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# 中國古代井鹽工具研究

劉德林 周志征 著



山東科學技術出版社

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藏书章

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## 《中国古代井盐工具研究》

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## 我们的希望(代序)

进行现代化建设必须依靠科学技术。作为科学技术载体的专著,正肩负着这一伟大的历史使命。科技专著面向社会,广泛传播科学技术知识,培养专业人才,推动科学技术进步,对促进我国现代化建设具有重大意义。它所产生的巨大社会效益和潜在的经济效益是难以估量的。

基于这种使命感,自1988年起,山东科学技术出版社设“泰山科技专著出版基金”,成立科技专著评审委员会,在国内广泛征求科技专著,每年补贴出版一批经评选的科技著作。这一创举已在社会上引起了很大反响。

但是,设基金补助科技专著出版毕竟是一件新生事物,也是出版事业的一项改革。它不仅需要在实践中不断总结经验,逐步予以完善;同时,也更需要社会上有关方面的大力扶植,以及学术界和广大读者的热情支持。

我们希望,通过这一工作,高水平的科技专著能够及早问世,充分显示它们的价值,发挥科学技术作为生产力的作用,不断推动社会主义现代化建设的发展。愿“基金”支持出版的著作如泰山一样,耸立于当代学术之林。

泰山科技专著评审委员会

1989年3月

# 前 言

伟大的中华民族历来以勤劳、勇敢、智慧的美称闻名于世。在漫长的人类社会历史进程中, 历尽艰辛、不屈不挠的中华民族, 正是以高度的睿智和勤奋, 缔造了光辉灿烂的古代文化。

在博大精深, 源远流长的中华民族文化中, 科学技术是一个重要的组成部分。中国古代科技, 曾在相当长的历史时期里, 走在世界前列。脍炙人口, 举世赞誉的四大发明——造纸、印刷术、火药、指南针, 对造福人类、推动世界历史的进步做出了杰出贡献。在中国古代繁星般的科技发明中, 以井盐工具为代表的钻井术, 乃是一种光彩夺目的明珠。

中国井盐生产, 历史悠久, 驰名中外。从公元前 250 余年伊始, 至公元 1840 年鸦片战争以前, 中国井盐开采技术一直遥居世界领先的地位。特别是在 11 世纪中叶, 我国“圆刃”深井钻头和“卓筒井”的诞生, 首先跨入钻凿深井的新技术阶段, 具有着划时代的意义。18 世纪末或 19 世纪初, 鱼尾钻头的创新, 更是中华民族奉献于人类的科技硕果。从 12 世纪开始, 至 19 世纪前, 这些重大科技先后传入西方各国, 推动了现代石油(包括天然气)工业、采矿工业的兴起和发展, 为世界文明做出了卓越的贡献。因此, 被国外誉称为“世界石油钻井之父”、“世界钻井之祖”。可以说, 这是“四大发明”之外, 我们祖先的又一项伟大创造, 致有不少学者称颂为“第五大发明”。英国科技史专家李约瑟无比兴奋地宣称: “古代和中古时期的中国科学成就, 一再表明足以使人眼光缭乱!”这是一个巨大的“金矿”! 可以认为, 中国古代井盐科学技术则是这个大型金矿中的“富矿”和“精矿”。试看如今自贡市盐业历史博物馆所藏的钻井工具, 种类繁多, 规格齐全, 设计科学, 制作精巧。鬼斧神工, 令中外学者叹为观止! 其千秋伟绩, 是理应彪炳史册而当之无愧的!

然而, 自北宋至今, 近 1000 年过去了, 此项创造竟然湮没不彰, 实为我国古代科技史及世界科技史上的一大缺失。今天, 为发掘、继承及弘扬祖国科技文化遗产, 刘德林、周志征两同志撰写了《中国古代井盐工具研究》一书。由于四川省科委、自贡市科委的重视, 将其列入“七五”期间重点科研项目, 多方予以关心、帮助, 从而促成了这部著作的迅速问世。这是古今中外第一部专门研究井盐、石油钻凿工具的学术著作, 填补了我国及世界盐井、石油工具史的空白, 是科技史研究方面的一项重大成果。

《中国古代井盐工具研究》一书有下列诸点是需要加以强调的:

第一, 中国古代井盐开采的发展, 根据钻凿使用的不同工具、井型特点、地质条件等因素, 大致可分为三个时期: 战国末年至北宋初为大口盐井时期; 北宋初至清初为卓筒井时期; 清中叶到清后期为小口深井时期。1835 年桑(兴)海井钻凿成功, 则是深井技术发展成熟的标志。本书研究时限集中于宋至清——钻凿工具更替、变化、创新最急剧、炽热和丰富的阶段, 作者除细尽阐释其发生、发展及演变过程外, 还平实而肯綮地评估其科技与历史的应有价值和地位。

第二, 井盐生产最重要的一环是钻井。前人曾有云: “煮海易、煮井难、煮滇井易, 煮蜀井难; 难凿井”。凿井取卤, 也正是井盐生产的特点, 由此以区别海盐和池盐。钻井技术难度大,

要求高而复杂。而钻井的速度和深度,除工匠技能等因素外,很大程度决定于钻井和修治的工具(包括地面设备)。工具本是生产力的重要组成因素,因之钻井、治井工具是反映钻井水平的重要标志,也是反映井盐生产水平的重要标志。此外,有关井盐记载之史籍,卷帙浩繁;现存的千奇万状之钻凿工具又可作实际之观察,且探究其多种学科相互渗透及交织的丰富内涵。当我国古代井盐科技研究领域尚属开拓阶段时,如何选择起步的方向和题目,不能不是一个值得反复思虑、多方权衡的热点。作者毅然以井盐工具研究(其中以钻治工具为主)作为突破口,恰是抓住了古代井盐科技的重心,也就是牵到了古代井盐科技的牛鼻子。选题本身已证明了研究者的远见卓识,他们今后定会不断有新的成果产生,是完全可以预计的。

第三,本书对于古代盐井钻凿的科技原理,如何在当今现实生活产生功能,进行了有价值的探索,作者提出的见地,对于石油(包括天然气)业、井盐业、采矿业、水文地质等部门所用的钻探工具、探测仪器、地面设备等的生产、试验、设计、改进、创新,无疑具有借鉴和启迪的作用。当然也完全有条件作为石油、采矿等大专院校师生及科技干部的重要参考书。因此,这确实是一部有意义、有价值的学术著作。

第四,在体例方面还不得不再多说几句话。本书突破了一般科技史流行的框架和模式,力图创造一种新的格局。总的来讲,全书共分三个部分,第一部分总论,第二部分井盐工具的发明及其演进;第三部分井盐工具图集。

总论主要论述我国以井盐工具为代表的钻井术在 11 世纪中叶发明后,逐步传入西方,推动了石油、天然气这类新能源的广泛勘探与开发,大大加速了西方现代新兴工业的迅猛发展。与此同时,进一步广泛地开采和利用地下的井水也跨入新的阶段。人所共知,水,是农业的命脉,也是工业锅炉的饮料,更是人们每天不可缺少的必需品。据有关资料统计,在世界上约有  $1/3$  的地区处于干旱和半干旱状态。由此可知,在全球一些(地面)无水或缺水地区,同样采用钻探石油的深井技术开发地下水,对于农业灌溉、工业及城乡人民供水,完善现代城市的建设,无疑都具有重要的价值。

由于开凿盐井的技术需要和社会对食盐的需求,民间巧匠首先发明了“圆刃”钻头,这是一种速度快、成本低、获利丰的先进凿井工具。用它钻凿的卓筒井,得以迅速发展与普及,促使北宋初四川盐荒获得了缓解。至明清时期,特别是清代,由于钻探工具的改进和完善,我国的深井钻凿技术更是取得了举世瞩目的成就。在总论中列举有近代世界上第一口超千米的深井、举世闻名的自流井大气田的开发、我国第一个岩盐体的发现和钻采及古代盐井冲击法钻井工艺——兼与现代旋钻法钻井工艺比较等实例,就是最好的说明。以井盐工具为代表的深井技术在对西方世界科技工艺做出了重大贡献的同时,不断创发、完善而系列化,直至 19 世纪依然名列世界前茅。时至今日,它还放出光彩,其科学原理广泛应用于石油(包括天然气)工业、采矿业、水文地质勘探等建设上,潜力是很大的。

井盐工具的发明及其演进这部分以史实为依据,并结合古代钻井技术的特点和当时井盐生产发展水平,从纵向(以一种新式工具出现时代为准)和横向(每类至少选择一种代表工具)进行全面地研究,了解它的发生、发展及其变化规律。同时,对各个历史时期一种新式工具的出现,与自然条件的密切关系也作了较详的、有益的研讨。这一部分内容为总论提供了“史证”。

井盐工具图集部分是以井盐工具实物为基础,采用机械制图和工具摄影相结合并加释文,



集大而成。它是我国井盐工具的精华,显示了我们先辈的光辉业绩和辛勤劳动智慧的结晶。这部分为第二部分井盐工具的发明和发展提供了“物证”。同时也为总论提供了科学依据。为此,全书三个部分,既是独立成篇,又是前后一贯首尾紧密相连的。

写到这里,我很难立即搁笔,还需要补说一点:《中国古代井盐工具研究》是刘德林、周志征两位著者潜心研究,夜以继日,苦耘3年收获的成果。他(她)们身居著名的“盐都”自贡,刘德林同志在盐业系统从事生产、技术、科研达30年,周志征同志在盐业历史博物馆工作,对盐史资料、工具征集、研究也近30年。因此,与其说《中国古代井盐工具研究》是他(她)们苦耘3年的成果,倒不如说是30年辛勤劳动的结晶。

中国古代井盐虽然遍及西北与西南,但是,主要集中于四川,而且小口深井技术的发明与发展也在四川,四川深井技术代表了中国和世界最高水平。为了理论与实践紧密结合、史籍与实物密切结合,著者不畏长途跋涉,赴川东、川北及川南等40余地、市、县行程数千里,考察古盐井、古盐场(厂)、古遗址,征集工具(实物),采录史料,造访名家,求教耄老,到现场调查。尤其在世界上最早发明钻井术的发祥地——井研地区,多方搜询,盘桓忘返,这种求实的精神,是研究工作者十分可贵的。

这部著作的出版,其取得的成功是完全可以预料的。美国地质调查局的地质学家罗伯特·海特博士曾参观了自贡市盐业历史博物馆的井盐发展科技陈列,他对于陈列的钻探工具群赞不绝口,十分惊慕,热情“建议将中国古代打井采卤的工具和技术译成英文,向世界出版。相信它是一本世界畅销的书,据我所知,现在世界上还没有这样的工具技术书”。是的,它必然成为“一本世界畅销的书”获得世界学术界的应有认可和评价,从而让钻井术与造纸、印刷术、火药、指南针并列生辉,为祖国争光,为中华民族争誉!

冉光荣

1989.8.1

## PREFACE

In the long process of history, the valiant and industrious Chinese people have created a splendid ancient culture. One important part of this time-honored Chinese culture is science and technology, which had in a considerably long period led the world and is still admired. The four great inventions, namely papermaking, printing, gunpowder and compass, had made outstanding contributions to the progress of world history and the welfare of mankind. Another invention which should be more famous to the world is well-drilling technique characterized by the well-salt instruments.

Chinese well-salt production has a long and honored history. In the period from about 250 BC to 1840 AD when the Opium War took place, Chinese well-salt exploiting technique had been the most advanced in the world. Especially during the middle of the 11th century, with the epoch-making creation of the ring-edged deep well drilling bit and the vertical well, China first came to the new technical stage of deep well drilling. The invention of the fish-tail bit at the turn of the 19th century is a even greater technical contribution of the Chinese people to the mankind. This technique found their way to the Western world from the 12th century to 19th century and promoted the development of the world's modern oil industry and mining industry as a whole, and has been admired by foreign scholars as "the father of the world's oil well drilling" and "the ancestor of well drilling in the world". We may safely say that this technique is another great invention of our ancestors after those Four Great Inventions and constituted the Fifth. British science and technology historian Joseph Needham excitedly claimed that "Chinese scientific achievements in the ancient times and middle ages time and again prove to be splendid and dazzling". We may believe that ancient Chinese well salt technique is the finest of the "gold mine" of Chinese culture. Just see the various scientifically designed and carefully wrought well drilling instruments in the Historical Museum of Salt Industry in Zigong City. They really deserve the astonished admiration of Chinese and foreign scholars and ought to be more conspicuous in the record of history.

Yet from the Northern Song Dynasty till now, almost 1,000 years lapsed and this invention remains obscure, which certainly is a regrettable and weighty absence of ancient Chinese and world history of science and technology. Today, in order to uncover and inherit the nation's cultural heritage, Liu Delin and Zhou Zhizheng have composed *Study of Ancient Chinese Well-salt Instruments*. The attention and help from the science committees of Sichuan Province and Zigong City have made possible the quick publication of the work. This will be a first book in the world on the instruments for well-salt and oil drilling and a significant achievement in the study of the history of science and technology.

The following are the points in the book that should be emphasized.

Firstly, the development of ancient Chinese well-salt exploitation could roughly be divided into three periods according to the different drilling instruments, the characteristics of well forms and geological conditions: big dimensioned salt-well period from late Warring States Period to early Northern Song Dynasty; vertical well period from early Song to early Qing Dynasty; small dimensioned deep well period from middle Qing to late Qing Dynasty. The success of the drilling of the Xinghai well in 1853 marked the maturity of deep well technique. This book focuses on the period from the Song Dynasty to the Qing Dynasty, when the invention and changing of drilling instruments are the most rich and rapid. Detailed accounts are given to the process of development and changes, and brief assessments are made as to their technological and historical value and positions.

Secondly, the most important part of well-salt production is well drilling. As the old saying goes: "It is easy to boil the sea, but difficult to boil the well; it is easy to boil the Yunnan well, but difficult to boil the Sichuan well. Difficult because you have to drill wells". Digging well is the characteristic of well-salt production as compared with those of sea-salt and lake-salt. Salt-well drilling demands difficult and complicated technique, and the speed and depth of the drilling to a large extent are dependent on the instruments (including ground equipment) for well drilling and maintenance. These instruments are important marks of well drilling technique and at the same time of the production level of well-salt. Besides, there are so many books about well-salt to be studied and so many tools to be observed that one is lost in them because they involve a blend of many branches of learning. As a beginning step in the study of ancient China's well-salt technique, choosing instruments for the direction and major issue as the book does is well considered and farsighted.

Thirdly, this book makes valuable investigation into the scientific and technical principles of ancient salt-well drilling and digging and their functions in today's life. The notions presented by the authors will undoubtedly inspire the designing and innovating of instruments for drilling, sounding and ground equipment in oil industry, well-salt industry, mining and hydrogeology. So this book might well be used as a text book for higher educational institutions in the line of oil production and mining, and as a reference book for cadres in the line of science and technology.

Fourthly, I would like to make some more remarks on the layout of the book. The book consists of three parts. The first part is an introduction. Part Two is about the inventions and development of well-salt instruments, and Part Three is a collection of illustrations. The introduction mainly dwells on how Chinese well drilling technique, characterized by well-salt instruments, after being invented in the middle of the 11th century, gradually passed to the West and promoted the exploitation and development of such new energy sources as oil and natural gas, and greatly accelerated the development of modern Western industry. Moreover, at a time when water is lacking in a large part of the world, these drilling

techniques will prove vitally important for agriculture, industry, and rural and urban life.

The invention and quick spread of the ring-edged bit and the vertical well had helped to alleviate the salt shortage in Sichuan in the Northern Song Dynasty. By the Ming and Qing Dynasties and especially the Qing Dynasty, because of the improvement and perfection of drilling instruments, China's deep well drilling technique had attracted the world's attention. In this part the authors listed such examples as the world's first over-1,000-meter deep well, the world famous exploitation of artesian-well gas field, the discovery and exploitation of China's first rock salt body, the pounding method in drilling technique of ancient salt-well and a comparison of this method with the spinning approach.

Part Two is a comprehensive discussion of the invention and development of the tools in the context of ancient well drilling techniques, salt production level of the times and natural conditions, while Part Three is a comprehensive collection of mechanical drawings and photographs of the salt-well instruments with explanatory notes to them. These two parts confirm the notions presented in the introduction.

The book is a crystallization of industrious work, including the hard and persevering field study by the authors for 3 years. They live in Zigong City which is known as the Capital of Salt. Liu Delin has been engaged in salt production and studies for 30 years. Zhou Zhizheng has worked at the Historical Museum of Salt Industry also for 30 years, having been collecting and studying the historical data and instruments. To complete this work, the authors had toured some 40 counties and cities in the East, North and South Sichuan where ancient salt production was focused and the small dimensioned deep well was invented and developed, for field investigation of the ruins of salt-wells, saltworks, and collected sample instruments and historical data and materials.

The success of this book could readily be expected. Doctor Robert Highet, a geologist from US Geological Investigation Bureau, once visited the exhibition of the development of well-salt science and technology at the Historical Museum of Salt Industry of Zigong City. He praised the well drilling instruments with astonished admiration, and fervently suggested: "these instruments and techniques of ancient Chinese for well drilling and bittern extraction should be translated into English and published to the world". He said "It would be a world best seller. As far as I know, there is no such a book of instrumental technique". I agree with him. This book will become a world best seller and win the deserved approval and assessment, and the technique of well drilling will be known as the Fifth Great Invention of the Chinese nation and win more honor for the Chinese people.

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# 第一篇 总 论

我们聪明智慧的祖先,在公元 11 世纪中叶最早发明了世界第一个深井钻头——圆刃铤(即圆刃钻头),并用它成功地开创了卓筒井工艺。自 11 世纪开始到 19 世纪以前,我国钻井技术一直走在世界的前列。12 世纪初,我国钻井技术传入欧洲,在欧洲成功地开凿了一批地下水自流井,其后又传到美洲新大陆和其他地区。如美国钻石油标准凿井具(《凿井工程》第 22 图)中的一字钻头(底部横一刃)、工字钻头(底部如马蹄状),与我国清代的银锭铤、双马蹄铤相仿。现代旋钻法钻井的“鱼尾”钻头,同我国冲击顿钻法“鱼尾”铤类同。现代旋钻法钻井工艺与我国古代冲击(顿)钻法凿井工艺分八道严密工序大致相同。因此,我国古代钻井技术西传,为现代西方石油(包括天然气)工业的兴起和自流井地下水的开发、深层岩盐(包括卤水)的钻采铺平了道路。为人类的文明和进步做出了重大贡献,所以被国外誉称“现代石油钻井之父”,确是当之无愧的。

我国古代凿井钻头,自宋初发明,迄至鸦片战争前夕(1840 年)已趋于成熟,凿井工艺亦臻于完善。公元 1835 年,四川自贡市桑(兴)海井钻深超千米,创造了当时世界的最新纪录,就是例证。举世闻名的自流井气田的开发,显示了我们先民的伟大业绩。这个气田至迟从明代万历年间(公元 1573~1619 年)开始,直到公元 1850 左右才进行大规模的开发,火井王——磨子井的钻凿成功,代表了当时的钻采新水平。稍后,于 1892 年,四川自贡在老井加深中,发现和开采了第一个岩盐矿体——大坟堡岩盐矿体。这个岩盐体

的发现和开采,为深井水溶法开了先河。

我国古代井盐工具的发明和发展,不仅过去为人类社会的文明做出了卓越的贡献,而且对于现在的石油、矿山工具的革新具有启示作用。所以,对井盐工具研究,不仅是为了总结前人的经验和创造,而且也是为了古为今用。如:川西南矿区的工程技术人员,应用古代井盐工具的原理,研制了油气井多种先进的工具。仅“打捞杯”一种,节约价值 100 多万元,推广应用后,成倍提高工效,创造了巨大的经济价值。又如:自贡矿山钻头厂,吸取井盐工具的优点,制造出西南第一流的钻头,并畅销全国各地,深受厂家的欢迎。

劳动创造了人类社会,而劳动首先是从制造和使用工具开始的。生产工具是生产力的重要因素,也是衡量社会生产力发展水平的重要尺度。马克思在《资本论》(第一卷)中讲:“各种经济时代的区别,不在于生产什么,而在于怎样生产,用什么劳动资料生产。劳动资料不仅是人类发展的测量器,而且是劳动借以进行的社会关系的指示器”<sup>〔1〕</sup>。因此考察社会生产发展的水平,“不在于生产什么,而在于怎样生产”,即是主要看它用什么工具生产。如石制工具(包括旧、新石器)标志着原始社会的生产水平,青铜工具标志着奴隶社会的生产水平,铁器工具则标志着封建社会的生产水平等等。同样,圆刃铤代表了宋代的井盐生产水平,铁钎、铁五爪等工具代表了明代的井盐生产水平,鱼尾铤、银锭铤、偏尖等工具群代表了清代的井盐生产水平。所以,研究古代劳动生产工具,对于了解当时的社会制度、经济形态、文化意识等,有