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Review

Wastes in Underground Coal Mines and Their Behavior during Mine Water Level Rebound—A Review

Philip Mittelstädt, Nele Pollmann *, Lotfollah Karimzadeh, Holger Kories and Christoph Klinger

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Abstract: Backfill materials of various origin and composition, abandoned machinery, oils, PCB, gallery support material and cables are the main wastes occurring in underground coal mines during the period of their abandonment. Bearing in mind that under increasing societal pressure most if not all underground coal mines are going to close sooner rather than later, it is important to understand the interactions of these waste materials with rising mine water during mine water level rebound to prevent adverse environmental effects, especially on surface and groundwater. To this end, the composition of mine water at decant points as well as the hydrogeochemical, temporal and spatial dynamics of mine water during rebound requires quantification. In the first part of this paper, an overview of waste materials in underground coal mines is presented. The second part focusses on the experiences gained in the Ruhr area, a closed underground coal mining region in western Germany, where mine water rebound has been ongoing for decades. In this regard, the mine water modeling program Boxmodell was applied during regulatory approval procedures to predict the hydrodynamics and hydrogeochemical development of the water rebound. The results of these investigations allow deep insights into the interactions of rising mine water with wastes as well as the complex chemical evolution of mine water and potentially occurring contaminants (e.g., PCB). The experiences regarding wastes in underground coal mines and the geochemical evolution of rising mine water gained in the Ruhr area can be utilized to support the planning of mine closure in currently still active underground coal mining areas worldwide.

Keywords: coal mine; waste material; Boxmodell; reactive transport; mine water level rebound

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1. Introduction

Mining is finite, yet the consequences of mining may be enduring if they are not addressed with the necessary diligence. Both the mining method and the extracted material may have adverse environmental consequences, e.g., when coal is used as a fuel. Coal mining and the use of coal are therefore considered unattractive from a wider societal point of view, even when they are economically attractive in some cases. Consequently, many scientists and policy makers consider a (global) termination of coal mining [1,2].

Currently, approximately 3200 active coal mines exist worldwide, and more than 50% of these are underground operations [3]. From the analysis of 97 closed underground and open-cut coal mines in Europe, Gombert et al. [4] conclude that the quantitative influence of coal mine water discharges is "substantial" and that "evaluating their environmental impact on surface and underground water is important". Therefore, this article intends to shed light on the processes during mine water level rebound in underground coal mines, whereby an emphasis is set on the interaction of mine water with waste materials. In this regard, the Ruhr area, a closed underground coal mining region in western Germany, provides an exceptionally well-documented example. The results of investigations related to this topic since the early 1980s until today are presented. In the Ruhr area, it is estimated

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Mine Wastes Mine Wastes:

Mine Wastes Bernd Lottermoser,2010-07-09 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 imp tance 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 cryst lography 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 rehabili tion 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 scienti c fundamentals of such wastes *Towards a Sustainable Management of Mine Wastes* Mostafa Benzaazoua,Yassine Taha,2020-03-06 The need for efficient and sustainable management methods of mine waste is continuously growing all around the world These waste products often present serious management problems due to their more or less significant amounts and possible environmental threats This Special Issue highlights the recent and new trends in sustainable mine waste management techniques Currently it is essential to sustainably manage mine waste considering social economic environmental and technical aspects In this Special Issue insights related to the following issues are highlighted the problems around mine waste the fine characterization of mine waste the latest available technical and environmental solutions to efficiently manage mine waste including treatment and processing before disposal and high value element recovery with the view of moving towards defining effective low cost and ecofriendly methods the recycling of mine waste products as alternative resources in different sectors and finally laboratory pilot and or industrial scale studies related to these topics of research Scientists and industry and governance stakeholders have to face these new challenges to find the best management practices for the future **Mine Wastes** Bernd G. Lottermoser,2003 Today s best practice in environmental mine waste management requires a thorough understanding of the wastes produced The knowledge of mine wastes represents a new interdisciplinary science and this book provides an introductory descriptive and analytic overview of the wastes produced in the mineral industry It describes the characterization prediction monitoring disposal and treatment as well as environmental impacts Intended for undergraduate courses it systematically builds the reader s understanding and knowledge of the wastes produced their physical and

chemical characteristics and how to deal responsibly with them on a short and long term basis The text employs 16 case studies spanning the world s mineral industry that elucidate best practice and specific challenges in mine waste management and site rehabilitation Mine Wastes and Water, Ecological Engineering and Metals Extraction Margarete Kalin-Seidenfaden,William N. Wheeler,2022-02-03 The book reviews past and present mine waste management processes It estimates global water consumption by major mining resources per annum This consumption will lead land use resources agriculture and water to collide with mining interests expected in the near future With the application of novel metal extraction processes and the adoption of ecological engineering as an approach to waste and water management a reduction in water and land consumption can be achieved Using these methodologies would make mining more sustainable Together with ore and metal recycling mining methods can be brought into the 21st century The book describes natural weathering processes and the microbiology of extreme environments also known as mine sites The role of microbes in weathering and remediation is emphasized along with case studies of the enhancement of various ecological processes which curtail weathering and transform pollutants creating ore bodies of the future This book has been written as an extension to a contribution to the Oxford Research Encyclopedia It adds depth and many examples from 40 years of multidisciplinary work with experts from geology hydrogeology geomicrobiology and algal physiology and chemistry items too extensive for the Encyclopedia **Mine Wastes** Bernd Lottermoser,2010-07-11 **Mine Waste Management in China: Recent Development** Di Wu,2019-07-30 This book introduces recent development of technologies for mine waste management in China For hard rock mines the main mine wastes are tailings and the tailings can be disposed above ground and or underground The technology of consolidated tailings stockpile CTS that disposes tailings above ground is introduced and the application of this technology is also demonstrated Besides the technology of cemented tailings or paste backfill CTB or CPB which deals with tailings underground is also discussed The properties of CTB materials and the utilization of CTB technology are described and analyzed For coal mines the main mine wastes are coal gangue and fly ash The technology of cemented coal gangue fly ash backfill CGFB that manages coal mine waste underground is presented The THMC coupling properties of CGFB materials are investigated which can contribute to a better design of stable durable and environmentally friendly CGFB mixtures The application of CGFB technology in a coal mine is also presented This book which systematically reviews and discusses the development of mine waste management technologies in China is expected to provide readers comprehensive information about mine waste management *Towards a Sustainable Management of Mine Wastes: Reprocessing, Reuse, Revalorization and Repository* Mostafa Benzaazoua,Yassine Taha,2020 The need for efficient and sustainable management methods of mine waste is continuously growing all around the world These waste products often present serious management problems due to their more or less significant amounts and possible environmental threats This Special Issue highlights the recent and new trends in sustainable mine waste management techniques Currently it is

essential to sustainably manage mine waste considering social economic environmental and technical aspects In this Special Issue insights related to the following issues are highlighted the problems around mine waste the fine characterization of mine waste the latest available technical and environmental solutions to efficiently manage mine waste including treatment and processing before disposal and high value element recovery with the view of moving towards defining effective low cost and ecofriendly methods the recycling of mine waste products as alternative resources in different sectors and finally laboratory pilot and or industrial scale studies related to these topics of research Scientists and industry and governance stakeholders have to face these new challenges to find the best management practices for the future *Environmental Aspects of Mine Wastes* J. L. Jambor,David W. Blowes,A. Ian M. Ritchie,2003 *Mine Wastes* B. G. Lottermosser,2007

Mine Wastes Bernd Lottermoser,2013-04-18 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 or ganizations and industry requires a textbook suitable for undergraduate students Un til recently undergraduate earth science courses tended to follow rather dassicallines focused on the teaching of palaeontology crystallography mineralogy petrology stratigraphy sedimentology structural geology and ore deposit geology However to day 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 exam ples of newly emerging disciplines This book has arisen out of teaching mine waste science to undergraduate and gradu ate science students and the frustration at having no appropriate text which documents the scientific fundamentals of such wastes **Mine Tailings** Akira Otsuki,Adrian Keith R. Caamiño,Sibele Nascimento,2025-11-01 Mine Tailings Fundamental and Engineering Aspects of Colloidal Fine Mine Wastes offers an in depth examination of mine waste and related issues such as storage safety environmental impact water management and sustainability The book begins with a review of regulations and global standards for tailings management that is followed by an analysis of common types of tailings storage facilities The book delves into the behavior of tailings materials including particle interactions dispersion aggregation and the rheology of mineral suspensions It covers soil mechanics and toxic substance treatment as well as managing the closure and safety of mine waste management facilities Additionally it addresses the environmental social and governance factors essential for sustainable mining operations making it a valuable resource for those concerned with mine waste management This comprehensive text is crucial for researchers and engineers aiming to understand and mitigate the impacts of mine waste

Examines the fundamental aspects of mine tailings and their implications on the global mining industry as well as relevant new technologies Explores the characterization and evaluation of mine tailings behavior under different chemical and physical environments Provides in depth discussions on issues related to the environment energy water sustainability and the circular economy **Environmental Impact of Abandoned Mine Waste** Claudio Bini,2012 Since the dawn of civilisation until the last decades of the past century mining activity especially that concerning base and precious metals represented a resource for human population owing to its importance in many fields of interest By the second half of the last century however mining activity declined until final closure in the face of developing countries owing to decreasing mineral resources and to metal price drop In this book the effects of former mine activities and the related environmental problems are discussed with the ultimate goal of investigating the fate of potentially toxic elements in the environment and their impact on the conterminous land **Underground Disposal of Coal Mine Wastes** Study Committee to Assess the Feasibility of Returning Underground Coal Mine Wastes to the Mined-Out Areas,National Science Foundation (U.S.),1975 **Occurrence and Behaviour of Metals in Coal-mine Wastes of Central Scotland** A. J. Kimber,1982 *Mine Waste Management* Hutchison,Richard D. Ellison,1992-02-21 Mine Waste Management bridges the gap between mine operators regulators and design engineers concerned with the safe design and operation of mine waste management units It provides a comprehensive approach for determining the amount of engineered containment that needs to be provided to reduce the risk to water resources to acceptable levels The approach considers all pertinent aspects including the intrinsic properties of the waste as well as site specific conditions such as climate geology and distance to water resources Topics covered in Mine Waste Management include an evaluation of the performance of waste containment at modern mining operations the mine waste characterization disposal facility liner and closure designs ground water monitoring heap leach operations and an analysis of the cost impacts of mine waste disposal The material presented contains technical discussions and information as well as recommendations on how the technical issues can be accommodated in mine waste regulations The book is brimming with technical design charts tables and equations to provide hands on aid to designers Furthermore each chapter concludes with regulatory considerations that incorporate the proposed technical design approaches Mine Waste Management is a valuable resource for mining industry professionals regulators mine waste facility designers mine superintendents and managers consulting engineers and students in environmental engineering mining and metallurgy **The Environmental Impact of Mine Waste** Maria Ledin,Karsten Pedersen,Avfallsforskningsrådet,1995 *Underground Disposal of Coal Mine Wastes* Study Committee to Assess the Feasibility of Returning Underground Coal Mine Wastes to the Mined-Out Areas,1977

Sustainable Waste Management Practices for the Mining Sector Through Recycling of Mining Waste Suchismita Satapathy,Meghana Mishra,Manas R. Das,2024-11-20 Mining waste management is an important issue for the mining industry since it entails the safe and responsible disposal of waste created during mining operations This waste

comprises tailing waste rock and other mining wastes that if not adequately managed can pose environmental and health problems Effective waste management solutions are required to reduce the environmental impact of mining and preserve the long term viability of mining operations These initiatives include improving mining practices to reduce waste generation establishing effective waste treatment and disposal systems and participating in community outreach and education programme In recent years there has been a growing emphasis on the use of new mining waste management technologies and practices The adoption of modern filtration systems bio remediation techniques and the rehabilitation of abandoned mining sites are examples of these Overall good mining waste management is critical for guaranteeing the mining industry long term sustainability and protecting the environment and communities where mining operations take place Sustainable waste management is the implementation of practices and strategies that aim to minimize aim the negative impact of mining waste while promoting resource efficiency and long term economic viability it involves employing a thorough approach that considers the entire mining waste lifetime from generation to disposal and seeks to reduce waste generation reuse or recycle items and appropriately dispose of any remaining rubbish It attempts to extend the life of materials while reducing the waste volume that is incinerated or dumped in landfills To lessen the detrimental environmental economic social and effects in consumption a thorough approach to sustainable waste management must concentrate on the life cycle of a product Mining wastes can be categorized into overburden waste rock tailings and mine water During mineral extracted beneficiated and processed mining wastes are produced The first stage known as extraction which is the first layer sacking of minerals Typically blasting is used to do this which produces a significant amount of garbage soil debris and other material This is usually only concentrated within the periphery of a mine rental place and occasionally on public land and is useless to the industry The amount of waste produced increases with the size of the mine Because they produce far more trash than underground mines opencast mines are consequently more pollutant intensive Use of tailing waste of iron mines with clay for producing bricks can lead to consumption of large quantities of the waste materials and managing it in an environmentally friendly way On the other hand it can reduce consumption of top soil for making bricks and improve construction materials availability Similarly for preparation of ceramics and polymer composite these wastes can be used which will help in solving social environmental problem Mine Waste Hydrogeochemistry D. Kirk Nordstrom,David Blowes,Carol Ptacek,Ian Ritchie,Heather Jamieson,Rob Bowell,2021-06-01 Mine Waste Hydrogeochemistry covers all the fundamental properties and principles associated with metal mining and coal mining wastes their environmental consequences and their remediation It provides a solid scientific basis for planning and managing solid and liquid wastes from mining activities which will inform students researchers engineers and mine managers The degradation of air quality water quality and soil and sediment quality from mining activities involves complex processes involving physics chemistry microbiology fluid dynamics and mineralogy and mineral processing This subject matter is complex and requires technical skill in laboratory work field work and

theoretical calculations This book provides the most up to date synthesis of the numerous papers and studies on this subject available in one book for students instructors consultants and researchers Mine Waste Hydrogeochemistry is intended to fill that void Covers the basic scientific principles necessary to understand mine waste contamination Includes real world examples of remediation activities and their successes and failures Synthesizes information gained from hundreds of studies including tailings and waste piles worldwide stream and river studies affected by mine drainage and mineralogical characterization combined with water compositions **Tailings and Mine Waste '08** The Organizing Committee of the 12th International Conference on Tailings and Mine Waste,2008-11-17 Tailings and Mine Waste08 contains papers from the twelfth annual Tailings and Mine Waste Conference held by Colorado State University of Fort Collins Colorado The purpose of this series of conferences is to provide a forum for discussion and establishment of dialogue among all people in the mining industry and environmental community regardin

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