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汶川地震地质灾害

WENCHUAN EARTHQUAKE
GEOHAZARDS

中国科学院工程地质力学重点实验室

Key Laboratory of Engineering Geomechanics, CAS

伍法权 胡瑞林 岳中琦 等著

F.Q. Wu, R.L. Hu, Z.Q. Yue and others

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内 容 提 要

2008年5月12日,在我国四川省汶川发生了震惊中外的8级地震,其地震危害面之广、强度之大、余震持续时间之长,乃国内外罕见。本图集着重反映本次地震引发的次生地质灾害状况,主要内容包括汶川地震地质背景、滑坡、崩塌、泥石流、堰塞湖等地质灾害的特点,以及这些次生地质灾害对建筑物、路面、桥梁等造成的破坏情景。

本图集科学、系统地反映了汶川地震地质灾害的形成、发育规律;既有直观表述,又有一定深度的分析;可供地震、地理、地质、地质工程、岩土工程等地球科学领域的科研、教学人员参考使用,也可供减灾、防灾及相关业务部门人员参考。

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中国科学院工程地质力学重点实验室

《5.12 汶川地震地质灾害》

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5.12 WENCHUAN EARTHQUAKE

GEOHAZARDS

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Rescues against the earthquake

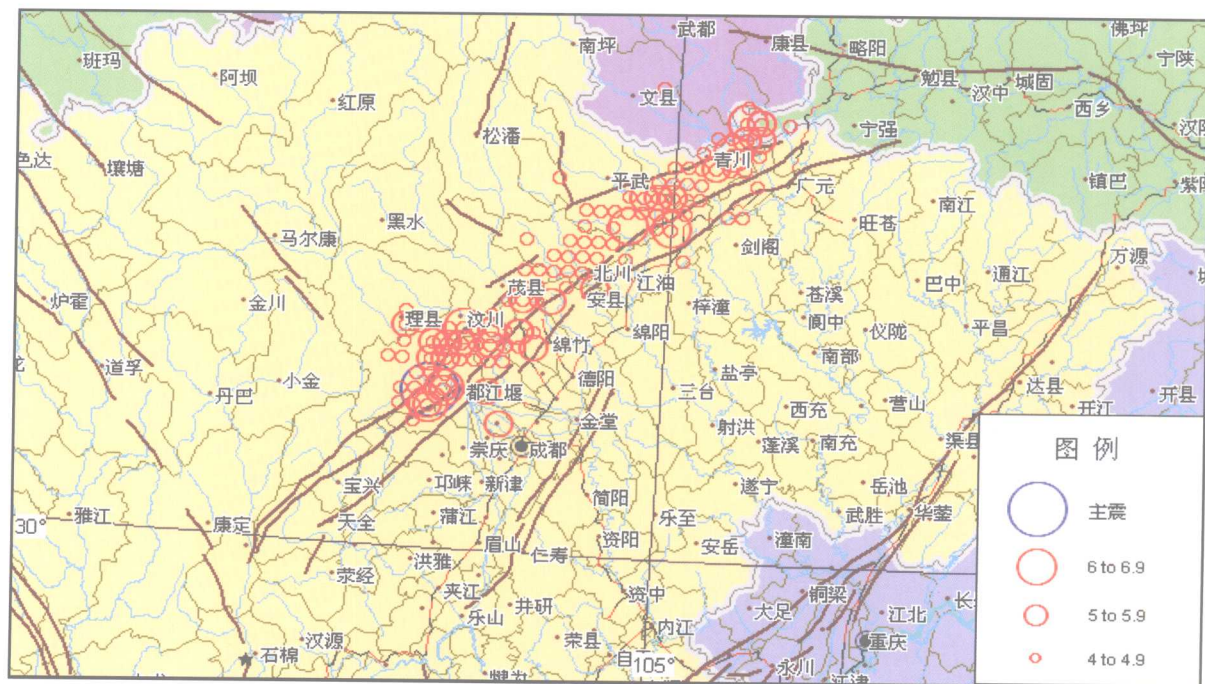
1 绪言 Preface

2008年5月12日14时28分,四川省汶川县映秀镇附近(北纬31.0°,东经103.4°)发生里氏8.0级地震,主震持续时间近120秒,震中烈度达到11度。截至2008年8月2日8时,已记录到4级以上余震245次。

地震波及范围包括四川、宁夏、甘肃、青海、陕西、山西、河南、北京、上海、贵州、西藏等16个省、自治区、直辖市,重灾县达51个。据民政部报告,截至2008年6月22日12时,地震已造成69181人遇难,374171人受伤,18522人失踪。地震直接摧毁大量建筑物,倒塌、严重损毁和损毁房屋涉及450万户,1000余万人无家可归。22万公里道路被摧毁,2900多座桥梁倒塌,27个隧道受损,造成灾区交通线瘫痪。重灾区面积达10万平方千米,据估计仅四川省直接经济损失超过10000亿元人民币。

地震引发了强烈的滑坡、崩塌、泥石流、堰塞湖等次生地质灾害。次生地质灾害严重加剧了地震的破坏力,估计占总灾害的三分之一。

我们试图将这些地质灾害用现场照片的形式汇集在本现场调查报告中,为地震地质灾害防治提供原始资料。



2008.5.12 四川汶川8.0级地震4.0级以上余震分布图

引自中国地震局(2008年5月27日)

Mainshock and aftershocks with magnitude of 4.0 & above of the Wenchuan Earthquake
After China Earthquake Administration (May 27, 2008)

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汶川地震地质灾害

WENCHUAN EARTHQUAKE GEOHAZARDS



映秀镇漩口中学楼房倒塌
Ruined buiding of Xuankou High School in
Yinxu Town

At 14:28, May 12, 2008, a devastating earthquake with Richter scale 8.0 occurred at the latitude 31.0° and longitude 103.4° near Yingxiu town of Wenchuan county in Sichuan Province of China. The mainshock lasted for 120 seconds and epicenters' intensity is 11 degree. After the mainshock, many aftershocks occurred. By 8 am, August 2, 2008, there were 245 aftershocks with the magnitude 4 or above.

The strong mainshock seismic waves propagated to a very large area covering 16 provinces including Sichuan, Ningxia, Gansu, Qinghai, Shaanxi, Shanxi, Henan, Beijing, Shanghai, Guizhou, and Xizang (Tibet). A total of 51 counties were heavily damaged or affected. Based on the report of Ministry of Civil Affairs of the People's Republic of China, the earthquake had killed 69,181 people, injured 374,171 people and missed 18,522 people by the 12:00, June 22, 2008. Buildings and houses of 4.5 million families were directly ruined, collapsed, heavily damaged or damaged by the Earthquake. A total of 10 million persons lost their homes. A total of 220,000 km-long roads and highways were destroyed, more than 2,900 bridges were collapsed. A total of 27 tunnels were affected. The ground transportation system of the disaster areas were malfunctioned. The heavily damaged region was estimated more than 100,000 km². The direct economic lost of Sichuan province only was estimated more than 1 trillion RMB.

The Earthquake induced devastating secondary geohazards including landslides, rock collapses, debris flow, and slide dam lakes. The secondary geohazards heavily enlarged the damages of the Earthquake and was estimated to account for 1/3 of the total damages.

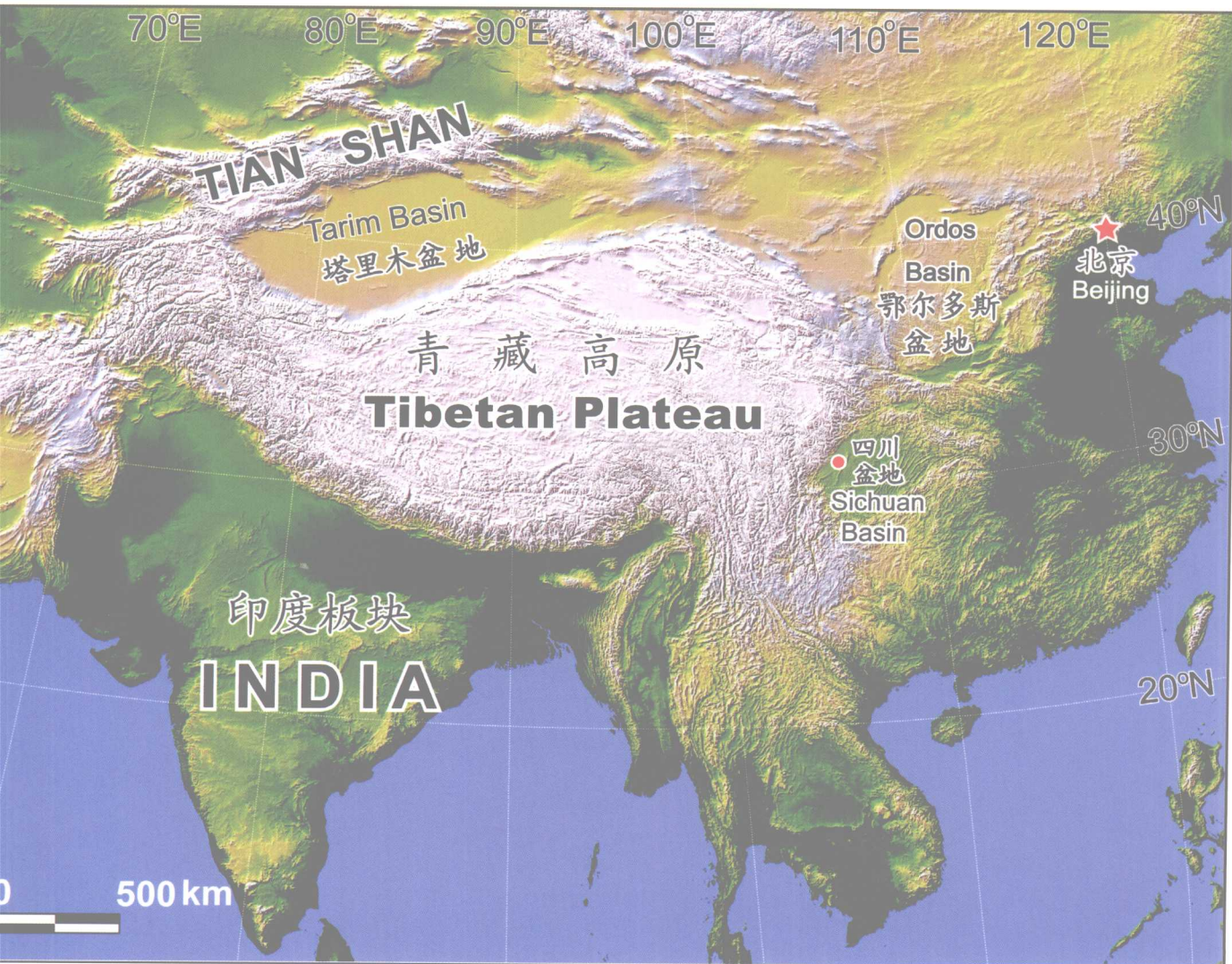
We try to show the geohazards with field photographs in this field investigation report' so that the factual data can be recorded and used to prevent and mitigate geohazards induced by earthquake in the future.

2

汶川地震地质背景 Geological Background

5.12 汶川 8.0 级地震发生在青藏高原东缘的龙门山断裂带，该地区地处青藏高原与四川盆地的构造边界。自第四纪以来，新构造运动十分活跃。

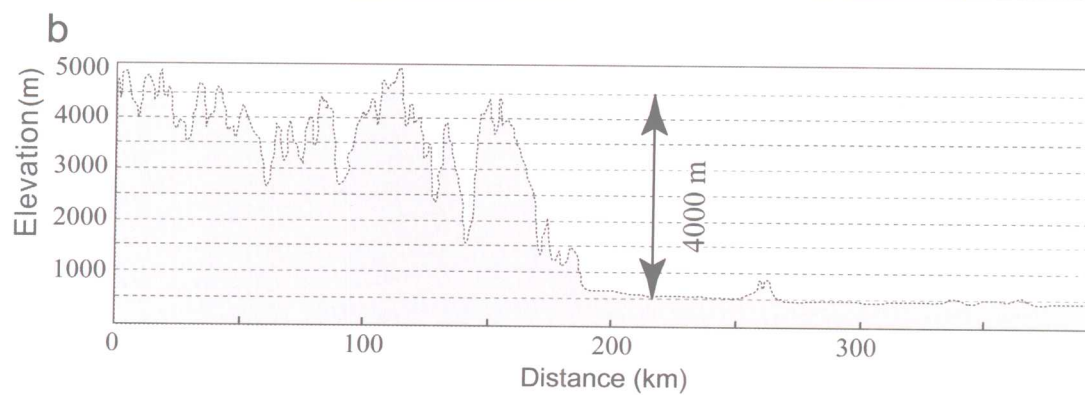
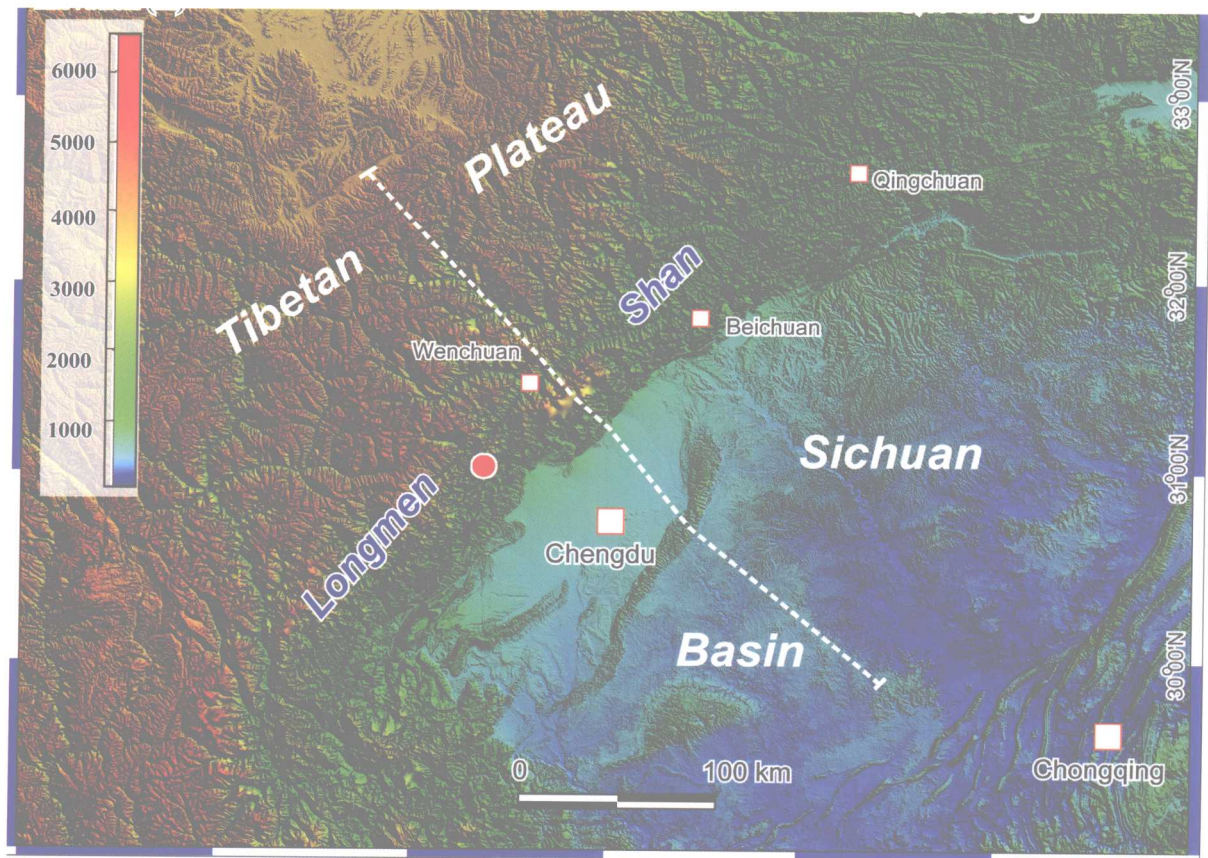
The 5.12 Wenchuan Earthquake happened at the Fault zone of Longmen Shan (Dragon's Gate Mountains) in the eastern edge of the Tibetan Plateau. The region locates the tectonic boundary of Sichuan basin and Tibetan Plateau. The neotectonic movement is very active.



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汶川地震地质灾害

WENCHUAN EARTHQUAKE GEOHAZARDS

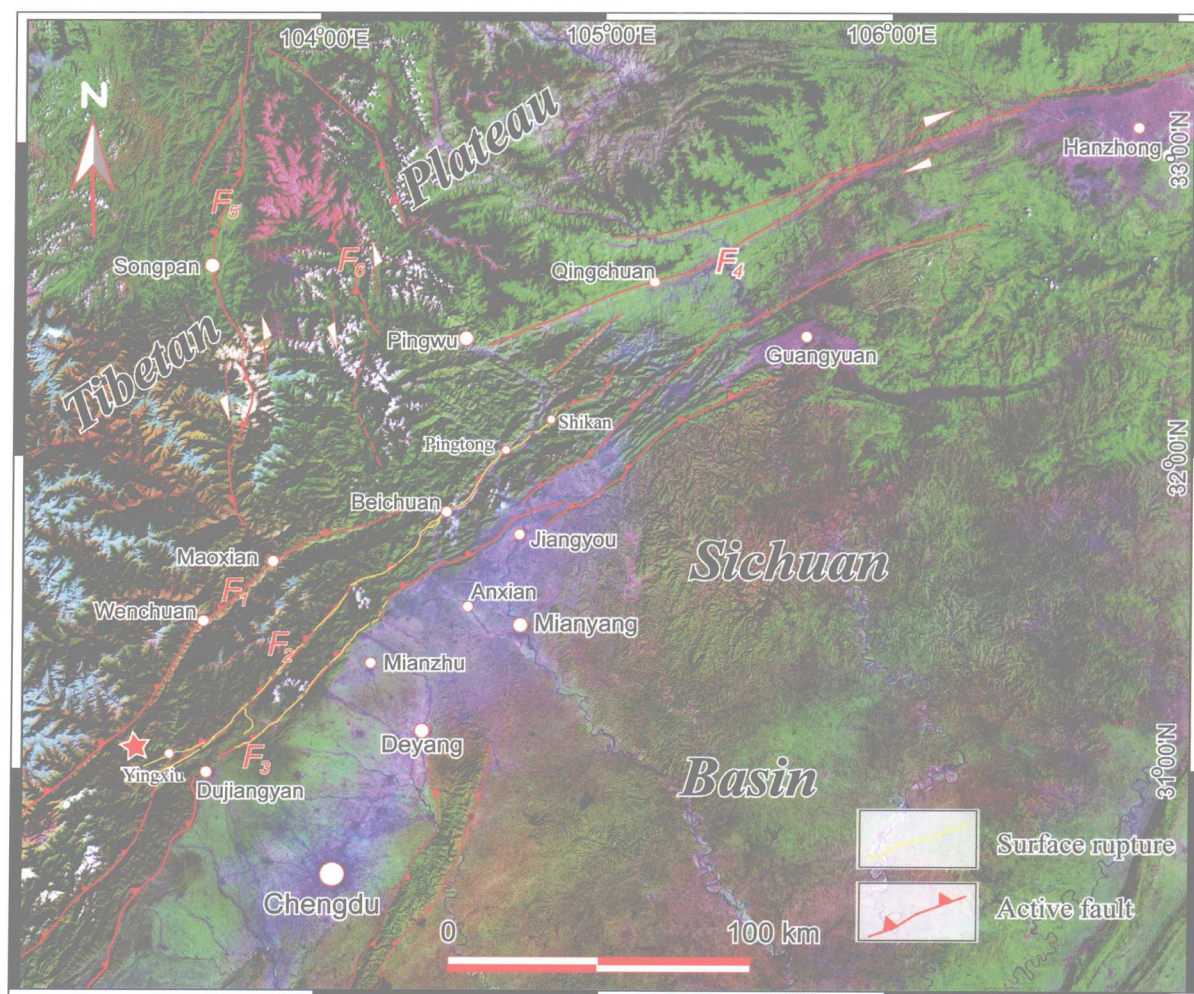


龙门山地震断裂带是青藏高原周边地形梯度变化最强烈的地区，在50km范围内从四川盆地平均海拔600m左右，迅速变为5000m左右的高原，地形高差达4400m。

The Longmen Shan earthquake fault zone is the edge region of Tibetan Plateau with the highest changes in land topographical gradients. The altitude at its foreland in Sichuan basin is 600 m and increases to 5000 m on the Plateau over a horizontal distance of 50 km. The altitude difference is 4400 m.

龙门山地震断裂带为一条长约500km，宽30~50km的北东走向的构造带，主要由四条断裂带组成： F_1 ：汶川—茂汶断裂； F_2 ：映秀—北川断裂； F_3 ：灌县—安县断裂； F_4 ：平武—青川断裂，这些断裂带晚第四纪以来的活动性质以挤压逆冲为主，并伴有右旋走滑分量。此次汶川8.0级大地震形成长近300km的地震断裂带。

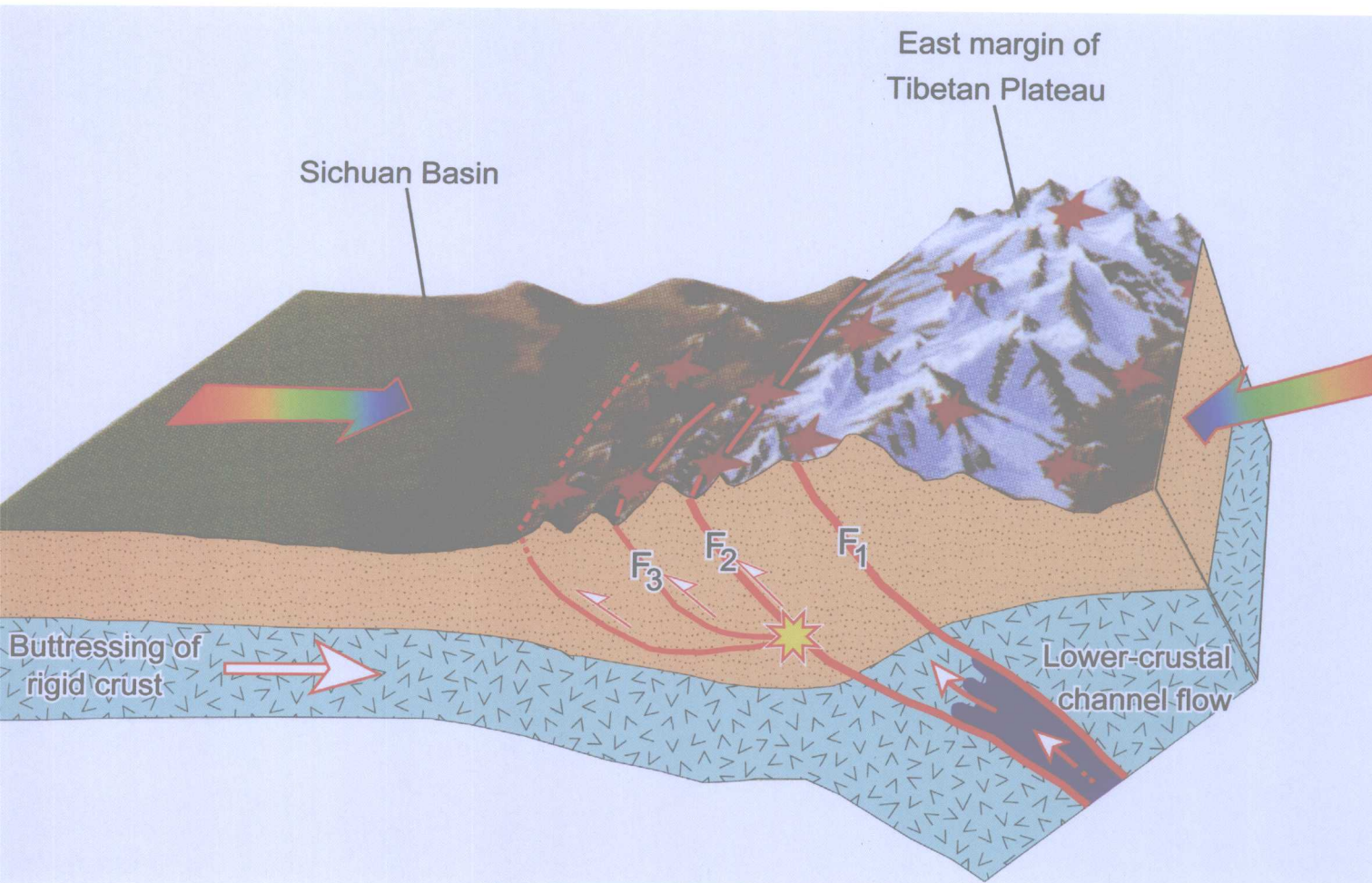
Longmen Shan fault zone is of 500 km long and 30 to 50 km wide with north-eastern striking direction. It is composed of four faults: F_1 : Wenchuan–Maowen fault; F_2 : Yingxiu–Beichuan fault; F_3 : Guanxian–Anxian fault; F_4 : Pingwu–Qingchuan fault. Since Late Quaternary, the active characteristics of the faults have been mainly compressing and thrusting with right rotational sliding component. This Wenchuan earthquake formed a quake faulting zone of 300 km long.



龙门山地震断裂带的活动构造
Active fault system of the Longmen Shan
Earthquake Fault Zone

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汶川地震地质灾害 WENCHUAN EARTHQUAKE GEOHAZARDS



汶川地震发震的地球动力学机制模型
Geodynamic mechanism model for focal
mechanism of Wenchuan Earthquake

龙门山地震断裂带的构造变形十分强烈,其新生代隆升可能与青藏高原的下地壳流引起的向东挤出与四川盆地坚硬结晶基底的阻挡之间的相互作用有关,此次大地震的发生很可能是下地壳流向东挤出所产生长期应力积累释放的结果。

Structural deformation of the Longmen Shan earthquake fault zone is very strong. The uplift of the zone in Cenozoic may be due to the interaction between the eastern extrusion induced by the lower-crustal channel flow beneath Tibetan Plateau and the buttressing of the rigid crust of Sichuan basin. The occurrence of this Earthquake may be a result of the release of the long-time stress accumulation caused by the eastern extrusion of the lower-crustal channel flow.

3

滑坡 Landslides

滑坡是山体沿一稳定的破裂面发生整体下滑现象。据调研(殷跃平,2008),本次地震诱发的滑坡、崩塌、泥石流约 15000 处,其中滑坡 1700 处,约占总的新增地质灾害的 31%,其数量虽不算最多,但规模特别大,造成的危害十分惨重,是最主要的致灾因子。



北川县王家岩滑坡是北川旧城变为废墟的主要原因,直接掩埋 1600 人 (李晓摄)
The Wangjiayan landslide is the main cause that ruined Beichuan old town and buried 1600 people

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WENCHUAN EARTHQUAKE GEOHAZARDS



映秀牛圈沟高速远程滑坡 – 碎屑流滑坡
A high-speed and long-distance landslide
and debris flow landslide at Niujuangou
near Yingxiu town

Landslide is the phenomenon that a portion of the mountain rock and soil mass slides down along a fractured surface. According to Yin (2008), the Earthquake induced landslides, collapses, and debris flows at about 15,000 sites. The landslides occurred at 1700 sites and accounted for 31% of the total secondary geohazards. Although they were only about 11 % of the total geohazard sites, the landslides had extremely large sizes, caused extremely serious damages and, were the most significant factor causing the geohazard.

汶川 5.12 地震滑坡灾害死亡人数表(≥ 30 人)(不完全数据)*

序号	灾害点名称	灾害类型	灾害点位置	灾害体规模 (10^4m^3)	因灾死亡 (人)
1	城西滑坡	滑坡	北川县老城王家岩	480	1600
2	樱桃沟滑坡	滑坡	北川县陈家坝乡茶园梁村	188	906
3	北川新中滑坡	滑坡	北川县新县城中学新区	240	500
4	景家山崩塌	崩塌	北川县城南主干道	50	60
5	韩家山滑坡群	滑坡	北川县桂溪乡杜家坝村 1 社	30	50
6	陈家坝滑坡	滑坡	北川县陈家坝场镇	1200	400
7	红岩村滑坡	滑坡	北川县陈家坝乡红岩村	480	141
8	太洪村滑坡	滑坡	北川县陈家坝乡太洪村(堰塞湖)	200	150
9	东河口滑坡	滑坡	青川县红光乡东河口村	1000	260
10	大岩壳崩塌	崩塌	青川县曲河乡建新村	70	41
11	郑家山滑坡群	滑坡	平武县南坝镇新平村	1250	60
12	林家坝滑坡	滑坡	平武林家坝	200	60
13	马鞍石滑坡群	滑坡	平武县水观乡马鞍石村	400	34
14	罐滩滑坡	滑坡	安县雒水镇罐滩	144	100
15	一把刀一小岗箭 滑坡崩塌	滑坡、崩塌	绵竹县绵远河沿江路	滑坡、崩塌 密集带	50
16	红村电站滑坡	滑坡	石旂县石亭江红村电站	100	150
17	黎明村滑坡	滑坡	都江堰市紫坪铺镇黎明村(213 线)	20	120
18	小龙潭崩塌	崩塌	彭州市银厂沟景区	5.4	100
19	大龙潭沟口崩塌	崩塌	彭州市银厂沟景区	10	100
20	谢家店滑坡	滑坡	彭州市九峰村 7 社	400	100
21	连盖坪滑坡	滑坡	彭州市团山村	40	30
22	泰安 9 组崩滑体群	崩塌	都江堰市青城山镇周家坪	3 个单体总计 120 万立方米	62
23	映秀—汶川 公路滑坡崩塌	滑坡、崩塌	都江堰—九寨沟旅游公路沿线	滑坡、 崩塌密集带	1000
合计					6074

* 本资料引自殷跃平《工程地质学报》，2008，No.04)

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汶川地震地质灾害

WENCHUAN EARTHQUAKE GEOHAZARDS

Fatalities (≥ 30 persons) due to landslides caused by the Earthquake

No.	Disaster Site Name	Type of disasters	Location	Landslide Volume (10,000 m ³)	Fatalities
1	West town landslide	Landslide	Wangjiayan of old town in Beichuan	480	1600
2	Yingtaogou landslide	Landslide	Chayuanliang village of Chenjiaba town in Beichuan county	188	906
3	Beichuan new middle school landslide	Landslide	New zone of middle school at new town in Beichuan county	240	500
4	Jingjiashan landslide	collapse	Main road at south of Beichuan	50	60
5	Hanjiashan landslide	Landslide	Dujiaba village of Guixi town in Beichuan county	30	50
6	Chenjiaba landslide	Landslide	Chang town of Chenjiaba in Beichuan county	1200	400
7	Hongyan village landslide	Landslide	Hongyan village	480	141
8	Taihong village landslide	Landslide	Dahong village of Chenjiaba town in Beichuan county (barrier lake)	200	150
9	East river landslide	Landslide	Donghekou village of Hongguang town Qingchuan county	1000	260
10	Taiheqiao collapse	collapse	Jianxin village of Quhe town in Qingchuan county	70	41
11	Zhenjia mountain landslide group	Landslide	Xingping village of Nanba town in Pingwu county	1250	60
12	Lingjiaba landslide	Landslide	Linjiaba of Pingwu county	200	60
13	Maanshi landslide group	Landslide	Maanshi village of Shuiguan town in Pingwu county	400	34
14	Taotan landslide	Landslide	Guantan of Jushui town in An county	144	100
15	Yibadao and Yixiaogangjian landslide	Landslide and collapse	Yanjiang road along Mianyu River of Mian county	extensive zones of landslides and collapses	50
16	Hong village power station landslide	Landslide	power station of Shitingjiang Hong village in Shiren county	100	150
17	Liming village landslide	Landslide	Liming village of Ziping town in Dujiangyan city (line 213)	20	120
18	Xiaolongtan collapse	collapse	scenic zone of Yingchanggou in Penzhou city	5.4	100
19	Dalongtan ditch collapse	collapse	scenic zone of Yingchanggou in Pengzhou city	10	100
20	Xiejiadian landslide	Landslide	Jiufeng village in Penzhou city	400	100
21	Liangaping landslide	Landslide	Tuanshan village in Penzhou city	40	30
22	Taian 9 collapse	collapse	Zhoujiaping of Qingchengshan town in Dujiangyan city	120 for all the 3 parts	62
23	Yingxiu-Wenchuan road landslide and collapse	Landslide and collapse	Highway from Doujiangyan to Jiuzhaigou	extensive zones of landslides and collapses	1000
	Total				6074

After Yin (2008), *Journal of Geological Engineering*, No.04, 2008

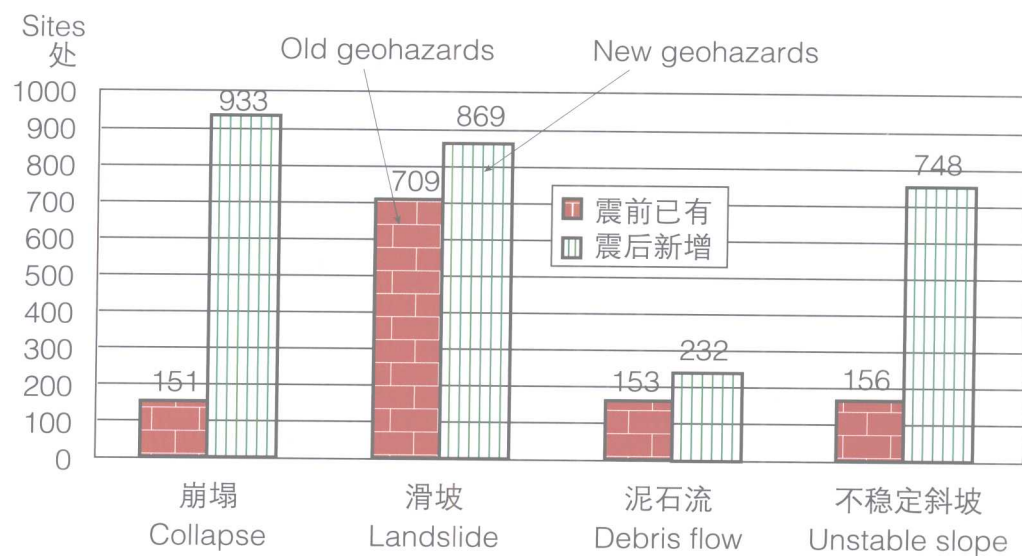


图1 极重灾区地震前后地质灾害隐患比例(据殷跃平,2008)
Fig.1 Statistics of the potential geohazard sites in the epicenter zones before and after the Earthquake



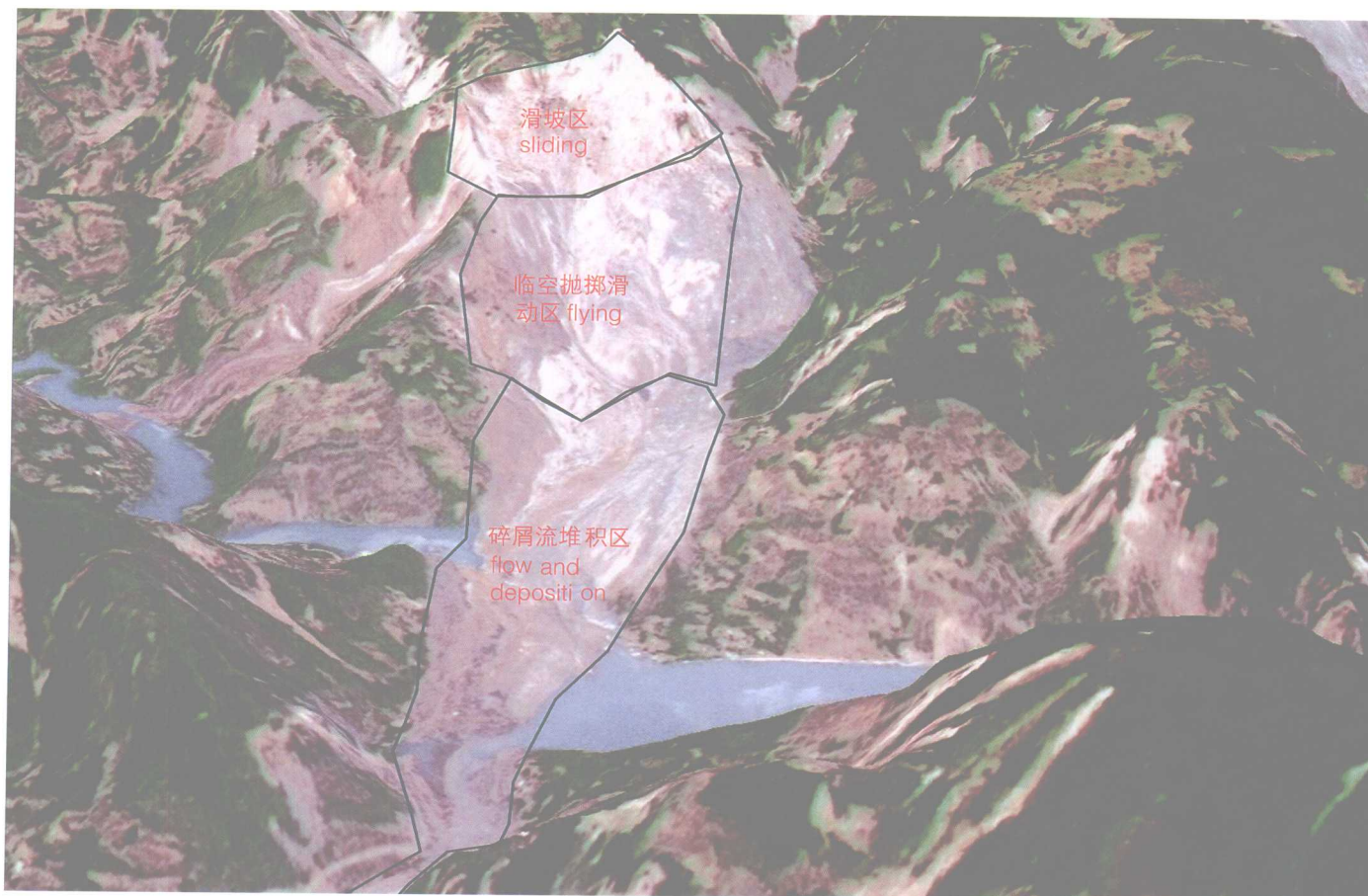
北川县老城王家岩山体滑坡 (李晓摄)
The Wangjiayan landslide in old Beichuan town

• 地震抛射型高速远程滑坡

The high-speed and long-distance landslides
triggered by the ground shocking

在本次地震过程中，高速远程滑坡是一种危害最为严重、比较常见的类型。此类滑坡多以高位崩塌为主，受地震动力抛射作用和地形坡降的控制，以高速碎屑流形式，经历了高位崩滑—低空飞行—远程抛洒—气垫冲击等演变过程。比较著名的高速远程滑坡有青川东河口滑坡、平武南坝镇新平村滑坡群、映秀牛圈沟滑坡、北川县城王家岩滑坡等。

During the earthquake, the high-speed and long-distance landslides were the most serious and relatively common type. They were formed from the collapses at high positions and then transformed to high-speed debris flow under the control of kinetic energy from both the ground shocking and altitude reduction. The process of high speed debris flows experienced collapses at high positions, low attitude flying, long-distance scattering and air-cushion impact. Some well-visited landslides of this type are Donghekou landslide in Qingchuan, landslide group at Xinping village of Nanba Town in Pingwu county, Niujuangou landslide in Yingxiu town as well as the Wangjiayan landslide at Beichuan town.



抛射型高速远程滑坡——青川东河口滑坡 (宽 200 ~ 600m, 长 2500m, 面积 1.09km², 体积 1250 万 m³, 掩埋 260 人, 据许强)
The high-speed and long-distance landslide —— Donghekou landslide in Qingchuan (200 ~ 600 m wide, 2500 m long, the area 1.09 km² and the volume 12.5 million m³, buried 260 people, after Qiang XU)