



普通高等教育“十二五”规划教材

PUTONG GAODENG JIAOYU "12·5" GUIHUA JIAOCAI

**Mining of Non-ferrous Metal Deposits**

# 有色金属矿床开采

主 编 占丰林 叶 萍  
副主编 凌征华 俞 惠



冶金工业出版社  
Metallurgical Industry Press



普通高等教育“十二五”规划教材

# Mining of Non-ferrous Metal Deposits

## 有色金属矿床开采

主 编 占丰林 叶 萍  
副主编 凌征华 俞 惠

北 京  
冶 金 工 业 出 版 社  
2011

## 内 容 提 要

本书为冶金类院校英语专业和采矿工程专业开设的有色金属方面特色课程所用的教材之一。全书共分6章, 主要内容包括: 采矿和有色金属矿床简介、炸药与爆破、有色金属矿山运输、有色金属矿山通风、岩石力学以及有色金属矿床采矿方法等。为便于教学, 每章前附有本章的中文内容摘要, 每章后附有本章的专业术语词汇表及复习思考题。

本书可作为冶金类院校英语专业本科生的泛读教材、采矿工程专业本科生的专业英语教材和采矿概论双语课程的教材, 也可作为采矿工程专业人员出国考察访问、进修或攻读学位前的培训或自学教材, 还可供广大采矿工程师及采矿工程技术人员学习参考。

## 图书在版编目(CIP)数据

有色金属矿床开采 = Mining of Non-ferrous Metal Deposits:  
英文/占丰林, 叶萍主编. —北京: 冶金工业出版社, 2011.5  
普通高等教育“十二五”规划教材  
ISBN 978-7-5024-5463-0

I. ①有… II. ①占… ②叶… III. ①有色金属矿床—  
金属矿开采—高等学校—教材—英文 IV. ①TD862

中国版本图书馆 CIP 数据核字(2011)第 055280 号

出 版 人 曹胜利

地 址 北京北河沿大街嵩祝院北巷 39 号, 邮编 100009

电 话 (010)64027926 电子信箱 yjchs@cnmip.com.cn

责任编辑 廖 丹 美术编辑 彭子赫 版式设计 孙跃红

责任校对 王永欣 责任印制 张祺鑫

ISBN 978-7-5024-5463-0

北京印刷一厂印刷; 冶金工业出版社发行; 各地新华书店经销

2011 年 5 月第 1 版, 2011 年 5 月第 1 次印刷

787mm×1092mm 1/16; 15.5 印张; 371 千字; 230 页

32.00 元

冶金工业出版社发行部 电话:(010)64044283 传真:(010)64027893

冶金书店 地址:北京东四西大街 46 号(100010) 电话:(010)65289081(兼传真)

(本书如有印装质量问题, 本社发行部负责退换)

# 前 言

随着我国市场经济的发展壮大，行业分工越来越细、越来越综合，对专门人才、特色人才和复合应用型人才的需求日益旺盛，这对我国高等教育的人才培养也产生了巨大的影响。2007年，教育部高等学校外语专业教学指导委员会评估组专家对一些大学的英语专业本科教学工作提出了“走特色办学之路”的建议。因此，高校专业特色化是当前人才培养的方向。

有色金属采矿、选矿和冶金是冶金类院校的强势特色专业。因此，此类高校的英语专业应具有有色冶金特色。特色专业需要特色系列教材，目前市场上正式出版的有色金属采矿、有色金属选矿和有色金属冶金方面的英文教材比较少。同时冶金类院校采矿工程专业使用的专业英语教材的专业知识不够深入系统。本书是冶金类院校英语专业和采矿工程专业开设的有色金属方面特色课程所用的教材之一，旨在使这些院校英语专业和采矿工程专业的学生通过专业英语的学习掌握采矿工程专业知识，使英语专业和采矿工程专业的学生不仅能够用英语进行日常会话、翻译，还可以熟练地使用英语进行采矿工程专业方面的听、说、读、写、译，这也是当今冶金采矿行业最稀缺的复合应用型人才之一。

本书可作为冶金类院校英语专业本科生的泛读教材、采矿工程专业本科生的专业英语教材和采矿概论双语课程的教材，也可作为采矿工程专业人员出国考察访问、进修或攻读学位前的培训或自学教材，还可供广大采矿工程师及采矿工程技术人员学习参考。在本书实际使用过程中，使用者可根据使用目的的不同和学时的多少进行选择性的讲解、学习或阅读。

全书共分6章，主要内容包括：采矿和有色金属矿床简介、炸药和爆破、有色金属矿山运输、有色金属矿山通风、岩石力学以及有色金属矿床采矿方法等。本书由占丰林教授、叶萍副教授担任主编，凌征华教授、俞惠副教授担任副主编。其中第1、3、5、6章由占丰林编写，第2章由叶萍编写，4.3~4.6节

## II 前 言

由凌征华编写，4.1~4.2节由俞惠编写，全书由占丰林统稿。

本书在编写过程中参考了国内外相关书籍、论文或网页，在此对这些参考资料的作者表示诚挚的感谢。由于编者水平有限，书中难免有疏漏之处，敬请广大读者批评指正。

编 者  
2011 年元月

# CONTENTS

|          |                                                                             |           |
|----------|-----------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction to Mining and Non-ferrous Metal Deposits</b>                | <b>1</b>  |
| 1.1      | Mining's Role                                                               | 1         |
| 1.1.1    | Minerals, Rocks and Ore                                                     | 1         |
| 1.1.2    | Professional Terms of Mining                                                | 2         |
| 1.1.3    | Mining and Civilization of Mankind                                          | 4         |
| 1.1.4    | Advancement of Mining Technology                                            | 6         |
| 1.1.5    | Man, Technology and Mineral Economics                                       | 9         |
| 1.1.6    | Conservation in Mining                                                      | 12        |
| 1.1.7    | Influence of Mining on Environment                                          | 13        |
| 1.1.8    | Future of Mining                                                            | 13        |
| 1.2      | Non-ferrous Metal Deposits                                                  | 14        |
| 1.2.1    | Non-ferrous Metals                                                          | 14        |
| 1.2.2    | Deposits and Ores of Non-ferrous Metals                                     | 15        |
| 1.2.3    | Technologic Deposits                                                        | 18        |
| 1.2.4    | Extraction Methods of Valuable Components                                   | 19        |
| 1.2.5    | Deposit Evaluation and Mineral Resources                                    | 20        |
| 1.3      | China's Non-ferrous Metals Industry                                         | 24        |
| 1.3.1    | Introduction                                                                | 24        |
| 1.3.2    | Current Situation and Future Outlook of China's Non-ferrous Metals Industry | 32        |
|          | Professional Terms                                                          | 35        |
|          | Exercises                                                                   | 36        |
| <b>2</b> | <b>Explosives and Blasting</b>                                              | <b>37</b> |
| 2.1      | Characteristics of an Explosive Reaction                                    | 37        |
| 2.2      | Comparative Properties of Explosives                                        | 40        |
| 2.2.1    | Strength                                                                    | 40        |
| 2.2.2    | Detonation Velocity                                                         | 40        |
| 2.2.3    | Density                                                                     | 41        |
| 2.2.4    | Detonation Pressure and Borehole Pressure                                   | 42        |
| 2.2.5    | Water Resistance                                                            | 43        |
| 2.2.6    | Fume Class                                                                  | 43        |

|             |                                                       |           |
|-------------|-------------------------------------------------------|-----------|
| 2. 2. 7     | Sensitivity .....                                     | 43        |
| <b>2. 3</b> | <b>Commercial Explosive Products .....</b>            | <b>44</b> |
| 2. 3. 1     | Nitroglycerin-Based Explosives .....                  | 45        |
| 2. 3. 2     | Nitroglycerin .....                                   | 46        |
| 2. 3. 3     | Straight ( Nitroglycerin) Dynamite .....              | 46        |
| 2. 3. 4     | Ammonia Dynamite .....                                | 46        |
| 2. 3. 5     | Low-Density Ammonia Dynamite .....                    | 46        |
| 2. 3. 6     | Blasting Gelatin .....                                | 47        |
| 2. 3. 7     | Straight Gelatin .....                                | 47        |
| 2. 3. 8     | Ammonia Gelatin .....                                 | 47        |
| 2. 3. 9     | Semigelatin .....                                     | 47        |
| 2. 3. 10    | Permissible Explosives .....                          | 47        |
| 2. 3. 11    | Pneumatic Breaking Systems .....                      | 48        |
| 2. 3. 12    | Liquid Oxygen Explosive ( LOX) and Black Powder ..... | 48        |
| 2. 3. 13    | Dry Blasting Agents .....                             | 49        |
| 2. 3. 14    | Slurries ( Water Gels) .....                          | 50        |
| <b>2. 4</b> | <b>Blasting Accessories .....</b>                     | <b>52</b> |
| 2. 4. 1     | Blasting Caps .....                                   | 52        |
| 2. 4. 2     | Detonating Cord .....                                 | 52        |
| 2. 4. 3     | Primers and Boosters .....                            | 53        |
| <b>2. 5</b> | <b>Explosive Prices .....</b>                         | <b>53</b> |
| <b>2. 6</b> | <b>Choosing an Explosive .....</b>                    | <b>53</b> |
| <b>2. 7</b> | <b>Blasthole Loading Methods .....</b>                | <b>55</b> |
| 2. 7. 1     | Loading Small-Diameter Boreholes .....                | 55        |
| 2. 7. 2     | Loading Large-Diameter Boreholes .....                | 58        |
| <b>2. 8</b> | <b>Controlled Blasting Techniques .....</b>           | <b>59</b> |
| 2. 8. 1     | Line Drilling .....                                   | 60        |
| 2. 8. 2     | Presplitting .....                                    | 60        |
| 2. 8. 3     | Cushion Blasting .....                                | 61        |
| 2. 8. 4     | Smooth Blasting .....                                 | 61        |
|             | Professional Terms .....                              | 61        |
|             | Exercises .....                                       | 62        |
| <b>3</b>    | <b>Haulage of Non-ferrous Metal Mines .....</b>       | <b>63</b> |
| <b>3. 1</b> | <b>Underground Haulage .....</b>                      | <b>63</b> |
| 3. 1. 1     | Mine Cars and Track .....                             | 63        |
| 3. 1. 2     | Rail-Haulage System .....                             | 67        |
| 3. 1. 3     | Trucks and Tractor-Trailers .....                     | 69        |
| 3. 1. 4     | Underground Dumps .....                               | 71        |

|                                                                         |            |
|-------------------------------------------------------------------------|------------|
| 3.1.5 Transportation of Men Underground .....                           | 75         |
| 3.2 Surface Haulage .....                                               | 80         |
| 3.2.1 Railroad Haulage .....                                            | 80         |
| 3.2.2 Truck Haulage .....                                               | 88         |
| Professional Terms .....                                                | 93         |
| Exercises .....                                                         | 93         |
| <b>4 Ventilation of Non-ferrous Metal Mines .....</b>                   | <b>94</b>  |
| 4.1 Mine Atmospheres and Gases .....                                    | 94         |
| 4.1.1 Ventilation's Role .....                                          | 94         |
| 4.1.2 Nature of the Mine Atmosphere .....                               | 95         |
| 4.1.3 Mine Gases .....                                                  | 96         |
| 4.2 Mechanical Ventilation .....                                        | 97         |
| 4.2.1 Fan Laws .....                                                    | 98         |
| 4.2.2 Selection of Fans .....                                           | 98         |
| 4.3 Natural Ventilation .....                                           | 98         |
| 4.4 Booster Fans .....                                                  | 99         |
| 4.5 Primary Ventilation Systems—Non-ferrous Metal Mines .....           | 99         |
| 4.5.1 Air Volumes .....                                                 | 100        |
| 4.5.2 Method of Mechanical Ventilation .....                            | 101        |
| 4.6 Ventilation for Environmental Control—Non-ferrous Metal Mines ..... | 101        |
| 4.6.1 Health and Nuisance Considerations .....                          | 101        |
| 4.6.2 Dust Characteristics .....                                        | 102        |
| 4.6.3 Assessment of Air Conditions .....                                | 102        |
| 4.6.4 Survey Procedure .....                                            | 103        |
| 4.6.5 Dust-sampling Instruments .....                                   | 103        |
| 4.6.6 Dust-control Techniques .....                                     | 104        |
| Professional Terms .....                                                | 113        |
| Exercises .....                                                         | 113        |
| <b>5 Rock Mechanics .....</b>                                           | <b>114</b> |
| 5.1 Rock and Rock Mechanics .....                                       | 114        |
| 5.2 Identification and Classification of Rock .....                     | 114        |
| 5.2.1 Intact Rock .....                                                 | 114        |
| 5.2.2 In-situ Rock .....                                                | 115        |
| 5.3 Mechanical Properties and Behavior of Rock .....                    | 116        |
| 5.4 Strength and Fracture Mechanics .....                               | 118        |
| 5.4.1 Limiting States of Stress .....                                   | 118        |
| 5.4.2 Mechanics of Brittle Fracture .....                               | 121        |

|        |                                                                                                                                                                               |     |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 5.5    | Stress in Rock .....                                                                                                                                                          | 123 |
| 5.6    | Mechanical Property Tests .....                                                                                                                                               | 126 |
| 5.6.1  | Definitions and Concepts .....                                                                                                                                                | 126 |
| 5.6.2  | Laboratory Instrumentation .....                                                                                                                                              | 127 |
| 5.7    | Instrumentation and Procedures for Field Tests .....                                                                                                                          | 128 |
| 5.7.1  | Instruments for Visual or Photographic Observations in Boreholes .....                                                                                                        | 128 |
| 5.7.2  | Instruments for Measuring Deformation .....                                                                                                                                   | 129 |
| 5.7.3  | In-situ Stress Determination .....                                                                                                                                            | 130 |
| 5.8    | Heat-transfer Model of High-temperature Non-ferrous Metal Mine<br>Stopes and Its Solution .....                                                                               | 131 |
| 5.8.1  | Introduction .....                                                                                                                                                            | 131 |
| 5.8.2  | Heat-transfer Model of High-temperature Non-ferrous Metal Mine Stopes .....                                                                                                   | 132 |
| 5.8.3  | Differential Equation of Rock Heat-transfer .....                                                                                                                             | 132 |
| 5.8.4  | Rock Heat-transfer in High-temperature Non-ferrous Metal Mine<br>Stopes Due to Spontaneous Combustion of Ore .....                                                            | 134 |
| 5.9    | 3D Simulating Analysis of a High-temperature Non-ferrous Metal Mine<br>Stope Reinforced in Advance with Grouted Cable Bolts by<br>Using ANSYS Software .....                  | 136 |
| 5.9.1  | Introduction .....                                                                                                                                                            | 136 |
| 5.9.2  | Simulating Limits .....                                                                                                                                                       | 137 |
| 5.9.3  | Model Selection .....                                                                                                                                                         | 137 |
| 5.9.4  | Mechanical Parameters of ANSYS Analysis .....                                                                                                                                 | 138 |
| 5.9.5  | Establishing Models .....                                                                                                                                                     | 139 |
| 5.9.6  | Meshing Models .....                                                                                                                                                          | 139 |
| 5.9.7  | Loading .....                                                                                                                                                                 | 140 |
| 5.9.8  | Solving Results .....                                                                                                                                                         | 140 |
| 5.9.9  | Analyzing the Results .....                                                                                                                                                   | 142 |
| 5.10   | Rock Anchoring Mechanism in High-temperature Non-ferrous<br>Metal Mine Stopes—Theory of Swelling-rising Concrete Arch with<br>Tree-root-shaped Cable Bolt Reinforcement ..... | 142 |
| 5.10.1 | Model of “Theory of Swelling-rising Concrete Arch with Tree-root-shaped<br>Cable Bolt Reinforcement” .....                                                                    | 142 |
| 5.10.2 | Main Viewpoints of “Theory of Swelling-rising Concrete Arch with<br>Tree-root-shaped Cable Bolt Reinforcement” .....                                                          | 144 |
|        | Professional Terms .....                                                                                                                                                      | 145 |
|        | Exercises .....                                                                                                                                                               | 146 |
| 6      | Mining Methods of Non-ferrous Metal Deposits .....                                                                                                                            | 147 |
| 6.1    | Mining Method Selection .....                                                                                                                                                 | 147 |

|       |                                               |            |
|-------|-----------------------------------------------|------------|
| 6.1.1 | Classification of Deposits and Rock .....     | 147        |
| 6.1.2 | Selection of Underground Mining Methods ..... | 148        |
| 6.1.3 | Selection of Surface Mining Methods .....     | 163        |
| 6.2   | Underground Mining .....                      | 169        |
| 6.2.1 | Shrinkage Stopping .....                      | 169        |
| 6.2.2 | Sublevel Caving .....                         | 175        |
| 6.2.3 | Filled Stopes .....                           | 183        |
| 6.3   | Surface Mining .....                          | 187        |
| 6.3.1 | Drilling Machines .....                       | 187        |
| 6.3.2 | Excavation and Loading .....                  | 196        |
| 6.3.3 | Open-pit Copper Mining .....                  | 204        |
|       | Professional Terms .....                      | 228        |
|       | Exercises .....                               | 229        |
|       | <b>References</b> .....                       | <b>230</b> |

# 目 录

|                            |           |
|----------------------------|-----------|
| <b>1 采矿和有色金属矿床简介 .....</b> | <b>1</b>  |
| 1.1 采矿的作用 .....            | 1         |
| 1.1.1 矿物、岩石和矿石 .....       | 1         |
| 1.1.2 采矿专业术语 .....         | 2         |
| 1.1.3 采矿与人类文明 .....        | 4         |
| 1.1.4 采矿技术的发展 .....        | 6         |
| 1.1.5 人、技术与矿物经济学 .....     | 9         |
| 1.1.6 在采矿过程中保护资源 .....     | 12        |
| 1.1.7 采矿对环境的影响 .....       | 13        |
| 1.1.8 采矿的未来 .....          | 13        |
| 1.2 有色金属矿床 .....           | 14        |
| 1.2.1 有色金属 .....           | 14        |
| 1.2.2 有色金属矿床与矿石 .....      | 15        |
| 1.2.3 矿床的技术含义 .....        | 18        |
| 1.2.4 有用矿物回收方法 .....       | 19        |
| 1.2.5 矿床评价与矿物资源 .....      | 20        |
| 1.3 中国有色金属工业 .....         | 24        |
| 1.3.1 简介 .....             | 24        |
| 1.3.2 中国有色金属工业现状与未来 .....  | 32        |
| 专业术语 .....                 | 35        |
| 复习思考题 .....                | 36        |
| <b>2 炸药与爆破 .....</b>       | <b>37</b> |
| 2.1 炸药反应特征 .....           | 37        |
| 2.2 炸药特性比较 .....           | 40        |
| 2.2.1 威力（猛度） .....         | 40        |
| 2.2.2 爆速 .....             | 40        |
| 2.2.3 密度 .....             | 41        |
| 2.2.4 爆炸压力和炮孔压力 .....      | 42        |
| 2.2.5 抗水性 .....            | 43        |
| 2.2.6 炮烟级别 .....           | 43        |
| 2.2.7 感度 .....             | 43        |

|                        |    |
|------------------------|----|
| 2.3 商品爆炸物 .....        | 44 |
| 2.3.1 硝化甘油基炸药 .....    | 45 |
| 2.3.2 硝化甘油 .....       | 46 |
| 2.3.3 正系硝甘炸药 .....     | 46 |
| 2.3.4 硝酸铵硝甘炸药 .....    | 46 |
| 2.3.5 低密度硝酸铵硝甘炸药 ..... | 46 |
| 2.3.6 胶质炸药 .....       | 47 |
| 2.3.7 正系胶质炸药 .....     | 47 |
| 2.3.8 硝酸铵胶质炸药 .....    | 47 |
| 2.3.9 半胶质炸药 .....      | 47 |
| 2.3.10 安全炸药 .....      | 47 |
| 2.3.11 压气破碎系统 .....    | 48 |
| 2.3.12 液氧炸药和黑火药 .....  | 48 |
| 2.3.13 干爆炸剂 .....      | 49 |
| 2.3.14 浆状(水胶)炸药 .....  | 50 |
| 2.4 爆破器材 .....         | 52 |
| 2.4.1 雷管 .....         | 52 |
| 2.4.2 导爆索 .....        | 52 |
| 2.4.3 起爆药包和传爆药包 .....  | 53 |
| 2.5 炸药价格 .....         | 53 |
| 2.6 炸药选用 .....         | 53 |
| 2.7 炮孔装药方法 .....       | 55 |
| 2.7.1 小直径炮孔装药 .....    | 55 |
| 2.7.2 大直径炮孔装药 .....    | 58 |
| 2.8 控制爆破技术 .....       | 59 |
| 2.8.1 密集空眼 .....       | 60 |
| 2.8.2 预裂爆破 .....       | 60 |
| 2.8.3 缓冲爆破 .....       | 61 |
| 2.8.4 光面爆破 .....       | 61 |
| 专业术语 .....             | 61 |
| 复习思考题 .....            | 62 |
| 3 有色金属矿山运输 .....       | 63 |
| 3.1 地下运输 .....         | 63 |
| 3.1.1 矿车与轨道 .....      | 63 |
| 3.1.2 铁路运输系统 .....     | 67 |
| 3.1.3 卡车与拖拉机拖车 .....   | 69 |
| 3.1.4 地下自卸设备 .....     | 71 |
| 3.1.5 人员运输 .....       | 75 |

|                          |            |
|--------------------------|------------|
| 3.2 地面运输 .....           | 80         |
| 3.2.1 铁路运输 .....         | 80         |
| 3.2.2 汽车运输 .....         | 88         |
| 专业术语 .....               | 93         |
| 复习思考题 .....              | 93         |
| <b>4 有色金属矿山通风 .....</b>  | <b>94</b>  |
| 4.1 井下大气 .....           | 94         |
| 4.1.1 通风的作用 .....        | 94         |
| 4.1.2 井下大气特性 .....       | 95         |
| 4.1.3 井下气体 .....         | 96         |
| 4.2 机械通风 .....           | 97         |
| 4.2.1 扇风机定律 .....        | 98         |
| 4.2.2 扇风机选择 .....        | 98         |
| 4.3 自然通风 .....           | 98         |
| 4.4 局扇 .....             | 99         |
| 4.5 有色金属矿山主要通风系统 .....   | 99         |
| 4.5.1 风量 .....           | 100        |
| 4.5.2 机械通风方法 .....       | 101        |
| 4.6 环境对有色金属矿山通风的要求 ..... | 101        |
| 4.6.1 健康与公害 .....        | 101        |
| 4.6.2 粉尘特点 .....         | 102        |
| 4.6.3 空气质量评价 .....       | 102        |
| 4.6.4 量测程序 .....         | 103        |
| 4.6.5 粉尘取样设备 .....       | 103        |
| 4.6.6 粉尘控制技术 .....       | 104        |
| 专业术语 .....               | 113        |
| 复习思考题 .....              | 113        |
| <b>5 岩石力学 .....</b>      | <b>114</b> |
| 5.1 岩石和岩石力学 .....        | 114        |
| 5.2 岩石的鉴定与分类 .....       | 114        |
| 5.2.1 完整岩石 .....         | 114        |
| 5.2.2 原岩 .....           | 115        |
| 5.3 岩石的力学性质与行为 .....     | 116        |
| 5.4 强度与断裂力学 .....        | 118        |
| 5.4.1 应力极限状态 .....       | 118        |
| 5.4.2 脆性断裂力学 .....       | 121        |
| 5.5 岩体应力 .....           | 123        |

|                                                         |            |
|---------------------------------------------------------|------------|
| 5.6 岩石力学性质试验 .....                                      | 126        |
| 5.6.1 定义和概念 .....                                       | 126        |
| 5.6.2 实验仪器 .....                                        | 127        |
| 5.7 现场测试方法与仪器 .....                                     | 128        |
| 5.7.1 钻孔可视仪器 .....                                      | 128        |
| 5.7.2 变形测量仪器 .....                                      | 129        |
| 5.7.3 地应力测定 .....                                       | 130        |
| 5.8 有色金属高温采场传热模型及其解法 .....                              | 131        |
| 5.8.1 引言 .....                                          | 131        |
| 5.8.2 有色金属高温采场传热模型 .....                                | 132        |
| 5.8.3 岩体热传导微分方程 .....                                   | 132        |
| 5.8.4 有色金属高温采场矿石自燃发火时围岩内的热传导 .....                      | 134        |
| 5.9 注浆长锚索预控顶有色金属高温采场 ANSYS 三维仿真分析 .....                 | 136        |
| 5.9.1 引言 .....                                          | 136        |
| 5.9.2 模拟岩层范围 .....                                      | 137        |
| 5.9.3 选择模型 .....                                        | 137        |
| 5.9.4 ANSYS 分析力学参数 .....                                | 138        |
| 5.9.5 创建模型 .....                                        | 139        |
| 5.9.6 划分网格 .....                                        | 139        |
| 5.9.7 加载 .....                                          | 140        |
| 5.9.8 求解结果 .....                                        | 140        |
| 5.9.9 结果分析 .....                                        | 142        |
| 5.10 有色金属高温采场岩体锚固机理——膨胀抬升锚索树根筋<br>混凝土拱理论（简称胀锚拱理论） ..... | 142        |
| 5.10.1 胀锚拱理论模型 .....                                    | 142        |
| 5.10.2 胀锚拱理论要点 .....                                    | 144        |
| 专业术语 .....                                              | 145        |
| 复习思考题 .....                                             | 146        |
| <b>6 有色金属矿床采矿方法 .....</b>                               | <b>147</b> |
| 6.1 采矿方法选择 .....                                        | 147        |
| 6.1.1 矿床和岩石分类 .....                                     | 147        |
| 6.1.2 地下采矿方法选择 .....                                    | 148        |
| 6.1.3 露天开采方法选择 .....                                    | 163        |
| 6.2 地下开采 .....                                          | 169        |
| 6.2.1 留矿采矿法 .....                                       | 169        |
| 6.2.2 分段崩落采矿法 .....                                     | 175        |
| 6.2.3 充填采矿法 .....                                       | 183        |
| 6.3 露天开采 .....                                          | 187        |

|                    |            |
|--------------------|------------|
| 6.3.1 露天钻机 .....   | 187        |
| 6.3.2 挖掘与装载 .....  | 196        |
| 6.3.3 露天铜矿开采 ..... | 204        |
| 专业术语 .....         | 228        |
| 复习思考题 .....        | 229        |
| <b>参考文献 .....</b>  | <b>230</b> |



## Introduction to Mining and Non-ferrous Metal Deposits

本章介绍一些采矿专业术语、有色金属矿床概念、采矿与人类文明、采矿对环境的影响、矿床评价与资源保护以及有用矿物回收方法，最后阐述中国有色金属工业的现状与未来。

### 1.1 Mining's Role

#### 1.1.1 Minerals, Rocks and Ore

In the year 1971, the number of known elements amounted to 104. Fifteen of these have been made only in the laboratory, others may have persisted from the primitive atmosphere, but, by and large, elements originated from magmas or igneous rocks of the outer rocky shell of the earth. Only eight elements constitute 98% by weight of the earth's crust. These are oxygen, 47%; silicon, 28%; aluminum, 8%; iron, 5%; and sodium, magnesium, potassium and calcium, less than 4% each. These common elements and the other less common ones are the building blocks of minerals, of which there are over 2000 varieties.

According to Webster: "A mineral is an inorganic substance occurring naturally in the earth and having a consistent and distinctive set of physical properties and a composition that can be expressed by a chemical formula. The term is sometimes applied to organic substances, such as coal." Thus, minerals are precise combinations of elements. Rocks, as distinct from minerals, are composed of assemblages of minerals.

When minerals are found in sufficient concentration to warrant extraction by mining, the mineralized area is considered an ore deposit. The definition of ore is mineral that can be extracted from the ground at a profit. The economic connotation is implicit in the word ore.

Since most of the useful elements compose such a small percentage of the earth's crust, the occurrence of ore deposits as we know them would not have transpired had not geologic processes concentrated the elements.

### 1.1.2 Professional Terms of Mining

Extensive coverage of the many descriptive terms used in mining may be found in a good mining glossary, such as is available from the Superintendent of Documents, but for convenience a number of the more common definitions are given here.

Mining may be defined, as by A. B. Cummins, as the act, process or work of extracting minerals or coal from their natural environment and transporting them to the point of processing or use. Mining techniques are applied to extracting metallic minerals, such as ores of gold, copper, lead or zinc; to fuels, such as coal, anthracite, lignite and tar sands; and to nonmetallic minerals, such as limestone, sand and gravel, clay and stone, sulfur and salt. These are just a few of the many minerals extracted by mining processes.

A mine, therefore, is an excavation made in the earth for the purpose of extracting minerals. Such excavations may be at the surface or underground, or both surface and underground methods may be employed.

The selection of mining methods is made to effect the most economic recovery of the minerals ( see Section 6.1 ). Formerly, the type of deposit and the physical characteristics of the deposit and the enclosing rocks were the dominant factors in selecting the mining method. Today, preservation of the environment can be equally important in determining the method.

Most base metal deposits are composed of several valuable minerals mixed with waste minerals called gangue. In mining, the objective is to extract as much of the valuable mineral as possible and leave behind the waste. The material coming from the mine, called ore, is naturally a combination of valuable minerals and gangue.

The ore, in the case of metallic deposits, usually is processed at the mine to concentrate the valuable mineral for shipment to the smelter or other refining facility. The gangue is discarded.

Nonmetallic deposits and fuels, unlike metalliferous deposits, contain more of the valuable mineral or element than of waste. Nonmetallic minerals, also called industrial minerals, are prepared at the mine into a finished product, or the prepared mineral may be shipped elsewhere for additional treatment before being marketed.

Coal usually is washed at the mine to remove to the maximum extent possible slate and other impurities, and then shipped to the power plant, coke ovens or other consumer. A modern development is the construction of power plants at the mine, which have become known as “mine mouth power plants.”

There are several types of surface mines. In an open-pit mine, an excavation open to the surface is dug to extract metallic ores ( see Section 6.3 ). In the typical open pit, digging progresses in terraces. In a strip mine, the overlying surface material ( called spoil, overburden or waste ) is removed to expose a coal bed for digging. A quarry is an excavation for extracting stone, sand or gravel. In a placer mine, the valuable material is found on the bedrock beneath gravel in stream beds, fossil stream beds or flood plains and is recovered by panning, hydraulicking or dredging. Seawater processing, wherein salt or magnesium is extracted by evaporation or chemical processing, although