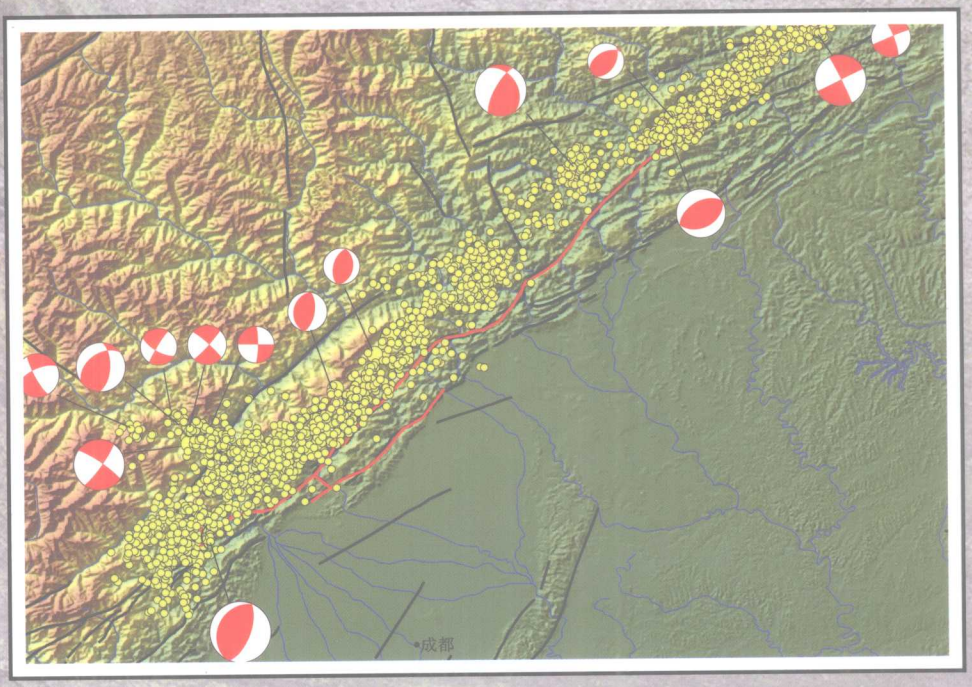
中央级公益性科研院所基本科研业务专项资助

# 汶川8.0级地震地壳动力学研究专辑

中国地震局地壳应力研究所

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## 内 容 提 要

本书为中国地震局地壳应力研究所对2008年汶川8.0级大地震的研究专辑，内容包括对汶川特大地震所做的中期预测理论基础、遥感地质、地震地质和建筑物等地震灾害考察、地壳动力学环境和震源物理过程模拟、流体、应力应变监测资料分析等方面的研究成果，共收集论文10篇，个别论文已经或将在其他刊物发表。

本书可供地球动力学研究、地震预报、工程地质、建筑设计、施工等领域的人员及有关大专院校的师生阅读。

**汶川8.0级地震地壳动力学研究专辑**

中国地震局地壳应力研究所

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# 编 委 会

# 前　言

2008年5月12日14时28分在我国四川省汶川地区（北纬31.0°，东经103.4°）发生了举世震惊的8.0级特大地震。霎时间屋毁人亡、山河改观。此次地震不仅在震中区附近造成灾难性的破坏，而且在四川省和邻近省市造成大范围破坏，其影响波及到除黑龙江、吉林、新疆外几乎全国大部分地区，甚至南亚和东亚地区都有感，其断层破裂时间之长、断裂破裂长度之大、能量之强，都远远地超过了唐山地震，这是新中国成立以来我国大陆发生的破坏性最为严重的地震。

灾情牵动了亿万人民的心，受到了党和国家领导人的高度重视。震情就是命令。地震发生后中国地震局迅速组队奔赴灾区进行抗震救灾，对地震灾害损失进行评估和地震地质考察。中国地震局地壳应力研究所在地震发生后的第一时间启动地震应急预案，成立了汶川地震现场救援、现场应急和科学考察、震情研究、应急救援保障等工作组，在参加中国地震局组织的任务同时与中国地震灾害防御中心联合，先后派遣50多人赴地震灾区开展救援、应急和科学考察工作，并集全所力量开展与汶川大地震相关的震情会商。

地壳应力研究所作为国家地震科研事业性单位，在汶川地震发生后，专门拨出科研业务专项资金，设立了20多个课题，用于对此次地震开展系统性科学考察和研究。广大科研人员肩负着地震科技工作者的使命，日以继夜地工作，在很短时间里从航空遥感震灾图像室内解译进一步到野外实地的考察实证，从对汶川地震的发震构造龙门山断裂带活动特征的研究到探索大地震的复发周期，从对震源机制解析到对发震动力机制的分析和数值模拟，从区域构造应力背景场的第一手测量到多手段连续的动态地震监测，从对汶川地震的中长期预测到根据实时的前兆观测资料对强余震做出判断，取得了对汶川地震的多方面的认识。本专辑既汇集了上述科研工作的成果，也体现了我所老一辈地震工作者为地震科学探索锲而不舍的

工作精神，比较全面地反映出了我所科技人员对汶川地震开展的工作，汇集保存了地震之后留下来的一批珍贵的第一手资料，为今后进一步的研究提供借鉴和参考。

汶川地震的发生对地震科技工作提出了巨大的挑战，同时也为我们不断地认识地震孕育和发生的物理过程提供了难得的机会，伴随着地震观测技术的提高和研究方法的进步，地震向地球科学家和地震学家揭示出来的物理过程的信息较以前丰富多了，我们必须抓住机遇，开展深入广泛的研究，这必将提高我们对地震这一地球内部复杂现象的认识水平。

由于时间仓促，错误和认识上的不足在所难免，敬请读者指正。

编委会

2009 年 5 月

# 目　录

## 地震构造与灾害

Preliminary Observations of the Faulting and Damage Pattern of $M_S$8.0 Wenchuan, China, Earthquake …… Furen Xie　Zhenming Wang　Yi Du　Xiaoliang Zhang (3)

The Earthquake Damage and Improvement of Rural Dwelling Bearing Walls …… Lu Ming　Yu Aiqin (11)

四川龙门山断裂带典型地点汶川 8.0 级地震地表破裂及晚第四纪强震多期活动证据 …… 谢新生　江娃利　孙昌斌　冯西英　黄伟　盛强 (18)

汶川 8.0 级地震发震断层逆冲活动的断错阶地与古地震初步研究 …… 田勤俭　王林　郝凯　马保起　张世民 (38)

龙门山断裂带大震复发特征与复发间隔估计…… 任俊杰　张世民　马保起　田勤俭 (48)

汶川 8.0 级地震地表破裂平通镇段的变形特征…… 何仲太　马保起　田勤俭　张世民 (61)

龙门山中央断裂南段晚第四纪活动的证据…… 吕志强　丁锐　张世民 (70)

应用雷达卫星影像判读四川龙门山断裂带晚第四纪活动及其野外调查 …… 江娃利　谢新生　张景发　刘旭东　龚丽霞　姜文亮　孙昌斌 (79)

利用遥感资料绘制汶川地震烈度图 …… 蔡山　张景发　陈文凯　张磊 (104)

平武－青川断裂第四纪活动特征的遥感解译研究 …… 路静　张景发　姜文亮　龚丽霞 (109)

都江堰市移动通信系统及其建筑物震害特征 …… 陆鸣　李鸿晶　温增平　田家勇　熊立红　杜修力　于爱勤 (119)

汶川 8.0 级强震记录的近断层效应初步分析 …… 兰景岩　吕悦军　彭艳菊　赵建涛　张力方　谢卓娟 (128)

汶川 8.0 级大地震沿中央断裂崩塌、滑坡分布规律 …… 陈明金　黄雅虹　吕悦军 (138)

## 地壳动力环境

汶川 8.0 级地震发震构造大震复发间隔估算

…… 谢富仁　张永庆　张效亮　张红艳 (145)

壳幔通道流参与下的陆内汇聚作用与汶川地震的动力学机制

…… 张世民　谢富仁　黄忠贤　任俊杰 (154)

龙门山断裂带及附近地区的形变场与汶川地震动力机制分析 …… 朱守彪 (174)

龙门山断裂带地壳精细结构与汶川地震发震机理

…… 雷建设　赵大鹏　苏金蓉　张广伟　李凤 (183)

汶川地震及其强余震震源机制解与龙门山地区构造应力场分析

…… 崔效锋　宁杰远　胡幸平　王艳华　俞春泉　陶开 (193)

川滇地区构造应力场特征与汶川地震同震效应的数值模拟研究

…… …… 陈连旺　李红　陆远忠　李玉江　叶际阳 (205)

汶川 8.0 级地震断层滑动机制研究 …… 杜义　谢富仁　张效亮　荆振杰 (225)

汶川 8.0 级地震映秀-南坝段断层的活动方式、形变特征及其形成机制探讨

…… 卢海峰　张世民　马保起　侯治华 (237)

汶川 8.0 级地震前后龙门山断裂垂直活动特征与孕震机理解释

…… 焦青　杨选辉　范国胜　许丽卿　王博 (247)

汶川地震构造断裂带的震前地壳深部原地应力测量 ……

…… 郭啟良　张彦山　王成虎　丁立丰 (256)

利用 2008 年汶川地震序列获得的震区应力状态

…… 张永庆　谢富仁　Susanna J. Gross (265)

2008 年汶川 8.0 级地震视应力与震前地震视应变场时空演变特征

…… 张彬　杨选辉　李捷 (277)

龙门山断裂带重力场及深部构造特征分析

…… 焦孟梅　张景发　姜文亮　陈学波　路静　肖克炎 (284)

汶川地震前电离层等离子体异常现象分析 …… 董健　颜蕊　张景发 (293)

汶川 8.0 级地震的地震构造问题 …… 田勤俭 (302)

## 地震监测预报

汶川 8.0 级地震中长期预测的理论基础 …… 安欧 (315)
汶川 8.0 级地震对中国大陆地下流体影响特征分析
…… 刘耀炜 马玉川 任宏微 杨选辉 孙小龙 (346)
汶川地震流体同震响应及其对强（余）震判定的指示意义
…… 杨选辉 刘耀炜 马玉川 张彬 孙小龙 任宏薇 刘永铭 (361)
四川汶川 8.0 级地震地应力异常——来自压磁顿率应力测量系统的记录
…… 张培耀 张道仪 朱万宁 范良龙 陈若萍 延军 (371)
2008 年汶川 8.0 级地震前分量式钻孔应变仪台网观测的变化
…… 邱泽华 唐磊 周龙寿 阚宝祥 (389)
汶川 8.0 级地震前周边地区钻孔体应变的相关变化 …… 宋荣 邱泽华 (403)
汶川地震前川滇地区动力环境及应变积累 …… 焦青 范国胜 (412)
汶川 8.0 级地震前震区附近观测到的断层形变异常特征
…… 荆燕 张鸿旭 李宏 范良龙 熊玉珍 (423)
全国地热前兆台网在汶川地震前的异常分析…… 赵刚 王军 何案华 王子影 (436)
汶川地震后地热前兆台网的响应研究 …… 赵刚 王军 何案华 王子影 (445)
昌平地震台汶川地震前兆测项同震响应综合对比分析
…… 张国红 刘福生 柳艳智 宋朝忠 杨选辉 王勇 (453)
对汶川 8.0 级大地震“前驱波”的多台站统计检验 …… 周龙寿 邱泽华 唐磊 (464)

# Contents

## Seismic Structures and Disasters

Preliminary Observations of the Faulting and Damage Pattern of $M_S$8.0 Wenchuan, China, Earthquake
..... *Furen Xie Zhenming Wang Yi Du Xiaoliang Zhang* (3)

The Earthquake Damage and Improvement of Rural Dwelling Bearing Walls
..... *Lu Ming Yu Aiqin* (11)

Evidence of Multi-stage Strong Earthquakes During Late Quaternary and Surface Ruptures of Wenchuan $M_S$ 8.0 Earthquake at Typicalplaces along the Longmenshan Fault Zone in Sichuan Province
..... *Xie Xinsheng Jiang Wali Zhang Jingfa Sun Changbing Feng Xiying Huang Wei Sheng Qiang* (36)

A Preliminary Study of Paleoearth-quakes and Offset Terraces by Reverse Faulting on the Fault of Wenchuan *M*8.0 Earthquake
..... *Tian Qinjian Wang Lin Hao Kai Ma Baoqi Zhang Shimin* (47)

Characteristics and Recurrence Intervals of Large Earthquake along the Longmenshan Fault Zone
..... *Ren Junjie Zhang Shimin Ma Baoqi Tian Qinjian* (60)

Deformation Feature of the Surface Rupture of Wenchuan Earthquake ($M_S$8.0)at the Pingtong Town
..... *He Zhongtai Ma Baoqi Tian Qinjian Zhang Shimin* (69)

Evidence of Late Quaternary Slip of the South Segment of Longmenshan Central Fault
..... *Lü Zhiqiang Ding Rui Zhang Shimin* (78)

Interpretation of Activity of Longmengshan Fault zone in Sichuan during Late Quaternary Based on the Radar Satellite Images and Surveying
..... *Jiang Wali Xie Xinshen Zhang Jinfa Liu Xudong Gong Lixia Jiang Wenliang Sun Changbing* (100)

A Study on Mapping Seismic Intensity Distribution by Use of RS Data
..... *Cai Shan Zhang Jingfa Chen Wenkai Zhang Lei* (108)

Quaternary Activities of the Pingwu-Qingchuan Fault from Interpretation of RS Images
..... *Lu Jing Zhang Jingfa Jiang Wenliang Gong Lixia* (118)

The Damage Characteristics of Mobile Communication System and Its Building in Dujiangyan City Caused by Wenchuan Earthquake
..... *Lu Ming Li Hongjing Wen Zengping Tian Jiayong Xiong Lihong Du Xiuli Yu Aiqin* (127)

A Preliminary Analysis on the Near-fault Effect of Strong-motion Observations from the $M_S$8.0 Wenchuan Earthquake, China
..... *Lan Jingyan Lü Yuejun Peng Yanju Zhao Jiantao Zhang Lifang Xie Zhuojuan* (137)

Distribution of Collapses and Landslides along Longmenshan Central Fault Induced by Wenchuan $M_S$8.0 Earthquake
..... *Chen Mingjin Huang Yahong Lü Yuejun* (142)

## Crustal Dynamic Environment

Estimation of Wenchuan $M_S$8.0 Earthquake Recurrence Interval
..... *Xie Furen Zhang Yongqing Zhang Xiaoliang Zhang Hongyan* (153)

Channel Flow and Intracontinental Convergence at the Eastern Margin of Tibetan Plateau and the Geodynamic Mechanism of Wenchuan Earthquake
..... *Zhang Shimin Xie Furen Huang Zhongxian Ren Junjie* (172)

The Deformation in and around the Longmenshan Fault and Analysis of Dynamic Mechanisms of the Wenchuan Earthquake ($M_S$8.0), 2008
..... *Zhu Shoubiao* (182)

Fine Seismic Structure under the Longmenshan Fault Zone and the Mechanism of the Large Wenchuan Earthquake
..... *Lei Jianshe Zhao Dapeng Su Jinrong Zhang Guangwei Li Feng* (191)

Focal Mechanism Solutions of Wenchuan Earthquake and Its Strong Aftershocks and Tectonic Stress Field in Longmenshan Region
..... *Cui Xiaofeng*[1] *Ning Jieyuan*[2] *Hu Xingping Wang Yanhua Yu Chunquan Tao Kai* (203)

Numerical Modeling of Tectonic Stress Pattern and Co-seismic Influence of Wenchuan 8.0 Earthquake in Sichuan-Yunnan Area, China
..... *Chen Lianxiang Li Hong Lu Yuanzhong Li Yujiang Ye Jiyang* (223)

The Mechanism of Fault Slip of $M_S$8.0 Wenchuan Earthquake
..... *Du Yi Xie Furen Zhang Xiaoliang Jing Zhenjie* (236)

Active Mode, Deformation Characteristics, and Dynamic Mechanism in Yingxiu-Nanba Section of the $M_S$8.0 Wenchuan Earthquake Fault
..... *Lu Haifeng Zhang Shimin Ma Baoqi Hou Zhihua* (246)

The Interpretation of Mechanism and the Vertical Activity Characteristics of Longmenshan Fault before and after the *M*8.0 Wenchuan Earthquake
..... *Jiao Qing[1] Yang Xuanhui Fan Guosheng Xu Liqing Wang Bo* (255)

In-situ Stress Measurement in Deep Boreholes on the Seismic Faults before Wenchuan Earthquake
..... *Guo Qiliang Zhang Yanshan Wang Chenghu Ding Lifeng* (264)

Background Stress State Estimated from 2008 Wenchuan Earthquake Sequence
..... *Zhang Yongqing Xie Furen Susanna J. Gross* (276)

Research on the Seismic Apparent Stress and the Space-time Evolution of Characteristic of the Seismic Apparent Strain Field of Wenchuan 8.0 Earthquake in 2008
..... *Zhang Bin Yang Xuanhui Li Jie* (283)

Analysis of the Gravity Field and Deep Structure Characteristics in Longmenshan Fault
..... *Jiao Mengmei Zhang Jingfa Jiang Wenliang Chen Xuebo Lujing Xiao Keyan* (292)

Analysis on the Ionospheric Plasma Anomalies before Wenchuan Earthquake
..... *Dong Jian Yan Rui Zhang Jingfa* (301)

Discussion on Tectonic Background of the Wenchuan *M*8.0 Earthquake
..... *Tian Qinjian* (311)

## Earthquake Monitoring and Prediction

Theoretical Basis of Mid-long Term Forecast of the 2008 Wenchuan $M_S$ 8.0 Earthquake
..... *An Ou* (345)

Analysis of the Effect of Wenchuan $M_S$8.0 Earthquake on Underground Fluid in China
…… *Liu Yaowei Ma Yuchuan Ren Hongwei Yang Xuanhui Sun Xiaolong* (360)

Coseismic Fluid Response to Wenchuan Earthquake and Its Meaning for Strong(after)Shock Judgement
… *Yang Xuanhui Liu Yaowei Ma Yuchuan Zhang Bin Sun Xiaolong Ren Hongwei Liu Yongming* (370)

Anomalous Earth Stress of the $M_S$8.0 Wenchuan Earthquake in Sichuan, China Recording from Piezomagnetic Frequency Measurement of the Earth Stress
…… *Zhang Peiyao Zhang Daoyi Zhu Wanning Fan Lianglong Chen Ruoping Yan Jun* (388)

Observations of Strain Changes Prior to the Great 2008 Wenchuan Earthquake by the 4-component Borehole Strainmeter Network
…… …… *Qiu Zehua Tang Lei Zhou Longshou Kan Baoxiang* (402)

The Related Changes of Borehole Strain in the Surrounding Areas before Wenchuan $M_S$8.0 Earthquake …… *Song Mo Qiu Zehua* (411)

The Dynamic Environment and Strain Accumulation in Chuan-Dian Area before Wenchuan earthquake …… *Jiao Qing Fan Guosheng* (422)

Abnormal Changes of Crustal Deformation before Wenchuan $M$8.0 Earthquake Observed around the Epicenter
…… *Jing Yan Zhang Hongxu Li Hong Fan Lianglong Xiong Yuzhen* (435)

Geothermal Anomalies before the Wenchuan Earthquake Observed by the National Station Network
…… *Zhao Gang Wang Jun He Anhua Wang Ziying* (444)

A Study on the Responses of Geothermal Precursor Station Network to Wenchuan Earthquake
…… *Zhao Gang Wang Jun He Anhua Wang Ziying* (452)

A Research on Coseismic Response of Changping Station to the Wenchuan $M_S$8.0 Earthquake
…… *Zhang Guohong Liu Fusheng Liu Yanzhi Song Chaozhong Yang Xuanhui Wang Yong* (463)

A Statistical Study of Precursory Waves before the Great Wenchuan $M_S$8.0 Earthquake with the Observation Data of 16 Stations
…… *Zhou Longshou Qiu Zehua Tang Lei* (477)

# 地震构造与灾害

Seismic Structures and Disasters

# Preliminary Observations of the Faulting and Damage Pattern of $M_S$ 8.0 Wenchuan, China, Earthquake

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**Abstract** Wenchuan, China, earthquake ($M$8.0) created another large disaster in 2008. Preliminary investigations show that: up thrust of the northwest wall is main vertical slip on the Yingxiu-Beichuan segment; not only reverse faulting is major, but also has biggish strike slip on the segment of the north of Beichuan, and strike slip offset is greater than the vertical one in some place. About 70,000 people are confirmed to have been killed, 380,000 were injured, and 20,000 are still missing. The total economic loss is estimated to have exceeded US$ 110 billion. Although earthquakes can not be prevented and are difficult to predict, disasters caused by them can be mitigated. The purpose of this paper is to summarize some lessons on seismic hazard mitigation learned from preliminary observations of fault rupture, ground motion, building damage, and other manifestations of the Wenchuan earthquake. This earthquake demonstrates that more effort needs to be spent on strengthening buildings and mitigating potential induced hazards in order to save life. This earthquake also demonstrates that there is a need for geologists to provide better information on seismic hazard such as potential sites of surface rupture and induced slope failure.

## Introduction

The $M$8.0 Wenchuan earthquake occurred at 14: 28 on May 12, 2008, and caused great damage in Sichuan, Gansu, and Shaanxi Provinces of China. The epicenter was located at 30.989°N, 103.329°E (Fig. 1) in Wenchuan County of Sichuan Province. The highest recorded peak ground acceleration (PGA) was about 1.00g (Li *et al.*, 2008). More than 30 aftershocks of magnitude 5.0 or greater were recorded within two months following the main shock (Fig. 1), with the largest being $M$6.5. The Wenchuan earthquake and some of its large aftershocks triggered massive landslides and rockfalls. About 70,000 people are confirmed to have been killed, 380,000 were injured, and 20,000 are

still missing. The total economic loss is estimated to have exceeded US$110 billion.

The Wenchuan earthquake occurred along the LongmenShan thrust fault belt, which forms the boundary between the Qinghai-Tibet Plateau and the Sichuan Basin (Burchfiel *et al.*, 2008). The Longmen Shan thrust belt consists primarily of three faults: the frontal fault (Guanxian-Jiangyou-Guangyuan), the central fault (Yingxiu-Beichuan-Chaba Linjueshi), and the back fault (Wenchuan Maoxian-Qingchuan) (Fig. 1). As delineated by the aftershock distribution (Fig. 1), the total rupture length of the Wenchuan earthquake is about 300 km. Surface rupture was observed along the Yingxiu-Beichuan segment of the central fault and the Guanxia-Jiangyou segment of the frontal fault (Fig. 1). No surface rupture was observed along the back fault. Figure 1. Main event and aftershocks of the Wenchuan *M*8.0 earthquake and Longmen Shan thrust faults.

## Surface Rupture

The observed surface rupture along the Yingxiu-Beichuan segment was about 210 km and the vertical offset varied along the Yingxiu-Beichuan segment from about 1.0～2.0 m near its southern end, to about 5.0 m in its center part (south of Beichuan, and to about 1.0～2.0 m near its northern end. A vertical offset of about 2 m and a right-lateral offset of about 0.5 m (photo location *A* in Fig. 1) is apparent in Yingxiu Town of Wenchuan County, near the southern end (Fig. 2). Collapsed buildings can be seen on the hanging wall in Fig. 2(a). Figure 2(b) shows 6.5 m right lateral and 5.6 m vertical offsets in Leigu Town of Beichuan County (photo location *B* in Fig. 1) near the center of the segment. Vertical and right-lateral offsets of about 2.0 and 1.9 m, respectively, were found in Pintong Town of Pinwu County (photo location C in Fig. 1)near the northern end of the segment (Fig. 2c).

A nearly 70 km long surface rupture was also observed between Wafeng Town of Dujiangyan and Hanwang Town of Mianzhu along the Guanxia-Jiangyou segment (Fig. 1). Vertical and right-lateral offsets of about 1.0 and 0.5 m, respectively, were observed along the Guanxia-Jiangyou segment. Figure 2(d) shows a 1.0 m vertical offset and 0.4 m right-lateral offset near Hanwang town of Mainzhu (photo location *D* in Fig. 1).

The distribution of the observed ground motion is closely related to surface rupture. The PGA (E-W) contour map (Fig. 7) of the Wenchuan earthquake was posted on China Earthquake Administration [CEA] website HYPERLINK http://www.cea.gov.cn; 99 www.cea.gov.cn; 99 (last accessed on July 29, 2008). As shown on the website, the higher PGA on the hanging wall side and along the direction of the rupture (i.e., from southwest to northeast) were recorded. The area of the highest PGA is coincident with the area of the largest rupture offset near Beichuan (Fig. 1). The southwest corner of the foot