

SEVENTH EDITION

# WILLS' Mineral Processing Technology

# 矿物加工技术

(影印版)

AN INTRODUCTION TO THE PRACTICAL ASPECTS  
OF ORE TREATMENT AND MINERAL RECOVERY

B.A. Wills • T.J. Napier-Munn and staff of the

**JKMRC**  
Julius Kruttschnitt  
Mineral Research Centre

 THE UNIVERSITY  
OF QUEENSLAND  
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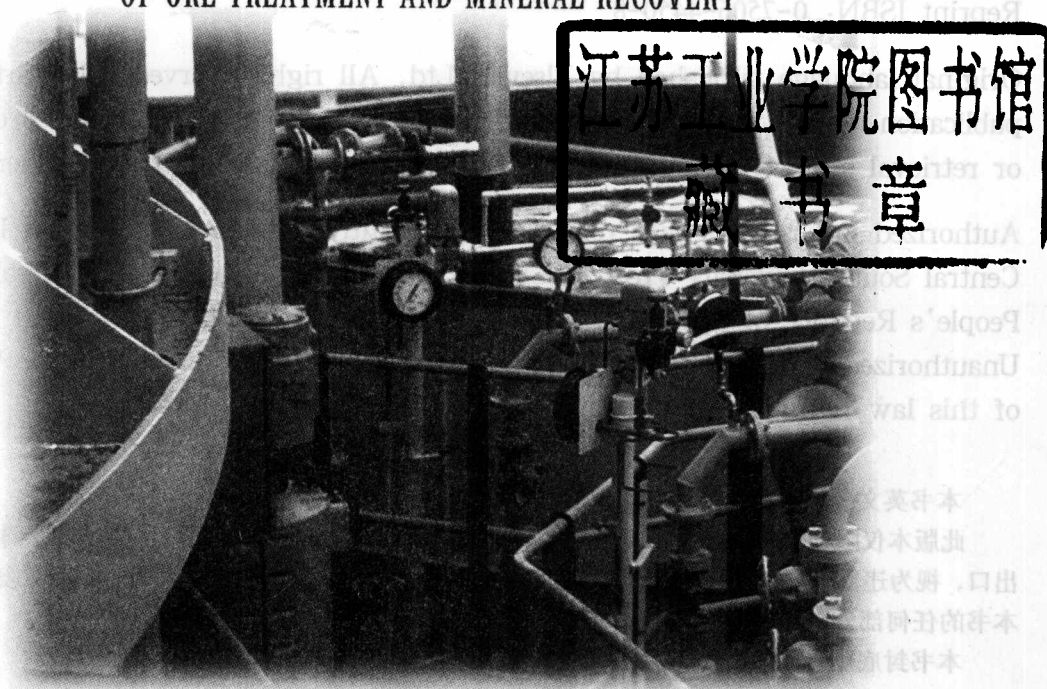
内容简介

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B. A. Wills T. J. Napier – Munn

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## 内 容 简 介

本书是使用最广泛的英文版矿物加工教材, 介绍了矿石处理与矿物回收的实用技术, 历经 30 余年已出版七版。全书共 16 章, 主要涉及矿石与矿物加工关系的一般介绍、选前处理、取样及在线分析和过程控制、粒度分析、粉碎及破磨设备、筛分与分级、重力和重介质分选、浮选、磁选和电选、脱水和尾矿处理等内容。既包含了经典的矿物加工技术, 也介绍了矿物加工最新技术和设备。

全书在对原理进行阐述的基础上, 辅以实际应用的例子, 同时配有丰富的插图以帮助理解文章内容。书中英文句法工整, 适合具有一般英文水平的专业技术人员阅读, 可作为矿物加工专业技术人员的参考书和相关专业学生全面了解专业知识的教材。

B.A.Wills, T.J.Napier-Munn

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# Wills' Mineral Processing Technology

# Wills' Mineral Processing Technology

## An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery

Seventh Edition

Barry A. Wills

*Revised by*  
Staff of the Julius Kruttschnitt Mineral Research Centre  
*The University of Queensland*

*Editor*

Tim Napier-Munn



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# Preface to 7th Edition

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Although mining is a conservative industry, economic drivers continue to encourage innovation and technological change. In mineral processing, equipment vendors, researchers and the operations themselves work to develop technologies that are more efficient, of lower cost and more sustainable than their predecessors. The results are apparent in new equipment and new operating practice. Any textbook needs to reflect these changes, and Barry Wills' classic is no exception.

It is nearly 30 years since *Mineral Processing Technology* was first published, and it has become the most widely used English-language textbook of its kind. The sixth edition appeared in 1997 and Barry and his publishers felt that it was again time to bring the text up to date. They approached the Julius Kruttschnitt Mineral Research Centre at the University of Queensland to take on the challenging task. My colleagues and I agreed to do so with some trepidation. The book's well-deserved reputation and utility were at stake, and the magnitude of the task was clear. Revising someone else's text is not an easy thing to do successfully, and there was a real danger of throwing the baby out with the bath water.

The value of *Mineral Processing Technology* lies in its clear exposition of the principles and practice of mineral processing, with examples taken from practice. It has found favour with students of mineral processing, those trained in other disciplines who have converted to mineral processing, and as a reference to current equipment and practice. It was important that its appeal to these different communities be preserved and if possible enhanced. We therefore adopted the following guidelines in revising the book.

The 7th edition is indeed a revision, not a complete re-write. This decision was based on the view that "if it ain't broke, don't fix it". Each diagram, flowsheet, reference or passage of text was considered as follows. If it reflected current knowledge and practice, it was left unchanged (or modestly updated where necessary). If it had been entirely superseded, it was removed unless some useful principle or piece of history was being illustrated. Where the introduction of new knowledge or practice was thought to be important to preserve the book's currency, this was done. As a consequence, some chapters remain relatively unscathed whereas others have experienced substantial changes.

A particular problem arose with the extensive references to particular machines, concentrators and flow-sheets. Where the point being illustrated remained valid, these were generally retained in the interest of minimising changes to the structure of the book. Where they were clearly out of date in a misleading sense and/or where alternative developments had attained the status of current practice, new material was added.

It is perhaps a measure of Barry Wills' original achievement that it has taken more than a dozen people to prepare this latest edition. I would like to acknowledge my gratitude to my colleagues at the JKMRRC and elsewhere, listed below, for subscribing their knowledge, experience and valuable time to this good cause; doing so has not been easy. Each chapter was handled by a particular individual with expertise in the topic (several individuals in the case of the larger chapters). I must also thank the editorial staff at Elsevier, especially Miranda Turner and Helen Eaton, for their support and patience, and Barry Wills for his encouragement of the enterprise. My job was to contribute some of the chapters, to restrain some of the more idiosyncratic stylistic extravagancies, and to help make the whole thing happen. To misquote the great comic genius Spike Milligan: the last time I edited a book I swore I would never do another one. This is it.

Tim Napier-Munn  
December 2005

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## *Contributors*

## *Acknowledgements*

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# Introduction

## Minerals and ores

### Minerals

The forms in which metals are found in the crust of the earth and as sea-bed deposits depend on their reactivity with their environment, particularly with oxygen, sulphur, and carbon dioxide. Gold and platinum metals are found principally in the *native* or metallic form. Silver, copper, and mercury are found native as well as in the form of sulphides, carbonates, and chlorides. The more reactive metals are always in compound form, such as the oxides and sulphides of iron and the oxides and silicates of aluminium and beryllium. The naturally occurring compounds are known as *minerals*, most of which have been given names according to their composition (e.g. galena – lead sulphide,  $\text{PbS}$ ; sphalerite – zinc sulphide,  $\text{ZnS}$ ; cassiterite – tin oxide,  $\text{SnO}_2$ ).

Minerals by definition are natural inorganic substances possessing definite chemical compositions and atomic structures. Some flexibility, however, is allowed in this definition. Many minerals exhibit *isomorphism*, where substitution of atoms within the crystal structure by similar atoms takes place without affecting the atomic structure. The mineral olivine, for example, has the chemical composition  $(\text{Mg}, \text{Fe})_2 \text{SiO}_4$ , but the ratio of Mg atoms to Fe atoms varies in different olivines. The total number of Mg and Fe atoms in all olivines, however, has the same ratio to that of the Si and O atoms. Minerals can also exhibit *polymorphism*, different minerals having the same chemical composition, but markedly different physical properties due to a difference in crystal structure. Thus, the two minerals graphite and diamond have exactly the same composition, being composed entirely of carbon atoms, but have widely different properties due to the arrangement of the carbon atoms within the crystal

lattice. The term “mineral” is often used in a much more extended sense to include anything of economic value which is extracted from the earth. Thus, coal, chalk, clay, and granite do not come within the definition of a mineral, although details of their production are usually included in national figures for mineral production. Such materials are, in fact, *rocks*, which are not homogeneous in chemical and physical composition, as are minerals, but generally consist of a variety of minerals and form large parts of the earth's crust. For instance, granite, which is one of the most abundant *igneous* rocks, i.e. a rock formed by cooling of molten material, or *magma*, within the earth's crust, is composed of three main mineral constituents, feldspar, quartz, and mica. These three homogeneous mineral components occur in varying proportions in different parts of the same granite mass.

Coals are not minerals in the geological sense, but a group of bedded rocks formed by the accumulation of vegetable matter. Most coal-seams were formed over 300 million years ago by the decomposition of vegetable matter from the dense tropical forests which covered certain areas of the earth. During the early formation of the coal-seams, the rotting vegetation formed thick beds of *peat*, an unconsolidated product of the decomposition of vegetation, found in marshes and bogs. This later became overlain with shales, sandstones, mud, and silt, and under the action of the increasing pressure and temperature and time, the peat-beds became altered, or *metamorphosed*, to produce the sedimentary rock known as coal. The degree of alteration is known as the *rank* of the coal, the lowest ranks (lignite or brown coal) showing little alteration, while the highest rank (anthracite) is almost pure graphite (carbon).