Minerals in your life

EuroGeoSurveys
European Geological Data for Society

The Geological Surveys of Europe

Foreword

When people hear or see the word minerals, chances are that their first thoughts will be of food supplements. Many will know that minerals are important to us, but probably not exactly how, and certainly not to what extent.

Please have a look around you: most if not all objects you see will be made of or contain minerals. The walls of the building you are probably sitting in, the road outside, the telephone in your pocket. The car, bicycle, bus or train that may have brought you to where you are right now. Furthermore, if you are in your office or study: tens of substances that were derived and refined from minerals in the computer on your desk, and there are some in your pens, pencils, stapler and hole punch, and probably in the desk itself too. It takes minerals to bring you your water, electricity and gas. Even the page you are reading now contains mineral filler and the ink is mineral-based too!

Mart van Bracht
President
EuroGeoSurveys
The Geological Surveys of Europe

There is no end to the list. If we had no minerals, we would be back in the Stone Age… or actually to the age before, because stone is made of minerals too.

Miners say: "if it can't be grown it has to be mined." This is true, we get our minerals from the Earth. However, before a mineral is mined, it has to be found, and after mining it still takes a lot of work before a mineral is ready for use. There is a whole world behind minerals that we would like to introduce to you. This book will tell you about minerals in your daily life, which minerals we use for what, what they look like, and where and how we get them.

'MINERALS IN YOUR LIFE' has been produced by experts of the Geological Surveys of Europe; each chose a mineral that is typical of their country. I hope that you enjoy reading this book as much as we did putting it together.

Contents

Foreword 1
The cartoonists 5
Minerals in support of the EU economy 6
EuroGeoSurveys Mineral Resources Expert Group 8
Message from private sector 10

INTRODUCTION
The Earth as a resource 14
Classification of mineral resources 20
European Minerals Production 22

A DAY IN THE LIFE OF NORMAN 26
Copper 28
Kaolin 32
Zinc 36
Feldspar 40
Sepiolite 44
Bauxite 48
Dolomite 52
Graphite 56
Beryllium 60
Aggregate 64
Tungsten 68
Gypsum 72
Titanium 76
Lithium 80
Indium 84
Platinum 88
Gold 92
Germanium 96
Potash 100
Quartz sand 104
Moler (clayey diatomite) 108
Rare earth elements 112
Salt 116
Calcium carbonate 120
Talc 124
Baltic Amber (succinite) 128
Clay minerals 132
Iron 136
Nickel 140
Recycled aggregates 144

APPENDICES
Mineral deposits 148
Europe's mineral endowment 150
Environment and mining 154
Mineral Production in European Countries, 2007-2011 158
Common uses of major mineral raw materials 174
Glossary 176
Sources 192
Members 196

Editor EuroGeoSurveys
Authors EuroGeoSurveys Mineral Resources Expert Group
Design Simona Binni and Marcello Iozzoli
Project manager Claudia Delfini
Layout and production www.tango-grafix.be
Distribution EuroGeoSurveys – Brussels
Patron Minerals Intelligence Network for Europe - Minerals4EU - FP7Project

© 2014 by EuroGeoSurveys, Rue Joseph II, 36/38, 1000 Brussels, Belgium

All rights reserved. No part of this publication may be reproduced in any manner without permission.
All images are © the artists, reproduced with the kind permission of the artists and/or their representatives.

Photos by the courtesy of Christian Burlet and the Geological Survey of Belgium

ISBN 9789090281476

The cartoonists

The cartoonist

Simona Binni

was born in Rome on 30-10-1975. She attended Scuola Romana del Fumetto where studied 'illustration and comics'. She currently works as a comic artist with American publishers (GrayHaven Comics), illustrator and storyboard artist for publicity (Telecom Italia; Cloudpeople website); collaboration with "Nuct" (Scuola Internazionale di Cinema e Televisione) and "Brand Portal Agency".
http://simonabinni.blogspot.it

The colourist

Marcello Lozzoli

was born in Rome on 20-06-1987. In 2006, he began his first degree in Graphic Design and in October 2011 he graduated in «Visual Arts and Entertainment Painting» at The Academy of Fine Arts in Rome.
From 2010 to June 2013 he attended a course of Illustration and Comics at the SRF Roman School of Comics. In the same period he completed an online Master Class in Digital Painting from the Computer Graphics Master Academy (CGMA) based in Los Angeles, California.
His previous work includes the design for the cover of the Institute for Environmental Protection and Research's (ISPRA) publication «Forgotten Fruits and recovered biodiversity».
He actively collaborates, in Italy and abroad, with several publishers in digital colouring and in the creation of concept art for American video games.
http://marcelloiozzoli.blogspot.it

The photographer

Christian Burlet

is geologist at the Royal Belgian Institute of Natural Sciences - Geological Survey of Belgium (GSB). He graduated from the University of Liège in 2002. He works at the GSB on the mineralogy of cobalt ores and geo-materials (Democratic Republic of Congo).

The photographer thanks the Royal Belgian Institute of Natural Sciences for the access to their mineralogical collections, in particular Marleen deCeuckelaire, Tommy Dheuvart, Thierry Leduc and Sophie Decree.

Minerals in support of the EU economy

The Geological Surveys of Europe, through the Mineral Resources Expert Group of EuroGeoSurveys, and other partners including the key industrial players, are carrying out the Minerals4EU project that will provide until now the most extensive data and high-quality knowledge-based products on mineral resources and their utilization around Europe.

Minerals4EU is developing a permanent EU Mineral intelligence network and is designing a European Minerals Yearbook. It will also contribute to the design of the future European Geological Data Infrastructure.

The project will firstly establish the EU minerals intelligence network structure, comprising European minerals data providers and stakeholders, and transform this into a sustainable operational service.

In this way Minerals4EU will contribute to and support decision making on the policy and adaptation strategies of the European Commission.

The target is to integrate the best available mineral expertise and information based on the knowledge base of national Geological Surveys and other relevant stakeholders, in support of public policy-making, industry, society, communication and education purposes at European and international levels.

In particular, at the project completion, in 2016, the European Union citizens will benefit of tools and expertise to enhance and support resource efficiency, minerals supply security and sustainable mineral development for Europe.

EuroGeoSurveys Mineral Resources Expert Group

MEMBERS		
Nikos Arvanitidis	Chair, Sveriges Geologiska Undersökning	SGU
Daniel Cassard	Deputy Chair, Bureau de Recherches Géologiques et Minières	BRGM
Arben Pambuku	Albanian Geological Survey	AGS
Maria Heinrich	Geological Survey of Austria	GBA
Albert Schedl	Geological Survey of Austria	GBA
Sebastian Pfleider	Geological Survey of Austria	GBA
Christian Burlet	Geological Survey of Belgium – GSB	GSB
Miko Slobodan	Hrvatski geološki institut – Croatian Geological Survey	HGI_CGS
Christodoulos Hadjigeorgiou	Ministry of Agriculture, Natural Resources and Environment Geological Survey Department	GSD
Ivo Sitensly	Czech Geological Survey	CGS
Petr Rambousek	Czech Geological Survey	CGS
Karen Hanghøj	Geological Survey of Denmark and Greenland	GEUS
Jørgen Tulstrup	Geological Survey of Denmark and Greenland	GEUS
Diogo Rosa	Geological Survey of Denmark and Greenland	GEUS
Mare Kukk	Geological Survey of Estonia	EGK
Asko Käpyaho	Geological Survey of Finland	GTK
Raimo LAHTINEN	Geological Survey of Finland	GTK
Saku VUORI	Geological Survey of Finland	GTK
Patrice Christmann	Bureau de Recherches Géologiques et Minières	BRGM
Peter Buchholz	Bundesanstalt für Geowissenshaften und Rohstoffe	BGR
Henrike Sievers	Bundesanstalt für Geowissenshaften und Rohstoffe	BGR
Thomas Oberthür	Bundesanstalt für Geowissenshaften und Rohstoffe	BGR
Kostas Papavasileiou	National Center for Sustainable Development - Institute of Geology and Mineral Exploration - Greece	EKBAA - IGME
Kostas Laskaridis	National Center for Sustainable Development - Institute of Geology and Mineral Exploration - Greece	EKBAA - IGME
Annamaria Nador	Geological and Geological Institute of Hungary	MAFGI
Zoltán Horváth	Geological and Geological Institute of Hungary	MAFGI
Gerry Stanley	Geological Survey of Ireland	GSI
Mauro Lucarini	Istituto Superiore per la Protezione e la Ricerca Ambientale – Geological Survey of Italy	ISPRA
Juozas Mockevicius	Geological Survey of Lithuania	LGT
Charles Galea	Malta Resources Authority	MRA
Michael Schembri	Malta Resources Authority	MRA
Tom Heldal	Geological Survey of Norway	NGU
Jan Høst	Geological Survey of Norway	NGU
Schiellerup Henrik	Geological Survey of Norway	NGU
Rognvald Boyd	Geological Survey of Norway	NGU
Stanislaw Wolkowicz	Polish Geological Institute – National Research Institute	PGI - NRI
Stanislaw Mikulski	Polish Geological Institute – National Research Institute	PGI - NRI
Barbara Radwanek-Bak	Polish Geological Institute – National Research Institute	PGI - NRI
Janina wiszniewska	Polish Geological Institute – National Research Institute	PGI - NRI
Daniel Oliveira	Laboratório Nacional de Energia e Geologia	LNEG
Marian Munteanu	Geological Institute of Romania	GIR
Grigory Brekhov	A. P. Karpinsky All Russia Geological Research Institute	VSEGEI
Vitaly Shatov	A. P. Karpinsky All Russia Geological Research Institute	VSEGEI
Aleksey Sokolov	A. P. Karpinsky All Russia Geological Research Institute	VSEGEI
Boris Mikhailov	A. P. Karpinsky All Russia Geological Research Institute	VSEGEI
Peter Balaz	State Geological Institute of Dionyz Stur	SGUDS
Zoltan Nemeth	State Geological Institute of Dionyz Stur	SGUDS
Duška Rokavec	Geological Survey of Slovenia	GeoZS
Manuel Regueiro	Instituto Geologico y Minero de España	IGME
Juan Locutora	Instituto Geologico y Minero de España	IGME
Santiago Martin	Instituto Geologico y Minero de España	IGME
Lisbeth Hildebrand	Sveriges Geologiska Undersökning	SGU
Rainer Kündig	Bundesamt für Landestopografie, Landesgeologie	SWISSTOPO
Paul Bogaard	Geological Survey of the Netherlands	TNO
Michiel van der Meulen	Geological Survey of the Netherlands	TNO
Evi Petavratzi	British Geological Survey	BGS
Gus Gunn	British Geological Survey	BGS
Andrew Bloodworth	British Geological Survey	BGS
Boris Maliuk	State Geological and Subsurface Survey of Ukraine	SGSSU/UkrSGRI

Message from the private sector

EUROMETAUX
EUROPEAN ASSOCIATION OF METALS

Eurometaux is the European association of the non-ferrous metals industry. It is composed of a wide network of companies producing, transforming and recycling non-ferrous metals in Europe. Our members also include national federations, and European and International commodity associations. Our objective is to enable the entire value chain of the non-ferrous metals industry to prosper in the EU and contribute towards more sustainable societies.

Our industry contributes to a significant 2% of gross domestic product in the EU; it employs more than 400,000 people directly, and another 1,000,000 indirectly.

Durable and infinitely recyclable, metals are fundamental to all areas of a sustainable modern society: **transport** (aluminium for strength and lightness, zinc for corrosion protection, nickel & chromium for stainless steel) - **construction** (zinc, copper, lead) - **electronics**, **domestic**, **consumer goods** (computers, mobile phones) - **packaging** (aluminium and tin to keep food fresh, protect it from light & air, heat it rapidly) - **energy** (silver and copper conduct electricity; batteries - lead, lithium-ion, nickel-cadmium; solar cells - aluminium, silicon, cadmium, copper, indium - there is no renewable energy without non-ferrous metals) - **health & medicine** (essential trace elements include zinc, copper, manganese; lead screens protect from X-rays).

The European industry is the world leader in recycling non-ferrous metals.

Annick CARPENTIER - Sustainability Director

euromines

Euromines, representing the producers of 42 different raw materials in Europe provides a platform for the industry to discuss all matters arising from the extraction and use of mineral raw materials.

Raw materials are what our societies and our living standard is built on. Very often we take these materials and the products resulting from them for granted. However, with an ever-increasing population growth and the wish to ensure a sustainable standard of living for most people we need to ensure a sustainable supply of these raw materials. This is what the members of Euromines do on a daily basis and continue to improve continuously. Extraction and beneficiation of mineral raw materials is at the beginning of an important supply and value chain.

Thus is very much supporting this publication as it shows the relevance of raw materials in our all lives. Without these raw materials we would not be able to maintain our way of life whether it is with regard to food and medicine, transportation, infrastructure and buildings, and most consumer products.

Corina Hebestreit - Director

IMA Europe

The **European Industrial Minerals Association IMA-Europe**, brings together a number of European associations specific to individual minerals, currently: calcium carbonate, borates, sepiolite, andalusite, mica, vermiculite, bentonite, lime, feldspar, silica, talc, diatomite, kaolin and plastic clays. IMA-Europe's primary mission is to represent its members at European Union level. Promoting the interests of the industrial minerals industry on all non-commercial issues, IMA-Europe encourages a policy and regulatory framework that supports the sector's competitiveness in the EU.

The topics covered by the Association range from the properties and safe use of minerals to their extraction and processing through to their end-use applications. Health and safety at the workplace, environmental protection, product safety and awareness about the importance of industrial minerals for society are at the core of IMA Europe's priorities. One of the IMA-Europe missions is to inform the public at large of the importance of industrial minerals in our daily life: «Minerals, your world is made of them!». This book contributes, in a very original way, to raise awareness on the fact that not only our contemporary technologies and infrastructures, but also our greatest innovations for the future all rely on minerals. We invite the reader to discover the true wealth that minerals represent for our generation, and the next ones.

Michelle WYART-REMY - Director General

Message from the private sector

Since 1987, **UEPG - the European Aggregates Association**, has strongly promoted the interests of sand, gravel and crushed rock producers. This includes extraction of sand and gravel from the sea floor. We represent our Members (national associations and companies) on economic, technical, health & safety and environmental policies.

With more than 3 billion tonnes of aggregates production, 16,000 mostly small and family owned companies and around 25,000 extraction sites we are a huge sector of the non-energy extractive industry. As aggregates are used massively for the construction of houses, roads, rails and all kind of infrastructures and are bulky, transport distances do matter. This is why local access to resources is key to us.

Minerals are all around and you may think that is also the case for sand, gravel and rock. But sand from the Deserts cannot be used for construction.

We welcome and support the Initiative of EuroGeoSurveys 'Minerals In Your Life' to highlight the role played by minerals and to provide information which you may not have been aware of. We wish you a pleasant reading.

Arnaud Colson
UEPG President

European Federation of Geologists

Our modern society depends on minerals, as it has since pre-civilization. Because minerals are recovered from beneath the earth's surface, the work of geologists is vital to achieving sufficient and sustainable mineral supply. The European Federation of Geologists (EFG) promotes and supports excellence in the professional practice of geology in all applications, including the exploration for and exploitation of minerals. At EFG, we believe that, to tackle this challenge, scientific and technical excellence is not enough - we must involve everyone, from policy makers to ordinary people in achieving consensus in balancing the demand for minerals against the imperatives to limit damage to the environment and keep the public safe.

This book addresses this aim brilliantly, by showing on a simple way how minerals are present in our everyday life and how critical they are to a wide range of industries, from pharmaceuticals to electronics or civil construction.

EFG congratulates Eugeosurveys for this opportune initiative and I wish that you, reader, find this book as interesting and engaging as I did.

Isabel Fernandez
Executive Director of EFG (eurogeologists.eu)

The Earth as a resource

A day of minerals

We all use and depend on the earth's mineral resources. Minerals extracted from the earth underpin every aspect of our daily life including the food we eat, the homes we live in, the power we use, where we work and how we travel and communicate with others.

The importance of minerals in everyday life is however hardly recognized by the vast majority of people although the average person consumes in the EU and uses tens of tons of minerals every year. Day after day, from the early morning to the late evening, there will be many activities relied on, and likewise, many products consumed and used, containing minerals.

Turning on the electric light switch in the morning, for example, we need to use copper and aluminium products, whereas for coffee drinking, we use pots made of silica sand or feldspar. Taking a shower requires water supply pipes often made by copper, iron, nickel and chromium. Brushing our teeth with toothpaste we use calcium carbonate, phosphate, gypsum, fluorite and dolomite.

The car we drive on our way to work is composed of many different components that were manufactured from minerals. The tires use calcium carbonate and clay. The glass of the car windows are made from silica sand and feldspar. The engine is made out of iron, lead, molybdenum, chromium, nickel and zinc. Getting to the office and turning on the computer we use products manufactured from gold, silica, nickel, aluminium, zinc, iron and thirty other metals, all derived from minerals.

When coming home in the evening, by warming up our meal we use the microwave oven made from silica, copper, gold, iron and nickel. We enjoy our refreshments in a glass or ceramic mug of silica, calcium carbonate and feldspar, watching at the same time the television made of components using silica, iron, copper, aluminium and nickel.

The intention of this Book is to outline the many functions and uses minerals have in our daily lives. To get people to understand that most of the things and products meeting our needs are made of minerals.

What are minerals?

Minerals are naturally occurring substances that have distinctive chemical and physical properties. They are the building-blocks of the rocks that form the Earth. There are more than 4500 recognised minerals; some are very common whereas others are uncommon. Many minerals are used in society in a wide range of applications like construction, manufacturing, agriculture and energy supply. These minerals are called economic minerals.

Minerals are commonly distributed in the Earth's crust in small amounts. However when they are found in sufficient concentrations and in sufficient volumes they may form economically valuable resources, known as mineral deposits. These have formed by geological processes throughout Earth's history. In some places, e.g. at the mid-oceanic spreading ridges and near subduction zones, deposits with economic minerals are still being formed today.

Types of economic minerals

There are two main categories of minerals, Energy and Non-Energy Minerals (NEM). The latter are the subject of this book. In the context of this work and in line with the European Raw Materials Initiative, the non-energy minerals have been subdivided into three groups: metallic minerals, industrial minerals and construction minerals.

Metallic minerals are the normal sources of metals which have a wide variety of uses. For example, iron (in the form of steel) is used in cars or for frames of buildings, copper is used in electrical wiring, nickel is used in jet engines and aluminium is used in aircraft and to make drink cans. Precious metals, such as gold, are used in jewellery and electronics, e.g. mobile phones and flat screens.

Industrial minerals are non-metallic minerals used in a wide range of industrial applications including the manufacturing of chemicals, glass and fertilizers. Examples of industrial minerals are salt, potash, clays, limestone, silica sand, feldspar, talc and gypsum.

Construction minerals include sand and gravel, brick clay, crushed rock aggregates and recycled aggregates. Construction minerals are normally produced in large quantities and used in the manufacture of concrete, bricks and pipes and in the building of houses and roads.

The minerals value chain

The minerals value chain is the cycle of activities involved in the usage of minerals including exploration, mining, quarrying, mineral processing, metallurgy, recycling and rehabilitation. Here follows a brief description of these main activities:

Mineral exploration is undertaken in order to find mineral deposits that might be suitable for exploitation. A variety of methods and techniques may be used, including geological mapping, aerial photography and satellite images, and geochemical surveys (looking at the chemistry of soil and water which may indicate the presence of certain minerals). Sampling of the rocks is carried out both at the surface and through drilling boreholes into the ground. The final stage of mineral exploration is a desk-top study that evaluates all factors that are relevant to the decision to mine: geological, mining, environmental, political and economical.

At this stage, the financial aspects are also considered, including the cost of mining, metallurgy, legal and government factors. The initial costs to set up the mine and run it (termed capital and operational costs) are compared to the expected income from the products of the mine over its lifetime.

This provides the mining company with a business case that might justify an application for planning permission to extract the mineral.

Mining. A mineral deposit has to be extracted from the ground where it is situated through mining. This may take place at the surface in open pits or underground. Which of these that is chosen depends on many factors, such as the shape, orientation and depth of the deposit and the strength of the mineral-bearing and surrounding rock. Surface mining is typically used when the mineral deposit is located close to the surface. It is more economical than underground mining but can have a more significant impact on the surrounding environment. In underground mining, the "ore"* is extracted below the surface with as little waste as possible. Operating mines range in size from small underground mines producing less than 100 tonnes of ore per day to large open pits, some of which move thousands of tonnes of mineral and waste rock per day.

* It is common in the minerals sector to refer to ore. Ore is the valuable part of the rock and may be a metal, a mineral or even the rock itself, although it normally is used to describe the valuable part of the first two.

Processing. When the minerals have been extracted from the ground they need to be processed to a form that is useful to us. This usually involves removing any unwanted impurities and processing to increase the concentration of the economic mineral.

Metallurgy. After concentrating the mineral, it may be transported to another site for further processing. Metallic minerals may be smelted or refined to produce metal close to the mine. For example pure iron metal is recovered from magnetite concentrates.

Recycling. Waste materials are by-products that form in all previous activities in the value chain. Recycling and re-use of waste materials increase the supply of valuable secondary resources and encourages a more resource efficient economy. Many critical minerals and metals may be collected through recycling of mining related waste materials. However, even with the important contribution from recycling, minerals extracted from the Earth still supply most of our daily needs.

Rehabilitation. Modern mine rehabilitation begins already at the start of a mining project and aims at minimizing the environmental effects of mining. Rehabilitation is an on-going process throughout the period of mining, and the land is typically restored for further use as recreational or agricultural land. Today, new mines are typically required to have closure and restoration plans in place before mining starts, and they must also set aside the cost for reclaiming the site in a trust. Despite environmental measures, some abandoned mines may continue to be a problem and a negative legacy of the minerals industry. In most cases, however, old mining areas can be successfully rehabilitated and recultivated. There are many examples of reclaimed mine sites which now provide excellent leisure activities such as walking, adventuring, golfing and sporting in general. There are also other examples worldwide where ecologically rich environments have been created by the mining industry, and now are protected from other types of development.

The Earth as a resource

The role of minerals

Our modern society is totally dependent on non-energy minerals (NEM). They are essential for manufacturing and the supply of renewable «green» energy. They also provide the materials to build homes, schools, hospitals and infrastructure needed by sustainable communities. Despite the recent financial downturn across the globe, the demand for raw materials, such as NEM, will increase as attempts are made to boost economies and push the growth of manufactured goods. A continuous supply of minerals will, in other words, be necessary also in the future.

There is no doubt that mining can bring positive benefits to the host countries but these can come at a cost to the environment and local communities if the mines are not managed properly. The fundamental aim must be for the benefits of development to be distributed as widely as possible and for the negative impacts on people and environment to be minimized.

Mining-generated wealth has the potential to improve the economy, infrastructure and quality of life of the host country, region and community, and brings opportunities for economic growth and diversification. Mining generates revenue for governments through royalty and tax income. It also brings skilled employment, technology transfer and training for people, together with further jobs through the multiplier effect. Mining can bring substantial improvements in physical, social, legal and financial infrastructure. Economic growth and development can come at a cost to the environment. While mining has historically affected its surrounding environment, advances in technology and changes in management techniques mean that many negative impacts are now avoidable. Increasingly, mining companies are making efforts to reduce the remaining environmental impact of mining and to minimize the footprint of their activities throughout the mining cycle, including restoration of land and ecosystems after mining.

Growing needs and demand

The society has become increasingly dependent on a range of minerals. In the past, the extraction of minerals has allowed the standards of living to continuously improve around the world. Earlier societies, such as the Stone Age, through the Copper, Bronze and Iron Ages, are classified by their use of minerals. Today we take developments in our standard of living for granted, and there are clear signs that the need for minerals is growing fast. There are obvious indications that this trend will continue, taken also into account the facts that,

- about 60 tonnes of aggregates are used to build an average house. If we include the associated infrastructure, such as roads, this can be as high as 400 tonnes. Minerals are used in building houses, schools, libraries, hospitals, offices and shops but also in building bridges and tunnels.

The Earth as a resource

- in every car there are over 15,000 components made from minerals.
- most of the environmental technologies and applications (e.g. wind turbines, photovoltaic cells, electric and hybrid vehicles) allowing energy production from renewable resources will use, so called, high-tech metals (e.g. Rare Earth Elements-REE, Platinum Group Metals-PGM, niobium, lithium, cobalt, indium, vanadium, tellurium, selenium) that were derived or refined from minerals, which Europe is strongly import dependent on.
- every year, around the world, we use about 45 billion tonnes of natural resources. On average, each person uses 16 tonnes of all kinds of minerals, e.g. ores, stones, ceramics etc., per year. People in rich countries consume up to 10 times more natural resources than those in the poorest countries.
- by 2050, the world population is predicted to reach almost 10 billion and the demand for natural resources will also increase from 45 billion tonnes to 140 billion tonnes.

Our standard of living has, however, its price and we need to be aware of the true costs.

The production of the minerals we need in and for our daily life is associated with negative impacts although the related research community is working hard to minimize these. The extraction and processing of natural resources is often very intensive in the use of materials, energy, water and land. These activities therefore often bring about environmental problems. Social problems are also often linked to extraction and mining activities, including poor working conditions and low wages. We must be prepared to embrace the principles and practices of sustainability in all aspects of minerals extraction, processing and use.

Potential of European mineral resources

The EU is highly dependent on imports of mineral raw materials that are crucial for a strong European industrial base, a sustainable and competitive growth and a thriving society. There is a particular importance and an increasing demand for a group of minerals and metals characterized as critical raw materials. The EU is self-sufficient in the production of construction minerals, including aggregates (sand, gravel and crushed natural stone), various brick clays, gypsum and natural ornamental or dimension stone. The EU also has a large production of industrial minerals supplying a very wide range of industries. For some minerals, such as magnesite, fluorspar, bentonite, kaolin and potash, Europe is an important global producer. In contrast, the European economy is highly dependent on the import of ores and metals. Only a small number of metal ores are extracted within the EU, but EU is still a relatively important producer for some, such as chromium, copper, lead, silver and zinc. This production is, however, totally insufficient to meet the European demand. For several metals, including rare earth elements and platinum group elements used in electronics and green technologies industries, the EU completely relies on imports. The resulting annual shortage is about €11 billion, of which 90% corresponds to metallic minerals, particularly those of major high-tech applications. Recycling of metal scrap represents around 40% to 60% of the input to EU's metal production, according to industry estimates.

At the same time, Europe's mineral potential is under-explored, both with regard to the subsurface (particularly deeper than 150 metres) and the seabed in the EU member states' exclusive economic zones. Major opportunities of access to raw materials exist within the EU today, especially for mining at greater depths or in small deposits. The ocean bed could also contain valuable raw materials, such as copper, zinc, gold, silver and rare earth metals, leading to growing worldwide competition for marine mineral deposits. A framework of stable economic and technological conditions makes a sustainable and resource efficient exploitation possible in Europe.

A four-year (2009-2013), EU co-funded project, ProMine (http://promine.gtk.fi/), has created and provided a well documented knowledge base of Europe's non-energy raw material resource potential (see attached map).

The database demonstrates that Europe hosts a large number of mineral deposits ranging from precious metals (gold, silver, platinum group elements), base metals (aluminium, copper, lead, zinc, tin), iron and metals used to make steel (cobalt, chromium, manganese, nickel, vanadium, tungsten), high tech and rare metals (bismuth, germanium, gallium, mercury, lithium, rare earth elements, antimony, tantalum, titanium, zirconium), minerals for chemical use (e.g. barite and fluorite) to fertilizer minerals (e.g. phosphate), building material and several other industrial rocks and minerals.

The high import dependence of strategic and critical minerals has a serious impact on the sustainability of the EU manufacturing industry. This problem can only be solved by more intense and advanced exploration for new mineral deposits on land and the marine environment. As a matter of fact, mineral resources on the seafloor receive a growing European interest with respect also to the exploration potential of rare earth elements, cobalt, selenium, tellurium and other high-tech metals.

This book is an attempt to bring people closer to the fascinating world of minerals and to the understanding of their critical importance for our societies.

Each European country member of EuroGeoSurveys has selected an important mineral, and one or more national experts have described it. To make the book more various and interesting, the choice of the writing style has been left to the authors, and the reader will certainly enjoy discovering how each of them has interpreted the way of describing the complexity of nature using simple terms, sometimes with the help of anecdotes. However, although the book is to be enjoyed by anyone, also geology lovers or those who want to go a bit more in depth in understanding the world of minerals will find a short technical section at the end of each description, entitled 'Where is it found'.

Nikolaos Arvanitidis
Chairman
Mineral Resources
EuroGeoSurveys

Classification of mineral resources

In the context of this work minerals can be either minerals sensu stricto or rocks. Minerals are naturally occurring solid substances having a definite chemical composition and atomic structure. Diamond, quartz, mica and feldspar are examples of minerals. Rocks on the other hand are also solid, naturally occurring and are normally made up of a mineral or several minerals. Granite, limestone and sandstone are examples of rocks. An example of a rock which is not made up from a mineral is coal.

It is common in the minerals sector to refer to ore. Ore is the valuable part of the rock and may be a metal, a mineral or even the rock itself, although it is normally used to describe the valuable part of the first two.

Minerals may be divided into five somewhat arbitrary groups to distinguish between their common uses or occurrence:

- Native metals
- Metallic minerals
- Industrial minerals
- Precious and semi-precious stones
- Construction rocks and minerals

Native metals - a few metals may occur on their own without any other element, e.g. gold may occur unbound to other elements. Another example is native copper. However, zinc for example does not occur as an element in its own right, rather it is bound to sulphur or some other combination of elements.

Metallic minerals - this is the normal way metals occur. Metallic elements are bound together with other elements, especially sulphur and oxygen. An example of the former is zinc sulfide (sphalerite - ZnS) while an example of the latter is one of the iron oxides (magnetite - Fe_3O_4). The sulphur or oxygen has to be liberated from the metallic element to produce the raw metal.

Industrial minerals - this group is more easily defined by what they are not rather than what they are. A common description is that they are minerals of economic value that are not metallic minerals, fuels or precious stones. They are used in a wide variety of industrial processes. Examples include barite, calcite, clays, fluorspar, graphite, gypsum, limestone, lithium, rare earth elements, silica and talc.

Also some minerals with metallic elements are considered to be industrial minerals. Such minerals are not produced for their metals but rather for the physical and/or chemical properties of the minerals themselves. Examples include corundum (Al_2O_3) and rutile (TiO_2). Industrial minerals are used in the manufacture of ceramics, chemicals, electronic components, fertilizers, filters, glass, household goods (detergents), paints, paper and plastics.

Precious and semi-precious stones - these are easily described by their use - primarily for jewellery but there are some industrial uses, such as industrial grade diamonds for use in the manufacture of cutting tools. Typical examples include amethyst (SiO_2), diamond (diamond - elemental carbon - C), emerald - beryl ($Be_3Al_2(SiO_3)_6$), ruby (corundum - Al_2O_3) and sapphire (corundum - Al_2O_3).

Construction rocks and minerals - these are rocks and minerals used for the construction of buildings and infrastructures. Sometimes they are referred to as bulk commodities as they are normally produced in large quantities. There are a wide range of these commodities, from sand and gravel to crushed rock aggregates; from dimension stone (stone cut or shaped into regular shapes for the purpose of building) to clays for bricks and a number of specialist materials, for example clays for tiles gypsum for plaster, lime for mortar, quartz for insulation materials or sand for filtration materials.

Gerry Stanley
Geological Survey of Ireland (GSI)

European Minerals Production

For a relatively restricted land mass, the geology in Europe varies considerably and, as a consequence, the continent has a rich endowment of different kinds of economic minerals. Historically, the economic development of individual European countries has been built on the resources contained within their own borders but increasingly in the twentieth and twenty-first centuries the demand within Europe has exceeded its capacity to supply. As a consequence, many European countries are dependent on imports for the majority of the minerals needed to support the standards of living demanded by society. As global demand for, and production of, minerals has grown, the share of the total production held by many European countries has generally declined. However, a variety of minerals are still produced within Europe as described below under broad categories. The accompanying table (page 158) contains production statistics for 25 minerals, by European country, over the five year period 2007-2011.

Clearly, statistical information for 'Europe' depends on the definition used for that term. This text and the accompanying table include all countries in which the national geological survey is a member of the European Geological Surveys (EGS) organisation. This is different from many other uses of the term because it is neither limited to the European Union (EU) nor does it include all the EU member states. In particular, the Geological Research Institute from Russia is a member of EGS and this makes a significant difference to the 'European share' of global production for many minerals.

Construction minerals

The quantity of primary aggregates produced for construction exceeds all other minerals produced in most countries. It is a low-value, bulk commodity that is usually extracted close to where it is needed. Transporting bulk materials over any significant distance greatly adds to the cost and for a low-value commodity it is therefore generally not economic to do so. However, aggregates are traded across national borders where a particular type is in short supply in a particular country.

Statistics for aggregates production are notoriously difficult to compile due to the incomplete nature of the available data and issues of compatibility in definitions between different countries. The BGS has attempted to do this for many European countries for several years but a variety of caveats is attached to the reported statistics (see the notes below the accompanying table). However, no attempt has been made to collect data on primary aggregates more widely, in particular relating to Russia.

The production of aggregates is typically a reflection of the size of an individual country's construction sector, and will increase or decrease in accordance with the strength of that sector. In some respects this is also a reflection of the economic conditions in each country. Over the five years 2007 to 2011, aggregates production in most European countries has declined, despite a small increase for many in 2011 compared to 2010. The exceptions to this general trend are Austria (where 2011 figures are 14% higher than 2007), Belgium (essentially flat), Germany (1% higher), Norway (16% higher) and Poland which is the only country to have experienced an increase in the production of aggregates in each year, resulting in an overall growth in output of 36% over the five years. This contrasts sharply with the trend in Ireland, Greece and Spain where aggregates production has fallen by 75%, 69% and 57% respectively.

Industrial minerals

This group comprises a wide range of non-metallic, non-energy minerals which are used in manufacturing or industrial processing. These include feldspar, graphite, gypsum, kaolin (also known as china clay), potash, salt and talc. In contrast to metals, where the refined marketable product is produced to just a few recognised standards, industrial minerals depend largely on their intrinsic 'as mined' physical and chemical properties. Therefore the suitability of industrial minerals for particular end uses depends entirely on the individual properties of each deposit. Industrial minerals are less precisely defined than metals and can grade into one another making it difficult to compare statistics between countries, for example, kaolin grades into kaolinitic clay.

With such a wide range of products in this category, it is perhaps not surprising that production trends in recent years have also been highly variable. Many commodities experienced a dip in production during the recession of 2008 and 2009 but have since recovered with levels of output in 2010 and 2011 that are similar to those in 2007. However, it is clear that the industrial minerals producers in some countries have fared better than others. For example, feldspar production in Portugal has fallen by 53% in 2011 compared to 2007, whereas in the Ukraine feldspar production has increased by 134% over the same period. Gypsum production in Hungary has fallen by 88%, while in Croatia gypsum output has increased by 35%.

Europe's share of the world's total output of industrial minerals varies according to the commodity concerned. For feldspar the proportion has varied from 31% in 2008 down to just 9% in 2010, but has risen to 17% in 2011 and Europe's gypsum production has declined from 22% of the world's total in 2007 to 17% in 2011. In contrast, Europe's share of talc production has remained between 16% and 18% through this five year period and Europe's share of kaolin production has increased from 29% in 2008 to 33% of the world's total in 2011.

Metals

Historically Europe's demand for metals was met by indigenous sources, but from the middle of the nineteenth century it became clear that other continents have larger and often higher-grade deposits that could be worked at comparatively low cost. Consequently, Europe has been a significant importer of metals for more than a century. Despite this, European countries retain some important metal mines and several metal smelting and processing operations.

Metal mining in European countries appears generally to have fared better over the 2007 to 2011 period than industrial minerals, with many more countries experiencing overall positive growth trends in production over that period, despite many falls in output in 2008/9 due to the recession. For example, Finland's production of chromium ores and concentrates shows a 25% overall increase between 2007 and 2011, despite a 60% drop between 2008 and 2009. The production of iron ore in Norway has increased by more than 300% between 2007 and 2011, largely as a result of the reopening of the Sydvaranger mine at the northern tip of the country in 2010. Nickel mine production in Finland has increased by more than 430% over the same period due to an increase in the number of producing mines from two to four (Hitura, Talvivaara, Kylylahti and Kevitsa mines).

In terms of the world's total output, Russia is obviously one of the largest producers of many metals but other European countries also make

important contributions. For example, Russia contributes between 2% and 4% of chromium ores and concentrates to the world's total, while Finland and Albania together add another 3%. Russia's output of mined copper represents 4-5% of the world's total, while other European countries (principally Poland, Bulgaria, Sweden, Portugal and Spain) add another 4-5% to the total.

For other metals the European share of the world total is dominated by Russia's output. For example, Russia's output of mined gold represents 7-8% of the world's total whereas other European countries contribute less than 1% between them. Russia's production of mined nickel represents between 15% and 19% of the world's total, while other European countries (mainly Greece and Finland) contribute another 1-3%.

Conclusion

Statistical information and analysis for 'Europe' depends on the definition used for that term. The inclusion of Russia makes a significant difference to the figures, particularly when considering the production of metals. However, even allowing for this, there are many important mines within Europe which are extracting a wide variety of minerals for the benefit of European society. The global recession of 2008/9 caused a noticeable reduction in output from many countries, but in a significant number of cases the statistics indicate that production has subsequently recovered or even increased compared to 2007. Although globally European countries only contribute a small amount to the world's total production for many minerals, nevertheless, these contributions remain important.

Teresa Brown
British Geological Survey (BGS)

A DAY IN THE LIFE OF NORMAN

The drawing represents just one of many uses of the mineral.

Copper

Copper is used as electrical wiring for appliances such as a clock radio, refrigerator, dishwasher, microwave, washing machine and clothes dryer, television, stereo, telephones and computer equipment.

Kaolin

Kaolin is used in all kinds of paper: paper table napkins, paper handkerchiefs, paper boxes, newspapers, books, toilet paper.

Zinc

Zinc is used in anti-dandruff shampoo.

Feldspar

Feldspar is used in the manufacturing of ceramics.

Sepiolite

Sepiolite is used as an effective litter for absorbing animal waste, and is also used in some deodorants.

Bauxite

Bauxite is used in the production of car and motorcycle parts, castings for tyre manufacture would be an example.

Dolomite

Dolomite is used as an aggregate for both cement and bitumen mixes.

Graphite

Graphite is the main ingredient in pencils. By mixing graphite and clay in different proportions one can vary the hardness of the pencil lead.

Beryllium

Beryllium is used in the manufacture of airbags for the automobile industry.

Aggregate

The most important application of aggregates is in building and construction.

Tungsten

Tungsten anodes are used in the X-ray tubes in computer tomography.

Gypsum

Gypsum is mainly used as a plaster cast.

Titanium

Titanium is used in many sporting goods: tennis rackets, golf clubs, cricket bats, hockey sticks, football helmet grills, and bicycle frames and components.

Lithium

Lithium batteries are used in GPS (Global Positioning Systems) and camera's and such.

Indium

Indium is used in the manufacture of solders (a fusible metal alloy used to join together metal workpieces and which has a melting point below that of the workpiece).

Platinium

Platinum is used in hi-tech computing and telecommunications systems, such as mobile phones and electrical instruments.

Gold

Gold is involved in people's lives in multiple ways, such as the make up of their regular or occasional appearance (i.e. the wearing of rings, earrings, broaches, etc.).

Germanium

Germanium is used for the production of multi-junction solar panels, one of several technologies used to produce photovoltaic cells.

Potash

Potassium is one of the three primary nutrients essential for plant growth and which forms the basis of fertiliser production.

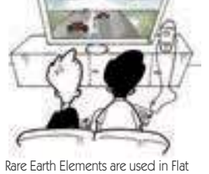
Quartz sand

Quartz sand is used in all kinds of glass industries, from the usual glass bottles and window glazing, to the high quality manufactured glass ware.

Moler (clayey diatomite)

Moler is used in animal feed (as a carrier for vitamins and feed additives) and on the barn floor (to reduce bad odours, keep the floor dry and hygienic).

Rare Earth Elements



Rare Earth Elements are used in Flat Panel displays (FPD). The blue colour is based on europium phosphors; the green colour on terbium, gadolinium, yttrium and lanthanum phosphors; and the red colour is based on phosphors containing yttrium, gadolinium and europium.

Salt

Salt is a common kitchen ingredient used to enhance the flavour of food.

Calcium carbonate

An important mineral found in toothpaste is calcium carbonate. It is an abrasive ingredient, and these abrasives give the toothpaste its cleaning power.

Talc

Talc is used in make up.

Baltic amber (succinite)

Amber is used as an element of decoration (i.e. amber lampshades or lamps, and caskets) or jewellery (necklace, ear rings, bracelet, ring, tie-pin, cuff-link).

Clay minerals

Several clays are used in the food industry as an anticaking agent and carrier material of pigments. Bentonite for example is used as a clarifier for making fruit juice, wine and cocoa oil. It removes the undesirable proteins and other materials from the liquid.

Iron

Iron is mainly used in the manufacture of steel for the construction industry.

Nickel

Nickel alloys, such as Inconel, are generally used in the engines of turbine aircraft where their high temperature, corrosion, and oxidation resistance are invaluable.

Recycled aggregates

Secondary aggregates are extensively used to build foundations for roadway pavements, and as a substitute for virgin aggregates in new asphalt pavements.

COPPER

Cyprus

Copper is used as electrical wiring for appliances such as a clock radio, refrigerator, dishwasher, microwave, washing machine and clothes dryer, television, stereo, telephones and computer equipment.

What it looks like

Copper is a basic known chemical element noted with the symbol Cu and atomic number 29 on the periodic table. The name comes from the Greek, "Kyprios" meaning Cypriot that is coming from "Kypros" meaning Cyprus, where copper was exploited in antiquity around 3000 B.C.

In its native mineral form, copper is a soft metal that, when fresh, displays a pinkish-orange-brown colour like a bright new 5 cent Euro coin. When oxidized, it produces a greenish blue colour coating film that protects the metal from further attack. Pure native metallic copper is rarely found in nature. It is usually found as Copper Ores like sulfide, oxide, carbonate, or mixed ores. More than 160 copper-bearing minerals have been identified in nature.

How we obtain it

Most copper ores are extracted from open-pit mines by the process of drilling and explosive blasting. The treatment process takes place in the Dressing Plant and it aims to produce concentrates of copper. The concentration of ore with approximately 15 to 35% copper is accomplished on the site by crushing, grinding, flotation and purification. The copper concentrates can be turned to pure copper cathodes in two different ways – a) the application of Bio-leaching and Hydro-metallurgy process including Leaching and Electro-winning or b) the application of Pyrometallurgy process including Smelting and Electrolysis.

The major producers of copper are Chile, Peru, China, USA, Indonesia, Australia, Russia and Zambia. The annual world production of copper is approximately 17 millions tones. Much of the copper we use today is a product of recycling.

Use of the product

Copper is the third mostly used metal in the world after iron and aluminium. It is useful for its ductile and malleable properties making it easy to form into various shapes including wires. Due to its excellent high electrical and thermal conductivity, copper is commonly used in: Household items (piping, lightning rods, cooling units such as refrigerators and air conditioners, other electrical appliances), in the Electricity & Energy sector (wind turbines, photovoltaic cells, electric generators, electric transformers), in the Communication sector (short-range cables, wires, links and Printed Circuit Boards for computers and electronic equipment), in the Transport industry (automobiles, trains, trucks and airplanes), in Coinage and as a Fungicide. Copper is often alloyed with Zinc (Zn) and Tin (Sn) to form brass and bronze respectively which are stronger materials and maintain the properties of copper like malleable, corrosion resistant, germicidal and antimicrobial.

Dr **Morriseau** has a BSc and MSc in Geology and Mining Geology, respectively in Czeck Republic and a Ph.D. in Geology from the University of Orleans in France. Dr Morisseau is being employed by the Geological Survey Department since 1976 and currently is the Director. Dr Morisseau has extensive experience in the field of mineral resources and the exploration for copper and chromite deposits and she was involved in research projects with academic institutions and planning of sustainable development of the mineral resources of Cyprus.

Mr **Christodoulos Hadjigeorgiou** has a BSc and MSc in Geology at the State University of New York (SUNY) at Stony Brook, New York, USA. He worked for a decade in the extractive industry of Cyprus until his employment as a Geological Officer at the Geological Survey Department in 2001 and currently holds the position of a Senior Geological Officer and heads the Economic Geology Section of the Department. Mr Hadjigeorgiou has an extensive experience in the field of mineral resources and he has been involved in research projects and planning of sustainable development of the mineral resources of Cyprus.

Geological Survey
Department of
the Republic of Cyprus

Health impacts

Copper is found in many kinds of food (vegetable and animal products), in drinking water and in air. Humans absorb the necessary amount of copper for human health and proper growth by everyday eating, drinking and breathing. It is needed especially in the liver and muscles. A deficiency of copper in the human body can cause a drop in metabolism, high triglycerides, higher sensitivity to ultra-violet light, or depression.

Actions in our daily life

By using telephones, mobile phones, tablets, computers, cars, trains, airplanes, all electrical appliances, coins, hi-tech computerized medical equipment, heating and air-conditioning equipment and playing brass musical instruments.

Where is it found

Copper ore deposits are classified according to the lithology and geologic environment in which they are found and fall into three categories: the porphyry type deposits, the strata-bound deposits and the massive sulfide deposits.

Porphyry copper deposits are associated with igneous intrusive rocks with copper sulfide minerals disseminated in them. They tend to occur in discontinuous belts such as the one found in mountainous regions in western North and South America. Another porphyry belt starts from Papua New Guinea and goes through Indonesia, Philippines, China and ends in parts of Siberia.

Strata-bound deposits are found in sedimentary rocks such as shales and sandstones as copper bearing silicates, carbonates and sulfides. The strata-bound copper reserves are found in the African copper belt (Zambia and Democratic Republic of the Congo), the Zechstein basin in Eastern Europe and the north central United States.

Massive sulfide deposits are large concentrations of various sulfide minerals which are found as large bodies in volcanic rock sequences in Ophiolites known as "Cyprus-type deposits". They are formed as a product of deep-sea volcanic activity along mid-oceanic ridges, by the circulation of hydrothermal fluids, rich in metallic elements, which reach the sea floor as "black smokers" and precipitate as sulphide minerals. Such deposits are also formed today in the Pacific and Indian oceans. Important massive sulfide deposits are found in eastern Canada, eastern United States, Australia, South Africa, the Philippines and Cyprus.

Other EU countries producing this mineral

The EU countries producing copper are in alphabetical order: Bulgaria, Cyprus, Finland, Poland, Portugal, Romania, Serbia, Spain and Sweden. The EU member production of copper accounts only for approximately 4% of the world production.

KAOLIN

Czech Republic

Kaolin is used in all kinds of paper:
paper table napkins, paper handkerchiefs,
paper boxes, newspapers, books, toilet paper.

What it looks like

Kaolin is a clay mineral, composed of Aluminium, Silicon and water. It has various appearances as a result of its origin. It has whitish colour and extremely low hardness (Mohs hardness scale 1,5 - 2) and can, in fact, be easily disintegrated. As most clays, by adding water, kaolin becomes plastic.

It may look as a clay or any hard rock from which has originated: granite, gneiss, or the feldspar containing sandstone transformed into Kaolinite (please see the decription of Feldspars made by Italy). Those changes originated by hydrothermal or climatic alteration in the rocks or during transport and sedimentation of their material.

How we obtain it

Kaolin is extracted mostly superficially by big excavators in open pits. Small deposits of extremely high quality can be still obtained by underground mining. It is hard to find a raw kaolin of suitable quality for direct use. The extracted raw material is therefore transported for beneficiation by trucks. There casually exist deposits, where total amount of raw kaolin can be used after a simple crushing and milling in ceramics. In paper filling and especially coating, quartz admixture could cause damage to the machinery due to its high abrasivity.

The beneficiation process aims to improve quality (whiteness) and remove harmful components (quartz, micas, organic matter). The most common beneficiation system used is the wet process, that involves crushing and milling with addition of water, followed by elimination of coarse particles in sieves and of finer particles in hydrocyclones or centrifuges. Water is then removed in sedimentation tanks adding a setting agent to make the process quicker and continues in filter presses, to be finally dried by heat obtained in furnaces with heat exchangers. The resulting kaolin can be distributed in water suspension in tanks, as clay mud, as semi-dried kaolin noodles or in the form of dry white powder. The whiteness of kaolin (lowered mostly by the admixture of Iron) can be increased using electromagnetic separators or by a chemical reduction way.

The amount of the washable kaolin ("outwash") in the raw material is mostly around 30 - 40%, nevertheless, to obtain products of high quality, it can sometimes reach only 10%.

Use of the product

Kaolin has a wide variety of applications. The principal uses include ceramics (as the principal filling mass as well as the enamel cover), refractory and high-refractory (mullite) ceramics, paper industry (filling and coating material, namely in chalk papers), rubber industry (filler), industry of plastics (filler) and cosmetics and medicaments (filler in pills and tablets). A progressive kind of use of kaolin includes glass fibres. A typical every day life may include:

1. After we get up, we see the painted walls of the room (kaolin as filler of paints).
2. We enter the bathroom: its walls are covered by wall tiles, the floor by floor tiles. We wash ourselves in a porcelain washbowl, we make our needs in a porcelain toilet. Toilet paper, soap and tooth paste probably contain kaolin as filler. Maybe, some of us may use its also in powdered cosmetics and as a medicament in the form of tablets or pills. Also chewing gum may contain kaolin.
3. We go for lunch. All kinds of whitewares, made from porcelain or stoneware (or even

Jiří Jiránek, RNDr. and CSc., Charles University Praha. Geologist of kaolin company in Kaznějov (1973-1978), advisor for industrial minerals in the Ministry of Mining of Nicaragua (1982-1984), head of the Raw Resources Dept. (1990-1992) and of the research project Non-traditional Industrial Minerals, Czech Geological Survey (1986-1992). Later, Czech Ambassador in Latin America, now retired.

Czech Geological Survey

plastics) contain kaolin: plates and saucers, dessert plates, dishes and salad bowls, little pots. Kaolin is also in table napkins.

4. Whenever we use our car, motorcycle or bicycle, we are not only worn by pneumatics with kaolin as the principal filler; kaolin 1 is also contained in all their plastic and rubber parts.
5. In many spheres of the men activity including school children, we use various kinds of paper: printing and copying paper, letter paper, exercise-book paper, school and textbooks. Also school rubber contains kaolin as filler.
6. In the street, we may see the pillars for distribution of electric power. Its insulators are of electro-porcelain made of kaolin.
7. We do shopping. We use wrapping paper and we'll surely pay with kaolin inside the banknote paper.
8. Back at home. If it is cold, we'll make a fire in a fireplace. It is probably revested by fireclay (chamotte). We'll take newspaper or book; their paper was made from mixture of cellulose with kaolin. And we may drink coffee or tea from china-wear cup.

Health impacts

Kaolin has no negative Health impacts - this can be illustrated by using kaolin in medical pills and tablets (where more than 99% of the mass is a pure kaolinite), hygienic products (soap, tooth-paste, cosmetics), etc.

Anecdotes

The original locality from which kaolin took its name was Kao-Ling in the Jiangxi province in China. As porcelain from China was already known to the Europeans, in the 18th Century it was also discovered in Europe.

Actions in our daily life

- Soap and tooth paste use
- Painting the wall
- Writing on paper
- Reading books, magazines and newspapers
- Printing and copying on paper
- Taking a pill or tablet
- Using cosmetics
- Eating from porcelain or plastic dishes
- Drinking coffee or tea from porcelain cups
- Using washroom and WC

Where is it found

Due to its low hardness, kaolin is preserved in depressions of geomorphologic or tectonic origin, mostly covered by younger sediments. It might appear during origin of its source rocks or during kaolinization of their outcrops later in convenient climatic conditions (Carboniferous, Cretaceous and Tertiary). In humid tropics, kaolins of low quality may form. The hydro-thermally originated kaolins may be found near to active volcanoes, nevertheless, their deposits are of limited sizes and their properties suddenly change.

Europe (27%), as well as Asia, North (32%) and South America (9%) and Australia are today the most important kaolin producing regions. The production of USA + UK + Brazil + China represents 56% of the world production. The worldwide production of kaolin reaches more than 40 Mt annually.

Other EU countries producing this mineral

They are (alphabetically) the following countries: Austria, Bulgaria, Czech Republic, France, Germany, Italy, Poland, Portugal, Spain, United Kingdom (Cornwall, Devon).

Other minerals with similar properties

The raw kaolin mostly contains admixture of other clay minerals (e. g. illite) and quartz, which is mostly in greater amount than proper kaolin and can be used as building and filtration sand. The uses of kaolin coincide sometimes with the uses of calcium carbonate, which can be even cheaper and of better properties as to the whiteness and finer grain-size (filling and coating of papers, as well as in other fillers).

Zinc is used in anti-dandruff shampoo.

What it looks like

Zinc is a naturally occurring, lustrous, bluish-white metallic element. Commonly it appears dull in many applications although in some it has a silvery appearance. It is the 24th most common element in the earth's crust.

How we obtain it

Sphalerite* ore taken from the ground is processed, firstly by grinding (normally to sub 100µm particle size) followed by froth flotation to produce a zinc concentrate (a sphalerite stockpile). This water based process requires liquid removal in the final stages, usually by thickening (water removal) and filter pressing (squeezing the paste).

Mine site zinc concentrate is processed to separate zinc from sulphur. Heating (roasting) to about 1,000°C oxidizes the sphalerite, thereby forming zinc oxide and sulphur dioxide. Sulphur dioxide reacts with further oxygen and with the zinc oxide to form zinc sulfate ($ZnSO_4$). Either electrolysis or pyrometallurgical processes are then used to produce pure zinc. Electrolysis is more commonly used today. An electric current is passed through the $ZnSO_4$ to deposit Zn on the cathodes (negative electrodes). Zinc metal is scraped from the cathodes, melted and cast into zinc ingots 99.995% pure.

* Sphalerite: ((Zn, Fe)S) is a mineral that is the chief of ore of Zinc

Use of the product

Zinc prevents rusting or corrosion of steel when applied as a protective surface coating by galvanizing (electro-plating). Corroding steel loses surface flakes that detach and expose more steel to corrosion. Coating of steel with zinc oxide provides a continuous surface layer that protects steel from corrosion.

Zinc is easily formed into many shapes in the die-casting process. Molten zinc (along with minor amounts of other metals such as aluminium or copper) is injected under pressure into a steel mold (die) to make a cast shaped by the mold. Zinc is ideal for casting owing to high casting tolerances, its strength, ductility, rigidity, toughness and ease of finishing. It does not spark, can be machined easily, has low energy costs (owing to its low melting temperature) and gives the cast long life (again because of the low melting point - heat shock induced by injection of higher temperature alloys or metals would lead to a shorter life span of the cast).

Zinc is alloyed with copper to form brass. Brass has a bright gold-like appearance, is malleable (greater than bronze or zinc), possesses excellent acoustic properties and therefore is used to make brass musical instruments, ornaments, and low friction applications such as gears, bearings, ammunition casings and zip fasteners.
Zinc is an important metal because it can:

- Prevent corrosion when used as a protective coating on other metals or alloys (especially steel).
- Be cast into many shapes.
- Be alloyed with other metals, especially copper to make brass.
- Be used as a food supplement, and for medical purposes.

Its main uses are: galvanizing (50%); die-casting (17%); brass making (17%); and miscellaneous (16%) such as chemicals, pharmaceuticals, plastics, paint and coinage.

EurGeol **Gerry Stanley** PGeo has a BSc Hons (geology) from University College, Dublin, an MSc (geology) from Acadia University, Nova scotia, Canada and an MSc (mining engineering) from the Camborne School of Mines, UK. Gerry has worked in mineral exploration and development in Ireland and in the Geological Survey of Ireland where he is Head of the Minerals Programme.

Gerry is a former President of the Irish Association for Economic Geology and is the current President of the Institute of Geologists of Ireland.

Geological Survey of Ireland

Health impacts

Zinc is essential for healthy human growth. The average human body contains 2.5g Zn and the average intake is 15mg/day in the Western diet obtained from lamb, beef, herring, sunflower seeds, cheese and additives to breakfast cereals. Zinc deficiency can cause birth defects, lead to delayed healing, cause skin irritation and loss of the sense of taste, and encourages many chronic illnesses. In medicine, zinc is used to combat colds, as an antiseptic ointment, in calamine lotion, anti-dandruff shampoos, and in sun blockers (ZnO). Zinc's anti-oxidant properties protect against premature aging of the skin and muscles of the body. In hospitals, brass fittings and surfaces assist in controlling MRSA and other pathogens, unlike steel surfaces where they can survive.

Actions in our daily life

- Sun screen lotions
- Calamine lotion
- Rust proofing - street signs, electric cable pylons, and galvanized roofs
- Music - brass instruments
- Die-cast parts in cars - door handles, safety belts, and engine parts
- Die-cast parts in electrical appliances - toasters, kettles, food mixers, televisions etc.
- Fertilizers in agriculture - ZnO to ameliorate zinc deficient soils
- House construction - roofs, guttering, down pipes
- Brass - plumbing fittings, ornaments

Where is it found

Zinc occurs in nature principally as a sulfide although it may occur as a carbonate or a silicate. The most common and important zinc mineral is sphalerite (ZnS). Zinc is mined principally from sulfide orebodies although non-sulfide zinc orebodies are known.

There are six main zinc orebody types - sedimentary exhalative (sedex), Mississippi Valley Type (MVT), volcanogenic massive sulphides (VMS), Broken Hill Type (BHT), carbonate replacement deposits (CRD) and Irish Type. The Irish Type deposits have features that are common to both the sedex and MVT deposit types and can be considered a hybrid of the two types. Sulfide ores of zinc are formed by the precipitation of metals from one or more hydrothermal (literally hot waters) fluids. Because of the several types of zinc deposits, they occur in a wide variety of rock types although clastic sedimentary (siltstone and sandstones - sedex) and carbonate rocks (limestones and dolomites - MVT, CRD and Irish Type) predominate.

Zinc is readily recycled and today approximately 60% of the total world supply of zinc comes from primary mine production with 40% coming from recycled sources.

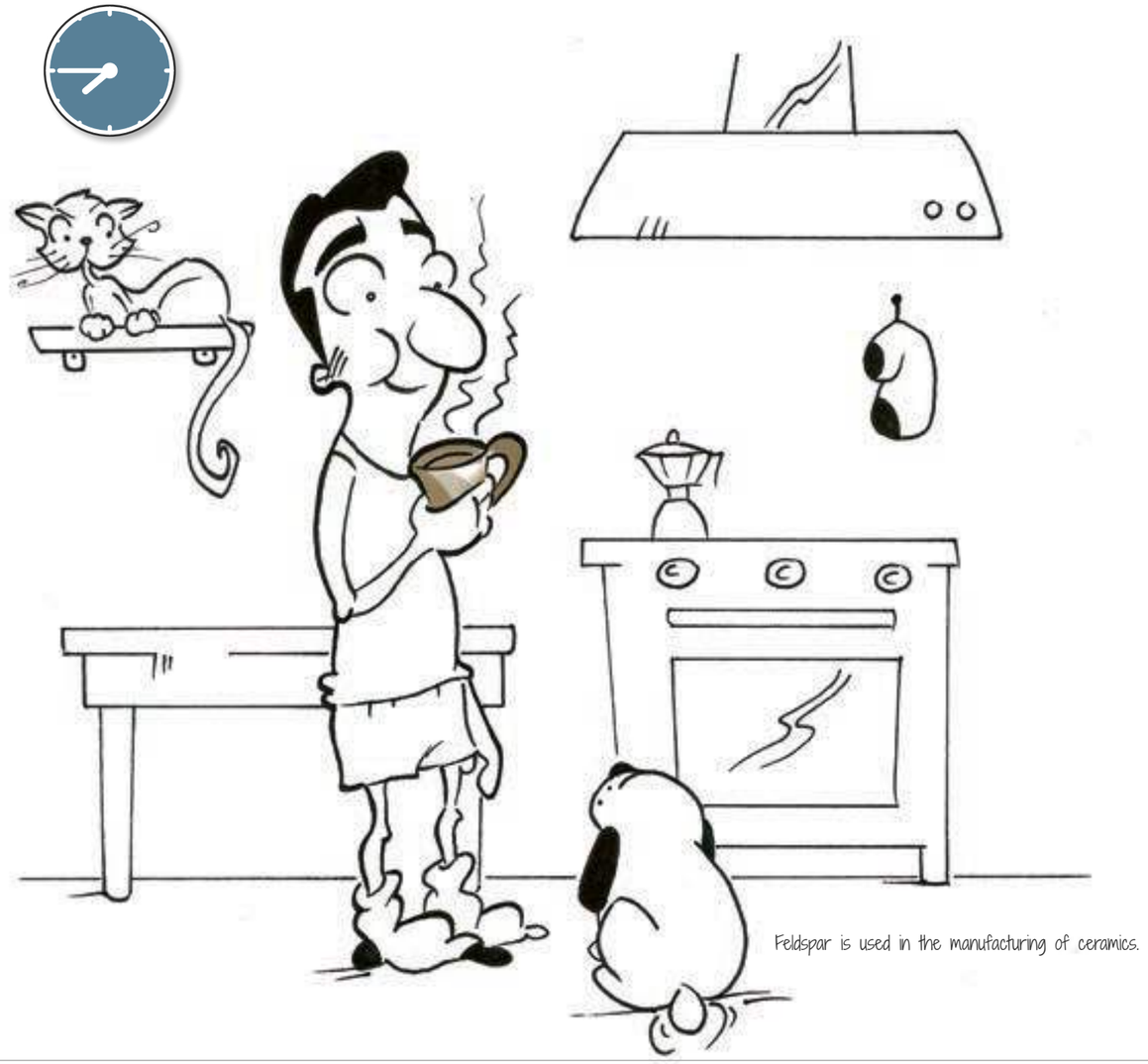
In Europe the most important zinc mining countries are Ireland, the Russian Federation, Sweden and Poland, in that order. Ireland produces some 2.5% of the world's zinc which represents 32% of European production. The concentrate produced by mines in these countries and from concentrate produced around the world is smelted and refined in Belgium, Bulgaria, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, the Russian Federation and Spain.

Other zinc containing minerals

Other minerals that contain zinc include smithsonite ($ZnCO_3$) and wurtzite ($(Zn,Fe)S$).

Other minerals occurring with zinc

In most zinc orebodies lead (Pb) is a common associated mineral and lead-zinc orebodies are almost always considered together. Within such orebodies silver (Ag) is another common element association and in some orebodies cadmium (Cd), germanium (Ge) or indium (In) can be important economic trace elements. In addition, pyrite (FeS_2) is common although not usually economically important.



Feldspar is used in the manufacturing of ceramics.

What it looks like

Feldspars is the name of the main minerals' group making up about 60% of Earth's crust. Feldspars belong to the group of the so-called 'aluminosilicates', i.e. minerals composed of aluminium, silicon and oxygen and another element. In the case of Feldspars this element can be Potassium, Sodium, Calcium or Barium. Feldspar minerals have a hardness equal to 6 in the Mohs' Scale of Hardness (whose maximum value is 10, corresponding to the hardness of diamonds) and are usually white or very light in colour. Feldspar upon weather conditions changes to kaolin, a clay mineral used in ceramic industries.

How we obtain it

In general after mining sandy deposits, processing phases include washing, screening, classifying, leaching, flotation and drying. Open-pit methods are applied for hard-rock mining. After the feldspar ore is drilled and blasted, secondary breakage occurs by means of drop balls. Ore is then loaded by hydraulic shovel onto trucks for transport or directly in the adjacent crushing plant. The crushing is done by means of a jaw crusher, gyratory crusher and then by rod mills. The slime is frequently removed with hydrocyclones. Flotation process removes mica and iron-bearing minerals. The product consists now of a mixture of feldspar and quartz. The production of a high-grade feldspar product requires another rougher flotation step followed by filtration, drying and cleaning (by magnetic separation). Then, feldspar is stored in bulk as it is ready for commercial use. Tailings, waste residue of feldspar ore processing, account for 30% to 40% of the head feed. Waste products are dewatered in settling ponds, by filtration, or in tailing plants. Solid material usually is sent to landfill or sometimes used as fill material in mining.

Use of the product

More than 70% of the feldspars produced in the EU are used in the ceramic industry, and most of the rest in the glass production. In ceramics manufacturing feldspar is the second most important ingredient after clay. Feldspar does not have a strict melting point, since it melts gradually over a range of temperatures. This greatly facilitates the melting of quartz and clays. Feldspar improves the strength, toughness, and durability of the ceramic body, and cements the crystalline phase of other ingredients, softening, melting and wetting other batch constituents. In the ceramic flooring sector, feldspar is the main constituent in the body composition. In the manufacture of glass the alkali content in feldspar acts as flux, lowering the glass batch melting temperature, and thus reducing production costs. The alumina acts as a stabiliser and increasing resistance to impact, bending, and thermal shock, increases viscosity during glass formation, and inhibits devitrification. Feldspars are used in manufacturing industry, paint, plastics, fiberglass, electrical insulators, rubber, mild abrasives, urethane, latex foam, adhesives, road aggregates and as a welding rod coating. Feldspar assists the enamel composition, assuring the absence of defects and the neatness of the end product: e.g. enamel frits, ceramic glazes, ceramic tile glazes, sanitary ware, tableware, electrical porcelain and giftware. Beneficial properties of feldspars include good dispersibility, chemical inertness, stable pH, high resistance to abrasion, low viscosity at high filler loading, interesting refractive index and resistance to frosting. Finally, there is no recycling of feldspar by producers. However, glass container producers use recycled glass (cullet), thereby reducing feldspar consumption.

Mauro Lucarini is Researcher at the Geological Survey of Italy - ISPRA.

He conducts researches in various fields of Earth Sciences such as Hydrogeological and Coastal Hazards, and carries on studies on the Effects of Earthquakes on Environment.

Member of the MREG, Mineral Resources Expert Group, and responsible for the Minerals4EU Project as the point of contact of ISPRA, and Member of the National Inter-Institutional Working Group on Extractive Industry.

Geological Survey of Italy

ISPRA

Health impacts

According to the European legislation, feldspar that contains less than 1% of quartz is classified as an inert and non reactive material, with quartz content between 1-10% the product is classified as potential dangerous, and when contains more/equal of 10% quartz is classified as dangerous.

Health effects caused by the feldspar may produce irritation upon contact with eyes and prolonged or repeated exposure may cause skin irritation. Inhalation of excessive quantities of feldspar dust may irritate the respiratory tract and the prolonged exposure to feldspar dust could adversely affect respiratory function including fibrogenic response. The product, containing crystalline silica as an impurity, can cause cancer and/or silicosis because of chronic exposure by inhalation.

Anecdotes

European interest in porcelain began during the XIII century when European merchants, such as Marco Polo, decided to travel towards China and came back with silks, spices and porcelain tableware.

Until the XVIII century many European pottery artists unsuccessfully attempted to copy the Chinese porcelain. However, notwithstanding all the efforts, Europe would wait until 1708, when German alchemists, Friedrich Böttger or Ehrenfried Walther von Tschirnhaus, identified the two main components of Chinese porcelain, kaolin and feldspar. Certainly Böttger established the first porcelain production in Europe (Meissen Factory). In 1717, C.K. Hunger, a colleague of the alchemist, succeeded in gaining information on porcelain's composition and fled to Vienna. Here Hunger came into contact with Du Paquier, a military consul, who wanted to become the main competitor of Meissen Factory, utilizing special kilns for porcelain.

The first Italian factory started up by Venetian Francesco Vezzi, a rich goldsmith who persuaded Hunger to move to Venice.
The second Italian factory was founded in Doccia (Siena) by the Marquis Ginori, who started up industrial activities in 1740.
Not long after, in 1743 the Borbonic factory of Capodimonte launched its activity, producing soft porcelain thanks to the architect Sanfelice.

In the early 1800, in Europe, the industrial revolution was soon extended to porcelain production, gradually making it a product more affordable to most parts of the population. Conversely, in China, production was still limited and available only for noble people.

The political upheavals which then occurred in Italy, characterising the early half of XIX century, affected all sectors of everyday life. Since 1850, a simply decorated type of porcelain product became established in Naples characterising wall dishes, statuettes and architectural ornaments, leading to a "Revivals" style in central-northern Italy and to "Naturalism" in southern Italy (Capodimonte porcelain). After the Unification of Italy (1861), all the national arts were reformed and some technical schools were founded to keep alive the Neapolitan porcelain tradition.

Actions in our daily life

Drinking a cup of milk, washing hands in a washbasin or washing in a shower tray, looking in the mirror while brushing hair or while putting on make-up, driving a car.

Where is it found

Common Feldspar can be chemically classified as mixtures of three main members: orthoclase, albite and anorthite. They can be categorized into two main groups: K-Feldspars (or alkali feldspars) and Plagioclases. The first represents the solid solution between orthoclase and albite (intermediate terms: microcline, sanidine, anorthoclase), while the second the mixture between albite and anorthite (intermediate terms: oligoclase, andesine, labradorite, bytownite). Most feldspars crystallize from a melt in igneous rocks.

Feldspars can be found in all rocks' types, mainly in igneous ones (extrusive and intrusive), being the most common rock-forming mineral. Feldspar minerals are main components of granites and can occur also in many types of metamorphic rock. They are relevant minerals of many sedimentary rocks, like beach sands and alluvial deposits, because of physical weathering of feldspar-bearing rocks.

In 2011, Italy was the world's largest producer, with 23% of the total world output. Other major producers are Turkey (21%), China (11%), Thailand (5%), USA (3%) and many other countries.

Other EU countries producing this mineral

Feldspars are also mined and produced in several EU countries, including Spain, France, Poland, Czech Republic, Germany, Portugal, Bulgaria, Sweden, Finland, Norway, Greece, Slovakia, Romania and United Kingdom.

SEPIOLITE

Spain

Sepiolite is used as an effective litter for absorbing animal waste, and is also used in some deodorants.

What it looks like

In hand, the specimen has an earthly look and has a light cream color, but its most distinct characteristic is that it is very light in weight. Microscopically sepiolite is formed by hollow fibers or tubes, this morphology gives sepiolite its absorbent properties. A nice Sepiolite bed as seen in the field, can be seen on the following page. (Cabañas de la Sagra, Toledo, Spain).

How we obtain it

Commercial exploitation is done in opencast quarries, usually selecting richer beds or layers after removal of overburden. The operation comprises open pit mining using bulldozers or front head loaders to rip the sepiolite, then leaving the material for sun and air drying.

Use of the product

Sepiolite´s main use is as a general absorbent, particularly as pet litter (cat and bird cage litters, pet absorbent baths), but also as an industrial absorbent. Sepiolite has also many other uses, sometimes with an adequate pretreatment, i.e in environmental uses to absorb oil spills, deodorants, filtration and bleaching earths, water effluent treatment, waste treatment and management, rheological agent, in agriculture (soil conditioning, fluid carriers for pre-germinated seeds, seed coating, suspension media for pesticides and fertilizers, phytosanitary carriers), polyesters, ceramics, asphalt coatings, paints, pharmaceutical uses, in animal feeds (growth promoter, carrier of supplements and binder of feeds) as fungicide agent and as sorbents in desalinization, catalysts carrier, decolorizing agents, filter aids, anticaking agents, cigarette filters, plastisols, rubber, detergents, cosmetics grease thickeners, NCR paper, drilling fluids and cleaning of stone materials in restoration projects.

Health impacts

No health caution are known for sepiolite.

Anecdotes

A tale of a cat and a rabbit

I once had a nice and well educated cat called Xia, which was happy at home and had its nice sepiolite box to care for his intimate moments. One day a friend of mine had the occurrence of bringing home a rabbit for my birthday. Black, as I decide to call him, was completely white, except for its nose and ears, and was quite big, in fact bigger than Xia. Black was also a well-educated rabbit, so, to Xia's astonishment, took over her sepiolite box.

The fight for the sepiolite box started to be ferocious and Black used his back legs to expel Xia from the box, whilst Xia ambushed Black around the house taking a swat to his face whenever she could. Black then developed quite a technique of playing dead. The war went on for some time, until poor Xia started to take the worst part in blows and "accidents". Finally I had to give Black to someone else. That same day Xia recovered her sepiolite box, and the first thing she did was to empty with fury the whole box of the sepiolite with her back legs.

Professor Manuel Regueiro is BSc Geology, by the Complutese University of Madrid (1979). Since 2005, he is Chief of External Affairs of the Geological Survey of Spain (IGME), although he has been working (and still works) the last 18 years as a specialist on industrial minerals and rocks in the Industrial Minerals and Rocks Department of the Mineral Resources Division of the Spanish Geological Survey and as Associate Professor of the Department of Crystallography and Mineralogy of the School of Geology of the Complutense University of Madrid, where he lectures on subjects such as Mining Geology in 5th course of Geology and Mineral Raw Materials in 1st course of Material Engineering.

Geological Survey of Spain

SEPIOLITE Spain

Actions in our daily life

To care for the welfare of your pets at home.

Where is it found

Sepiolite is a type of clay thus its deposits are usually sedimentary formed in arid environments (although it can also exist as a secondary mineral in serpentine rocks). In Europe only Spain has commercial deposits of sepiolite, and in particular Madrid has the biggest world deposit of sepiolite.

Other EU countries producing this mineral

None

Other minerals with similar properties

There are other clays used as pet litters: palygorskite, and bentonite.

Photo courtesy of Marisa Garcia Romero. Dpt Crystallography + Mineralogy. Faculty of Geology. UCM. Madrid. Spain

BAUXITE

Croatia

Bauxite is used in the production of car and motorcycle parts, castings for tyre manufacture would be an example.

What it looks like

The name bauxite derives from a small town in southern France, named Les Beaux-de-Provence, near Arles. It means beautiful or handsome in French (beaux is plural from beau and also refers to a lover or a sweetheart). Here, in Les Beaux, almost two hundred years ago (1821) bauxite was sampled for the first time by the French chemist Pierre Berthier who wanted to decide if the staff was suitable for production of iron. Decision was negative due to the low content of iron. However, the high quantity of aluminium was detected and thus Les Beaux lent its name to the new ore. Denomination "bauxite" instead of the then correct "beauxite" was accepted about the year 1861, on the suggestion of a French chemist Saint-Claire Deville.

Bauxite is a rock. Not quite an ordinary rock, though. Compared with other rocks that we intuitively experience as such while travelling routinely across our European countryside - say sandstone, or granite, or limestone (of which, obviously, many include the very word "stone" to denote their "rockiness" while the other part of the name is for their origin) - bauxite is indeed a kind of exotic. We are attracted to it at the first sight, mostly for its worm spectra of ochre-red-pink-purple-brown colors shading the isolated spots in otherwise white Mediterranean landscapes all the way from Spain to Greece.

How we obtain it

Today, bauxite is the only ore that is used for commercial extraction of aluminium, containing 15 - 25 percent of the pure metal. The most part of the ore comes fom the open pit mines, often after removal of large quantities of the rock overburde. very rarely it is extracted by the underground excavations (for example, in Greece). Since clay may be present in many bauxite deposits it has to be removed before the ore processing, usually by combination of washing, wet screening and cycloning.
The metal extraction from raw material is gradual and complex. Historically, the first economical process for producing aluminium was invented by the French chemist Saint-Claire Deville.
He first succeeded, by chemical reduction of silica, to obtain metallic aluminium and stirred therewith a great sensation on the "World Expo" in Paris in 1855 presenting "silver from lime" in the form of span-long bars in a glass-box.
It was later discarded for a new Bayer process (developed in 1889 by a German scientist Karl Bayer) to extract aluminium oxide (alumina) from bauxite in a much more efficient and, accordingly, cheaper way, leaving aside an ugly but, above all, unthinkably poisonous "red mud" as a by-product. However, another process is needed to obtained pure aluminium from alumina. It was developed independently by two scientists from both sides of the Atlantic - Paul Héroult and Charless Hall - and correspondingly named Hall-Héroult method. Without excessive technicalities, it will suffice to say that both Bayer and H-H processes consume enormous amounts of energy, particularly electric energy, since they are essentially electrolysis.

Use of the product

About 90% of the world production of bauxite is used for making alumina (aluminium oxide), most of which is consumed in the manufacture of aluminium. Aluminium is omnipresent, used almost everywhere. The bauxite is less so. We can't live without using it because it meets our needs in extremely diverse ways combining a variety of unusual properties. Aluminium is recognized as being a strong

Zoran Peh is Scientific Advisor in the Croatian Geological Survey, Zagreb, Croatia. He holds Ph.D in Geology from the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Croatia (1994). He is a principal investigator of the research project "Map of the Mineral Resources of the Republic of Croatia" (from 2005) and a research team member of the project "Basic Geochemical Map of the Republic of Croatia" (a former principal investigator), a former chairman of the Scientific Council of the HGI-CGS (2005-2009) and former Croatian Contact Person for EuroGeoSurveys (2005-2009).
Experience in ore geochemistry (karst bauxites) and environmental (soil) geochemistry, mathematical geology, and geomorphology, as well as geological mapping.

Croatian Geological Survey

and malleable metal. Also, it is very light and resistant to corrosion, a good conductor of heat and electricity. It can be polish to produce highly reflective surfaces. All these properties make it ideal for construction of aircrafts, vehicles and, even, ladders. For these purposes very often an alloy is employed named duralumin (with small additions of copper, magnesium and manganese) since it strengthens all aforementioned properties of the mother metal. Due to its resistance to corrosion and its easy shaping it is a very good staff for production of drink cans and roofing materials.

Because it is light and non-corrosive it is required in manufacture of window frames and greenhouses. Its good thermal conductivity makes it suitable for production of boilers, cookware and dishes. Its good electric conductivity leads to use for overhead power cables hung from pylons while high light reflectivity makes it ideal for reflectors, mirrors and heat resistant clothing used by firemen.

As for bauxite in its raw form (a rock formed of many minerals), 10% of it serves as a raw material for production of refractories, abrasives (especially bauxites with higher content of silica), and various chemicals applied mainly in purification of water and in manufacture of paper, aluminous cements, petroleum catalysts, various materials for refinement of kerosene and other petroleum products, and a number of other purposes. One of the particularly effective usages of bauxite is in the oil industry and that is in the form of proppant (the "one that helps" or "supports"), the propping agent usually in the form of ceramic beads being utilized in the drilling process (it props open fracture and permits oil and gas flow). Just a note at the end: in the days of yore bauxite was used in production of alum and vitriol. These products were precious then.

Health impacts

For a long time now aluminium is exploited even in pharmacy as a cure for reducing the effects of gastric acidity - as a balanced gel composed of aluminium and magnesium hydroxides. And here lies danger, some say: connection between aluminium and Alzheimer's disease is nowadays less a myth than a longstanding scientific controversy. Does aluminium truly endanger our health and should we therefore give up aluminium pans, antacids, or aluminium-containing antiperspirants, or is it just the hype? Not an easy issue for anyone since humanity has become so dependent on it.

Bauxite does not impact our health, as far as production of aluminium oxide is not concerned. However, the process of alumina production may heavily endanger our environment due to pollutants concentrated in the "red mud", particularly in the vicinity of alumina production lines.

Anecdotes

One of the "good" properties of aluminium is associated with its malleability and I still remember that funny scene after so many years. I recall the day driving my bicycle over a dusty, bumpy, country road in search for a good fishing place with my boyfriends. The bike was simple (no such thing as a "mountain bike" those days), single-speed, made of aluminium all over, from wheels to the handlebar. It was so light you could almost raise it with a finger. The drive was demanding since both each and every hole on the road and each and every fishing spot by the road required the full attention. It was only naturally that the fishing rod stuck in the front spokes. It doesn't matter that my nose felt weird after the elegant somersault and not-so-elegant spreading in the dust. Fishing pole was broken and the front wheel was bent quite visibly. How desperate I might have been trying to fix the damage instantly. Believe it or not, the rim yielded and I was lucky to flatten it out at the spot. Even the spokes had not become so loose to defy being fixed with ease later, and whole incident passed unnoticed by my parents. Had it not been aluminium, a strong but soft metal, the repair would have taken quite a different route. No bikes like that anymore. These days more exotic aluminium alloys (with titanium and magnesium) are in use and even such things as carbon fiber.

Actions in our daily life

Aluminium is so enmeshed with our everyday actions that it looks sometimes so trivial. Do you know what your pencil, or pencil holder, is made of when you take it in your hand in order to write down something (provided that you avoid using your PC, or even typewriter which is "anachronism plain and pure"). And when you awake early in the morning, is it not one of the first things you do to reach for the dishes in your kitchen and fix you something to eat and drink. And what you eat, have that not perforce stayed in the fridge overnight wrapped in the aluminium foil. Later, perhaps, sitting on the bench in the nearby park, resting in the shade, you open the can with your favorite refreshing drink watching parents strolling by with a baby in a pushchair. All that is a collage made of everyday life clips that include aluminium as our inseparable companion in this modern, man-made, world. No place for bauxite; it is just a pat of scenery we can sincerely adore only if we are far away from what is artificial (aluminium) and closer to nature.

Where is it found

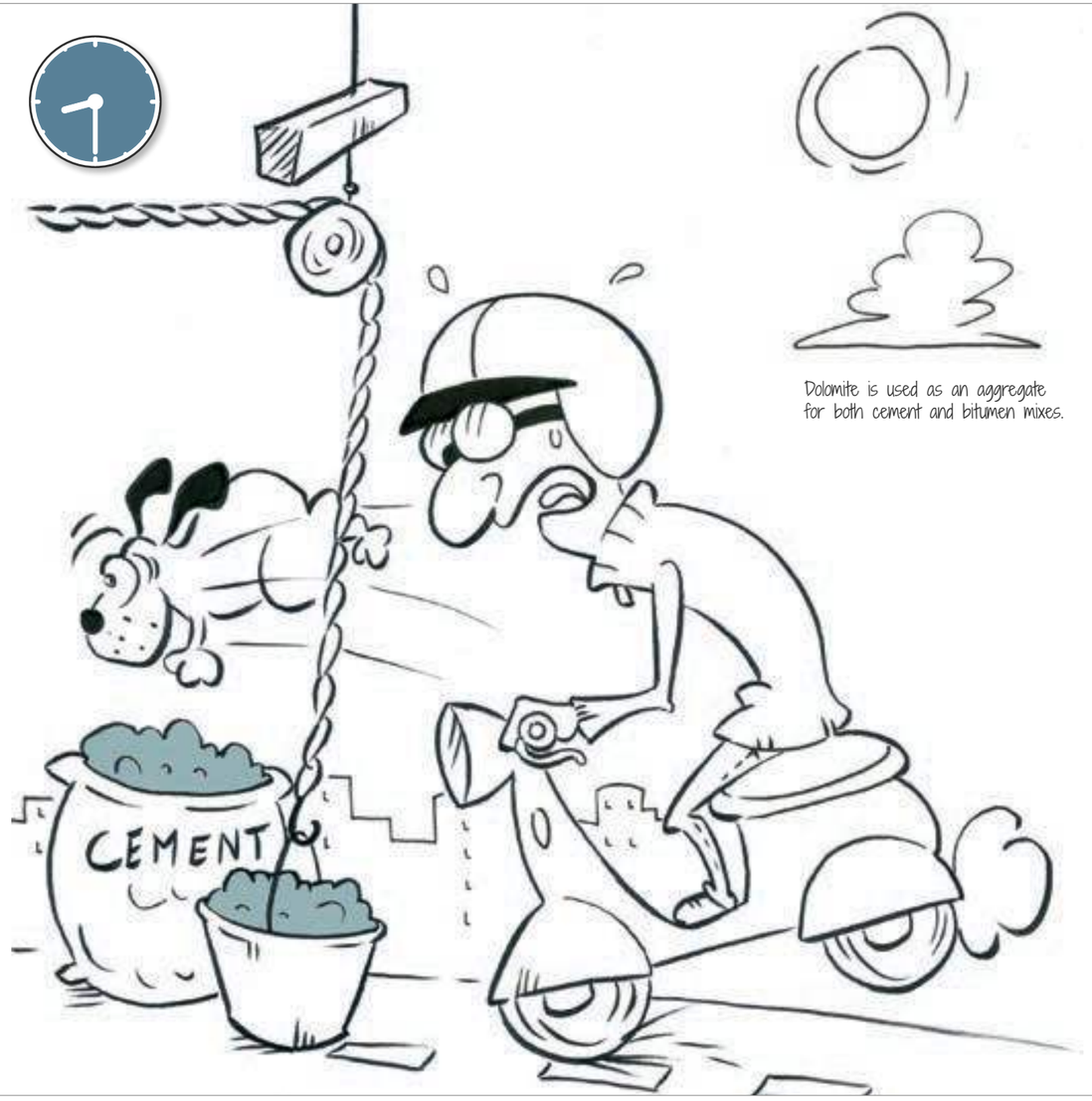
Bauxite properly deserves to be called the rock since in fact it is an aggregate of various minerals. More than 170 various minerals have been found so far but not more than ten of them are rock-forming. Among them, even including the rock-forming ones, aluminium-bearing minerals are those that really matter - aluminium hydrates including boehmite, diaspore and hydrargillite in quantity varying around 45-60% - a fact that makes bauxite an aluminium ore. The first of them is most common in European bauxites (monohydrate bauxite). A few other minerals can be also of interest sometimes, particularly iron oxyhydroxides such as goethite (and limonite) that are mostly responsible for aforementioned tint. Rarely, we can find very pure, white, bauxites, for example in Montenegro. Other minerals worth considering are titanium minerals such as ilmenite and rutile, and, lately, the list is enriched by the very profitable rare earth element minerals.

As for their ubiquity and genesis, it must be noted that majority of European bauxites pertain to the karst type meaning that they originated on karstified carbonate bedrock during subaerial exposure of the carbonate platform.

No wonder, all Mediterranean countries are more or less rich with bauxite deposits and occurrences, especially Greece, albeit they may be found in other parts of Europe. There is also another type related to weathering crusts of alumosilicate (mostly igneous) rocks. It is called lateritic bauxite but is practically absent in Europe while the biggest producers in the world such as Australia abound in them. It may be very instructive if we mention that European bauxite mining market accounts for only 8.2% of global reserves while Australia alone with its five mines supplies around 23% of the total world production. Thus, Europe is a modest producer (and consumer also) of bauxite, with Greece containing about 30% of regional (European) reserves and Russia (albeit predominantly on its Asian side) the remaining 70%.

DOLOMITE

Belgium



Dolomite is used as an aggregate for both cement and bitumen mixes.

What it looks like

Dolomite is a carbonate mineral composed of calcium magnesium carbonate $CaMg(CO_3)_2$. The mineral dolomite forms white, gray, yellowish to pink, crystals and crystal twinning is common. Tabular crystals (µm to m), sometimes with curved faces (saddle-shaped) are frequent, but columnar and stalactitic habits also occur. Its hardness is medium (3.5 to 4 in the 0-10 Mohs's scale). The mineral dolomite easily splits along definite planes (cleavage), yielding smooth surfaces.
The mineral can be dissolved in hot and concentrated hydrochloric acid but is poorly solved in dilute hydrochloric acid or in hot vinegar. If iron and manganese can replace magnesium, only pure dolomite is chosen for industrial purposes.

How we obtain it

Dolomite rocks are important oil reservoir rocks because average dolomite has usually higher porosity than limestone. Dolostones can be the host rock for Fe, Zn, and Pb sulfides ore deposits (e.g.: sulfides veins in Tournaisian dolostones in Belgium between Namur and Liège). The rock is drilled and blasted. The blocks are loaded by giant trucks, crushed (many times if necessary), washed and screened. The best quality rocks are calcined in rotary kilns.

Granulometries are sieved. Derived products are a product of chemical and physical treatments. Blocks, gravel, sands, filler, dolomite and derived products are transported by boat, trucks, silo-trucks and trains (tank-wagon)and delivered to a large panel of customers.

Use of the product

If we look at it from our «daily life» perspective, the most important use, by volume, is in the construction industry. Dolomite and limestone are used in similar ways; they are crushed and used as an aggregate for both cement and bitumen mixes. Road builders mix it with concrete and asphalt and it is used as a ballast for railways. Like limestone, dolostones are used as a construction resource for local consumption because of low transportation cost. Because its yellowish colour, dolostones are used as building stones and gravel for garden paths and driveways (e.g. "golden" gravel). High-quality industrial dolomites obtained after calcination are rare and dedicated to the fabrication of high value products. Pure dolostones are used in the chemical industry as a source of magnesium metal and of magnesia (MgO). Pure dolime (CaO.MgO -also called dolomitic lime) is a constituent of refractory bricks for furnace linings. Dolomite is used in the production of glass and ceramics. Lime and magnesia improve the durability of the glass but magnesia also inhibits the devitrification process, which is important in the manufacture of flat glass. For this last use, a very low iron content is required to produce colourless glasses. The use of dolostone as a flux has notably increased since environmental contamination has become an issue of concern, because the resulting slag can be recycled e.g. for lightweight aggregate, without environmental harmful effects. Finely ground dolomite is used for filler applications in plastics, paints, rubber, adhesives and sealants. Pure white (high brightness) filler grades are preferred in this case. The steel industry uses dolomite as a sintering agent in processing iron ore and as a flux in the production of steel. The use of dolostone as a flux has notably increased since environmental contamination has become an issue of concern, because

Eric Goemaere, Senior geologist.
Geological Survey of Belgium, head of section Applied geology and Geoinformation.

Operation Direction earth and History of Life, Royal Belgium Institute of Natural Sciences.

Specialties: geological model of Belgium, sedimentology of siliciclastic rocks (Devonian), petrology of sedimentary rocks, clay mineralogy and clay geology, raw material (characterization and sourcing), building stones geoheritage, archaeometry applied on stones, ores, pigments, minerals, ceramics, bricks… (Prehistory, Antiquity, Middle Age, Modern Times).

Geological Survey of Belgium

the resulting slag can be recycled e.g. for lightweight aggregate, without environmental harmful effects. In the past, dolomite was a source to produce magnesium (now replaced by other sources and processes).

Health impacts

Dolomite is non toxic. Dolomitic lime is non-toxic and has few or no negative environmental effects. Throughout its activities, quarry workers tend to limit environmental impact by using the most recent techniques and production methods considered to be the best available technologies. This includes reducing dust, noise, and vibrations, as well as washing trucks and cleaning all access roads. Calcite and dolomite mining mainly created a modification of landscape, but in many countries abandoned quarries are restored to reach a new natural state: planting projects, ponds, green areas, maintenance plans developed with local authorities, as well as the creation of nature reserves.

Anecdotes

Dieudonné Sylvain Guy Tancrède de Dolomieu usually known as Déodat de Dolomieu (Dolomieu, Isère, 1750 - Chateauneuf 1801) was a French geologist. The mineral and the rock dolomite and the largest summital crater on the Piton de la Fournaise volcano were named after him. During one of his field trips to the Italian Northern Alps, Dolomieu discovered a calcareous rock which, unlike limestone, did not effervesce in weak acid. He published these observations in 1791 in the Journal de Physique. In March 1792, the rock was named dolomie (or dolomite, in English) by the Swiss chemist Nicolas-Théodore de Saussure.
But Dolomieu was not the first to describe the dolomite. The Austrian naturalist Belsazar Hacquet was the first to distinguish it from the limestone and described it already in 1778.

Actions in our daily life

Dolomite as a mineral has very few uses. However, dolostone has an enormous number of uses because it occurs in deposits that are large enough to mine. Some villages are built with dolostones as dimension stone, with special yellowish hot colors (geoheritage).
But dolomite is a typical hidden friend!
It is commonly used as antacids (neutralizes stomach acid), base for face creams, baby powders, or toothpaste, calcium or magnesium nutritional supplements for animals and humans…

Where is it found

"Dolomite" is a word that is used by geologists in two different ways: a) as the name of the mineral dolomite; and b) as the name of a rock known as dolomite, dolostone or dolomite rock. Dolostone is the sedimentary carbonate rock, which is composed predominantly of the mineral dolomite. The bulk of the dolomite constitutes dolostone formations that occur as thick units of great areal extent in many sequences of chiefly marine strata. Dolomite is found all over the world, and is quite common in sedimentary rock sequences. Vast deposits of dolomite are present in the geological record, but the mineral is relatively rare in modern environments.

The mineral occurs occasionally in high-temperature metamorphic rocks (dolomitic marbles, Mg-rich talc schists) and low-temperature hydrothermal veins. It is often found in ultrabasic igneous rocks, notably in "carbonatites" and "serpentinites".
As limestones, also dolostones are exploited in large quarries in several European countries, especially in Belgium.

Other EU countries producing this mineral

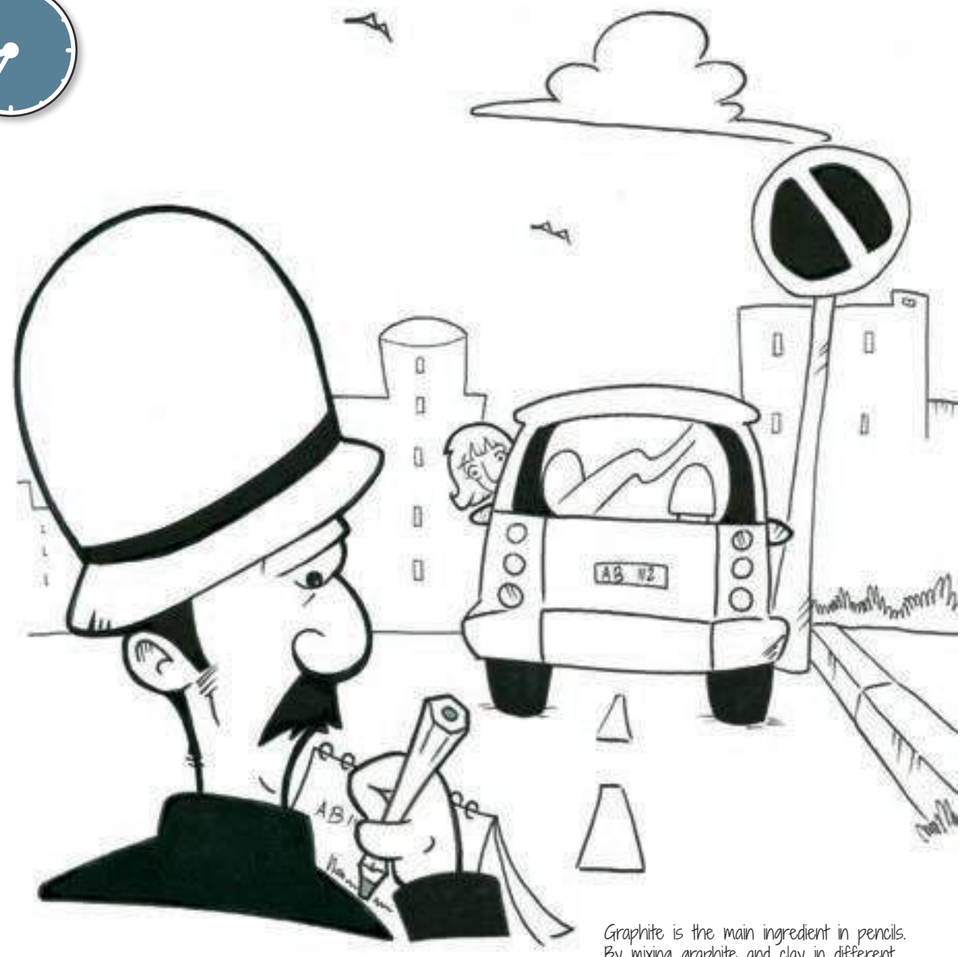
Regarding, the occurrences of dolomite in sedimentary, metamorphic and peculiar magmatic rocks, it occurs in numerous European countries (Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Poland, Portugal, Romania, Spain, Sweden, Switzerland, UK…).

Other minerals with similar properties

As a mineral, dolostone (dolomite) shares many of the same properties as limestone (calcite and other minerals).

GRAPHITE

Norway



Graphite is the main ingredient in pencils. By mixing graphite and clay in different proportions one can vary the hardness of the pencil lead.

What it looks like

Graphite is a soft, greyish, lustrous mineral build entirely of carbon atoms. The grain size is often fine, but naturally occurring coarse grained graphite is an important and valuable industrial mineral. The price of graphite is highly dependent on grain size. Coarse grained graphite is usually referred to as «flaky graphite» because graphite crystals form thin, flat, plate-like grains. The low hardness* gives graphite a well known application as a writing medium in pencils. Rubbing your thumb against a rock sample containing a small percentage of graphite will give your finger a waxy grey coating.

How we obtain it

World wide, graphite is mined from open pits or in underground operations. In North Norway flaky graphite has been mined on the island of Senja continuously since 1932. Current production on Senja is taking place at Skaland where graphite is extracted from underground deposits in multiply deformed, high-grade metamorphosed, Late Archean metasedimentary gneisses. Beneficiation of the graphite involves crushing and grinding and several steps of flotation to produce a series of end-products for various applications.

Use of the product

Graphite has long-standing uses in lead pencils and as a mechanical lubricant, but today graphite is also a high-technology material used in composites, electronics and foils. Graphite has a unique set of properties that makes it an essential component in an extremely wide range of applications.

Graphite is electrically and thermally conductive, it is both lubricating and refractory and retains strength at very high temperatures. Graphite is chemically resistant and the mono-layer version - the graphene building blocks - is one of the strongest materials ever tested. The main modern uses of natural graphite is in high-temperature applications, such as crucibles and furnaces, in steel production, brake pads and linings for cars, and in electrical applications and batteries for the complete range of portable consumer electronics. It is also important in electric vehicles. In fact the so-called lithium-ion battery, found in almost all mobile electronic equipment, contains twice as much graphite as lithium. Fuel cell technology is expected to increase demand for natural graphite significantly.

Graphene is predicted to be the material of the future - a one atom thick layer of graphite carrying all the properties of ordinary graphite in combination with extraordinary strength, stability and flexibility, low weight and transparency. According to the European Commission report on defining critical raw materials, the EU is 95% dependent on imports of graphite to supply the European industry. The criticality issue probably mainly applies to the flake segment.

Health impacts

Graphite is a non-poisonous non-toxic substance, even though over-exposure to inhalable graphite dust may give rise to «coal workers pneumoconosis». Pure graphite consists entirely of carbon atoms. It is used

Håvard Gautneb is a senior geologist at the Geological Survey of Norway. He has more than 20 years or experience with the geology of industrial mineral deposits and in particular in the geology of graphite deposits. He has investigated graphite deposits from Artic Norway to sub Sahara Africa. He has written more than 100 professional reports and papers in the field of industrial minerals.

Dr. **Henrik Schiellerup** studied geology at the University of Århus, Denmark, and received his PhD from the Norwegian University of Science and Technology in Trondheim, Norway. With a background in igneous petrology, volcanology and ore geology he is heading the Mineral Resources group at the Geological Survey of Norway.

Geological Survey of Norway

GRAPHITE Norway

as a homeopathic remedy, primarily against skin disorders.

Anecdotes

The name graphite, is derived from the ancient Greek word, meaning "to write". Graphite is the main constituent in pencils. By mixing graphite and clay in different proportions one can vary the hardness of the pencil "lead" (more clay harder lead). Graphite is among the softest minerals that exists, but it is chemically identical to diamond, the hardest mineral in nature.

Actions in our daily life

Charging or using your mobile phone or tablet. Writing with a pencil. Driving an electric vehicle. Stepping on the brakes in your car.

Where is it found

Graphite forms in different ways, and the process controls the resulting type of graphite. The processes mostly involves metamorphosis of carbon-rich material, and graphite is therefore primarily found in rock types such as gneiss, schist and marble. Deposits of fine grained, poorly crystalline or amorphous graphite may result if coal seams are subjected to low grade regional metamorphism or contact metamorphism. Deposits of the more attractive, coarse grained, flaky graphite, generally require much higher temperature and pressure, and high-grade metamorphosis of organic-rich sediments is the standard mode of formation. Vein-type graphite is a rare type of deposit where graphite is deposited by reduction of carbon-rich high-temperature fluids.

In 2012 major graphite producers included China, India and Brazil as the main players, with European contributions from Norway, Austria, Romania and Ukraine. Graphite is also produced synthetically.

Other EU countries producing this mineral

The Norwegian graphite mine in Skaland is the northernmost deposit in production in Western Europe. Austria, the Czech Republic and Ukraine all have significant production.
In 2012 the previously active graphite mine in Kropfmühl in German Bavaria was reopened.

BERYLLIUM

Russia

Beryllium is used in the manufacture of airbags for the automobile industry.

What it looks like

Beryllium is a silver-white relatively hard but brittle metal. It is light (1.5 times lighter than aluminum) but at the same time strong (stronger than steel) and heat-resistant (does not lose useful properties at a temperature of 700-800 °C). It is actively covered with a stable BeO oxide film when exposed to the air. It is a rare element: average beryllium concentration in the earth's crust is about 4 ppm (parts-per-million, there are 6 mg of the minerals per kg of rock).

How we obtain it

There are several ways of beryllium extraction: the main problem is to distinguish it from its constant associate - aluminium, characterized by similar properties. Beryllium is produced by electrolysis of beryllium chloride melt with added sodium chloride at a temperature of 300 °C or by magnesium thermal reduction of beryllium halides. The required beryllium salts are obtained by the processing of raw materials using following methods:

- sulphuric - raw material is treated with concentrated sulphuric acid at 300 °C, and then the sinter is treated with water
- alkaline or sulphate - beryl is sintered with soda or potash and the resulting aluminates and beryllates are leached with water
- fluoride - beryl is sintered with sodium hexafluorosilicate at a temperature of 750 °C, resulting in a water soluble beryllium fluoride complex
- chloride - beryl is heated at a temperature of 1000 °C in an atmosphere of gaseous chlorine in the presence of coal, and then beryllium and aluminum chlorides are separated.

Use of the product

Alloying
Beryllium is used as a dopant to various alloys based on aluminium, nickel, magnesium, copper, and other metals. This dopant ensures high hardness, good electrical conductivity, thermal conductivity and strength, corrosion resistance. Best known are beryllium bronze (copper-beryllium alloys) used in the production of springs which are capable of up to 20 million load cycles. The addition of 0.5% of beryllium in steel allows producing springs springing at red heat. Beryllide (intermetallic compounds of beryllium with tantalum, niobium, zirconium, and other refractory metals) is characterized by exceptional hardness and resistance to oxidation; it can operate for more than ten hours at a temperature of 1650 °C.
Production of beryllium and lithium alloys is believed to be promising, because they will be lighter than water.

X-ray engineering
Beryllium weakly absorbs X-rays, so it is used for manufacturing X-ray tube windows through which the X-rays come out, and windows of X-ray and wide-range gamma ray detectors, through which radiation enters the detector.

Nuclear technology
Beryllium and its compounds are used effectively as neutron moderators and reflectors. Beryllium can withstand neutron currents for tens of years being almost the best material for filters in thermonuclear fusion plants, fuel cell membranes and other constructions of nuclear reactors and neutron sources.

Laser materials
Beryllium aluminate is used for manufacturing solid state emitters (rods, plates).

Aleksey Sokolov graduated from the Leningrad (St. Petersburg) University in 1977; earned PhD in Geology in 1984. In 1977-1993 worked at the Institute of Arctic Geology dealing with Mesozoic biostratigraphy of the Arctic regions. From 1994 took a job at the Academician F.N. Tschernyschew Geological Museum (CNIGR museum) at A.P. Karpinsky Russian Geological Research Institute (FGUP VSEGEI). Director of the Museum since 2005.

A.P. Karpinsky
all Russia Geological
Research Institute - VSEGEI

BERYLLIUM

Russia

Airspace engineering
Material for manufacturing heat shields and gyroscopic devices for guidance and orientation systems in high-speed aircrafts, ballistic missiles, space vehicles, submarines and surface vessels. A special grade of metal with extremely high reflectivity was developed for space optical mirrors. Construction material for manufacturing rocket and aircraft engines and skins: more than a thousand details for modern aircrafts are made of beryllium bronze.

Rocket propellant
Beryllium and some of its compounds (as a solution in liquid ammonia, as beryllium hydride, beryllium borohydride solution in liquid ammonia) are regarded as promising solid propellant with the highest specific impulses.

Refractory materials
Beryllium oxide is one of the best refractory materials used in special cases.

Health impacts

Beryllium is found in plants grown on beryllium-bearing soils and in animal tissues and bones. Beryllium is harmless to plants, but it causes the so-called beryllium rachitis with animals. Elevated amounts of beryllium salts in the nourishment contribute to the formation of soluble beryllium phosphate in the organism. Constantly "stealing" phosphate, beryllium thereby contributes to the weakening of bone tissue.
Many of beryllium compounds are toxic. They can cause inflammation of the skin and beryllosis - irritation of the respiratory tract, sometimes accompanied by pulmonary edema and suffocation. Permissible beryllium content in the air is 0.001 mg/m3, that is significantly less than acceptable limits for most metals, even such toxic as lead.

Anecdotes

French chemist Louis Nicolas Vauquelin, who had discovered beryllium, suggested calling it "glucinum" due to sweet taste of its salts (from the Greek glycos - sweet), and in Russia, until the middle of the 19th century the beryllium oxide was named "sladkozem."

Historians write that the Roman emperor Nero loved to watch gladiator fights through a large emerald crystal. And even during the fire in Rome, which he had set on fire, he was delighted with the raging fire looking at it through his emerald, and paints of the fire mingled with the green stone in dark, ominous tongues.

Pure beryllium was obtained only at the end of the 19th century and for a long time people could not find an application to it: in a variety of reference books and encyclopedias of the early 20th century, it was written about beryllium: "has no practical application."

One of amazing qualities of beryllium is its high acoustic permeability: the sound speed in air is 340 meters per second, in water 1490 meters per second, but in beryllium the same sound travels with a velocity of 12,500 meters per second.

It has been proposed to take samples from the Earth's mantle using the so-called "nuclear needle", a miniature nuclear reactor with a diameter of 60 cm enclosed in a heat insulating case of beryllium oxide with a heavy tungsten tip. It has been assumed that high temperatures generated in the reactor (more than 1100 °C) would have to cause melting of the rocks and advancing of the reactor to the Earth's center. At a depth of about 32 km, the heavy tungsten tip should be separated, and the reactor, which become lighter than the surrounding rock, have to take samples from the depths inaccessible at present and rise to the surface.

Actions in our daily life

Jewelry, surgical instruments, needles for injection, springs for Swiss watches (an alloy of nickel, beryllium and tungsten) or details of writing mechanism in ballpoint pens.

Where is it found

In contrast to other rare metals, beryllium is mostly concentrated in the form of its own minerals among which beryl, phenacite and bertrandite are of commercial importance. The main beryllium raw material is bertrandite ore.

Industrial sources of beryllium are proper beryllium deposits and complex deposits, in which beryllium is an important by-product.

Beryllium is a typical lithophile element common for acidic, sub-alkaline and alkaline magmatic rocks. The highest concentrations of beryllium are typical of some mafic minerals and muscovite (tens, sometimes hundreds of ppm). In alkaline rocks, beryllium is almost completely dissipated; in acidic rocks it can be accumulated in post-magmatic products - pegmatite and pneumatolytic-hydrothermal bodies. In pegmatite, beryllium forms its own minerals, but about 10% of the element occurs in the isomorphic form in rock-forming and accessory minerals (microcline, albite, quartz, mica, etc.).
Beryllium enters into the composition of about 100 minerals - silicates and alumosilicates, phosphates, oxides and borates, but only six of them are rather widespread: beryl ($Be_2Al_2[Si_6O_{18}]$), chrysoberyl (alexandrite) (Al_2BeO_4), bertrandite ($Be_4(OH)_2[Si_2O_7]$), phenacite ($Be_2[SiO_4]$), helvine ($Mn_8[BeSiO_4]_6S_2$), and danalite ($Fe_4(BeSiO_4)_3S$). Transparent beryl varieties of different colors (emerald, aquamarine, alexandrite, heliodor, vorobievite and others) are gems. Their colour depends on the presence of various metals in impurities (iron, chromium, vanadium, manganese, lithium, and cesium). Arsenopyrite, albite, wolframite, cassiterite, quartz, columbite-tantalite group minerals, lepidolite, muscovite, feldspar, rutile, spodumene, topaz, tourmaline, phlogopite, fluorite and other minerals are found in association with beryl.

Beryllium minerals deposits are known in Russia, Ukraine, Austria, and Norway. As concerns beryllium reserves, Russia is second in the world (15%) after Brazil (30%). 50% of world production is mined in the U.S.A., 35% in Russia, and 10% in Kazakhstan.

AGGREGATE

Netherlands

The most important application of aggregates is in building and construction.

What it looks like

Aggregate is the catch-all term for sand, gravel and crushed rock. According to its definition in construction, aggregate is particulate mineral matter. In simpler terms, it is small pieces of rock.

Aggregate is omnipresent in our built environment; nobody will have any difficulty recognizing it. Sand and gravel aggregates look exactly like the source materials they are produced by sieving and classifying. Crushed rock fragments look like angular pebbles, just as the ones that make up alluvial fans in mountainous areas.

Aggregate is not a particularly beautiful mineral resource … until you zoom in. The photo at the top of the following page shows sand from a Lower Pleistocene river deposit in the central Netherlands that is commonly used for aggregate production. Most grains are quartz (SiO_2), which is one of the most abundant minerals in the Earth's crust. Quartz is glassy and translucent, but impurities, admixtures or coatings may give the mineral a colour or change its opacity. The large reddish grain on the left, for example, contains some iron oxide. You also see some orange-yellow grains, caused by a coating of limonite, an iron mineral. The lower photo on the next page shows sand from a glacial melt water deposit (Drente Formation, middle Pleistocene, central Netherlands). The material is more angular and variegated in terms of grain size and mineralogy. Generally, the composition of aggregate is of secondary importance. It is grain size that matters.

How we obtain it

Aggregates are produced from superficial resources. Sand and gravel are either dredged from rivers, the seabed or a pit, or they are excavated in a quarry. Rock for crushing is quarried.

Use of the product

The most important application of aggregates is in building and construction, either in a bound form such as asphalt or cement concrete, or as loose material, for example for constructional filling, in railway or roof ballast, in drainage filters and so on. Each application requires a specific grain size composition.

Health impacts

Certain common rock types used for crushed aggregate contain uranium and/or thorium, the decay of which produces radon. Radon is a colourless, odourless radioactive gas; long-term exposure may cause lung cancer. The emission of radon from rock is a natural process that normally does not present health risks because concentrations remain low. But when a radon-emitting aggregate is present in the walls or floors of a building, potentially dangerous concentrations of radon gas may build up in spaces that are poorly ventilated.

Anecdote

The availability of aggregates for building is taken for granted just as much as that of tap water or electricity: imagine not being able to build a road for lack of sand. But consumption is considerable! Dutch use of aggregates amounts to about a bucket per person per day. This makes aggregate the most used mineral resource and, after water, the second-most used Earth resource altogether.

Michiel van der Meulen is chief geologist at the Geological Survey of the Netherlands. He started working on resources and supplies of construction minerals at the Directorate General of Public Works and Water Management. At the Survey, he continued working on minerals, while his scope broadened to supplying geological information in general.

Geological Survey of the Netherlands

TNO

Forming the Dutch coastal and fluvial lowlands took a net average amount of about 30 million cubic meters of sediment per year since the last Ice Age. The Dutch use more than twice that amount in construction.

Actions in our daily life

There is hardly any activity in our daily life that is not enabled by aggregates, directly or indirectly. Aggregate is the main ingredient of our built environment, where we live and work, the latter also including the production of all other minerals in this book.

Where is it found

Aggregates are sourced as locally as possible because road transportation is costly. Exceptions occur where shipping is an option, which is much cheaper. For example, high-quality crushed aggregate is shipped from large coastal quarries in Scotland and Norway to the Netherlands, a country that has no resources of crushable rock. On the continent, major rivers such the Rhine and Danube are important distribution pathways.

But people will mostly work with what is available within a circle of just of tens of kilometres. In coastal and fluvial lowlands this would typically be sand and gravel deposited by rivers or the sea. Where no usable sediments occur, rock is crushed.

The shallow Dutch subsurface consists largely of sand. Just as in most of Europe, the availability of resources is not a problem, but access may be due to planning restrictions.

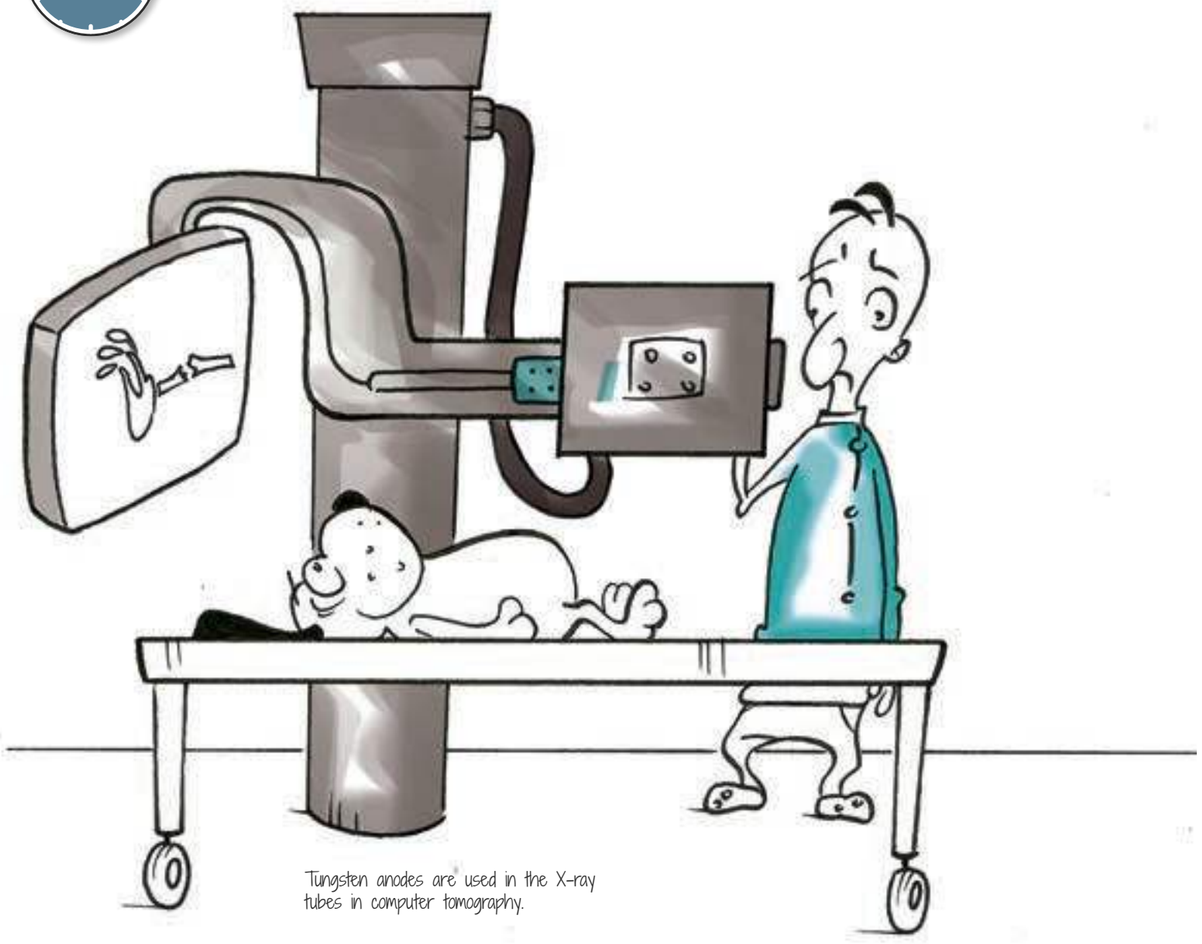
Other EU countries producing this mineral

Aggregate is produced all over the EU; most countries are largely self-reliant.

Photos courtesy of P.C. van der Klugt, TNO Geological Survey of the Netherlands.

TUNGSTEN

Austria



Tungsten anodes are used in the X-ray tubes in computer tomography.

What it looks like

Tungsten is an extremely hard and very dense steel-gray to tin-white metal, naturally occurring in the earth's crust only in form of chemical compounds. Although more than thirty tungsten bearing minerals are known, only two of them are of economic importance, namely scheelite ($CaWO_4$) and wolframite [(Fe, Mn) WO_4].

Scheelite is calcium tungstate mineral with high density and of white, yellow, brown or green colour. Pure scheelite has a strong bluish-white fluorescence under UV-light, a characteristic property which is applied in prospecting and mining that mineral.

Wolframite is an iron manganese tungstate mineral of greyish-black colour that is chemically the intermediate between ferberite (Fe rich) and huebnerite (Mn rich).

How we obtain it

Tungsten is usually mined underground. Open pit mines exist, but are rare. Exploitable grade of primary tungsten ore is typically 0,5% WO_3 in vein deposits, 0,3% WO_3 in high-tonnage underground, and 0,1% WO_3 in open pit mines. Tungsten mines are relatively small and rarely produce more than 2000 t of ore per day. Mining methods for tungsten ore are not at all exceptional and usually are adapted to the complex geology of the ore deposit.

Most tungsten ores contain less than 1.5% WO_3. Ore concentrates traded internationally require 65-75% WO_3. Therefore crude ore needs a beneficiation in ore dressing plants, mostly situated in close proximity to the mines.
The ore is first crushed and milled to liberate the tungsten mineral crystals from gangue material. Tungsten ores can easily be separated mechanically by gravity processes. Further purification is accomplished by flotation (for scheelite) or by high-intensity magnetic separation (for wolframite).

Use of the product

The melting point of tungsten (3420° C) is the highest among metals and it resists corrosion. It is a good conductor of electricity and acts as a catalyst in chemical reactions. Tungsten is the heaviest naturally occurring material except gold. When combined with carbon as tungsten carbide it exhibits diamond-like hardness. These unique properties of tungsten make it indispensable in a variety of industrial applications and products, which are present throughout our modern world.

Due its hardness and wear resistance, over 50% of the world tungsten production is used in producing hard materials based on cemented tungsten carbide, by far the most common tungsten compound. Tungsten carbide-based materials have a great variety of applications, including the use in cutting and drilling tools. The second largest application is in the production of special hard steels, with extreme resistance to corrosion and high temperatures.

The high melting point making pure tungsten metal suitable for high temperature applications in energy- and lighting technology, and in the space industry.

The high density of tungsten is used in weights and counterweights for vibration damping in aerospace, automotive, sport and telecommunications applications.

Tungsten serves also as a substitute for lead and is used as radiation-shielding in medical

Dr. **Albert Schedl** studied geology at the University in Vienna, Austria. Since 1989 he is working at the Department of Mineral Resources at Geological Survey of Austria. He is specialised in ore deposits and compiled a GIS-based mine inventory for Austria.

Furthermore he is responsible for the ongoing multi-year programme 'Geochemical Survey of Austria' and involved in environmental risk assessment projects, concerning abandoned mine sites in Austria.

Geological Survey of Austria

engineering. X-ray tubes for medical use have emitter coils made of tungsten. Tungsten is also used in microchip technology and liquid crystals displays.

Health impacts

Tungsten was originally considered a metal that remains stable in soil and did not dissolve easily in water and was therefore held nontoxic. Now it is a growing concern to U.S. Environmental Protection Agency (EPA) and the U. S. Department of Defense because recent research indicates that tungsten may not be as stable as was indicated in earlier studies. Varying soil properties such as pH may cause tungsten to dissolve and leach to the groundwater: Therefore tungsten is now classified as an «emerging contaminant» of concern. Currently, there are only few informations about the transport mechanism of tungsten in the environment and its implications to human health available. Further actions depend on the results of ongoing researches.

Anecdotes

The chemical symbol of tungsten 'W' is based on the original German name of the element 'Wolfram'. The entymological roots of this word going back to the 16th century tin smelters in the Saxony-Bohemian Erzgebirge in Germany. The presence of tungsten in the tin ores caused lots of problems during the tin smelting. Foam appeared on the surface of the tin melt and fixed valuable tin in form of droplets within that foam. The smelter said, that this unknown mineral (at that time called 'Wolf' '; English: the wolf) eats up the tin. 'Ram' probably derived from a High Middle German word meaning 'dirt'.

The Anglo-Saxon nomenclature uses the name 'tungsten' for the element. This name was given 1757 by the famous Swedish mineralogist and chemist Axel Friedrich Cronstedt to a new mineral, later called scheelite. The name is composed by the two Swedish words 'tung' (heavy) and 'sten' (stone), a reference to the high density of scheelite.

Actions in our daily life

Getting a mobile phone vibration alert, caused by an unbalanced-mass motor made of tungsten heavy metal; driving a car with tungsten based elements in electronics, window heating system, tyre studs and vibration damping in diesel engines using crankshafts made of high-density tungsten heavy metal; writing with ballpoint pens using tungsten carbide balls; dental drilling at the dentist using tungsten based tools, X-ray examination with tungsten components in the X-ray tube and protective aprons.

Where is it found

Tungsten ore deposits of economic importance are generally formed by magmatic-hydrothermal processes related to granitic intrusions. The main deposit type of tungsten can be found in peripheral parts of intrusions in form of greisen and porphyry deposits. Stockwork orebodies and vein fields are situated within the granites or in surrounding host rocks. Economically most important are skarn deposits in the contact zone of carbonate bearing rocks with felsic intrusions.

The major tungsten deposits are situated in the proximity of orogenic belts as, for example in the Circumpacific belts in the Far East (China, Korea, Thailand, Myanmar, Japan) and North or South America (Canada, USA, Bolivia, Peru), the Alpine belt (from France to Turkey) and the Variscian belt (Portugal).

The richest and biggest tungsten ore deposits in the world are located in the Chinese provinces of Jiangxi, Guangdong and Hunan, where all important types of tungsten ore deposits can be found. The biggest mine in Europe is the Mittersill tungsten mine in Austria, which is in operation since more than 35 years.

The world tungsten production is about 82.000 t (2011) per year. The world tungsten supply is dominated by the production and exports of China. China produces more than 80% of the world mine production and ranks also first in the world in terms of tungsten reserves (about 60%). Other places with significant mines are Russia, Canada, USA, Bolivia, Portugal, Austria, Rwanda and Peru.

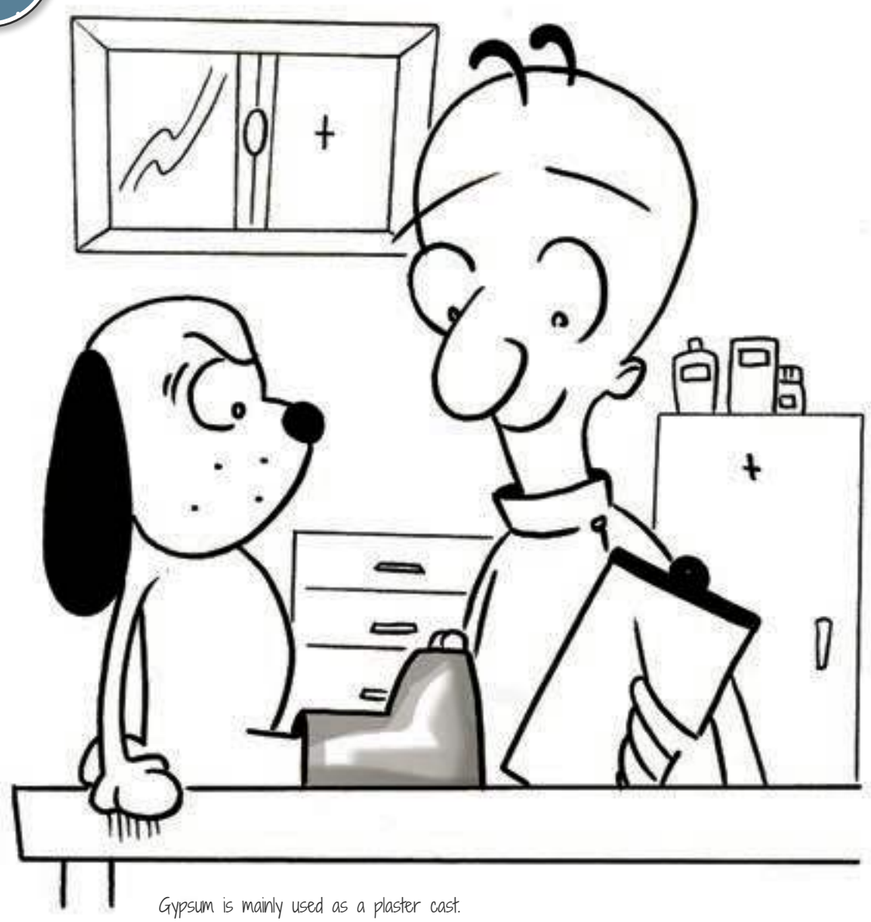
Photo: Blue fluorescence of scheelite under UV-light.

Other EU countries producing these minerals

97,8% of the global tungsten production is mined outside of the EU (2011). Tungsten producing countries (based on mining of wolframite or scheelite) in the EU (2011) are only Portugal (819t), Austria (706t) and Spain (337t). By far the main importing country for tungsten ores and concentrates, tungstates and ferrotungsten within the EU is Germany.

GYPSUM

Emilia Romagna (Italy)



Gypsum is mainly used as a plaster cast.

What it looks like

Gypsum is a calcium sulphate dihydrate, namely with two water molecules ($CaSO_4.2H_2O$). The crystals can vary widely in size, from less than a millimetre to several metres (e.g. more than 15 m-long and 1 m-large in the Naica Crystal Cave in Mexico). Crystals larger than 2 mm in size are called selenite (from the Greek selene = moon) and are generally colourless and transparent with a pearlescent sheen. These crystals are frequently twinned and form so-called "arrow-head" or "swallowtail" shapes.

Gypsum can form layers of selenite up to 40 m-thick or else thin laminar gypsum, layers informally known as balatino (from the Sicilian word "balata", that means it can be separated into plates).

Some varieties, like desert rose, have crystals which are arranged in the shape of a rose, and are rough (due to the presence of sand impurities), yellow, brownish or reddish in colour.

How we obtain it

Gypsum is extracted from underground mines or, more often, from open cast quarries. Processing is extremely simple as water and heat are the only things required to transform the mineral by, all intents and purposes, cooking it. First of all the gypsum is crushed in mechanical grinders, generally powered by electric motors. Waste products from processing natural gypsum are used to make paper and aggregates, both easily recyclable.

Use of the product

- In medicine it is used in orthopaedics (plaster casts) and orthodontics (for dental impressions). It is also used as a filler in pills.
- In building it is used for walls, ceilings, as an interior covering (sheets of covered plasterboard) or plaster blocks. Blocks (solid or honeycomb) are traditional products that are most frequently used for single or double internal stud walls, in residential or unheated spaces. Gypsum is also used to produce plaster and stucco and is a key ingredient in cement, where it delays the setting time.
- In the ceramics industry it is used for making forms, casts and master models.
- In schools was used to produce chalk, now replaced by calcium carbonate rocks.
- In agriculture is it used as a soil conditioner and amendment, and is a component in fertilizers.
- In art and archaeology it is one of the oldest minerals known to man, and has been used since time immemorial to make casts of human faces (e.g. the inhabitants of Pompeii were cast in gypsum), reproductions of statues, and impressions.
- In oenology, it was used in ancient times for the so-called "plastering of wine", which was the common practice, above all in France and Sicily, of adding calcium sulphate (plaster of Paris) to wine. Calcium sulphate can be added to grape must in order to "plaster the wine", in other words to improve its acidity.

Health impacts

Gypsum poses no health hazard, as is borne out by its widespread use in the bio-medical field. Gypsum is a natural substance whose properties ideally respond to modern-day notions of sustainable building.

Michela Grandi is geologist at the Emilia-Romagna Geological, Seismic and Soil Survey (SGSS).

She graduated from the University of Bologna and started to work at SGSS in 2000, after a three years experience in the field of applied geology to the territorial planning in the province of Forlì-Cesena administration. In the SGSS, she mainly worked on a digital mapping project and geological cartography (CARG) of Italy; now she is working in the web communication, still involved in webgis cartography production and in the international activities.

Servizio Geologico sismico e dei suoli

Anecdotes

In Emilia-Romagna mining of gypsum has always been of great socio-economic importance. In Bologna, the region's administrative centre, gypsum contributes to the beauty of the city's famous towers, the bases of which are constructed of blocks of selenite gypsum with spectacularly dazzling crystals.

Emilia-Romagna is home to the largest, most striking outcrop of the Gessoso-Solfifera Formation (Messinian, upper Miocene) in Italy: the Vena del Gesso, or Gypsum Vein. This consists of a gypsum ridge, up to 230 m-thick which extent for approximately 25 km from the Sillaro Valley to that of the Lamone (Romagna). The Vena del Gesso, like all Messinian gypsum in the Mediterranean, is the geological record of one of the more dramatic paleoclimatic and paleoceanographic event occurred in the Earth history. Approximately 6 million years ago, during the so called "Messinian salinity crisis", all the Mediterranean became a giant salina, and huge amount of evaporites were deposited (up to 2 km in the deepest parts), composed predominantly of gypsum and rock salt.

Taking organic material trapped inside the selenite crystals of the Vena del Gesso in Romagna, scientists were able to replicate the oldest cyanobacterial DNA ever extracted.

Actions in our daily life

- Building a wall
- Writing on a blackboard
- Taking a pill
- Fertilizing agricultural soil

Where is it found

Gypsum is a mineral that is deposited in evaporitic sedimentary environments, formed as a result of direct chemical precipitation of sea water in environments like coastal lagoons (sabkhas) and coastal basins, and by continental water in ephemeral basins (playas).

It is also found in volcanic environments, where it precipitates directly from fumaroles or from hot springs in the form of concretions or crystals of various shapes and sizes.

At a temperature of approximately 52 °C (Hardie 1967) gypsum is partially dehydrated leading to partial or complete loss of the two water molecules and the formation of anhydrous gypsum ($CaSO_4.H_2O$) or anhydrite ($CaSO_4$). This process normally occurs following burial of around 800-1000 m of rock. The gypsum formed as a result of rehydration of these rocks is characterized by a microcrystalline structure which has several different names (saccharoid, alabastrine). Within faults and fractures, gypsum is generally fibrous in appearance, and this is described as sericolite.

Other EU countries producing this mineral

Gypsum is mined and produced in Italy (especially in Tuscany, Emilia-Romagna and Sicily), Spain, France, Germany, Austria, Greece, the United Kingdom, Poland and the Soviet Union. Spain is the leading producer in Europe.

Ukraine

Titanium is used in many sporting goods: tennis rackets, golf clubs, cricket bats, hockey sticks, football helmet grills, and bicycle frames and components.

What it looks like

Titanium is a lustrous transition metal with a silver color, low density, high strength and resistance to corrosion. Two latter properties are most useful especially the highest strength-to-weight ratio of any metal.
In its unalloyed condition, titanium is as strong as some steels, but 45% lighter. In addition, it is slow to react with water and air, as it forms a passive and protective oxide coating that protects it from further reaction. Titanium is fairly hard (although not as hard as some grades of heat-treated steel), non-magnetic and a poor conductor of heat and electricity.

How we obtain it

About 6.0 and 0.7 million tonnes of rutile and ilmenite have been mined in 2011, respectively. Total reserves of titanium are estimated to exceed 600 million tonnes. However, relatively high market value of titanium is mainly due to its processing. Because the metal reacts with oxygen at high temperatures it cannot be produced by reduction of its dioxide. Titanium metal is therefore produced commercially by the complex and expensive Kroll batch process. In this process, the oxide is first converted to chloride through carbochlorination, whereby chlorine gas is passed over red-hot rutile or ilmenite in the presence of carbon to make $TiCl_4$. This is condensed and purified by fractional distillation and then reduced with 800°C molten magnesium in an argon atmosphere.

Use of the product

About 186,000 tonnes of titanium metal sponge were produced in 2011, mostly in China (60,000 t), Japan (56,000 t), Russia (40,000 t), United States (32,000 t) and Kazakhstan (20,700 t). Titanium is used in steel as an alloying element (ferro-titanium) to reduce grain size and as a deoxidizer, and in stainless steel to reduce carbon content. Titanium is often alloyed with aluminium, vanadium, copper, iron, manganese, molybdenum, and with other metals. Applications for titanium mill products (sheet, plate, bar, wire, forgings, castings) can be found in industrial, aerospace, recreational, and emerging markets. Powdered titanium is used in pyrotechnics as a source of bright-burning particles.

Titanium dioxide is used in house paint and artist paint. The paint is permanent and provides good coverage. It is an excellent reflector of infrared radiation. Titanium oxide is used in some cosmetics to disperse light. Titanium tetrachloride is used to iridize glass. Since the compound fumes strongly in air, it is also used to produce smoke screens. Vinyl siding capstock includes about 10% titanium dioxide, which is a pigment and provides resistance to breakdown from UV light.

Based on the beneficial and efficient properties of photocatalytic and hydrophilic conversion functions of nano-titanium dioxide (nano-TiO_2) irradiated with ultraviolet light, environmental friendly and safety on human health, high stability and low costs, nano-TiO_2 is assumed to be more and more extensively applied in sustainable agriculture. In poultry houses, photocatalyst coating with nano-TiO_2 could be used to oxidize and destroy bacteria in the presence of light and humidity.

Titanium dioxide is an excellent reflector of infrared radiation. The paint is also used in solar observatories. Since titanium does not become magnetized, it is used in the structural parts surrounding computer components such as

Dr. hab. Geol.-Mineral Sci. **Boris Malyuk** - Graduated in 1981 from Department of Geology, Lviv University, Ukraine, and in 1999 from Centre of Geostatistics, Ecole des Mines de Paris, France. Obtained Candidate of Science (PhD) Degree in Geotectonics in 1984, and extended Doctor of Science Degree in Petrology in 1991.

At present - Director, Center for International Cooperation, SRDE «Geoinform of Ukraine».

State Geological and Subsurface Survey of Ukraine

disk drives and microchips, which can be ruined by stray magnetism. Exploration vehicles used in the high-pressure environment of deep oceans also rely on the high strength and light weight of titanium structures.

The automotive industry uses titanium in automotive components including connecting rods, valves, and suspension springs. Race-technology in a road car requires weight savings and use of titanium in its engine, suspension and exhaust to improve performance: faster acceleration, better handling, higher cornering speeds and increased fuel economy. By using titanium, it also offers natural corrosion resistance and durability and a virtually unlimited life span.

Titanium is used in condensers and turbine blades in electric power plants. It is also incorporated into the architecture of buildings, roofs, piping and cable. Titanium dioxide is one of the whitest substances known and is used as a base pigment in many paints. Evolving applications for nanotitanium dioxide include thermal coatings, structural plastics, and environmental catalysts for water treatment or auto emissions.

The most widely used titanium alloy, Ti-6Al-4V, is present in 45% of industrial applications. Some uses of this alloy are aircraft gas turbine disks and blades, airframe structural components, and prosthetic devices. Titanium also is used in the petrochemical industry in heat exchangers and reactors. The sporting goods industry uses the metal in the manufacture of bicycles, golf clubs, tennis rackets, and wheelchairs designed for disabled people who want to participate in a sport.

Health impacts

Elemental titanium and titanium dioxide is of a low order of toxicity. The International Agency for Research on Cancer (IARC) has listed titanium dioxide within Group 3 (The agent is not classifiable as to its carcinogenicity to humans). Excessive exposure in humans may result in slight changes in the lungs. Titanium powder dust inhalation may cause tightness and pain in chest, coughing, and difficulty in breathing. Contact with skin or eyes may cause irritation. No environmental effects have been reported.

Anecdotes

It is only about $6 to buy a pound of titanium. That's less than going to the movies! That's more like popcorn and pop at the movies.

Actions in our daily life

Riding a bicycle. Traveling with aircrafts. House painting.

Where is it found

Titanium is concomitant to other elements in nature. It is the ninth-most abundant element in the Earth's crust (0.63% by mass) and the seventh-most abundant metal therein. Its proportion in soils is approximately 0.5 to 1.5%. It is contained in most igneous rocks and in sediments derived from them and occurs primarily in the minerals anatase, brookite, ilmenite, perovskite, rutile and titanite (sphene).

Of these minerals, only rutile (TiO_2) and ilmenite ($FeTiO_3$) have economic importance although are not observed in high concentrations. Significant titanium-bearing ilmenite deposits are known in Western Australia, Canada, China, India, Mozambique, New Zealand, Norway, Ukraine and South Africa.

Other EU countries producing this mineral

About 50% of titanium ores are produced in Australia (20%), South Africa (20%), and Canada (10%). In Europe, titanium is produced commercially in Norway and Ukraine. All EU member states need to import titanium to meet their demands.

Portugal

Lithium batteries are used in GPS (Global Positioning Systems) and camera's and such.

What it looks like

Elemental lithium is a very soft, silver-white metal in colour that under standard conditions of temperature and pressure is the lightest metal and the least dense solid element. As all alkali metals, lithium is highly reactive and flammable and for this reason it is typically stored immersed in mineral oil. When cut open, lithium exhibits a bright metallic luster, but contact with moist air quickly corrodes the surface to a dull silvery grey, then black tarnish. In nature we do not see lithium in this state due to its high reactivity and it occurs as compounds.

How do we obtain it?

In Europe, lithium minerals are typically quite close to the surface and hence mostly mined in open cast (open pit) mines. In this case, because these minerals occur in pegmatite veins, the usual method of mining involves stripping away the overburden exposing the pegmatite veins which are then selectively removed and processed. This type of mining is also commonly used for a variety of other minerals such as bitumen, clay, coal, copper, coquina, diamonds, gravel and stone, granite, gypsum, limestone, marble, copper, iron, gold, silver, molybdenum and uranium.

In contrast, in the salars (or salt flats) of South America (the so called "lithium triangle" - Bolivia, Argentina and Chile), which are composed of a salt surface crust that can vary from tens of centimetres to several metres in thickness, overlying brine (a saturated solution of sodium chloride, lithium chloride and magnesium chloride in water) saturated sediments, the mining method differs somewhat. Here, the brine is abstracted and pumped into evaporation ponds. Through various evaporation steps it is possible to achieve the required concentration of lithium to get lithium carbonate, which is then further processed.

Depending on the mining method and the product obtained, be it hard rock mineral concentrates or brines, further, often complex, processing techniques must be applied to obtain elemental lithium.

Whatever the product , the production of Li metal involves an initial conversion to lithium carbonate. Lithium carbonate is a stable white powder, which is a key intermediary in the lithium market because it can be converted into specific industrial salts and chemicals, or further processed into lithium metal.

Another method of obtaining lithium is by recycling of existing lithium-ion batteries. Facilities in Belgium, Germany, Japan, the US and Canada can now all process batteries for their lithium and other components.

Use of the product

Lithium (oxide) is a widely used flux for processing silica. It works by reducing the melting point and viscosity of the material and leading to glazes of improved physical properties including low coefficients for thermal expansion making it a widely used component of ovenware. Due to its high electrochemical potential, lithium is an important component of the electrolyte and of one of the electrodes in batteries.

A typical lithium-ion battery can generate approximately 33% more voltage than lead-acid or zinc-carbon cells. These are high energy-density rechargeable batteries used to power a series of portable communication

Daniel P. S. de Oliveira is an economic geologist and is Head of the Mineral Deposits and Geophysics Research Unit at LNEG.

His main research interests lie in the fields of metallogeny and genesis of mineral deposits but also has a keen interest in the exploration, geochemistry and geochronology of ore deposits.

National Laboratory of Energy and Geology

devices such as laptop computers and cell phones. The same batteries used to power personal communication devices are now a standard feature in hybrid vehicle technology.

Lithium is also commonly used in the manufacture of high temperature lubricating greases. When used as a flux for welding or soldering, metallic lithium promotes the fusing of metals during the process and eliminates the forming of oxides by absorbing impurities. Alloys of the metal with aluminium, cadmium, copper and manganese are used to make high-performance aircraft parts. Lithium has a number of other applications; it is used in air purification, as pyrotechnic colourants and oxidisers in fireworks and flares, in specialist optics for Infra-red and ultraviolet applications. It is also used in the production of polymers and fine chemicals, as rocket propellants in the military, in the nuclear industry and in medicine as treatment of bipolar disorder.

Health impacts

Not known

Where is it found

The extraction of lithium takes place from two geological contexts:
1- hard rock minerals: from zoned pegmatites where it is extracted both in open pit and underground mines as is the case in Europe, and
2- salts: from mineral springs, salt flats/brine pools. The world's producers of lithium are Canada, United States, Bolivia, Chile, Brazil, Argentina, Zimbabwe, Australia, China, Spain and Portugal, which is the major European producer. Lithium occurrences are also known in Russia, Mozambique, Namibia, Congo, Serbia, Finland and Afghanistan.

Lithium never occurs freely in nature and occurs in a number of pegmatitic minerals, the most common being: Spodumene [$LiAl(SiO_3)_2$], Ambligonite [$LiAl(F,OH)PO_4$], Lepidolite [$KliAl\ (OH,F)_2Al(SiO_4)_3$], Petalite [$LiAl(Si_2O_5)_2$], Triphylite [$Li(Fe, Mn)PO_4$], Lithiophillite [$Li(Mn, Fe)PO_4$].

Other EU countries producing this mineral

Portugal is the only major producer of lithium in Europe. It is produced mainly from deposits in the north and centre of the country in the Serra d'Arga, Covas do Barroso, Escalhão-Barca de Alva, Massueime, Mangualde, Gouveia, Guarda and Segura regions. Spain also produces lithium for the vitroceramics industry in the municipality of La Fregeneda.

Indium is used in the manufacture of solders (a fusible metal alloy used to join together metal workpieces and which has a melting point below that of the workpiece).

What it looks like

Indium is a soft, silver-white metal with the atomic number 49, chemical symbol In and is named for the indigo blue line in its spectrum. Indium has the unusual physical property that when it is bent (that is, when it is stressed) it creates a sound similar in pitch to a scream.

How we obtain it

Indium is recovered during the production of primary commodities such as zinc and copper by means of complex procedures, many of which are proprietary to each producer. One zinc recovery method consists of the Waelz Process followed by leaching (the process of extracting minerals from a solid by dissolving them in a liquid) and purification prior to electrolytic recovery (passage of a direct electric current through an ionic substance that is either molten or dissolved in a suitable solvent, resulting in chemical reactions at the electrodes and separation of materials) of zinc as cathodes and subsequent containment of the indium fraction in the residues.

Use of the product

Indium has a multitude of uses and the first large-scale application for indium was as a coating for bearings in high-performance aircraft engines during World War II and later in engines of Formula 1 racing cars. The uses of indium have since evolved to more high-tech applications.

Indium is used in the synthesis of the semiconductor copper indium gallium selenide (CIGS), which is used for the manufacture of thin film solar (photovoltaic) cells that are becoming common as alternative sources of household energy producing devices. It is also used in semiconductors (InSb, InAs, InP) in transistors, thermistors and IR-detectors In-selenide in solar cells.

Indium is also used as a thermal interface material by personal computer enthusiasts in the form of pre-shaped foil sheets fitted between the heat-transfer surface of a microprocessor and its heat sink so that efficient cooling of the processor components can take place.

Indium oxide can be used as a transparent conductive coating applied to glass substrates for making of electroluminescent panels. Indium tin oxide transmits visible light but reflects infrared this and can this be used in applications such as defogging of windshields in aircraft, goggles for welders to protect their eyes from heat radiation and heat-reflecting coating of buildings to make them more energy efficient and as a light filter in low-pressure sodium vapour lamps.

Indium compounds are used to manufacture semiconductors and are used in light-emitting diodes (LEDs) and laser diodes based on compound semiconductors and it is one of many substitutes for mercury in alkaline batteries to prevent the zinc from corroding and releasing hydrogen gas. However, perhaps the most commonly known use is for LCD production.

Daniel P. S. de Oliveira is an economic geologist and is Head of the Mineral Deposits and Geophysics Research Unit at LNEG. His main research interests lie in the fields of metallogeny and genesis of mineral deposits but also has a keen interest in the exploration, geochemistry and geochronology of ore deposits.

Nikolaos Arvanitidis - Dr. Economic Geologist with more than 35 years as Researcher at the Geological Institute of Stockholm University in Sweden, R&D Project Manager on mineral exploration and development projects and Regional Division Director at the Institute of Geology and Mineral Exploration (IGME) in Greece, Senior Specialist at the Geological Survey of Finland (GTK) and presently Head of Bedrock and Geochemistry Division of the Geological Survey of Sweden (SGU). Chair of the Mineral Resources Expert Group at EuroGeoSurveys (EGS), Executive Secretary of the European Technology Platform for Sustainable Mineral Resources (ETP SMR) and active member of the European Innovation Partnership on Raw Materials (EIP RM) Strategic Implementation Plan (SIP).

Very small amounts of indium are used in aluminium alloy sacrificial anodes (for salt water applications) to prevent passivation (a process that involves a shielding the outer layer of a material against corrosion - normally applied as a microcoating) of the aluminium. Indium is used as a conducting adhesive to bond gold electrical test-leads to superconductors. In the form of wire it is used as a vacuum seal and a thermal conductor in cryogenics and ultra-high vacuum applications and can be used as a calibration material for differential scanning calorimetry.

Indium is further used in the manufacture of solders (a fusible metal alloy used to join together metal workpieces and which has a melting point below that of the workpiece).

Indium's melting point of 156.5985 °C is a defining fixed point on the International Temperature Scale, (ITS-90). Indium's high neutron capture cross section for thermal neutrons makes it suitable for use in control rods for nuclear reactors. In is used to determine magnitudes of neutron fluxes and because indium emits gamma radiation, it is used in indium leukocyte imaging, or indium scintigraphy, a technique of medical imaging.

Furthermore, it can be used in dental and goldsmith alloys and in the manufacture of mirrors (In is as good as Ag but it has better corrosion resistance). Finally, one more use that might be of interest is the fact that indium alloys are easily composed for a specific melting range. Thus it can be used to create the perfect pop up thermometer that will tell you exactly when your roasted turkey is ready to go from the oven to the table.

Health Impact

Pure indium in metal form is considered nontoxic by most sources. In the welding and semiconductor industries, where indium exposure is relatively high, there have been no reports of any toxic side-effects.

Actions in our daily life

A house with photovoltaic panels OR a person watching a LCD screen

Where is it found

Elemental Indium forms only a very few rare minerals, such as roquesite ($CuInS_2$), sakuraiite [$(Cu,Zn,Fe,In,Sn)_4S_4$], indite ($FeIn_2S_4$), cadmoindite ($CdIn_2S_4$) and dzhalindite [$In(OH)_3$], which are never abundant enough to be sources of ore. We therefore find indium commonly as trace-metal nano domain inclusions in minerals that contain zinc and copper. Two good examples of this association are inclusions of indium in stannoidite in the Neves Corvo mine and in sphalerite and stannite in the Lagoa Salgada orebody; both located within the Iberian Pyrite Belt.

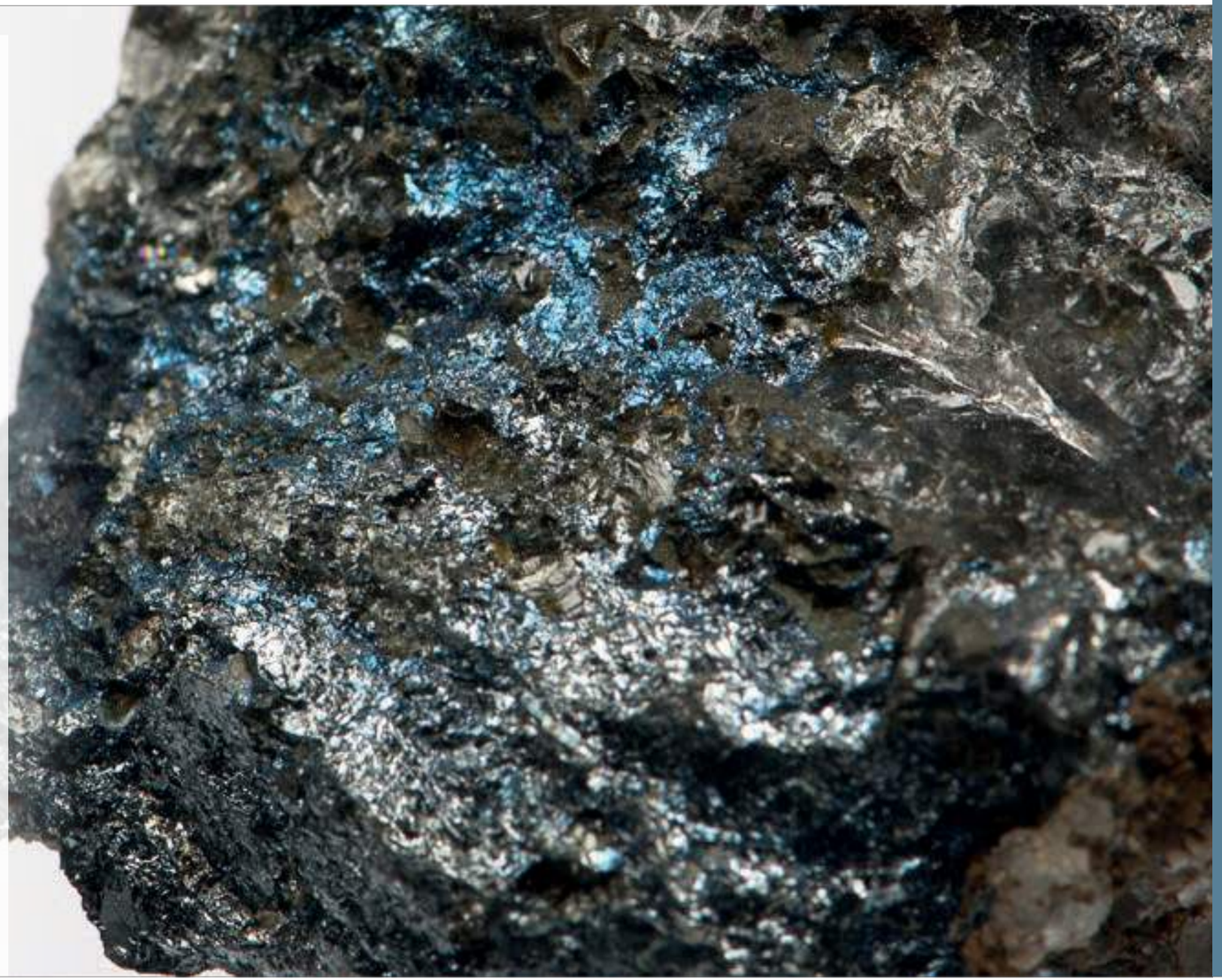
The world's leading producers of indium are China, Canada, Japan and South Korea. Indium occurrences are known in Bolivia, Kosovo, Russia, Uzbekistan, Ukraine, Portugal, Finland, Germany, Italy, Peru, Sweden and the USA.

Other minerals with the same product

The main indium-bearing minerals are: roquesite (CuInS2), indite (FeIn2S4) and dzhalindite [In(OH)3]. However, elemental indium can also be present in nano domains within bornite, tetrahedrite-tennantite, stannoidite, stannite and sphalerite.

Other EU countries also producers of this mineral / minerals

There are no primary producers of indium in Europe. Europe is best described as an indium processor with refineries and smelters in Belgium (Hoboken) and France (Auby).



Germany

Platinum is used in hi-tech computing and telecommunications systems, such as mobile phones and electrical instruments.

What it looks like

Up to now about 95 Platinum Group Minerals (PGM) are known. They look very different. Some occur in form of native metals or as alloys looking like "the little silver" in Spanish: platino. In other PGM the metals are bonded to a variety of ligands including sulphur, arsenic, antimony, tellurium, selenium and even oxygen.

How we obtain it

In Colombia the PGM´s are produced out of the river sands by heavy mineral separators. 99% of the world PGM production comes from underground mines. Drilling, blasting or cutting are the typical mining techniques for getting the crude material out of the ore body. On the surface the crude ore is beneficiated by physical and chemical processes in order to get a PGM concentrate. Finally Platinum Group Metals are won by smelting and refining.

Use of the product

Platinum Group Elements (PGE) are noble metals. Noble metals are characterized by extremely slow or even a lack of chemical activity. They resist corrosion and oxidation for a long time compared with other metals. Platinum Group Minerals (PGM) are listed by the European Commission as critical raw materials. A mineral is labelled "critical" when the risks for supply shortage and its impact on the economy is higher compared with the other raw materials. As mentioned above 98% of the annual world production derives from just 5 mining districts.

The failure risk for a continuous and sufficient supply is the highest compared to other metals. Moreover, PGE cannot be substituted by other materials in many existing and emerging technologies due to their specific chemical and physical properties.

About 45% of the annual platinum production is used as catalysts in cars and in the chemical industry. About 30% went to jewelry. The remaining 25% are spread to a variety of applications like electrodes, drugs, investment, sensors, plugs, medical instruments, dental prostheses and even mobile phones.

Health impacts

Platinum as a noble metal is not very dangerous, but platinum salts can cause several health effects. Platinum bonds are applied as a medicine against cancer. The South African National Institute for Occupational Health (NIOH) is currently undertaking research on the potential health effects of platinum-mining on workers in the platinum industry. Platinum and palladium are emitted into the air, the soil and into the groundwater through the exhausts of cars using leaded gasoline. What the effects of platinum on the biosphere and the environment may be, is not yet clear and further research is needed especially if platinum is substituted by palladium which can more easily get incorporated in animals and plants.

Anecdotes

From 1889 to 1960, a platinum-iridium alloy bar, known as the International Prototype Meter defined the length of a meter. The International Prototype Kilogram remains defined by a cylinder of a 90:10 platinum-iridium alloy made in 1879. Since 1830 iridium and iridium-osmium

Prof. Dr. **Bernhard Stribrny** studied geology at the Goethe-University in Frankfurt am Main, Germany. As Director and Professor of the Federal Institute for Geosciences and Natural Resources in Hannover he carried out research work on platinum and base metal deposits worldwide.

Since 2003 he is honorary professor at Albert-Ludwigs-University in Freiburg, Germany.

Federal Institute for Geosciences and Natural Resources

BGR

alloys are used to form the wear-point of iridium-tipped gold dip or fountain pen nibs.

Actions in our daily life

Starting a car with a catalyst. Buying wedding rings. Collecting platinum coins. Writing a letter with an ink pen.

Where is it found

Platinum Group Minerals are very rare. In 200 million grains of sand only 1 grain of platinum occurs on the average. In 2011 the world production reached 195 t of platinum (Pt) and 214 t of palladium (Pd). The mines operating in the South African Bushveld Layered Ultramafic Complex are by far the world greatest producers with 145 t Pt or 85% of the total world production. At Noril´sk-Talnakh and on the Kola peninsula the Russian Pt production amounted in 2011 25 t or 13% of the total world production.

11 t Pt were mined in the Great Dyke, Zimbabwe, 7 t Pt in Sudbury, Canada and 4 t Pt in the Stillwater complex, USA. In these magmatic deposits the PGM´s occur as small single minerals or associated and intergrown in other minerals like sulphides or chromites. The grain sizes are mostly below 0.1 to 0.001 mm and the grains are only visible under the microscope. 1 t Pt is paned in Colombia, like in historical times, as heavy minerals in stream sediments.

Sperrylite $PtAs_2$, Braggite (Pt,Pd)S, cooperite (PtS), isoferroplatinum Pt_3Fe, moncheite $PtTe_2$, are the most common and economically most important Platinum Group Minerals.

World Platinum producers and EU share

98% of PGM are produced in just 5 mining districts worldwide. All EU member states need to import theses noble metal to meet their demands. Just a few kilograms of Platinum Group Elements are produced in the EU from black shales in the Polish Kupferschiefer.

Gold is involved in people's lives in multiple ways, such as the make up of their regular or occasional appearance (i.e. the wearing of rings, earrings, broaches, etc.).

What it looks like

Gold is a chemical element (symbol: Au) and a mineral at the same time because it frequently occurs in native (metallic) state. Gold can form alloys with silver, mercury and copper.
The alloys of gold and silver are also known under the name electrum. Due to its properties, gold was used by man since prehistoric times.

- Gold has yellow colour, which makes it easy to remark, even in tiny grains. Gold colour is the base of its attraction and of its widespread use in jewelry.
- In its native state, gold is resistant to corrosion, which makes possible the preservation of its colour and luster for a long time, unlike other metals (copper, silver), which get tarnished.
- Gold has a high density (19.3 g/cm^3), more than twice the density of iron. This favoured gold accumulation in certain places (river beds, beaches) on the surface of the Earth.
- Gold occurrence in metallic state made possible its use by people before the development of the methods necessary for the extraction of other metals (e.g., iron, copper, lead, aluminum).
- Gold is soft, malleable and ductile. This allowed its shaping in very thin pieces (one ounce of gold can be hammered into 16 m^2 of gold leaf) without much heating, thus its manufacturing without very complex tools.

How we obtain it

Gold from sediments is extracted by gravitational methods, with various techniques, all of these based on moving water: panning, sluicing, use of blanket table etc. These methods can be seen as improved versions of the natural sedimentary processes that concentrate gold.

The visible gold from veins can be extracted in underground and open pit mines. The gold disseminated in hard rocks needs to be liberated by the milling of the ore, an operation that increases the costs of gold extraction.

One traditional method of gold extraction from rocks, known for thousands years, is named amalgamation and is based on gold capability to form alloys with mercury. The ore is brought in contact with mercury and the gold is drawn into the mercury. The gold-mercury mixture is then treated with nitric acid, which dissolves the mercury, leaving the gold behind. Mercury can also be removed by heating, as it has a vaporisation temperature (356.7°C) lower than the melting point of gold (1064°C). Amalgamation is not widely used in the present because of the high toxicity of mercury.

Another method of gold extraction, particularly efficient for the ores with very fine gold grains, is leaching. The traditional leaching method uses cyanide as leaching agent. This method was created in 1887, in Scotland. Its use increased the recovery of the gold from the Witwatersrand Basin (South Africa) from ca. 65% to ca. 95%. The finely milled ore or the flotation concentrate is mixed with a dilute solution of cyanide. Air is bubbled through the mixture to help gold forming a soluble complex ion with the cyanide: $Au(CN)_2^-$.
The gold from solution is precipitated with zinc powder, then it is refined by smelting and treatment with nitric acid to remove zinc and silver. Because of their high toxicity, cyanides are more and more frequently replaced by other leaching agents, such as ammonia, iodine or iodide, thiosulfate or thiourea.

Gold purification can be accomplished by smelting. Gold is melted with some chemical substances that react with the other metals, leaving an almost pure gold (99.9% Au).

Marian Munteanu is Senior Researcher in the Geological Institute of Romania.

He holds a Ph.D. in Geology (Metallogeny) from the Alexandru Ioan Cuza University in Iaşi, Romania (1998).

Previous employment with the National Agency of Mineral Resources (Romania), University of the Witwatersrand (South Africa) and Anglo Platinum (South Africa).

Experience in geological mapping (Romania), manganese deposits (Romania), Ni-Cu and PGE magmatic deposits (China).

Geological Institute of Romania

Use of the product

Gold had a great and, frequently, mystic influence on people from the beginning of mankind, being used as jewelry, instrument of treasure, raw material and measure for money (universal currency) but also being associated with divinity and royalty, promoting the yellow colour as a noble one in many civilizations. It is also the symbol of the winners (gold medalists) and persistence (most wedding rings are made of gold). More recent medical and high-tech uses complete the importance of the metal in everyday life.

Pure gold is too soft for most manufacturing purposes. This is why it is used in alloys with other metals, which can alter its colour, generating varieties of white gold (allied with nickel, silver or palladium), red or pink gold (with copper) or blue gold (allied with iron). On the purpose of briefly stating of gold content in an alloy, the karat/carat system is used. Pure gold has 24 karat while an alloy with 50% Au has 12 karat, one with 75% Au has 18 karat etc.

Ornamental gold
The oldest and most widespread (>50%) use of gold is in jewelry and ornamental objects for people, buildings and objects. Gold foil (gold leaf) is used in coating of palaces, temples, churches, statues, icons, books, frames etc.

Gold as savings instrument
Gold plays the role of a universal currency converter. People can invest in gold as an inflation-proof commodity and a private store of wealth. Most states, through their central banks, make gold reserves to ensure financial stability against inflation.
People are inclined to buy gold in times of economic crisis on the purpose of protecting their assets against financial depreciation.

Gold in dentistry
Gold was used as teeth fillings since the 19th century. Gold foil (24 karat) was pressed in the cleaned tooth cavities, layer by layer and, due to its malleability, the metal got intimately bound to the tooth. Cast gold alloys are also used for tooth fillings and for gold dental crowns. Gold alloys are used in dental restorations because they have a thermal expansion similar to the teeth, they are soft enough not to wear off the opposite teeth and they last for 15-30 years. Some people or cultures consider gold teeth restorations as a note of distinction.

Gold in industry
Gold is a very good electricity conductor and is used for fuses, switches, connectors, electronic circuits and chips in computers, cell phones or TV sets. Gold is also used in catalytic convertors or as lubricant against cold welding (very useful in space, where many other lubricants can break down or evaporate). Gold is part of many surgical instruments and of electronic equipment used in medicine. Gold is also a component of some special glasses.

Health impacts

Being chemically inert, gold has no dangerous impact on the natural or domestic environment.

Anecdotes

The legend of Jason and the golden fleece is inspired by an old method that uses fleeces put on the river beds. Gold grains settle on the fleece, separating from the other rock fragments. The fleece is dried and shaken to release the gold grains.

Actions in our daily life

Gold is working for you every time you: socialize on facebook, watch television, play games or work on your computer, call your friends or relatives on a mobile phone, watch youtube, make payments and do shopping online.

Gold is involved in people's life in multiple ways, from the make up of their regular or occasional appearance (wearing of rings, earrings, broches, etc.), to routine activities, such as making calls on cell-phone, making payments and shopping online, socializing on facebook, watching television or youtube, playing games or work on computer.

Where is it found

In most rocks, gold has the concentration of the order of 0.001 gram per ton (g/t). In order to form a deposit worth mining, gold has to be concentrated by a factor of ca. 1000 (to reach values of more than 1 g/t). Gold can be concentrated in very diverse geological environments, as native gold or as a component of more complex minerals. The most accessible gold is contained in sands and gravels, where it can occur as fine flakes and grains or as coarser pieces (nuggets). Nuggets can reach the weight of several tens of kilograms. The old gold-bearing sedimentary rocks can be metamorphosed, which is the case of the gold-rich conglomerates from the Witwatersrand basin in South Africa (age of 2.7-3.1 billion years), which represents the largest gold field ever discovered on Earth.

The primary sources of gold are the magmatic rocks of various compositions, from granites to andesites and basalts. Under the action of hydrothermal solutions (hot fluids), the gold from magmatic rocks is dissolved and transported, then it is deposited in veins, where it is associated with sulphur-rich minerals, quartz and carbonates. Beside native gold, such hydrothermal veins may contain gold compounds with sulphur, tellurium, arsenic, antimony and bismuth. The gold from sedimentary rocks originates from the erosion of magmatic or hydrothermal gold. Gold can also be recovered as a secondary product from the deposits mined for other metals (e.g., Ni, Cu, Cu-Pb-Zn, platinum group elements).

An important proportion of the annual gold production (37% in 2012) is from recycling: from scrap jewelry and dental works, from electronic waste etc.

Other EU countries producing this mineral

The EU leaders in gold production are Finland, Sweden and Bulgaria. Gold is also produced in Serbia, Poland, Romania, Slovakia and United Kingdom (BGS, 2013).

GERMANIUM

France

Germanium is used for the production of multi-junction solar panels, one of several technologies used to produce photovoltaic cells.

What it looks like

Germanium is a chemical element, a metal, noted with the symbol Ge. Its atomic number is 32. In the periodic table of elements it belongs to a group of technologically very important semi-conductor elements, including arsenic, gallium, indium, selenium, silicium. The element was discovered in 1885 by a German chemist, Clemens Winkler, who named in honour of his homeland, Germany (Germania is the latin name for Germany).

Germanium is a brittle silvery-white metal like element. It does not exist as a native metal in nature and germanium bearing minerals with a high percentage of germanium are very rare (these are germanium bearing metallic sulfides such as argyrodite, briartite, germanite or renierit). The main economic source of germanium is as trace element ("by-product") in sulfidic zinc ore deposits.

How we obtain it

While the production of Germanium is closely related to the production of zinc, it has been reported by the International Zinc Study Group that only about 5% of the germanium contained in zinc ore is actually recovered. From sulfidic zinc ores, germanium is recovered from flue gas released during the roasting of sphalerite concentrates and from electrolytic cell sludge. Germanium in fly ashes resulting from coal burning or gasification is recovered by leaching and extraction of the germanium from the leachate.

Use of the product

Germanium has a remarkable structure of its electronic cloud, making it very suitable for the production of semi-conductors. Germanium is listed by the European Commission as a critical raw material. A mineral is labelled "critical" when the risks for supply shortage and its impact on the economy is higher compared with the other raw materials. As mentioned above 68% of the annual world production derives from China, while this raw material could be produced in many other locations. The germanium related supply risk is rated high (about 3 out of a maximum of 5 on the scale set by the European Commission). Due to its electronic properties, Germanium cannot be substituted by other materials in most of its applications.

About 30% of the annual Germanium production is used as a doping agent for the manufacturing of optical fiber glass used in modern information and communication technologies, 25% went into the manufacturing of infra-red optics especially for night-vision systems, 25% for polymerisation catalysis (production of polyethylene terephthalate widely used, for instance, for the production of plastic bottles used for mineral water and other drinks),15% goes into the production of multijunction photovoltaic cells, achieving the highest solar energy conversion rates. Their high production costs limit their use to space applications. The remaining 5% are spread to a variety of applications including the production of phosphors, of drugs (including chemotherapy in cancer treatment) and metallurgical applications.

Health impacts

Few data on germanium metabolism exist. It does not not appear to be a trace element of importance to human health. Inorganic germanium compounds found in some nutritional supplements can cause renal dysfunction.

Dr. **Patrice Christmann** studied geology at the Joseph Fourier University in Granoble, France. As Head of BRGM's mineral resources department and current head of BRGM's mineral resources strategy division he carries out research on mineral economics worldwide.

Since 2011 he is a member of the International Resource Panel established under the United Nations System (United Nations Environmental Programme).

French Geological Survey

Anecdotes

While Germanium was discovered in 1886 by the German chemist Clemens Winkler, its first industrial scale applications occurred only in 1947, with the discovery of the transistor, opening the era of solid-state electronics. While before 1945, only a few hundreds kilograms Germanium were produced worldwide, by the end of the fifties the production had soared to 40,000 kilograms.

Actions in our daily life

Drinking bottled water. Using the amenities of the Internet and of modern telecommunications. Providing night vision for rescue operations.

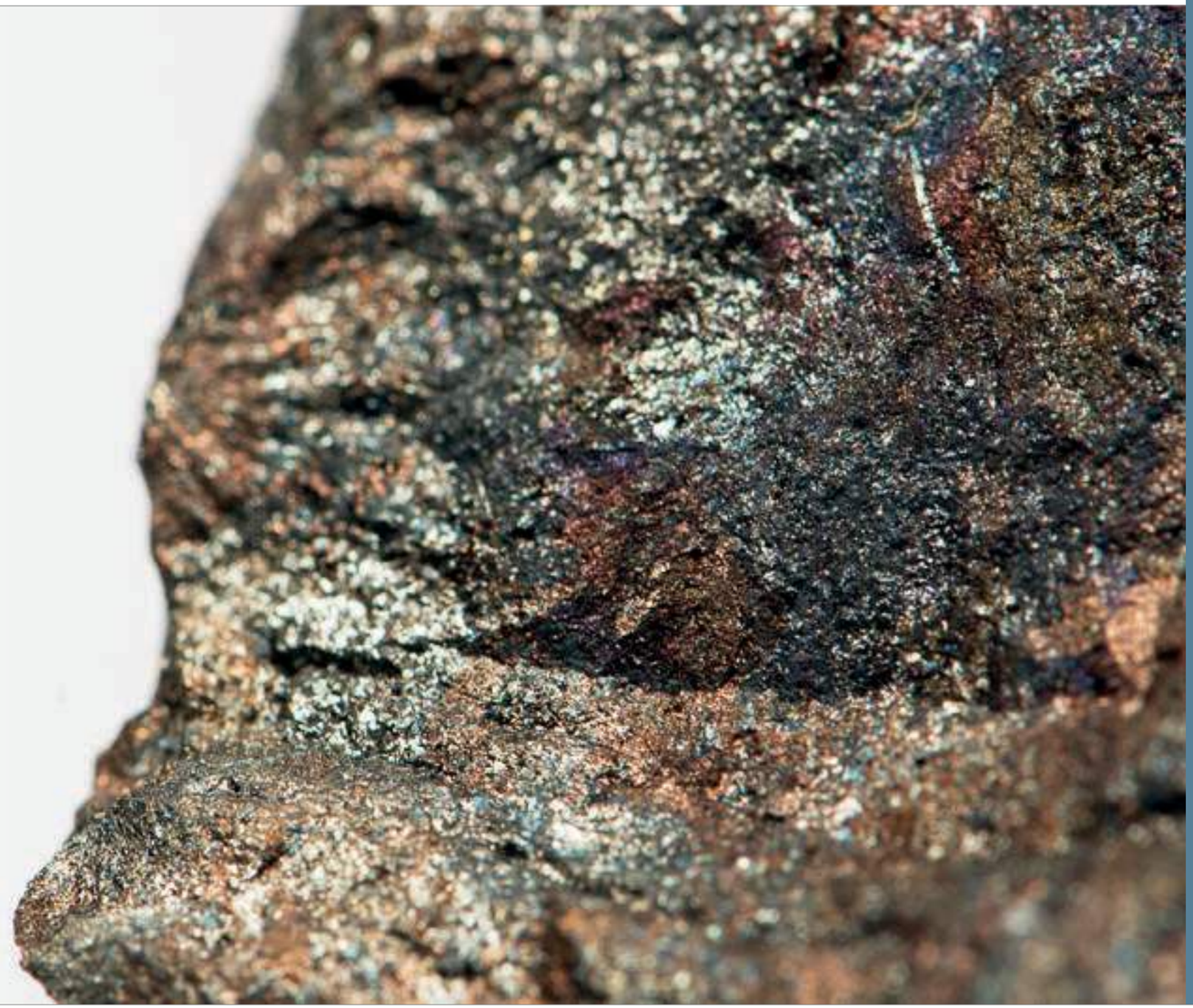
Where is it found

Germanium is rare. In 1 million grains of sand only 1.5 grain of Germanium occurs on the average. As Germanium is only recovered as a by-product, there is no mine production, only recovery from zinc refining or fly-ash processing. Only six Germanium rich minerals are known, and these minerals are rare due the low abundance of Germanium in the Earth crust (1.5 g/ton, a relative abundance similar to arsenic, tantalum or molybdenum). Several other minerals, especially sphalerite, the main zinc ore or coal can have Germanium as a by-product. Germanium never occurs in native form but together with other elements such as aluminium, arsenic, copper, hydrogen, iron, oxygen, silver, sulphur, zinc. The economic sources of Germanium are, by order of importance, sphalerite (ZnS, zinc sulfide that can in some deposits include up to 800 g/t of Ge) and some coal deposits. Coal can have Ge contents of over 1.000 g/t. Therefore Ge is recovered from fly ash of burning coal.

In 2011 the world refinery production estimated by USGS reached 118 t of Germanium, including about 30% of Germanium recycled essentially from manufacturing (primary) waste. 68% of the production came from China. Ukraine, Russia and Japan. The respective weight of production from sphalerite and fly ash is unknown.

Other EU countries producing this mineral

85% of Germanium is produced in just 2 countries (China and Ukraine). The EU production is not documented but Umicore reports the production of an unspecified quantity of secondary Germanium at its Olen plant, located in Belgium. It recycles Germanium contained in optic fibers and other materials.



POTASH

United Kingdom

Potassium is one of the three primary nutrients essential for plant growth and which forms the basis of fertiliser production.

What it looks like

Potash is a generic term for a variety of potassium-bearing minerals and refined products. There are many potassium-bearing minerals but only those that are water-soluble are of significant commercial interest. Sylvite (potassium chloride, KCl) is by far the most important source of potash worldwide, because of its solubility and high potassium content, and accounts for all the potash produced in the UK to date. Sylvinite is a mixture of sylvite and halite (salt, NaCl) in varying proportions. Sylvite is typically colourless to white, but may be grey, yellow or red-orange due to inclusions, with a glassy appearance Potassium minerals rarely occur in pure form and the mined material is invariably a physical mixture of salts.

How we obtain it

Bedded potash deposits, which can form large, high grade ore bodies are extracted by underground mining methods, typically involving drilling, blasting and cutting, using continuous mining machines. The ore is conveyed to the surface for crushing and processing. A small amount of the sylvinite ore produced in the UK is sold directly as a fertiliser for sugar beet production. However, the vast majority is crushed and ground and potassium chloride is recovered from the salt and other constituents. Deep potash deposits can be extracted using solution mining, in which the salt is dissolved by injecting water into drill holes in the underground deposit. A range of processes including natural solar evaporation and artificial crystallisation-evaporation cycles are used to precipitate salts from both naturally occurring and solution mining potash brines. The world's largest potash producers in 2011 were Canada (31%), Russia (19%), Belarus (15%), Germany (9%) and China (7%) (Brown et. al. 2012a).

Use of the product

Potassium is one of the three primary nutrients essential for plant growth and which form the basis of fertiliser production globally. Potassium is involved in the production, transport and accumulation of sugars in plants, assists their hardiness and resistance to water stress, pests and disease. Potash applied as fertiliser replaces potassium removed from the soil through plant harvesting and animal grazing. About 90 per cent of UK potash production is consumed in the manufacture of fertiliser.

Potash is used in a diverse range of fertiliser products, varying from granular and coarse grades suitable for direct application as a single nutrient fertiliser through to fine grades for the production of more complex fertilisers, consisting of nutrient blends. Global potash demand is primarily linked to agricultural productivity, which is growing rapidly. About half of the fertiliser used globally is applied to cereal crops. Potash is also used in animal feed supplements, which aid animal growth and milk production. Small quantities of potash and derived compounds are used by the chemical and pharmaceutical industries for the manufacture of a diverse range of goods, varying from soaps to speciality glass, explosives, matches and pyrotechnics, and in water softening and meat curing.

Health impacts

Potassium is described as 'a nutrient essential for life'. A lack of potassium will adversely affect crop yield and quality. Potassium

Paul Lusty is economic geologist with more than 10 years experience, specialising in exploration for metals, mineral deposit research, resource evaluation and analysis of the supply-demand dynamics and economics of a range of minerals critical to the economy.

He leads the BGS 'Ore Deposits and Commodities' Team.

British Geological Survey

deficiency in plants is often expressed as yellowing or browning of the leaves, spotting and scorching of the leaf margins. The human body requires a daily intake of potassium, equating to about 2 kilograms of K_2O annually (IPI, 2012). Potassium is required to maintain good health, being essential for a range of bodily functions including building proteins, breaking down carbohydrates, muscle development and normal body growth. High doses of potassium can be toxic to the human body and the intake of some potassium compounds is very harmful and even lethal.

Anecdotes

Historically wood ash leached in metals pots was the principal source of potassium, resulting in the term 'potashes' or potash (IPI, 2012).

Actions in our daily life

Growing crops. Feeding animals. Healthy human diet / lifestyle. Glass production. Explosives. Liquid soap / shampoo.

Where is it found

Potash occurs in bedded evaporate deposits, which were formed by salt precipitation from brines resulting from the extreme evaporation of seawater in restricted ancient seas. Potassium-rich mineral deposits have been formed throughout geological time, although the vast majority of global reserves are found in Palaeozoic age (542-251 million years) rocks. Commercially important potassium-bearing minerals are carnallite (hydrated potassium, magnesium chloride), kainite (hydrated potassium, magnesium sulphate-chloride) and polyhalite (hydrated potassium, magnesium, calcium sulphate). Deposits are distributed globally, with Canada and Russia accounting for more than 80 per cent of global reserves (USGS, 2012). Potassium is also common in many surface (e.g. the Dead Sea, Israel and the Great Salt Lake, USA) and underground brines.

Other EU countries producing this mineral

Europe produced 4.1 million tonnes of potash (K_2O content) or about 12 per cent of global production in 2011. European production is dominated by Germany (78%). The UK has emerged as an important world producer of potash in the last 30 years, contributing about 11 per cent to European production in 2011, a similar amount to Spain (Brown et al. 2012b).

Other minerals with similar properties

Potassium fertilisers are essential for healthy plant growth and there are no substitutes and the mineral cannot be recycled. Unconventional sources of potassium, such as certain sands, potassium feldspars, smelting slags and waste from sugar beet production have been examined in the past without success.

QUARTZ SAND

Slovenia

Quartz sand is used in all kinds of glass industries, from the usual glass bottles and window glazing, to the high quality manufactured glass ware.

What it looks like

Quartz sand is naturally occurring granular, unbounded type of sediment, whose primary component is quartz. Quartz is a hard mineral which does not fracture easily. It is chemically and heat resistant with good optical and electric characteristics. The quartz minerals are clear to white and can display any colour. Quartz grains in sand range in diameter from 0.0625 mm (or 1⁄16 mm) to 2 mm. When the matrix or cement bounds its grains, it turns into sedimentary rock - quartz sandstone.

How we obtain it

Quartz sand is usually extracted in open-pits by digging; then it is ready to be used as an aggregate. It can be further processed by flotation to separate and to purify sand from clay and heavy minerals. After process of flotation almost pure quartz sand becomes a non-metal mineral raw material. However, sand is also mined from beaches, inland dunes and dredged from ocean bottom and riverbeds.

Quartz sand can be also produced from solid siliceous rocks (chert, quartz sandstone and conglomerate, quartzite) by crushing and grinding.

Use of the product

- Global demand for Quartz sand in EU is around 280 mil. tons per year.
- It is used in manufacturing (for example as an abrasive, for glass and filters…), and it is used to make different construction materials (for example concrete, isolation materials, silica bricks…).
- Due to use in hydraulic fracturing its demand increases for 4,5% in a period from 2012 - 2016.

The applications in which quartz sand is used as a base ingredient are uncountable and very different. Quartz sand is the raw material of glass, that is indispensable in our daily lives. Just think of crystal, flat glass, hollow glass and other applications like fibreglass, glass wool, glass for technical purposes (television tubes) or optical glass (spectacles and binoculars).

Quartz sand is necessary in the ceramic industry in its the most purified form. As such it is then used in particular for flame-resistant bricks, sanitary, kitchenware and tiles.
Less pure quartz sand is used mostly for casting metals sand and sand cores.
The chemical applications are wide-ranging as well. Quartz derivatives are used in e.g. fertilizers, pharmaceutical preparations, as a binding agent in paint and glue, in the production of cosmetics, as a component in detergents and washing-powder.
Innumerable fillers are produced with a base of quartz sand, like paint, polymeric concrete, silicone paste, mortar, ornamental plaster, tile glue, etc.

Quartz sand is also used in water filters, on golf links and sports fields, for well boring, as brake-sand for trams and trains, as litter-sand in aviaries and aquariums. Gritted on the ground, quartz sand is an excellent subfloor for ungulates in a zoo, where when walking they grind their hooves. It is known that the building sector is an important buyer of quartz sand for ornamental bricks, cement tiles, cellular concrete, floors, gable- and roof tiles, road asphalt, insulation material, etc.

Mrs. **Duška Rokavec**, Ph.D., is the Head of the Department of Economic Geology. She has 25 year experiences as research assistant for evaluation and assessment of non-metal mineral deposits, economic geology with classification and categorization of reserves and resources, spatial planning of open pits etc. She is qualified as a court expert for mineral deposits and surface mining and she has gained the designation of European Engineer.

She has contributed to creating and competing national Mining Act and Statutory Acts, as well as in estimating MR values for the purpose of imposing taxes. She co-operated in establishing and maintaining the MR database, including mining cadaster. She is a vice-president of national Republic Commission for determining mineral reserves and resources.

Geological Survey of Slovenia

GeoZS

Health impacts

While Quartz sand is generally non-toxic, some activities, however, require precautions. Because of the fine quartz dust resulting from sandblasting it is now obligatory that bags of quartz sand used for sandblasting have warnings for respiratory protection that would prevent inhalation of the dust. A material safety data sheet (MSDS) states that the excessive inhalation of this fine quartz sand could be a serious health concern. In areas of high pore water pressure sand and salt water can form quicksand, which is a colloid hydrogel that behaves like a liquid and could be mortal dangerous.

Many sand's uses require a significant dredging industry, raising environmental concerns over fish depletion, landslides, and flooding. Countries such as China, Indonesia, Malaysia and Cambodia ban sand exports, citing these issues as a major factor.

Anecdotes

Repnica is a pit dug into Pliocene quartz sand, which was deposited in the Pannonian Sea millions of years ago in the Bizeljsko area (SE Slovenia). These pits are named after turnips, which were mainly stored in them by local farmers. The great advantage of repnicas was that for their construction people did not need either building material or heavy equipment. Some repnicas were built more than two hundred years ago and today they represent indigenous, natural, historical, ethnological and cultural heritage of the area. The total thickness of sand, which contains approx. 70% of quartz, is estimated to 200 m. Due to high cohesion of sand, repnicas are stable and do not need any support or retaining walls. Flow lines in the sand have created beautiful shapes on the ceilings of repnicas and give the impression of frescoes. Because of their suitable internal climatic conditions they are now mostly used for aging and storage of wine. The usefulness, which lasts for years, and the uniqueness of their creation made them become an attraction of the Bizeljsko - Sremič Wine Road.

Actions in our daily life

Quartz sand is the most common variety of sand. It impacts our daily life in many ways as it is used for various purposes like water filtration, industrial casting, for construction purposes and glass manufacturing. Eventually, the transparency and clearness of the glass in our windows makes the world seem more beautiful.

Where is it found

Sand is transported by water and wind and is deposited as of beaches, dunes, sand spits, sand bars and related features. Quartz sand deposits can be found all over the world in deserts, on coasts and river sediments due to its high resistance on mechanical and chemical weathering.

Other EU countries producing this mineral

Other EU countries are also producers: Belgium, Great Britain, France, Italy, Netherlands, Germany, Spain, Portugal, Scandinavia etc.

MOLER (CLAYEY DIATOMITE)

Denmark & Greenland

Moler is used in animal feed (as a carrier for vitamins and feed additives) and on the barn floor (to reduce bad odours, keep the floor dry and hygienic).

What it looks like

Moler (clayey diatomite). Moler is rich in diatomite, which is easy to recognize by its light, pale and powdery character. Dry moler is white with a beige hue, but it becomes olive-green-grey to brownish under water-saturated conditions. Moler is sometimes called Mo-clay in English. The word "ler" means clay and "mo" is an old Danish term for white and fine. Moler feels like clay, when it is wet, but it contains only about one third of clay (smectite). The remaining part is made up of opal-A diatom frustules. This is biogenetic silica, which grows as hard-shelled algae in the sea. The silica was deposited on the seafloor after the plankton had died and is mixed with the clay minerals. The moler was deposited in the North Sea Basin in the earliest Eocene (ca. 55 million years ago) in thin layers alternating with 180 volcanic ash layers. The volcanic ash results from volcanic activity on Greenland, Scotland and Faeroe Islands related to the opening of the North Atlantic Ocean. With an electron microscope the diatoms can be studied at high magnifications. Here it can be seen that the diatoms consists of porous rings and tubes.

How we obtain it

Moler is mined in open pits, where the excavation follows the trend of the hillcrests created by the ice push. Therefore the excavation resulted in characteristic elongated pits.

Use of the product

Moler is very porous and absorbent on a microscopic level. Therefore, moler is used for cat litter (it strongly reduces the bad odors), absorbents, carrier and animal feed additive. Furthermore it is used as insulation material and as soil conditioner. Very clean diatomite is used for beer filtering, but moler is not used for this purpose.

Health impacts

Moler has no health impact. In contrast, its clean quality is much appreciated in the agricultural industries where it is used as an animal feed additive.

Anecdotes

When the moler is dry, the number of voids in the diatom frustules makes it so light that it floats on the water. In the moler outcrops many fossils of birds, fishes, insects, reptiles and plants have been found. Because the sediment is so soft, many specimens are contained in a 3D shape and some of the birds still had recognizable feathers.

Actions in our daily life

When we wish to keep cats hygienically at home we instruct them to use the litter box, which is filled with moler aggregates.
When taking care of growing plants without biological pollution the moler granules are a very good alternative to ordinary soil. When repairing a car, moler products can absorb oil spills and keep the floor from getting slippery.

Stig A. Schack Pedersen, Dr. Scient., is responsible for the geological mapping of the land surface of Denmark. During the past 25 years he has been consulted by clay companies in Denmark about the exploration of clayey diatomite – the moler.

Geological Survey of Denmark and Greenland

MOLER (CLAYEY DIATOMITE)

Denmark & Greenland

Where is it found

Moler crops out in the hilly landscape plowed up by the massive ice sheet that reached northern Denmark during the last Ice Age. The massive ice sheet thrust layers of sediment on top of younger material. The moler was brought up to the surface in this way, without the push from the ice sheet it would still have been burrowed deep beneath the surface.

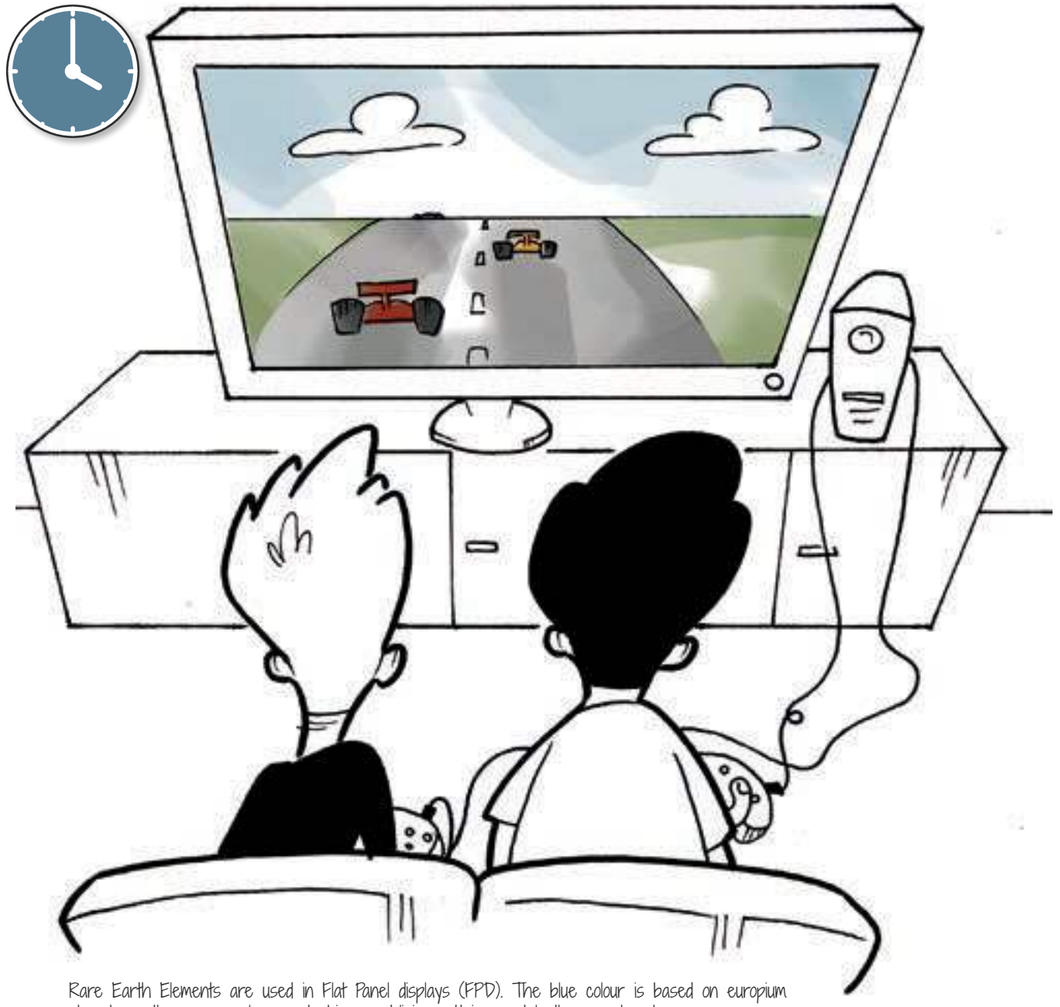
Other EU countries producing this mineral

Moler is only produced in Denmark. Alternative products produced from calcareous diatomite are produced in Spain. The Bann Clay from Northern Ireland is a diatomaceous earth, which is used as a filtering agent, absorbent and abrasive.

Other minerals with the same product

Cat litter and absorbents may be produced from bentonite. Various types of chalk powder may be used as carrier and feed additives. Zeolites are alternative products for feed additives with an absorbent property.

Denmark & Greenland



Rare Earth Elements are used in Flat Panel displays (FPD). The blue colour is based on europium phosphors, the green colour on terbium, gadolinium, yttrium and lanthanum phosphors; and the red colour is based on phosphors containing yttrium, gadolinium and europium.

Most REEs have a silvery white metallic appearance; their oxides show a range of colours, from white and yellow to black. However, normally we will never have a chance to see the colour because they mainly occur as very minor ingredients in component parts in e.g. smartphones, computers and displays in computers and televisions.

How we obtain it

No two REE deposits are alike; they differ with respect to mineralogy and grade. Low-grade deposits (down to 1% REE in ore) may be economic if they contain other economic products in addition to the REE. REEs are usually excavated from open pits, and after crushing and milling of the ore, physical separation is used to concentrate the REE-minerals. The concentrate is then treated through varies types of leaching processes which dissolves the REE-minerals. Finally the liquid with the dissolved REE is treated to separate the individual REE from one another. A wide range of REE-products can be produced, each of them is usually tailor-made for specific end products.

Use of the product

Rare earth metals and REE-containing alloys are used in a wide range of daily life devices such as, in the screens and memory of smart phones, in glass lenses of digital cameras and in the motor of electric bikes. Importantly, REE are a key constituent in "green" and energy efficient technology such as wind turbines, energy storage technology, petroleum refining and automotive catalysts. All types of cars, but especially electrical and hybrid cars, depend on REEs for their electrical motors, generators, and window screens. REEs are also extensively used in lighting as coatings that create variations in colour and brightness, as fluorescent and in cathode ray tubes, LED and laser. Colours in flat screens and smart phones are created with different REEs.

Can it be substituted with other elements

Due to the unique physical and chemical properties for REEs all substitutes are less effective; however, for certain applications one of the REE may substitute for another.

Health impacts

The most significant Health impacts comes from mining and the processes transforming the REE-mineral into REE-metal or alloy. However, many REE-deposits are associated with uranium and thorium and will therefore be found in somewhat radioactive ores.

Anecdotes

Mining of REE started in the fifties, with USA as the major producer. In the mid-eighties, REE demand increased dramatically in response to the growing computer and green technology industries, and China started a large number of REE-mining operations to fill the demand gap. In the beginning of the new millennium Western industries began to move their production facilities for windmills, electronic devices, batteries etc. to China to benefit from the lower production costs. At the same time, American REE production was abandoned,

Per Kalvig, PhD., has been working with the Rare Earth Element occurrences in southern Greenland for many years, both for the Geological Survey of Denmark and Greenland for the Risø, National Laboratory, and for the private minerals sector.

Geological Survey of Denmark and Greenland

which left the REE-market open to the expanding Chinese industry, and consequently China became a hub for the entire REE-value-chain including the metallurgical and technological knowledge leading to their strong control of the market.

The price of the REE Lanthanum increased from $5/kg in 2010 to $140/kg in 2011 because of uncertainties regarding possible restrictions on exports from China. The prices are now decreasing again in response to the extensive exploration and high expectations for new deposits coming into production over the next few years. This sparked an international debate about the future of the Chinese monopoly on REEs, and has brought resource supply risk on the political agenda worldwide.

Actions in our daily life

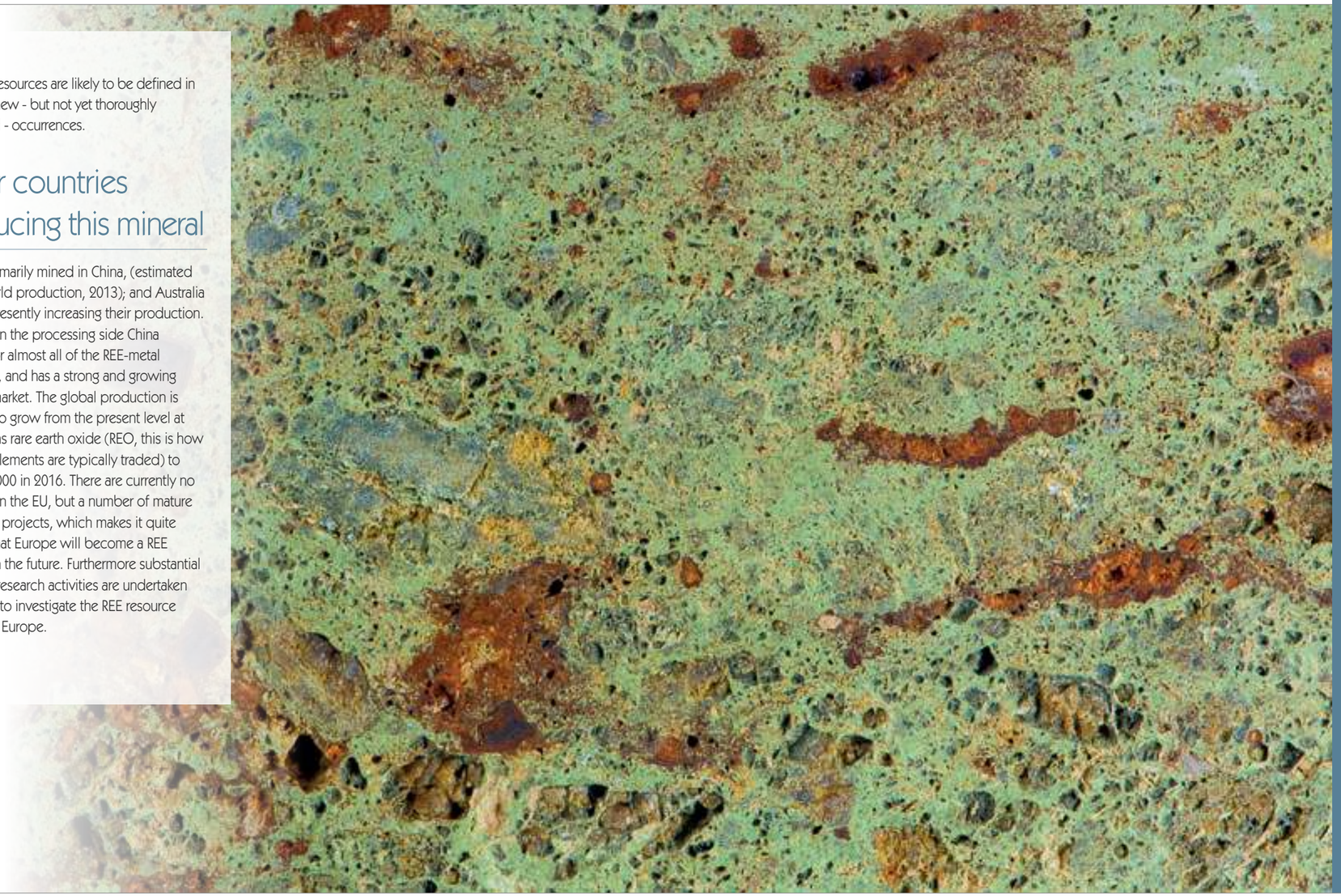
Your computer, your smartphone, your car, your green electricity, your colour-television and many other everyday technologies, wouldn't be the same - or even exist, if not for REEs.

Where are they found

Minerals containing REEs are found throughout the earth and are, despite their name, quite common. However, REE does not fit easily into the common silicate minerals, and are therefore mainly found in rare geological environments. More than three hundred different REE-containing minerals are known. The percentage of REE in each mineral varies from a few percent to almost eighty percent, and the ratio of the individual REE varies as well. Thus, some of the REE minerals are more interesting to the mining industry than others. The most common commercial REE minerals are bastnäsite, monazite, and xenotime. Though REE minerals are not so rare, commercial deposits are rare. Enrichment of the REE-minerals is connected to specific geological environments, such as areas where the continents are breaking, like the present-day East African rift zone, or areas where REE-minerals have been concentrated by erosional process. REE resources are known from all continents, and there are several deposits in Europe (Sweden, Greenland, Greece). Many of these deposits are currently being investigated by the mining industry. Intensive REE-exploration over the past decade has resulted in a very large REE reserve base and additional resources are likely to be defined in about 500 new - but not yet thoroughly investigated - occurrences.

Other countries producing this mineral

REEs are primarily mined in China, (estimated 80% of world production, 2013); and Australia and USA presently increasing their production. However, on the processing side China accounts for almost all of the REE-metal production, and has a strong and growing domestic market. The global production is predicted to grow from the present level at 110 000 tons rare earth oxide (REO, this is how Rare Earth Elements are typically traded) to about 140 000 in 2016. There are currently no producers in the EU, but a number of mature exploration projects, which makes it quite possible, that Europe will become a REE producer in the future. Furthermore substantial geological research activities are undertaken these years to investigate the REE resource potential in Europe.



Malta

Salt is a common kitchen ingredient used to enhance the flavour of food.

What it looks like

It occurs in the form of cubic crystals. When in large crystals it is transparent while when finely ground it is white. Sea salt may assume a light pinkish colour due to the presence of microscopic organisms. It may assume other colours depending on the impurities present. It is highly soluble in fresh water. Because of certain impurities it often appears wet. The deliquescent impurities absorb water from the surrounding air and prevent it from flowing freely. For this reason magnesium carbonate is added to table salt to make it flow freely. The most obvious test for Halite is its taste.

How we obtain it

Sea salt is obtained from salt evaporation ponds sometimes also known as salt pans. These consist of a few large pools known as warming pools each say 20m by 10m and about 1m deep which are filled with sea water and left to warm up in the sun. Once warm, the water is distributed by an elaborate canal system into small artificial rockcut shallow pools each about 2m by 3m and about 20cm to 30cm deep, located at the coastline. The seawater is left to evaporate under the hot Summer sun to leave a small white shining salt deposit. This salt is swept into small heaps and gathered and deposited in a shed where any remaining water is allowed to seep out. The process takes about a week after which the pools are filled again with seawater and left to evaporate in the sun . So the cycle is repeated as long as the weather permits. The salt harvesting process is very labour intensive. When it occurs in the subsurface in the form of rock it is extracted in underground mines by blasting, loaded on track mounted trollies and lifted to the surface. These salt mines may contain 99% pure salt.

Use of the product

Salt is a common kitchen ingredient used to enhance the flavour of dishes. It has many industrial applications such as a preservative in the food canning industry, for the production of chemicals like hydrochloric acid. In cold climates in winter is often used to free our roadways from ice or snow. This happens because salt lowers the freezing point of water. A 10-percent salt solution freezes at 6 C, and a 20-percent solution freezes at -16 C. When in solution salt is highly corrosive. For the same reason people who live close to the sea know how corrosive the marine environment is.

Health impacts

Salt is essential not only to life, but to good health. Sodium is an essential ingredient for the proper functioning of the body cells. That is why the importance of salt in our daily diet. Deficiency in Sodium may lead to symptoms of hyponatremia like nausea and vomiting, headache, confusion, lethargy, fatigue, loss of appetite, restlessness and irritability, muscle weakness, spasms, or cramps, seizures, and decreased consciousness or coma. In medicine, salin or saline solution, is a general phrase referring to a sterile solution of sodium chloride (salt) in water, but is only sterile when it is to be placed parenterally (such as intravenously); otherwise, a saline solution is a salt water solution. The sterile solution is typically used for intravenous infusion, rinsing contact lenses, nasal irrigation, and often used to clean a new piercing.

Saviour Scerri got his BSc in Physics and Chemistry from the University of Malta in 1972 and his Doctorate in Geology from the University of Milan in 1976. He started his career as a ground engineer. After four years Joined the Oil Exploration Department of the Government of Malta which for many years was also a Member of EUROGEOSURVEYS. Presently he is working as a Consulting Geotechnical Engineer and is a part time lecturer (Geology) at the University of Malta.

Malta Resources Authority

Anecdotes

The word salary comes from the latin word 'salarium'. Some believe that the Romans paid their soldier with salt and the word salary derives from it. Others believe that salt might have been only a sort of allowance to the soldier's pay. Others note that soldier more likely derives from the gold solidus, with which soldiers were known to have been paid, and maintain instead that the salarium was either an allowance for the purchase of salt or the price of having soldiers conquer salt supplies and guard the Salt Roads (Via Salaria) that led to Rome.

Regardless of the exact connection, the salarium paid to Roman soldiers has defined a form of work-for-hire ever since in the Western world, and gave rise to such expressions as «being worth one's salt».

Actions in our daily life

- The Chef in a restaurant kitchen adding salt while cooking
- A waiter in restaurant distributing salt while setting the tables
- A housewife preparing a salt solution to preserve salted olives
- A nurse in a hospital fixing a saline solution drip next to a patient
- A young lady spraying a saline spray to open her blocked nose
- A truck spreading salt on a snowbound roadway

Where is it found

As a mineral it is known as Halite by geologists, having the chemical formula NaCl, commonly known as, table salt. When mined from evaporitic rocks it is known as rock salt while because it may often be produced by the evaporation of sea water it is also known as Sea Salt.

Salt forms about 35 to 38 parts per 1000 parts of sea water and crystallizes out as sea salt when sea water is evaporated. The Maltese Islands have a long dry summer, practically with no rain from May till August. Being an island surrounded by the sea, it has the ideal environment for the production of salt by the evaporation of sea water. During geological times, evaporation of large enclosed basins or basins with limited connections to the open ocean similar to the present-day Persian Gulf, has produced very thick rock sections known as evaporites. These are the rocks produced during geological times by the evaporation of sea water which besides halite contains many other minerals like gypsum (Calcium Sulphate) and dolomite, now deeply buried and protected from solution by groundwater by the overlying rocks. When it occurs as a rock it is known as rock salt and is produced by mining hence the classical name: Salt Mines. When deeply buried it may become plastic and is squeezed upwards by the weight of the surrounding rocks to form cylindrical bodies known as salt Domes.

Other EU countries producing this mineral

Italy, Spain and Greece.

Other minerals with similar properties

Halite is not the only salt found dissolved in seawater. Sea water contains traces of almost all the known elements including gold. The most common salts associated with seawater are: that are generally considered to be the most representative of marine evaporates are calcite, gypsum and anhydrite, halite, sylvite, carnallite, langbeinite, polyhalite.

CALCIUM CARBONATE

Greece

An important mineral found in toothpaste is calcium carbonate. It is an abrasive ingredient, and these abrasives give the toothpaste its cleaning power.

What it looks like

Calcium carbonate or calcite is composed of three elements which are of particular importance for all organic and inorganic materials on our planet: carbon, oxygen and calcium.

Its molecular formula is $CaCO_3$. Calcite is the main mineral forming rocks such as limestone, chalk or marble, and while all contain the same substance, each has different processes underlying its formation. Calcium carbonate is a white solid, non-toxic and odorless.

How we obtain it

Limestone, either in the form of calcium carbonate or dolomite, is extracted selectively, according to its physical and chemical characteristics. Limestone is extracted, more often, from open cast quarries. Pure calcium carbonate (e.g. for food or pharmaceutical use), can be produced from a pure quarried source (usually marble).

Limestone usually has to be extracted by means of blasting but the softest types can be excavated mechanically. The extracted stone is processed further, for example, by crushing, sifting, grinding, refining or burning, to process natural calcium carbonates of the highest quality, known generically as Ground Calcium Carbonate (GCC). Commercial grades of calcium carbonate have been developed to meet the technical demands of different requirements by optimising properties such as fineness, particle size distribution and colour. Marble is the main raw material which is used for the production of GCC.

Use of the product

Calcium carbonate or calcite, has been used since prehistoric times to the present day. Its history shows how we have been able to utilise the unique properties to improve the quality of life through the ages.

Today, calcium carbonate powders and precipitated products, are among the most important and versatile materials used by industry in an increasingly wide range of applications. GCC related products are used in multiple aspects of our everyday life:

- When we get out of bed in the morning, we step onto the carpet (calcium carbonate is used in the carpet backing).
- Since calcium is essential for healthy bones and teeth, calcium carbonate is used as dietary calcium supplement. We need water to take the tablet. Calcium carbonate is used in the treatment of drinking water.
- We're on our way to the office in our car. Thanks to calcium carbonate that is used as cost-reducing fillers by extending or replacing the more expensive resins, allows automakers to produce more affordable for us consumers, thinner, lighter automotive parts. The paint on the outside of our car contains calcium carbonate to reduce the opacity or hiding power of paints and is useful for their bulking properties. Calcium carbonate is also a key ingredient for the tyres and car exhaust system, helping to reduce our carbon footprint.
- When we get to work we print a report or write a note to a colleague on a piece of paper. The papers we use contain calcium carbonate.
- Your busy morning has given you a slight headache. You take a pain reliever of which calcium carbonate forms the base ingredient.
- Your headache has disappeared, but your stomach is growling. It's time for lunch! Your sandwich is packaged in a film made with calcium carbonate.

Konstantinos Laskaridis. Dr. rer. nat. University of Erlangen-Nuernberg, Geologist, Senior

Researcher in the Economic Geology Dept. of EKBAA -IGME since 1991 and Head in the same Dept. since 2009.

He is Technical Responsible for the Accredited Ornamental Stones Quality Control Laboratory of EKBAA -IGME, since 1999. For more then 20 years he is actively involved in European and National R&D projects for Ornamental Stones and Industrial Minerals.

National center for sustainable development

Institute of Geology and Mineral Exploration

- After lunch you sneak a few candies and a piece of chewing gum - both of which contain calcium carbonate.
- The children in school write on the blackboard. Although gypsum has been the traditional mineral used in blackboard chalks, today most chalks are made of calcium carbonate.

Health impacts

Calcium carbonate is widely used medicinally as an inexpensive dietary calcium supplement or gastric antacid. It may be used as a phosphate binder for the treatment of hyperphosphatemia (primarily in patients with chronic renal failure).

It is also used in the pharmaceutical industry as an inert filler for tablets and other pharmaceuticals. As a food additive it is designated E170; INS number 170. Used as an acidity regulator, anticaking agent, stabiliser or colour it is approved for usage in the EU, USA, Australia and New Zealand. It is used in some soy milk and almond milk products as a source of dietary calcium; one study suggests that calcium carbonate might be as bioavailable as the calcium in cow's milk. Calcium carbonate is also used as a firming agent in many canned or bottled vegetable products.

German researchers have created a way to use calcium carbonate to produce hollow microspheres and nanospheres capable of delivering cancer drugs to a specific target in the body.

Excess calcium from supplements, fortified food and high-calcium diets, can cause the milk-alkali syndrome, which is highly toxic and can be fatal. In 1915, Bertram Sippy introduced the «Sippy regimen» of hourly ingestion of milk and cream, and the gradual addition of eggs and cooked cereal, for 10 days, combined with alkaline powders, which provided symptomatic relief for peptic ulcer disease. Over the next several decades, the Sippy regimen resulted in renal failure, alkalosis, and hypercalcaemia, mostly in men with peptic ulcer disease. These adverse effects were reversed when the regimen stopped, but it was fatal in some patients with protracted vomiting. Milk alkali syndrome declined in men after effective treatments for peptic ulcer disease arose.
During the past 15 years, it has been reported in women taking calcium supplements above the recommended range of 1.2 to 1.5 g daily, for prevention and treatment of osteoporosis, and is exacerbated by dehydration. Calcium has been added to over-the-counter products, which contributes to inadvertent excessive intake. Excessive calcium intake can lead to hypercalcaemia, complications of which include vomiting, abdominal pain and altered mental status.

Actions in our daily life

Babies' diapers, toothpaste use, building a wall, writing on a blackboard, writing on a paper, taking a pill, fertilizing agricultural soil, clean tarnish on silver.

Principal applications

As a natural mineral, calcium carbonate has a multitude of characteristics that make it an ideal raw material for widely differing uses.

- Food for human consumption
- Mortars and Plasters
- Building materials
- Glass production
- Sugar Refining
- Agriculture and Forestry, Animal feed
- Paper
- Chemicals
- Paints and coatings
- Plastics
- Sealants and adhesives
- Rubber
- Films

Where is it found

The Earth's crust contains more then 4% calcium carbonate, making it one of nature's most abundant raw materials. Calcium carbonate is normally found as a white mineral (calcite) which occurs naturally in chalks, limestones and marbles. Some of these rocks were formed by inorganic processes, but many are of organic origin. Rocks are not the only calcium carbonate deposits in nature. Almost all stretches of water and countless plants and animals contain huge amounts of calcium carbonate as well. These natural resources are linked by the calcium carbonate cycle.

The first stage is the sedimentation process, from which chalk and limestone originate. Chalk is a poorly compacted sedimentary calcium carbonate rock, whose diagenesis is incomplete. A completed sedimentation process results in the formation of limestone. If the sedimentation process takes place in magnesium containing water, a dolomitization may result. Part of the calcium ions in the crystal lattice are replaced by magnesium ions, leading to the formation of dolomite $CaMg(CO_3)_2$.

Marble is a metamorphic rock resulting from the recrystallisation of limestone under high pressure and temperature. All carbonate rocks are subjects to erosion. They dissolve under the influence of wind, temperature and water, and the cycle is ready to start anew. The most common crystal arrangement for naturally-occurring calcium carbonate is the hexagonal form of calcite. Less common is aragonite, which has a discrete or clustered needle, orthorhombic crystal structure.

Calcium carbonate rock occurs throughout the world and is readily available. However, the mining of industrial minerals is possible only in a few deposits worldwide. Extraction is only worthwhile if the purity, whiteness, thickness and homogeneity of the stone is appropriate, and even then intensive treatment is necessary to process top quality natural calcium carbonates (ground calcium carbonate).

Other EU countries producing this mineral

In addition to Greece (especially in Ionian Islands and Northern Greece), Calcium Carbonate is mined and produced in Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Norway, Poland, Portugal, Sweden, Romania, Russia, Slovakia, Slovenia, Spain, the United Kingdom, etc..

TALC

Slovakia

Talc is used in make up.

What it looks like

Talc (in chemical terms, hydrated magnesium silicate) is the softest known mineral.
Its hardness on the Mohs scale is only 2.0-2.5. You can easily scratch it by a fingernail. Its colour ranges from white shades (gray, yellowish, brownish) to pale green and it has greasy feel. Talc usually occurs in the form of distorted masses, foliated sheets and plates. Crystallized forms are very rare. Talc is hydrophobic[1], insoluble[2], acid-resistant, chemically inert[3] and non-toxic. It is not explosive or flammable; it has neither aroma nor taste.

How we obtain it

Talc is extracted by conventional - open pit and also underground mining. During the mining process contamination with other rock material should be avoided. Contamination can cause problems in applications where talc is being used, impurities and hard particles must be removed. Therefore, talc ores are then sorted (friction sorting, flotation, drying, crushing, grounding and micronization). Depending on final use, talc is further treated by milling, coating or heating to reach demanded properties and qualities (composition, particle size, brightness etc.).

1 Hidrophobic: physical property of molecule that is repelled from a mass of water.
2 Insoluble: incapable of being dissolved.
3 Chemically inert: term used to describe a substance that is not chemically reactive.

Use of the product

People are using products made from talc every day. It is widely used in production of ceramics (floor and wall tiles), cosmetics (soap, body powder, blushers and eye shadows), paint (color concentrates, inks, enamels, varnishes, putties, body fillers, mortars), paper, pharmacy products (carrier for medicated powders, lubricant, coatings). Talc is also added to the asphaltic materials used to make roofing materials, improving their weather resistance. Talc is very useful in food products. It is chemically inert and thus approved as a carrier for food colourings and as a separating agent (for example in rice). Special properties of talc are utilized for production of chewing gum or in olive oil separation process. Talc is also used for seed coating, in fertilizers and as a carrier for insecticides, fungicides and herbicides.

Talc is used as reinforcing filler in thermoplastics for computer, TV and electronic device housings where they provide dimensional stability, reduced thermal expansion, heat and flame resistance and enhanced scratch and mar resistance. The automotive industry uses talc as fillers in lightweight plastics and engineering thermoplastics. It is used for plastics production for under-the-hood components (engine covers, headlamp bases, heating, ventilation and air conditioning units, bumpers) and interior components (dashboards, interior trims). Talc is hydrophobic and electrically neutral; hence it is an ideal component for insulator production for wire and cable applications. Talc is also used for production of cordierite ceramics, which are important components for automotive exhaust catalytic converters. Further, talc is used in tyres and other rubber goods to improve their mechanical and fire resistance properties. Soapstone is also used as ornamental stone in architectural applications (countertops, interior and exterior surfacing).

Peter Balaz (40), economic geologist, obtained PhD degree in Mining Geology and Geological Survey in 2005 from the Technical University in Kosice. Head of Mineral Resources and Geophysics Department in the State Geological Institute of Dionyz Stur. Editor of the Slovak Minerals Yearbook. Government Plenipotentiary in Joint Organization Interoceanmetal. Member of the EGS Mineral Resources Expert Group.

State Geological Institute Of Dionyz Stur

Health impacts

Solid forms of talc are assumed to be safe; most concerns are only after prolonged exposure to its powder form. It has an inert dust effect, but not a toxic effect. Occupational exposure to talc has not been listed as a known or suspected human carcinogen. Occupational exposure limits to dust are legally implemented throughout Europe.

Anecdotes

Vikings hewed soapstone (talc-schist) directly from the stone face, shaped it into cooking-pots, and sold these at home and abroad. They brought them along wherever they went.

Soapstone smoking pipes have been found among Native American Indian artifacts.

During World War II, talc was on the list of critical minerals. It was used for the manufacture of high-frequency radio insulators.

Whiskey stones are small soapstone cubes that are refrigerated and then used to chill a glass of whisky (or any other drink). They do not melt and dilute the drink. A few whiskey stones can keep a drink cold for 30 minutes or more.

Actions in our daily life

- Hand washing with the soap
- Doing a makeup
- Taking a pill
- Chewing a gum
- Driving a car
- Painting a wall
- Writing letter on the paper
- Using electric devices.

Where is it found

Talc is a common metamorphic mineral. It is formed either through regional or contact metamorphosis of carbonate sediments or through hydrothermal alteration of magnesium-rich magmatic rocks. Talc deposits can be found throughout the world in various geological structures. The leading world producers are China, South Korea, India, United States, Finland, Brazil, France and Japan.

Other EU countries producing this mineral

In 2011, the largest EU-35 producer was Finland, contributing 38% to European total of 1.12 Mt, followed by France (36%), Austria (12%), Italy (10%) and others (4%). EU 35 share on total world talc production was 14.4%.

Green talc

BALTIC AMBER (SUCCINITE)

Poland

Amber is used as an element of decoration (i.e. amber lampshades or lamps, and caskets) or jewellery (necklace, ear rings, bracelet, ring, tie-pin, cuff-link).

What it looks like

Baltic amber has been the best known and highly valued type of fossil resin since ancient times. Its chemical composition is dominated by carbon (61-81%) together with a variable amount of hydrogen and oxygen as well as a small quantity of sulphur. Baltic amber contains 3-8% succinite acid, which makes it different from other fossil resins. It often contains beautifully preserved plant-structures and remains of insects and other animals.

Succinite differs in colour and transparency. The most common one is in diverse shades of yellowish, but also white, brown, reddish or vaguely greenish or bluish varieties occur. Pieces of amber are transparent, only translucent or even completely opaque, which stems from the amount of gas bubbles.

Amber is very light with a density of 0.96-1.096 g/cm^3 and floats in marine salty water. Its hardness on the Mohs scale is only 2.0-2.5. Hydrocarbons in the blue amber turn the sun's ultraviolet light into blue light. Amber electrifies negatively, and attracts shreds of paper when rubbed with, for example, wool. Baltic amber, as well as other fossil resins, is flammable. However, it has unique soothing and aromatic smell.

How we obtain it

In the Sambia deposit of Paleogene age, Baltic amber is strip-mined from a depth of 50 m at most. Overburden of Pleistocene and Neogene sediments is removed by walking excavators, then hydromechanics methods are used after reaching a bed of amber-bearing blue earth. Amber-bearing soil is washed out with the help of hydro-monitor by streams of water and then delivered by pipeline to a sorting station. The process of separating raw amber material from blue earth gives pure material that is subsequently segregated into classes depending on size.

In Volhynia (Ukraine) amber production takes place by strip mining as well. Amber-bearing sediments are located above the granite deposit. Sand with amber is extracted from water-filled excavation by dragline excavators and overburden spreaders. Output is delivered directly onto a set of sieves at a sorting station.

In the vicinity of the Gulf of Gdansk (Poland), the hydraulic borehole method is used for amber recovery from shallow deposits of the Holocene age. Craters are created from the ground level with a strong stream of water directed vertically down. Water is injected into the soil through a flexible hose inserted into the sediment manually with handling rods. The water washes out the output (amber with detritus) and brings it to the surface where it is caught in nets. Separation of amber from residue takes place by rinsing in brine (water solution of table salt).
Amber can be also found along the southern coast of the Baltic Sea on beaches after storms.

Use of the product

The most common and known usage of Baltic amber is in jewellery for pendants, necklaces, brooches, bracelets, rings or earrings. Men's jewellery is becoming increasingly popular, i.e. cuff-links, tie-pins or signet rings. At times amber is a decoration for articles of everyday use such as cutlery, beer mugs, boxes, picture/mirror frames, even chairs, tables or lamps. Succinite is a material willingly used by artists. The best known and outstanding amber work is the Amber

Ph.D. **Regina Kramarska** studied geology at Wroclaw University, Poland. As a research specialist of the Polish Geological Institute - National Research Institute, Branch of Marine Geology she specialises in geological marine cartography and amber-bearing sediments in the Baltic area. Since 2012 she has been responsible for Marine Geology Programme at PGI-NRI. She is a member of International Amber Association.

Ing. **Anna Malka** studied geology at the AGH University of Science and Technology in Krakow, Poland. Since June 2009 she works at the Polish Geological Institute-NRI. History of amber mining is one of her main research interests.

Polish Geological Institute - National Research Institute

BALTIC AMBER (SUCCINITE)

Poland

Room in the Catherine Palace of "Tsarskoye Selo" near Saint Petersburg. Raw amber material is also used in sacred art (chalices, shrines, missal covers). The aromatic and resinous smell of burned amber found application for incense used in churches as well as habitable areas. Apart from the elimination of unpleasant odor, the smoke of burning amber has anti-bacterial properties, alleviates inflammation of the upper respiratory tract and repels insects.

Succinite is also used in medicine, pharmacy and chemistry. A product of dry distillation of raw amber - amber acid has beneficial effects on human health, as proven by scientific tests, and is an ingredient of many medicines, ointments and amber tinctures. Amber has regenerative and anti-aging properties and is a component of some cosmetics - creams, shampoos, hair-conditioners, bath lotions and perfumes. Amber bioactivity is also used in gardening, since amber acid stimulates growth of certain cultivated plants.

Health impacts

Baltic amber has a very positive effect on the human body. Succinite's beneficial properties have been known since ages. At the start amber was used in magic and folk medicine. Later, it received recognition from famous doctors such as the Polish prominent astronomer Nicholas Copernicus. Thanks to its therapeutical and conditioning properties amber acid has recently become a natural ingredient of medicaments and cosmetics. It is effective as a bio-stimulator, i.e. stimulates the nervous system, strengthens the body's natural immunity, and is anti-phlogistic and anti-toxic. It is a base for certain ointments and creams for rheumatism, asthma and skin ulcers. As well, amber-based specimens are used in bronchi, throat and thyroid disease therapy. The cosmetics industry takes advantage of amber acid ability to control free radicals, smooth out wrinkles and prevent skin-aging.

Anecdotes

Many legends have arisen around amber. The oldest Greek myth speaks of Phaeton, son of Helios and the nymph Climene. Phaeton grew up with his mother and many doubted his Godly parentage. To convince his son, Helios allowed him to ride a solar chariot, but this task was beyond Phaeton's skills. He failed to control the chariot, brought the Sun too close to the Earth and set the latter on fire. To prevent disaster Zeus struck Phaeton with a flash of lightning, throwing him down to the mythical River Eridanus. Phaeton's sisters, the Heliads, who mourned him on the river bank, were turned into poplars, while their tears, which fell into the water, became golden electron-amber.

In Poland, there is another legend linking amber with human tragedy during the Flood. Tears of innocent people and children turned into clean and most beautiful varieties of amber, while tears of sinners became darkened and misty amber.

Actions in our daily life

- Wearing of amber jewellery (necklace, ring, tie-pin, cuff-link etc.) - every day or on more ceremonial occasions, i.e. when going to the theatre or on a date
- Everyday body care using amber-containing cosmetics (washing hair, taking a bath, putting on face cream)
- Putting on make-up in front of an amber framed mirror
- Buying of gifts, giving souvenirs (i.e. amber statuette, amber box, jewellery, lamp with an amber lampshade)
- Drinking of amber tincture during problems with bronchi, the throat or thyroid
- Rubbing of amber ointment on aching joints i.e. when experiencing rheumatism problems
- Visits to museums and churches (works of decorative art, sacred objects made from raw amber, amber incenses).

Where is it found

Baltic amber accumulations belong to secondary deposits of sedimentary origin. Primary source of these deposits was amber of resin-producing trees growing in present-day north and central Europe area in Eocene period (ca. 40 mln years BP).

The largest Baltic amber resources occur on the Sambian Peninsula (Russia) and in western part of Gulf of Gdansk (Poland) within sediment called "blue earth". The blue earth is composed of silt and fine-grained sand grayish green in colour with glauconite and muscovite, deposited in Late Eocene in a shallow marine reservoir. Smaller deposits of succinite were found in Volhynia (Ukraine) and southeastern Poland. Slightly different is deposit from Bitterfeld (Germany), which is dated at the turn of the Oligocene and Miocene (ca. 23 mln years BP). There amber occur within grayish black sand and silt with muscovite and large quantities of organic matter and brown coal.

During the Pleistocene ice age amber-bearing sediment from Sambia and the Gulf of Gdansk was carried in glacial, fluvioglacial and fluvial transport onto areas of present-day Latvia, Lithuania, Belarus, Poland, Germany as well as Jutland. In such manner many small amber deposits came into existence but nowadays all those of economic importance became almost completely exhausted.

The youngest amber deposits are related to origin and evolution of the Baltic in the Holocene period. In these times amber was washed out from sediments exposed in Sambian cliffs and then transported by currents to the coast of the Gulf of Gdansk (Poland) and in the area of the Curonian Spit (Russia, Lithuania). This created nest, or pocket and lens like amber-bearing bodies of Holocene deposits, that are easy to extract. Single succinite occurrences were also reported from Siberia and Canada's Axel Heiberg and Somerset Islands.

Presently, the most intense production of Baltic Amber takes place in Russia near the town of Yantarny where amber resources reach a volume of 132 000 tonnes. This area has been mined for amber since prehistoric times and available records show with continuous excavation since the 17th century. According to published data, total amber production in 1948-2007 was 27,148.8 tonnes, ranging from about 130 to over 800 tonnes per year. According to official data, in 2011 amber production in Sambia was 340 tonnes.

Raw amber extraction on Ukraine is up to 30-40 tonnes per year. Extraction of Holocene amber deposits in Poland at the Gulf of Gdansk is of local importance.

Hungary

Several clays are used in the food industry as an anticaking agent and carrier material of pigments. Bentonite for example is used as a clarifier for making fruit juice, wine and cocoa oil. It removes the undesirable proteins and other materials from the liquid.

What it looks like

Clay minerals: illite, kaolinite, montmorillonite, vermiculite, talc. Clays have very small sized particles so with the naked eye the individual minerals are invisible. Their structures can be examined with electron microscopes and using X-Ray. Kaolinite looks like a book with sheets of paper, montmorillonite is like waving water and illite has fibrous structure.

How we obtain it

The clay is extracted in quarries by excavators and bulldozers. Before use different admixtures are added to the clay: quartz to prevent cracking; feldspar which makes the melting point decrease; pigments if necessary and in case of bricks and tiles small organic particles (e.g. saw-dust) which burn during the firing and make pores; and some water. This mixture goes through a press and is cut into pieces (e.g. bricks and tiles) or it is poured in a mold (e.g. bowls and ornaments) so the ceramics receive their shape. Then they dry on 20-150 °C while their water content decreases to 2-3%. The ceramics are fired to 800-1050 °C, the glaze to 1350-1400 °C.

Use of the product

Products made of clays are everywhere in our homes: the walls are made of bricks; the roof, walls of bathroom and floor are covered by different tiles and in the bathroom there are porcelain toilet bowl and the tap. When we eat, usually we use porcelain tableware. Technical ceramics are also made of porcelain because it is electrically insulating. Clay minerals can be found in cosmetics, foods, paints, paper and cat litter. Clays are good for insulation when doing waste management and for protection before and during flooding.

Health impacts

Several clays are used in food industry as anticaking and carrier material of pigments. They are indigestible so go through the human body without any change and damage. Clays are used in wellness treatments. Due to the slight radioactivity, good heat storage capacity, organic material and mineral content of mud or healing mud, it assists the metabolism, stimulates the circulation, and heals joint diseases and rheumatism.

Anecdotes

Clays are very small minerals, however they play important role in our life. When you drink your morning coffee or afternoon tea, it is important to have a good quality cup - it affects your daily mood. Sometimes it is annoying when you dirt with mud but think how important and useful clays are. Clays are also of great importance in the creation of statues and monuments.

Actions in our daily life

- Eating, drinking, using tableware
- Bathing, using sanitary ware and wall tiles
- Being in a house or building made of bricks, covered by roof tiles
- Walking on floor tiles
- Having a cat, using cat litter

Katalin Sári has obtained her Bachelor degree in 2009 at the University of Debrecen where she wrote her thesis about a brickyard. Then she graduated in 2012 at the University of Szeged. She is working in Geological and Geophysical Institute of Hungary from 2012.

Dr. Zoltán Horváth is the Head of the Department of Earth Resources in the Geological and Geophysical Institute of Hungary. His special field is diverse including environmental and quaternary geology and pedology (PhD), but nowadays industrial raw materials and mineral classification are in the focus.

Geological and Geophysical Institute of Hungary

CLAY MINERALS

Hungary

Where is it found

Clay minerals commonly can be found in soils and mud, in lakes, on river floodplains and as clayey stones in cliffs. However, if we aim to produce ceramics, good quality and large amount of clay is needed. Common clay or ball clay is mainly deposited in lakes, seas or floodplains of rivers, so they are quarried from sediments of former lakes, seas and floodplains. There are formations mainly made of one type of clay minerals: for example, the bentonite mostly consists of montmorillonite and kaolin is made of kaolinite. Due to the weathering of some minerals (e.g. feldspars) clay minerals are forming in soils. Clays can be found in caves also.

Other EU countries producing this mineral

All countries have small and large clay quarries. Most often manufacturing industry is connected to the quarry, for example, brickyard or china factory. The biggest European clay extractors are Spain and Italy.

Other minerals with similar properties

Different types and ratio of clays, quartz, mica (e.g. muscovite) and other minerals (e.g. hematite) are used in the building industry. If we look into the microscope to see the content of an ancient brick the above mentioned minerals often can be seen next to some minerals in trace depending on the local conditions (e.g. calcite).

Iron is mainly used in the manufacture of steel for the construction industry.

What it looks like

Pure iron is a silver-white metal that is quite soft and easily worked. When exposed to (moisture) air and (oxygen-rich) water iron quickly corrodes or rusts (it forms a red powder called iron oxide hydrate). Iron easily bonds with oxygen and sulphur which makes native iron unusual to find in nature. There are only a few minerals that are economically important for extracting iron. Hematite, Fe_2O_3 and magnetite, Fe_3O_4 are the primary ore minerals for extracting iron.

How we obtain it

Most of global iron ore is mined in vast open pits but there are also underground mines. After drilling and blasting, the ore is crushed before further processing (i.e. dressing, screening, grinding or flotation) in a concentrator plant where the iron contents are increased (upgraded) by removing impurities (waste rock). The final concentrates are pellets (hard, agglomerated small balls), lump or sinter fines.

Refining iron concentrates is mainly done in the blast furnace process at a steel mill, in which carbon (coke) is added together with other additives such as crushed limestone to reduce the oxygen in the iron concentrates to metallic iron. There are also direct reduction processes. These may be based on coal or natural gas.

In both processes, carbon monoxide is used to reduce the ore, in the latter case also hydrogen gas.

Most of the molten iron (pig iron or hot metal) then goes directly to a basic oxygen furnace (BOF) for conversion to steel by removing most of the residual carbon. After adding different elements (alloys) depending on which kind of steel and after casting crude steel is produced. After hot or cold rolling finished steel products, such as plates, coils, bars, tubes or wires, are produced. The rest of the molten iron is poured into molds to produce pig iron for casting purposes.

Use of the product

Almost all (98%) of globally produced iron ore goes to making steel. Steel is an alloy of (mostly) iron, carbon and other elements with carbon content less than 2%. Steel is the most used and important engineering material in the world due to its high strength relative to weight and cost effectiveness. The usage of iron (in steel) is about 20 times more than all other metals usage put together. About 60% of iron and steel products are used in construction and transportation. 20% are used in machinery manufacture.

The rest are used for packaging, in power and energy sectors and in various household appliances and other equipment.

Health impacts

Iron is an essential trace element for almost all living organisms. Plants need iron for proper growth. Humans and animals need iron for making energy and for transportation of oxygen in the blood. In humans the main part of the iron is bounded to the protein hemoglobin (in red blood cells) that transports oxygen to tissues in the body. Myoglobin, the compound that carries oxygen to the muscle cells, also requires iron.

Mr **Peter Åkerhammar** works at the Division of Mining Industry, Department of Mineral Resources at SGU Head office in Uppsala. He has a M.Sc. in Mining Engineering from Luleå University of Technology.

Geological Survey of Sweden
SGU

According to the World Health Organisation, iron deficiency (anemia) is one of the most common nutrient deficiencies in the world. An overdose of iron supplements can cause toxicity in adults and children.

Actions in our daily life

Boiling or frying an egg in a pan on the stove for breakfast. Driving your car or taking the bus. Hammering a nail. Twisting a nut or a bolt with a wrench.

Where is it found

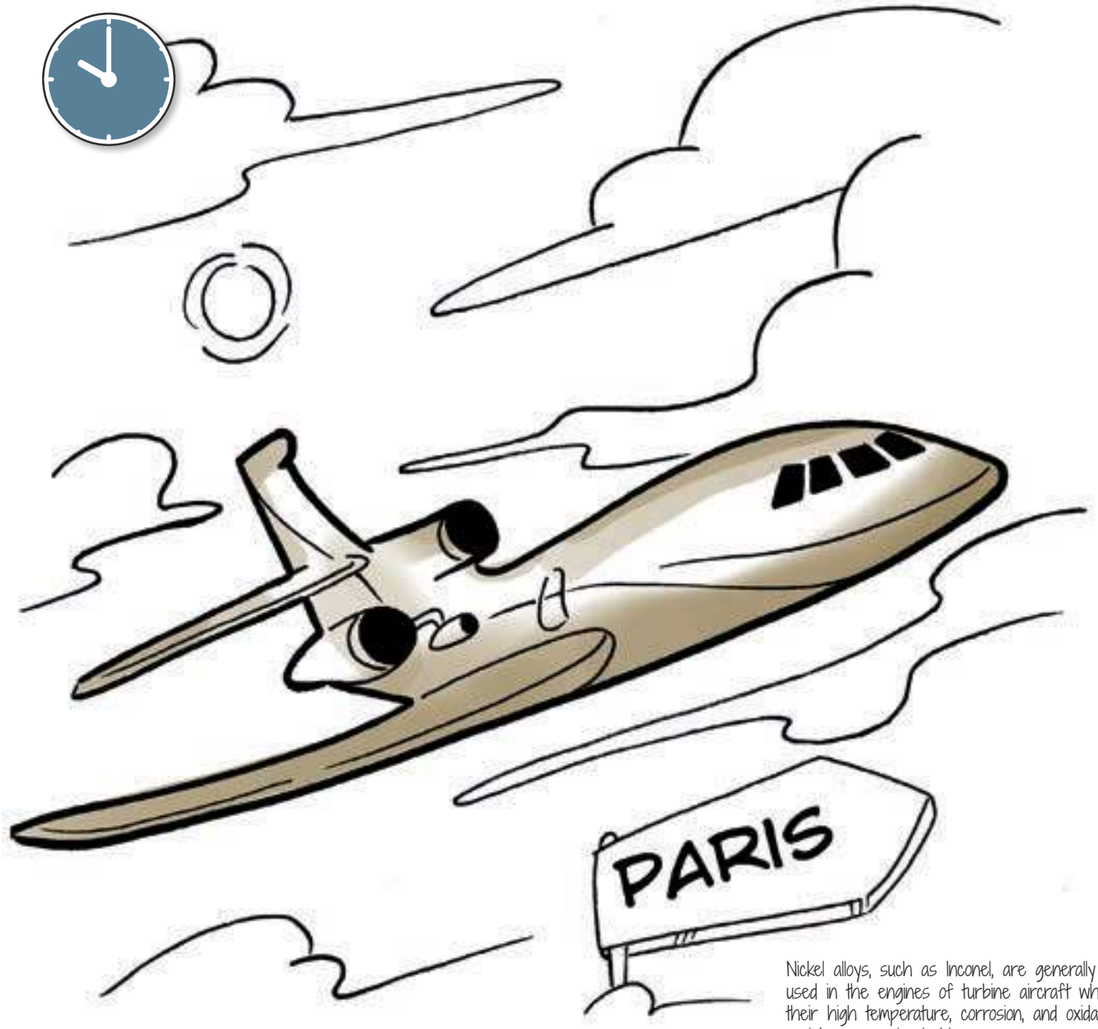
Iron is the fourth most abundant element, consisting about 5-6%, in the Earth's crust. The most economically important iron minerals in nature are iron oxides as stated above. Most of the world's important iron ore deposits are found in iron-rich sedimentary rocks, so called banded iron formations (BIF). They occur on all continents but there are some magnetite deposits of igneous origin or association that also are of importance.

Iron ore is mined in more than 50 countries around the world. The seven largest of these producing countries account for about three-quarters of total global production. In 2012 worldwide production of iron ore was nearly 1 900 Mt. Australia, Brazil, China, India and Russia are the major iron ore producers in the world. Iron ore producing countries in Europe (excl. CIS) include Sweden, Turkey, Norway, Bosnia and Herzegovina, Austria and Germany.

Other EU countries producing this mineral

Sweden is by far the largest iron ore producer in EU-27 with more than 90% of all production. Other EU-countries that produce iron ore are Austria and Germany. In 2012 EU-27 was the third largest iron ore importer in the world after China and Japan.

Finland



Nickel alloys, such as Inconel, are generally used in the engines of turbine aircraft where their high temperature, corrosion, and oxidation resistance are invaluable.

What it looks like

Nickel is silvery-white metallic and lustrous element that occurs naturally in the Earth´s crust. It is one of the most common elements on Earth, and most of it is concentrated on the Earth´s core.

How we obtain it

In addition to pure nickel metal, the most common forms of nickel in use are ferro-nickel, nickel oxides and other chemicals. Recyclability of nickel is high, and secondary or "scrap" nickel is commonly used to supplement newly mined metal. The amount of primary nickel used annually in the world is about 1.4 million tonnes. Nickel is extracted from its ores by many different ways. Over 23 countries are currently mining nickel ores and 25 countries have a smelting and/or refining facilities. In Europe the most important Ni mining countries are FYROM, Greece, Finland and Turkey. Largest nickel smelters and refineries in Europe operate in Norway, Finland, United Kingdom, Greece and FYROM.

In Finland, nickel is mined with copper, cobalt and zinc from four mines, of which two are open-pit mines and two underground mines.

The ore is sulfidic type with it´s origins in a prehistorical volcanic activity. Extracted ore is smelted and refined in western Finland in one of the Europe´s largest industrial centers for nickel production.

Use of the product

Comfort in our everyday lives relies heavily on the nickel containing products. These include food preparation via pans and other equipment, drinking water purification, health care, heat and power generation, construction, transportation, and electronics such as mobile phones.

Nickel is also essential for healthy plant life. Most nickel-containing products have long life-times averaging between 25-35 years, and many applications lasting even longer. Oldest metallic artefacts containing nickel date back more than 2,000 years. Nickel´s name comes from the Saxon term 'Kupfernickel', Devils' Copper, reflecting the thoughts of 15th century miners that nickel ore looked red-brown like copper but it was difficult to mine and caused them to be poisoned (actually it was the fault of arsenic!).

First coins in the USA, prepared in the mid 1850´s, were made of an alloy of nickel and copper. The "nickel" in these coins was not thus in its pure form, but shortly after this, Switzerland used pure nickel in its coins.

Mari Tuusjärvi is a geologist and works as a research scientist at the Geological Survey of Finland (GTK). Her research interests lie in the economic, environmental and social performance of the mining industry, mining scenarios and mining related material flows and life cycles.

Jussi Pokki (M.Sc.) is researcher at Geological Survey of Finland (GTK). He works with information services on geological resources and in international projects promoting sustainable use of mineral resources.

Nikolaos Arvanitidis - Dr. Economic Geologist with more than 35 years as Researcher at the Geological Institute of Stockholm University in Sweden, R&D Project Manager on mineral exploration and development projects and Regional Division Director at the Institute of Geology and Mineral Exploration (IGME) in Greece, Senior Specialist at the Geological Survey of Finland (GTK) and presently Head of Bedrock and Geochemistry Division of the Geological Survey of Sweden (SGU). Chair of the Mineral Resources Expert Group at EuroGeoSurveys (EGS), Executive Secretary of the European Technology Platform for Sustainable Mineral Resources (ETP SMR) and active member of the European Innovation Partnership on Raw Materials (EIP RM) Strategic Implementation Plan (SIP).

Geological Survey of Finland

GTK

After the discovery of stainless steel in the early 20th century, the use of nickel in the construction intensified. Nickel increases markedly the corrosion and high temperature resistance of the iron based structures. This made the stainless steel a preferable construction material for chemical plants and allowed the realisation of the jet engines in practise. Based on these developments, growth in demand for nickel raw materials increased strongly in the 20th Century.

Health impacts

The most common harmful health effect of nickel in humans is an allergic reaction. Approximately 10-20% of the population is sensitive to nickel. For people who have breathed dust containing nickel compounds, the most serious harmful health effects have been chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus.

These have been detected for people working in nickel refineries or nickel-processing plants, as the levels of nickel in these workplaces used to be much higher than usual levels in the environment.

Anecdotes

Difficult environments and extremely high temperatures are the favourites of nickel. It is tough, malleable and provides exellent corrosion resistance. Recyclability of Nickel containing products is good. One of the best-known nickel containing materials is stainless steel.

Actions in our daily life

- Next time you are in a restaurant waiting for your food to arrive, take a look at the back of your fork or spoon. The numbers printed on the back of cutlery (18/10, 18/8 or 18/0) refer to the percentage of chromium and nickel content. The higher the percentage of nickel, the higher the quality. The best cutlery is generally made with a high percentage of nickel because nickel increases the strength and corrosion resistance of the stainless steel.
- Nickel is a critical component of rechargeable batteries.
- A thin nickel alloy layer is crucial to the hard disc drives in mobile phones, MP3 players, computers and video game consoles.
- Nickel contributes to renewable energy. For example, a large wind turbine contains 500kg of nickel.
- The success rate of coronary surgeries has increased from 60 to 90% with the development of a stent made out of NitinolR a nickel-titanium alloy.
- Nickel-containing stainless steel's corrosion-resistant properties allow the use of the most effective cleaning products and extremely high water temperatures to keep surfaces hygienic.
- For decades, nickel-containing stainless steels have been the standard industrial and common domestic food contact materials for many reasons, including durability and safety.
- Surgical equipment and instruments have to be reliable, safe and ready to use. Nickel containing stainless steel meets these needs thanks to its durability and hygienic as well as corrosion-resistant properties.
- Although nickel makes up less than 1% of the weight of a mobile phone, it is vital to its functioning.

- The unique properties of nickel alloys play a key role in contributing to aircraft fuel efficiency in two ways. First, nickel alloys have increased the efficiency of jet engines because they allow for increased operating temperatures. Secondly, nickel alloys have helped to reduce the weight of aircraft frames.

Collected from Nickel institute´s publication "Nickel in Society".

Where is it found

Nickel occurs in nature principally as oxide, sulphide and silicate minerals, and is mainly mined from two types of ore deposits: laterites and sulfides. Laterite ores of nickel formed through weathering of nickel-bearing rocks on earth's surface, and occur typically in tropical climates around the equator, the arid regions of Western Australia and humid areas of Eastern Europe. Sulfide ores of nickel are formed in volcanic and water circulation processes at a deep parts of earth's sub-surface. Sulfidic ores of nickel can be found practically anywhere where volcanic activity has prevailed during the Earth´s history (which is a very long time!).

Other EU countries producing this mineral

In addition to Finland other important Ni producing countries in Europe are Norway, Finland, United Kingdom, Greece and FYROM.

Other minerals with similar properties

Principal ore minerals in laterites are nickeliferous limonite and garnierite, and in sulfides are pentlandite and millerite.

Sulfide ores typically contain other metals in addition to nickel which could be utilised. These include base metals such as copper (Cu), cobalt (Co), and precious metals such as gold (Au) or platinum (Pt), palladium (Pd) and rhodium (Rh).

RECYCLED AGGREGATES

Switzerland

Recycled aggregates are extensively used to build foundations for roadway pavements, and as a substitute for virgin aggregates in new asphalt pavements.

What it looks like

Both natural and recycled aggregates are granular materials composed of rock fragments, mineral grains, or a mixture thereof. Not only are they the most mined materials of the minerals sector, produce the highest added value, and employ the largest workforce; they are also indispensable for civil engineering, construction and agriculture. Railway lines and roadway pavements directly use aggregates for embankments or foundations. Buildings and other infrastructure projects like bridges and asphalt roads require enormous amounts of concrete and asphalt, which are made of 80-90% aggregates.

Natural aggregates consist of crushed rock or naturally occurring gravel and sand, which are extracted from virgin sources like quarries and gravel pits.

Alternative aggregate sources, on the other hand, can be classified as recycled (derived from recycling of previously used aggregate materials) or as artificial (new materials purposefully produced as substitutes for primary aggregates). Natural and recycled aggregates have some resemblance (Fig. 1), but different properties and suitability for various applications.

How we obtain it

Recycled aggregates are produced by selective deconstruction of buildings and roads. The construction and demolition rubble is sieved, crushed, screened and sorted, either at a permanent recycling plant, or directly at the deconstruction site. On-site processing has the advantage that there is no need to transport the large mass-low value rubble to a designated recycling facility. This cuts costs, material wear and energy use, thus also reducing CO_2 emissions.

Use of the product

Recycled aggregates are mainly used for the construction of railway embankments, road bases, asphalt pavements, and as structural fill. They are also increasingly being used for the construction of eco-friendly buildings, where they substitute for natural sand and gravel in concrete.

Artificial aggregates can have properties superior to natural aggregates in some applications such as hydraulic engineering: for the construction of canals and levees, Electric Arc Furnace (EAF) steel slag is preferred due to its high bulk density and angular surface structure.

Health impacts

The use of recycled aggregates reduces the rate at which we need new gravel quarries and demolition waste disposal sites. Conflicting land use demands, environmental regulations, as well as rising costs for landfilling restrict the extraction of natural aggregates and make the production of recycled aggregates interesting, not only from the environmental and social point of view, but also economically. However, threshold values for the emission of potentially harmful substances can restrict some applications of recycled aggregates.

Mark Simoni studied geology at the Swiss Federal Institute of Technology Zurich, Switzerland. He is working at the Swiss Geotechnical Commission SGTK, which carries the mandate of the Swiss Geological Survey Swisstopo to monitor mineral resources in Switzerland.

His interests are to contribute to a more holistic understanding of sustainable mineral resource acquisition, optimal use, and efficient recovery in the wider context of resource governance.

Geological Surveys of Switzerland - SWISSTOPO

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office of Topography swisstopo
Swiss Geological Survey

Anecdotes

In Switzerland environmental regulations and nationally protected landscapes hinder the development of new gravel pits and hard rock quarries for the extraction of natural aggregates. A lurking aggregate supply bottleneck was recognised in 2003, but it took 10 years, several Federal Supreme Court verdicts, and a modification of the Federal Sectoral Plan for Traffic to resolve this conflict. Of 34 geologically suitable localities for new hard rock quarries, 31 were excluded as unrealisable, mainly due to technical, environmental and political objections [3, 4]. In the meantime more than 35% of the national demand for broken hard rock had to be covered by imports from Germany and Austria. It seems peculiar that a country with so much rock material in the famous Swiss Alps has to import rock.

Increased use of recycled aggregates can substantially contribute to mitigating such supply shortages, and close material loops.

Actions in our daily life

- Working or living in any building that could be constructed with recycled concrete, as for instance an office, school, dental practice or cellar.
- While walking along a picturesque hiking trail the agricultural and scenic landscape can be enjoyed even more because the recycling of aggregates reduces the need for construction waste disposal sites.
- Riding the train to work over recycled broken hard rock in the railway embankment, driving a car to work over an asphalt road, walking a dog along a gravel path or pavement with artificial aggregates.
- Taking a walk along a river where the river bank is enforced with Electric Arc Furnace (EAF) steel slag or strolling along a lake where the causeway embankment contains EAF.

Where is it found

More than six percent of the total aggregate production consists of recycled aggregates which are produced from construction and demolition debris and reclamation of demolished roads. Artificial products, like foamed blast furnace slag or steel furnace slag, form a two percent share. Construction materials are the main consumers of aggregates. Conversely, the transportation infrastructure and concrete frame structures of buildings and industrial sites are also major sources for recyclable aggregate material. The geographical distribution of recycled aggregates is constrained to populated areas, where an effort is made to recover used material as a substitute for natural aggregates.

In Europe an estimated 510 million tonnes of construction and demolition waste are generated every year, which amounts to 40% of the total waste [1]. Complete recycling of construction and demolition waste could satisfy about 20% of the total aggregate demand in the developed world, however, only 6% of the produced aggregates in the European Union in 2010 came from recycling [2]. This low recycling contribution is mainly the result of absent or non-binding regulations, or solely monetary considerations that disregard sustainability aspects.

Countries such as Switzerland, Belgium, the United Kingdom and Germany achieve very high rates of aggregate recovery and reuse. By imposing bans or taxes on landfilling recyclable materials ('zero landfill') countries such as the Netherlands promote near complete aggregate recycling. This offers a double advantage: less waste is produced, and the need for natural aggregates and hence the extraction of (finite) natural resources is cut back.

Mineral deposits

What is a deposit?
Mineral deposits are naturally occurring geological bodies that may be worked for valuable metals, nonmetallic minerals, coal or any other useful minerals and rocks. Deposits of minerals from which valuable metals can be recovered are called ore deposits, the minerals containing these metals are called ore minerals. Minerals of little or no value which occur with the ore minerals are called gangue. Some gangue minerals may be used as by-products; for instance rock for road making material, or limestone for fertilizer. Valuable raw materials which are not metals or energy minerals or gemstones are called industrial minerals.

Concentration
Most mineral deposits, especially ore minerals, are natural enrichments produced by different geologic processes. The normal levels or amounts of elements in the earth's crust are very low. To be commercial, metals must be found in much higher concentrations than the average abundance of the metal in the earth's crust.

The means by which concentration of the metals occurs to form orebodies and mineral deposits are natural geological processes. Mineral deposits occur in many forms which are dependent upon their original genesis, their later deformation or changes caused by weathering or other surficial processes.

Today we speak of the value chain of a commodity which deals with the entire life cycle of the commodity. The fact that most minerals are not renewable resources has led to greater emphasis on re-use (reworking ancient mine waste) and recycling (also known as urban mining) both of which lead to greater sustainability. Substitution of more common commodities for rare ones also increases sustainability. Re-use, recycling and substitution extends resource life and reduces mine waste and smelter effluents (a smelter is a processing facility which separates a metal from the mineral, for example lead from the lead mineral galena - PbS).

Classification
There are many different ways of categorising mineral deposits, but classification schemes considering genetic aspects and rock associations are most common. The simplest classification is a threefold division, in which the genesis of the deposit is emphasized, namely magmatic, hydrothermal and sedimentary or surficial (residual) deposits. This corresponds with the universal rock classification in terms of igneous, metamorphic and sedimentary and reflects the fundamental processes within the earth's crust, with the caveat that in this discussion metamorphism represents a fundamental ore forming process (hydrothermal) rather than a process of change as understood in the study of rocks. In addition many deposits are changed by the subsequent effects of pressure and temperature.

Distribution
Mineral deposits are not equally distributed in the earth's crust nor did they form at the same time. Some minerals are usually found in one type of deposit (diamonds, for example, are usually found either in kimberlite pipes or in a rock known as lamproite), others are found in several different deposit types (gold for example is found in many different deposit types and as a by-product in several others). Regions with favourable conditions for the concentration of useful minerals are termed minerogenetic or metallogenetic provinces and the favourable time during which some deposits formed of the same type is known as a minerogenetic or metallogenetic epoch. During tectonically active (orogenic) periods mountain building is accompanied by plutonic and volcanic activity and mineralisation of magmatic and hydrothermal origin occurs. During quieter epochs deposits form by processes of sedimentation, weathering, evaporation, supergene (oxidation of earlier formed deposits) enrichment, and mechanical action (placer deposits).

Maria Heinrich
Albert Schedl, Geological Survey of Austria (GBA)
Gerry Stanley, Geological survey of Ireland (GSI)

Europe's metallic endowment

What is Europe's global mineral budget?
Are all useful mineral commodities present in Europe, in a quantity adapted to our needs, or do we have gaps? Is there still some chance to discover new 'reserves', or since Europe is an old mining continent, do we have consumed all our endowment? These questions regularly come again, and the advices are divided over this issue. We will try here to make the point and explain why answering to these questions which look simple is not so easy.

What do we mean by 'endowment'?
Before calculating it at European scale, endowment is first calculated for each commodity of each mineral deposit. Endowment is the sum of cumulated past production, reserves (the part of the deposit which has been recognized in detail and which is theoretically exploitable) and resources (a part less well known which could be possibly exploitable - but this has to be demonstrated). These three headings are theoretically independent: reserves do not include production and resources do not include reserves.

What is Europe's mineral endowment?
The following map produced by the EU-FP7 project ProMine (http://promine.gtk.fi/) gives an idea of Europe's mineral potential. Each deposit is portrayed by a symbol which shape and colour indicate the main commodity it contains. The size of the symbol reflects the size of the deposit for its main commodity: very large (class A), large (class B), medium-sized (class C). In order to keep the map readable, small deposits (class D) and occurrences have not been reported. For the same reason only the main commodity is reported. It should be noted that most of deposits contain several commodities and that a deposit may be "large" for one or two commodities and "medium" or "small" for some other related commodities.

Which lessons can we draw from this map?

- Europe's endowment covers a large range of commodities from precious metals (Au, Ag, Platinum Group Elements [PGE]), base metals (Al, Cu, Pb, Zn, Sn), iron and ferro-alloy metals (e.g., Co, Cr, Fe, Mn, Mo, Ni, V, W), high tech and rare metals (e.g., Bi, Ge, Ga, Hg, Li, Rare Earths, Sb, Ta, Ti, Zr), minerals for chemical use (e.g., barite, fluorite), to fertilizer minerals (phosphate) and (although not represented here) ceramic and refractory minerals, building material and dimension stones, several speciality and other industrial rocks and minerals and,of course, energy commodities like uranium.
- Spatial distribution of the different commodities is not homogenous. It is linked to the type of deposit and to the geological history and the geodynamic evolution of the different parts of the continent. Nb and Rare Earth deposits are mainly associated with alkaline rocks and carbonatites and located within the Fennoscandian Shield. For Au and Ag from epithermal deposits, the potential is high along the Tethyan suture, in southeastern Europe, and especially from Slovakia to Greece. For Sn and W, the potential is mostly related to late-orogenic Hercynian granites and follows the Hercynian arc from Galicia-Portugal, British Cornwall, French Brittany and French Massif Central to western Bohemian Massif. Cu and Mo porphyry-type deposits are typical from the evolution of the western Tethyan suture and subsequent Alpine orogeny in late Cretaceous and Cenozoic, especially in southeast Europe e.g. Skouries porphyry Cu-Au in Greece. They are also present in the Fennoscandian Shield. Fe and W deposits of skarn-type occur where carbonate rocks are cut by younger intrusions. In Europe, they are distributed in three major domains, the Precambrian of the Fennoscandian Shield, the Hercynian domain in southern Europe, and the Cenozoic Carpathian-Balkan domain. The Fe, Cu and Au association of IOCG-type can be found essentially in two Paleoproterozoic districts in the Fennoscandian Shield, the most important being Kiruna (northern Sweden), but also Bergslagen (central Sweden). The Fe, Ti and V 'mafic' association is clearly related with Precambrian series in the Fennoscandian Shield. Major Ni, Cr, Cu and PGE 'mafic-ultramafic' deposits are also located in the Fennoscandian Shield, mainly in the Fenno-Karelian area, but also in chromite deposits hosted by Tethyan ophiolites in Balkan Peninsula. Orogenic gold deposits belong to three groups, Paleoproterozoic orogenic deposits related to greenstones in the Fennoscandian Shield, Hercynian deposits in the northern Iberian Peninsula, the French Massif Central and the Bohemian Massif, and Tertiary mineralizations in the Greek Rhodope massif. Nb, Ta, Sn, Li and Be deposits of pegmatite-type are present in the Fennoscandian Shield and in the Variscan zone, from the northwestern Iberian Peninsula, Cornwall, Brittany and the northern part of the French Massif Central, to the eastern Alps (Austria). Beside these major groups, additional pegmatite deposits can be found in most other Paleozoic ranges (e.g. the Pyrenees, Corsica, Vosges Mountains and Bohemian Massif). The Zn, Pb, Ag and Ba 'carbonate-hosted' association is mainly found in Great Britain, in Derbyshire, in the northern Pennines, in the upper Silesian district (southern Poland) and the southern Europe from Galicia, in Spain, to the Central Alps with possible extension in eastern Europe and Greece. Sandstone- and shale-hosted Cu, U and Pb deposits include the major copper mineralization in the Kupferschiefer Permian sediments which occurs essentially in southern Poland (Lubin district), but also in Germany (Mansfeld, Richelsdorf, Spremberg). It also includes Paleoproterozoic black shales of Talvivaara in Finland (Ni, Co, Cu). Fe, Mn, Ba, K, Na and Sr 'sedimentary' deposits include Scandinavian BIFs and Jurassic oolitic iron deposits in England (e.g. Northampton), France (e.g. Lorraine), Germany (e.g. lower Saxony), Belgium (e.g. Campine), Poland (e.g. Silesia), etc. The Cu, Pb and Zn 'volcanogenic massive sulfide' deposits are distributed in three major provinces, the Paleoproterozoic districts of Skellefte and Berslagen, in Sweden, and Vihanti-Pyhäsalmi and Otokumpu, in Finland, the Upper Paleozoic district of the southern Iberian province (e.g. Rio Tinto in Spain, Neves Corvo in Portugal) and the Upper Cretaceous district of Skouriotissa, Mavrovouni and Limni in Cyprus. Fe, Al, Ni and Cu 'residual deposits' are found essentially in southern Europe e.g. Greece. Main types of mineralization are bauxites, lateritic nickel, residual concentration in carbonated ores (Mn, Fe …), or gossan-type concentration on sulfides ore (Cu, Au…). Polymetallic Pb, Zn, Ag, Cu, Ba, F and U veins are related to the Hercynian orogeny. Main vein-types are i) Pb-Zn-Cu-Ag veins extracted since the Middle Age essentially for silver (the Erzgebirge, the Vosges Mountains, the Black Forest,…), ii) antimony veins in the Brioude-Massiac district (France), iii) peripheral tin and tungsten veins near felsic intrusions (e.g. Portugal, France), iv) fluorite and barite low temperature veins along the border of the Hercynian domain (e.g. France). Uranium veins are found in two Hercynian domains (French Massif Central and Czech Bohemian Massif). Polymetallic Pb, Zn, Ag, Au veins and manto-type replacement deposits related to Alpine orogeny, are found in Olympias -Stratoni district in Greece, Madjarovo field in Bulgaria and Trepca ore belt in Serbia.
- Several deposits are very large for at least one commodity. Among the most famous, one can cite Lubin (Poland - Cu), Rammelsberg (Germany - Zn-Pb-Cu), Kiruna (Sweden - Fe), Aitik (Sweden - Cu-Ag-Au), Outokumpu (Finland - Cu-Co-Zn), Neves Corvo (Portugal - Cu-Zn-Sn), Las Cruces (Spain - Cu-Zn-Au), Navan (Ireland - Pb-Zn), Vourinos (Greece - Cr), Luzenac (France - talc), Jelsava (Slovakia - Mg).

Europe's mineral endowment

- A way to give a first idea of Europe's mineral endowment is to compare it to the estimated world mine and then to convert it in equivalent numbers of years of world production. These numbers outline important endowments for some commodities such as vanadium (64 equivalent years of world production), mercury (103), lithium (71), rare earth elements (51), tantalum (62), titanium (96) and magnesium (373). On the other hand, Europe shows a limited endowment (0.5 to 3 equivalent years of world production) for Au and PGE (precious metals), Be, Bi, Cd, Ga, Re, Sb, Se and Zr (speciality and rare metals). The endowment in base metals is significant with equivalent numbers of years of world production ranging from 10 to 22. Concerning iron and ferro-alloys metals (e.g., Co, Fe, Mn, Mo, Nb, Ni, W) the global endowment looks weaker than for base metals with equivalent numbers of years of world production around 11.

Europe's endowment thus appears to be relatively significant. However it also appears, that in the present state of knowledge, to be insufficient. Current demand exceeds production and Europe is heavily dependent on mineral and metal imports. This issue can be addressed in two concomitant ways. The search for new deposits is the first one. It is widely accepted that Europe, or at least certain countries or regions, are clearly underexplored. In several places (a majority?) we have no estimate of the potential of the shallowest 500 or 1,000 m of the crust. The second way is to re-explore ancient deposits. Mine closure may result from technical or economy problems. The use of high-resolution indirect methods like geophysics and the construction of 3D predictive models coupling geology and geophysics can help visualizing the 'old' deposit and locating efficiently reconnaissance deep (and costly) drilling for the search of vertical and lateral extensions.

Daniel Cassard
Bureau de Recherches Géologiques et Minières (BRGM)

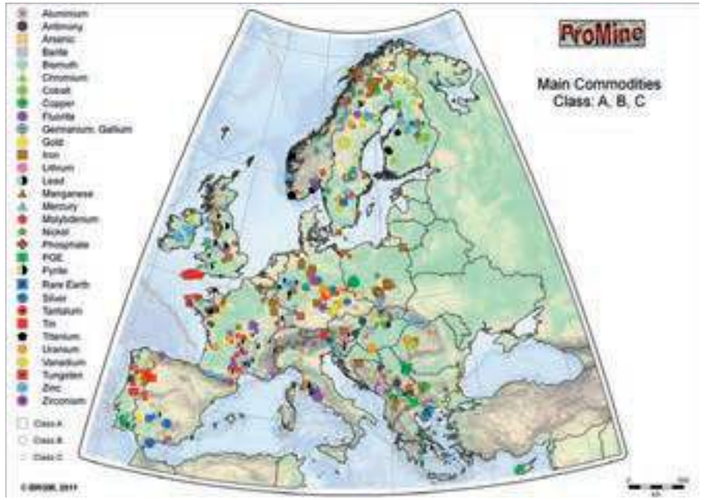


Fig. 1: Main mineral and metal resources in Europe based on the ProMine Mineral Deposit
(The research leading to these results has received funding from the European Community's Seventh Framework Programme ([FP7/2007-2013] [FP7/2007-2011]) under grant agreement nr 228559.
This publication reflects only the author's view, exempting the Community from any liability).

Environment and mining

Introduction
The mining supplies the society with essential minerals and energy - it is part of our life. Like any other industrial activities entailing the use of land or sea, mining inevitably has an ecological footprint and, although the actual land-take is comparatively small compared to some other industrial activities and land uses, the impacts on the natural environment still need to be considered and addressed where relevant (EU 2011). So while exploration and exploitation high environmental standards must be followed; during the permitting process different environmental licenses have to be obtained.

What is environment?
The environment is built of different interacting natural and artificial elements which have to be considered during the exploration and exploitation.

Natural environment
The natural environment consists of natural living or non-living things such as the flora, fauna, surface water and groundwater, air, soil and rocks. Their protection and treatment during the mining activity is put down in Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). These are put down in the following EU environmental Directives (EU 2011):

- Directive 2001/42/EC on the evaluation of the effects of certain plans and programmes on the environment (commonly referred to as the 'SEA' Directive)
- Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, as amended in 1997 (97/11/EC), 2003 (2003/35/EC) and 2009 (2009/31/EC) - (commonly referred to as the 'EIA' Directive).

To avoid the pollution, monitoring is necessary e.g. the quality of groundwater and air is observed around the mine regularly.

Biodiversity
Biodiversity conservation is high on the EU political agenda. At the European Summit in Gothenburg in 2001, the European Union set itself the goal "to halt the loss of biodiversity in the EU by 2010". This commitment is firmly embedded in all aspects of EU policy (EU 2011).

The living world is sensitive and strongly connected to other parts of the natural environment such as soil and water. Removal of soil and intervention into the flora (world of plants) and fauna (world of animals) can only be done in the mining business when the strict regulatory requirements have been met, that is, ecosystem can keep its functions in the area.

For example a potential groundwater and surface water pollution could endanger flora and fauna. The alteration of water flow could cause the disappearance of habitats. However, in quarries new habitats can appear (lakes, wetlands, sandy quarry walls for birds).

Soil
The soil is weathered rock debris containing organic matters; different creatures live on and inside the soil. It develops over a long time, so it is valuable and its protection is particularly important.

The surface mining starts with removal of the soil. The removed soil should be used as its original function during reclamation, based on soil conservation plans prepared by experts.

Surface and groundwater
Observation the strict environmental regulations can promote the surface and groundwater pollution. Mining can cause alteration in the chemical composition and drainage of the surface waters (rivers, lakes, seas and oceans) and groundwater.

The changing of composition could mean pollution which can affect to the flora and fauna of surface waters or endanger the clearness of drinking-water. Pollution of groundwater can occur during underground ore mining; e.g. if a sulphur containing ore get in touch with oxygen, acid is generated which can dissolve pollutant from rocks e.g. heavy metals. Surface waters can be contaminated during the processing of minerals.

During (even surface or underground) exploitation the groundwater usually has to be pumped in order to reach the mineral. This could affect the water level and flow causing water management problems which affect the soil and the flora. Surface mines can change the natural flow of surface waters also; streams can dry up or new ones can be created.

Air
In surface mines dust pollution can occur that can be avoided by regular sprinkling or by collecting the dust through ventilation systems which end up in filters. The mining operation must meet the requirements of noise and vibration control also.

Built environment
Beside the natural environment, the human-made surroundings are also part of the environment: buildings, infrastructure, parks, former settlements as archaeological sites recently, etc. Its most valuable elements belong to the cultural heritage and are under protection, so in these areas the mining is prohibited. Mining areas usually are not situated directly next to the settlements but sometimes can cause damages of the built environment. Rarely for example, pits of underground mines can be collapsed causing surface subsidence which can result in damages of buildings, roads, underground cables and channels. This process can be prevented by backfilling and caving.

Landscape
The landscape consists of natural and artificial elements which represent individual value and should be protected. The purpose of landscape management is to preserve the valuable natural systems and characteristic built features or construction traditions.

The mining could interrupt the continuity of the landscape so the restoration has great importance. However, the mining could be part of the landscape, e.g. in old mining regions.

Conflict management
It is easier and better to prevent the conflicts than manage them. During the permitting process discussions with different authorities (e.g. authority responsible for environment or cultural heritage) are necessary but it is also important to hold public hearings and come to an agreement with the local communities. This consultation helps to avoid conflicts.

Some species are so endangered that they require their core habitats to be protected. Collectively, these sites make up the Natura 2000 Network, an ecological network of nature conservation sites spanning all 27 EU countries (Figure 1, EU 2011).

There is no automatic exclusion of mining activities in and around Natura 2000. Instead, extractive activities shall follow the provisions outlined in Article 6 of the Habitats Directive to ensure that these activities do not adversely affect the integrity of Natura 2000 sites (EU 2011). However, in practice Natura 2000 means a significant obstacle of mining.

Fig. 1: European Natura 2000 Network across EU-27, status January 2010 (EU 2011). European Union, 2011: Non-energy mineral extraction and Natura 2000 – Guidance Document.

The following environmental laws and policies are also of relevance to the mining activities (EU 2011):

- Directive on the Management of waste from extractive industries (2006/21/EC)
- Environmental Liability Directive (2004/35/EC).
- Water Framework Directive (2000/60/EC) and Groundwater Directive (2006/118/EC)
- Marine Strategy Framework Directive (2008/56/EC)
- EU Strategy on Sustainable Use of Natural Resources
- The precautionary principle

Table 2: Natura 2000 and related directives (EU 2011)

Mine reclamation

After the exploitation ended, the mining area has to be restored. Rehabilitation is "the process of converting derelict land to usable land and may include engineering as well as ecological solutions" (EU 2011). The rehabilitation plan is an integral part of the mining project and part of the permit conditions.

The reclamation of surface and underground mines is significantly different. The pits of underground mines change the original groundwater flows and are hazardous because of the unpredictable collapses. For these reasons the pits have to be backfilled. The exploited waste rock is suitable for this purpose because the pit-heap also has to be restored.

The rehabilitation of surface mines can be carried out in different ways. If the aim is to restore the nearly original state, the first step is to make the surface even, then to replace the soil and plant vegetation. The soil needs long time to pack and have stable water management.

The open mines can be also restored in a way that they get a new function. The mining activity uncovers rocks and structures which usually are not directly visible and are geologically interesting. These former mines can be converted into educational trail. In other cases the open pit can turn into a lake serving the tourism as a holiday spot or a fishpond.

Next steps

It is very important to know the sensitivity of the area which is target of mining activity. Environmental impact assessments need to be involved the following chapters: presentation of the detailed geographic, geological, hydro-geological and other environmental information of the area, a description of the mining activities and the potential effects on environmental elements are taken into account. A lot of data from the contractors who carry out the exploitation of the area, but the national government and EU support of basic research and development of monitoring network are also important. Improving the EU mineral knowledge base that would allow assessing the potential overlapping of Natura 2000 sites with established or potential EU mineral resources should be further investigated, taking into account the results of the actions proposed by the EU Raw Materials Initiative in this regard.

References

European Union, 2011: Non-energy mineral extraction and Natura 2000 - Guidance Document.

Zoltán Horváth & Katalin Sari
Geological and Geophysical Institute of Hungary (MFGI)

Fig. 3: Abandoned dacite quarry as a possible new colonization place of species (Börzsöny Hill, Hungary)

Mineral Production in European Countries, 2007-2011

		2007	2008	2009	2010	2011
Production of primary aggregates (See notes 2 to 7)						
World total	no data	no data	no data	no data	no data	
Europe - total of countries listed below	tonnes	3 095 000 000	2 930 000 000	2 565 000 000	2 438 000 000	2 468 000 000
Austria	tonnes	54 478 681	66 308 310	60 022 944	54 582 235	62 373 503
Belgium	tonnes	51 600 000	50 600 000	51 000 000	52 000 000	52 000 000
Bulgaria	tonnes	29 806 551	40 791 984	28 550 531	22 075 900	26 985 792
Croatia	tonnes	...	7 275 077	6 583 880	3 646 572	5 012 106
Cyprus	tonnes	13 129 470	14 174 480	11 467 987	12 981 444	11 816 397
Czech Republic	tonnes	71 447 000	71 583 000	65 281 000	56 510 000	58 141 000
Denmark	tonnes	7 410 639	5 573 935	2 533 492	2 681 877	1 940 032
Estonia	tonnes	15 387 540	11 581 600	9 946 480	9 277 000	10 656 140
Finland	tonnes	113 000 000	113 000 000	84 000 000	84 000 000	89 000 000
France	tonnes	423 400 000	408 380 000	355 730 000	343 150 000	357 610 000
Germany	tonnes	478 300 000	475 000 000	462 000 000	447 000 000	482 000 000
Greece	tonnes	90 000 000	85 000 000	65 000 000	42 250 000	27 462 500
Hungary	tonnes	47 862 853	53 678 160	51 399 219	51 200 000	35 971 140
Ireland	tonnes	130 000 000	85 000 000	65 000 000	50 000 000	32 000 000
Italy	tonnes	267 534 821	266 153 090	248 936 332	231 333 048	241 638 236
Lithuania	tonnes	15 606 343	16 382 571	7 878 598	8 936 731	10 232 939
Netherlands	tonnes	69 437 000	67 622 000	47 000 000	40 000 000	40 000 000
Norway	tonnes	66 388 000	67 155 000	64 425 000	67 145 000	77 070 000
Poland	tonnes	186 242 829	188 777 558	193 331 696	215 439 700	259 037 600
Portugal	tonnes	71 221 157	68 465 263	64 454 375	56 691 754	53 000 000
Romania	tonnes	32 182 699	36 012 120	27 918 191	25 859 540	31 693 558
Slovakia	tonnes	19 808 725	23 863 455	22 153 226	21 841 273	15 875 798
Slovenia	tonnes	35 827 253	34 153 560	29 329 728	25 037 532	20 317 444
Spain	tonnes	423 000 000	332 000 000	256 000 000	242 000 000	182 000 000
Sweden	tonnes	84 083 843	85 562 014	71 900 000	74 000 000	74 000 000
Switzerland	tonnes	55 700 000	42 000 000	42 000 000	42 000 000	45 000 000
United Kingdom	tonnes	241 770 000	213 469 000	170 852 000	155 903 000	165 041 000
Mine production of antimony						
World total	tonnes	182 000	120 000	128 000	148 000	147 000
of which Europe [1]	tonnes	* 3 000	* 3 000	* 3 000	* 3 000	* 3 000
Russia	tonnes	* 3 000	* 3 000	* 3 000	* 3 000	* 3 000
Production of bauxite						
World total	tonnes	213 000 000	214 000 000	198 000 000	226 000 000	248 000 000
of which Europe [1]	tonnes	8 886 000	8 360 000	7 552 000	7 302 000	7 982 000
France	tonnes	160 000	* —	* —	* —	* —
Greece	tonnes	2 125 900	2 174 000	1 935 000	1 902 000	2 324 000
Hungary	tonnes	546 310	511 337	317 000	365 000	277 800
Russia	tonnes	6 053 900	5 675 000	5 300 000	5 035 000	5 380 000
Production of chromium ores and concentrates						
World total	tonnes	25 200 000	24 800 000	20 100 000	27 500 000	26 300 000
of which Europe [1]	tonnes	1 527 000	1 748 000	952 000	1 332 000	1 281 000
Albania	tonnes	194 760	220 536	288 759	334 467	187 788
Finland	tonnes	556 000	614 000	247 000	598 000	693 000
Russia	tonnes	776 681	913 000	416 194	* 400 000	* 400 000

		2007	2008	2009	2010	2011
Mine production of cobalt						
World total	tonnes (metal content)	58 000	82 000	87 000	136 000	151 000
of which Europe [1]	tonnes (metal content)	3 710	2 600	2 380	2 600	2 820
Finland	tonnes (metal content)	* 120	* 100	* 27	* 140	480
Russia	tonnes (metal content)	3 587	2 502	2 352	2 460	2 337
Production of cobalt metal						
World total	tonnes	53 200	57 200	59 800	76 600	82 300
of which Europe [1]	tonnes	19 800	19 200	17 400	18 000	19 600
Belgium (a)	tonnes	2 825	3 020	2 150	2 600	3 187
Finland	tonnes	9 173	9 645	8 970	9 429	10 627
France	tonnes	305	311	368	302	354
Norway	tonnes	3 939	3 719	3 510	3 208	3 067
Russia	tonnes	3 587	2 502	2 352	2 460	2 337
Mine production of copper						
World total	tonnes (metal content)	15 500 000	15 600 000	15 900 000	16 200 000	16 200 000
of which Europe [1]	tonnes (metal content)	1 439 000	1 416 000	1 408 000	1 471 000	1 516 000
Albania	tonnes (metal content)	2 384	3 633	2 596	2 672	4 378
Bulgaria	tonnes (metal content)	116 157	107 195	110 652	112 904	114 603
Cyprus	tonnes (metal content)	3 012	2 986	2 380	2 595	3 660

		2007	2008	2009	2010	2011
Finland	tonnes (metal content)	13 600	13 300	14 600	14 700	14 000
Poland	tonnes (metal content)	451 900	429 687	439 365	425 700	426 700
Portugal	tonnes (metal content)	90 182	89 026	86 462	74 011	82 200
Romania	tonnes (metal content)	2 213	308	3 129	5 127	6 355
Russia	tonnes (metal content)	690 000	705 000	675 700	702 700	713 100
Spain	tonnes (metal content)	6 281	7 071	17 663	54 335	67 983
Sweden	tonnes (metal content)	62 905	57 688	55 414	76 514	82 967
Production of refined copper [8]						
World total	tonnes (metal content)	17 800 000	18 200 000	18 300 000	19 000 000	19 500 000
of which Europe [1]	tonnes (metal content)	3 428 000	3 489 000	3 388 000	3 572 000	3 658 000
Austria	tonnes	81 400	106 700	96 200	113 700	112 500
Belgium	tonnes	394 000	395 800	373 700	389 000	393 600
Bulgaria	tonnes	69 900	114 200	183 600	195 400	201 100
Cyprus	tonnes	3 012	2 986	2 380	2 595	3 660
Finland	tonnes	109 870	131 249	105 411	120 528	124 360
Germany	tonnes	665 517	689 763	668 945	704 300	708 800
Italy	tonnes	28 600	24 200	6 500	1 800	2 000
Norway	tonnes	34 200	37 000	33 900	36 200	36 000
Poland	tonnes	532 975	526 808	502 462	547 074	571 000
Romania	tonnes	18 589	15 300	4 600	—	—

		2007	2008	2009	2010	2011
Russia	tonnes	948 300	876 800	855 000	899 600	912 000
Spain	tonnes	308 372	319 050	329 356	347 518	353 790
Sweden	tonnes	213 894	227 774	205 759	190 497	219 316
Ukraine	tonnes	19 500	21 700	20 000	23 400	20 000
Production of feldspar						
World total	tonnes	21 544 000	22 940 000	20 319 000	22 724 000	20 875 000
of which Europe [1]	tonnes	6 122 000	7 204 000	2 081 000	2 044 000	3 641 000
Bulgaria	tonnes	* 90 000	* 90 000	* 80 000	* 80 000	* 80 000
Czech Republic	tonnes	514 000	488 000	431 000	388 000	407 000
Finland	tonnes	48 980	45 250	23 120	28 013	26 292
France	tonnes	* 650 000	* 650 000	* 550 000	* 650 000	* 650 000
Germany	tonnes	171 303	161 416	140 000	* 150 000	* 150 000
Greece	tonnes	95 000	62 000	55 737	23 050	10 200
Italy	tonnes	3 524 389	4 727 000	* 4 700 000	* 4 700 000	* 4 700 000
Norway	tonnes	65 000	62 000	48 000	56 000	25 271
Poland	tonnes	497 900	599 100	445 500	513 700	* 550 000
Portugal	tonnes	378 521	230 427	210 266	169 722	179 600
Romania	tonnes	41 477	22 995	14 317	6 049	3 814
Russia	tonnes	* 160 000	* 160 000	* 160 000	* 160 000	* 160 000
Slovakia	tonnes	—	10 000	13 000	—	—
Spain	tonnes	683 134	690 256	597 496	691 894	* 650 000
Sweden	tonnes	25 000	22 000	18 000	22 000	30 000
Ukraine	tonnes	76 305	83 420	84 757	146 016	178 614
United Kingdom	tonnes	1 112	430	—	—	—

		2007	2008	2009	2010	2011
Mine production of gold [9, 11]						
World total	kilograms (metal content)	2 350 000	2 290 000	2 490 000	2 590 000	2 600 000
of which Europe [1]	kilograms (metal content)	169 000	197 000	221 000	220 000	205 000
Bulgaria	kilograms (metal content)	3 964	4 160	4 482	4 489	5 302
Finland	kilograms (metal content)	1 639	1 336	3 808	5 644	6 438
Poland (3)	kilograms (metal content)	883	902	814	776	703
Romania	kilograms (metal content)	* 500	500	* 500	* 500	* 500
Russia	kilograms (metal content)	156 912	184 488	205 236	201 300	185 263
Slovakia	kilograms (metal content)	92	198	346	534	398
Sweden	kilograms (metal content)	5 159	4 953	5 542	6 285	5 994
United Kingdom	kilograms (metal content)	88	163	187	177	202
Production of graphite [10]						
World total	tonnes	2 500 000	2 400 000	2 200 000	2 100 000	2 100 000
of which Europe [1]	tonnes	28 000	29 000	52 000	35 000	37 000
Austria	tonnes	—	250	750	420	925
Czech Republic	tonnes	3 000	3 000	—	—	—
Norway	tonnes	3 000	4 100	4 562	6 270	7 789
Romania	tonnes	—	—	24 352	6 633	...

		2007	2008	2009	2010	2011
Russia	tonnes	* 14 000	* 14 000	* 14 000	* 14 000	* 14 000
Ukraine	tonnes	* 8 000	* 8 000	* 8 000	* 8 000	* 8 000
Production of gypsum						
World total	tonnes	157 200 000	151 200 000	138 000 000	138 300 000	141 300 000
of which Europe [1]	tonnes	33 900 000	31 000 000	24 500 000	23 000 000	23 700 000
Austria (b)	tonnes	1 063 844	1 087 259	910 945	872 273	815 438
Bulgaria	tonnes	234 300	21 200	127 600	109 200	114 800
Croatia	tonnes	170 721	* 250 000	318 139	248 675	231 008
Cyprus	tonnes	330 000	412 000	317 000	333 000	335 000
Czech Republic	tonnes	66 000	35 000	13 000	5 000	11 000
France (b)	tonnes	* 3 500 000	2 338 910	1 887 260	2 065 814	2 452 204
Germany (b)	tonnes	1 898 000	2 112 000	1 898 000	1 822 000	2 021 000
Greece (b)	tonnes	836 967	1 000 000	730 000	* 600 000	587 000
Hungary (b)	tonnes	26 000	15 940	19 766	20 000	3 000
Ireland, Republic of	tonnes	* 700 000	* 600 000	* 400 000	* 300 000	* 300 000
Italy	tonnes	* 1 600 000	* 1 600 000	* 1 600 000	* 1 600 000	* 1 600 000
Poland (b)	tonnes	1 581 299	1 499 901	1 326 928	1 399 000	1 500 000
Portugal	tonnes	418 035	372 731	335 189	336 755	337 272
Romania	tonnes	1 004 150	832 248	720 713	639 010	* 660 000
Russia	tonnes	* 3 000 000	* 3 600 000	* 2 900 000	* 2 900 000	* 2 900 000
Slovakia (b)	tonnes	151 000	152 000	131 000	87 000	88 000
Spain	tonnes	14 535 422	11 955 753	8 181 315	6 990 249	* 7 100 000
Switzerland	tonnes	* 300 000	* 300 000	* 300 000	* 300 000	* 300 000
Ukraine	tonnes	741 580	1 160 910	711 490	678 610	675 950
United Kingdom	tonnes	* 1 700 000	* 1 700 000	* 1 700 000	* 1 700 000	* 1 700 000

		2007	2008	2009	2010	2011
Production of iron ore						
World total	tonnes	2 052 000 000	2 205 000 000	2 275 000 000	2 620 000 000	3 012 000 000
of which Europe [1]	tonnes	211 000 000	200 000 000	179 000 000	205 000 000	216 000 000
Austria (h)	tonnes	2 152 825	2 032 671	2 002 131	2 068 853	2 206 910
Germany (i)(j)	tonnes	421 711	455 100	363 699	390 353	489 091
Norway	tonnes	630 000	746 000	896 000	3 266 000	2 532 100
Romania	tonnes	8 157	—	—	—	—
Russia	tonnes	105 000 000	99 900 000	92 000 000	95 500 000	104 000 000
Slovakia	tonnes	570 000	392 000	—	—	—
Sweden	tonnes	24 714 000	23 888 000	17 677 000	25 292 000	26 113 000
Ukraine	tonnes	77 930 000	72 688 000	66 452 000	78 541 000	80 900 000
United Kingdom	tonnes	* 300	145	—	—	—
Production of kaolin [11]						
World total	tonnes	27 500 000	27 300 000	23 800 000	25 200 000	25 700 000
of which Europe [1]	tonnes	8 400 000	7 800 000	7 900 000	8 200 000	8 600 000
Austria	tonnes	16 929	16 460	18 148	18 914	18 897
Belgium	tonnes	* 300 000	* 300 000	* 300 000	* 300 000	* 300 000
Bulgaria	tonnes	* 240 000	* 220 000	* 140 000	* 190 000	* 250 000
Czech Republic (c)	tonnes	682 000	664 000	488 000	636 000	660 000
France	tonnes	307 253	335 520	350 000	350 000	350 000
Germany (d)	tonnes	3 842 514	3 622 159	4 513 753	4 578 097	4 898 516
Greece	tonnes	30 000	4 360	—	3 493	2 056
Hungary	tonnes	2 136	—	—	—	—
Italy	tonnes	* 180 000	* 180 000	* 180 000	* 180 000	* 180 000
Poland (e)	tonnes	153 670	165 615	136 561	250 000	143 000

		2007	2008	2009	2010	2011
Portugal	tonnes	183 598	217 434	274 925	273 890	322 041
Romania	tonnes	7 576	3 060	651	326	—
Russia	tonnes	* 45 000	* 45 000	* 45 000	* 45 000	* 45 000
Slovakia	tonnes	46 000	44 000	10 000	—	4 000
Spain (e)	tonnes	489 428	355 739	270 298	310 993	302 580
Ukraine	tonnes	244 000	240 000	* 100 000	* 100 000	* 100 000
United Kingdom	tonnes	1 671 426	1 355 365	1 059 848	* 1 000 000	* 1 000 000
Production of lithium						
World total	tonnes (Li content)	20 800	20 500	14 100	20 300	24 600
of which Europe [1]	tonnes (Li content)	766	752	708	815	771
Portugal	tonnes (Li content)	591	593	635	682	638
Spain	tonnes (Li content)	176	159	73	133	133
Mine production of nickel						
World total	tonnes (metal content)	1 585 000	1 556 000	1 359 000	1 540 000	1 826 000
of which Europe [1]	tonnes (metal content)	326 000	312 000	282 000	307 000	317 000
Albania	tonnes (metal content)	2 197	3 500	550	1 954	5 414
Finland	tonnes (metal content)	3 600	6 200	1 600	12 100	19 100
Greece	tonnes (metal content)	21 200	18 600	9 600	16 100	21 700
Norway	tonnes (metal content)	378	377	336	348	339

		2007	2008	2009	2010	2011
Russia	tonnes (metal content)	279 800	266 800	261 900	270 000	270 000
Spain	tonnes (metal content)	6 630	8 136	8 029	6 296	—
Ukraine	tonnes (metal content)	* 12 000	* 8 000	—	—	—
Smelter/refinery production of nickel [12]						
World total	tonnes	1 428 000	1 397 000	1 340 000	1 472 000	1 615 000
of which Europe [1]	tonnes	504 000	495 000	431 000	484 000	494 000
Austria	tonnes	900	500	700	1 000	1 000
Finland	tonnes	55 000	51 963	41 556	49 772	49 823
France	tonnes	14 800	13 700	13 900	14 400	13 700
Greece	tonnes	18 668	16 640	8 269	13 960	18 530
Norway	tonnes	87 600	88 700	88 577	92 185	92 000
Russia	tonnes	272 000	257 700	244 800	262 300	265 700
Ukraine	tonnes	20 600	24 700	15 800	21 900	17 100
United Kingdom	tonnes	34 050	40 800	17 800	28 900	36 300
Mine production of platinum group metals (all forms) [13, 14]						
World total	kilograms (metal content)	542 000	475 000	462 000	481 000	492 000
of which Europe [1]	kilograms (metal content)	172 600	141 500	139 800	144 500	136 200
Poland	kilograms (metal content)	* 50	* 50	* 50	* 50	* 50
Russia (k)	kilograms (metal content)	172 500	141 400	139 700	144 400	136 100
Production of potash						
World total	tonnes (K_2O content)	34 500 000	32 800 000	20 800 000	33 000 000	35 100 000

		2007	2008	2009	2010	2011
of which Europe [1]	tonnes (K_2O content)	10 971 000	10 093 000	6 401 000	9 975 000	10 613 000
Germany Potassic salts	tonnes (K_2O content)	3 636 504	3 280 467	1 825 139	3 023 941	3 214 696
Russia	tonnes (K_2O content)	6 373 100	5 935 400	3 690 900	6 128 100	6 500 000
Spain Chloride	tonnes (K_2O content)	531 739	472 952	481 455	418 778	436 026
United Kingdom Chloride	tonnes (K_2O content)	430 000	403 800	* 403 800	* 403 800	* 462 000
Production of salt						
World total	tonnes	225 000 000	270 000 000	279 000 000	278 000 000	282 000 000
of which Europe [1]	tonnes	59 000 000	59 000 000	61 000 000	63 000 000	64 000 000
Albania	tonnes	* 47 000	* 47 000	* 47 000	* 47 000	* 47 000
Austria	tonnes	736 896	867 177	1 035 094	1 071 937	1 150 643
Bulgaria	tonnes	2 000 000	2 100 000	1 300 000	1 900 000	2 200 000
Croatia	tonnes	32 536	54 937	57 186	66 835	53 963
Denmark	tonnes	557 917	496 593	511 063	601 046	* 600 000
France	tonnes	6 139 840	* 6 000 000	6 100 000	* 6 100 000	* 6 000 000
Germany	tonnes	13 394 000	13 841 391	16 872 474	16 610 640	17 441 001
Greece	tonnes	212 000	* 220 000	* 189 000	* 190 000	* 190 000
Italy	tonnes	4 383 560	5 412 449	3 678 234	4 006 882	2 912 128
Netherlands	tonnes	6 177 000	6 200 000	5 967 000	5 982 000	6 866 000
Poland	tonnes	4 307 660	4 107 927	4 285 343	4 631 215	4 414 500
Portugal	tonnes	654 636	675 794	666 903	663 535	679 343
Romania	tonnes	2 475 349	2 526 774	2 072 744	2 388 357	2 248 940
Russia	tonnes	2 200 000	1 800 000	1 600 000	* 2 000 000	* 2 000 000

		2007	2008	2009	2010	2011
Slovakia	tonnes	117 000	109 510	41 000	—	—
Slovenia	tonnes	3 029	535	2 924	59	4 291
Spain	tonnes	4 144 429	4 302 728	4 201 723	4 451 302	* 4 500 000
Switzerland	tonnes	353 000	368 000	554 000	643 000	478 324
Ukraine	tonnes	5 547 852	4 425 317	5 394 512	4 908 186	5 938 000
United Kingdom	tonnes	5 600 000	5 565 000	6 166 000	6 666 000	* 6 700 000
Production of talc						
World total	tonnes	8 300 000	8 100 000	7 500 000	7 400 000	7 800 000
of which Europe [1]	tonnes	1 513 000	1 472 000	1 236 000	1 302 000	1 271 000
Austria	tonnes	153 409	154 577	111 388	138 367	132 018
Finland	tonnes	535 882	527 686	375 302	419 345	429 494
France	tonnes	* 420 000	* 420 000	400 000	400 000	400 000
Greece	tonnes	200	* 200	* 200	* 200	* 200
Italy	tonnes	117 643	* 110 000	* 110 000	* 110 000	* 110 000
Norway	tonnes	* 34 000	* 30 000	23 350	6 392	8 191
Portugal	tonnes	12 367	11 657	11 567	11 981	15 462
Romania	tonnes	1 513	1 843	570	296	131
Russia	tonnes	* 150 000	* 150 000	* 150 000	* 150 000	* 150 000
Slovakia	tonnes	—	—	—	7 000	7 000
Spain	tonnes	78 042	59 299	47 218	51 897	11 957
Sweden	tonnes	7 000	4 000	4 000	4 000	3 000
United Kingdom	tonnes	2 850	2 410	2 861	2 633	3 709
Production of titanium minerals						
World total	tonnes	11 900 000	11 800 000	10 600 000	11 200 000	11 700 000
of which Europe [1]	tonnes	1 582 000	1 615 000	1 371 000	1 564 000	1 570 000

		2007	2008	2009	2010	2011
Norway	tonnes	882 000	915 000	671 000	864 000	870 000
Ukraine	tonnes	* 700 000	* 700 000	* 700 000	* 700 000	* 700 000
Mine production of tungsten						
World total	tonnes (metal content)	56 500	64 400	64 700	68 600	72 900
of which Europe [1]	tonnes (metal content)	6 700	6 300	7 500	5 100	6 300
Austria	tonnes (metal content)	1 117	1 122	887	975	861
Portugal	tonnes (metal content)	846	981	823	799	818
Russia	tonnes (metal content)	* 4 700	* 4 000	* 5 500	* 3 000	* 4 200
Spain	tonnes (metal content)	—	194	284	303	425
Mine production of zinc						
World total	tonnes (metal content)	11 200 000	12 000 000	11 600 000	12 400 000	12 800 000
of which Europe [1]	tonnes (metal content)	1 021 000	1 025 000	974 000	982 000	1 017 000
Bulgaria (f)	tonnes (metal content)	14 453	12 819	9 339	9 904	10 977
Finland	tonnes (metal content)	38 900	27 800	30 233	55 562	64 115
Greece	tonnes (metal content)	20 700	24 200	17 800	18 400	21 200
Ireland, Republic of	tonnes (metal content)	400 900	398 200	385 700	342 500	344 000
Poland	tonnes (metal content)	129 600	132 400	115 500	92 800	87 800

		2007	2008	2009	2010	2011
Portugal	tonnes (metal content)	24 380	37 900	501	6 422	4 227
Romania	tonnes (metal content)	849	14	* 3 000	* 5 000	* 5 000
Russia	tonnes (metal content)	177 000	204 000	214 000	235 000	252 000
Spain	tonnes (metal content)	—	—	5 900	17 323	33 197
Sweden	tonnes (metal content)	214 576	187 987	192 502	198 687	194 021
Production of slab zinc						
World total	tonnes	11 400 000	11 800 000	11 400 000	12 900 000	13 000 000
of which Europe [1]	tonnes	2 549 000	2 501 000	2 177 000	2 426 000	2 404 000
Belgium	tonnes	254 000	251 000	137 000	281 000	282 000
Bulgaria	tonnes	98 100	101 700	92 700	92 300	83 300
Finland	tonnes	305 543	297 722	295 049	307 144	307 352
France	tonnes	129 000	118 000	161 000	162 000	164 000
Germany	tonnes	294 735	292 284	* 153 000	165 000	170 000
Italy	tonnes	102 100	107 100	103 400	104 700	110 200
Netherlands	tonnes	234 000	250 000	224 000	264 000	261 000
Norway	tonnes	157 027	145 469	138 973	148 862	153 200
Poland	tonnes	141 900	142 500	139 100	135 000	94 100
Romania	tonnes	58 342	61 978	1 000	—	—
Russia	tonnes	263 000	263 000	208 000	241 000	245 000
Spain	tonnes	509 000	466 000	515 000	517 100	527 100
Ukraine	tonnes	2 600	3 800	8 800	7 600	6 600

Notes

1. "Europe" here means the countries represented by the members of European Geological Surveys: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine and United Kingdom.

2. So far as possible, production statistics for primary aggregates include construction sand; gravel, pebbles, shingle and flint; crushed stone used for concrete aggregates, roadstone and other construction uses; granules, chippings and powders.

3. Where official sources show more than one series for primary aggregates the higher series has generally been used.

4. Where marine sands and gravels have been identified, these are included in primary aggregates.

5. Information on primary aggregates may be incomplete or absent due to reporting methods, confidentiality or lack of available information.

6. Production of primary aggregates from many small operations are not officially compiled in all countries. The minimum number of employees for which establishments are required to report production varies between different countries and can also vary from year to year.

7. Quantities of sand from sand and gravel operations may be discarded due to low demand. This may or may not be included in the primary aggregates statistics.

8. Figures for refined copper relate to both primary and secondary material, whether electrolytic or fire refined. Metal recovered from secondary materials by remelting alone is excluded.

9. In several countries substantial amounts of gold produced in small operations are not recorded in the official statistics used when compiling this table.

10 The statistics for graphite includes all forms of amorphous and crystalline graphite but excludes synthetic material.

11. In addition to the countries listed Denmark is believed to produce kaolin; Greece and Norway are believed to produce gold.

12. Data for smelter or refinery production of nickel relate to refined nickel plus the nickel content of ferro-nickel, nickel oxide and nickel salts.

13. Wherever possible, figures for platinum group metals relate to quantities thought to be recovered from ores originating in the country stated.

14. In addition to the production listed, concentrates produced in Spain, and possibly other countries, are believed to be processed in China to recover platinum group metals.

Symbols

— zero
... data not available

Footnotes

* Estimate
(a) Some cobalt metal production in China is recorded in Belgium
(b) Including anhydrite
(c) Beneficiated
(d) Washed and dried
(e) Washed
(f) Metal content of ore
(g) Metal production
(h) Including micaceous iron oxide
(i) Including manganiferous iron ore
(j) Used as aggregate in the construction industry
(k) Sales from mine production and stocks

Common uses of major mineral raw materials

compiled by Patrice Christmann, BRGM (2013)

Raw material	Aeronautics	Agriculture	Automobile	Chemical industry (including plastics)	Construction	Consumer goods	Defence	Glass industry	Energy production, transport or storage	Health	Information and communication technologies	Metallurgy	Optics
Aluminium	X		X	X	X	X	X		X	X	X		
Antimony	X		X	X	X	X	X		X		X		
Baryte				X					X	X			
Beryllium	X	X	X			X	X		X	X	X		
Bismuth			X	X		X	X		X	X	X		
Boron				X				X			X		X
Cadmium									X				
Chromium	X		X	X	X	X	X		X	X	X		
Cobalt	X	X		X		X	X	X	X	X	X		
Copper	X	X	X	X	X	X	X		X	X	X	X	
Fluorite												X	X
Gallium	X		X			X	X		X		X		
Germanium	X			X		X	X	X	X		X		
Gold					X				X		X		
Hafnium									X				
Indium	X		X			X	X		X		X		
Iron	X	X	X	X	X	X	X		X	X	X	X	
Lead			X				X	X	X				
Lithium	X		X	X		X	X	X	X	X	X		X

Common uses of major mineral raw materials

Raw material	Aeronautics	Agriculture	Automobile	Chemical industry (including plastics)	Construction	Consumer goods	Defence	Glass industry	Energy production, transport or storage	Health	Information and communication technologies	Metallurgy	Optics
Magnesite												X	
Magnesium	X		X			X	X		X	X	X	X	
Manganese		X	X	X	X	X	X		X		X	X	
Mercury													
Molybdenum	X	X	X	X			X		X	X	X		
Nickel	X	X	X	X	X	X	X		X	X	X		
Niobium			X		X		X		X			X	
Palladium	X		X	X		X			X		X		
Phosphate rock		X		X			X			X			
Platinum			X	X		X			X	X			
Potash		X		X						X			
Rare earth	X		X	X		X	X	X	X	X	X	X	X
Rhenium	X			X					X			X	
Rhodium			X	X		X		X			X		
Selenium		X		X					X	X	X		X
Silver				X		X			X	X	X		
Sulphur		X		X					X	X			
Tantalum	X		X			X	X		X		X	X	
Tellurium				X					X			X	X
Tin			X	X		X		X	X		X	X	
Titanium	X			X		X	X		X			X	
Tungsten	X		X	X			X		X		X	X	
Vanadium	X		X	X		X	X		X	X	X	X	
Zinc		X	X	X	X	X	X		X	X		X	
Zirconium	X			X		X	X		X	X		X	

Glossary

Copper

Porphyry: a variety of igneous rock of any composition that contains conspicuous phenocrysts (large-grained crystals) in a fine-grained groundmass.

Sulfide: a mineral compound characterized by the linkage of sulphur with a metal or a semimetal such as chalcocite Cu_2S, or chalcopyrite $CuFeS_2$.

Igneous: a rock or mineral that solidified from molten or partly molten material, i.e from magma or lava. Igneous rocks constitute one of the three main rock types, the others being sedimentary and metamorphic rocks.

Mountain belt: a range of mountains that can stretch for hundreds or thousands of kilometers.

Shale: an indurated, laminated sedimentary rock consisting mainly of clay-sized minerals and with cleavage parallel to bedding.

Sandstone: a sedimentary rock composed mainly of sand-sized minerals or rock grains and more or less firmly united by cementing material such as silica, iron oxide, or calcium carbonate.

Strata-bound deposit: a mineral deposit confined to a single stratigraphic unit. The term can refer to a stratiform deposit, to variously oriented orebodies contained within the unit, or to a deposit containing veinlets and alteration zones that may or may not be strictly conformable with bedding.

Basin: a large low-lying area where surface drainage is confined to the basin and the streams do not leave the basin. Geological basins are one of the two most common places inland which collect sediment, the other being lakes.

Ophiolite: a section of the Earth's oceanic crust and the underlying upper mantle that has been uplifted and exposed above sea level.

Mid-oceanic ridge: a continuous, seismically active, median long mountain range on the ocean floor, extending through the North and South Atlantic Oceans, the Indian Ocean, and the South Pacific Ocean. It is a broad, fractured swell with a central rift valley, from which magma flows and forms new oceanic crust. As the magma cools and hardens it becomes part of the mountain range.

Hydrothermal fluid: a subsurface hot water / fluid capable of transporting metals in solution.

Black smoker: a submarine hot spring that occurs on the deep sea floor near spreading centers. It ejects hot water, hydrogen sulfide, and mineral particles under great pressure and provides nutrients for sulphur bacteria.

Open pit mine: is a surface mining technique of extracting rock or minerals from the earth by their removal from an open pit or borrow.

Dressing plant: a general term for the processes of milling and concentration of ores.

Bio-leaching: the use of organisms such as bacteria to facilitate the extraction of metals through the process of leaching from the ores.

Hydrometallurgy: a method of separation of a metal in aqueous solution from ore and its subsequent precipitation in metallic form.

Leaching: the process of extracting soluble metals or salts from a rock or ore by means of percolating water or a solution, either by natural action or industrial process.

Electrowinning: an electrochemical process in which a metal dissolved within an electrolyte is plated onto an electrode. This process is used to recover metals such as cobalt, copper, gold and nickel from solution in the leaching of ores, concentrates, etc.

Pyrometallurgy: the metallurgy involved in winning and refining metals in which heat is used, as in roasting and smelting. It is the most important and oldest class of the extractive industry.

Thermal conductivity: the property (ability) of a material to conduct heat.

Winning: the excavation, loading and removal of ore from the ground.

Kaolin

Gneiss: is a metamorphic rock form characterized by banding caused by segregation of different types of rock. It is mostly composed of quartz, feldspar and mica.

Granite: is a common type of intrusive igneous rock which is granular in texture. It is mostly composed of quartz, feldspar, mica and/or amhibole.

Arkose: is a detrital sedimentary rock. Its difference from normal sandstones is in an admixture of feldspars.

Mohs scale: of mineral hardness characterizes the scratch resistance of various minerals through the ability of a harder material to scratch a softer material. It was created in 1812 by the German geologist and mineralogist Friedrich Mohs.

Monoclinic: is a mineral that crystallizes in the monoclinic system (with only one plane of symmetry).

Triclinic: is a mineral that crystallizes in the triclinic system (no plane of symmetry).

Geomorphology: is the scientific study of landforms and the processes that shape them.

Outcrop: is a visible part of bedrock (consolidated rock) or ancient superficial deposits that appears above the surface of the Earth.

Carboniferous: the Carboniferous is a geologic period that extends from the end of the Devonian Period, about 358.9 million years ago, to the beginning of the Permian Period, about 298.9 ± 0.15 Ma.

Cretaceous: is a geologic period and system from circa 145 ± 4 to 66 million years (Ma) ago. In the geologic timescale. The Cretaceous follows the Jurassic.

Tertiary: is a geologic period from 65 million to 1.806 million years ago, a time span that lies between the superseded Secondary period and the Quaternary.

Coagulation agent: is formulated to assist in the solids/liquid separation of suspended particles in solution. It accelerates the sedimentation from a suspension.

Glossary

Filter press: is a separation process, specially employed by solid/liquid separation using the principle of pressure drive, provided by a slurry pump.

Heat exchanger: a piece of equipment built for efficient heat transfer from one medium to another, without any direct contact with the source of the heat.

Electromagnetic separator: a device in which a strong magnetic field is employed to remove magnetic materials from a sand or a concentrate, or to selectively remove or separate their constituent minerals.

Enamel: an opaque or semi-transparent glossy substance that is a type of glass, applied by vitrification to metallic or other hard surfaces for ornament or as a protective coating.

Refractory: a refractory material is one that retains its strength at high temperatures.

Mullite: a rare silicate mineral of post-clay genesis. In the refractory ceramic products, its origin is artificial (from kaolinite).

Glass fiber: a material consisting of numerous extremely fine fibers of glass.

Stoneware: a vitreous or semi-vitreous ceramic ware made primarily from non-refractory fireclay.

Fireclay: a term applied to a range of refractory clays used in the manufacture of ceramics.

Chamotte: a refractory ceramic product, mostly in the form of bricks.

Feldspar

Tectosilicate: framework silicates which have a three dimensional structure of silicate tetrahedra with SiO_2 or a 1:2 ratio. This is the largest mineral group comprising nearly 75% of the Earth's crust.

Orthoclase: member of the feldspar group, formula $KAlSi_3O_8$.

Albite Sodium plagioclase: formula $NaAlSi_3O_8$. (See plagioclase).

Anorthite Calcic plagioclase: formula $CaAl_2Si_2O_8$. (See plagioclase).

K-feldspar: potassium feldspar. (See microcline, orthoclase, sanidine).

Plagioclase: minerals with composition between $NaAlSi_3O_8$ (Albite=Ab) and $CaAl_2Si_2O_8$ (Anorthite=An); commonly the series is designated in terms of the mole fraction of the anorthite component (An) as follows: albite (An 0% to 10%), oligoclase (An 10% to 30%), andesine (An 30% to 50%), labradorite (An 50% to 70%), bytownite (An 70% to 90%), anorthite (An 90% to 100%). (See feldspar).

Microcline: a member of the feldspar group, formula $KAlSi_3O_8$. (See feldspar).

Sanidine: is a high temperature, potassium-rich alkali feldspar, formula $(K,Na)AlSi_3O_8$.

Bytownite: a mineral present in many basic igneous rocks, consisting of a calcic plagioclase feldspar.

Feldspar: group of minerals composed of aluminosilicates of potassium, sodium, calcium or barium, whose chemical composition results from miscibility of the following components: $KAlSi_3O_8$ (orthoclase, microcline), $NaAlSi_3O_8$ (albite), $CaAl_2Si_2O_8$ (anorthite) (See anorthite, microcline, orthoclase, sanidine, plagioclase).

Labradorite: a feldspar mineral, is an intermediate to calcic member of the plagioclase series.

Andesine: a silicate mineral, a member of the plagioclase feldspar solid solution series.

Oligoclase: is a rock-forming mineral belonging to the plagioclase feldspars. In chemical composition and in its crystallographic and physical characters it is intermediate between albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_2O_8$).

Polymorphism: property of crystallizing in two or more distinct forms with same chemical composition, e.g. andalusite-kyanite-sillimanite series.

Cleavage:

a) Tendency of a rock to split along closely spaced planar surfaces, originated by recrystallization and strain during metamorphism and tectonic deformation; the type of rock, strain intensity, and metamorphic grade, control the type of cleavage developed; (See slaty cleavage, crenulation cleavage, schistosity, and rough cleavage).

b) The splitting of a mineral along its crystallographic planes, thus reflecting crystal structure.

Extrusive rocks: refers to the mode of igneous volcanic rock formation in which hot magma from inside the Earth flows out (extrudes) onto the surface as lava or explodes violently into the atmosphere to fall back as pyroclastics or tuff.

Intrusive Rocks: refers to the Igneous rocks which form by the crystallization of magma at a depth within the Earth.

Pegmatite: rocks that form in the late stages of crystallisation of a granitic molten rock in a magma chamber, compounding large crystals of minerals like beryl and tourmaline.

Dyke: a tabular or nearly tabular body of igneous rock that cuts across the geological structure of a pre-existing rock body, filling cracks.

Vein: mineral body, thin in relation to its other dimensions, which cuts the older country rock.

Plutonic: igneous rock that has formed beneath the surface by consolidation from magma. Plutonic rocks are usually coarse grained, but not all coarse - grained rocks are plutonic.

Leucogranite: are light colored granitic rocks with almost no dark minerals.

Monzogranite: is biotite granite rocks that are considered to be the final fractionation product of magma.

Micaschist: is a medium-grade metamorphic rock[1] with medium to large grains of mica flakes in a preferred orientation (nearby mica flakes are roughly parallel). Schists rich in mica are called mica schists, and include biotite or muscovite.

Glossary

Phyllades: is a metamorphic rock of epizone. Near slate is characterized by a layered structure and can charge in sheets. His type of cleavage on the entire mass of the rock is called pervasive.

Granitoid: a term for any granitic rock.

Paragneiss: a gneiss derived from a sedimentary rock. (See gneiss).

Jaw crusher: a machine for crushing rock or ore between two heavy steel jaws.

Rod mill: a pulverizing machine that uses loose iron rods as the grinding media.

Hydrocyclones: is a device to classify, separate or sort particles in a liquid suspension based on the ratio of their centripetal force to fluid resistance. This ratio is high for dense (where separation by density is required) and coarse (where separation by size is required) particles, and low for light and fine particles. Hydrocyclones also find application in the separation of liquids of different densities.

Flotation process: is a method of separation widely used in the wastewater treatment and mineral processing industries.

Mica: a mineral group consisting of silicates characterized by very perfect basal cleavage, the general formula of the group is (K,Na,Ca) $(Mg,Fe,Li,Al)_2$-3$(Al,Si)4O_{10}(OH,F)_2$.

Garnet: a group of minerals of formula $x_3y_2(SiO_4)_3$ where x=Ca,Mg,Fe_2+,Mn_2+ and y=Al,Fe_3+,Mn_3+,V_3+,Cr.

Ilmenite: is a weakly magnetic titanium-iron oxide mineral which is iron-black or steel-gray. It is found all over the world.

Magnetic separation: is a process in which magnetically susceptible material is extracted from a mixture using a magnetic force. This separation technique can be useful in mining iron as it is attracted to a magnet.

Lined ball mill: a type of grinder, is a cylindrical device used in grinding (or mixing) materials like ores, chemicals, ceramic raw materials and paints.

Air classifier: is an industrial machine which sorts materials by a combination of size, shape and density.

Tailing: are the materials left over after the process of separating the valuable fraction from the uneconomic fraction (gangue) of an ore.

Soda ash: is a sodium salt of carbonic acid.

Flux: a ceramic flux functions by promoting glass formation in clay bodies and glazes. Fluxes are used in glazes to lower the high melting point of silica. The most commonly used fluxes in a ceramic glaze are lead, boric, soda, potassium, lithium, calcium, magnesium, barium, zinc and strontium. These are introduced to the raw glaze as compounds, for example lead as lead silicate.In clay bodies a flux creates a limited and controlled amount of glass, which works to cement crystalline components together. Fluxes play a key role in the vitrification of clay bodies by reducing the overall melting point, which allows for a more efficient kiln firing.

The most common fluxes used in clay bodies are feldspars. The two most common feldspars in the ceramic industry are potash feldspar (orthoclase) and soda feldspar (albite).

Glass batch: is used to determine the correct mix of raw materials (batch) for a glass melt.

Thermal shock: thermal shock occurs when a thermal gradient causes different parts of an object to expand by different amounts. Some glass-ceramic materials include a controlled proportion of material with a negative expansion coefficient, so that the overall coefficient can be reduced to almost exactly zero over a reasonably wide range of temperatures.

Viscosity: is a measure of the resistance of a fluid to gradual deformation by shear stress or tensile stress.

Devitrification: the process of nucleation and growth of crystals in glasses at subsolidus temperatures.

Glassy phase: is the reversible transition in amorphous materials (or in amorphous regions within semicrystalline materials) from a hard and relatively brittle state into a molten or rubber-like state. An amorphous solid that exhibits a glass transition is called a glass.

Glazes: a layer of compacted sintered oxide formed on some metals.

Batch: a mixture of weighed materials such as a batch of glaze or slip or a clay body.

Urethane: type of polymer used as binder in coatings. Characterized by a high flexibility and good chemical resistance.

Latex foam: in latex foam process fine ground feldspar is used as a filler because it seems to have no effect on the pH stability.

Casting powders: a powder applied to the inside of a mold before teeming to prevent the metal from sticking to the mold.

Filler: inclusion deliberately added to the clay by the potter.

Extender: a substance added to another substance to modify, dilute, or adulterate it.

Frit: is a ceramic composition that has been fused in a special fusing oven, quenched to form a glass, and granulated.

Tableware: dishes or dishware used for setting a table, serving food and for dining.

Chemical inertness: it means no or very less ability to react with other elements or compounds, it depends mainly on the valency of elements.

Refractive index: is a dimensionless number that describes how light, or any other radiation, propagates through that medium.

Nepheline syenite: plutonic rock, variety of feldspathoid syenite, in which nepheline is the most abundant feldspathoid.

Pyrophillite: is a phyllosilicate mineral composed of aluminium silicate hydroxide.

Spomudene: is a pyroxene mineral consisting of lithium aluminium inosilicate, $LiAl(SiO_3)_2$, and is a source of lithium.

Glossary

Sepiolite

Serpentinite: a metamorphic rock consisting almost wholly of serpentine and relics of primary minerals.

Fungicide agent: a chemical substance that destroys or inhibits the growth of fungi.

Catalyst carrier: a neutral material used to support a catalyst, such as activated carbon, diatomaceous earth, sepiolite or activated alumina.

Anticaking agent: an anticaking agent is an additive placed in powdered or granulated materials, such as table salt, to prevent the formation of lumps and for easing packaging, transport, and consumption.

Plastisols: a suspension of PVC particles in a liquid plasticizer; it flows as a liquid and can be poured into a heated mold. When heated to around 177 degrees Celsius, the plastic and plasticizer mutually dissolve each other. On cooling the mold below 60 degrees C, a flexible, permanently plasticized solid product results.

NCR paper (Non-carbon copy paper) or **carbonless copy paper** (CCP): a thin sheet of paper used as an alternative to carbon paper to make a copy of an original, handwritten (or mechanically typed) document without the use of any electronics. This type of copying paper is made of a sandwich of a series of very thin sheets of paper coated with micro-encapsulated dye or ink and/or a reactive clay. The back of the first sheet is coated with micro-encapsulated dye and the lowermost sheet is coated on the top surface with a clay that quickly reacts with the dye to form a permanent mark. Any intermediate sheets are coated with clay on top and dye on the bottom.

Bauxite

Boehmite: a grayish, brownish, or reddish orthorhombic mineral form of aluminium hydroxide (monohydrate), AlO(OH).

Diaspore: a white, gray, yellowish, or greenish orthorhombic mineral form of aluminium hydroxide (monohydrate), AlO(OH).

Gibbsite (or hydrargillite): a white or tinted monoclinic mineral form of aluminium hydroxide (trihydrate), $Al(OH)_3$.

Goethite: a yellowish, reddish, or brownish-black mineral form of iron hydroxide (monohydrate). It is the commonest constituent of many forms of natural rust or of limonite.

Limonite: a general field term for a group of brown, amorphous, naturally occurring hydrous iron oxides whose real identities are unknown but is now considered to have a variable composition (and variable chemical and physical properties) and to consist of any of several iron hydroxides (commonly goethite) or of a mixture of several minerals (such as hematite, goethite, and lepidocrocite) with or without presumably adsorbed additional water.

Karst: a term applied to the characteristic landscape and structures developed in limestone, dolomite, gypsum, and other soluble rocks by the effects of chemical weathering (solution). The karst scenery may include sinkholes, caves, doline, poljes, underground water flows, etc.

Laterite: a residual deposit formed in situ in hot and wet tropical areas by the chemical breakdown of silica-rich (igneous and siliciclastic) rocks.

Alumina: aluminum oxide (Al_2O_3) produced from bauxite by the Bayer process.

Bayer process: the principal industrial means of refining bauxite to produce alumina.

H-H process: a process extracting pure aluminium from alumina. It was developed independently by two scientists from both sides of the Atlantic - Paul Héroult and Charless Hall - and correspondingly named Hall-Héroult (H-H) method.

Propping agent: sand, gravel, or particles of other material (such as sintered bauxite or ceramic beads) suspended in drilling fluid during formation fracturing to keep (prop) open cracks in the rock when the fluid is withdrawn. Also known as proppant.

Alumina cement: usually known as High Alumina Cement (HAC), it differs from common Portland cement being composed of calcium aluminates rather than calcium silicates.

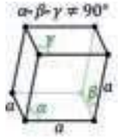
Petroleum catalysts: fluid catalytic cracking (FCC) is one of the most important conversion processes used in petroleum refineries. It is widely used to convert the high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils to more valuable gasoline, olefinic gases, and other products.

Vitriol: historical name of Sulphuric acid, a highly corrosive strong mineral acid.

Alum: both a specific chemical compound and a class of chemical compounds. The specific compound is the hydrated potassium aluminium sulfate (potassium alum).

Dolomite

Rhombohedral: a rhombohedron is a three-dimensional figure like a cube, except that its faces are not squares but rhombi (each rhombus has a losange shape). It is a special case of a parallelepiped where all edges are the same length andused to define the rhombohedral lattice system.



Cleavage:

a) Tendency of a rock to split along closely spaced planar surfaces, originated by recrystallization and strain during metamorphism and tectonic deformation; the type of rock, strain intensity, and metamorphic grade, control the type of cleavage developed; (See slaty cleavage, crenulation cleavage, schistosity, and rough cleavage).

b) The splitting of a mineral along its crystallographic planes, thus reflecting crystal structure.

Ankerite: mineral of dolomite group with calcium, and iron, magnesium and manganese.

Dolomitic marble: a marble containing more than 90 vol% dolomite. Metamorphic rock composed mainly of dolomite crystals. The crystalline texture is the result of metamorphosis of limestone/dolostone by heat and pressure.

Glossary

Talc schist: soapstone is a talc-schist, which is a type of metamorphic rock. It is largely composed of the mineral talc and is thus rich in magnesium. It is a metamorphic rock dominated by the mineral talc. Some talc schists formed by hydrothermal metamorphism of dolomitic marbles and are thus rich in magnesium. Samples have a mottled creamy white color and a slick and soapy feel (also known as steatite or soaprock).

Carbonatites: are intrusive or extrusive igneous rocks defined by mineralogic composition consisting of greater than 50 percent carbonate minerals.

Dolomitic lime: carbonate rock with 10% to 50 vol% of the mineral dolomite.

Lime: lime is calcium oxide (CaO), commonly known as quicklime or burnt lime. Lime is produced by dissociating the chemical constituents of limestone, which is composed of the mineral calcite ($CaCO_3$), by heating it to temperatures up to 1300° C. This heating process, called calcination, results in the production of lime and carbon dioxide (CO_2).

Lightweight aggregate: a type of coarse aggregate that is used in the production of lightweight concrete products such as concrete block, structural concrete, and pavement.

Tungsten

Earth crust: the crust of the Earth is composed of a great variety of igneous, metamorphic, and sedimentary rocks. The crust is underlain by the mantle.

Scheelite: is a calcium tungstate mineral with the chemical formula $CaWO_4$.

Wolframite: is an iron manganese tungstate mineral with the chemical formula (Fe, Mn) WO_4.

Habit: the characteristic crystal form or combination of forms of a mineral. including characteristic irregularities when idiomorphic.

Fluorescence: is the emission of light by a substance that has absorbed light or other electromagnetic radiation. Many minerals have a distinctive fluorescence under ultraviolet light.

Ferberite: is the iron endmember of the manganese - iron wolframite solid solution series.

Hübnerite: is the mangan endmember of the manganese - iron wolframite solid solution series.

Stockwork: is a complex system of structurally controlled or randomly oriented veins. Stockworks are common in many ore deposit types and in greisens.

Greisens: a highly altered granitic rock or pegmatite, formed by hydrothermal wall-rock alteration autogenic alteration of a of a granite and is a class of endoskarn.

Skarn deposits: are most often formed at the contact zone between granitic intrusions and sedimentary carbonate rocks such as limestone or dolomites.

Felsic intrusion: is the intrusion of magma with a specific chemical composition (SiO_2 65-75%, low content of Fe, Mg, Ca, high content of K, Na).

Orogenic belt: the process of mountain formation, especially by a folding and faulting of the earth's crust.

Gangue: is the commercially worthless material associated with ore minerals in an ore deposit that surrounds, or is closely mixed with, a wanted mineral in an ore deposit.

Gypsum

Selenite: gypsum crystals exceeding 2 mm in size; prismatic, acicular or lenticular shape, often twinned.

Anhydrite: calcium sufate.

Gypsum: dihydrate calcium sulfate.

Gypsum: most common sulphate mineral found on Earth surface, whereas in the subsoil is anhydrite is more commonly found. Its main variety are: selenitic (big transparent prismatic, acicular or lenticular, often twinned crystals); alabastrine or saccharoidal (white microcrystalline crystals); sericolitic (satin spar fibrous crystals).

Saccharoid Granular or micro-crystalline fabric resembling that of loaf sugar cubes.

Alabastrine: a microcrystalline variety of gypsum, often white and translucent, used for ornamental objects or work, such as lamp bases, figurines, etc.

Sericolite: fibrous gyspsum, often found as veins and fractures infill.

Sabkhas: supratidal depositional environments forming along arid coastlines and are characterized by evaporite-carbonate deposits with some siliciclastics.

Fumaroles: is an opening in a planet's crust, often in the neighborhood of volcanoes, which emits steam and gases such as carbon dioxide, sulphur dioxide, hydrogen chloride, and hydrogen sulfide.

Lithium

Molten salt electrolysis: is a method of using a direct electric current (DC) to drive an otherwise non-spontaneous chemical reaction. Electrolysis is commercially highly important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell.

Froth flotation: is a process for selectively separating hydrophobic materials from hydrophilic materials.

Acid roasting: is a metallurgical process involving gas-solid reactions at elevated temperatures with the goal of purifying the metal component(s). Often before roasting, the ore has already been partially purified, e.g. by froth floatation.

Carbonation: is the process of dissolving carbon dioxide in a liquid. The process usually involves carbon dioxide under high pressure.

Spodumene: is a pyroxene mineral consisting of lithium aluminium inosilicate, $LiAl(SiO_3)_2$.

Amblygonite: is a fluorophosphate mineral, $(Li,Na)AlPO_4(F,OH)$, composed of lithium, sodium, aluminium, phosphate, fluoride and hydroxide.

Glossary

Lepidolite: is a lilac-grey or rose-colored member of the mica group with the formula $K(Li,Al,Rb)_3(Al,Si)_4O_{10}(F,OH)_2$. It is a secondary source of lithium.

Petalite: is a lithium aluminium phyllosilicate mineral $LiAlSi_4O_{10}$, crystallizing in the monoclinic system. Petalite is a member of the feldspathoid group. It occurs as colourless, grey, yellow, yellow grey, to white tabular crystals and columnar masses.

Triphylite: is a scarce phosphate mineral. It forms a solid solution series with the often associated mineral lithiophilite.

Lithiophillite: is a mineral containing the element lithium with the formula $LiMnPO_4$. It occurs in pegmatites often associated with triphylite.

Platinum

Sperrylite: is a platinum arsenide with formula: $PtAs_2$ and is an opaque metallic white mineral which crystallizes in the cubic system. It was discovered by the American chemist Francis Louis Sperry, in 1889 at Sudbury, Canada.

Braggite: is a platinum and /or palladium sulfide with formula: (Pt,Pd)S which might contain some nickel. It is a dense (specific gravity of 10), steel grey, opaque mineral. It was first described in 1932 in the Bushveld Igneous Complex, South Africa. William Henry Bragg analyzed the crystal structure of this mineral using X rays for the first time.

Cooperite: is a grey platinum sulfide, PtS, generally in combinations with sulfides of other elements such as palladium and nickel. In 1928 it was first characterized by the South African metallurgist Richard A. Cooper in the Bushveld Igneous Complex.

Isoferroplatinum: is an alloy of platinum and iron with formula: Pt_3Fe. It is a cubic bright white mineral and is found for example as heavy mineral in fluviatile placers.

Moncheite: is a steel-grey hexagonal platinum telluride with formula: $PtTe_2$ which might contain palladium and bismuth. It name comes from the Monche Tundra, Russia.

"Critical" minerals or **"strategic" minerals** cannot be substituted by other materials. Their risk for supply shortage and their economical impacts in case of shortage is higher compared to other raw materials.

Gold

Alloy: A homogeneous mixture of two or more metals.

Nugget: a piece of naturally occurring metallic gold.

Conglomerate: coarse grained sedimentary rock composed of rounded to subangular fragments (pebbles, cobbles, boulders), set in a fine grained matrix of cemented sand or clay.

Andesite, basalt: volcanic rocks.

Panning: gold separation from fine-grained sediments, using a vessel of pan shape and water.

Sluicing: method of gold separation from fine-grained sediments, which uses the water flowing through man-made channels.

Blanket table: a table covered with a blanket, over which water with gold-bearing sands flow, leaving the gold grains on the blanket.

Cyanide: any chemical compound that contains monovalent combining group CN. This group, known as the cyano group, consists of a carbon atom triple-bonded to a nitrogen atom.

Ammonia: is a compound of nitrogen and hydrogen. It is a colourless gas with a characteristic strong smell.

Thiosulfate: is a chemical compound that contain sulphur, oxygen and hydrogen.

Thiourea: is an organosulphur compound (i.e., organic compounds that contain sulphur).

Smelting: is a form of extractive metallurgy based on the melting of the ore.

Malleability: is a physical property of metals that defines the ability to be hammered, pressed or rolled into thin sheets without breaking.

Catalytic converter: is a chemical filter designed to reduce the polluting emissions of a car.

Potash

Sylvinite: is a mixture of sylvite (potassium chloride) and halite (salt). Kainite: is a mineral salt that consists of potassium chloride and magnesium sulphate and is used as a fertiliser.

Palaeozoic: a geological era spanning from 541 to 252 million years ago.

Fertiliser: is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more nutrients essential to plant growth.

Animal feed: is food given to domestic animals.

Quartz sand

Piezoelectric: is the electric charge that accumulates in certain solid materials in response to applied mechanical stress.

Chemical weathering: is caused by rain water reacting with the mineral grains in rocks to form new minerals (clays) and soluble salts. These reactions occur particularly when the water is slightly acidic.

Mechanical weathering: takes place when rocks are broken down without any change in the chemical nature of the rocks.

Hydraulic fracturing: is the fracturing of rock by a pressurized liquid.

Quicksand: is a colloid hydrogel consisting of fine granular material (such as sand or silt), clay, and water.

Colloid hydrogel: a hydrocolloid is defined as a colloid system wherein the colloid particles are hydrophilic polymers dispersed in water.

Glossary

Calcium carbonate

Aragonite: mineral, polymorphous with calcite, formula $CaCO_3$.

Orthorhombic: in crystallography, the orthorhombic crystal system is one of the seven different mineral lattice symmetry groups.

Chalk: soft fine grained limestone, usually white consisting mostly of calcitic remains from microorganisms, and minor silt and clay.

Dolomitization: the partial of complete calcification of dolomite.

Dolomite: the mineral $CaMg(CO_3)_2$.

Hyperphosphatemia: often, calcium levels are lowered (hypocalcemia) due to precipitation of phosphate with the calcium in tissues.

Firming agents: are food additives added in order to precipitate residual pectin, thus strengthening the structure of the food and preventing its collapse during processing.

Talc

Hydrophobic: is the physical property of a molecule (known as a hydrophobe) that is repelled from a mass of water.

Regional metamorphism: a type of metamorphism in which the mineralogy and texture of rocks are changed over a wide area by deep burial and heating associated with the large-scale forces of plate tectonics.

Contact metamorphism: is the name given to the changes that take place when magma is injected into the surrounding solid rock.

Cordierite ceramics: is a type of magnesium aluminum silicate with particularly good thermal shock properties.

Soapstone:

a) Scientifically: metamorphic rocks composed 30-70% talc. Carbonate content, if present, up to 70%. Any other single mineral species (chlorite, serpentine, olivine, amphibole, pyroxene etc.) less than 50%.

b) Commercially: rocks consisting 30-70% talc, carbonate, chlorite and serpentine. They have a soapy feel and are soft enough to be carved with a knife.

Baltic amber

Fossils: remains or traces of prehistoric plants animals preserved in rocks.

Succinite acid: a crystalline organic acid which occurs in living tissue as an intermediate in glucose metabolism. Molecular formula $C_4H_6O_4$.

Secondary deposit: a mineral deposit formed when a primary mineral deposit is subjected to chemical and/or mechanical alteration. Secondary deposits are divided into three groups: sedimentary rocks, secondarily enriched ore deposits, and residual or detrital ore deposits.

Eocene: is a geologic epoch of the Paleogene Period, land extends from 55.8 to 33.9 million years before the present.

Oligocene: is the last geologic epoch of the Paleogene Period and extends from about 33.9 million to 23 million years before the present.

Miocene: is the first geological epoch of the Neogene Period and extends from about 23 to 5.3 million years before the present.

Brown coal: is a combustible brown or brownish-black sedimentary rock that was formed by alteration of dead plant material.

Pleistocene: is a geological epoch referred to as the Ice Age which lasted from about 1.8 million years to 11,700 years before the present.

Holocene: is the most recent geological era and which includes the present time. It began 11,700 years ago.

Overburden: is the material (sterile rocks) that lies above mineral deposits.

Walking excavators: excavator able to wheel or 'walk' on steep terrain without winching, perfect for removing sediment from difficult sites.

Hydro-monitors: is a method used in the strip mining that uses high-pressure jets of water to dislodge rock material or move sediment.

Strip mine: a mine in which the valuable material is exposed at the surface by removing a strip of overburden.

Dragline: an excavating tool used in many strip mine in which the dredge is attached only by cables and is drawn towards the machine during the filling operation.

Clay minerals

Illite: clay mineral of the phyllosilicate group. It is common in soils and sediments and argillaceous sedimentary rocks and in some low grade metamorphic rocks as well.

Kaolinite: a common clay mineral formed by the weathering or hydrothermal alteration of feldspars and other aluminous silicate minerals, with general formula $Al_2(Si_2O_5)(OH)_4$.

Montmorillonite: is a very soft phyllosilicate group of minerals that typically form in microscopic crystals, forming a clay.

Vermiculite: is a hydrous, silicate mineral that is classified as a phyllosilicate and that expands greatly when heated.

SEM: a scanning electron microscope (SEM) produces useful images mainly of a (mineral) sample surface by using focused beam of electrons. SEM can have resolution better than 1 nm (10 angstroms).

TEM: transmission electron microscopy (TEM) uses a beam of electrons is transmitted through an ultra-thin specimen and interacting with the sample as it passes through. This technique is especially good for researching of the microstructure of minerals.

Tuff: lithified pyroclastic deposit made of ash grains (<2 mm diameter) exceeding 75%.

Muscovite: a member of the mica group, usually white, general formula $KAl_2(AlSi_3)O_{10}(OH,F)_2$.

Glossary

Hematite: a major ore mineral of iron, also found as an accessory mineral in many rocks, with formula Fe_2O_3.

Iron

Magnetite: a magnetic mineral, formula Fe_3O_4. An important ore mineral of iron.

Pellets: iron ore particles rolled into small balls and compacted by heating. Typically around 10 - 15 mm in diameter.

Lump: iron ore product typically 6 to 40 mm in granular size.

Fines: fine-grained iron ore product, typically less than 6 mm in granular size.

Coke: is a fuel with few impurities and high carbon content, usually made from coal.

Pig iron: also called hot metal or crude iron. This intermediate product is a result of smelting iron ore with a high-carbon fuel such as coke, in a blast furnace usually with limestone as a flux.

Basic oxygene furnace: is a method of primary steelmaking in which carbon-rich molten pig iron is made into (crude) steel.

Steel: is an alloy of iron, carbon and other elements with carbon content below 1.7 percent.

Nickel

Laterite: are soil types rich in iron and aluminium, formed in hot and wet tropical areas.

Garnierite: is a general name for a green nickel ore which is found in pockets and veins within weathered ultramafic (rich in Mg and Fe) rocks.

Pentlandite: is an iron-nickel sulfide mineral $(Fe,Ni)_9S_8$.

Millerite: is a nickel sulfide mineral NiS.

Recycled aggregates

Demolition waste: is debris from deconstruction of buildings, roads or bridges.

Sources

Copper (page 30)

- http://geology.com/usgs/uses-of-copper
- www.eurocopper.org/copper/copper-education.html
- www.copper.org/resources/properties
- www.copper.org/resources/market_data/pdfs/annual_data.pdf
- www.australianminesatlas.gov.au/education/fact_sheets/copper.html
- www.princeton.edu/~ota/disk2/1988/8808/880807.PDF
- http://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2012-coppe.pdf
- http://en.wikipedia.org/wiki/Copper
- http://resources.schoolscience.co.uk/CDA/14-16/chemistry/copch0pg5.html
- Cyprus, copper and the Sea, Nicosia 1992, The Government of Cyprus. ISBN:9963-37-000-4

Feldspar (page 42)

- http://minerals.usgs.gov/minerals/pubs/commodity/myb/
- www.mineraliindustriali.it
- www.tschirnhaus-gesellschaft.de/e_index.html
- Asselborn E., Chiappero P.-J., Galvier J. (2005) - Minerali. Collana: Le piccole guide enciclopediche. Gribaudo/Konemann Ed.
- British Geological Survey. 2013. European mineral statistics 2007-2011. (Keyworth, Nottingham: British Geological Survey).
- Cushion J., Haslam M. (1973) - Quattro secoli di Porcellana. De Agostini Ed., Novara.
- Deer, W., Howie, R., & Zussman, J. (2001). Framework silicates: feldspars. Rock forming minerals;4A. London: Geological Society of London, second edition.
- Elzea Kogel J., Trivedi N. C., Barker J. M., Krukowski S. T. (2006) - Industrial Minerals & Rocks: Commodities, Markets, and Uses. 7th Edition, SME, Inc.
- Kauffman, R.A. and Van Dyk, D., 1994, Feldspars: in Carr, D.D. and others, eds., Industrial minerals and rocks (6th edition): Littleton, CO., Soc. for Mining, Metallurgy, and Exploration, Inc.
- Mottana A., Crespi, R. Liborio G.. (1995) - Minerali e rocce, Mondadori Ed.

Potash (page 102)

- Brown TJ, Shaw RA, Bide T, Petavratzi E, Raycraft ER, Walters AS. 2012a. World Mineral Production 2007-11. British Geological Survey.
- Brown TJ, Hobbs SF, Mills AJ, Petavratzi E, Raycraft ER, Shaw RA, Bide T. 2012b. European Minerals Statistics 2007-11. British Geological Survey.
- International Potash Institute (IPI). 2012. Potassium a Nutrient Essential for Life.
- USGS. 2012. Mineral Commodity Summaries 2012: Potash.

Quartz sand (page 106)

- http://geomaps.wr.usgs.gov/parks/coast/sand/sand.html
- https://en.wikipedia.org/wiki/Sand (Silica sand MSDS. Simplot (2011-03-13). Retrieved on 2011-11-24.)
- www.economist.com/node/14588255
- http://en.wikipedia.org/wiki/Sand_mining
- www.unisbm.com/solution/sand/silica-sandmakingmachine-37.html
- www.toerismelommel.be/fb111vkwe875uogc1rlgc27.aspx?eyeIng=3
- www.geocaching.com/geocache/GC1WRKJ_singing-sands-cache?guid=ff383d01-311d-4d71-b613-39ac66b3bc9d
- http://search.gmdu.net/hohohoi/Glass%20Concrete.html
- www.bizeljsko.si/zanimivosti/repnice.html
- Ministry for Infrastructure and Spatial Planning, 2013: Mineral resources in 2012. Geological Survey of Slovenia, Ljubljana, 2013

All figures are made by S. Mozetic, 2013, GeoZS

Calcium carbonate (page 122)

- www.calcium-carbonate.org.uk/calcium-carbonate.asp
- www.wisegeek.org/what-is-calcium-carbonate.htm
- www.omya.com/C125728900639D06/direct/calciumcarbonate-dolomite
- www.reade.com/Products/Minerals_and_Ores/calcium_carbonate.html
- www.imerys-perfmins.com/pdf/Carbonate_Brochure_A4_Oct2012.pdf
- www.ima-europe.eu/about-industrial-minerals/industrial-minerals-ima-europe/calcium-carbonate
- http://australianmuseum.net.au/Geological-ore-deposits/
- Results of the research accomplished within the CSF III 2003-2008 project of the I.G.M.E. "Greek Ornamental Stones' by-Products and Wastes' Management and Utilization Study - Contribution in the Sector's Viable Growth".
- Roskill, 2005. "The Economics of Ground Calcium Carbonate", 2nd Edition, Roskill Information Services Ltd, ISBN 0 86214 502 3, pp. 7, 44.
- www.ihs.com/products/chemical/planning/ceh/fine-ground-and-precipitated.aspx
- www.roskill.com/reports/industrial-minerals/ground-and-precipitated-calcium-carbonate-1/leaflet
- www.fiercedrugdelivery.com/story/calcium-carbonate-templates-make-cancer-drug-delivery-vehicles/2013-07-09
- http://minerals.usgs.gov/minerals/pubs/country/europe.html

Talc (page 126)

- European Mineral Statistics 2007-11 (BGS)
- World Mineral Production 2007-11 (BGS)
- http://geology.com
- www.mondominerals.com
- http://minerals.usgs.gov
- www.imerystalc.com
- www.americantalc.com

Baltic amber (page 130)

- Kosmowska-Ceranowicz B, 2012: Amber in Poland and in the World. Warsaw University Press. Warszawa.
- Kasiński J., Kramarska R., 2008: Sedimentary environment of amber-bearing association along the Polish-Russian Baltic coastline. EDGG, Heft 236 - II. Bitterfelder Bernsteinkolloquium: 46-57.
- Kostyashova Z. V., 2007: The history of the Kaliningrad Amber Factory 1947 - 2007. Kaliningrad Amber Museum. Kaliningrad.
- www.rg.ru/2012/09/08/yantar-anons.html
- www.amber.com.pl
- www.amber.org.pl/english/bursztynisko-bulletin

Sources

- http://amberif.amberexpo.pl/mtgsa2010/library/File/AMBERIF/SYMPOZJUM/Amberif_2013_symposium.pdf
- www.pgi.gov.pl/images/stories/przeglad/pg_2008_08_01_09.pdf
- http://en.wikipedia.org/wiki/Pha%C3%ABton

Iron (page 138)

- Raw Materials Data, IntierraRMG, Stockholm
- World Health Organization - Iron deficiency anaemia: www.who.int/nutrition/topics/ida/en/index.html
- World Steel Association - Raw Materials Fact Sheet: www.worldsteel.org/publications/fact-sheets.html

Nickel (page 142)

- Nickel institute: Nickel in Society -report: www.nickelinstitute.org/~/media/Files/MediaCentrePublications/NiInSociety/NiInSoc-EN.ashx#Page=1

Recycled Aggregates (page 146)

- The Cement Sustainability Initiative (CSI) (2009). Recycling Concrete. 40 pp. Available online at: www.wbcsdcement.org/pdf/CSI-RecyclingConcrete-FullReport.pdf. Accessed 05.08.2013.
- UEPG (2012). Annual Review 2011-2012. A sustainable Aggregates Industry for a sustainable Europe, European Aggregates Association UEPG. 38 pp. Available online at: www.uepg.eu/uploads/Modules/Publications/uepg---ar2012---en_v1.pdf. Accessed 05.08.2013.
- Federal Office for Spatial Development ARE (2012). Evaluation of potential areas for hard rock quarries in landscapes of national relevance (in German language). Bern, Federal Office for Spatial Development ARE, Switzerland. 18 pp. Available online at: www.are.admin.ch/dokumentation/publikationen/00022/00391/?lang=de. Accessed 05.08.2013.
- Bärtschi, C.J. (2012). Kieselkalke der Schweiz: Charakterisierung eines Rohstoffs aus geologischer, petrographischer, wirtschaftlicher und umweltrelevanter Sicht. Contributions to the Geology of Switzerland, geotechnical serie, No 97, Swiss Geological Survey Swisstopo; Swiss Geotechnical Commission SGTK; ETH Zurich. 160 pp. Available online at: http://e-collection.ethbib.ethz.ch/show?type=diss&nr=19451.

Overview of recently finished, on-going and recently EU granted projects of direct relevance to mineral raw materials

Short name	Full title	Website
ProMine	Nano-particle products from new mineral resources in Europe	http://promine.gtk.fi
EuroGeoSource	Sharing data and services on energy and mineral resources in Europe	www.eurogeosource.eu
EURARE	Development of a sustainable exploitation scheme for Europe's Rare Earth ore deposits	www.eurare.eu
EO-MINERS	Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation	www.eo-miners.eu
SARMa	Sustainable Aggregates Resource Management	www.sarmaproject.eu
SNAP-SEE	Sustainable Aggregates Planning in South East Europe	http://snapsee.eu
ERA-MIN	Network on the Industrial Handling of Raw Materials for European Industries	www.era-min-eu.org
Minerals4EU	Minerals Intelligence network for Europe	www.eurogeosurveys.org/minerals4eu

MEMBERS

GBA

GSB

HGI-CGS

GSD

CGS

GEUS

GTK

BRGM

BGR

NCSD

IGME

MFGI

GSI

ISPRA

SGSS

TNO

NGU

PGI

LNEG

GIR

VSEGEI

SGUDS

GeoZS

SGU

IGME

swisstopo

SGSSU

BGS

MRA