

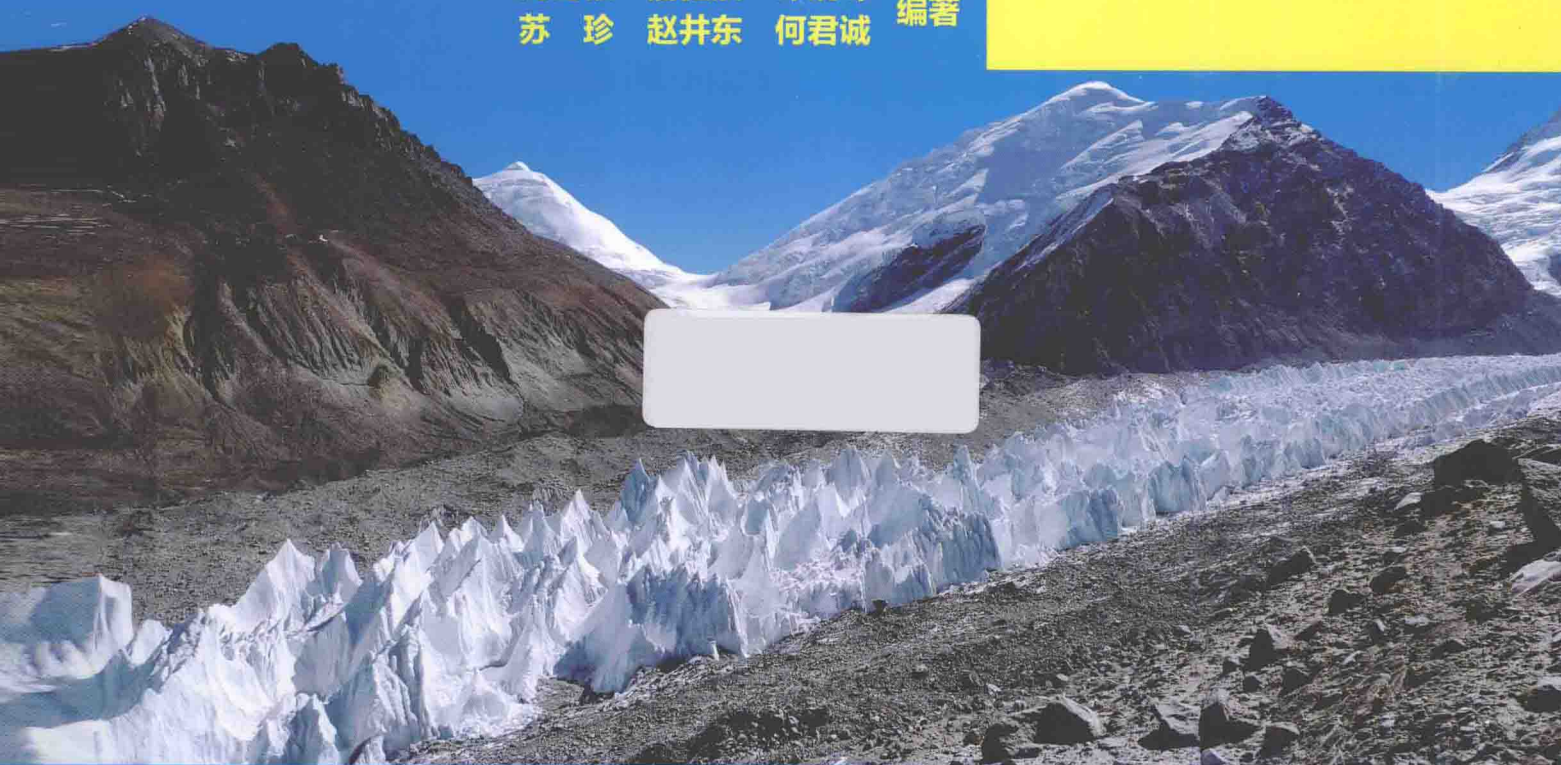
上海文化发展基金会资助项目

G · L · A · C · I · E · R · S
AND GLACIAL LANDSCAPES IN CHINA

中国冰川图鉴



刘时银 蒲健辰 邓晓峰 编著
苏 珍 赵井东 何君诚



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中国西部拥有世界上最高大的山脉和最广阔的高原,其发育有现代冰川 46 377 条,面积约 59 425 平方千米,占亚洲山地冰川面积的 50% 左右。中国是全球中低纬度山地冰川面积最多、规模最大的国家,冰储量约 5 600 立方千米。第四纪末次冰期最盛期时,冰川规模要比现在大好几倍。这些冰川是亚洲大江大河的重要发源地。冰川的存在与我国及周边国家人民的生活与建设有着密切的关系。冰川不仅是宝贵的淡水资源,也是宝贵的旅游资源。冰川还是气候变化的指示器、冰川规模变化以及冰层中所记录的气候和环境变化信息,在了解过去和预测未来气候变化的研究中发挥着越来越重要的作用。作为山地环境的组成要素之一,冰川波动也会造成灾害,对山地环境以及下游人类活动产生重要的影响。

近年来,由于全球气候显著变暖,水循环加快,冰川消融增强。为了深入了解和监测中国冰川变化情况,中国科学院寒区旱区环境与工程研究所冰冻圈科学国家重点实验室 2006 年承担的科技部科技基础性工作专项项目“中国冰川资源及其变化调查”,围绕中国冰川变化开展调查,除采用遥感技术外,还组织了多次面向全国各大冰川区的野外考察,在野外考察期间,拍摄了大量精彩的照片,较为全面地反映了中国冰川分布与变化状况。

自 1958 年中国科学院成立专门的科研机构以来,我国的现代冰川研究已跨过了 50 多年的历史。在此期间,冰川研究紧密围绕西部经济社会发展需要,科研人员对各山脉的冰川开展了广泛的考察和研究。上海科学技术出版社 1980 年出版的原中国科学院冰川冻土研究所编的《中国冰川》,是我国编辑出版的第一部专门介绍中国冰川的画册,内容涵盖 1958~1980 年我国历次冰川考察拍摄的照片以及取得的一些成果及有关科学知识等,以中英文两种文字发行,很受读者欢迎。自 1980 年以来,我国冰川科学研究取得了长足的发展,特别是一系列冰芯钻探、定位与半定位冰川监测、空白地区的野外考察等活动,拓展了我们对中国冰川的认识水平。本书力图从这些考察和观测活动,特别是“中国冰川资源及其变化调查”项目相关的考察活动中,挑选出拍摄质量较高,知识性和观赏性较强的照片,加上我们从国内长期从事冰川研究的学者手中收集到一批珍贵照片,汇编成册,让广大读者直观地了解中国冰川资源及其近期变化。希望读者在欣赏优美的自然景观的同时,认识中国的冰川及其价值。

本书精选照片 340 余张、1 张中国西部现代冰川与平衡线高度分布图以及 4 张 3D 影像图,并按中国冰川分布、冰川类型、冰面景观、冰川地貌、冰川变化、冰川资源与灾害,以及冰川野外考察等进行编辑,各部分都有简要的文字说明,以概括每一部分照片所要表达的基本内容和冰川学的基础知识。

本书由刘时银、蒲健辰、邓晓峰、苏珍、赵井东、何君诚 (Jon Harbor)

编著、除收编作者拍摄的照片外，以下专家学者亦为本书提供了宝贵的照片：L.D. 道尔古辛（原苏联）、丁良福、杜建括、段克勤、高新生、郭万钦、郭治龙、韩海东、黄宗虎、井哲帆、李炳元、李刚、李晶、李向应、李英奎、李真、李忠勤、刘潮海、刘巧、柳景峰、鲁安新、马秋华、上官冬辉、税晓洁、宋玉江、谭晴、田立德、王飞腾、王杰、王宁练、王欣、王志超、王宗太、魏俊锋、效存德、许向科、杨惠安、姚檀栋、姚晓军、张祥松、张盈松、赵华标、郑本兴、朱国才等，以及绿色和平组织特许使用的2张照片。此外，徐成琳参与了部分编辑工作。编者在此对上述专家和同事的大力支持表示衷心感谢。

本书大部分照片是在下列项目支持下相关考察活动期间所拍摄的：科技部科技基础性工作专项“中国冰川资源及其变化调查”（2006FY110200）与“中国西部主要冰川作用中心冰量变化调查”（2013FY111400）、国家自然科学基金重大项目（41190084）“第三极地球系统中水体的多相态转换及其影响”、国家国际科技合作项目（2010DFA92720）、中国科学院知识创新工程重要方向项目“天山冰冻圈与环境研究”（KZCX2-YW-GJ04）、“西部冰川变化监测及其影响评估方法研究”（KZCX2-YW-301）与“西昆仑山地区第四纪冰川与环境变化研究”（KZCX2-EW-QN304）以及国家自然科学基金面上项目“西昆仑山地区第四纪冰川演化序列研究”（41071010）。一些老照片可追溯到我国开展冰川研究之初，能够获得这些照片，离不开国家各类项目的长期支持。

Western China includes the world's highest mountain systems and widest plateau (the Qinghai-Xizang Plateau). With 46,377 glaciers covering an area of 59,425 km², and with an ice volume of 5,600 km³, China's mountains are home to about 50% of Asia's alpine glaciers. In the past these glaciers were much larger than at present, including during a time known globally as the Last Glacial Maximum during the Quaternary geologic period. Glaciers in China are very important sources of water for Asian rivers, including the Yangtze (Changjiang), and the Ganges. Glaciers play an important part in people's lives and in economic development in China and neighbouring countries. They are precious resources for fresh water and tourism. Glaciers are also an indicator of climate change and, because they get bigger and smaller with changing temperature and snowfall, some scholars have described them as "the thermometers of the Earth". Glaciers and glacial landforms provide key information for studying climate change in the past and for predicting climate in the future. Glacier fluctuations also produce large floods that significantly affect the mountain environment and that can disrupt human activities in the rivers fed by glaciers. Recent global warming has intensified glacier melting (ablation) and increased glacier hazards.

In order to better understand and monitor glacier changes in China, in 2006 a research team coordinated by the editor of this album from the State Key Laboratory of Cryospheric Sciences, Cold and Arid Regions Environmental and Engineering Research Institute of Chinese Academy of Sciences started a project supported by the Ministry of Science and Technology of China, "Investigation of Glacier Resources and their Changes in China" (Grant No: 2006FY110200). The main purpose of this project is to investigate the current status of glaciers in China and how they are changing. Remote sensing and field expeditions have produced information that is analyzed using geographical information system techniques. During field expeditions, researchers have taken many photos of glaciers they have surveyed. This album includes photos from this project and previous expeditions and aims to provide readers with a visual way to learn more about glaciers in western China and their role in water resources and climate change.

Since the founding of the first Institute for Glaciological Research by the Chinese Academy of Sciences in 1958, many scientists have explored the mysteries of glaciers in western China. Their efforts have given us a fundamental understanding of glaciers and their important role in economic and social development in western China. These efforts have included extensive glacier field investigations and observations in numerous mountain systems over many decades. The album, *Glaciers in China*, compiled by the Institute of Glaciology and Geocryology of the Chinese Academy of Sciences, and published by the Shanghai Science and Technology Press in 1980, was the first album devoted to visually introducing glaciers to readers in China. *Glaciers in China* contained photos taken during glacier expeditions from 1958 to 1980 and was published in both Chinese and English. Since 1980, extensive field investigations and monitoring programs have been undertaken on glaciers in almost all of China's mountain ranges. This has included ice core drillings on some ice fields as well as the establishment of new glaciological stations. This album includes pictures from

these field campaigns, and most were taken during the glaciological expeditions related to the project "Investigation of Glacier Resources and their Changes in China" (2007-2012). Our goal was to compile an album of high quality photos that would help readers understand how glacier research is done, and understand the significant roles that glaciers and glacier changes play in the natural and social environments of western China.

This album contains more than 340 photos, 1 distribution map of glaciers and their equilibrium-line altitude (ELA) in western China, and 4 satellite images draped over three-dimensional digital elevation models. These photos, map, and satellite images are organized into chapters focused on glacier distributions, glacier types, supraglacial landscapes, glacial geomorphology, glacier changes, glacier resources and disasters, and glacier expeditions (appendix). A brief written introduction is provided to help readers understand the pictures and their significance of glaciers in China.

This book was compiled by Liu Shiyin, Pu Jianchen, Deng Xiaofeng, Su Zhen, Zhao Jingdong, and Jon Harbor. Most of the photos were taken by the editors, however, the following experts and scholars have also contributed pictures that greatly improve the quality of this album: L. D. Dolgushin (the former Soviet Union), Ding Liangfu, Du Jiankuo, Duan Keqin, Gao Xincheng, Guo Wangqin, Guo Zhilong, Han Haidong, Huang Zonghu, Jing Zhefan, Li Bingyuan, Li Gang, Li Jing, Li Xiangying, Li Yingkui, Li Zhen, Li Zhongqin, Liu Chaohai, Liu Qiao, Liu Jingfeng, Lu Anxin, Ma Qihua, Shangguan Donghui, Shui Xiaojie, Song Yujiang, Tan Qing, Tian Lide, Wang Feiteng, Wang Jie, Wang Ninglian, Wang Xin, Wang Zhichao, Wang Zongtai, Wei Junfeng, Xiao Cunde, Xu Xiangke, Yang Hui'an, Yao Tandong, Yao Xiaojun, Zhang Xiangsong, Zhang Yingsong, Zhao Huabiao, Zheng Benxing, Zhu Guocai, et al. In addition, Xu Chenglin has helped with editing of the early version of the album. The editors hereby express their sincere appreciation for their support and generosity in allowing us to use their photos and the editing work.

Most of the photos in this album were taken during scientific investigations supported by the following projects: Special Basic Research Project of the Ministry of Science and Technology "Investigation of Glacier Resources and their Changes in China" (2006FY110200); "Investigation on Ice Mass Changes of Primary Glacier Centers in western China" (2013FY111400); "Multi-phase Conversion of Water and its Influences in the Third Pole Earth System" (41190084) granted by the National Natural Science Foundation of China; International Science Cooperative Project of the Ministry of Science and Technology (2010DFA92720); and projects from the Chinese Academy of Sciences (KZCX2-YW-GJ04, KZCX2-YW-301 and KZCX2-EW-QN304); and "Study on the Quaternary Glacial Sequence in the western Kunlun Mountains" (41071010) granted by NSFC. Harbor's work was supported by Purdue University, USA, and Stockholm University, Sweden. Some of older photos in this album can be traced back to the beginnings of glacier research in China. This album would not have been possible without the support of these projects and the many scholars involved in them, including those mentioned above. The editors express their sincere thanks for this support.

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第一章 中国冰川分布

CHAPTER 1 DISTRIBUTION OF GLACIERS IN CHINA

冰川是指陆地上多年积雪经变质演化形成,并处于流动状态的冰体。冰川冰不同于河冰、湖冰、海冰等自然冰体,在自重作用下发生运动是其基本特征。冰川均可根据物质收支状态划分为积累区和消融区,在积累区与消融区之间,年积累量与年消融量相等的点的连线为冰川物质平衡线,夏末冰川上粒雪与冰的界限称为雪线,略高于平衡线高度。地球表面任何地区,只要其年平均气温低于 0°C 且积雪可在该区域维持多年存在,均可发育冰川。因此,冰川是寒冷气候的产物,且随气候变化而变化。

中低纬度地区现代冰川多依托高大山体而发育,高大山地为冰川发育提供了广阔的积累空间和有利的水热条件。中国现代冰川发育在西部地区,包括喜马拉雅山、横断山、念青唐古拉山、冈底斯山、唐古拉山、祁连山、阿尔金山、喀喇昆仑山、昆仑山、天山、萨吾尔山、阿尔泰山以及羌塘高原和东帕米尔高原等14个地区。在这些山系中,天山、喀喇昆仑山、昆仑山、念青唐古拉山和喜马拉雅山5座山系是我国冰川的主要分布区,共发育有冰川33 847条,面积46 872平方千米和冰储量4 701立方千米,分别占中国冰川总条数、总面积与总冰储量的73%、79%和84%。天山山系现代冰川条数最多,但冰川面积和冰储量则是昆仑山最大,分别占中国冰川总面积与总冰储量的21%和23%。其余3座山系的冰川按冰储量依序为念青唐古拉山(18%),喜马拉雅山(13%)和喀喇昆仑山(12%)。在14个地区中,萨吾尔山的冰川最少,仅在海拔3 835米穆斯套岭两侧发育了少量的冰川。

按国际冰川编目规范中水系划分原则,中国西部河流归属于10个一级水系。西北内流区划分为中亚(伊犁河和哈拉湖流域区)和东亚(准噶尔流域区、塔里木盆地流域区、吐鲁番—哈密流域区、河西走廊流域区、柴达木盆地流域区等)内陆流域区,青藏高原内部也为内流区。这三大内流区分布有冰川27 024条、面积35 469平方千米和冰储量3 575立方千米,分别占中国冰川总条数、总面积和总冰储量的58%、60%和64%。外流区共包括7个一级流域,这些流域的冰川是长江、黄河、雅鲁藏布江等大江大河的发源地,分布有冰川19 353条,面积23 956平方千米,冰储量2 025立方千米,分别占中国冰川总条数、总面积和总冰储量的42%、40%和36%。在外流区中,冰川数量规模最小的是黄河流域,其冰川条数、面积和冰储量仅占中国冰川总条数、总面积和总冰储量的0.4%、0.3%和0.2%。

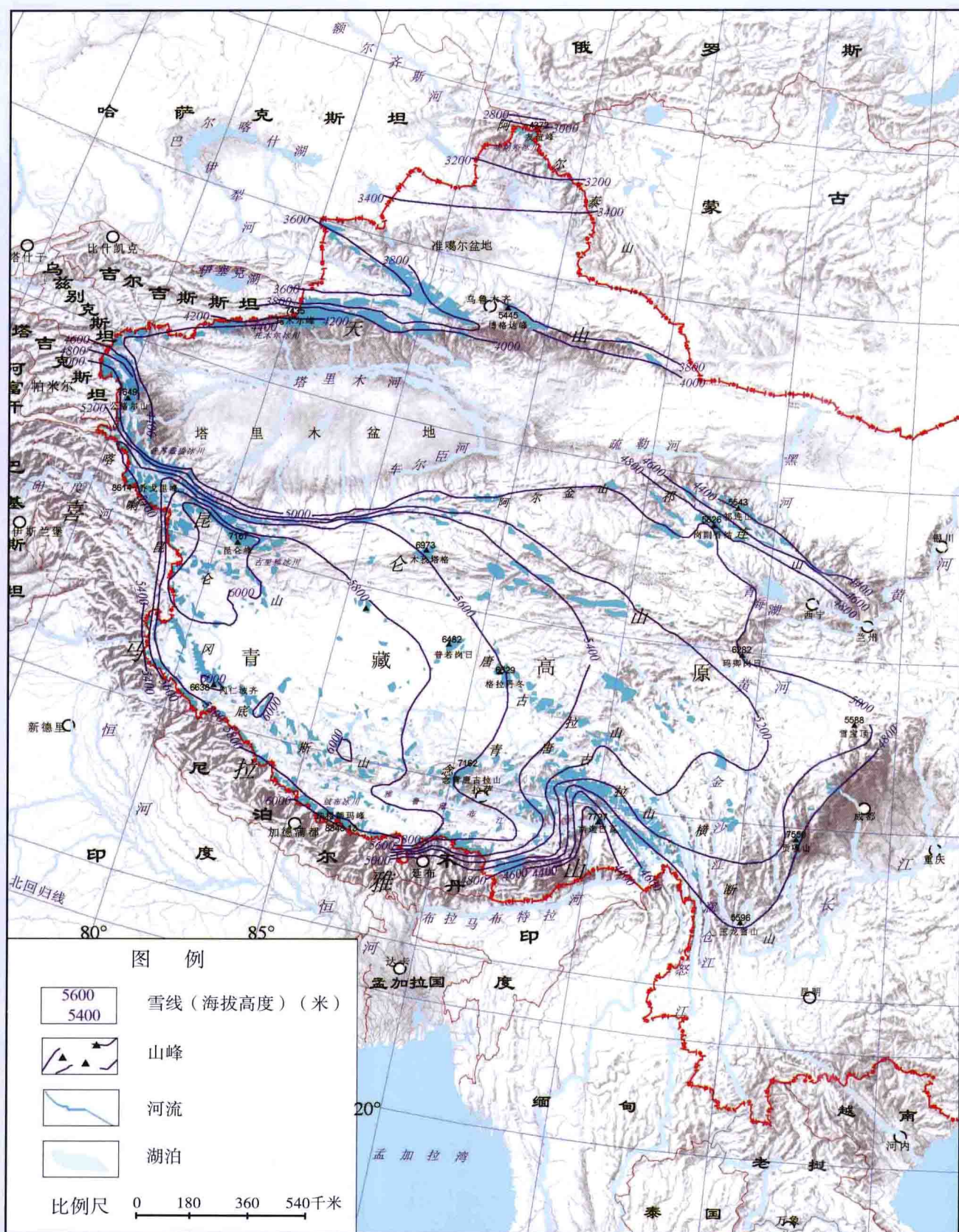
A glacier is a solid, thick and compact ice mass on land that forms through the recrystallization of snow and that moves forward under its own weight. The movement of the ice and its location on land are fundamental characteristics of a glacier that differentiate it from other forms of ice, including river ice, lake ice, and sea ice. Scientists divide a glacier into two parts: the accumulation area where more snow turns into ice than melts each year, and an ablation area where there is more melting of ice than accumulation. Glacier ice flows from the accumulation area into the ablation area. The boundary between these areas is called the equilibrium line (or snowline). At the equilibrium line altitude (ELA), the annual accumulation is equal to the annual ablation. Glaciers only develop in regions where snow can survive for many years and turn into ice, and so they are a product of cold climates and fluctuate with climate change.

In low latitude and mid latitude regions, glaciers occur in high mountain areas where cold conditions provide a favorable climate for snow accumulation. Alpine glaciers occur today in many parts of western China (west to 105°E), including the following mountain ranges: the Himalayas, Hengduan, Nyainqentanglha, the Gangdise, Tanggula, Qilian, Altun, Karakoram, Kunlun, Tianshan, Sawuer, Altai, Qiangtang Plateau and Eastern Pamir Plateau. The Tianshan, Karakoram, Kunlun, Nyainqentanglha and the Himalayas have 33,847 (73%) of China's glaciers, with an area of 46,872 km² (79%) and an ice volume of 4,701 km³ (84%). The Tianshan Mountains have the largest number of glaciers while the Kunlun Mountains have about 21% of the area and 23% of the volume of all glaciers in China. Ice volumes in the Nyainqentanglha, the Himalayas and the Karakoram are 18%, 13% and 12% respectively of the total volume of glaciers in China. In the Sawuer Mountains only small glaciers occur around the highest peak, Musitaoling.

Based on the classification scheme of the World Glacier Inventory, there are ten first-order drainage basins in western China. The Ili River and Karakul Lake Basin make up the Central Asia Endorheic drainage ("endorheic" refers to a drainage basin with no outlet to a river or ocean), and the Junggar Basin, Tarim Basin, Turpan-Kumul Basin, the Hexi Corridor and the Qaidam Basin are part of the East Asia endorheic drainage. The interior basins of the Qinghai-Xizang Plateau make up an independent endorheic drainage. In these inland basins there are 27,024 glaciers with an area of 35,469 km² and ice volume of 3,575 km³, representing 58%, 60% and 64% of the total glacier number, area and volume in China. The 7 other are drainage basins are exorheic (they drain to another river or the ocean), including the Yangtze River, the Yellow River, and the Yarlung Zangbo River valley etc. These drainage basins include 19,353 glaciers with an area of 23,956 km² and ice volume of 2,025 km³, which account for 42%, 40% and 36% of the number, area and volume of glaciers in China. The Yellow River is the least glaciated exorheic drainage, accounting for only 0.4%, 0.3% and 0.2% respectively of China's glacier number, area and volume.

右图: 中国西部现代冰川与平衡线高度分布图 (苏珍 提供)

The distribution of glaciers and their equilibrium-line altitudes in western China (Provided by Su Zhen)



第一节 喜马拉雅山

Section 1 The Himalayas

喜马拉雅山是世界上最高大雄伟的山系，东起雅鲁藏布江大拐弯处的南迦巴瓦峰（海拔 7 782 米），西止印度河的南迦帕尔巴特峰（海拔 8 125 米），全长 2 400 千米。山脊线海拔在 5 500~8 000 米。中印、中尼边境上的大喜马拉雅山是其主山脊，这里群峰耸立，拥有海拔 7 000 米以上高峰 50 多座，海拔 8 000 米以上高峰 10 座，中尼边界上的珠穆朗玛峰海拔 8 844.43 米，为世界第一高峰。中国境内部分发育冰川 6 472 条，面积 8 418 平方千米。这些冰川均是以高大山峰为中心，呈辐射状分布，或沿山脊呈羽状分布，多数为长度较短的山谷冰川。

The Himalayas is the largest and highest mountain system on our planet. It stretches 2,400 km from Namcha Barwa (7,782 m asl, at the Great Canyon of the Yarlung Zangbo River) in the east to Nanga Parbat (8,125 m asl, the source region of the Indus River) in the west. Its ridges are at elevations of 5,500~8,000 m asl, and the main ridge of the Greater Himalaya includes the China-India and China-Nepal borders. The Himalayas include more than 50 peaks over 7,000 m in elevation, 10 peaks over 8,000 m, and Qomolangma (Everest), the highest peak in the world with an elevation of 8,844.43 m. There are 6,472 glaciers with an area of 8,418 km² in the Chinese part of the Himalayas, and they are mostly valley glaciers.

珠穆朗玛峰地区东绒布冰川（井哲帆 摄）
The East Rongbuk Glacier, a valley glacier in the Qomolangma (Everest) area, the Himalayas (by Jing Zhefan)



喜马拉雅山冰川群（刘时银 摄）
A bird's-eye view of glaciers in the Himalayas (by Liu Shiyin)





喜马拉雅山纳木那尼峰地区冰川 (赵华标 摄)
Mt. Naimona'nyi and its glaciers, the Himalayas (by Zhao Huabiao).



世界第一高峰——珠穆朗玛峰 (柳昇峰 摄)
Qomolangma (Everest), the highest peak in the world (by Liu Shengfeng).



第二节 横断山

Section 2 Hengduan Mountains

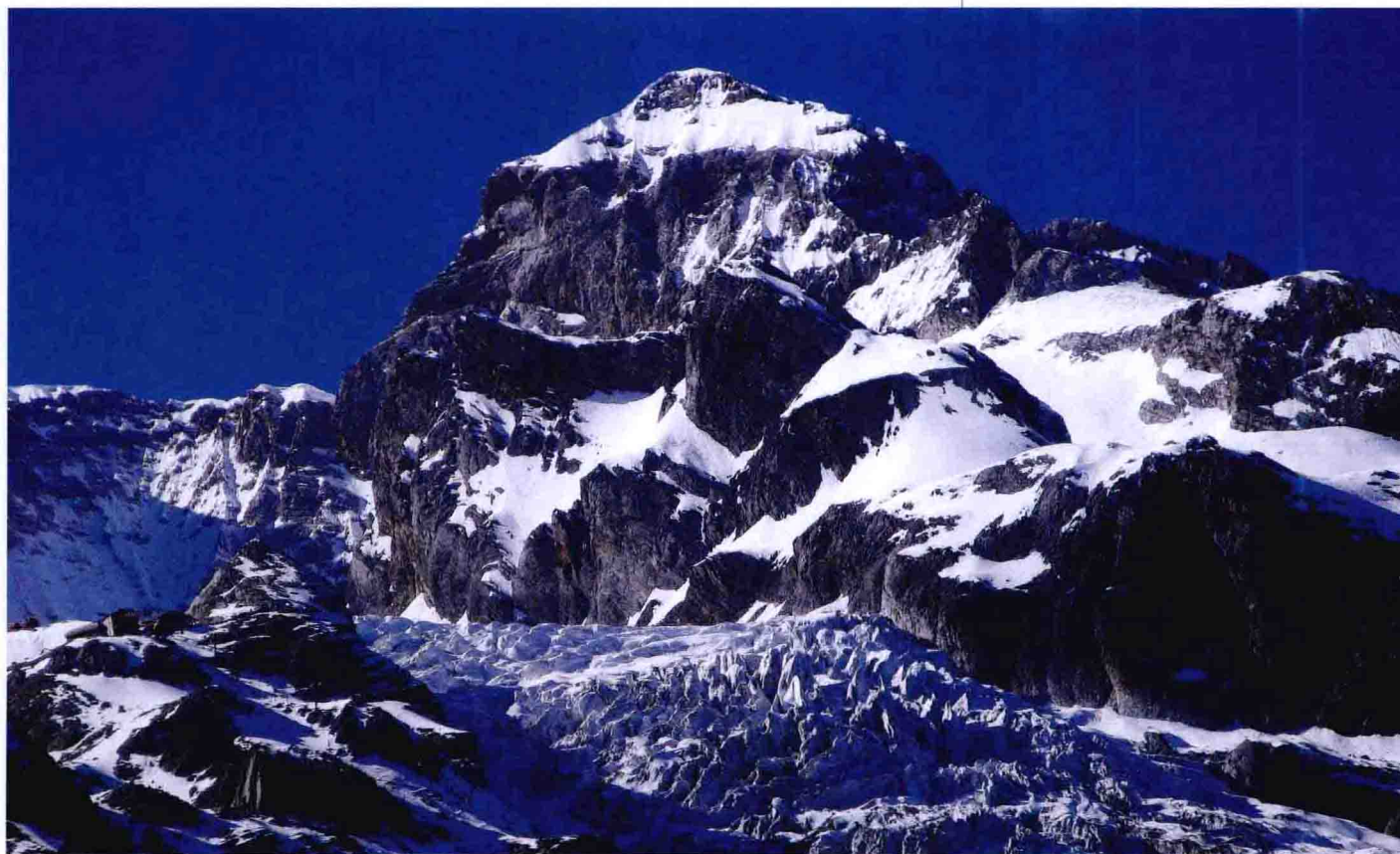
横断山是青藏高原东部一系列南北走向山脉的总称，这里高山深谷平行排列，地势北高南低。山岭海拔 5 500~6 000 米或更高，最高峰——贡嘎山高达 7 556 米。冰川集中分布在西藏的伯舒拉岭、云南与西藏交界的梅里雪山和川西的贡嘎山，共发育有现代冰川 1 725 条，面积 1 579 平方千米，其中玉龙雪山冰川位于中国现代冰川分布的最南端，雪宝顶冰川处于中国现代冰川分布的最东缘。

The Hengduan Mountains are a parallel series of north-south oriented mountain ranges at the eastern margin of the Qinghai-Xizang Plateau. These mountains are generally at 5,500~6,000 m asl. Mt. Gongga is the highest peak with an altitude of 7,556 m asl. The northern Hengduan Mountains are higher than the southern mountains, and glaciers occur mainly in Boxoila Ling (in East Tibet), Meli Snow Mountain (between Yunnan and Tibet Provinces) and Mt. Gongga (in West Sichuan). There are 1,725 glaciers with an area of 1,579 km². Among these glaciers, the southernmost modern glaciers are found in Mt. Yulong, and the easternmost in Mt. Xuebaoding.



玉龙雪山白水河流域 1 号冰川近景 (蒲健辰 摄)

Close-up view of Glacier No. 1 in the Baishui River Valley, Mt. Yulong (by Pu Jianchen).

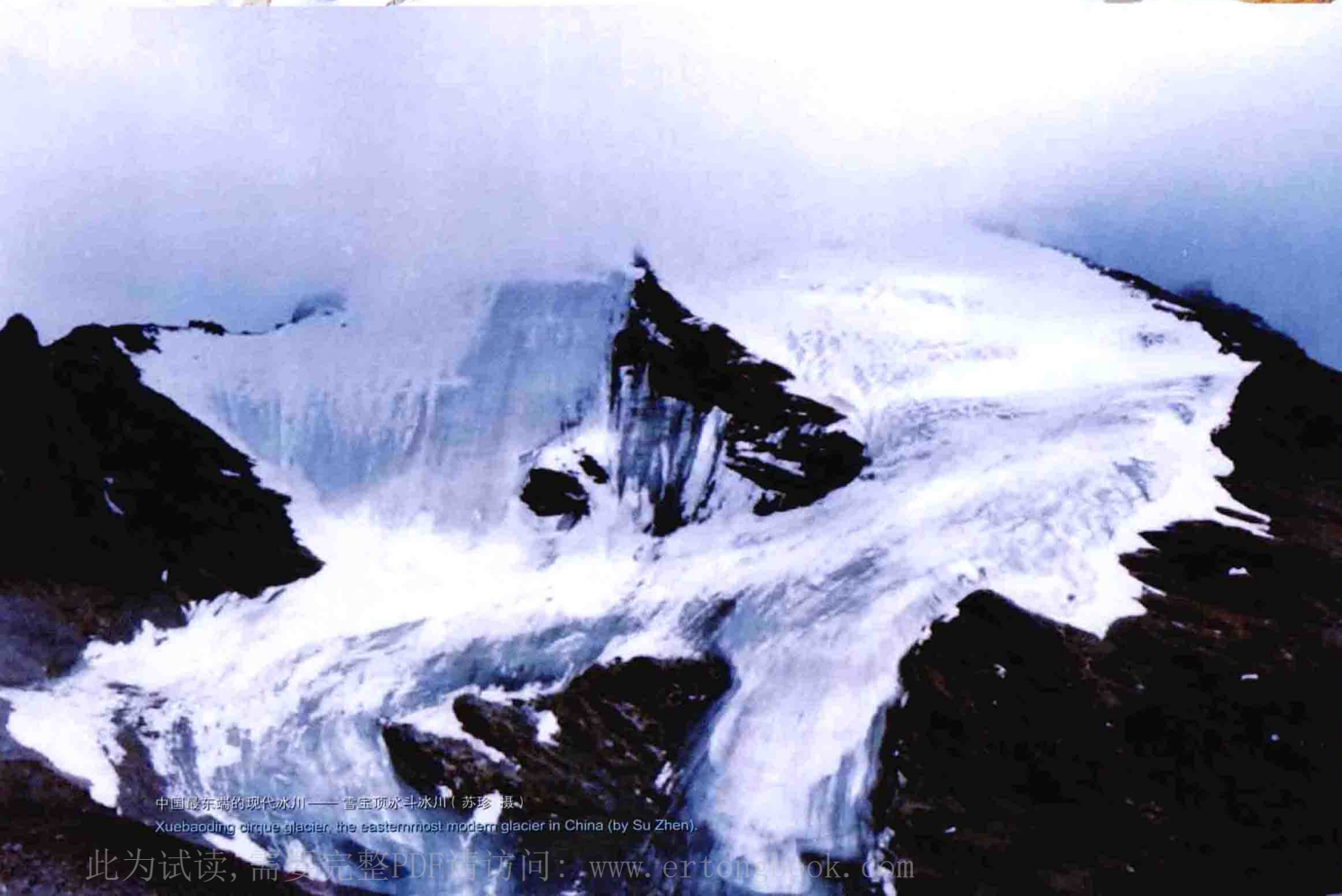


中国分布最南端的现代冰川——玉龙雪山白水河流域 1 号冰川 (蒲健辰 摄)

Glacier No. 1 in the Baishui River Valley, Mt. Yulong, the southernmost modern glacier in China (by Pu Jianchen)



贡嘎山东坡最大山谷冰川——海螺沟冰川 (李晶 摄)
Hailuoguo Glacier, a valley glacier on the east slope of Mt. Gongga (by Li Jing).



中国最东端的现代冰川——雪宝顶冰斗冰川 (苏珍 摄)
Xuebaoding cirque glacier, the easternmost modern glacier in China (by Su Zhen).