Bernd G. Lottermoser

Mine Wastes

Characterization, Treatment, Environmental Impacts

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Second Edition

With 70 Figures and 43 Tables

Springer

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Preface

This book is not designed to be an exhaustive work on mine wastes. It aims to serve undergraduate students who wish to gain an overview and an understanding of wastes produced in the *mineral industry*. An introductory textbook addressing the science of such wastes is not available to students despite the importance of the mineral industry as a resource, wealth and job provider. Also, the growing importance of the topics "*mine wastes*", "*mine site pollution*" and "*mine site rehabilitation*" in universities, research organizations and industry requires a textbook suitable for undergraduate students. Until recently, undergraduate earth science courses tended to follow rather classical lines, focused on the teaching of palaeontology, crystallography, mineralogy, petrology, stratigraphy, sedimentology, structural geology, and ore deposit geology. However, today and in the future, earth science teachers and students also need to be familiar with other subject areas. In particular, earth science curriculums need to address land and water degradation as well as rehabilitation issues. These topics are becoming more important to society, and an increasing number of earth science students are pursuing career paths in this sector. Mine site rehabilitation and mine waste science are examples of newly emerging disciplines.

This book has arisen out of teaching mine waste science to undergraduate and graduate science students and the frustration at having no appropriate text which documents the scientific fundamentals of such wastes. There are books which cover the principles and practices of environmental management at mine sites (Hutchison and Ellison 1992; Mulligan 1996) and the environmental impacts of mining (Ripley et al. 1996). There are also a number of books and reports addressing particular mine waste topics such as tailings (Ritcey 1989), sulfide oxidation (Alpers and Blowes 1994; Evangelou 1995), mine waters (Morin and Hutt 1997; Younger et al. 2002; Younger and Robins 2002), acid mine drainage (Skousen and Ziemkiewicz 1996), mine water treatment (Brown et al. 2002), and cyanide-bearing wastes (Mudder et al. 2001). Some of these books and reports, written for researchers or industry practitioners, contain a lot of useful theoretical or practical information. However, a single introductory text explaining the scientific principles of problematic mine wastes is still missing. This book aims to fill this gap and will thereby complement the existing literature. It has been written with undergraduate science, environmental science and engineering students in mind who have already gained a basic knowledge in chemistry and the earth sciences. Details of mineralogical and geochemical aspects have been deliberately omitted from this work as these are already covered by the existing literature. This book will be particularly of use to those students with a preliminary understanding of inorganic chemistry, hydrology, mineralogy, and geochemistry. Postgraduate students working on mine wastes are advised to consult the specialized literature.

I would like to express my appreciation to the many colleagues and students who fuelled my interest in wastes. Of all my colleagues I am most grateful to Associate Professor Paul Ashley (University of New England, Armidale, Australia) whose cooperation over the years has been so enjoyable and most stimulating. The funding and technical support for my research programs and those of my students came over the years from the Australian Research Council, Australian Institute of Nuclear Science and Engineering, Australasian Institute of Mining and Metallurgy Bicentennial Gold '88 Endowment Fund, Environment Australia, Deutsche Forschungsgemeinschaft, Alexander von Humboldt Foundation, University of New England, James Cook University, State Government agencies of New South Wales, South Australia and Queensland, and various private companies. An Alexander von Humboldt Fellowship made this book possible. Special thanks to Johanna for her professional editing, encouragement and understanding. To my family, especially my mother, Gisela and Hella – thank you for being there! To Gisela, thank you for an amazing trip to Greenland (Case Study 4.2). Finally, this book would not have happened at all without the initial suggestion by my father – dieses Buch ist für Dich.

Contents

Glossary

Table G.1. Standard International (SI) system of units

Physical quantity	Basic unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	Mole	mol

Table G.2. Derived and SI-related units

Physical quantity	Unit	Symbol / Conversion
Force	Newton	$N = kg\ m\ s^{-2}$
Energy, work, heat	Joule	$J = N\ m$
Electric potential	Volt	$V = J\ A^{-1}\ s^{-1}$
Conductance	Siemens	$S = A\ V^{-1}$
Specific conductance	Microsiemens per centimeter	$\mu S\ cm^{-1}$
Area	Hectare	$ha = 10^4\ m^2$
Liquid volume	Liter	$l = 10^{-3}\ m^3$
Solid volume	Cubic meters	m^3
Flow	Liters per second	$l\ s^{-1}$
Weight	Tonne (metric)	$t = 10^3\ kg$
Celsius temperature	Degree Celsius	$°C = K - 273.15$
Radioactivity	Curie	$Ci = 3.7 \times 10^{10}$ disintegrations s^{-1}

Table G.3. Weight-based concentrations

Unit	Symbol
Parts per billion	$ppb = \mu g\ kg^{-1}$
Parts per million	$ppm = mg\ kg^{-1}$
Weight percent	$wt.\% = (kg\ kg^{-1}) \times 100$

Table G.4. Volume-based concentrations

Unit	Symbol
Micrograms per liter	$\mu g\ l^{-1}$
Milligrams per liter	$mg\ l^{-1}$
Volume percent	vol.% = $(l\ l^{-1}) \times 100$

Table G.5. Prefixes to SI and derived SI units

Prefix	Symbol	Value
Mega-	M	10^{6}
Kilo-	k	10^{3}
Centi-	c	10^{-2}
Milli-	m	10^{-3}
Micro-	μ	10^{-6}
Nano-	n	10^{-9}
Pico-	p	10^{-12}

Table G.6. Abbreviations

(aq)	Aqueous
B.C.	Before Christ
ca.	Circa
cf.	Compare with
e.g.	For example
etc.	Et cetera
EC	Electrical conductivity
Eh	Oxidation potential relative to the standard hydrogen electrode
i.e.	That is
(g)	Gas
(l)	Liquid
REE	Rare earth elements: La to Lu
(s)	Solid
TDS	Total dissolved solids
UV	Ultraviolet radiation