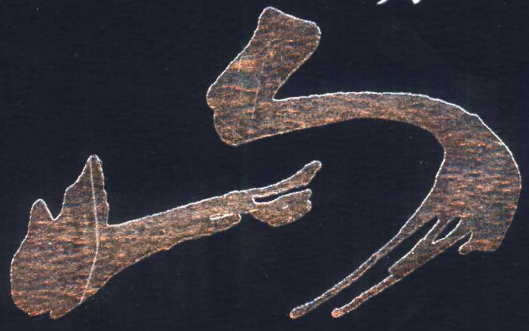
郭良 相石宝 赵松龄 著

冰期之崂



LAOSHAN MOUNTAIN DURING QUATERNARY ICE AGE

Guo Liang, Xiang Shibao, Zhao Songling

上海科学技术出版社

冰期之崂山

LAOSHAN MOUNTAIN DURING QUATERNARY ICE AGE

Guo Liang, Xiang Shibao, Zhao Songling

郭　良　相石宝　赵松龄　著

上海科学技术出版社

图书在版编目(CIP)数据

冰期之崂山／郭良，相石宝，赵松龄著.—上海：上海科学技术出版社，2007.5

ISBN 978-7-5323-8833-2

Ⅰ.冰… Ⅱ.①郭…②相…③赵… Ⅲ.崂山—冰川—研究 Ⅳ.P343.752

中国版本图书馆CIP数据核字（2007）第014668号

地图批准号：沪S(2007)013号

上海世纪出版股份有限公司
上海科学技术出版社 出版、发行
（上海钦州南路71号 邮政编码200235）
新华书店上海发行所经销
上海精英彩色印务有限公司印刷
开本 889×1194 1/16 印张14 插页4
字数：340千字
2007年5月第1版
2007年5月第1次印刷
印数：1－1500
定价：160.00元

“冰期之崂山”课题研究领导小组

组　长　王玉华

副组长　王爱建　王德武　杨　林　柳　晶　徐会堂　王明先　王正安

成　员　崔代红　胡孝国　官曙明　宋应涛　毕玉泉　黄淑波　曲宝光
王淑岩　刘宗华　胡泽绪　江晴世　陈国华　羌学军　徐升才
冯玉兵　王　超　谢　军　李红伟　董志顺　邵先国　王健光
段存刚　纪香玲　周大孝　戴衍华　姜波先　袁梅青　张淑霞
朱　岗

The Research-Supervision Group of the Project *Laoshan Mountain during Quaternary Ice Age*

Director　Wang Yuhua

Vice directors　Wang Aijian, Wang Dewu, Yang Lin, Liu Jing, Xu Huitang, Wang Mingxian, Wang Zheng' an

Members　Cui Daihong, Hu Xiaoguo, Guan Shuming, Song Yingtao, Bi Yuquan, Huang Shubo, Qu Baoguang, Wang Shuyan, Liu Zonghua, Hu Zeshu, Jiang Qingshi, Chen Guohua, Qiang Xuejun, Xu Shengcai, Feng Yubing, Wang Chao, Xie Jun, Li Hongwei, Dong Zhishun, Shao Xianguo, Wang Jianguang, Duan Cungang, Ji Xiangling, Zhou Daxiao, Dai Yanhua, Jiang Boxian, Yuan Meiqing, Zhang Shuxia, Zhu Gang

前 言

为纪念李四光先生《冰期之庐山》一书发表60周年，我们把近几年来对崂山地貌的调查研究结果，撰写成《冰期之崂山》，以敬献给这位中国第四纪冰川学研究的奠基者和所有牵挂中国第四纪冰川学研究的人们，从而证明先驱者开创的事业得到了新的发展。

李四光教授是我国第四纪冰川学研究的奠基人，是20世纪我国最著名的地质学家之一。他于1921年在太行山东麓和大同盆地，首次发现第四纪冰川遗迹。此后又在长江中下游庐山、黄山、九华山、天目山等地发现了各类冰蚀、冰碛地形和冰碛物，并于1937年完成了经典名著《冰期之庐山》的初稿。由于战争影响，该书到了1947年才正式出版发行，庐山从而成为中国第四纪冰川地质学的诞生地。李四光教授敏锐而开放的科学实践思想、频繁而持久的调查研究活动是他能取得重大成就的重要原因之一。李四光教授的实践精神、严谨作风鼓舞着我们对崂山的古冰川遗迹进行周密的调查研究。在调查过程中，我们不断地采用自我否定的办法，尽量不用冰川活动理论来解释，但是用其他原理又都无法完整解答崂山地貌的成因，所以，我们以能够找到一种实事求是的理论方法而备感欣慰。

我们长期在崂山工作，熟悉这里的一山一水、一草一木，具备从事崂山地质地貌研究的多种有利条件。可以毫不夸张地说，我们踏遍了崂山的山山水水、沟谷脊岭；统计了飞来石的数量与分布、测量了冰碛海岸的长度；调查了崂山冰臼的分布；勘测了古冰舌的走向；发现了冰碛海岛的形成等。在掌握大量实际资料之后，迫使我们不得不承认：崂山和庐山一样，都存在古冰川遗迹。也许是由于交通或者其他的原因，李四光教授未能选择崂山进行研究，这是件非常遗憾的事情。要不然《冰期之崂山》一书将属于他。本书作者相信：崂山保存的古冰川遗迹的系统性、完整性远胜于庐山、黄山。

在我国18 000多公里的海岸线上，崂山东侧拥有惟一的一段具有10多公里长的冰碛海岸，岸内还有崂山山麓冰川所遗留下来的漂砾海，也称石海，其面积大于10公里^2，堪称我国东部低山丘陵区石海之最；海岸上有延伸到黄海中的古冰舌堆积，并形成崂山海岸特有的冰碛陡崖。这种崂山特有的冰碛海岸，在全球中纬度海岸上也是非常罕见的。

崂山有我国海拔最低的冰臼，表明崂山一带的古冰川活动带有大陆冰川的性质。冰臼是在冰层的洞穴中，冰川融水进入冰洞以后，形成自上而下旋转流。经长期旋转侵蚀冰川底部的石块或丘顶，会在岩石的表面形成非常圆的侵蚀洼地，久而久之，就

形成了冰臼。有时在冰臼内还会出现口小肚大的形状。崂山的冰臼竟出现在高潮线附近，如崂山的鹤山冰臼，出现在海拔10米以内，堪称为我国海拔最低的冰臼。通过多次调查发现，崂山从低海拔的海岸到海拔千米的许多峰顶都有冰臼与冰臼群的分布。天波池、瑶池、仰天池、石盆石碗、神臼等，都是崂山先民们发现的冰臼，至今保存完好。尽管国内外的其他山地也有冰臼，但崂山冰臼具有海拔低、数量多、分布广、圆度好、类型多、年代各异等系列特点，是其他山区所无可比拟的。崂山东侧的黄海中，有数以百计的冰碛群岛与礁石。该冰碛群岛中的每个岛、礁，都是一个单一的漂砾，它们是在全新世海面升起后，才沉没于黄海中。这种海上漂砾岛式景观，在我国只有崂山才有。

海水中的冰椅石、劈石，以及其他异形石的发现，进一步证明：崂山和山东半岛的其他山区一样，更新世期间的山地冰川具有大陆冰川的性质。比房子还大的冰椅石、异形石与劈石在海中构成小岛，其本身就具有重要科学价值。崂山还拥有我国东部低山丘陵区，比较完整的中碛堆积垄，我们要感谢崂山的先民们将其保留至今，使我们能够用于科学研究。崂山中碛堆积垄宛然弯曲的走向，记录了两条古冰川相互依赖的情景。崂山由两条古冰川形成的中碛堆积垄的发现，为确认中国东部低山丘陵区存在大型古冰川活动，又提供了新的证据。

崂山的漂砾具有个体大、分布广，从黄海海岸到千米之高的崂顶一带，均有漂砾分布。漂砾搬运距离差异甚大，有的已有数公里之遥，如崂山东侧黄海海岸，由白色花岗岩组成的小岛，就是从远处被古冰川驮运而来。崂山有许多长达20米左右的巨型漂砾，个别的已达海岸线一带。当这些巨大漂砾，因冰川消融而被随地遗弃时，它能盖住几个较小的冰碛，而形成堆积洞，如犹龙洞、白龙洞、白云洞等。如能留意观察，可以发现，那些巨型漂砾与其下的较小漂砾的接触面间，并不存在碰撞面，也就是说，较小漂砾面没有被砸毁的痕迹。这一情景记录了巨大岩块是慢悠悠地沉降下来。只有古冰川搬运与堆积才能记录如此有惊无险之情景，而其他搬运营力都会给其下的砾块予以重创。另外，崂山的许多漂砾，具有独来独往、我行我素的分布格局，也展示出崂山一带具有大陆冰川的性质。

崂山有许多条完整的古冰舌堆积，据不完全统计，已达60余条。其中的大多数分布在崂山的东侧。到目前为止，仍可以看到许多古冰舌堆积，它们按一定的比降进入黄海，在岸边形成海蚀陡崖。崂山的许多村落都建在古冰舌上。古冰舌剖面集中了冰川堆积的众多特点：冰碛剖面上可见到冰川堆积具有杂乱无章、无分选、无层次、带

擦痕、含劈石、棱角明显、堆积物的前缘突然终止等一系列堆积特征。在崂山能保存如此多的古冰舌堆积，为国内罕见，使崂山因古冰川遗迹保存最佳而将闻名于世。

崂山已发现了两个冰川湖沉积，海拔高度相近，都形成了具有一定厚度的季候泥沉积，韵律层次非常清晰，可统计沉积年龄。季候泥沉积层的前缘都有巨大的漂砾组成的终碛堤。在崂山发现的季候泥沉积，都属于终碛堤后面阻塞型冰川湖。不言而喻，只有古冰川活动的环境，才能形成季候泥沉积。崂山阻塞型冰川湖的发现进一步证明崂山地区确实存在古冰川活动遗迹。

崂山是我国冰消期地貌学诞生的摇篮，冰臼、冰椅石、劈石、海中冰椅石、海中劈石、融水侵蚀槽等均在崂山被发现。由此可以进一步推动古冰川学和冰消期地质学的研究与发展。

崂山是我国东部古冰川资源保存最佳、自然形态很好的名山。崂山蕴藏着丰富的古冰川科普旅游景点群，有待开发利用。崂山古冰川遗迹的发现，特别是冰碛海岸、冰碛群岛、海中冰椅石与劈石、冰碛物中的季候泥、终碛、中碛、大面积的石海以及众多古冰舌堆积景观的发现，为我国东部存在古冰川遗迹这一重大科学问题，提供了新的佐证。可以认为，崂山这一宝贵资源一旦得到利用，将会大大提高崂山作为国家重点风景名胜区的风景资源的科学价值，也必将为崂山旅游增添新的内涵。

本书共分十章。除崂山基础地质，特别是崂山花岗岩的研究资料为引用其他研究者的成果以外，有关崂山古冰川方面的资料均为野外调查所得。本书由崂山风景区管理委员会郭良、相石宝，中国科学院海洋研究所赵松龄等有关专家共同完成，国家海洋局第一海洋研究所徐兴永做了许多野外和室内研究工作。在完稿过程中，还引用了一些有关文献和网上资料，在此表示感谢。由于作者水平有限，难免挂一漏万，也肯定尚有许多的古冰川遗迹未能识别出来。科学探索永无止境，深入实际尤为重要，欢迎读者批评指正，不吝赐教。

郭 良

2006 年 10 月

Preface

To commemorate the 60th anniversary of publishing *Quaternary glaciations in the Lushan area, Central China* written by late Dr. J. S. Lee, the founder of research on the Quaternary glaciation in China, the authors of this book, *Laoshan Mountain during Quaternary Ice Age* wish to dedicate it with our respect for Dr. Lee and present it to all others who are concerned in this field, marking a new research level in the cause that pioneered by Dr. Lee.

As one of the most famous geologists in 20th century in China, Prof. J. S. Lee was the father of the Quaternary glaciation study. He discovered for the first time the glaciation traces in the east side of Taihang Mountain and Datong Basin, Shanxi Province, and more glaciation records including glacier erosion and deposits, and moraines in the areas of low-middle stream of Yangtze River covering Lushan, Huangshan, Jiuhuashan and Tianmushan, etc in the eastern provinces of China. In 1937, Lee finalized his classical work of *The Glaciation in Lushan* but it was not published until 1947 due to warfare impact. Therefore, Lushan has since then become the birthplace of China's geology of the Quaternary glaciation. With his perceptive and open-minded scientific believe, Prof. Lee conducted multiple investigations resulting in breakthrough in geology of the glaciation, which greatly inspired us for relaying the cause. In our study, we have been intended to work with no preconceptions, tried not to explain with glaciation model what we observed in the field. However, with whatever external geological agents we applied, no one could explain ideally the geomorphic features in Laoshan but glaciation. We are therefore content for having established a system that integrates truth with fact.

We have been working in Laoshan region for a long time and are familiar with every piece of the land and every corner of the mountain, which provided us advantages for conducting the research. In fact, we have scanned every inches of the area of creak and valley, and made thousands of measurements for the number and distribution of exotic rocks; the length of the moraine coast, the distribution of the potholes, and the direction of ancient glacier tongue; and discovered moraine islets, and so on. The large amount of the observational data have convinced us that all these phenomena were formed during Quaternary glaciation same as those in Lushan. Probably, because of inaccessibility, Lee did not trip in Laoshan for investigation, which is regret; otherwise, he should have been credited with this book. The authors believe that the glaciation profile in Laoshan is much better preserved than those in Lushan and Huangshan.

Among over 18 000 km long coastline, an only sector of dozen kilometer is the moraine coast joined by boulder sea left out from piedmont glaciation in Laoshan. The "boulder sea" or "rock sea" is distributed in an area over 10 km^2, which is unique and the largest among all the kind of low-elevation glaciation in China's eastern hilly regions. Near the moraine coast, moraine of an ancient glacier tongue reaches to the Yellow Sea, forming a Laoshan-specific moraine cliff, which is very rare in the world's middle altitude zones.

In addition, the elevation of the glacial potholes observed in Laoshan is the lowest among those

of others in China, showing the nature of continental glaciation. A glacial pothole is formed due to swirling water running through a hole in ice from top to bottom. When time was long enough for the water flushing against the rock surface underneath the glacier, round and sometimes jar-shaped potholes with small mouth but large cavity, were shaped. Surprising is that the potholes are situated near spring tide line. For example, glacial potholes in Heshan of Laoshan occur below 10 m above sea level, which is the lowest one in elevation among those in China. In fact, single or multiple potholes in Laoshan region can be seen in a wide elevation range from coastal zone to many hilltops of Laoshan as high as 1 000 m above sea level. Many large potholes have been named by local residents in Laoshan, such as Tianbo Pool (Heavenly Ripple Pool), Yaochi Pool (Jade Pool), Yangtian Pool (Sky-facing Pool), Stone Basin, Stone Bowl, and Shen Jiu (Divine Mortar), etc, in well-preserved condition. Although potholes distributed in other areas of China, those in Laoshan are featured with low-elevation, large amount, and wide distribution, in well-rounded shape, multiple types and different ages. In the Yellow Sea east of Laoshan, hundred of islets or reefs of moraines appear, many of them are made of a large boulder. These islet and reefs were not flooded until the Holocene Epoch when sea level rose. This phenomenon is very unique in Laoshan.

Moreover, so-called "chair-shaped rock", cleavage rock, and other shaped rocks explicitly indicate the continental glaciation in the Pleistocene Epoch piedmont of Laoshan and other hilly areas of the Shandong Peninsula. Some larger-than-house chair-shaped stones, other object-shaped stones, and cleavage stones stand up in the sea as islets, which is scientifically important. In Laoshan, middle moraine ridges have more complete profiles than those of the others' in China's eastern low-elevation mountainous regions, thanks to local ancestors for keeping the ridges intact in good preservation so that geological research can be taken. The natural bending of a middle moraine ridge jointly formed by two ancient glaciers provided new clues of large scale glaciation in China's eastern low hilly regions.

In terms of boulders in Laoshan, they are large in size and wide in distribution from coastal zone to the Laoshan Peak over 1 000 m above sea level. Some boulders have been moved for several kilometer from the original place. For example, along the Yellow Sea coast east of the mountain, many islets are built by boulders of whitish granite that were carried by glaciers over a good distance off. In the area, there are many large boulders over 20 m in diameter, several ones have arrived at the coast. Some other large boulders were unloaded from glaciers and became roofs of caves inside moraine deposits. Such caves are "Youlong Cave", "Bailong Cave" and "Baiyun Cave", etc. Close observation at the bottom contact to underneath smaller boulders shows no collision in-between but slow dropping, which is no surprise by glacier agent, exclusively; any other geological agents could have caused clear and heavy hit against the boulders. In addition, each boulder in Laoshan has feature of its own in occurrence; all of them manifested the nature of continental glaciation in Laoshan region.

At present, over 60 well-preserved moraines of ancient glacier tongues on which some local villages are built. Most of the tongues are situated in eastern flank of the Laoshan, and reach the Yellow Sea in different slopes resulting in cliffs alongshore. Geological sections of the tongues demonstrated features of various glaciation deposits, such as randomly placed rocks without sorting and bedding, cleavage stones with sharp edges, and sudden truncation of moraine body at the front end. These well-

preserved deposits of glacier tongues in Laoshan are rare in China, highlighting Laoshan with unique feature as a famous place among scientific communities in the world.

In Laoshan, deposits of two glacier lakes have been recognized. They distribute in similar elevation with varvs of certain thickness in clear seasonal lamination from which sedimentary ages can be dated. The varvs were deposited in glacial lakes behind terminal moraine dams formed by huge boulders blockage. The discovery of glacier lake indicate further the occurrence of ancient glaciation in Laoshan region.

Laoshan presents us a complete profile of geomorphic bodies formed during deglaciation, including potholes, chair-shaped stones, cleavage stones, flutes or troughs and so on, in land or in water. Research on them will deepen our geological understanding on ancient glaciation and deglaciation.

In summary, Laoshan owns best-preserved geological records of ancient glaciation among eastern China provinces, and has rich geological as well as tourism resources that to be developed. Large amount of geological data of ancient glaciation in Laoshan provided geologists with many new materials disclosing once-existed glaciation in China's eastern part, especially moraine coast, moraine islets, submerged chair-shaped stones and cleavage stones, moraine-embedded varvs, terminal and middle moraines, large-area rock sea, and special landform of many glacier tongues. Expectedly, exhibiting these rare geological phenomena will help developing tourism resources in Laoshan region, enriching more attractive scientific contents to this national park.

This book is composed of 10 chapters. Most data used in the book were collected in the field, except for the general geology mainly the geology of the Laoshan granite that was from references. This book is the outcome of our group including Guo Liang and Xiang Shibao from the Administration Committee of Laoshan National Park; Zhao Songling from the Institute of Oceanology, CAS, China, and others. Xu Xingyong from the First Institute of Oceanography, SOA, China, put great efforts on field and lab work. Special gratitude to cited literature and data from internet in our monograph. Limited by available knowledge, some glacial traces may have not been recognized, as scientific exploration is an endless cause with hard fieldwork. Therefore, thoughtful, divergent viewpoints, any constructive ideas and comments are welcome and appreciated.

Guo Liang

October, 2006

目 录

Contents