

中国煤矿 水害预防及治理

王永红 沈文 著

煤炭工业出版社

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内 容 简 介

本书是一本矿井水害预防及治理研究方面的专著。第一部分以水文地质学理论为基础,系统论述了中国主要含煤地层的基底、内部和盖层的水文地质环境特征及中国煤矿水害与含煤地层水文地质环境的关系;第二部分重点分析和解剖了我国重大煤矿突水事故的典型案例,对各矿区水文地质条件、突水发生经过、突水原因进行了分析,并对水害治理的实际方法进行了详细探讨;第三部分是煤矿水害防治研究方面的几项专题研究成果,这些专题研究内容均涉及煤矿突水机理及突水预测等的关键问题。

本书可供矿山、水利、交通等行业的勘查、设计、施工和生产部门的工程技术人员阅读,也可供各有关高等院校、科研机构的水文地质、工程地质、采矿等有关学科的科研人员、研究生和本科生参考。

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Introduction

The book, on the basis of hydrogeologic theories, discusses in a systemic way the hydrogeologic environmental features of the substrate, the inside and the cover of the major coal-bearing formations in China, and the connections between flood catastrophes and the hydrogeologic conditions of the coal-bearing formations, with an emphasis on presenting the hydrogeologic conditions and characteristics of some heavily-watered coal mines in both North China and South China. In Part Two, typical cases of water bursts in 28 major coal mines are presented with systemic and detailed examinations of the causes and the processes of the bursts from different angles and based on varied hydrogeologic circumstances. As basic and practical materials for the prevention and control of coal mine flooding in China, the book will be of great referential value owing to its Chinese characteristics. A summary of the research results from several special topics is revealed in Part Three, all dealing with such key issues as the mechanism of water bursts and their forecasting, e. g., the new method of watching the destruction of water-producing fracture zones by cover extraction and the dynamic process of fracture development; hydraulic fracturing tests by floor extraction to destroy rock mass to block water; centrifugal model tests on the mechanism of subsidence and the analysis of test results; and prediction and forecasts of floor water bursts through multi-source information combination, etc.

Upon the occasion, I feel greatly indebted to those who have paid much attention and given enthusiastic guidance to the book, among whom are Prof. Liu Tianquan, academician of Chinese Academy of Engineering, Prof. Song Zhenqi, academician of Chinese Academy of Sciences, Asso. Prof. Chen Jiangzhong, Dr. Sui Wanghua, Dr. Ge Zhonghua, Lecturers Sun Yajun and Yin Zongde, Dr. Shi Longqing, Mr. Xu Tiantao and all the friends who have given me constant support.

I have been working on the book for the past four years and experienced countless hardships. However, there might be limitations or even loopholes in it due to various causes. Therefore, every criticism from the readers will be sincerely appreciated.

前 言

由于特定的国情和条件,煤炭是我国社会主义现代化建设和人民日常生活的重要能源,煤炭工业是我国的基础工业。然而,特殊的地质地理环境,决定了我国煤矿水文地质条件与世界其它国家相比,是极其复杂的,我国煤炭资源的开采受水害的威胁严重,尤其是随着开采深度、开采强度、开采速度、开采规模的增加和扩大,以及新煤田的大面积开发,水害威胁愈来愈严重。特别是华北石炭二叠纪煤田已成为我国煤炭生产的主要煤田,而华北煤田恰恰位于岩溶水文地质类型区,水文地质条件极为复杂,突水事故频繁发生。据不完全统计,我国国有重点煤矿目前已有上百亿吨受水威胁的储量。给煤矿防治水工作和实现安全生产带来更大的困难和更为艰巨的任务。因此,煤矿水害预防及治理的研究已成为我国和世界各产煤国都迫切需要解决的重大课题,因而也是我国六五、七五和八五科技攻关的课题。

我国多年矿井水害防治及治理的理论和实践表明,矿井水文地质环境特征、突水机理和突水预报及监测是矿井水害预防及治理研究的中心内容。矿井水文地质条件是矿井水害治理研究的基础,突水机理是这一研究的核心,而预测预报是这一研究的主要目标。不言而喻,三者相辅相成,只有从条件上搞清楚突水的特征和基础,从根本上突破突水机理的实质,才能有针对性、有实际效果地实施突水预测预报,也才能有根据地采取有效的防治措施,从而引起对突水机理研究的逐步深化和突破,把对矿井水害防治的研究推向一个新的发展阶段。

正是基于以上认识,本书以水文地质学的理论为基础,系统地论述了中国主要含煤地层的基底、内部和盖层的水文地质环境特征及中国煤矿水害与含煤地层水文地质环境的关系,并重点介绍了中国北、南方的大水矿区的水文地质条件和特征、第二部分着重分析了我国28个重点煤矿突水事故的典型案例,从不同侧面、不同地质条件和特点出发,系统分析了各矿区(井)在不同的水文地质条件下发生突水事故的经过、原因以及水害治理的实际方法和过程。本书搜集了大量的富有中国煤矿水害特色的宝贵资料,这对全面认识我国煤矿突水事故的发生和寻求正确的水害治理方法,有着重要的参考价值;第三部分是煤矿水害防治研究方面的几项专题研究成果,这些专题研究内容均涉及煤矿突水机理及突水预测等关键问题,如采动顶板破坏导水裂缝带的观测新方法及裂缝发育的动态过程,采动底板破坏岩体阻水的压裂试验,地面沉降机理的离心模拟试验及其成果分析,多源信息拟合法底板突水预测预报等。

值此书出版之际,特向那些给本书诚心关怀和热情指导的专家、学者们表示衷心的感谢,感谢刘天泉院士、宋振骥院士的悉心指导,感谢陈江中副教授、隋旺华博士、葛中华博士、孙亚军讲师、尹增德讲师、施龙青博士等的帮助和支持,感谢徐天涛同学的帮助,还要由衷感谢那些对本书寄予热情期望和关怀而未能在这一一列出的朋友们。

由于水平所限、书中谬误之处在所难免,尚祈读者不吝指正。

作 者

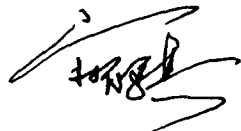
1996年6月于北京

序 (1)

煤炭资源的开发利用一直是我国经济发展的重要组成部分和既定国策。然而,我国煤田水文地质条件极为复杂,煤矿突水事故频繁发生,严重威胁着煤矿的安全生产、并已造成了巨大的经济损失和严重的后果。因此,对煤矿水害的预防及治理一直是煤炭工业必须解决的重大课题之一。目前,对矿井水害防治的研究在理论上还处于探索阶段,在工程上远远满足不了煤炭工业现代化安全生产的需要;而且尚有许多问题没有得到解决,如对岩体在矿山压力、原始构造应力的影响下,在水的作用下的变形、破坏、失稳,尤其是对强渗、突水通道的形成条件和突水机理的认识还相当模糊。因此,上述问题的研究对我国煤矿水害的治理有着十分重要的现实意义和长远的战略意义。

这本专著首次比较系统地分析了中国煤矿水害的水文地质条件和特征,整理和介绍了我国煤矿重要突水事故的典型案例。这对认识我国煤矿突水事故的发生和水害的治理方法,有着重要的理论和实际意义。本书还论述了这一研究领域的新成果和新进展,这也是作者多年科研工作的结晶。这些内容均涉及到煤矿突水机理及突水预测等研究的关键问题,如采动顶板破坏中导水裂缝带观测新方法及裂缝发育的动态过程、采动底板破坏中岩体阻水能力的压裂试验、地表沉陷机理的离心模拟试验等等。作者还比较深入地研究了裂缝带的各组合结构(传递岩梁),裂缝张开、闭合发生发展的动态过程,从而把透水通道随采场推进形成、发展以至封闭的时间和条件的研究,提高到一个新的水平,把井下透水时间、地点及水量的预测理论推进到一个新的阶段。这些研究成果在国内都属首次,有其创见性和先进性,不仅有着重要的学术意义,还有着重大的工程价值。为此,特将该书推荐给读者,希望也相信该书对丰富和推动我国煤矿水害的预防及治理研究,会起到积极的作用。同时,也希望更多的有关这方面的著作问世,把我国煤矿水害治理研究的理论和技术提高到一个新水平。

中国科学院院士



1996年6月

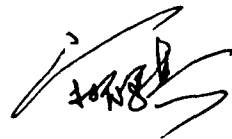
Preface (1)

The exploitation and utilization of coal resources, an established state policy, has been playing an important part in the development of our national economy. However, hydrogeologic conditions in the Chinese coal mines are extremely complicated and flooding occurs constantly, which threatens safe production and has caused huge losses and serious consequences. Therefore, the prevention and control of coal mine flooding remains a big problem to be tackled.

At present, the theoretical study of the issue is only at an initial stage, and in the field of engineering, it can not meet the requirements for safe production of the modernized coal industry. A lot of problem remain to be solved, e. g. , the problem of rock mass deformation, destruction and instability affected by mine pressure and primeval structural stress and worked by the force of water; and problems concerning strong permeability, formation of flooding passage and the mechanism of water bursts are still confusing.

The monograph analyses in a comparatively systemic way the hydrogeologic conditions and features of coal mine flooding in China with a presentation and summarization of some typical cases of coal mine flooding, which is of both theoretical and practical values. The book also discusses some research results and recent developments in this field — the fruits of many years of hard work by the authors. Key topics in the study of the mechanism of flooding and forecasts are dealt with, such as the new method of watching the water-inducing fracture zones damaged by top extraction and the dynamic process of fracture development, the fracturing tests on the capability of rock mass water hindrance during floor extraction and the centrifugal simulation tests on the mechanism of ground subsidence, etc. The authors conducted detailed study on the dynamic process of the occurrences and developments of fracture opening and closing in each composition structure of the fracture zones, hence giving impetus to researches into the time and conditions of the formation, expansion and close of permeable passages as extraction advances, and enhancing the forecasting of the time and spots of water bursts and their volume. The research results mentioned above, both original and creative in China, are of important academic importance and engineering values.

I thereby recommend this book to our readers, hoping that it will enrich and motivate the research into the prevention and control of coal mine flooding in China; meanwhile, I wish to see more publications in this field so as to carry forward the theory and technology of this subject.



Song Zhenqi

Academician of Chinese Academy
of Sciences

June 16, 1996

序 (2)

众所周知，矿井水害是危及煤矿安全生产的 5 大灾害之一。矿井水害预防、治理及预报的研究，不仅是中国、也是世界各产煤国家都迫切需要解决的重大课题。

由于我国煤矿水害预防的复杂性和艰巨性，这方面的著述一直较少。而《中国煤矿水害预防及治理》专著，在这一研究领域作了可喜的努力和探索。作者从水文地质学的基础理论出发，比较系统地分析了我国煤矿水害的地质环境及突水特征；论述了这一领域的新理论、新成果和新进展。这是作者多年来在该领域研究的成果。该书的内容新颖、丰富，有些内容和观点尚属首次提出，富有创见性和先进性，该书既有重要的学术意义，也有重大的工程价值。但愿它对促进我国煤矿水害防治和研究及工程技术进步起到有益的促进作用。

中国工程院院士

A handwritten signature in black ink, appearing to read '刘天泉' (Liu Tianqiang), with a long horizontal stroke extending to the right.

1996 年 6 月

Preface (2)

As is known to all, flooding is one of the five major catastrophes endangering safe production in coal mines. Naturally, researches concerning the forecast, prevention and control of coal mine flooding have been taken seriously not only in China, but in other coal-producing countries as well. However, writings dealing with this issue have been scarce due to the complexity and enormous difficulty of coal mine flooding in China.

Valuable explorations have been made in "The Prevention and Control of Coal Mine Flood Catastrophes in China", in which the authors, proceeding from the basic theories of hydrogeology, systematically analysed the geologic environment and chief features of coal mine flooding in China, with a presentation of new theories and advanced method in this field.

With its substantial contents and originality the book, is of academic importance and engineering values, which, I believe, will give impetus to researches concerning the prevention and control of coal mine flooding.



Liu Tianquan

Academician of Chinese
Academy of Engineering

June, 1996

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第一篇 中国煤矿水文地质环境概述

第一章 中国的聚煤期与主要含煤地层

第一节 中国的聚煤期

自从地球上出现植物，便有了成煤的物质条件。震旦纪的石煤是浅海菌藻类植物形成的，寒武纪、奥陶纪、志留纪的腐泥无烟煤也是由以浅海藻类为主的低等植物形成的。泥盆纪之后，陆地上生长了植物，并形成了丛林，加之当时受地表海陆分布、地壳隆起与沉降，以及沉积作用等因素的影响，形成了各个地质时代的腐植煤。

中国各地质时代聚煤作用是不均衡的。几个较强的聚煤作用时期是：

早古生代：早寒武世

晚古生代：早石炭世

晚石炭世—早二叠世

晚二叠世

中生代：晚三叠世

早、中侏罗世

晚侏罗世—早白垩世

新生代：第三纪

上述 8 个聚煤期中，除早寒武世属于菌藻植物时代且形成腐泥无烟煤外，其它 7 个聚煤期均为腐植煤的聚煤期。而后 7 个聚煤期中，以晚石炭世—早二叠世、晚二叠世、早侏罗世—中侏罗世、晚侏罗世—早白垩世 4 个聚煤期的聚煤作用最强，中国具有开采价值的主要煤层也均属这 4 个聚煤期。

第二节 中国的主要含煤地层

据 1987 年的不完全统计，不包括西藏自治区和台湾省，中国已开发的大小煤田约 187 个。含煤地层属晚古生代石炭二叠纪的占 38%，通称华北型煤田；属二叠、三叠纪的占 30%，通称华南型煤田；属中生代侏罗纪和白垩纪的占 28%，通称华北、东蒙煤田；属新生代第三纪的占 4%。

一、晚古生代石炭二叠纪煤系地层

（一）华北型晚古生代石炭二叠纪煤系地层

华北型晚古生代石炭二叠纪含煤建造在华北广泛发育。自中石炭世形成广阔的聚煤拗陷，经中石炭世、晚石炭世、早二叠世沉积，形成中石炭世本溪组、晚石炭世太原组、早二叠世山西组和下石盒子组 4 个含煤地层，其中除本溪组含煤性差外，其余三个含煤地层含煤性均好，尤以山西组和下石盒子组的含煤性最好，是中国煤矿主要开采煤层的层位。

华北型晚古生代石炭纪、二叠纪含煤地层广泛分布，北界为阴山、燕山及长白山东段；南界为秦岭、伏牛山、大别山及张八岭；西界为贺兰山、六盘山；东界则为黄海、渤海。遍及京、津、晋、冀、鲁、豫的全部，辽、吉、内蒙古的南部，甘、宁的东部，以及陕、苏、皖的北部（图 1—1）。

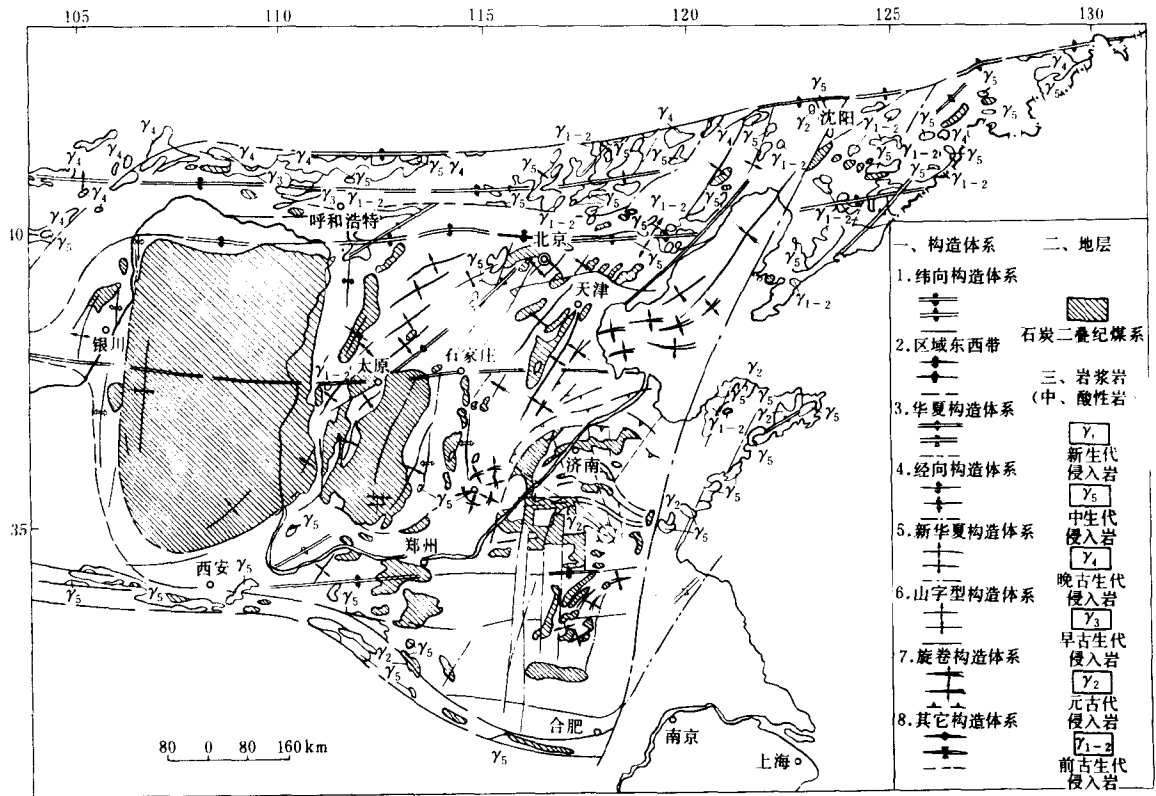


图 1—1 华北构造体系与石炭二叠纪煤系分布略图

(二) 南方型晚古生代石炭纪、二叠纪含煤地层

晚古生代石炭、二叠纪含煤地层在中国南方也广泛发育。主要分布在秦岭巨型纬向构造带和淮阴山字型构造带以南，川滇经向构造带以东的华南诸省。具有工业价值的含煤地层有：晚石炭世测水组、早二叠世官山段和梁山段以及晚二叠世龙潭组或吴家坪组，其中晚二叠世龙潭组是中国南方最重要的含煤地层（图 1—2）。

二、中生代含煤地层

(一) 晚三叠世含煤地层

中国晚三叠世含煤地层分布于天山—阴山以南，而主要含煤地层又大部分分布于中国南方，即：昆仑—秦岭—大别山以南。重要的含煤地层有：湘赣的安源组、粤东北的艮口群、闽浙一带的焦坪组、鄂西的沙镇溪组、四川盆地的溪家河组、云南的一平浪群、滇东和黔西的大巴冲组、西藏的土门格拉组。在昆仑—秦岭构造以北，晚三叠世重要含煤地层有：鄂尔多斯盆地的瓦窑堡组，新疆的塔里奇克组，以及吉林东部局部保存的北山组等。

(二) 早、中侏罗世含煤地层

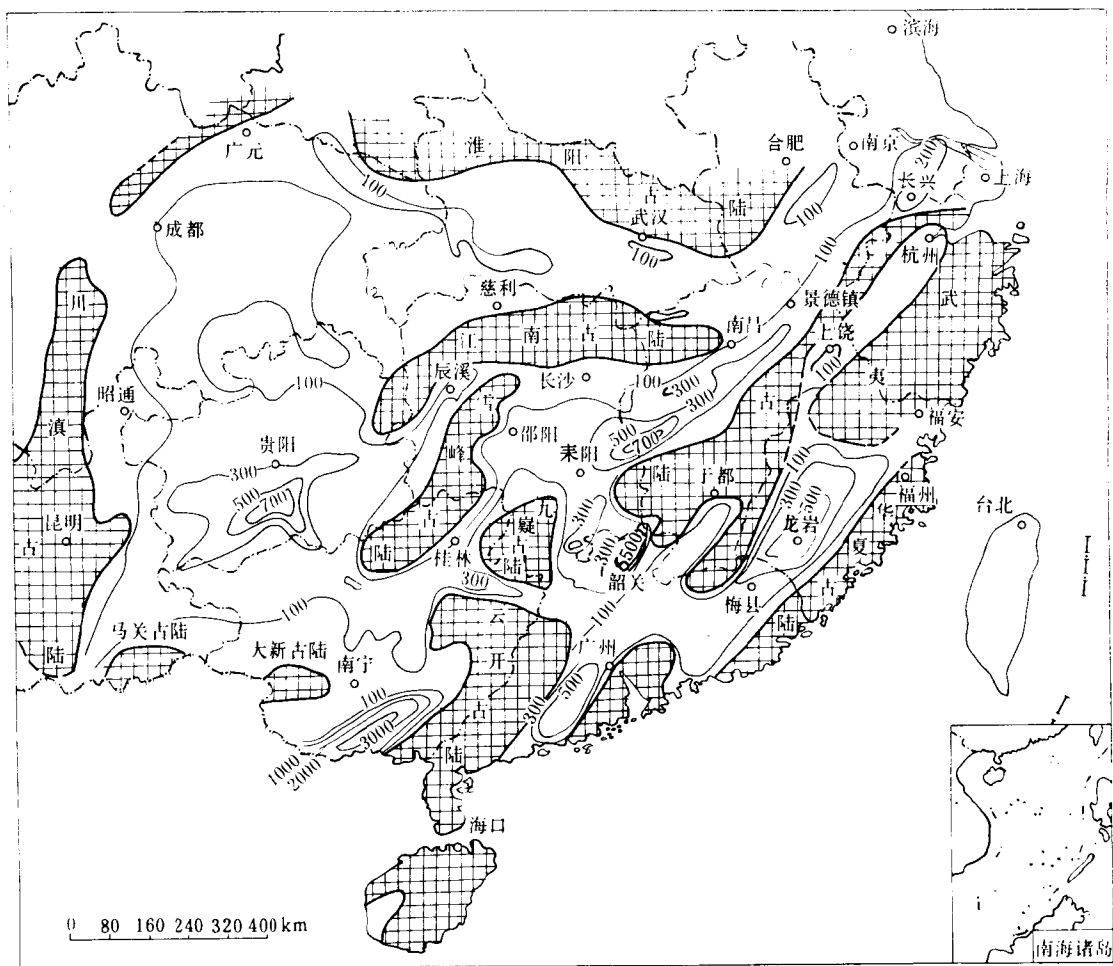


图 1—2 华北晚二迭世龙潭组等厚线图

中国早、中侏罗世的聚煤范围较晚三叠世广泛，几乎遍及全国多数省区。但聚煤作用最强的主要在中国的西北和华北地区（图 1—3），以新疆自治区的储量最为丰富。主要含煤地层有：鄂尔多斯盆地的延安组、山西大同盆地的大同组、北京的窑坡组、北票的北票组、同蒙古石拐子的五当沟组、河南的义马组、山东的坊子组、青海的小煤沟组、新疆的水西沟群等。

（三）晚侏罗世—早白垩世含煤地层

晚侏罗世—早白垩世是中国中生代的第三个重要聚煤期。含煤建造多数发育于孤立的断陷型内陆山间盆地或山间谷地之中，聚煤盆地面积较小，但含有厚或巨厚煤层。上侏罗统一白垩统是中国东北和内蒙古东部地区最重要的含煤岩系，中国最厚的煤层大都属于本区（图 1—4）。主要含煤地层有：黑龙江的穆林组，辽宁的沙海组、阜新组，内蒙古的伊敏组、霍林河组，吉林的九台组等。

三、新生代含煤地层