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## **Rare Earth Elements** - Volker Zepf 2013-02-14

This thesis deals with Rare Earth Elements (REE), especially with neodymium used in permanent magnets, from a very scientific basis by providing basic research data. Despite the fact that REE are newsworthy and very important elements for a considerable bandwidth of today's technologies, accompanied by the monopolistic supply-situation and Chinese politics, there are inexplicable data discrepancies about REE which have been recognized frequently but usually have not been addressed accordingly. So this analysis started with the hypothesis that the four application areas, namely computer hard disk drives (HDD), mobile phones, wind turbines and e-mobility (automotive traction), account for about 80% of the global annual neodymium-demand. The research methodology was a laboratory analysis of the composition of used magnets for HDDs and mobile phones and a literature and official report analysis of wind turbine and automotive neodymium use. The result was amazing and the hypothesis had to be withdrawn as these four areas only account for about 20% of neodymium use. This result raises some questions concerning actual use and thus potential recycling options.

*The Rare-earth Elements and Their Compounds* - Don M. Yost 1947

## **Handbook on the Physics and Chemistry of Rare Earths** - J.-C. G. Bunzli 2013-09-28

The rare earths represent a group of chemical elements, the lanthanides, together with scandium and yttrium, which exhibit similar chemical properties. They are strategically important to developed and developing nations because they have several applications in catalysis, the defense industry, aerospace, the materials and life sciences and in sustainable energy technologies. The Handbook on the Physics and Chemistry of the Rare Earths is a continuing authoritative series that deals with the science and technology of the rare earth elements in an integrated manner. Each chapter is a comprehensive, up-to-date, critical review of a particular segment of the field. The work offers the researcher and graduate student a complete and thorough coverage of this fascinating field. Individual chapters are comprehensive, broad, critical reviews Contributions are written by highly experienced, invited experts Gives an up-to-date overview of developments in the field

*Critical Mineral Resources of the United States* - K. J. Schulz 2017

As the importance and dependence of specific mineral commodities increase, so does concern about their supply. The United States is currently 100 percent reliant on foreign sources for 20 mineral commodities and imports the majority of its supply of more than 50 mineral commodities. Mineral commodities that have important uses and face potential supply disruption are critical to American economic and national security. However, a mineral commodity's importance and the nature of its supply chain can change with time; a

mineral commodity that may not have been considered critical 25 years ago may be critical today, and one considered critical today may not be so in the future. The U.S. Geological Survey has produced this volume to describe a select group of mineral commodities currently critical to our economy and security. For each mineral commodity covered, the authors provide a comprehensive look at (1) the commodity's use; (2) the geology and global distribution of the mineral deposit types that account for the present and possible future supply of the commodity; (3) the current status of production, reserves, and resources in the United States and globally; and (4) environmental considerations related to the commodity's production from different types of mineral deposits. The volume describes U.S. critical mineral resources in a global context, for no country can be self-sufficient for all its mineral commodity needs, and the United States will always rely on global mineral commodity supply chains. This volume provides the scientific understanding of critical mineral resources required for informed decisionmaking by those responsible for ensuring that the United States has a secure and sustainable supply of mineral commodities.

## **New Features on Magnesium Alloys** - Waldemar Alfredo Monteiro 2012-07-11

Magnesium alloys have been attractive to designers due to their low density (two thirds that of aluminium), the sixth most abundant on earth, is ductile and the most machinable of all the metals. This has been a major factor in the widespread use of magnesium alloy castings and wrought products, powder metallurgy components, sacrificial anodes for the protection of other metals, tools. The present book, "New Features on Magnesium Alloys", gives us an overview in some special areas of magnesium alloys concerning technological applications and eco-friendly requirements. Each chapter brings us a new facet relating to the magnesium alloy application: magnesium alloys quasicrystals used to magnesium alloys reinforcement; rare earth metals as alloying components in magnesium implants for orthopaedic applications; magnesium alloys surface treatment by applying physical vapor deposition processes; casting magnesium alloys subjected to laser treatment; ductility enhancement on special magnesium alloys; welding and joining processing of magnesium alloys; transport application of magnesium and its alloys.

## **Rare Earth Frontiers** - Julie Michelle Klinger 2018-01-15

Owing to their unique magnetic, phosphorescent, and catalytic properties, rare earths are the elements that make possible everything from the miniaturization of electronics, to the enabling of green energy and medical technologies, to supporting essential telecommunications and defense systems. An iPhone uses eight rare earths for everything from its colored screen, to its speakers, to the miniaturization of the phone's circuitry. On the periodic table rare earth elements comprise a set of seventeen chemical elements (the fifteen lanthanides plus scandium and yttrium). There would be no Pokémon Go without rare earths. Rare Earth Frontiers is a work of human geography. Klinger looks historically and geographically at the

ways rare earth elements in three discrete but representative and contested sites are given meaning.

China and the Geopolitics of Rare Earths - Sophia Kalantzakos 2018

Resource competition, mineral scarcity, and economic statecraft -- What are rare earths? -- Salt and oil : strategic parallels -- How China came to dominate the rare earth industry

Rare Earth Minerals - A.P. Jones 1995-12-31

30% discount for members of The Mineralogical Society of Britain and Ireland Rare Earth Minerals presents a current overview of this geologically and industrially important group of minerals. It presents a wide variety of formats, crystal structures, petrographic descriptions, analytical data and numerous illustrations from outcrop photos to SEM pictures and crystallographic models.

**Rare Earth Elements** - Volker Zepf 2013-03-04

This book deals with Rare Earth Elements, applying basic research data on neodymium used in permanent magnets. Surprisingly, analysis showed that hard drives, mobile phones, wind turbines and e-mobility account for much less use of neodymium than supposed.

Extractive Metallurgy of Rare Earths - Nagaiyar Krishnamurthy 2004-12-20

Extractive Metallurgy of Rare Earths compiles information from scattered sources that is often available only to specialists. It provides a complete and usable survey of the rare earth resources, extraction, and production of numerous end products that translates to both laboratory and industrial settings. This book is a source of industry expertis

Rare Earth - Peter D. Ward 2007-05-08

What determines whether complex life will arise on a planet, or even any life at all? Questions such as these are investigated in this groundbreaking book. In doing so, the authors synthesize information from astronomy, biology, and paleontology, and apply it to what we know about the rise of life on Earth and to what could possibly happen elsewhere in the universe. Everyone who has been thrilled by the recent discoveries of extrasolar planets and the indications of life on Mars and the Jovian moon Europa will be fascinated by Rare Earth, and its implications for those who look to the heavens for companionship.

**Rare Earth Chemistry** - Rainer Pöttgen 2020-10-26

This work introduces into the chemistry, materials science and technology of Rare Earth Elements. The chapters by experienced lecturers describe comprehensively the recent studies of their characteristics, properties and applications in functional materials. Due to the broad range of covered topics as hydrogen storage materials, LEDs or permanent magnets this work gives an up-to-date presentation of this fascinating research.

**Rare Earth Elements and Their Minerals** - Michael Aide 2020-06-17

This book describes the recent evolution of rare earth elements and their mineralogy, both natural and synthetic analogues. Authors review and document rare earth element chemistry in the aqueous environment and the petrology of the rare earth element-bearing mineral Allanite. Synthetic rare earth minerals and their applications is a rapidly evolving discipline important to medicine, advanced digital technologies, and solid-state physics. Authors report on the synthesis of a macrocyclic gadolinium complex and also gadolinium complexes and their applications in medicine. Authors present compelling advances in gadolinium isotopes and oxides as substrates for induced excitation and luminescent material sciences.

Element Recovery and Sustainability - Andrew J. Hunt 2013

Increased consumption of electronic equipment has brought with it a greater demand for rare earth elements and metals. Adding to this is the growth in low carbon technologies such as hybrid fuel vehicles. It is predicted that the global supply of rare earth elements could soon be exhausted. A sustainable approach to the use and recovery of rare earth elements is needed, and this book addresses the political, economic and research agendas concerning them. The problem is discussed thoroughly and a multi-disciplinary team of authors from the chemistry, engineering and biotechnology sectors presents a range of solutions, from traditional metallurgical methods to innovations in biotechnology. Case studies add value to the theory presented, and indirect targets for recovery, such as municipal waste and combustion ash are considered. This book will be essential reading for researchers in academia and industry tackling sustainable element recovery, as well as postgraduate students in chemistry, engineering and biotechnology. Environmental scientists and policy makers will also benefit from reading about potential benefits of recovery from waste

streams.

*Rare Earth Elements and Actinides* - Deborah A. Penchoff 2021

"Sponsored by the ACS Division of Nuclear Chemistry and Technology."

**Rare Earth and Critical Elements in Ore Deposits** - Philip L. Verplanck 2016

Critical Materials Strategy - Steven Chu 2011-05-01

This report examines the role of rare earth metals and other materials in the clean energy economy. It was prepared by the U.S. Department of Energy (DoE) based on data collected and research performed during 2010. In the report, DoE describes plans to: (1) develop its first integrated research agenda addressing critical materials, building on three technical workshops convened by the DoE during November and December 2010; (2) strengthen its capacity for information-gathering on this topic; and (3) work closely with international partners, including Japan and Europe, to reduce vulnerability to supply disruptions and address critical material needs. Charts and tables. This is a print on demand report.

*Rare Metal Technology 2015* - Neale Neelameggham 2016-12-01

This collection presents the papers from a symposium on extraction of rare metals as well as rare extraction processing techniques used in metal production. Paper topics include the extraction and processing of elements like antimony, arsenic, calcium, chromium, hafnium, gold, indium, lithium, molybdenum, niobium, rare earth metals, rhenium, scandium, selenium, silver, strontium, tantalum, tellurium, tin, tungsten, vanadium, and zirconium. Rare processing techniques presented include bio leaching, molecular recognition technology, recovery of valuable components of commodity metals such as magnesium from laterite process wastes, titanium from ilmenites, and rare metals from wastes such as phosphors and LCD monitors.

*Spectroscopic Properties of Rare Earths in Optical Materials* - Guokui Liu 2006-01-29

Aimed at researchers and graduate students, this book provides up-to-date information about the electronic interactions that impact the optical properties of rare earth ions in solids. Its goal is to establish a connection between fundamental principles and the materials properties of rare-earth activated luminescent and laser optical materials. The theoretical survey and introduction to spectroscopic properties covers electronic energy level structure, intensities of optical transitions, ion-phonon interactions, line broadening, and energy transfer and up-conversion. An important aspect of the book lies in its deep and detailed discussions of materials properties and the potential of new applications such as optical storage, information processing, nanophotonics, and molecular probes that have been identified in recent experimental studies. This volume will be a valuable reference book on advanced topics of rare earth spectroscopy and materials science.

**Separation Hydrometallurgy of Rare Earth Elements** - Jack Zhang 2016-02-10

This book describes in a comprehensive manner the technical aspects of separation of rare earth elements into individual elements for industrial and commercial use. The authors include details on and differentiate among the effective separation of rare earth elements for various parts of the world. They introduce new applications of separation of rare earth elements from concentrates of diverse ore types.

**Rare Earth Elements** - Gordon Haxel 2002

*The Rare Earth Elements* - J.H.L. Voncken 2015-12-24

This book deals with the rare earth elements (REE), which are a series of 17 transition metals: scandium, yttrium and the lanthanide series of elements (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium). They are relatively unknown to the wider public, despite their numerous applications and their critical role in many high-tech applications, such as high-temperature superconductors, phosphors (for energy-saving lamps, flat-screen monitors and flat-screen televisions), rechargeable batteries (household and automotive), very strong permanent magnets (used for instance in wind turbines and hard-disk drives), or even in a medical MRI application. This book describes the history of their discovery, the major REE ore minerals and the major ore deposits that are presently being exploited (or are planned to be exploited in the very near future), the physical and chemical properties of REEs, the mineral processing of

REE concentrates and their extractive metallurgy, the applications of these elements, their economic aspects and the influential economical role of China, and finally the recycling of the REE, which is an emerging field.

**Episodes from the History of the Rare Earth Elements** - C. H. Evans 1996-07-31

This is the first volume devoted entirely to the fascinating history of the discovery of the rare earth elements. Part I, 'Discovery', describes how the isolation and characterization of each new rare earth element confronted chemists with unparalleled difficulties for over 150 years. In addition, these elements introduced particular problems for Mendeleev's periodic table. Study of the rare earths occupied the best chemical minds of the day, including such notables as Gadolin, Berzelius, Mosander, Hisinger, Klaproth, Urban, Auer von Welsbach and Crookes. An interesting inclusion in the present work is a first-hand account by Marinsky of the discovery of the last rare earth element to be identified: promethium. Taken together, these chapters show how chemical discovery is limited by technology and how priority disputes arise and are settled. Part II, 'Application', has chapters on both the industrial uses of the rare earths and their application to pharmacology and medicine, where gadolinium is now a standard contrast-enhancing agent for magnetic resonance imaging (MRI). There is also a contribution from the director of the China Rare Earth Information Centre, which is appropriate as China has the world's largest deposits of rare earth minerals. Today, rare earth elements have a number of important industrial applications including their use as colorants, X-ray phosphors, lasers and magnets. Their unique properties have been widely exploited in biological and biochemical research. They also find increasing application in medicine. Audience: This volume will be of interest to chemists and historians of science and technology.

Rare Earths Industry - Ismar Borges De Lima 2015-09-10

Rare Earths elements are composed of 15 chemical elements in the periodic table. Scandium and yttrium have similar properties, with mineral assemblages, and are therefore referred alike in the literature. Although abundant in the planet surface, the Rare Earths are not found in concentrated forms, thus making them economically valued as they are so challenging to obtain. *Rare Earths Industry: Technological, Economic and Environmental Implications* provides an interdisciplinary orientation to the topic of Rare Earths with a focus on technical, scientific, academic, economic, and environmental issues. Part I of book deals with the Rare Earths Reserves and Mining, Part II focuses on Rare Earths Processes and High-Tech Product Development, and Part III deals with Rare Earths Recycling Opportunities and Challenges. The chapters provide updated information and priceless analysis of the theme, and they seek to present the latest techniques, approaches, processes and technologies that can reduce the costs of compliance with environmental concerns in a way it is possible to anticipate and mitigate emerging problems. Discusses the influence of policy on Rare Earth Elements to help raise interest in developing strategies for management resource development and exploitation Global contributions will address solutions in countries that are high RE producers, including China, Brazil, Australia, and South China End of chapter critical summaries outline the technological, economic and environmental implications of rare earths reserves, exploration and market Provides a concise, but meaningful, geopolitical analysis of the current worldwide scenario and importance of rare earths exploration for governments, corporate groups, and local stakeholders

Rare-Earth Metal Recovery for Green Technologies - Rajesh Kumar Jyothi 2020-03-25

This book examines the development, use, extraction, and recovery of rare earth metals. Rare earth elements (REEs) occupy a key role in daily life in industrial applications. They are one of the critical elements for energy and sustainable growth. REEs are utilized in many modern electrical and electronic devices such as smart phones, computers, LED lights etc. Recovery of the REEs from secondary resources represents a way to meet the growing demand for electronic devices. Because of their rarity, utility, and importance, the recovery, utilization and recycling of rare earth metals is of utmost importance. This book presents both current methods of processing rare earths from primary and secondary sources and new, green routes for their isolation and purification. The book also addresses their utilization, re-use, reduction, and recycling policies that exist globally. Applications in metallurgy, magnets, ceramics, electronics, and chemical, optical, and nuclear technologies are discussed.

**Rare Earths** - Zhaosen Liu 2013

This book contains twelve chapters written by both senior scientists with international fame and young

researchers who have been working at the frontiers of related fields for some years. It covers a variety of the most active research areas in rare earths research in recent years. The first five chapters concern a few hot topics on lanthanum photonics and luminescence. The following two chapters probe the physics behind the phenomena, which some theoreticians may be interested in. The first one makes thorough studies on an exotic phenomena, valency fluctuation occurring in metallic perovskite compounds due to the joint influences by both Ce and Eu elements inside. The latter demonstrates, with an example, how a novel ab initio method can be employed to calculate crystal parameters more accurately and efficiently. The final five chapters focus on the researches aimed at finding new applications of rare earths in industry and high technology based on their magnetic, chemical and electrochemical properties, such as, the magnetocaloric effects and performance in magnetic refrigeration of a class of amorphous materials containing heavy rare earth elements; the mechanism and applicability for rare earths to replace chromates as corrosion inhibitors; studies employing a defect cluster model to understand local ordered defect structure formation in doped ceria, and the possibility of using it to optimize the rare earth dopant in ceria for the purpose of improving the ionic conductivity of fluorite oxides? and fabrication and characterization of new La-Mg-Ni electrode alloys by doping them with lanthanides to improve the electrochemical cycle stability and discharge capacity. The audience for this book includes theoretical and applied physicists, specialists in instrumentation (electronics), engineers (electronic, chemical engineering, and biotechnology), chemists and materials scientists in industry and academia.

**Rare Earths** - Jacques Lucas 2014-09-09

High-technology and environmental applications of the rare-earth elements (REE) have grown dramatically in diversity and importance over the past four decades. This book provides a scientific understanding of rare earth properties and uses, present and future. It also points the way to efficient recycle of the rare earths in end-of-use products and efficient use of rare earths in new products. Scientists and students will appreciate the book's approach to the availability, structure and properties of rare earths and how they have led to myriad critical uses, present and future. Experts should buy this book to get an integrated picture of production and use (present and future) of rare earths and the science behind this picture. This book will prove valuable to non-scientists as well in order to get an integrated picture of production and use of rare earths in the 21st Century, and the science behind this picture. Defines the chemical, physical and structural properties of rare earths. Gives the reader a basic understanding of what rare earths can do for us. Describes uses of each rare earth with chemical, physics, and structural explanations for the properties that underlie those uses. Allows the reader to understand how rare earths behave and why they are used in present applications and will be used in future applications. Explains to the reader where and how rare earths are found and produced and how they are best recycled to minimize environmental impact and energy and water consumption.

Spectrographic Analysis of Rare-earth Elements - L. Allan White 1959

**Rare Metal Technology 2020** - Gisele Azimi 2020-01-20

This collection presents papers from a symposium on extraction of rare metals as well as rare extraction processing techniques used in metal production. Rare metals include strategic metals that are in increasing demand and subject to supply risks. Metals represented include neodymium, dysprosium, scandium and others; platinum group metals including platinum, palladium, iridium, and others; battery related metals including lithium, cobalt, nickel, and aluminum; electronics-related materials including copper and gold; and refractory metals including titanium, niobium, zirconium, and hafnium. Other critical materials such as gallium, germanium, indium and silicon are also included. Papers cover various processing techniques, including but not limited to hydrometallurgy (solvent extraction, ion exchange, precipitation, and crystallization), electrometallurgy (electrorefining and electrowinning), pyrometallurgy, and aerometallurgy (supercritical fluid extraction). Contributions are focused on primary production as well as secondary production through urban mining and recycling to enable a circular economy. A useful resource for all involved in commodity metal production, irrespective of the major metal Provides knowledge of cross-application among industries Extraction and processing of rare metals that are the main building block of many emerging critical technologies have been receiving significant attention in recent years. The

technologies that rely on critical metals are prominent worldwide, and finding a way to extract and supply them effectively is highly desirable and beneficial.

The Rare Earths - Alice Virginia Petar 1935

**Rare Earth-Based Corrosion Inhibitors** - Maria Forsyth 2014-08-12

Corrosion inhibitors are an important method for minimizing corrosion; however traditional inhibitors such as chromates pose environmental problems. Rare earth metals provide an important, environmentally-friendly alternative. This book provides a comprehensive review of current research and examines how rare earth metals can be used to prevent corrosion and applied to protect metals in such industries as aerospace and construction. Chapter 1 begins by examining the important need to replace chromate, and then goes on to discuss the chemistry of the rare earth metals and their related compounds. Chapter 2 considers the techniques that can be used to identify corrosion inhibition mechanisms and to test the levels of protection offered to different metals by rare earth compounds. Subsequent chapters consider in more detail how rare earth elements can be used as corrosion inhibitors in different forms and for different metals. This includes discussion on the potential of rare earth elements for self-healing, tunable and multifunctional coatings. Finally, chapter 10 considers the cost and availability of the rare earths and the potential health and environmental risks associated with extracting them. Provides a review of current research and examines how rare earth metals can be used to prevent corrosion and applied to protect metals in such industries as aerospace and construction. Includes discussion on the potential of rare earth elements for self-healing, tunable and multifunctional coatings. Considers the cost and availability of the rare earths and the potential health and environmental risks associated with extracting them.

**Rare Earth Elements** - Marc Humphries 2010-11

Contents: (1) Intro.; (2) What are Rare Earth Elements (REE)?; (3) Major End Uses and Applications: Demand for REE; The Application of REE in National Defense; (4) Rare Earth Resources and Production Potential; Supply Chain Issues; Role of China; (5) Rare Earth Legislation in the 111th Congress: H.R. 4866, and S. 3521, the Rare Earths Supply-Chain Technology and Resources Transformation Act of 2010; H.R. 5136, the FY 2011 Nat. Defense Authorization Act; P.L. 111-84, the FY 2010 Nat. Defense Authorization Act; (6) Possible Policy Options: Authorize and Appropriate Funding for a USGS Assessment; Support and Encourage Greater Exploration for REE; Challenge China on Its Export Policy; Establish a Stockpile. Illustrations.

**Critical and Rare Earth Elements** - Abhilash 2019-11-11

This book is aimed to compile the distribution of rare earth elements in various resources with their processing from secondary resources. It includes details of various processes developed for extraction of rare earth elements from varied raw materials ranging from e-wastes, tailings, process wastes and residues. It emphasizes importance of processing of the secondary resources to assist environmental remediation of such untreated wastes and get finished products. It covers all aspects of rare metals and rare earth metals in one volume covering extraction, separation and recycling of secondary resources for extraction of these metals along with relevant case studies.

**Handbook of Rare Earth Elements** - Alfred Golloch 2017-04-24

The Handbook of Rare Earth Elements focuses on the essential role of modern instrumental analytics in the recycling, purification and analysis of rare earth elements. Due to their numerous applications, e.g. in novel magnetic materials for computer hardware, mobile phones and displays, rare earth elements have become a strategic and valuable resource. The detailed knowledge of rare earth element contents at every step of their life cycle is of great importance. This reference work was compiled with contribution from an international team of expert authors from Academia and Industry to present a comprehensive discussion on the state-of-the-art of rare earth element analysis for industrial and scientific purposes, recycling processes and purification of REEs from various sources. Written with Analytical Chemists, Inorganic Chemists, Spectroscopists as well as Industry Practitioners in mind, the Handbook of Rare Earth Elements is an indispensable reference for everyone working with rare earth elements.

**Hydrometallurgy of Rare Earths** - Dezhi Qi 2018-05-15

Hydrometallurgy of Rare Earths: Extraction and Separation provides the basic knowledge for rare earth

extraction and separation, including flow sheet selection criteria and related technology. The book includes the latest research findings on all rare earth separation processes, methods of controlling operation costs, and strategies that help lower wastewater and waste solid discharge. It discusses many real process parameters and actual situations in rare earth separation plants, also examining the basic principles, technologies, process parameters and advances and achievements in the area of rare earth extraction and separation. In addition, the book covers extraction separation theory as developed by Professor Guanxian Xu and Professor Chunhua Yan and the creative use of a computational simulation program to replace the bench scale and pilot plant tests and directly design rare earth extraction separation processes. Outlines the theory of solvent extraction and separation of rare earths (REs) Provides the necessary tools for a REs separation plant design Includes a unique simulation program for the calculation of all process parameters Includes Chinese nomenclature that is useful for identifying the various processes, also comparing it to the global literature

Rare Earth Element - Jose Edgar Alfonso Orjuela 2017-07-26

Rare earth elements have significant physical and chemical properties, which have been made indispensable in many magnetic, electronic, and optical applications. For instance, rare earth magnets have high magnetic intensity that can be retained at high temperatures, making them ideal for aerospace applications. Moreover, rare earth elements allow to fabricate faster, smaller, and lighter devices such as cell phones and hard drives. They are also important for in-ear headphones, microphones, loudspeakers, optical fibers, smartphones, and tablet computers. All these technological possibilities have made sure that the rare earth elements are part of the daily life. Therefore, this book has a main objective to let the readers know useful information about the rare earth elements that possibly allow development of the researches in different fields of science where the rare earth elements are used.

*Rare Earth Element Resources: Indian Context* - Yamuna Singh 2020-04-18

This volume presents a brief introduction to the Rare Earth Elements (REE) and their discovery, mineralogy, deposit types and applications. The book focusses on the aspects of both natural and industrial REE resources of India. It covers geological, structural, geochemical, petrological, mineralogical and genetic aspects of the natural deposits, and provides an account of the available industrial sources. The relative merits and potential of the several resources for future development and directions for inputs in REE exploration are discussed at the end of the monograph.

*Detection of Rare Earth Elements and Rare Earth Oxides with Hyperspectral Spectroscopy* - Nina Kristine Bösche 2015

The continuously increasing demand for rare earth elements in technical components of modern technologies, brings the detection of new deposits closer into the focus of global exploration. One promising method to globally map important deposits might be remote sensing, since it has been used for a wide range of mineral mapping in the past. This doctoral thesis investigates the capacity of hyperspectral remote sensing for the detection of rare earth element deposits. The definition and the realization of a fundamental database on the spectral characteristics of rare earth oxides, rare earth metals and rare earth element bearing materials formed the basis of this thesis. To investigate these characteristics in the field, hyperspectral images of four outcrops in Fen Complex, Norway, were collected in the near-field. A new methodology (named REEMAP) was developed to delineate rare earth element enriched zones. The main steps of REEMAP are: 1) multitemporal weighted averaging of multiple images covering the sample area; 2) sharpening the rare earth related signals using a Gaussian high pass deconvolution technique that is calibrated on the standard deviation of a Gaussian-bell shaped curve that represents by the full width of half maxima of the target absorption band; 3) mathematical modeling of the target absorption band and highlighting of rare earth elements. REEMAP was further adapted to different hyperspectral sensors (EO-1 Hyperion and EnMAP) and a new test site (Lofdal, Namibia). Additionally, the hyperspectral signatures of associated minerals were investigated to serve as proxy for the host rocks. Finally, the capacity and limitations of spectroscopic rare earth element detection approaches in general and of the REEMAP approach specifically were investigated and discussed. One result of this doctoral thesis is that eight rare earth oxides show robust absorption bands and, therefore, can be used for hyperspectral detection methods. Additionally, the spectral signatures of iron oxides, iron-bearing sulfates, calcite and kaolinite can

be used to detect metasomatic alteration zones and highlight the ore zone. One of the key results of this doctoral work is the developed REEMAP approach, which can be applied from near-field to space. The REEMAP approach enables rare earth element mapping especially for noisy images. Limiting factors are a low signal to noise ratio, a reduced spectral resolution, overlaying materials, atmospheric absorption residuals and non-optimal illumination conditions. Another key result of this doctoral thesis is the finding that the future hyperspectral EnMAP satellite (with its currently published specifications, June 2015) will be theoretically capable to detect absorption bands of erbium, dysprosium, holmium, neodymium and europium, thulium and samarium. This thesis presents a new methodology REEMAP that enables a spatially wide and rapid hyperspectral detection of rare earth elements in order to meet the demand for fast, extensive and efficient rare earth exploration (from near-field to space).

**Geochemistry and Mineralogy of Rare Earth Elements** - Bruce R. Lipin 2018-12-17

Volume 21 of Reviews in Mineralogy treats a short course on the rare earth elements to about 80 participants in San Francisco, California, December 1-3, 1989, just prior to the fall meeting of the American Geophysical Union. Contents: Cosmochemistry of the Rare Earth Elements: Condensation and Evaporation Processes Radiogenic Isotope Geochemistry of Rare Earth Elements Partitioning of Rare Earth Elements between Major Silicate Minerals and Basaltic Melts An Approach to Trace Element Modeling Using a Simple Igneous System as an Example Rare Earth Elements in Upper Mantle Rocks Rare Earth Elements in Metamorphic Rocks Rare Earth Elements in Sedimentary Rocks: Influence of Provenance and Sedimentary Processes Aqueous Geochemistry of Rare Earth Elements Rare Earth Elements in Lunar Materials Compositional and Phase Relations among Rare Earth Element Minerals Economic Geology of Rare Earth Minerals Cathodoluminescence Emission Spectra of Rare Earth Element Activators in Minerals Extraction of Rare-earth Elements from Bastnaesite Concentrate - Van E. Shaw 1959