的。

人类对地震的认识，较之一百多年前只能对地震事件给出时间、地点和灾情方面粗略描述相比，今天已取得了根本性的突破，例如，经典地震波传播理论和全球及区域宽频带数字地震台网的建设，实现了对地震的精确定位，建立在以观测与实验数据为基础的震源物理模型的研究，使得我们对地震物理过程中的力学成因、构造条件及介质状态的精细结构，有了更为深刻的认识 and 了解，尤其是我国地震学家对某些类型的地震作出了一定程度的科学的成功预报，切实起到了减轻地震灾害的实际效果，形

成了具有中国特色地震预测预报科学体系。在科学的道路上,时时充满着探索的艰辛和面对失败的痛苦,只有在不断取得令人兴奋或鼓舞人心的成果,才会激励人们向更高目标奋进。

本书共12章,集中反映了由云南省科学技术厅资助的云南省“十五”重点科技攻关项目“云南强震中短期预测技术研究”(2001NG46)课题的研究成果,以全新的视野,从不同的分析角度主要研究了云南强震活动时间变化和空间分布特征及其显示的某些规律,以现代数字地震学新思路、新观点,利用云南数字地震观测资料,在震源理论、S波分裂、应力参数、地震波衰减、地震能量释放、地震临界破裂、强震危险地点搜索技术等方面作出了一系列深入的研究,特别是结合云南丰富多彩的地震类型,进行了预测预报方法的研究和探索,重点突出现代数字地震学研究和预测方法的成果。所体现的研究思路和技术途径代表现代数字地震学和预测预报科学研究的发展方向。书中的研究成果若能对读者有所启迪和帮助,就是我们的最大心愿。

社会要进步,经济要发展,国家要富强,人民要幸福,科技要创新。关爱生命,以人为本,是现代社会与科技进步和谐发展的结合点。现代科学的发展,尤其是自然科学的重要突破和发现,都与前辈科学家的成就紧密相关,也就是说后人是站在前人肩上迈向新的高度。面对地震预报这一世界性的科学难题,我们应当总结和继承前人的经验和成就,在地震预测科学道路上不断进取。伟大的物理学家爱因斯坦生前总结他在科学研究取得成就的“秘诀”,是用一个富有深刻哲理内涵的数学方程: $A = X + Y + Z$ 表示,A代表事业的成功,X代表付出的艰苦劳动,Y代表创新与正确方法,Z代表少说废话。这种对科学事业无限热爱和勇于献身的科学精神是我们所崇尚的。

参加课题的主要成员有秦嘉政、皇甫岗、钱晓东、苏有锦、叶建庆、李白基、王绍晋、刘祖荫、刘丽芳、和宏伟、赵慈平、李永强、邬成栋、徐彦、蔡绍平、刘学军、李忠华、张俊伟、赵洪声、刘翔、付虹、蔡静观、曹刻、沈荣臣、和国文、王世芹、李永莉、王琼伟、郭若瑾、王永安、黄云宝、黄毓珍、龙晓帆、卫爱民、胡辉等30多位专家和科技工作者,陈燕帮助做了大量编辑工作。在完成该课题的期间内,课题组的成员以高度的责任心、忘我的工作激情以及对地震科学探索的追求,为此付出了辛勤的劳动,也取得了丰硕的成果。

本书的出版经费得到云南省科技厅“十五”重点科技攻关项目“云南强震中短期预测技术研究”课题资助,在完成该课题的四年期间,不断得到主管该课题的省科技厅农社处管理工作人员的极大支持、关心和理解,为此,我们课题组全体成员谨此表示衷心地感谢。

不容忘记的是由于作者家人的理解和支持,作者除完成许多其他工作外,还放弃了大量的与家人团聚的休息时间,本书得以顺利完成,应包含他们所给予的宽容和奉献,谨此表示诚挚的谢意。

作者
2005年6月

Preface

Yunnan is one of areas with most frequent strong earthquakes happened in China Continent. According to 100 years statistics of earthquake activity from 1900, the seismic energy release of annual accumulation corresponds to the energy release of an earthquake of $M7$. In the temporal sequence, 3 earthquakes of $M5$ may happen in each year, 2 earthquakes of $M6$ in every 3 years and 1 earthquake of $M7$ in every 8 years. In the spatial distribution, taking the Honghe deep fault as a boundary, Yunnan is divided into two parts of west and east. Then the activities of strong earthquakes take place alternatively on west and east sides. The time gaps of quiescent and active periods are about 10 years. These obvious features of strong earthquakes shown in space and time have very important references to analyze, study and forecast the tendency of strong earthquakes.

In the process of modern civilization society advancement and fast development of global economy, many destructive earthquakes occurred in China, Japan, United States, Iran and India had caused great casualties and heavy economic losses, which arouse the high attention from governments all over the world to earthquake disasters. Especially, the huge $M9.0$ earthquake happened in Sumatra, Indonesia on December 26 of 2004 had caused great tsunami in Indian Ocean. This earthquake and its caused tsunami had killed 300,000 people and invaluable economic losses, which shocked the whole world. Due to frequent strong earthquakes happened in Yunnan, so it is the right area suffering heavy disasters in China. More than 30 years past from Tonghai $M7.8$ earthquake in 1970, earthquakes killed almost 20,000 people. The direct economic losses from earthquake disasters reach as high as several tens of billions Yuan RMB. From 1933 to 2003, the economic losses caused by mid damaging earthquakes account for about half of the total 17 billion Yuan RMB in whole China.

Earthquake forecasts and predictions are the most concerned problems in the world and they are also most difficult ones. For the purpose of reducing natural disasters and exploration of seismic science, the Chinese seismologists have been developing studies and practices of earthquake prediction for a long time. And some attractive noticed results have been acquired. However, it has a long way to go from scientific predictions. Earthquake prediction is a studying discipline taking the observations as bases. Breakthrough of earthquake prediction needs new observation data and new analyzing thought, especially the precursory physical quantities closely related to the seismogenic processes, such as function of force sources, media information and traveling attenuation. Namely, providing reliable, veritable, imper-

sonal and scientific information to seismology and earthquake prediction science is most important and basic condition. If lack of these conditions, trying to solve the difficult subject of earthquake prediction, through mathematic physical technique, computer processing or image display, is not realistic.

More than 100 years ago, when only rough description of time, location and disasters could be given. Nowadays, people's understanding to earthquake has radically breakthrough. For example, the classical theory of seismic wave traveling and the global and regional constructions of digital seismic networks with wide band have realized the precise positioning to earthquake. The studies of focal physical model based on the observations and experimental data have made us deeply understand the mechanical cause of formation, structural conditions and the fine structure of media status in the process of earthquake physics. Especially, Chinese seismologists have made successful predictions to some types of earthquakes to some extent, from which the seismic disasters actually had been reduced, and forming a scientific system of earthquake forecast and prediction with Chinese features. On the way to science, it is full of exploration difficulties and unsuccessful pains from time to time. The excited results are only way to inspirit people fighting forwards to a higher target.

This book contains 12 chapters, which concerntratedly reflects the studying results of the subject of Mid - short Term Forecast Technique Studies of Strong Earthquake in Yunnan (2001NG46) sponsored by Yunnan Scientific - technological Bureau in Tenth Five Plan. As newest eyeshot, we have mainly studied the temporal variation, spatial features and some patterns of strong earthquakes in Yunnan from different views. With new thought and new viewpoint of modern digital seismology, the digital seismic data are used to perform a series of deep studies, such as focal theory, S - wave split, stress parameters, attenuation of seismic wave, energy release of earthquake, seismic critical fracture, searching technique of risk area of strong earthquakes. Combining with the rich earthquake types in Yunnan, this paper has done a lot of studies and exploration in the methods of forecast and prediction, and the achievements in modern digital seismology and prediction have been emphasized. The studying thought and technological ways incarnated in this paper have represented the developing direction in digital seismology and studies of forecast and prediction. The results in this paper could help the readers if any.

Society needs advance, economy needs development, nation needs richness and mightiness, people need happiness and science and technology need creation. Concerning life and taking people as the roots are the combining points of constructing modern society, scientific and technological advance and harmonious development. The development of modern science, especially the important breakthrough and discovery in natural science, is closely related to the achievements of father scientists. Namely, the new comer steps high place on the father's shoulders. Facing at the global difficult subject of earthquake prediction, we should

summarize and inherit the father's experiences and achievements and fight forwards on the way of earthquake prediction science. Before Einstein's death, he summarized his secret of scientific studies by using a rich philosophy equation of $A = X + Y + Z$, where A expresses success, X for hard work, Y for creation and correct method and Z for saying few useless words. This spirit of loving science and contribution to science is worthwhile advocacy.

Members who participate in the subject are Qin Jiazheng, Huangfu Gang, Qian Xiaodong, Su Youjin, Ye Jianqing, Li Baiji, Wang Shaojin, Liu Zuyin, Liu Lifang, He Hongwei, Zhao Ciping, Li Yongqiang, Wu Chengdong, Xu Yan, Cai Shaoping, Liu Xuejun, Li Zhonghua, Zhang Junwei, Zhao Hongsheng, Liu Xiang, Fu Hong, Cai Jingguan, Cao Ke, Shen Rongchen, He Guowen, Wang Shiqin, Li Yongli, Wang Qiongwei, Guo Ruojin, Wang Yongan, Huang Yunbao, Huang Yuzhen, Long Xiaofan, Wei Aimin and Hu Hui et al. Chen Yan has done a lot of edition. During the period of doing the subject, the members of the subject had done hard work and achieved rich results with high responsibility and selfless ardor.

The publishing fees for this book is supported by subject of Mid – short Term Forecast Technique Studies of Strong Earthquake in Yunnan sponsored by Yunnan Scientific – technological Bureau in Tenth Five Plan. During the period of four years, Agricultural Section of Scientific – technological Bureau had given a lot of helps, concerns and understandings. For this purpose, the members of the subject express great thanks.

The unforgettable is the understandings and supports from the author's families. Besides other works, the authors had given up a lot of chances of getting together with their families. The finish of this book should include their toleration and contribution, great thanks to all of them.

Authors
June of 2005



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