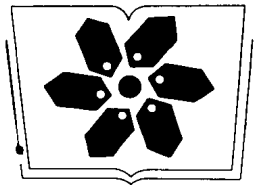
考古地球物理学

蒋宏耀 张立敏 著

科学出版社



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内 容 简 介

本书是我国第一部《考古地球物理学》，它全面而系统地论述了考古地球物理学的基本原理和方法，并通过国内外大量的应用实例，特别是我国考古地球物理工作的实例，进一步阐明了这些原理和方法在考古工作中的应用，同时还以适当的篇幅论述了综合地球物理方法的基本原则及合理运用，其内容之广和实例之多，在国内外均属罕见。

目前我国正在进行大规模工程建设，建设中碰到的文物保护问题层出不穷，因此，本书对于工程建设、考古及地球物理工作者来说，都是一本有价值的参考书。

本书可供工程建设、考古及地球物理方面的广大科技工作者、高等院校师生和相应领导及科技管理人员阅读。同时，此书对于热衷于保护人类文化遗产的人们，也有一定的参考价值。

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考古书店

前　言

“考古”在我们的心目中一直是一个神圣的字眼，因为它不但能让我们了解人类文明发展的历程，而且往往还能解决一些历史上千古不解之谜，为我国和全人类挽救了许多珍贵的精神和物质财富。我们是从事地球物理科研工作的，原以为我们与考古是可望而不可及，始终保持一个相当远的距离，谁知一个偶然的事件，竟使我们也与它沾上了边，很可能是结上了不解之缘。

1994 年初的一天，我们从报上看到了三峡库区文物保护工作正在紧张进行的消息，突然触发了应用地球物理方法来加速库区地下文物勘查的设想。因为我们认为，人类的财富可以分为两大类：一类是物质财富，一类是精神财富。当人们还不富裕的时候，眼睛往往盯着物质财富而忽略了精神财富；但当人们富裕之后，想要寻找精神财富时，却发现有许多珍贵的精神财富，竟在创造物质财富过程中遭到了破坏，造成了无可挽回的损失，实在令人痛心。

三峡库区一带是我国重要的文化区域，是南北文化和巴、蜀与楚文化交融的地带，历史上曾经几度辉煌，保存着许多珍贵的历史文化遗迹。已知的地面文物数量之多，分布之广，已经令人惊叹，而埋藏在地下的文物，数量和珍贵的程度，恐怕更难估计。特别是许多历史问题，如人类及文字的起源等问题，很可能有赖于三峡库区地下文物的发掘研究来解决。三峡工程的兴建，库区有大量珍贵文物被淹没，而它们一旦失去，将不可能复得。我国属于发展中国家，物质财富很不充足，在这种情况下，稍不留神，很可能会失去许多不可复得的精神财富，因此，我们想用地球物理方法协助考古界寻找地下文物，以加快库区文物保护工作的进程。

想法虽好，但由于我们没有这方面工作的经验，于是开始了文献的调研。查一查国内外文献，发现地球物理方法在国外考古中应用虽然不算少，但在国内却属凤毛麟角。而且三峡库区的地质地球物理条件也比较特殊，要在考古中成功地应用地球物理方法，就必须在三峡库区选择考古工作需要解决的问题进行必要的前期研究工作。当我们将想法向国家科委工业司魏金石研究员提出后，得到了国家科委的支持，同意在“八五”国家科技攻关计划关于三峡文物的项目中增加一项地下文物勘查方法的研究课题。后来这一课题又得到国务院三峡工程建设委员会移民开发局的支持。

1994 年夏天，我们在库区进行了踏勘并选择四川忠县的汉墓作为方法试验点后，三峡工程库区文物保护规划组组长俞伟超教授却强烈希望我们把方法试验点移到重庆市云阳县故陵镇，理由是：《水经注》记载这里有“楚都丹阳所葬”（公元前 677 年以前）的“六大坟”。这“六大坟”是三峡库区最大、也是最重要的墓葬，但由于时间久远（近三千年），地表已看不到“六大坟”的踪迹。经考古工作者多次寻找，在故陵镇长江边找到一个大土堆，老百姓称之为“帽盒岭”，传说是一个古墓。这里地下情况比较复杂，用传统的考古方法难以确定帽盒岭下是否有大墓存在，因而考古工作者不能肯定它

是否就是《水经注》中所载“六大坟”之一，保护规划不好做，所以希望我们用地球物理方法解决有没有大型墓的问题。然而试验点的转移却给我们的试验研究带来一系列的难题：

首先，作为方法研究，应该是从已知古墓上开始试验，然后将所得的成果推广到未知古墓。忠县有已经开挖的汉墓，也有尚未发掘的汉墓。而在未发掘的汉墓中又有已经勘探清楚的汉墓，它们在规模和时代上彼此相近。这样，先在已知、但未发掘的汉墓上做方法试验，研究出勘探汉墓的较佳方法，然后再在未勘探过的汉墓上探测，待发掘时验证，进一步改善方法，再推广到其他地区和不同类型的古墓，同时把方法研究的范围扩大到遗址等不同的勘探类型。通过实践→认识→再实践→再认识的过程，逐步形成一套适用于我国田野考古的地球物理方法。故陵没有已知的古墓供参考，对方法研究极为不利。

其次，故陵若真有《水经注》记载的楚墓，那么这些楚墓既是春秋以前的，又处于重庆市这个特殊的地区，墓葬应是什么类型，埋深大概是多少？谁也难以肯定。我们连要找的对象大体上是一个什么样的物理模型都不清楚，自然给研究工作带来了极大的困难。

第三，我们初次涉足考古领域，缺乏必要的考古知识，需要边学习、边工作。

在这样的情况下，与往常试验研究前的文献调研相比，我们更迫切地希望了解用地球物理方法勘查古墓的经验。这时我们才深切地感觉到，文献是那么少，又那么分散，于是就引发了在适当的时候写一本有关考古地球物理学的书的想法。这本书的内容主要应包括考古地球物理的理论基础，方法技术的基本概念及其应用条件和具体应用事例，特别是要突出我国的成果，反映我国的特色。例如古墓葬，一般考古碰到的古墓葬埋深不过几米，而我国的古墓，有的埋深近 30 米或更深，这在世界上也是罕见的，而且墓葬的类型多种多样。至于具体的野外观测和数据处理方法，都有相应的工作规范和处理软件可用，一般就可少讲了。此外，为了使初次从事考古地球物理的考古勘探工作者容易理解，本书写作力求简明易懂，许多不必要的数学公式和繁琐推导一概免除。我们希望这样一本书能为今后从事考古勘查工作的考古和地球物理工作者提供一点工作上的方便。

从这个想法出发，经过几年来考古地球物理勘查的实践和资料积累，我们终于完成了这本书。

本书内容的安排：第一章，概论，介绍了考古地球物理学的发展过程、它的命名和内容以及考古地球物理各种方法共同的一些问题；第二章到第七章，介绍各种考古地球物理方法，考虑到科学技术的飞速发展，地球物理方法和技术日新月异，所以，本书的重点是介绍它们的原理，其中虽也涉及某些观测、数据处理方法和物理模型，但目的只是为了更好地理解这些方法；第八章，综合地球物理勘查，着意论述综合的基本原则；第九章，古遗存的年龄测定方法；第十章到第十二章，考古地球物理方法应用的实例，主要反映我国考古地球物理工作的情况。遗憾的是，我国考古地球物理方面的工作本来就不多，而就是这些工作，或者没有发表，或者虽然发表，但语焉而不详，加以资料分散，找起来十分困难，以致本书搜集到的，就很有限了。

还需说明的是，虽然我们主观上想尽可能满足读者的需要，但是由于水平所限，因

此可能还有不少不完善和不如人意之处。“万事开头难”，这一句话可能为我们自己带来一点自我安慰。我们希望这本书能起到抛砖引玉的作用，让更多、更好的考古地球物理学的总结性著作更快地呈现到读者的面前，为我国考古事业和考古地球物理学科的发展做出更大的贡献。

最后，我们衷心地感谢刘光鼎院士和马在田院士对本书写作的支持，感谢张赛珍、王妙月、王懋基、寿宝奎诸教授审阅部分手稿及提出的宝贵建议。

PREFACE

"Archaeology" is always a holy word in our mind. It not only means to understand the process during the development of civilization, but also to discover a clue to some unsolved historical mysteries, and thus rescue valueable spiritual and material treasures. We are geophysicists specializing on seismology and exploration geophysics. We would not be involved in archaeology in our life time and even developed an indissoluble bond with it, had not an accidental event happened several years ago.

One evening at the beginning of 1994, we read a newspaper report about the full swing of protection works of cultural relics in the Three-Gorge Reservoir region and the difficulties in identifying underground cultural relics using traditional methods. This report suddenly provoked us to think that geophysical methods may be useful to accelerate prospecting of underground cultural relics in Reservoir region. The treasures of human being can be divided into two kinds: material treasure and spiritual treasure. When people work for their livings, they usually gaze at material treasures and neglect spiritual treasures. However, when people have extra money, they usually explore the spiritual treasures. With the dynasties up and down, a great deal of spiritual treasures have been destroyed in the process of creating material treasures , thus causing enormous losses beyond retrieve. It is distressful indeed.

The territory of Three-Gorge Reservoir is an important cultural region of our country. It is a blending zone of ancient southern Chinese culture with northern Chinese culture, as well as cultures of ancient Ba and Shu states with Chu state. This region has been splendid for several times in the history and preserves many valueable historical cultural relics. The abundance of the quantity and quality of known cultural relics on the surface of the earth and their wide spread have amazed everybody already, the amount and rarity of the cultural relics buried underground may shock the world. Owing to the construction of Three-Gorge Reservoir, a great deal of valuable historical relics will be inundated. Once they have been lost, they cannot be found again. Our country belongs to developing countries, material wealth is insufficient. Under this condition, we may lose enormous spiritual treasures, if we don't pay enough attention to them. Therefore we would like to help archaeologists to explore the underground cultural relics, using geophysical methods, with the aim of accelerating process of historical relics preservation in Reservoir region.

Although it was a good idea, but we lacked experience in these works, so we began to investigate literatures in this aspect. Looking up China and foreign literatures, we found that applications of geophysical methods in foreign archaeometry are not rare, but in our country they are rarity of rarities. In addition, the geological-geophysical conditions of Three-Gorge Reservoir region have their specific characteristics. If we want successfully to apply geophysical methods to the archaeometry, we must do some necessary earlier studies according to the selected archaeological problems

awaiting immediate solution. After we proposed our suggestion to professor Wei Jinshi, responsible cadre of Industrial Bureau of SCST, we enjoyed the support of the State Commission of Science and Technology. SCST agreed to add a new theme about the study on the exploration methods of underground cultural relics to the state project of tackle key problems of Three-Gorge Reservoir region in the period of the Eighth Five-Year Plan. Hereafter this task had also been supported by the Bureau of Migration and Development of the Commission of Three-Gorge Construction Project under the State Council.

In the summer of 1994, when we had made an on-the-spot survey in the Reservoir region and selected tombs of Han Dynasty at Zhong County of Chongqing City as the testing ground of our methods, Prof. Yu Weichao, head of the Planning Group on the protection of cultural relics of the Three-Gorge Reservoir region, strongly suggested that our testing ground could be transfered to Guling, a market town of Yunyang County in Chongqing City. His reason was: according to the record of《Shuijing Zhu》(an ancient Chinese book about river system in China), at Guling there were "six great tombs", which were buried in the period when the capital of ancient Chu state was Danyang (earlier than 677B. C.). These "six great tombs" are the greatest and the most important tombs in the Three-Gorge Reservoir region, but as a result of remote past (nearly 3000 years), they have not left any traces on the earth's surface. After repeated investigations, archaeologists found a big mound called "Maoheling" by native civilians, on the shore of Yangtze River. It is said that this is an ancient tomb. The underground conditions here are more complex. It is difficulty to use traditional archaeometrical methods to ascertain whether there is a great tomb, and thus archaeologists were not sure whether this is one of the "six great tombs" as《Shuijing Zhu》wrote. Therefore they felt embarrassed to work out a plan on the protection of these tombs and hoped we can use geophysical methods to solve the problem. The transfer of testing ground brought a series of difficult problems to our experiments:

First, the experiment in methods, as a rule, should begin on a known ancient tomb and then spread the positive results to the unknown ancient tombs. At Zhong County there are excavated and unexcavated tombs of Han Dynasty. Among the unexcavated tombs there are prospected tombs which are similar with excavated tombs in scales and period. We can test our methods on the prospected, but unexcavated tombs, develop more satisfied prospecting methods of the tombs of Han Dynasty, then explore untested tombs of the same period, and by means of verification improve the methods further. After this we may spread our methods to different types of ancient tombs and other places. At the same time we can also extend our studying field to other prospecting objects such as archaeological sites and so on. Through the process of "practice, knowledge, again practice, and again knowledge", a set of geophysical methods, satisfying archaeometry of our country will be step by step formed. It was disadvantageous to our method test without an ancient great tomb in Guling for reference.

Secondly, if there are great tombs of Chu state at Guling, as《Shuijing Zhu》wrote, these tombs are not only earlier than the Chunqiu Period (770B.C.-746B.C.), but also located in the specific region as Chongqing City. This raises questions: what is their type? How deep they are buried? Nobody can definitely answer these questions. When we did not even know what was the

physical model of surveyed object, it naturally brought great difficulties to the experiments.

Thirdly, it was the first time for us to set foot in archaeometrical field, we were short of archaeological knowledges and required to learn while working.

Under these circumstances, we hoped to know the experiences of prospecting ancient tombs, applying geophysical methods, more urgently than general investigation of literatures before scientific experiments. Here we profoundly felt that the literatures are so rare and dispersive, thus initiate our idea of writing an archaeogeophysical book in due course. The contents of this book should mainly include the theoretic fundaments of archaeogeophysics, basic concepts of its methods and techniques, conditions of its application and its case histories, especially stressing the achievements and reflecting characteristics of our country. Taking ancient tomb as example, the buried depths of ancient tombs in archaeometry are usually several meters, but the buried depths of some ancient tombs of our country are nearly 30 meters or more. It is seldom seen in the world. At the same time, the types of ancient tombs of our country are also many and varied. As for concret methods of field works and data processing, they may be less touched, because there are appropriate standards and softwards used. In order to facilitate understanding of archaeometrical workers engaged in archaeogeophysical prospecting for the first time, this book should be simple, clear and comprehensible, so a lot of unnecessary mathematical formulas and their tedious derivations are completely avoided. We hope this book can provide convenience for archaeologists and geophysicists, working hereafter on archaeometry.

From this opinion, we have finally completed this book through archaeogeophysical practice and material collection for several years.

The disposition of the contents of this book is: Chapter 1, introduction, introduces the developing process of archaeogeophysics, its nomenclature, contents and some common problems of various archaeogeophysical methods; Chapter 2 to Chapter 7 expound various archaeogeophysical methods, considering rapid development of science and technology, as well as the changing of geophysical methods and techniques with each passing day, this book puts its stress on the introduction of the fundaments of geophysical methods and techniques. Though it includes also some methods of field observation and data processing, or physical models, but its aim is to better understand these methods; Chapter 8, comprehensive geophysical exploration, discusses in particular the basic principles of comprehensive application of various methods; Chapter 9, dating methods of ancient relics; Chapters 10 to 12, case histories of archaeogeophysical prospecting, reflect mainly conditions of archaeogeophysical works of our country, but we are very sorry that the materials collected in this book are limited in number, because of the rarity of archaeogeophysical works in our country. In addition, part of these archaeogeophysical materials have not published, and published materials did not speak in detail, and what is more, they are dispersive, so that it is very difficult to seek them.

It is necessary also to state that although our subjective desire is to do our best to satisfy the requirements of readers, but there may be some imperfect and unsatisfied points owing to the limitation of our knowledge. "Everything is difficult at the beginning", maybe these words give us a little self-comfort. We wish that this book can play the role of "casting a brick to attract jade". A great many of better archaeogeophysical books with summarized character will be quickly presented before

readers, and make a greater contribution to the archaeogeophysical undertakings and the development of archaeogeophysics in our country.

Finally, We would like to thank academician Liu Guangding and academician Ma Zaitian for their supports to our writing this book, and professors Zhang Saizhen, Wang Miaoyue, Wang Maoji and Shou Baokui for their help in reviewing portions of the manuscript.

作者简介

蒋宏耀，湖南衡阳人，1956年毕业于原苏联列宁格勒矿业学院地球物理系，是中国科学院资源环境局研究员，长期从事地球物理和学科发展战略的研究，曾任中国地球物理学会副理事长、世界数据中心中国国家协调委员会秘书长等职。基于对国家珍贵文化遗产的爱护，参加了地下文物地球物理勘查方法的研究。通过这些年来的实践和资料积累，写出了《考古地球物理学》一书，希望给从事考古勘查的考古工作者和地球物理工作者提供一些工作上的方便。

作者简介

张立敏，祖籍山东安丘，生于北京，1960年毕业于北京大学地球物理系，是中国科学院地球物理研究所的研究员，长期从事地球物理学的研究，曾任中国地球物理学会副秘书长等职。基于对祖国历史和文化的热爱，她建议并主持了国家科委“八五”攻关项目中的三峡库区地下文物勘查方法研究，希望在国家进行大规模建设的同时，更为有效地抢救珍贵的历史文物，给人类了解自己的过去留下一点宝贵的资料。

目　录