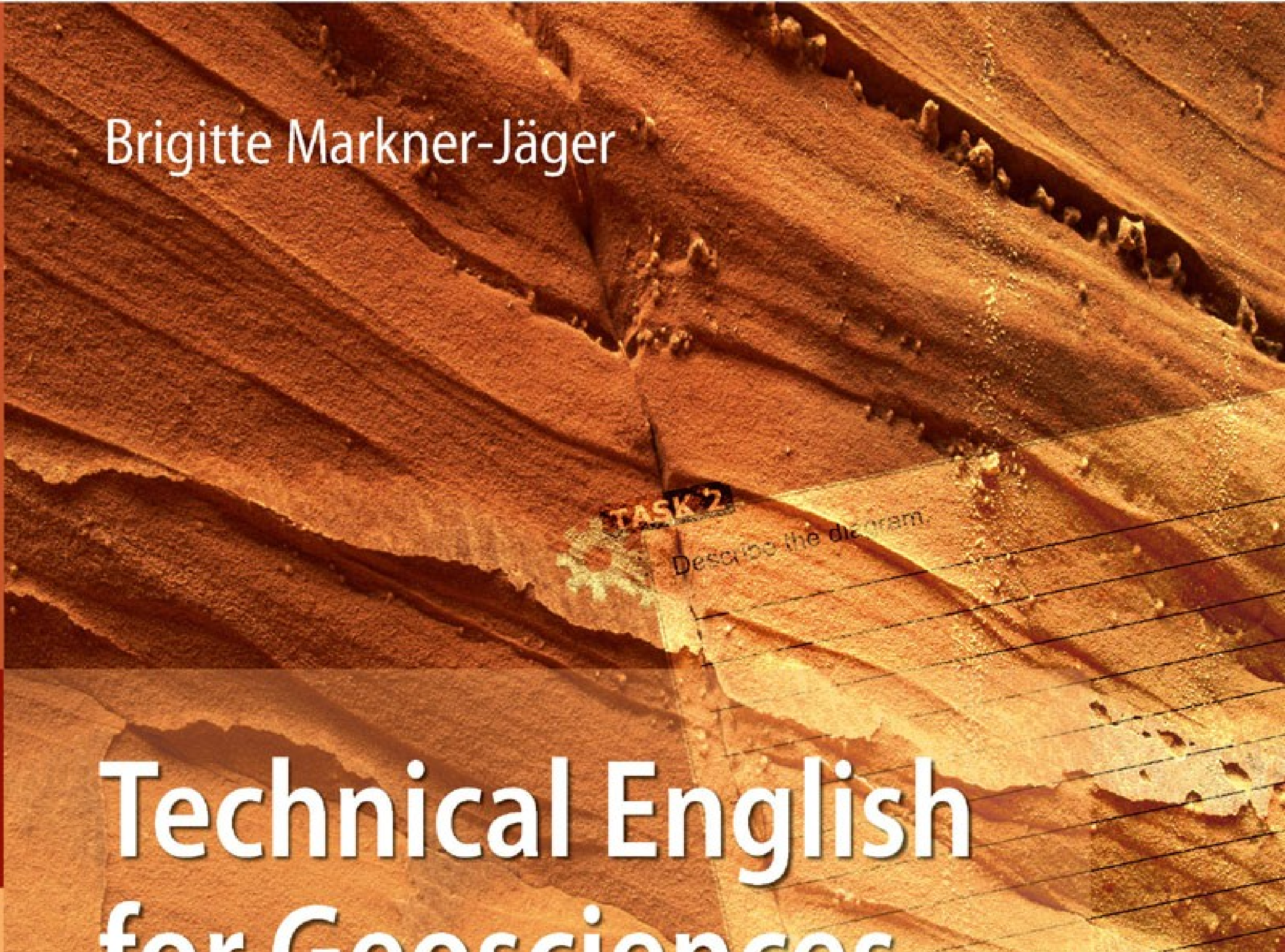
Brigitte Markner-Jäger



Technical English for Geosciences

A Text/Work Book

Springer

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Preface

English has become the "lingua franca" in our globalized scientific and economic world. Recognized scientific literature is mostly written in English; for understanding and writing science books or research articles a solid command of the English language is obligatory if a scientist wants to be taken seriously and discussed worldwide.
However, not only scientists need to be sufficient in English language knowledge, but also professionals working on international projects or working abroad, salespeople selling and buying on globalized markets, etc.

"Technical English for Geosciences" is intended to contribute to the acquisition or improvement of the English language as a language for specific purposes, in this case for the vast area of the Geosciences.

The book **"Technical English for Geosciences"** is primarily meant for students of applied geology and geoengineering, who study at universities and other related colleges or institutes to graduate with a diploma, bachelor's or master's degree.

However, for professionals working as geologists in different areas this book is a true treasure chest, too, if they want to broaden and improve their specific vocabulary.

"Technical English for Geosciences" is a language learning tool for English for specific purposes. A basic knowledge of the English language, especially receptive and productive skills as well as grammar fundamentals, are prerequisites.

Texts are taken from various literature sources to enable to deal with "real" texts from the "real" scientific world (from books, magazines, brochures, catalogues, websites, etc.). Topics are chosen from the vast field of geosciences.

In addition to geoscientific theories or models (such as plate tectonics, rock and water cycle, soil sciences, hydrogeology, mineralogy, climatology, meteorology, etc.) the role of geologists in mitigating geohazards or solving geotechnical problems is discussed.
Present and future professional opportunities are taken into account as well.
Therefore "mining", "construction" and "management of landfills and waste" are dealt with – to name but a few.
British or American English are mixed depending on the source of the text. The author of the book cannot vouch the accuracy of the content of the texts in each single case, but every effort has been done to avoid false facts. If we have overlooked mistakes of any kind, we kindly apologize for these.

The book is designed as a text and workbook. In addition to texts, tables, graphs,

etc. students will find various exercises in 38 units. Units can be studied separately according to students' special interests. They are sorted by content, not language difficulty.
Unfortunately only a small number of the available sources could be selected as topics, but most topics will be found in the module description of study courses.

The author welcomes both praise and constructive criticism.

Bochum 2008

Acknowledgements

While working on this book various people helped with advice. I am very indebted to all of them.

However, my special thanks go to Jonas Thiel who created the layout and the drawings. He never lost his patience with me – even when I restructured the work again and again. For me he is real design talent.

This book is partly the outcome of many lessons at the TFH Georg Agricola – University of Applied Sciences; hence my thanks are to the students of applied geology and geoengineering who supported me in our joint work with their critical comments towards texts and exercises.

In particular I would like to thank the Springer-Verlag for publishing my book and especially Dr. Christian Witschel who offered suggestions with the manuscript and gave practical advice.

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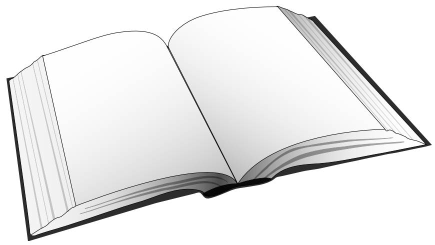
Unit 1 Applied Geology

What a study course in the UK looks like



University of Plymouth

Faculty of Science

An obvious choice if you have a clear view towards industry. You will acquire the skills necessary to locate and extract economically valuable resources, such as oil and metallic minerals, in a cost-effective and environmentally sensitive way. You will also be trained in geological techniques employed on major engineering projects and other vocational skills.

Stage 1

The first stage is taught jointly with the other geology degree courses and provides you with a broad foundation in geology. A combination of core and optional geological and non-geological modules allows you a flexible choice of study. Lecture and practical modules include Earth history; palaeontology; mineralogy; and sedimentology. Key skills such as effective study techniques and the application of IT are developed through tutorial-based modules. Training in geological fieldwork is undertaken in south west England and south Wales, including residential classes.

Stage 2

Stage two modules extend your core geology knowledge and skills and start focusing on topics related to your specialist pathway. Your studies will include geophysics; sedimentology; palaeontology; stratigraphy; petrology; structural geology; and tectonics. There is a strong emphasis on the practical side of geology, including observational and interpretative skills and how these are applied to solve problems relevant to the geological professions. Local and residential field classes provide ‚hands-on‘ experience in exploring the nature and distribution of geological resources and geohazards.

Stage 3

This part of the course allows you to select from an exceptionally broad range of specialist modules. Core or recommended modules include terrain evaluation; engineering geology; hydrogeology;
petroleum geology; hydrocarbon exploration; and the tectonic setting of mineral deposits. A wide range of option modules is available including geohazards and georesources and other modules from related geology degree courses. You will undertake an independent research project and fieldwork on relevant aspects of applied geology, as well as completing a module in personal development and professional skills.

Career opportunities

Our applied geology degrees provide not only a strong foundation for a career in geology, but also a science education relevant to a broad range of professional opportunities. The staff at Plymouth have wide experience in professional geology, so these courses have a natural bias towards a ‚hands-on' applied approach. Our graduates have been successful in a range of careers, including positions with geotechnical companies, the oil industry, in the provision of water supplies in the developing world and even exploring Antarctica. The skills taught are directly transferable to other careers including management, administration, information technology, teaching and research.

Adapted from: Applied Geology; University of Plymouth, Prospectus 2003; http://www.plymouth.ac.uk

TASK 1

Read the text and underline the technical terms for geology.
Provide a word list and give a translation if it seems necessary.

Technical terms	Translation
palaeontology	
mineralogy	
sedimentology	

TASK 2

Text work. Questions, remarks and examples.

1. What study fields of geology are explicitly mentioned in the description of the study course?

2. Hands-on experience and fieldwork are named as relevant aspects of applied geology. Give some examples for respective projects.

3. The range of career opportunities for graduated geologists are various. Quote them from the text and complete with your knowledge about professions for geologists.

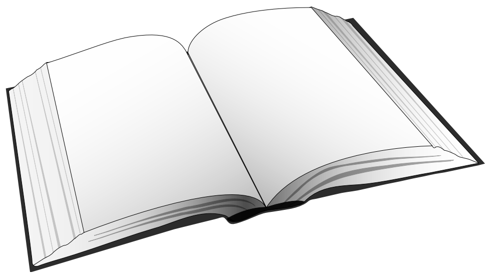
4. What kind of profession in “applied geology” would you like to obtain after graduation?

TASK 3

Compare the study structure and modules to the study courses at your university. Describe.

Unit 2 Geotechnology

What is Geotechnology?



The text provides the following answers to the question.

Geotechnology is the science and engineering of soil, rock, and the fluids they contain.

When you stop to think about it, almost everything humans build – except for space stations, of course; is constructed in or on the ground. Everything that‘s built needs a foundation of some kind. And each foundation depends on the condition of the earth on which it sits.

That‘s what geotechnology is all about: the nature of the earth itself and how it affects the things we build.

Many of our most pressing national issues relate in some way to geotechnologies. Earth sciences and engineering are more than just an esoteric field of study... they are of enormous importance in our daily lives and to our future.

Adapted from: http://www.geocouncil.org/whatis-geo2.html

TASK 1

The text concludes that almost everything in the man-built environment has to do with geotechnology. Explain why geotechnology is such a vast field of science.

____

____

____

____

____

Geotechnology helps us with problems of our daily life.

TASK 2

Match the sentence parts.
Geotechnology helps us to...

1 Help us analyse the foundations upon which all buildings and bridges sit, the tunnels our subways run through, the sewers and water systems that run underground,

2 Help us find ways to manage hazardous and radioactive waste,

3 Help us gain energy independence by increasing our understanding of how and where the earth produces gas, oil, minerals, geothermal energy, hydropower, nuclear materials, and compressed air,

4 Help us explore our remaining frontiers on earth,

5 Help us predict and mitigate natural disasters like

A earthquakes, volcanoes, landslides, floods, and slope failures.

B such as the polar regions and the ocean floor, and they will certainly be a part of our exploration of the universe beyond Earth itself.

C which are often stored in the ground.

D all of which help power our modern civilization.

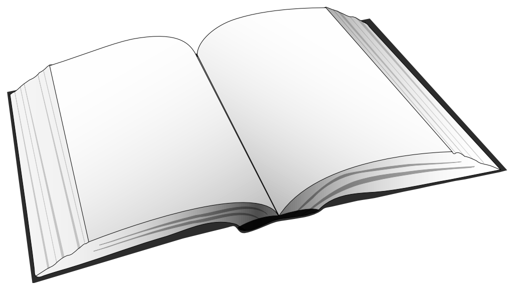
E almost everything that comprises our national infrastructure.

after: see source from text above

1__ 2__ 3__ 4__ 5__

Unit 3 Geotechnical Engineering

Another engineering course



Geotechnical Engineering Research Centre

The Centre has excellent laboratory facilities for soil testing and for construction and testing of models. The soil mechanics laboratory has triaxial and stress path apparatus, some with the capability of testing soft rocks at elevated stresses up to 70 MPa. The Centre also has cube, ring and simple shear equipment. Most of the soil testing apparatus has provision for microcomputer control and data recording allowing fully automatic stress path testing together with instrumentation for measurement of soil stiffness using local gauges and shear wave velocities. Much of this equipment was designed and developed in the Centre.

There is a geotechnical centrifuge for modelling structures such as foundations, slopes, retaining walls and tunnels up to the 1:200 scale to examine ground movements and collapse conditions.

An advanced image analysis system, developed in conjunction with the Engineering Research Centre permits the determination of fields of deformation to a high accuracy. The test data from correctly modelled geotechnical events are integrated via numerical analysis with fundamental knowledge of soil behaviour observed in the laboratory.

Short courses are provided in the theory and practice of specific topics in geotechnical engineering for practising engineers. Lecturers are drawn from the Centre and from industry.

Adapted from: Geotechnical Engineering Research Centre; City University London, Postgraduate Prospectus 2000

TASK 1

Read the text about geotechnical engineering and underline the technical terms. Provide a word lists and translate if it seems necessary.

Technical terms

English	Translation
soil testing	
soil mechanics	

Geotechnical Engineering Research Centre

The principal theme of current research is the investigation of geotechnical problems through analysis and experiment. Research has focused on the understanding and prediction of ground movements and a special feature has been the integration of laboratory testing and centrifuge (physical) modelling by the use of numerical analysis. The main topics of research are: determination of the fundamental constitutive relationships for soil through the principles of critical state soil mechanics: development of laboratory equipment and procedures for determination of soil parameters for design; studies of the behaviour of soft rocks and stiff soils at elevated stresses; examination of the behaviour of granular soils over a wide range of stress conditions: investigating the stability of landslides; understanding of geotechnical structures using physical model tests; development of finite element methods using critical state soil mechanics and verification of constitutive relationships using centrifuge model test data.

Current research projects being undertaken on the centrifuge include: surface and subsurface movements due to tunnelling in layered ground; deformation and collapse of slurry-supported excavations; behaviour of diaphragm retaining walls with temporary beam or prop supports: ground deformations near geotechnical structures in stiff clays: the influence of soil state on the load capacity of driven piles in sand: stability of granular cargo in bulk carrier ships. The centrifuge forms the hub of the London Geotechnical Centrifuge Centre, which has been established as a joint venture by City and London Universities.

Adapted from: Geotechnical Engineering Research Centre; City University London, Postgraduate Prospectus 2000

Technical terms

English	Translation
ground movements	
centrifuge modelling	

TASK 2

Text work.

1. Name some laboratory facilities for soil testing and construction.

2. What soil parameters can laboratory tests on soil mechanics show?

3. Name some centrifuge research projects.

TASK 3

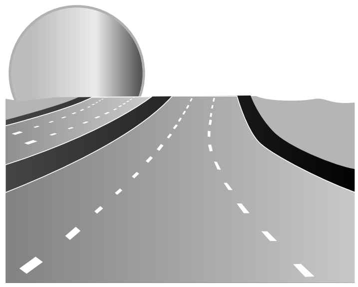
Compare the structure of courses and laboratory facilities with the study courses and facilities at your university.

TASK 4

If you compare the study courses "Applied Geology" and "Geotechnical Engineering", what main differences can be mentioned?

Unit 4 Geoengineering

The role of geoengineers in construction



Geology plus Engineering equals Geoengineering

The Geologist's Role in Determining a Motorway Route

The term usually used to describe the application of Earth Sciences to public works and civil engineering is engineering geology. By applying geological knowledge to engineering works a quantification of observations results. The classical techniques of observation are combined with those describing the mechanical characteristics of soils and rocks. It is on quantitative data that the builder must rely. Given these needs, a new type of engineer is emerging: the geotechnical engineer who is at once an applied geologist, a specialist in soil and rock mechanics and an expert in substructures.

The interests of the soil engineer must be wide: foundations for buildings and civil engineering projects, tunnels, dams, earthworks, to name a few. To illustrate this role, the planning and construction of a motorway will be examined. The research programme involves numerous techniques which follow in chronological sequence. The geologist takes part in the choice of the route, the identification of difficult zones (for example, stretches of compressible organic material, unstable natural slopes, blasting, special foundations), the study of fillings and cuttings, and the search for construction materials. An examination of a motorway will provide examples to show the role of the geologist and the methods that are used - selecting the route, handling a landslide, foundations of a civil engineering project.

The motorway route is subject to many factors other than those that relate to the terrain (e.g. socioeconomic requirements). Nevertheless, as the geologist and the soil engineer must propose the best route at lowest cost, they need to use to the maximum all available knowledge of regional geology. They must take account of lithology and tectonics to avoid placing the route in geologically dangerous zones (e.g. clay levels, strata with a high water content, alluvial plains with a high concentration of compressible peaty soils, unstable slopes). The applied geologist provides maps and precise geological sections with scales appropriate to the different types of works that are involved (from 1:1000 to 1:25 000).

A geological study goes through several stages. First of all, it requires a thorough knowledge of regional geology obtained from careful examination of the scientific literature. Local geological maps and the related memoirs must be read in conjunction with consultation of the archives of the mining. The bibliographical analysis is consolidated by field trips and systematic visits to existing sites. With a general picture in mind, the applied geologist proceeds to a geological survey using aerial photographs or precise topographical observation. Close attention to all these sources provides a considerable amount of information on the behaviour of the various geological formations.

Geologists are responsible for integrating into their observations of the surface, the geophysical data, the first mechanical drilling and the first attempts to identify soils in the laboratory. From this complementary information, it is then possible to estimate the cost of the different parts of the work.

The geological survey produces the following data:

1. Petrographical character of the surface formations to be encountered on the route.
2. Relations between the surface formations and those situated below them.
3. Surface water-groundwater connections in the above formations. Water is a major factor in civil engineering as the mechanical properties of soils depend directly on it.
4. Links between facies encountered and certain geotechnical properties. Laboratory experiments to identify the soils make it possible to draw up soil-engineering maps for the zone studied.

Source: from: Jean Dercourt u.a.: Geology. Principles and Methods; Graham & Trotman 1988; p. 318 f.

TASK 1

Name the steps of a geological study from the preliminary stages of planning a motorway route until construction work can begin. (s. task 2 first)

step 4

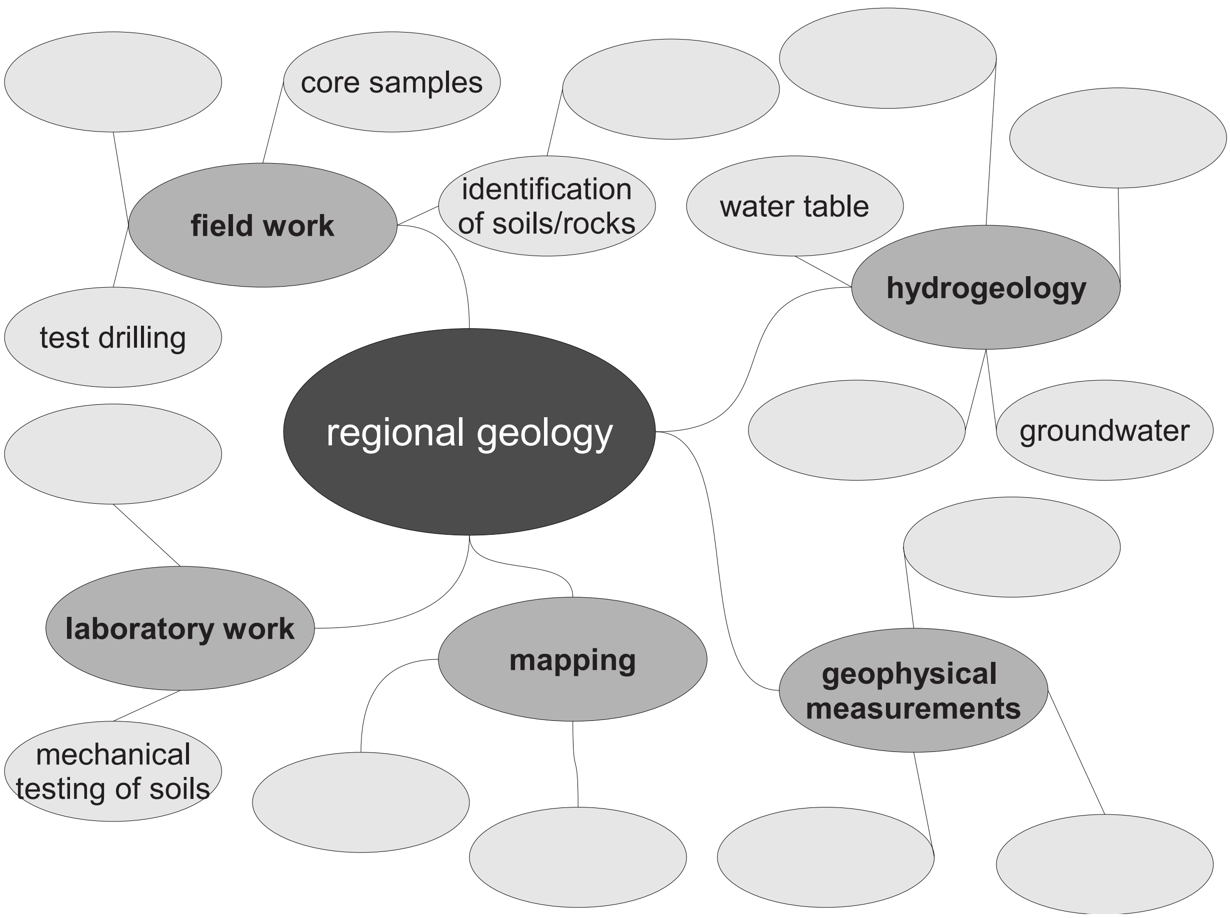
step 3

step 2

step 1

TASK 2

Before you start, do some brainstorming in your group for helpful words and put them into a mind map. Examples are given.



Geohazards and engineering

The Earth is a dynamic system and many of the natural disasters that occur are manifestations of geological processes in the crust and/or at the surface, often exacerbated by the effects of weather and human activity. Cumulatively, geohazards - including earthquakes, volcanic eruptions, landslides and tsunamis - account for enormous loss of life and damage to property. Earthquakes and volcanic eruptions, although not preventable, can be mitigated by risk assessment and disaster management planning. Other geohazards, such as landslides, are usually triggered by exceptional events, such as earthquakes or intense rainfall. Knowledge of the processes that formed river valleys can help in determining flood risk. In every case, an understanding of the geological processes can help to model risk and formulate strategies for avoidance or mitigation. BGS undertakes a full range of geotechnical and engineering geology investigations in the UK and internationally. Surveys are backed by laboratory services and databases covering geology, boreholes, man-made ground and hazardous ground conditions including slope instability, subsidence, solution cavities, clay heave/shrinkage, and abandoned mining. BGS scientists can provide developers, planners, financiers, civil engineers and insurers with site-specific information on ground conditions across the UK. Customised thematic maps address applications such as urban regeneration, derelict land characterisation, and linear route planning.

Source: BGS, brochure 2002

TASK 3

Read the text and underline/mark the important terms for geology and geoengineering and put them in a word list.

Technical terms

English	Translation

TASK 4

Answer the questions.

1. Why do natural disasters occur?

2. How can an understanding of geological processes help to prevent major catastrophes for human lives?

3. How can geological surveys and laboratory services be a help for civil engineers and planners?

Unit 5 The Rock Cycle

A model to describe the formation of different rock types

Rocks Tell the Story of the Earth

The Earth is made of rock, from the tallest mountains to the floor of the deepest ocean. Thousands of different types of rocks and minerals have been found on Earth. Most rocks at the Earth‘s surface are formed from only eight elements (oxygen, silicon, aluminum, iron, magnesium, calcium, potassium, and sodium), but these elements are combined in a number of ways to make rocks that are very different.

Rocks are continually changing. Wind and water wear them down and carry bits of rock away; the tiny particles accumulate in a lake or ocean and harden into rock again. The oldest rock that has ever been found is more than 3.9 billion years old. The Earth itself is at least 4.5 billion years old, but rocks from the beginning of Earth‘s history have changed so much from their original form that they have become new kinds of rock. By studying how rocks form and change, scientists have built a solid understanding of the Earth we live on and its long history.

Rock-forming and rock-destroying processes have been active for billions of years. Today, in the Guadalupe Mountains of western Texas, one can stand on limestone, a sedimentary rock, that was a coral reef in a tropical sea about 250 million years ago. In Vermont‘s Green Mountains one can see schist, a metamorphic rock, that was once mud in a shallow sea. Half Dome in Yosemite Valley, Calif., which now stands nearly 8,800 feet above sea level, is composed of quartz monzonite, an igneous rock that solidified several thousand feet within the Earth. In a simple rock collection of a few dozen samples, one can capture an enormous sweep of the history of our planet and the processes that formed it.

Types of Rocks

Geologists classify rocks in three groups, according to the major Earth processes that formed them. The three rock groups are igneous, sedimentary, and metamorphic rocks. Anyone who wishes to collect rocks should become familiar with the characteristics of these three rock groups. Knowing how a geologist classifies rocks is important if you want to transform a random group of rock specimens into a true collection.

Igneous Rocks

Igneous rocks, also called volcanic rocks, are formed from melted rock that has cooled and solidified. When rocks are buried deep within the Earth, they melt because of the high pressure and temperature; the molten rock (called magma) can then flow upward or even be erupted from a volcano onto the Earth‘s surface. When magma cools slowly, usually at depths of thousands of feet, crystals grow from the molten liquid, and a coarse-grained rock forms. When magma cools rapidly, usually at or near the Earth‘s surface, the crystals are extremely small, and a fine-grained rock results. A wide variety of rocks are formed by different cooling rates and different chemical compositions of the original magma. Obsidian (volcanic glass), granite, basalt, and andesite porphyry are four of the many types of igneous rock.

Common igneous (volcanic rocks) are basalt, andesite, and rhyolite. When magmas crystallize deep underground they look different from volcanic rocks because they cool more slowly and, therefore, have larger crystals. Igneous rocks cooled beneath the Earth‘s surface are called intrusive rocks. The intrusive equivalents of basalt, andesite, and rhyolite are gabbro, diorite, and granite, respectively.

Sedimentary Rocks

Sedimentary rocks are formed at the surface of the Earth, either in water or on land. They are layered accumulations of sediments: fragments of rocks, minerals, or animal or plant material. Temperatures and pressures are low at the Earth‘s surface, and sedimentary rocks show this fact by their appearance and the minerals they contain. Most sedimentary rocks become cemented together by minerals and chemicals or are held together by electrical attraction; some, however, remain loose and unconsolidated. The layers are normally parallel or nearly parallel to the Earth‘s surface; if they are at high angles to the surface or are twisted or broken, some kind of Earth movement has occurred since the rock was formed. Sedimentary rocks are forming around us all the time. Sand and gravel on beaches or in river bars look like the sandstone and conglomerate they will become. Compacted and dried mud flats harden into shale. Scuba divers who have seen mud and shells settling on the floors of lagoons find it easy to understand how sedimentary rocks form.

Common sedimentary rocks include sandstone, limestone, and shale. These rocks often start as sediments carried in rivers and deposited in lakes and oceans. When buried, the sediments lose water and become cemented to form rock.

Metamorphic Rocks

Sometimes sedimentary and igneous rocks are subjected to pressures so intense or heat so high that they are completely changed. They become metamorphic rocks, which form while deeply buried within the Earth‘s crust. The process of metamorphism does not melt the rocks, but instead transforms them into denser, more compact rocks. New minerals are created either by rearrangement of mineral components or by reactions with fluids that enter the rocks. Some kinds of metamorphic rocks--granite gneiss and biotite schist are two examples--are strongly banded or foliated. (Foliated means the parallel arrangement of certain mineral grains that gives the rock a striped appearance.) Pressure or temperature can even change previously metamorphosed rocks into new types.

Common metamorphic rocks include schist, marble, and gneiss. Sedimentary rock shale (formed mostly of clay sediments) when buried and heated to high temperatures (300-500°C) becomes transformed or metamorphosed into schist.

Source: http://interactive2.usgs.gov/learningweb/explorer/topic_rocks.htm

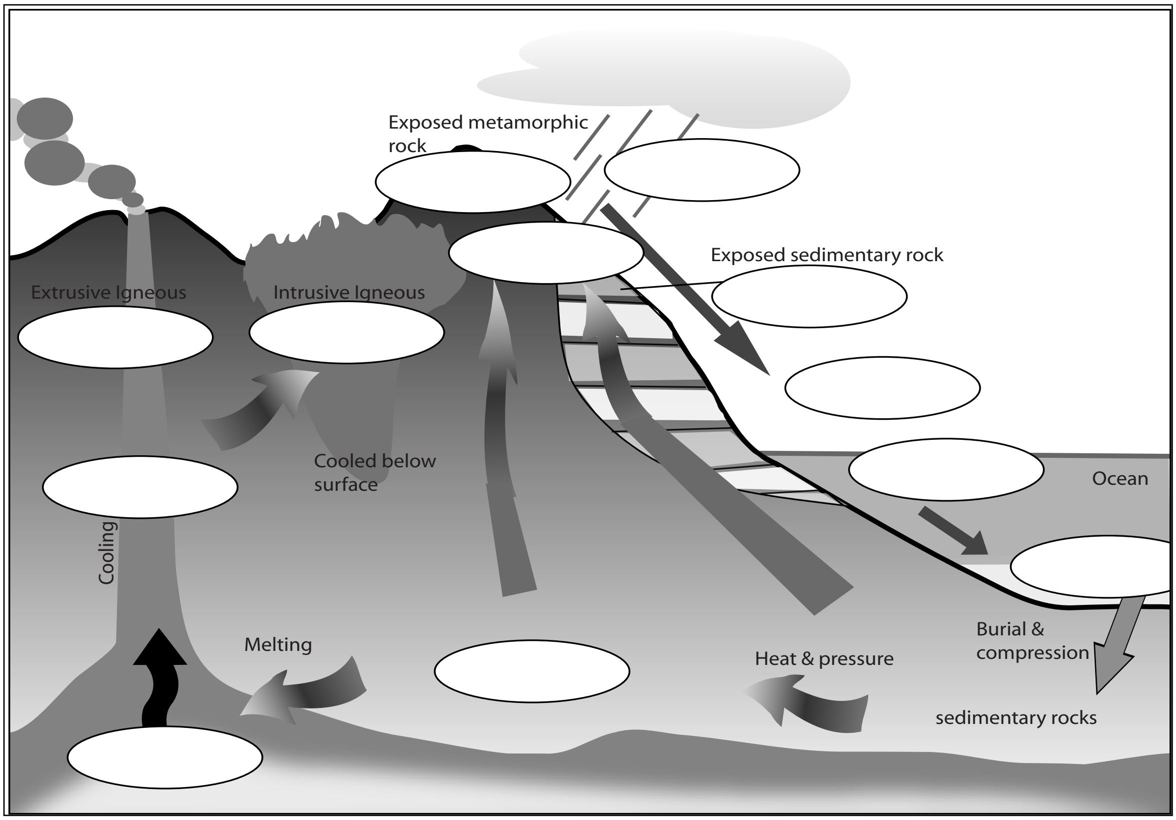
TASK 1

Match the three types of rocks to their definitions and put the examples of rocks into the table, too: “marble”, “granite”, “limestone”, “coal”, “slate”, “basalt”, “sandstone”, “shale” and “lava”

Types	Definition	Example
	These rocks were formed from the remains of animals or plants and other rocks which had been crushed together.	
	These rocks were formed when hot, molten volcanic material cooled and solidified.	
	These rocks were once igneous or sedimentary and were changed by great heat and pressure.	

TASK 2

Label the missing parts of the rock cycle and describe the steps when igneous sedimentary and metamorphic rocks are formed.



Deposition

Limestone

Weathering

Granite

Marble

Basalt

Magma

Exposure

Igneous rocks

Sediments

Metamorphic rocks

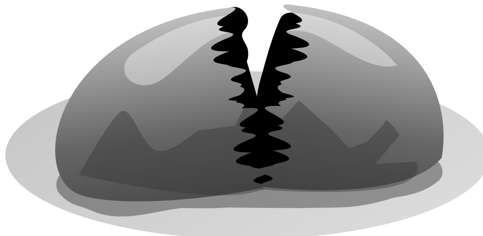
Erosion and transport

TASK 3

What is the difference between intrusive and extrusive rocks regarding the cooling process and the size of the crystals?

Unit 6 Rocks and Rock Mechanics

General principles of rock mechanics



Rock, Rocks

„Any mineral matter making up the Earth. As used by geologist, the term also includes unconsolidated material such as sand, mud, clay and peat; in addition to the harder materials described as rocks in conventional usage.“

Source: Chambers Dictionary of Science and Technology, 2000

Rock Mechanics

“The theoretical and applied science of physical behavior of rocks, representing a ‘branch of mechanics concerned with the response of rock to the force fields of its physical environment’.”

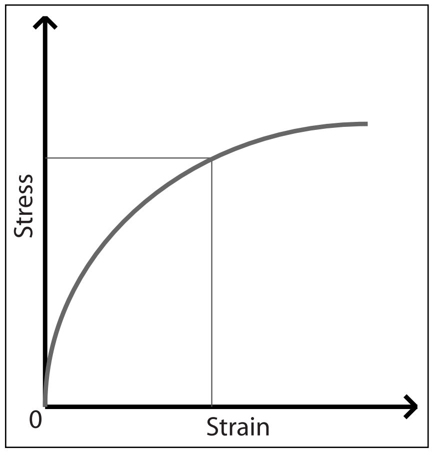
Source: Glossary of Geology, American Geological Institute, 2005

„The hard material of the Earth‘s crust exposed on the surface or underlying the soil.“

Source: DK Illustrated Oxford Dictionary, 2003

In general terms, rocks mechanics are important in geoengineering and civil engineering where underground works such as mine operations or tunnelling as well as surface constructions such as open quarries, highways or dam foundations are involved.

Stress-strain tests and analysis are fundamental in all works in rock mechanics. The relationships - normally obtained from tests in a laboratory - can be shown in a diagram. Rock samples are subjected to defined stress conditions. During the application of stress, a certain strain is developed.



Example:
Stress-strain relationships can be ductile or brittle; plastic or elastic etc.

Rock mechanics and soil mechanics are closely related and it is often difficult to draw the lines between the two sciences; e.g. a broken rock can develop a soil-like behaviour etc. (for further information on soils, s. units 11, 12, 13)

TASK 1

Match the sentence to form a complete sentence.

Rock is solid **1**	simple equipment as well as modern instrumentation is necessary. **A**
Soil may include **2**	to measure the stress needed to rupture a rock. **B**
To measure rock strength **3**	abrasion hardness, impact hardness and permeability. **C**
Rock strength can be measured **4**	weathered or broken rock. **D**
Strength test are carried out **5**	while soil is an unconsolidated, uncemented material. **E**
Rock tests may involve **6**	in the laboratory or in-situ. **F**

1__ 2__ 3__ 4__ 5__ 6__

Tests can measure different types of rock strength:
for example:

1. uniaxial compressive strength
2. tensile strength
3. shear strength
4. triaxial compressive shear strength
5. etc.

TASK 2

Fill in the gaps with the following words:
defects, information, mapping, sites, strength

Modern instrumentation in rock mechanics provides better ways of measuring the combined effects of rock ❶ ________________ and structural ❷ ________________.
A specific advantage to modern rock mechanics studies is that ❸ ________________ and materials can be tested in advance. Mine workings can then be designed in detail. The need for geologic ❹ ________________ and careful geologic ❺ ________________ is obvious, but the actual value of geologic information depends on how well it can be integrated with information on rock strength. Some special techniques are used in this respect.

Source: after: W.C. Peters: Exploration and Mining Geology, John Wiley & Sons: New York 1978, p. 151

TASK 3

Different equipment is needed for taking rock samples and testing rock mechanics. Complete the table.

Different testing equipment for rock mechanics are:

Testing Equipment	Complete
hand tools	rock hammers, rock picks, ...
devices	for splitting, cutting rocks, ...
machines	for testing strength, ...

Unit 7 Plate Tectonics, Tectonics and Faultings

Theories to describe the movement of the Earth

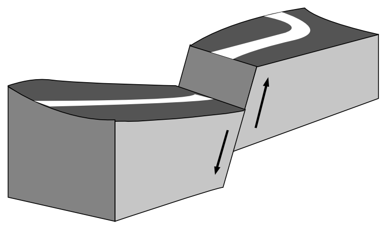


Plate tectonics is a theory which refers to how the earth's surface is built of plates.

When geologists discuss plate tectonics, they ideally depict three basic theoretical models of plate boundaries – knowing the fact that – when plates separate, collide or slide past each other – each plate is mostly influenced by a combination of the three major types.

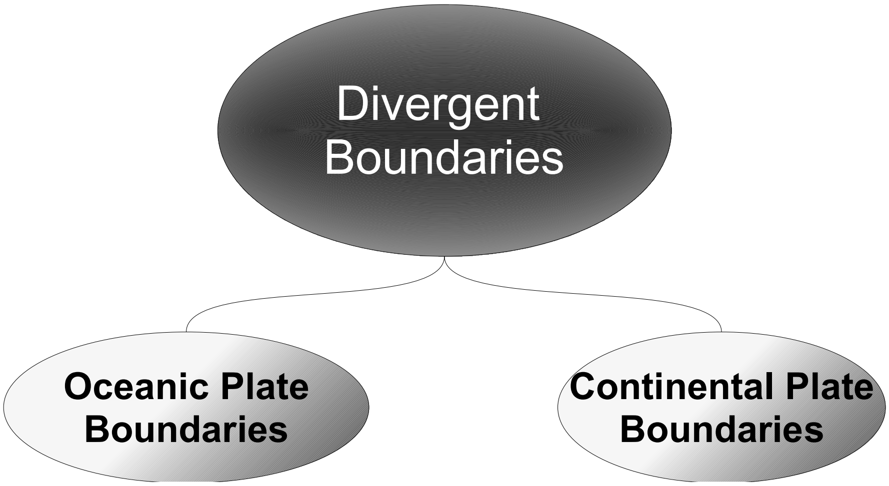
TASK 1

Match.

At...

divergent boundaries 1	plates slide horizontally past each other. A
convergent boundaries 2	plates move apart. B
transform-fault boundaries 3	plates come together. C

1__ 2__ 3__



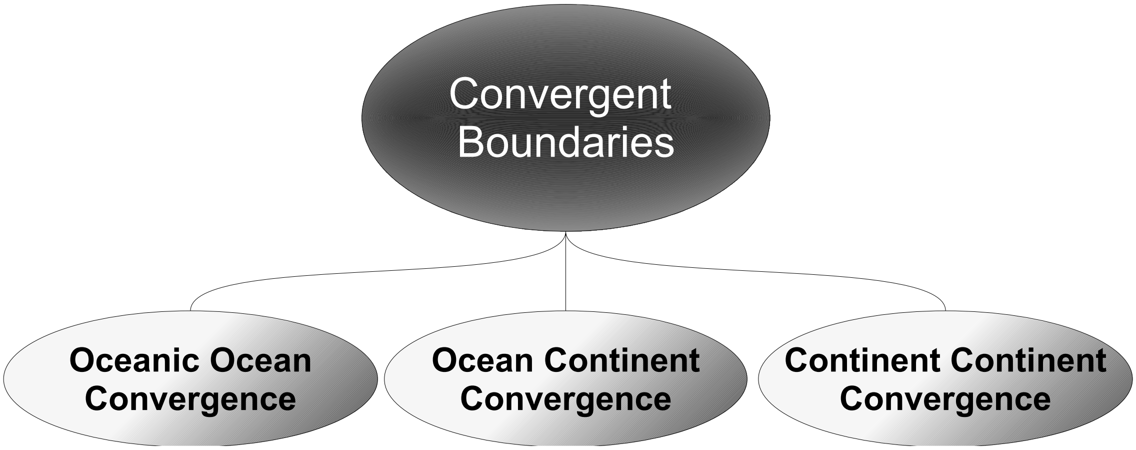
Oceanic Plate Separation

On the seafloor, the boundary between separating plates is marked by a mid-ocean ridge that exhibits active volcanism, earthquakes, and rifting caused by tensional (stretching) forces that are pulling the two plates apart. In one example, the Mid-Atlantic Ridge, seafloor spreading is at work as the North American and Eurasian plates separate and new Atlantic seafloor is created by mantle up-welling. The island of Iceland exposes a segment of the otherwise submerged Mid-Atlantic Ridge, allowing geologists to view the process of plate separation and seafloor spreading directly. The Mid-Atlantic Ridge continues in the Arctic Ocean north of Iceland and connects to a nearly globe-encircling system of mid-ocean ridges that winds through the Indian and Pacific oceans, ending along the western coast of North America. These spreading centers have created the millions of square kilometers of oceanic crust that now floor the world‘s oceans.

Source: Grotzinger, J. u.a.: Understanding Earth, W.H. Freeman and Company: New York 2007; p.23

Continental Plate Separation

Early stages of plate separation, such as the Great Rift Valley of East Africa, can be found on some continents. These divergent boundaries are characterized by rift valleys, volcanic activity, and earthquakes distributed over a wider zone than is found at oceanic spreading centers. The Red Sea and the Gulf of California are rifts that are further along in the spreading process. In these cases, the continents have separated enough for new seafloor to form along the spreading axis, and the ocean has flooded the rift valleys. Sometimes continental rifting slows or stops before the continent splits apart and a new ocean basin opens. The Rhine Valley along the border of Germany and France is a weakly active continental rift that may be this type of „failed“ spreading center. Will the East African Rift continue to open, causing the Somali Subplate to split away from Africa completely and form a new ocean basin, as happened between Africa and the island of Madagascar? Or will the spreading slow and eventually stop, as appears to be happening in western Europe? Geologists don‘t know the answers.



TASK 2

Explain in your own word what happens at convergent boundaries.

Two theories are combines with "plate tectonics"

1. The theory of "continental drift"

Means that continents are moving over the Earth's surface; i.e. continents are carried across the globe on the plates of the Earth's crust.

2. The theory of "seafloor spreading"

Means the creation of new oceanic crust at mid-ocean ridges and movement of the crust away from the mid-ocean ridges.

TASK 3

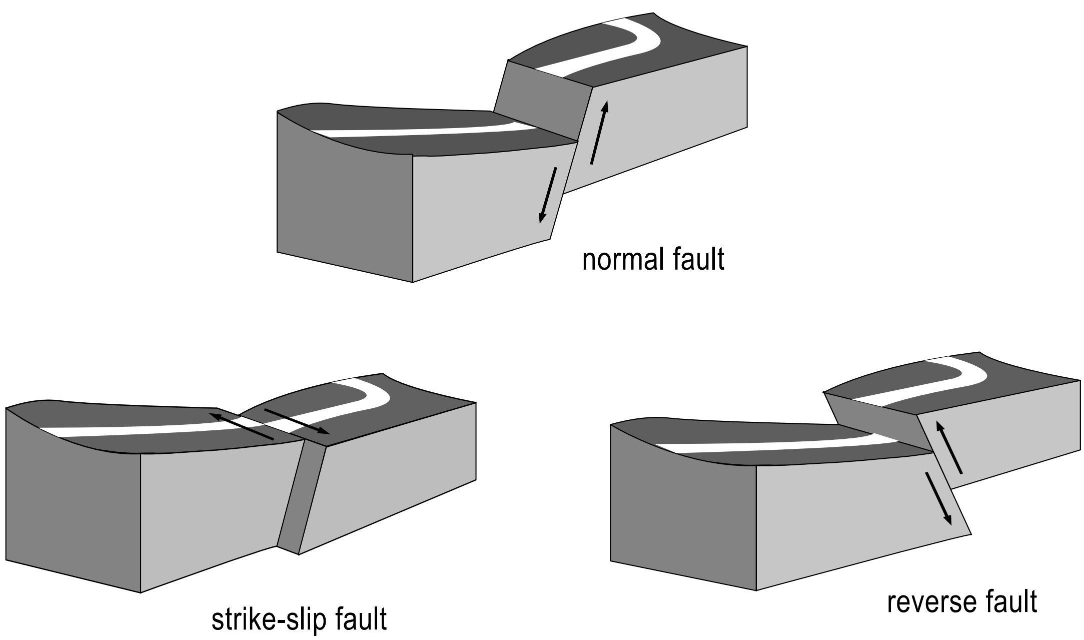
How can the theory of "continental drift" be proofed? (Think of a puzzle; matching rocks and fossils…)

How can the theory of "seafloor spreading" be proofed? (Think of mid-ocean ridges; varing ages of the sea floor; glacial deposits…)

Depending on the type of boundary one can find mountains, rifts, folding and faulting, earthquakes (s. Unit 8), volcanoes (Unit 9), and tsunamis (s. Unit 10).

Types of faults (rock fractures which show relative movement):

Faults



Like folds, **faults** are a common feature of mountain belts, particularly where the deformation is intense. Margins where plates collide, pull apart, or drift past each other are the sites of subduction zones, rift valleys, or transforms, all of which involve faults. Some transform faults - the San Andreas fault of California, for example - show such large displacements that the offset of the two plates may amount to hundreds of kilometers.

The different categories of faulting are distinguished by the direction of motion along the fracture plane (s. figure) **dip-slip fault** involves displacements up or down the dip of the plane. A **strike-slip fault** is one in which the movement is horizontal, parallel to the strike of the fault plane. A combination of dip-slip and strike-slip movements would describe an **oblique-slip fault**.
Faults need a further characterization since

the movement can be up or down, or right or left. A **normal fault** is one in which the rocks above the fault plane move down relative to the rocks below. A **reverse fault**, then, is one in which the rocks above the fault plane move up relative to the rocks below. A reverse fault, in which the dip is small, so that the overlying block is pushed mainly horizontally, is a **thrust fault**. Finally, if, as we face a strike-slip fault, the block on the other side is displaced to the right, then the fault is a **right-lateral fault; left-lateral faults** are displaced in the opposite direction (see figures).

Source: Press, F., Siever, R.: Earth, New York: W.H. Freeman and Company 1986; p. 91-92

Unit 8 Earthquakes

The intensity and magnitude of the shaking of the Earth

Intensity

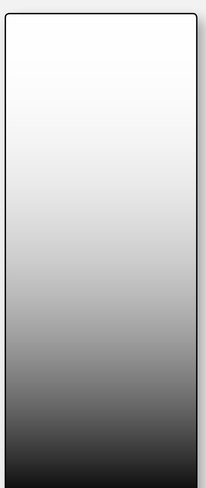
The intensity of an earthquake is a measure of ground shaking estimated from its observed effects, especially damage. The intensity can be listed on an “intensity scale”. Many of them have 12 degrees of intensity.

TASK 1

Fill in the 12 steps using following words. You can modify with the adverbs “very” or “slightly”.

damaging, destructive, davastating, observed, strong, weak

A simplified intensity scale (here based on the European Macroseismic Scale)



1. Not felt - detected by seismic instruments only
2. ______________ - felt by very few people
3. ______________ - felt by a few people indoors
4. ______________ - noticed by many people, windows and doors rattle
5. ______________ - some small objects fall over
6. ______________ - cracks to plaster, objects fall off shelves
7. ______________ - parts of chimneys fall
8. ______________ - large cracks in walls
9. ______________ - some houses collapse
10. ______________ - many houses collapse
11. ______________ - most buildings destroyed
12. Catastrophic - everything destroyed

Source: after: BGS, brochure 2002

Magnitude

Short period instruments are designed to record local earthquakes and are used to calculate local magnitude (ML). They are also used to calculate the body wave magnitude (mb) from the P-waves of world earthquakes, but are insensitive to the large amplitude surface waves which have frequencies of less than 0.05 Hz. The broadband station in Edinburgh has a frequency range of 0.003 to 50 Hz and is able to record the surface waves which can be used to calculate the surface wave magnitude (Ms) of world earthquakes.

The magnitude measures the size of an earthquake and the magnitude scale is logarithmic. It is related to the amount of seismic energy released into the earth‘s crust a magnitude 6 earthquake will move the ground 10 times that of a magnitude 5 event and release 32 times the energy. Peak acceleration or peak velocity are read histories (seismograms). Due to attenuation, different values of peak ground acceleration and peak ground velocity will be obtained from time histories taken at different distances from the earthquake focus.

Source: BGS; Brochure 2002

TASK 2

Complete the sentence parts.

1. The “Richter Magnitude Scale” and the “Moment Magnitude Scale” are

____

____

2. A seismogram is

____

____

3. Hz is

____

____

Seismic Waves

A seismogram, see below, is a record of an earthquake and is made up of P-waves, S-waves and surface waves. These waves travel away from the source at velocities characteristic of the rocks they are passing through. Typical velocities for these seismic waves in the UK are: P-waves 4-8 km/s, S-waves 2-5 km/s and surface waves 1.8-4.5 km/s. The arrival times of the P- and S-waves, at different stations, are used to determine the location of the earthquake. The P-wave, or primary compressional wave, is the first phase observed on the seismograms followed by the slower S-wave, or shear wave, then the surface waves. Identifying the first P-onset and the first S-onset and measuring the difference in arrival time from the time history determines the distance the earthquake is from the seismometer. The epicentre and depth of earthquake focus are determined using several P and S-readings using a triangulation process. Surface waves are not normally observed for local earthquakes which occur at depths >5 km and are observed principally on the broadband station for world earthquakes. In engineering terms, it is the S-wave component that poses the greatest threat to structures for a typical UK earthquake.

Source: BGS; Brochure 2002

TASK 3

Fill in: "L-waves", "P-waves" and "S-waves"

❶ ________________ can travel through any material including liquids and are faster than the other waves. ❷ ________________ will only pass through solids. The surface or ❸ ________________ are the slowest and are confined to the Earth's crustal layers. The worldwide seismographic network enables the location, strength and depth of focus of earthquakes to be determined and sheds much light on the structure of the Earth. Since ❹ ________________ cannot traverse the core there is a shadow zone on the far side of the globe from the epicentre.

Source: after: Chambers Dictionary of Science and Technology

TASK 4

Fill in: “fault lines”, “mantle”, “damage”, “surface”, “shakes” and “crust”

A phenomenon where the Earth‘s crust or the ❶ _______________ beneath it ❷ _______________ and the ❸ _______________ of the ground moves because of movement inside the ❹ _______________ along ❺ _______________, often causing ❻ _______________ to buildings.

Source: after: Chambers Dictionary of Science and Technology

TASK 5

Fill in: “movements”, “severe”, “strength”, “plates”, “rock” and “waves”

A sudden violent movement of the Earth‘s surface. Many earthquakes are relatively gentle, but the ❶ _______________ ones that cause great damage are caused by ❷ _______________ of the Earth‘s crust.
Geologists have discovered that under the continents and oceans the Earth‘s crust is made up of a number of sheets of ❸ _______________ called ❹ _______________ which can rub against each other or pull apart, creating the shock waves that form the earthquake.
The ❺ _______________ of the ❻ _______________ is measured on the Richter Scale and severe earthquakes where registered between 7 and 9 on the scale.

Source: after: Oxford Advanced Learner‘s Encyclopedic Dictionary

TASK 6

Describe where earthquakes normally occur using a simple plate tectonics model. (Remember: plates converge, split apart or slide past each other)

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TASK 7

Test your knowledge.
To determine and measure the size or intensity of an earthquake roughly three methods are used.
Match the different types "Richter Magnitude", "Modified Mercalli Magnitude" and "Moment Magnitude" to the definitions.

❶ ______________________

Logarithmic magnitude scale of ground motion registered by a seismograph measuring earthquake size.

❷ ______________________

Intensity scale in Roman numerals from I to XII given to the intensity felt by the shaking of the earth at a particular site.

❸ ______________________

Measurement of earthquake sizes related to the physical properties of the faulting it causes; a measurement which is directly taken from field measurements of the fault.

TASK 8

Discuss the role of geologist and geoengineers in locating, measuring and predicting earthquakes.

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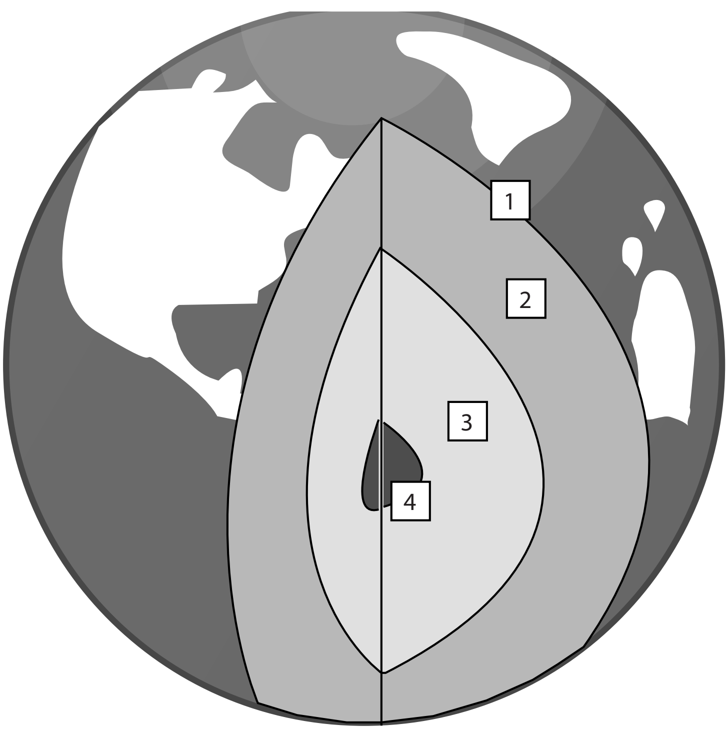
TASK 9

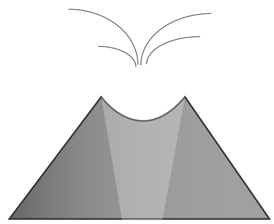
Test your knowledge about the Earth.

1. The Earth is the❶ ________________ largest planet and the ❷ ________________ closest planet to the sun.
2. The Earth has ❸ ________________ main layers.
3. The Earth has a solid ❹ ________________ inner core with a temperature of about ❺ ________________ °C,
4. and a ❻ ________________ metal ❼ ________________ core.
5. The third layer is the ❽ ________________.
6. Then comes the ❾ ________________, of which there are two different types, ❿ ________________ and oceanic.

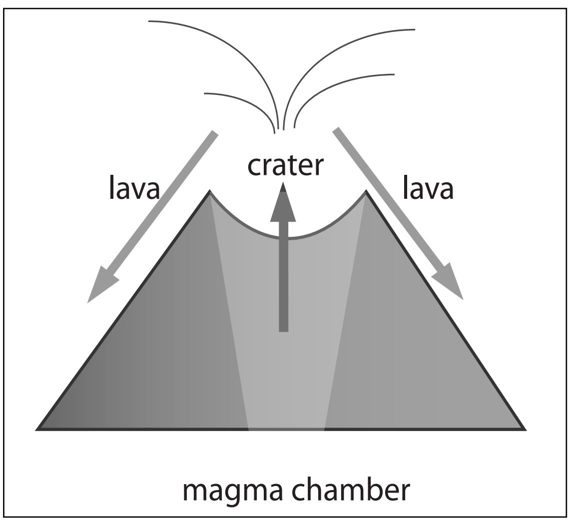


Unit 9 Volcanoes

Local devastation by volcanic eruptions



Volcanoes are mountains or hills with an opening through which lava, cinders, gases etc. come up from below the earth's surface. Scientists can decide between an active, a dormant or inactive and an extinct volcano which will probably not erupt again.



Structure of a volcano

TASK 1

Fill in: “vent/pipe”, “crater” and “cone”

The ❶ _______________ is an opening at the Earth’s surface or the passage through which volcanic materials are extruded during an eruption.
The ❷ _______________ is almost circular depression at the top or summit of a volcano where volcanic materials are released. The diameter of a volcano can reach from a few inches only to hundreds of miles.
The ❸ _______________ is a hill formed by (solidified) lava and pyroclastics that are built up around a volcanic vent.

Volcanic eruptions are major natural hazards on Earth. The hazard from a volcanic eruption depends on the type of volcano, on the time since the last eruption, on its geographical location and local climate.

Types and Effects of Volcano Hazards

Many kinds of volcanic activity can endanger the lives of people and property both close to and far away from a volcano. Most of the activity involves the explosive ejection or flowage of rock fragments and molten rock in various combinations of hot or cold, wet or dry, and fast or slow. Some hazards are more severe than others depending on the size and extent of the event taking place and whether people or property are in the way. And although most volcano hazards are triggered directly by an eruption, some occur when a volcano is quiet.
Volcanic eruptions are one of Earth‘s most dramatic and violent agents of change. Not only can powerful explosive eruptions drastically alter land and water for tens of kilometers around a volcano, but tiny liquid droplets of sulfuric acid erupted into the stratosphere can change our planet‘s climate temporarily. Eruptions often force people living near volcanoes to abandon their land and homes, sometimes forever. Those living farther away are likely to avoid complete destruction, but their cities and towns, crops, industrial plants, transportation systems, and electrical grids can still be damaged by tephra, lahars, and flooding.

Volcanic activity since 1700 A.D. has killed more than 260,000 people, destroyed entire cities and forests, and severely disrupted local economies for months to years. Even with our improved ability to identify hazardous areas and warn of impending eruptions, increasing numbers of people face certain danger. Scientists have estimated that by the year 2000, the population at risk from volcanoes is likely to increase to at least 500 million, which is comparable to the entire world's population at the beginning of the seventeenth century! Clearly, scientists face a formidable challenge in providing reliable and timely warnings of eruptions to so many people at risk.

Source: http://volcanoes.usgs.gov/Hazards/What/hazards.html

TASK 2

Answer the questions.

1. What happens when a volcano erupts?

2. Why are eruptions so extremely dangerous for people and the environment?

Location of Hazards Posed by Volcanoes

Volcanoes generate a wide range of activity that can affect the surrounding land, river valleys, and communities in different ways. Depending on the type, size, and duration of the eruptive activity, hazardous areas might exist only within a few kilometers of a volcano or extend to areas more than a hundred of kilometers from an active vent. We can identify areas most likely to be affected in the future by volcano hazards--lahars, lava flows, landslides, pyroclastic flows, tephra, and volcanic gases--through a detailed study of a volcano‘s natural history.

By knowing the distance that previous types of activity spread from a volcano and the present landscape, and learning from the effects of historical eruptions, we can identify hazardous zones around a volcano.

Volcano Hazard Areas Around the Globe

In order to determine the general location of volcano hazard areas on Earth, we first need to know where the world‘s most active volcanoes are concentrated. Active volcanoes are not randomly distributed over the Earth‘s surface. Instead, they tend to be located in linear volcanic mountain chains thousands of kilometers long on the edges of continents, in the middle of oceans, or as island chains. The locations of these volcanic chains are closely related to the way in which Earth‘s crust is divided into more than a dozen enormous sections or „plates“ and how the plates move relative to one another according to the theory of plate tectonics.

According to the theory of plate tectonics, these rigid plates, whose average thickness is about 80 km, move in slow motion.

Source: http://volcanoes.usgs.gov/Hazards/Where/WhereHaz.html

TASK 3

Where do volcanoes predominantly exist?

Ash properties & dispersal by wind

Small jagged pieces of rocks, minerals, and volcanic glass the size of sand and silt (less than 2 millimeters (1/12 inch) in diameter) erupted by a volcano are called volcanic ash. Very small ash particles can be less than 0.001 millimeters (1/25,000th of an inch) across. Volcanic ash is not the product of combustion, like the soft fluffy material created by burning wood, leaves, or paper. Volcanic ash is hard, does not dissolve in water, is extremely abrasive and mildly corrosive, and conducts electricity when wet.

Volcanic ash is formed during explosive volcanic eruptions. Explosive eruptions occur when gases dissolved in molten rock (magma) expand and escape violently into the air, and also when water is heated by magma and abruptly flashes into steam. The force of the escaping gas violently shatters solid rocks. Expanding gas also shreds magma and blasts it into the air, where it solidifies into fragments of volcanic rock and glass. Once in the air, wind can blow the the tiny ash particles tens to thousands of kilometers away from the volcano.

Ash particle size

The average grain-size of rock fragments and volcanic ash erupted from an exploding volcanic vent varies greatly among different eruptions and during a single explosive eruption that lasts hours to days. Heavier, large-sized rock fragments typically fall back to the ground on or close to the volcano and progressively smaller and lighter fragments are blown farther from the volcano by wind. Volcanic ash, the smallest particles (2 mm in diameter or smaller), can travel hundreds to thousands of kilometers downwind from a volcano depending on wind speed, volume of ash erupted, and height of the eruption column.

Hardness

The abrasiveness of volcanic ash is a function of the hardness of the material forming the particles are their shape. Hardness values for the most common particles are shown in the table below. Ash particles commonly have sharp broken edges which makes them a very abrasive material.

Source: http://volcanoes.usgs.gov/ash/properties.html

Mohs‘ scale of hardness

Scale Number	Mineral	Metal	Minerals in volcanic ash and their hardness
1	Talc		
2	Gypsum	Aluminium Copper	mica (H 2-3)
3	Calcite	Brass	
4	Fluorite	Iron	
5	Apatite	Steel	volcanic glass, pyroxene, amphibole (H 5-6)
6	Orthoclase (Feldspar)		plagioclase, alkali-feldspar (H 6-6.5)
7	Quartz		
8	Topaz		
9	Corundum	Chromium	

Source: http://volcanoes.usgs.gov/ash/properties.html

TASK 4

Fill in: “Ash”, “Block”, “Bomb”, “Cinder”, “Dust” and “Pumice”

❶ ________________: In general it is a fine powder of any material. As a volcanic material, it is a kind of volcanic ash, i.e. the finer fraction of ash.

❷ ________________: In general it is the powdery residue which is left after the burning of any substance. Volcanic ________________ are particles of finer pyroclastic material with a diameter under 20 mm.

❸ ________________: A pyroclast ejected which takes shape while flying through the air. It is larger in diameter than 64 mm.

❹ ________________: A pyroclastitic material in a solid state with sharp corners. Its diameter is also more than 64 mm.

❺ ________________: In general it is the residue of coal or wood that has stopped giving off flames but can still burn. As a pyroclastic fragment it falls to the ground in an essentially solid condition. It is formed by liquid lava cooling in the air.

❻ ________________: It is porous volcanic rock with a very low bulk density. It is so light that it can float in water. Often it is used as an abrasive material in polishing or cleaning.

TASK 5

Name negative effects of volcanic eruptions on the climate and their contribute to climate change.

Fertile Soils: The Plus Side of Volcanoes

Volcanic materials ultimately break down and weather to form some of the most fertile soils on Earth, cultivation of which has produced abundant food and fostered civilizations. -- Excerpt from: Tilling, 1985, Volcanoes: USGS General Interest Publication

Volcanoes can clearly cause much damage and destruction, but in the long term they also have benefited people. Over thousands to millions of years, the physical breakdown and chemical weathering of volcanic rocks have formed some of the most fertile soils on Earth. In tropical, rainy regions, such as the windward (northeastern) side of the Island of Hawaii, the formation of fertile soil and growth of lush vegetation following an eruption can be as fast as a few hundred years. Some of the earliest civilizations (for example, Greek, Etruscan, and Roman) settled on the rich, fertile volcanic soils in the Mediterranean-Aegean region. Some of the best rice-growing regions of Indonesia are in the shadow of active volcanoes. Similarly, many prime agricultural regions in the western United States have fertile soils wholly or largely of volcanic origin. -- Excerpt from: Kious and Tilling, 1996, This Dynamic Earth: The Story of Plate Tectonics: USGS General Interest Publication

The Earth‘s crust, on which we live and depend, is in large part the product of millions of once-active volcanoes and tremendous volumes of magma that did not erupt but instead cooled below the surface. Such persistent and widespread volcanism has resulted in many valuable natural resources throughout the world. For example, volcanic ash blows over thousands of square kilometers of land increases soil fertility for forests and agriculture by adding nutrients and acting as a mulch. -- Excerpt from: Brantley, 1994, Volcanoes of the United States: USGS General Interest Publication

Given enough rainfall, areas buried by new lava recover quickly; revegetation can begin less than one year after the eruption. Erosion and breakdown of the volcanic material can form fertile soils over periods of tens to thousands of years. These rich soils fostered the agricultural development of the Hawaiian Islands, as represented principally by the sugar, pineapple, coffee, and macadamia nut industries. -- Excerpt from: Tilling, Heliker, and Wright, 1987, Eruptions of Hawaiian Volcanoes: Past, Present, and Future: USGS General Interest Publication

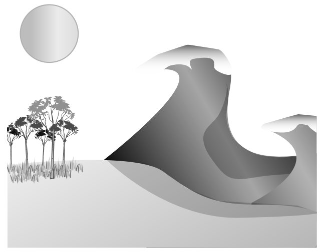
Source: http://vulcan.wr.usgs.gov/LivingWith/PlusSide/fertile_soils.html

TASK 6

Name positive aspects of volcanic eruptions.

Unit 10 Tsunamis

The role of geologist to predict geohazards



On 26th December 2004 mankind had to face one of the deadliest natural disasters. The Indian Ocean tsunami – probably the largest earthquake-generated tsunami – killed about 300,000 people.

What are tsunamis and how are they caused?

Tsunami, or seismic sea waves, are a series of very long wavelength ocean waves generated by the sudden displacement of large volumes of water. The generation of tsunami waves is similar to the effect of dropping a solid object, such as a stone, into a pool of water. Waves ripple out from where the stone entered, and thus displaced, the water. In a tsunami, the „stone“ comes from underneath the ocean or very close to shore, and the waves, usually only three or four, are spaced about 15 minutes apart.

Tsunami can be caused by underwater (submarine) earthquakes, submarine volcano eruptions, falling (slumping) of large volumes of ocean sediment, coastal landslides, or even by meteor impacts. All of these events cause some sort of land mass to enter the ocean and the ocean adjusts itself to accommodate this new mass. This adjustment creates the tsunami, which can circle around the world. Tsunami is a Japanese word meaning „large waves in harbors.“ It can be used in the singular or plural sense. Tsunami are sometimes mistakenly called tidal waves but scientists avoid using that term since they are not at all related to tides.

Tsunami are classified by oceanographers as shallow water surface waves. Surface waves exist only on the surface of liquids. Shallow water waves are defined as surface waves occurring in water depths that are less than one half their wavelength. Wavelength is the distance between two adjacent crests (tops) or troughs (bottoms) of the wave. Wave height is the vertical distance from the top of a crest to the bottom of the adjacent trough. Tsunami have wave heights that are very small as compared to their wavelengths. In fact, no matter how deep the water, a tsunami will always be a shallow water wave because its wavelength (up to 150 mi [240 km]) is so much greater than its wave height (usually no more than 65 ft [20 m]).

Shallow water waves are different than deep water waves because their speed is controlled only by water depth. In the open ocean, tsunami travel quickly (up to 470 MPH [760 km/h]), but because of their low height (typically less than 3 ft [1 m]) and long wavelength, ships rarely notice them as they pass underneath. However, when a tsunami moves into shore, its speed and wavelength decrease due to the increasing friction caused by the shallow sea floor.

Wave energy must be redistributed, however, so wave height increases, just as the height of small waves increases as they approach the beach and eventually break. The increasing tsunami wave height produces a „wall" of water that, if high enough, can be incredibly destructive. Some tsunami are reportedly up to 200 ft (65 m) tall. The impact of such a tsunami can range miles inland if the land is relatively flat.

Tsunami may occur along any shoreline and are affected by local conditions such as the coastline shape, ocean floor characteristics, and the nature of the waves and tides already in the area. These local conditions can create substantial differences in the size and impact of the tsunami waves even in areas that are very close geographically.

Source: http://science.jrank.org/pages/7014/Tsunami.html

TASK 1

Answer the questions to the text.

1. Why can you compare the generation of a tsunami wave to the effect of dropping a stone into water?

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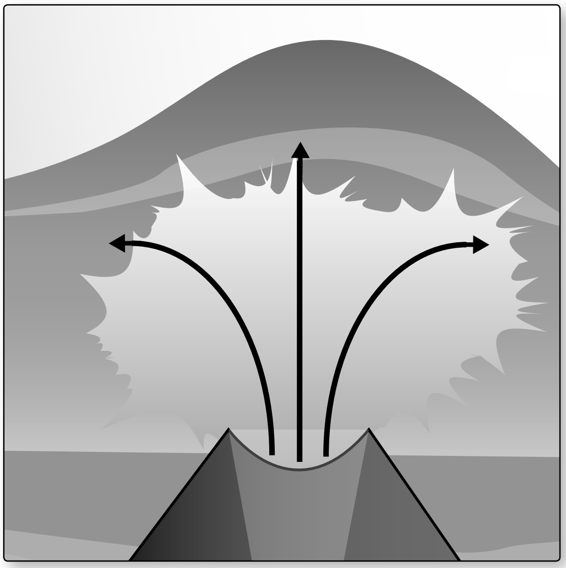
2. What causes for tsunamis are given in the text?

3. Why is the term “tidal waves” misleading when describing tsunamis?

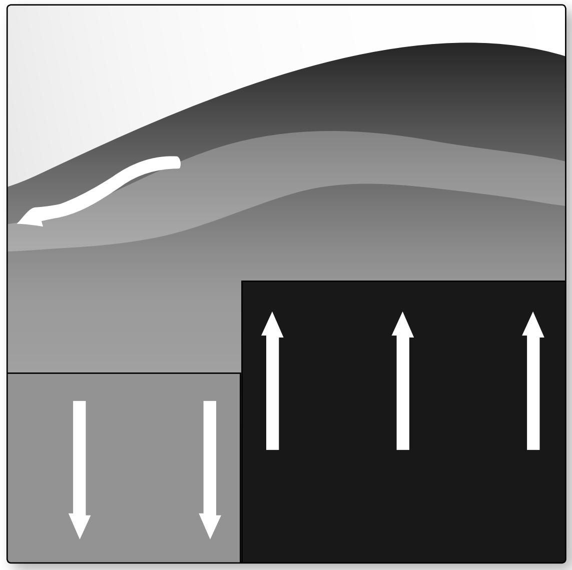
4. How are terms “wavelength” and “wave height” defined?

5. What are the differences between “shallow water waves” and “deep water waves”?

6. What kind of conditions may affect the occurrence of tsunamis?



Volcanic eruptions generate catastrophic waves.



Submarine earthquakes generate giant waves by dislocating the oceanic crust.

TASK 2

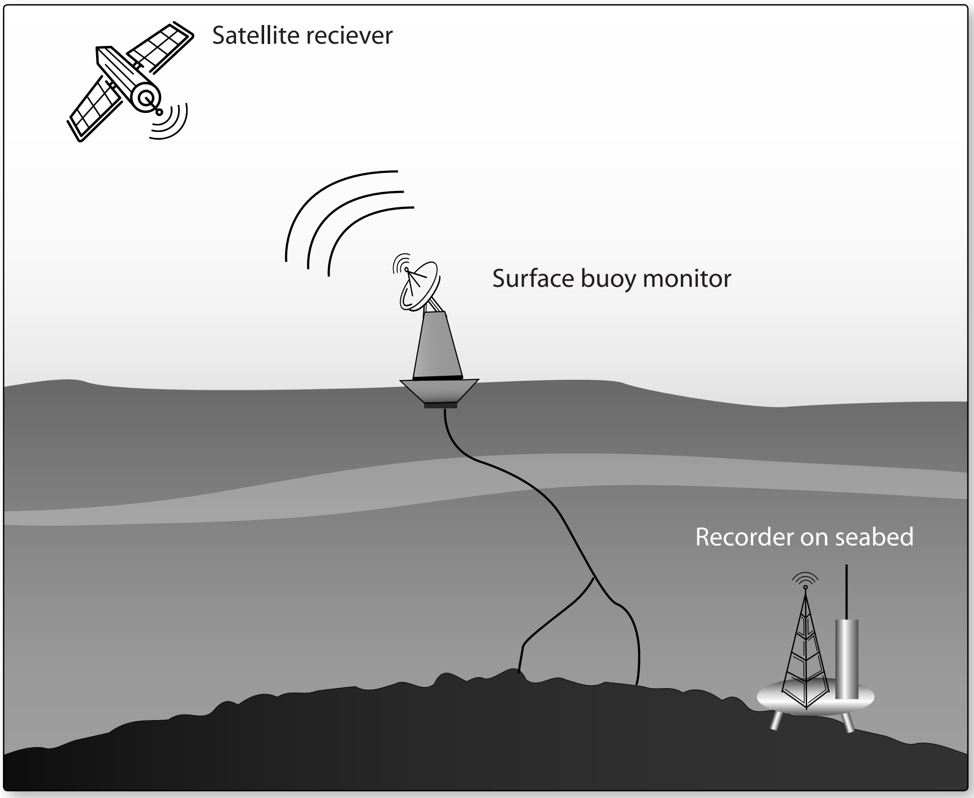
Describe the generation of tsunamis explaining the pictures in your own words.

Tsunamis cannot be prevented, even though measures can be taken to mitigate the risk on shore and to prevent destruction or even the loss of life.

TASK 3

Name, describe and discuss some measures. (Words to help: walls as barriers, floodgates, channels, etc.)

A tsunami early warning system

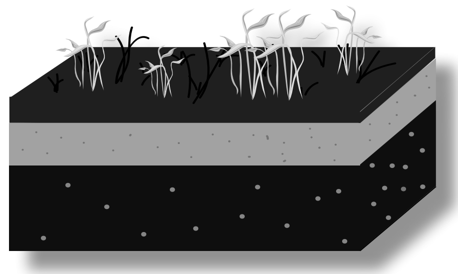


TASK 4

Describe the picture.

Unit 11 Soil Sciences and Soil Studies

The composition of soils



Composition of Soils

An important factor influencing the productivity of our planet‘s various ecosystems is the nature of their soils. Soils are vital for the existence of many forms of life that have evolved on our planet. For example, soils provide vascular plants with a medium for growth and supply these organisms with most of their nutritional requirements. Further, the nutrient status of ecosystem‘s soils not only limit both plant growth, but also the productivity of consumer type organisms further down the food chain.

Soil itself is very complex. It would be very wrong to think of soils as just a collection of fine mineral particles. Soil also contains air, water, dead organic matter, and various types of living organisms (Figure 1). The formation of a soil is influenced by organisms, climate, topography, parent material, and time. The following items describe some important features of a soil that help to distinguish it from mineral sediments.

A mass of mineral particles alone do not constitute a true soil. True soils are influenced, modified, and supplemented by living organisms. Plants and animals aid in the development of a soil through the addition of organic matter. Fungi and bacteria decompose this organic matter into a semi-soluble chemical substance known as humus. Larger soil organisms, like earthworms, beetles, and termites, vertically redistribute this humus within the mineral matter found beneath the surface of a soil.

Humus is the biochemical substance that makes the upper layers of the soil become dark. It is colored dark brown to black. Humus is difficult to see in isolation because it binds with larger mineral and organic particles. Humus provides soil with a number of very important benefits:

- It enhances a soil‘s ability to hold and store moisture.
- It reduces the eluviation of soluble nutrients from the soil profile.
- It is the primary source of carbon and nitrogen required by plants for their nutrition.
- It improves soil structure which is necessary for plant growth.

Organic activity is usually profuse in the near surface layers of a soil. For instance, one cubic centimeter of soil can be the home to more than 1,000,000 bacteria. A hectare of pasture land in a humid mid-latitude climate can contain more than a million earthworms and several million insects. Earthworms and insects are extremely important because of their ability mix and aerate soil. Higher porosity, because of mixing and aeration, increases the movement of air and water from the soil surface to deeper layers where roots reside. Increasing air and water availability to roots has a significant positive effect on plant productivity. Earthworms and insects also produce most of the humus found in a soil through the incomplete digestion of organic matter.

Source: http://www.physicalgeography.net/fundamentals/10t.html

TASK 1

Answer the questions for the text.

1. Why is the composition of soils so important for the ecosystem?

____

____

____

____

____

____

2. How is the formation of soils influenced?

____

____

____

____

____

____

3. What makes humus?

4. Explain the term “organic activities” in soils.

5. How can soils be influenced apart from organic activities?

The pie-chart shows the percentage of the four basic components of soils.

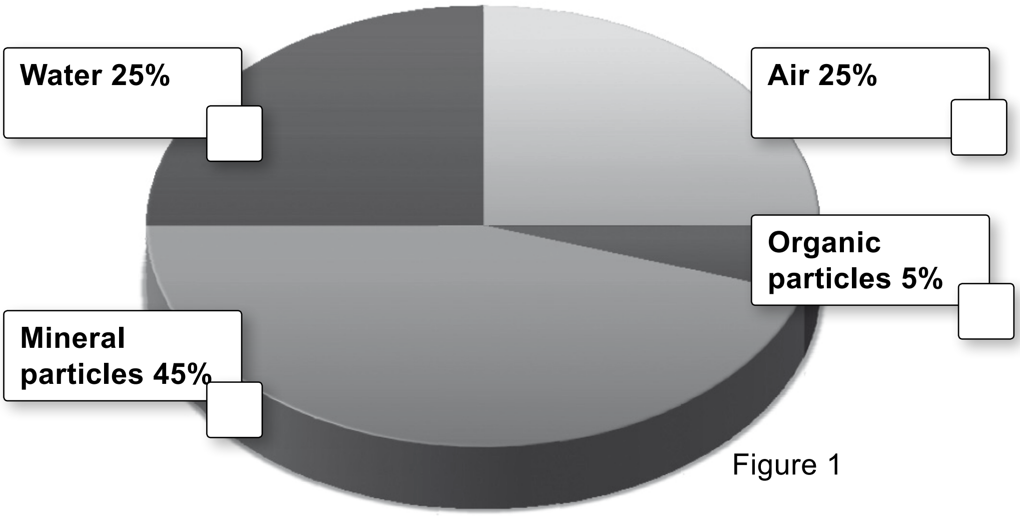


Figure 1

Most soils contain four basic components: mineral particles, water, air, and organic matter. Organic matter can be further sub-divided into humus, roots, and living organisms. The values given above are for an average soil.

TASK 2

Put the additional information to the component where they belong to.

It is essential for both animal and plant life in the soil. Nutrients are carried in a solution which enables plants to obtain them via the root system. **A**	A good soil requires spaces. Without these the soil becomes stagnant and compacted. Soil micro-organisms and plant roots both require an adequate supply of it. **C**	It is a mixture of living, dead and decomposing animal and vegetable materials. Humus forms from this process and helps to bind the particles together to form a crumb structure. **B**	These form the non-living skeleton of the soil. They are derived from the parent material by weathering. **D**

Soil Texture

The texture of a soil refers to the size distribution of the mineral particles found in a representative sample of soil. Particles are normally grouped into three main classes: sand, silt, and clay. The table describes the classification of soil particles according to size.

Type of Mineral Particle	Size Range
Sand	2.0 - 0.06 mm
Silt	0.04 - 0.002 mm
Clay	less than 0.002 mm

Clay is probably the most important type of mineral particle found in a soil. Despite their small size, clay particles have a very large surface area relative to their volume. This large surface is highly reactive and has the ability to attract and hold positively charged nutrient ions. These nutrients are available to plant roots for nutrition. Clay particles are also somewhat flexible and plastic because of their lattice-like design. This feature allows clay particles to absorb water and other substances into their structure.

Soil Profile and Soil Horizons

The soil profile consists of a number of distinct layers called horizons which usually have distinct boundaries.

TASK 3

Put the paragraphs into the correct order and label the horizons in the column with the letters used for the horizons.

The A horizon is found below the O layer. This layer is composed primarily of mineral particles, which has two characteristics: it is the layer in which humus and other organic materials are mixed with mineral particles, and it is a zone of translocation from which eluviation has removed finer particles and soluble substances, both of which may be deposited at a lower layer. Thus the A horizon is dark in colour and usually light in texture and porous. The A horizon is commonly differentiate into a darker upper horizon or organic accumulation, and a lower horizon showing loss of material by eluviation.

The C horizon is composed of weathered parent material. The texture of this material can be quite variable with particles ranging in size from clay to boulders. The C horizon has also not been significantly influenced by the pedogenic processes, translocation, and/or organic modification.

The O horizon is the topmost layer of most soils. It is composed mainly of plant litter at various levels of decomposition and humus.

☐

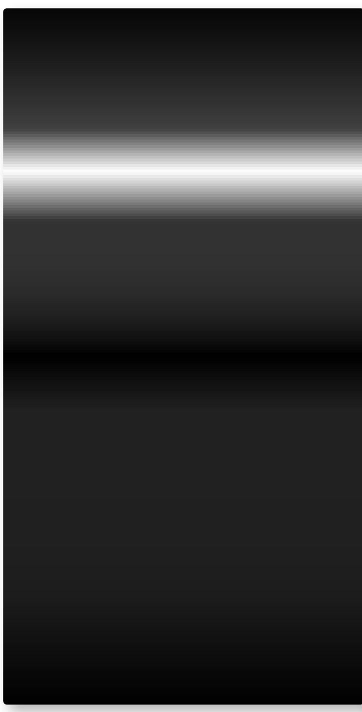
The final layer in a typical soil profile is called the R horizon This soil layer simply consists of unweathered bedrock.

☐

The B horizon is a mineral soil layer which is strongly influenced by illuviation. Consequently, this layer receives material eluviated from the A horizon The B horizon also has a higher bulk density than the A horizon due to its enrichment of clay particles. The B horizon may be coloured by oxides of iron and aluminium or by calcium carbonate illuviated from the A horizon.

☐

Source: http://www.physicalgeography.net



Horizon ___

Horizon ___

Horizon ___

Horizon ___

Horizon ___

TASK 4

Match the term "eluviation" and "illuviation" to the definitions. Where is the illuviation and eluviation layer located?

❶ ______

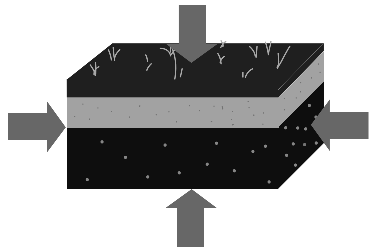
Refers to the movement of the fine mineral particles or dissolved substances out of an upper layer in a soil profile.

❷ ______

Refers to the deposition of fine mineral particles or dissolved substances in a lower soil layer.

Unit 12 Soil Testing Equipment I

Testing Equipment for Soil Compaction and Bearing Capacity



1 Introduction

The dynamic plate load test employing the light drop-weight tester is used in earthwork and road construction to determine the soil bearing capacity and the compaction or consolidation of soils and non-cohesive subbases, as well as for soil improvement application. The test method is suited for coarse-grain and mixed-grain soils having a maximum grain size of 63 mm. The test method may be used to determine the dynamic modulus of deformation of soil in the range Evg = 15 ... 80 MN/m²

Source: Controls Equipment for the Construction Industry, Catalogue 2005; p. 135

2 Fields of Application

TASK 1

Name some fields.

- ____________________
- ____________________
- ____________________
- ____________________

3 Advantages

TASK 2

Match the given advantages with the advantages in A-D.

Time-saving immediate evaluation of each measurement	1	Ideal for restricted access	A
Testing in locations not readily accessible	2	Fast result	B
Low testing weight	3	Simple one-man operation	C
No vehicle required for loading	4	Light weight	D

1__ 2__ 3__ 4__

4 Function

Place the load plate on the prepared surface to be tested and position the loading unit on the load plate. Connect the settlement meter. The drop weight is allowed to drop onto the spring element, the loading unit produces a defined impacted load and the overall amount of compaction (or settlement) of the soil under the load plate is measured. Once the measuring routine is started perform three impact cycles for the measurement. Following each cycle the meter displays the amount of settlement in millimetres. Upon completion of a series of measurements, the settlement is averaged, and the dynamic modulus of deformation is determined and displayed. Results can be printed out on a micro-printer or on a printer connected to a PC as necessary.

Source: Controls Equipment for the Construction Industry, Catalogue 2005; p. 135

5 Specifications

1. Load unit

15 kg: ❶ ______________________

10 kg: ❷ ______________________

7.07 kN: ❸ ______________________

18 ms: ❹ ______________________

cup springs: ❺ ______________________

2. Load plate with integral acceleration transducer

300 mm: ❻ ______________________

20 mm: ❼ ______________________

15 kg: ❽ ______________________

3. Electronic gauge

210x80x25 mm: ❾ ______________________

0.10 - 2.0 mm +/- 0.02 mm: ❿ ______________________

0 - 40 °C: ⓫ ______________________

(rechargeable) batteries: ⓬ ______________________

TASK 3

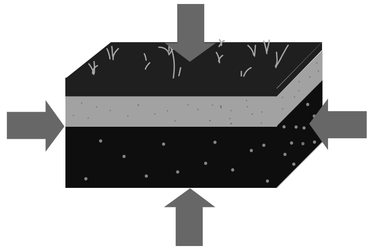
Write the ‘specifications’ into the appropriate lines.

1. duration of impact - total weight - max. impact force - spring element - drop weight

2. thickness of plate - diameter - total weight

3. temperature range - power supply - dimensions - measurement range of settlement

Unit 13 Soil Testing Equipment II



Stress Measurement Methods

General Introduction

The settlement of soil-supported foundations and the change in earth pressure due to small movement of retaining walls or other earth supports, the yield of soil caused by local application of load, are determined by the relation between stress and strain in soils. The experimental investigation used to determine the stress-strain relation is usually carried out with a triaxial compression test. During the test, the undisturbed soil samples are gradually stressed up to failure, which corresponds to the maximum shear strength. The test is performed placing a cylindrical soil sample, enclosed in a rubber membrane, in a triaxial cell and subjecting it to an isotropic fluid pressure. An axial load is subsequently applied on the specimen through a loading piston in such a way that the soil sample is deformed at a constant rate of strain. Generally speaking, the triaxial tests are performed to simulate different types of stress and drainage conditions that can occur in the subsoil because of the effect of building constructions, excavations, tunnelling etc.
Three different triaxial tests are usually performed for total and effective stress measurement.

Source: Controls Equipment for Construction, Catalogue 2005; p. 71

TASK 1

Match the description to the terms.
“dry”, “not dry”, “soil material in a loosely aggregated form”, “former loosely aggregated materials which have become firm or coherent rocks”, “emptied”, “not emptied”

consolidated: ____________________

____

____

unconsolidated: ____________________

____

____

drained: ____

____

____

undrained: ____

____

____

TASK 2

Fill in the gaps with:
"cause changes" or "do not cause changes"

Drained is the condition under which water is able to flow into or out of a mass of soil in the length of time that the soil is subjected to some change in load. Under drained conditions, changes in the loads on the soil ❶ ________________ in the water pressure in the voids in the soil, because the water can move in or out of the soil freely when the volume of voids increases or decreases in response to the changing loads.

Undrained is the condition under which there is no flow of water into or out of a mass of soil in the length of time that the soil is subjected to come change in load. Changes in the loads on the soil ❷ ________________ in the water pressure in the voids, because the water cannot move in or out in response to the tendency for the volume of voids to change

Source: after: J.M. Ducan, St. W. Wright: Soil Strength and Slope Stability, New York: John Wiley & Sons, New York 2005, p. 19

Total stress measurement: Unconsolidated Undrained (UU) tests

With this method the shear strength is measured with respect to total stress. The soil specimen (assumed saturated) is not allowed to consolidate, maintains its original structure and water content, so that its resistance only depends on the level of geostatic stress in the field.

Tests are usually carried out on three specimens of the same sample, subjected to different confining pressure. Provided that the soil is fully saturated, the effective stresses at failure is the same for each test.

The Mohr envelope, plotted with respect to total stress is horizontal and the shear strength is constant and equal to Cu (undrained shear strength).

Effective stress measurement Consolidated Undrained (CU) tests

With this test method the shear strength is measured in terms of effective stress. At least three specimens are allowed to consolidate (i.e. to change its structure and water content) at different level of confining pressure before failure.

During the failure stage the specimen is not allowed to drain and pore pressure is measured, so that the effective stresses are calculated as the difference between the total stress and the pore pressure.

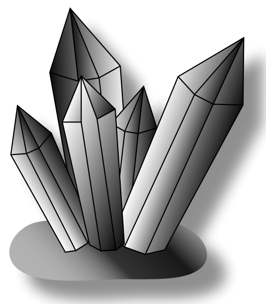
Effective stress measurement Consolidated Drained (CD) tests

This test method is similar to the „CU“ test as the shear strength can be related to the applied level of stress. At least three specimen are allowed to consolidate at different levels of confining pressure. The failure stage is carried out very slowly to prevent the increase of pore pressure inside the specimen, which is allowed to drain. The total and effective stresses are the same. Mohr circles are drawn for effective stresses at failure and the parameters c‘ and φ‘ are determined from the Mohr envelope.

Source: Controls Equipment for the Construction Industry, Catalogue 2005; p. 71

Unit 14 Mineralogy I

What makes a mineral?



TASK 1

Match the subfields of geology to their definitions.

mineralogy 1	the scientific study of rocks A
petrology 2	the scientific study of mineral behaviour under pressure and temperature B
mineral physics 3	the scientific study of minerals C

1__ 2__ 3__

The following text gives us some clues about the relation of rocks and minerals...

A rock can be defined in many ways, from the colloquial: a hard stone; to the engineering: a mass of material to be blasted or excavated. The geologist sees a rock as an assemblage of minerals. A mineral is a solid chemical compound that is characterized by a definite composition or a restricted range of chemical compositions and by a specific, regular architecture of the atoms that make it up. Like all chemical compounds, minerals are homogeneous: A mineral cannot be separated mechanically into different substances. Although a rock is a collection of the chemical elements that make it up, those elements are not distributed randomly. Each element is found in one or more minerals in a rock in proportion to the abundance of that mineral or minerals. Some minerals have complex chemical compositions, including many elements. Others are simple. Quartz, for example, is SiO_2, which consists of only two elements. A few elements - carbon, for example - are the only components of minerals: Graphite and diamond are composed only of carbon, each with a different architecture.

In coarse-grained rocks the minerals are large enough to be seen with the naked eye. In some rocks the minerals can be seen to have crystal faces, smooth planes bounded by sharp edges; in others, such as a typical sandstone, the minerals are in the form of fragments without faces. In fine-grained rocks, the individual mineral grains are so small that they can be seen only with a powerful magnifying glass, the hand lens that the field geologist carries. Some are so small that a microscope is needed to make them out.

Minerals have been conventionally defined as naturally occurring inorganic substances.

... and about the distinction of minerals by their properties.

On the basis of certain characteristics, particularly physical and chemical properties, several thousand minerals can be distinguished, each defined by its unique set of properties. Colour is one obvious characteristic. Differences in hardness were found to make it easy to distinguish between minerals that look similar. How minerals break apart, some showing smooth cleavage planes and others rough irregular fractures, proved to be a reliable way to identify certain minerals. Simple chemical tests were found useful in the field, such as dropping acid on a mineral suspected of being calcite ($CaCO_3$) to see whether the mineral would fizz as it dissolved, releasing carbon dioxide bubbles.

Early in the study of minerals it was realized that all grains or crystals of a mineral, like quartz, have just about the same qualities regardless of the kind of rock in which they are found. Some minerals, particularly those that have a more complex mixture of atoms, vary slightly in their properties, depending on their precise composition. A mineral like garnet, for example, has a number of varieties. Each variety has its own range of composition, such as the proportions of iron and other elements, and hence, its own set of properties.

Adapted from: Press, F., Siever, R.: Earth, 1986

TASK 2

Fill in the gaps.

Minerals, each of which has a distinctive set of ❶ ______________ and ❷ ______________ properties used to identify it, are either ❸ ______________ grained or ❹ ______________ grained.
In the first case the individual grains can be seen with the eyes, whereas in the second case the individual grains or ❺ ______________ are too small to be seen without magnifying glasses or microscopes.

adapted from: Press, 1986, p. 55

From the text and in your geology courses your have learned a lot about mineralogy. Test your knowledge now by fulfilling the following tasks. Work in groups.

TASK 3

Define the terms.

Mineral	Crystal structure

TASK 4

Name the most common mineral groups (6 groups) and put the following minerals (Apatite, Dolomite, Galena, Gypsum, Magnetite, Quartz) into the table. Fill in other minerals.

Group:						

TASK 5

Now decide if the following statements about minerals are true or false.
If they are false, correct the statements.

Statement	True	False
1. About 1000 different minerals are known.	☐	☐
2. From all the minerals known approximately 50 minerals form the Earth's crust.	☐	☐
3. The most common minerals groups are: silicates, carbons, carbonates, sulfides, sulfates, phosphates.	☐	☐
4. Minerals are artificial substances with a characteristic crystal structure.	☐	☐
5. The geometric array of atoms is a crystal structure.	☐	☐

TASK 6

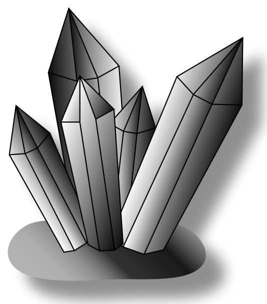
What information can you get by studying and analysing minerals in the laboratory? Think of various aspects and take into account: past climates, the composition of seawater, the formation of diamonds etc.

TASK 7

Discuss the role of minerals and their natural deposit as an economic resource.

Unit 15 Mineralogy II

Properties of minerals



As you have learnt from the text in the previous unit minerals are naturally occurring crystalline solids which can be identified by their basic physical, chemical and mechanical properties.

TASK 1

The most common minerals can be identified by **“luster”, ”hardness”, “cleavage and fracture”, “colour and streak”, “transparency”, “magnetism”, “specific gravity or density”** an **“crystal form”**
Match the definitions or description to the properties.

1. ________________________ is the property of breaking easily at random lines.
2. ________________________ is the measure of the ease with which the surface of a mineral can be scratched.
3. ________________________ is the characteristic of a mineral that tells how the mineral reflects light, i.e. how shiny it is.
4. ________________________ is the characteristic that tells you if you can see through it.
5. ________________________ can be seen; i.e. it is visual perception.
6. ________________________ is the shape in which the individual crystals grow.

7. ______________________ is the splitting of minerals along planes.

8. ______________________ the colour of a mineral under the top layer or coating of the mineral.

9. ______________________ is the property of a mineral which depends on the atomic weight.

10. ______________________ if a mineral has this property, it contains a high quantity of iron.

The descriptions of four minerals are given as an example.

Galena

Galena is an important source of lead. Galena‘s chemical symbol is PbS, which is lead and sulfur. Galena may also contain silver. The United States is the leading producer of lead in the world. Lead was used in pencils and paint until it was found to be poisonous to humans. Today pencil „lead“ is made of another mineral called graphite.

Galena is an iron sulfide and the main source of lead. Galena usually occurs in cubic crystals. If you hit a specimen of galena with a hammer it will shatter into small perfect cubic crystals. It has a metallic luster and a black to dark gray color and streak. Galena has a hardness of about 2.5 on Mohs hardness scale which is about as hard as your finger nail.

Calcite or Calcium carbonate

Calcite is pure calcium carbonate (CaC03). It is found in limestone and marble. It is the cementing agent that binds sediments together into sedimentary rocks. Marble is metamorphosed (changed by heat and pressure) limestone. The crystals formed from pure calcite are in the form of a perfect rhomboid. A rhomboid is a six-sided solid object in which the opposite sides are parallel. It has perfect cleavage in three directions. If you hit calcite with a hammer it will break into smaller but perfectly shaped rhomboids. Calcite is number twree on Mohs hardness scale. Calcite is the material that forms stalactites and stalagmites in caves.

Calcite is used as a fertilizer, cement, chalk, building stone, and for the manufacture of optical instruments.

Magnetite

Magnetite is a mineral that has a very high iron content. Magnetite has a black or brownish-red colour and a black streak. It has a hardness of about 6 on the Mohs’ hardness scale. It is one of two minerals in the world that is naturally magnetic. Magnetite is also known as lodestone.

Magnetite is an important source of iron ore and occurs in many igneous rocks.

Hematite or Iron ore

Hematite is the most important source of iron ore in the world. The production of iron has been important to nations of the world for over 2500 years. Today the addition of other minerals to iron has led to the production of steel which is vital to the economy of the major countries on Earth. Hematite has a red or black color but the streak is always red. The iron in the hematite turns red when it comes in contact with water and oxygen. In other words this rock is rusted! Hematite has a metallic or earthy luster. The hardness of hematite is about 5 on Mohs hardness scale. It has no cleavage and breaks with an uneven fracture. The reddish landscape of Mars is due to the oxidized iron on its surface. This tells us that water and oxygen must have been present on Mars at one time.

Source: http://volcano.und.edu/vwdocs/vwlessons/lessons/Minerals/Minerals11.html

TASK 2

Test your knowledge about Quartz. Fill in the words: “cleavage”, “crystal form”, “colourless”, “hardness”, “glass”, “grains”, “luster” and “pyramid”.

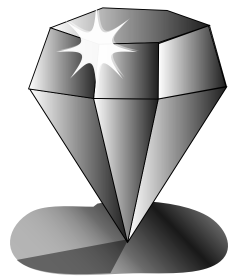
The Silicate “Quartz”

Its chemical formula is SiO_2. Quartz has a vitreous ❶ ________________, a ❷ ________________ of 7, and when pure, is completely clear and ❸ ________________. It looks like frozen water. It lacks ❹ ________________, but it commonly fractures conchoidally. Should quartz grow free from interferences it crystallizes customarily in a six-sided ❺ ________________, which is terminated by a sharp-pointed pyramid at each end. If quartz grows into cavities, as it commonly grows, it will possess only one ❻ ________________ on the end of crystal that extends into the opening. Crystal that grow into openings may sometimes reach length of 0.3 m or more. Usually quartz occurs in association with other minerals as tiny ❼ ________________ two to three millimeters across that generally lack crystal faces. Where fresh and unweathered the disseminated grains often sparkle like tiny fragments of ❽ ________________.

Source: after: Peter W. Birkeland u.a.: Putnam’s Geology, New York: OUP, 1978, p. 78

Unit 16 Mineralogy III

Diamond. The ultimate mineral



Mohs' hardness scale of mineral hardness: A method of identifying minerals.

Hardness	Mineral	Formula	Absolute Hardness
1	Talc	$Mg_3Si_4O_{10}(OH)_2$	1
2	Gypsum	$CaSO_4 \cdot 2H_2O$	2
3	Calcite (=Kalkspat)	$CaCO_3$	9
4	Flourite (=Flußspat)	CaF_2	21
5	Apatite	$Ca_5(PO_4)_3$(OH-, Cl- F-)	48
6	Orthoclase Feldspar	$KAlSi_3O_8$	72
7	Quartz	SiO_2	100
8	Topaz	$Al_2SiO_4(OH-, F-)_2$	200
9	Corundum	Al_2O_3	400
10	Diamond	C	1500

On the relative **hardness-scale** the mineral diamond is on top (hardness 10) and in terms of absolute hardness, a diamond is about four times harder than the next hardest mineral "corundum".

Hardness describes the scratch resistance of minerals; i.e. the ability of a harder material to scratch a softer material.

TASK 1

Read the text.

The Mineral Diamond

- **Chemistry: C, Elemental Carbon**
- **Class: Native Elements**
- **Subclass: Non-metallics**
- **Group: Carbon**
- **Uses: as a gemstone and abrasive.**

Diamond is the ultimate gemstone, having few weaknesses and many strengths. It is well known that Diamond is the hardest substance found in nature, but few people realize that Diamond is four times harder than the next hardest natural mineral, corundum (sapphire and ruby). But even as hard as it is, it is not impervious. Diamond has four directions of cleavage, meaning that if it receives a sharp blow in one of these directions it will cleave, or split. A skilled diamond setter and/or jeweler will prevent any of these directions from being in a position to be struck while mounted in a jewelry piece.

As a gemstone, Diamond‘s single flaw (perfect cleavage) is far outdistanced by the sum of its positive qualities. It has a broad color range, high refraction, high dispersion or fire, very low reactivity to chemicals, rarity, and of course, extreme hardness and durability.

In terms of it‘s physical properties, diamond is the ultimate mineral in several ways.

Source: http://www.galleries.com/minerals/elements/diamond/diamond.htm

TASK 2

Match the terms to the descriptions: **“clarity”, “hardness”, “lattice density”, “melting point”** and **“thermal conduction”**

❶ ______________________ Diamond is a perfect „10“, defining the top of Mohs‘ hardness scale.

❷ ______________________ Diamond is transparent over a larger range of wavelengths (from the ultraviolet into the far infrared) than is any other solid or liquid substance - nothing else even comes close.

❸ ______________________ Diamond conducts heat better than anything -five times better than the second best element, Silver!

❹ ______________________ Diamond has the highest melting point (3820 degrees Kelvin)!

❺ ______________________ The atoms of Diamond are packed closer together than are the atoms of any other substance.

after: see source from text above

TASK 3

Why is a diamond the ultimate gemstone?

____

____

____

____

____

____

TASK 4

The text goes on with a comparison of diamonds and graphites. Find the opposites of the words and fill in the gaps.

word	opposite
hard	
insulator	
abrasive	
transparent	
isometric system	

Diamond is a polymorph of the element carbon. Graphite is another polymorph. The two share the same chemistry, carbon, but have very different structures and properties. Diamond is ❶ ________________, Graphite is ❷ ________________ (the „lead“ of a pencil). Diamond is an excellent electrical ❸ ________________, Graphite is a good ❹ ________________ of electricity. Diamond is the ultimate ❺ ________________, Graphite is a very good ❻ ________________.

Diamond is ❼ ________________, Graphite is ❽ ________________. Diamond crystallizes in the ❾ ________________ and graphite crystallizes in ❿ ________________. Somewhat of a surprise is that at surface temperatures and pressures, Graphite is the stable form of carbon. In fact, all diamonds at or near the surface of the Earth are currently undergoing a transformation into Graphite. This reaction, fortunately, is extremely slow.

Physical Characteristics of Diamond

- Color is variable and tends toward pale yellows, browns, grays, and also white, blue, black, reddish, greenish and colorless.
- Luster is adamantine to waxy.
- Transparency crystals are transparent to translucent in rough crystals.
- Crystal system is isometric; 4/m bar 3 2/m
- Crystal habits include isometric forms such as cubes and octahedrons, twinning is also seen.
- Hardness is 10
- Specific gravity is 3.5 (above average)
- Cleavage is perfect in 4 directions forming octahedrons.
- Fracture is conchoidal.
- Streak is white.
- Associated minerals are limited to those found in kimberlite rock, an ultramafic igneous rock composed mostly of olivine.
- Other characteristics: refractive index is 2.4 (very high), dispersion is 0.044, fluorescent.
- Notable occurrences include South Africa and other localities throughout Africa, India, Brazil, Russia, Australia, and Arkansas.
- Best field indicator is extreme hardness.

Source: http://www.galleries.com/minerals/elements/diamond/diamond.htm

Unit 17 Minerals in Industry and Economy

Why are minerals so important?

TASK 1

Translate the English words.

economic development	→
exploration	→
hydrocarbons	→
minerals testing	→
prospectivity assessment	→
rehabilitation	→
raw materials	→
self-sufficiency	→
reservoir geology	→
state-of-the-art laboratories	→

TASK 2

Fill the English words from task 1 into the gaps of the following text.

A country's mineral wealth is a vital national asset. Minerals can play a fundamental role in wealth creation and ❶ _______________ as well as providing the essential ❷ _______________ needed to support a country's industry and the secondary employment it generates, can often load the way to economic ❸ _______________.
BGS can provide expertise in all areas of minerals' development from initial ❹ _______________ to reconnaissance geological and mineral surveys, to metallogenetic modelling, ❺ _______________ and final prospect evaluation. We have specialists in metallic and industrial minerals, coal geology and ❻ _______________, and can advise or such aspects as minerals planning; mineral, commodity and trade statistics; mineral processing; ❼ _______________ and basin analysis; small-scale mining; and geological and geoscientific modelling. Backed by ❽ _______________ and the latest information technology systems, BGS can provide experts at all stages of data gathering and the design of databases, including GIS and web-based systems. We are at the forefront of mineral-lifecycle analysis and specialise in developing complete solutions that take account of the environmental, economic and social implications of developing a resource through from ❾ _______________ to production, to post-production clean-up, and final ❿ _______________ and management of waste. This holistic approach aims to spread the benefits of mineral development as widely as possible, and assists decision-making at local, regional, national and international levels.

Source: after: BGS brochure, 2002

The intrinsic value of mineral resources

Indigenous mineral resources are valuable national assets. They can only be worked once, and then at locations where they are of the right quality and where they occur in sufficient quantity. A mineral resource can be regarded as ‚money in the bank' but once extraction is completed that particular resource is lost forever. Some of the demands for minerals can be met by recycling, but new minerals are still required. It is essential therefore that when these non-renewable resources are exploited it should be done with full regard to optimum utilisation, efficient extraction and processing methods and minimising waste.

Why are minerals important?

Minerals are important national resources and adequate supplies are essential for the development of a modern economy. Thay play a fundamental role in underpinning the growth of many important sectors of the UK economy and in contributing to the UK's high standard of living.

Minerals are basic and essential raw materials for:

construction: to develop, maintain and enhance our built environment and transport infrastructure

manufacturing: for the production of a wide range of industrial and consumer goods

fuel and power: for use in the home, industry and commerce

agriculture: to improve the productivity of the soil

The UK is largely self-sufficient in construction and energy minerals. However, it is almost entirely reliant on imports of metals, and largely dependent on imports of certain industrial (non-metallic) minerals, such as china clay, ball clay and potash, are also important exports.

Source: http://www.mineralsuk.com/britmin/mm3.pdf

TASK 3

Give more detailed examples and why minerals are important in industrial or agricultural areas.

construction

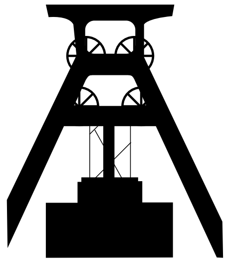
manufacturing

fuel / power

agriculture

Unit 18 Tara Mines I

A Zinc and Lead Mine in Ireland - Exploration and extraction of minerals



Facts and Figures about Tara Mines in Ireland

- Tara Mines is the largest zinc mine in Europe.
- Ore production totalled 2.02 m tonnes at a grade of 7.38 % Zn and 2.19 % Pb (1999).
- planned capacity of 2.55 m tonnes of ore mined annually yields lead and zinc concentrates containing some 200,000 tonnes of zinc metal respectively.
- The current known total reserves and resources support the mining of Navan ore bodies until the year 2008, and as exploration continues, it is anticipated that further reserves will be found.
- In 1986 Outokumpu, one of the world‘s leading base metal companies bought into Tara Mines by taking up 75 % of its shares.
- In 1989 the Irish government sold its 25 % holding in Tara Mines to Outokumpu, thus giving it full control.

Information adapted from: Brochure of Tara Mines, For further information see: http:\\www.outokumpu.com

TASK 1

Fill in the gaps: “alloys”, “galvanizing”, “iron”, “oxide” and “sulphur”

Zinc

Zinc, chemical symbol Zn, is a lustrous bluish-white metal. It is mainly used in ❶ _______________ steel to prevent rusting, in zinc die-casting alloys and in copper-based ❷ _______________, such as brass. Zinc is also essential to the growth of many kinds of organisms, both plant and animal. It is a relatively rare element in the Earth‘s crust where its average concentration is 70 parts per million (ppm). It combines with ❸ _______________ to form the mineral sphalerite (ZnS) which is the main commercial source of zinc. Sphalerite also contains about 0.2% cadmium, varying amounts of ❹ _______________ (up to 10%) and traces of indium, gallium and germanium of which it is the main source. It occurs naturally as the ❺ _______________ (ZnO), carbonate ($ZnC0_3$) and sulphate ($ZnSO_4$).

after: http://www.mineralsuk.com/britmin/zinc_23apr04.pdf

TASK 2

Why is zinc that important in industry?

Exploration

In the late 1960‘s, soil geochemistry revealed a strong zinc anomaly over the shallowly buried orebody to the north of the Blackwater River;

Today, exploration continues over the more deeply buried extensions of the orebody to the south west of the mine, and in the structurally complex area to the south.

Surface based and down-the-hole geophysics are employed as reconnaissance tools to direct the expensive deep diamond drill holes towards the best possible targets.

During the 1990‘s exploration discovered two new ore lenses in the deeply buried area to the south-west of the mine. Additional resources of 13.5Mt at 8.9% Zn and 1.8% Pb have been added to the Tara‘s resource base. Today exploration continues in these deeply buried areas and there is immense potential for the discovery of further resources. Geological and geophysical models guide exploration and use is made of advanced directional drilling, which allows the ore lenses to be accurately targeted while keeping costs to a minimum.

Directional drilling was successfully introduced at Tara to help explore the deeply buried extensions to the orebody in 1996. The technique allows numerous ‚daughter‘ holes to be drilled from a single ‚mother‘ hole providing considerable cost and time savings.

Since drilling began in 1970, over 1,500 surface boreholes have been completed producing over 500 kilometres of core. A further 14,000 holes have been drilled from underground mine openings. The high level of drilling is required to define the detailed geology of the host rocks; the attitude and grade of the complex ore lenses and the intensive faulting associated with the Navan area.

Incomplete information on orebody outlines would result in increased dilution due to the addition of waste rock into the ore blasted. Similarly, insufficient drilling could fail to identify the full extent of some ore lenses leaving some payable material undiscovered and unmined.

Source: Tara Mines

TASK 3

1. Which type of exploration drilling proofed to be the most successful one?

2. Why is such a high level of drilling required?

Orebody Evaluation and Mineral Reserves

Detailed geology and orebody definition results from interpretation of a combination of surface and underground diamond drill cores, assay results, borehole geophysics, geological mapping and local and regional geological knowledge .

Diamond drilling, a process which removes a small continuous „core“ of the rocks drilled, is carried out in several distinct stages.

Following initial widely spaced exploration drilling, ore is delineated from surface using an 80m to 160m grid. Where the ore lenses accur at greater depths, the directional drilling technique is used to provide holes approximately 50m apart on widely spaced drilling sections (160m). In key areas, intermediate holes are drilled from surface to provide more confidence in the continuity of ore and geological structure before expensive underground development takes place.

The „cores“ allow correlation of the geology from hole to hole (rock type, structure, depth etc) and determination of zinc-lead grade from assay values of the core. From this information, the geologists interpret the basic outline of the underlying orebody.

Underground exploration tunnels are then mined above the outlined orebody to allow drilling of a pattern of cored holes at a 25 metre spacing. This information, together with the mapping of geology exposed in the drifts themselves, allows a more detailed interpretation of the orebody based on which the main development and extraction of the mine is planned.

From the stoping drifts mined along the orebody footwall, a final stage of drilling, combined with further geological mapping, allows the geologists to interpret the precise detail of the geology, and the tonnage and grade of ore to be recovered from each individual production unit.

All of the geological data acquired through these stages is included in a computer database, together with information from the Survey, Mine Planning and Geotechnical Departments. Mineral reserves in mining blocks and in planned stopes are calculated by computer and the system also generates all plans and sections required by Geology and Mine Engineering.

Mineral Reserve/Resource categories are based on diamond drilling density and also on economic feasibility for mining.

„Resources“ are defined by 160 to 80m spaced drillholes from surface (Inferred category) together with marginally economic material drilled from underground tunnels at closer spacing (Indicated / Measured categories).

”Reserves“ consist of material drilled from underground at 25m spacing (Probable category) or 10-I5m spacing (Proven category), which is currently economical to mine.

Current (December 1999) reserves of 13.7Mt grading 9.5% Zn and 2.4% Pb and resources of 16.6Mt grading 6.3% Zn and:2.1% Pb are sufficient to extend the mine life to the year 2008 and beyond based on current economic factors and production rates.

Surface diamond drilling continues to add to these, replenishing some of the ore extracted from reserves in the course of production.

Source: Tara Mines

TASK 4

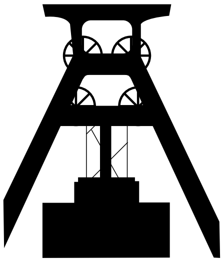
1. For mineral evaluation drilling must be combined with further geological mapping, borehole geophysics and general geological knowledge about the region of mining. Explain why?

2. What kind of information do geologists get from exploration drilling?

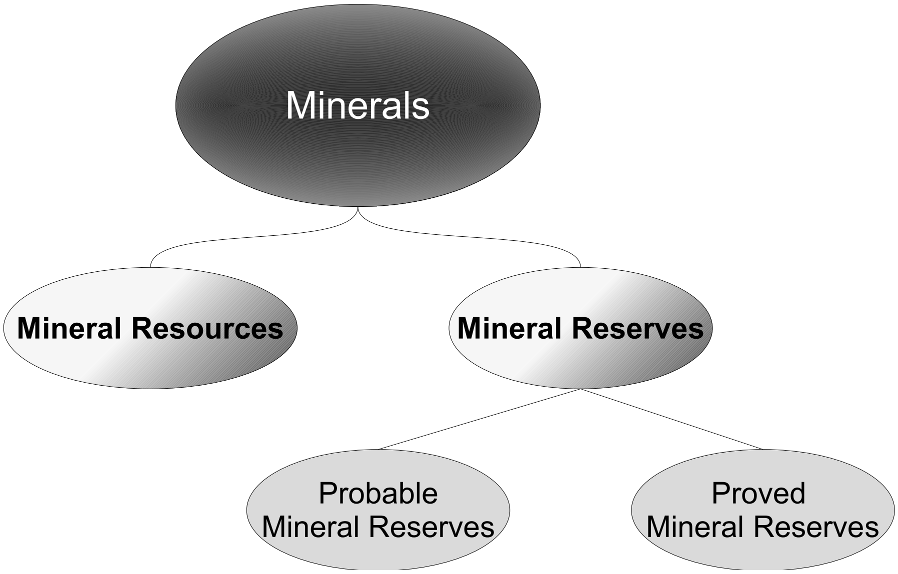
3. Explain what is meant by "economic feasibility for mining"?

Unit 19 Tara Mines II

Mining and production of minerals



Minerals – What makes a mine?



TASK 1

Fill in the terms "**resources**" or "**reserves**" into the text.

Mineral reserves and resources – what are they?

The words resources and reserves are often used in discussing economically important minerals. It is important to know the definitions of these two terms and to understand how they relate to one another, and to minerals in the ground.

Mineral ❶ ________________ are natural concentrations of minerals or bodies of rock that are, or may become, of potential economic interest as a basis for the extraction of a commodity. They have physical and/or chemical properties that make them suitable for specific uses and are present in sufficient quantity to be of intrinsic economic interest. Measurement of the size and shape of the ❷ ________________ is the first step towards delimiting a mineral ❸ ________________.

That part of a mineral ❹ ________________ that has been fully geologically evaluated and is commercially and legally mineable is called a mineral ❺ ________________. In the UK the term should strictly be limited to those minerals for which a valid planning permission for extraction exists, termed permitted ❻ ________________. Mineral ❼ ________________ are sub-divided in order of increasing confidence into probable mineral ❽ ________________ and proved mineral ❾ ________________. The ultimate fate of mineral ❿ ________________ is usually to be either physically worked out or to be made non-viable, either temporarily or permanently, be changing economic circumstances.

Source: after: http://www.mineralsuk.com/britmin/mm5.pdf

Mining and Production

Generally, **stopes** and **pillars** have been laid out with their long axes parallel to **strike**. This has reduced the amount of **footwall** development in waste and facilitated **stope** access through haulage pillars that are essentially aligned **down dip**.

Stope and **pillar** dimensions have evolved over time from an initial 12.5m width for both, to the present less rigid dimensions. Widths vary from 15m to 25m and are now determined on a case by case basis and are controlled by local features such as **bedding planes, faults, joints**, and adjacent openings. Heights are also variable and depend on the thickness of the ore, ranging from 5m to 60m. Average unit sizes are in the region of 15-25,000t per stope / pillar, giving rise to a total requirement of approximately 100 stoping units per year.

Stoping takes the form of **blasthole** open stoping. Either one or two **footwall** undercut **drifts** are driven (depending on stope width) in positions that maximize ore recovery and minimize waste dilution. A **hanging wall** drift is developed where the ore height exceeds 25m and a slot raise is then developed from footwall to the **hanging wall** contact, either at the end or the stope or centrally located depending on the **mucking** accessibility. This slot is widened to full stope width, the **footwall drift** is widened to provide a complete undercut and the main blasthole rings, drilled from the footwall, or **hanging wall drift**, if present, are blasted into this void. The ring drilling fan hole pattern, drilled at right angles to the long axis of the **stope**, is designed with a 2.2 m burden between rings and a 2.4m toe spacing between holes, although this can be changed to suit local conditions. Production **blasting** occurs at the end of day shift The broken ore is removed by loader from the stope and taken to one of the **crushing** stations either by loader or truck depending on the distance of travel.

The **blasting/mucking** sequence continues until the stope is completely mined out, after which it is filled with sandfill, cement and/or development waste, the proportions of which are determined by location and adjacent mining plans.

The sand fill material, which is the coarse fraction of the concentrator tailings, is transferred hydraulically to the stopes and pillars underground through surface pipelines, boreholes and an underground pipeline network. To facilitate the mining of pillars between sandfilled stopes cement is added to the sand to increase its cohesion at ratios of cement to sand of between 1:15 and 1:40. The ratio depends on the planned height of exposure. Each stope filling operation is planned to optimize future ore recovery from the pillars and the economics of designed cement additions are analyzed.

Ore from the remaining pillars is extracted in the same manner. Once they are mined the resultant voids are then backfilled with **unconsolidated sand and/or waste**.

The broken ore from both production and development is delivered to one of the four crushing stations where it is reduced in size to less than 150mm at rates of up to 400tph. Crushed ore is carried by **conveyor** to a storage bin of 3,600t capacity located adjacent to the production shaft from where it is fed to the shaft **skip loading pockets**. The ore hoisting cycle is automatic, the control of the ore feeders and transfer conveyors and skip loading being regulated by the hoisting cycle and the weigh cells at each loading pocket. Ore is **hoisted** in two 15t capacity **bottom dump skips** running in balance, tipped into a small bin at the headframe and then conveyed to a 30,000t surface storage facility. The shaft, 5.03m diameter inside the **concrete lining**, is equipped throughout in steel and contains two **hoisting** compartments, a ladderway, and a service compartment.

Source: Tara Mines

TASK 2

Before reading the text for further information about mining and the production of zinc in Tara Mines a thorough knowledge of terms used in mining and related fields is necessary.

English	Translation
stope	
pillar	
strike	
footwall	
faulage	
down dip	
bedding plane	
faults	
joints	
blast holes	
drift	
hanging wall	
mucking	
burden	
blasting	
crushing	
tailing	
conveyor	
shaft	
skip loading pocket	
hoisting	
bottom dump skips	
concrete lining	
unconsolidated sands	

footwall

____

____

____

faults

____

____

____

hanging wall

____

____

____

blasting

____

____

____

hoisting

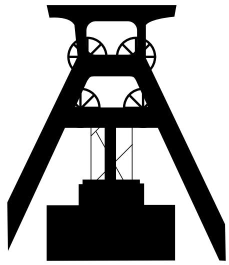
____

____

____

Unit 20 Tara Mines III

Processing of minerals



Processing

Tara ore contains zinc and lead sulphide minerals as well as smaller amounts of other non valuable metals. The host rock is limestone which contains both calcite and dolomite. These minerals are tightly bound together within the ore and the objective of ore processing is to recover the valuable lead and zinc minerals into two separate saleable grade concentrates. This is achieved in a number of processing stages.

1. Comminution

The first stage of the process is underground blasting and crushing of the ore to minus 150 mm. This primary crushed ore is hoisted to surface and stored in the coarse ore storage building.
The crushing process continues with two stages of cone crushing to produce a product size of minus 16mm. All equipment in the crushing area is enclosed and just is extracted to wet scrubbers. The ore is then mixed with water and fed to the grinding circuit. Steel grinding in three milling stages reduces the ore to 80% by weight minus 75 microns. The crushing and grinding circuits are fully automated using computer control and are monitored from the central control room. The finely ground ore slurry is then pumped to the next process stage -flotation. Here the lead and zinc minerals are separated from the waste rock to produce Tara's two products: lead concentrate and zinc concentrate.

2. Flotation

The flotation circuit consists of a series of cells. Each cell is equipped with a rotating agitator which disperses air and maintains the mineral particles in suspension. Various chemicals are added to the lead and zinc flotation circuits. The valuable minerals are „collected" and carried by air bubbles which form a froth phase on the top of each cell. This mineral bearing froth is allowed to overflow into collection launders. Water sprays are used to disperse the froth and the final products are pumped to separate dewatering circuits. Lead concentrate contains approximately 67% lead metal and the zinc concentrate contains 56% zinc metal.

3. Dewatering

Lead dewatering is carried out in two stages: thickening and pressure filtration, yielding a final residual moisture content of 6%. Zinc dewatering is also carried out in two stages:- thickening and pressure filtration, yielding a final residual moisture content of approximately 9%. Both circuits are automated using PLC control systems.

4. Tailings and Backfill

The waste by-product material from the flotation process is known as tailings. Slimes and fine particles are removed using hydrocyclones and are pumped to the tailings pond which is located 5km from the mine site. The suspended solids settle out and clean water is recirculated to the mine site for re-use in the various processes. The remaining coarser tailings particles (i.e. sand) are stored in sand tanks. When backfill is required underground, water and cement are added to the sand which is then pumped through boreholes into open stopes. Each year in excess of 1 million tonnes of tailings sand is pumped to the mine as backfill.

5. Concentrate Transportation and Monitoring

The concentrates are stored on site and transported by rail to a storage and ship loading facility at Dublin Port. From here they are shipped to smelters around Europe. The mill and concentrator complex is one of the most technically advanced in the world. Almost all of the process is computer controlled. Computers automatically monitor every aspect of the process and ensure that the maximum returns are achieved from the ore. On-site laboratory facilities enable checks on the quality of ore feed and concentrates being produced. Each day the laboratory receives 90 samples on which 310 analyses are carried out. The mill operates continuously seven days a week on 12 hour shifts. Currently 46 highly skilled people are employed in the operation of the processing division.

Source: Tara Mines

TASK 1

Decide if the following statements about processing stages are true or false.
If false correct.

	True	False
1. The objective of ore processing is to gain separate, valuable mineral concentrates.	☐	☐
2. Crushing and blasting of ore is the first step in processing the ores.	☐	☐
3. At the end of flotation process about 56% lead metal and about 67% zinc metal is obtained.	☐	☐
4. In both lead and zinc dewatering process no residue is left at all.	☐	☐
5. Tailings are transported to other mines in Europe.	☐	☐
6. Lead and zinc concentrates are transported to smelters.	☐	☐

TASK 2

What keywords belong to the different processing stages?

Agitating agent, air bubbles, blasting, crushing, computer controlled, chemical additives, dispersion of froth, filtration, grinding, moisture, milling, reducing size, residue, recirculation, refilling, shipping, suspension waste, water sprays

Step 1	Step 2	Step 3	Step 4	Step 5
Comminution	Flotation	Dewatering	Tailings and Backfills	Transportation and Monitoring

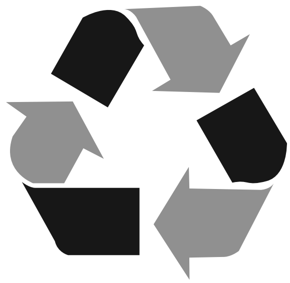
TASK 3

Summarize the processing stages/steps in one sentence.

step 5	
step 4	
step 3	
step 2	
step 1	The blasting, crushing, grinding and milling process takes place to get smaller sizes.

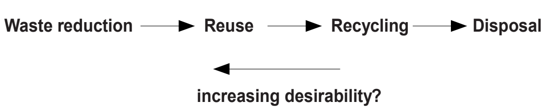
Unit 21 Minerals Recycling

Resource conservation and economic considerations



What is recycling?

Recycling is the collection and separation of minerals that have reached the end of their useful life, and their subsequent reprocessing to create useable products. The term covers a wide range of processes such as the crushing and screening of construction and demolition wastes, remelting and refining of metals and the recovery and return to use after cleaning and re-assembly of articles such as mechanical or electrical components. Recycling is a key element of the government's hierarchy of waste management options that also includes the minimization of waste and simple reuse of products.



Source: http://www.mineralsuk.com/britmin/mm6.pdf

Why is recycling important?

Recycling and reuse helps to protect the environment and ensures sustainable use of resources through:

- Energy conservation
- Waste minimization
- Resource conservation

For example, in the case of metals, the energy needed to remelt scrap metal is a fraction of that required to extract the metal from its ore. For construction minerals, the benefits are obvious when the use of recycled demolition waste (broken concrete etc.) reduces the need to provide crushed rock or gravel from quarries that may be in environmentally sensitive areas. A further environmental benefit lies in the fact that if more material is recycled rather than disposed of, there is less pressure for space on landfill sites. Resources conservation is also an important benefit of recycling even though there is no prospect of most parts of the world running out of them in the foreseeable future.

TASK 1

Answer the questions.

1. What is the difference between “reusing” and “recycling” a mineral or product?

2. Why does “recycling” play a more and more important part for a sustainable development and economy? (Before answering read the following text as well.)

Recycling of construction minerals

Non-metallic minerals used in construction are rarely recycled as minerals. Construction minerals are normally recovered and recycled is the form of manufactured materials such as concrete, brick, plasterboard and ceramic articles. The continual demand for construction minerals, such as sand and gravel and crushed rock, for commercial buildings, roads and houses, and the consequent expansion quarries to supply them, has been a powerful incentive to try to replace there minerals by recycled materials. These are derived from both construction waste, for example damaged bricks, and demolition waste, such as broken concrete, brickwork and masonry. An important contribution to supply is also made by secondary materials; these are materials that are waste products from industrial processes such as blast-furnace slag, which is used as aggregate and cement additive.

Recycling of industrial minerals

In the cases of many minerals used in industrial and manufacturing processes their valuable physical properties are either destroyed in use (for example plasticity of ceramic clays is lost during firing), or the minerals are dispersed and not readily recoverable in their original form. They may however be recovered and used in their manufactured from for other purposes, for example ceramic materials such as refractory bricks can be re-used as construction fill. Glass is a unique case among manufactured products based on industrial minerals in that like metals, it may simply be melted and reformed with savings in energy and raw material. It also can be used in broken form ("cullet") as a read-surfacing aggregate. Minerals that are valued for their chemical properties alone are generally either difficult or impossible to recycle; examples are the salt used to treat roads and the potassium and phosphorus minerals that are the basis of agricultural fertilizers.

http://www.mineralsuk.com/britmin/mm6.pdf

TASK 2

Fill in the gaps with following words: “balance”, “demolition”, “environmental”, “dismantling”, “landfill”, “production”, “to dispose of”, “labour”

Economic considerations

The cost of recovering materials from discarded products and ❶ ________________ is the major factor that limits the amount recovered. The chief costs are the energy and ❷ ________________ costs of collection, separation and identification, each of which has an ❸ ________________ impact. The recovery of, for example, certain minor metals from complex manufactured articles such as a computer may involve careful ❹ ________________ of the article concerned and the costs of doing so may well exceed those of the production cost of virgin materials. Thus while it may be environmentally desirable not ❺ ________________ the materials in a ❻ ________________ site or incinerator there may be a powerful economic case for doing so. The ❼ ________________ may be altered by designing products specifically for recycling, or by economic instruments from government such as the Landfill Taxes.

Source: after: http://www.mineralsuk.com/britmin/mm6.pdf

TASK 3

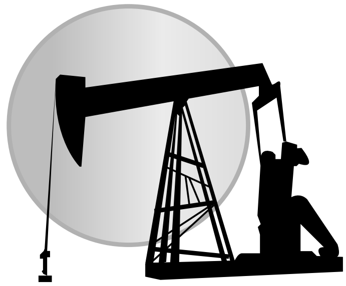
Match the sentence parts to form a complete sentence.

Recycling will undoubtedly increase in importance **1**	if their contribution is to be maximized. **A**
There will, no doubt, be much greater emphasis in the future **2**	as energy use is restrained by pollution concerns and as waste disposal becomes more problematic. **B**
However, it will be necessary to identify suitable sites for processing and storage of recycled materials **3**	on designing products for recycling. **C**

1__ 2__ 3__

Unit 22 Energy Sources I

Non-renewable sources: the fossil fuels coal, oil, and natural gas



The term “fossil fuel” refers to energy resources that come from the remains of plants and animals. The three fossil fuels are: coal, oil, and natural gas. But: Fossil fuels are a non-renewable energy resource. Once they are used, they are gone forever, and they can no longer be part of our energy system. Fossil fuels take millions of years to develop under extreme conditions.

FOSSIL FUELS

Fossil fuels occur in many ways, depending on the kind of sediment, the kind of organic matter trapped, and the changes that have occurred during the long geological ages since the organic matter was trapped.

Essentially all living organisms derive their energy from the Sun. The only known exceptions to this statement are a few animals that live around submarine hot springs on mid-ocean ridges; they derive their energy from the Earth‘s internal heat. The principal energy-trapping mechanism of living organisms that derive their energy from the Sun is photosynthesis. Plants combine water and carbon dioxide to make carbohydrates and oxygen.

This combination process uses energy and plants get the energy from sunlight. The oxygen formed during photosynthesis is passed into the atmosphere and in this way plants and sunlight control the composition of the atmosphere.

The organic compounds in plants is the fuel that keeps animals alive and active; animals are, therefore, secondary consumers of trapped solar energy. When one animal eats another a little bit of trapped solar energy is once again passed along. When plants or animals die and decay, oxygen from the atmosphere combines with carbon and hydrogen in the organic compounds to form H_20 and CO_2 once again. In the process a small amount of energy is released, so the photosynthesis reaction is reversed.

The rates at which organic matter is formed through photosynthesis, and broken down by decay, are essentially the same; if they were not essentially equal, the world would soon be covered by increasingly deep piles of organic matter. However, the growth and decay rates are not exactly the same. In many sediments, a little organic matter is trapped and buried before it is completely removed by decay. In this way some of the solar energy becomes stored in rocks-hence, the term fossil fuel. The amount of trapped organic matter is far less than 1 percent of the organic matter formed by growing plants and animals. However, from the late Proterozoic (about 600 million years ago) to the present, through which time the size of the biomass seems to have been as large as it is today, the total amount trapped has grown to be very large.

The kind of organic matter that is trapped in sediments plays an important role in the kind of fossil fuel that forms. In the ocean, tiny photosynthetic phytoplankton and bacteria are the principal sources of trapped organic matter. Shales are the sedimentary rocks that do most of the trapping. Bacteria and phytoplankton contribute mainly organic compounds called proteins, lipids, and carbohydrates and it is these compounds that are transformed (mainly by heat) to oil and natural gas. On land, it is higher plants such as trees, bushes, and grasses that contribute most of the trapped organic matter; they are rich in resins, waxes, and lignins, as well as carbohydrates in the form of cellulose. The trapped organic matter tends to remain solid and form coals although a certain amount of natural gas can be formed too. In many shales, burial temperatures never reach the levels at which the original organic molecules are , completely broken down. Instead, what happens is that an alteration process occurs in which wax-like substances with large molecules are formed. This material, called kerogen, is the substance in oil shales; it can be converted to oil and gas by applying sufficient heat.

Source: B.J. Skinner u.a.: Physical Geology, John Wiley & Sons 1987; p. 591

What is coal?

Coal is a hard, black, combustible sedimentary rock-like substance. It is made up of carbon, hydrogen, oxygen, nitrogen and various amounts of sulphur. There are three main types of coal - anthracite, bituminous and lignite.

Anthracite coal is the hardest and has more carbon, which gives it a higher energy content.

Lignite is the softest and is low in carbon content, high in hydrogen and oxygen content.

Bituminous is between. Today, the precursor to coal -peat- is still used as an energy source in many countries.

More about coal and coalification

Coal is our most abundant fossil fuel resource. Coal is a complex mixture of organic chemical substances containing carbon, hydrogen and oxygen in chemical combination, together with smaller amounts of nitrogen and sulfur. This organic part of coal has associated with it various amounts of moisture and minerals.

Coalification is the name given to the development of the series of substances known as peat, lignite or brown coal, sub-bituminous coal, bituminous coal, and anthracite. The degree of coalification, also called the rank of the coal, increases progressively from lignite to low rank coal, to high rank coal, to anthracite. The carbon content increases, while the oxygen and hydrogen contents decrease throughout the series. The hardness increases, while the reactivity decreases. Different amounts of heat and pressure during the geochemical stage of coal development cause these differences in rank. It is not due to the kind of plants the coal is formed from.

Information adapted from: http://www.bydesign.com/fossilfuels/links/html/coal.html

TASK 1

Match the sentence parts to form a complete sentence.

Peat 1

Lignite 2

Anthracite coal 3

Coke 4

Bituminous coal 5

Graphite 6

is a very soft, brownish-black material with a carbon content of about 70%. A

is the result, when coal is heated and compressed further, it is almost completely pure carbon. B

can be found in marshy places. It has a carbon content of about 50%. C

is a very hard coal with a carbon content of about 90%. D

is the material which is obtained after the coal degasification process and is primarily used as a fuel in the steel making industry. E

is harder than lignite, but softer than anthracite coal. F

1__ 2__ 3__ 4__ 5__ 6__

One of the main uses of fossil fuels is to generate electricity. Coal is still the number one for electricity generation.

TASK 2

Discuss the role of coal as an energy resource. Think of various aspects such as: distribution of coal seams; economic considerations of underground and surface mining; environmental problems such as local landslides etc.

Oil and Petroleum

Petroleum is a mixture of liquid hydrocarbons (chemical compounds containing only hydrogen and carbon) plus various impurities such as sulfur. Unprocessed petroleum is usually called crude oil, although it has been called mineral oil and Seneca oil, named for the Seneca Indians of Western Pennsylvania. The name petroleum is from a combination of Latin words meaning „rock oil“. We refer to it here simply as oil.

As found in the earth, oil may have a variety of properties. Some forms are black, others dark green, and some light like kerosene. The liquid ranges from very viscous to easy-flowing. Crude oil usually consists of a mixture of hydrocarbons having varying molecular weights and differing from one another in structure and properties. These various species are separated into groups, or fractions, by a process of distillation called refining. Oil fuel, in all of its usable forms, is a refined product, unlike coal and natural gas which can often be burned in their natural condition.

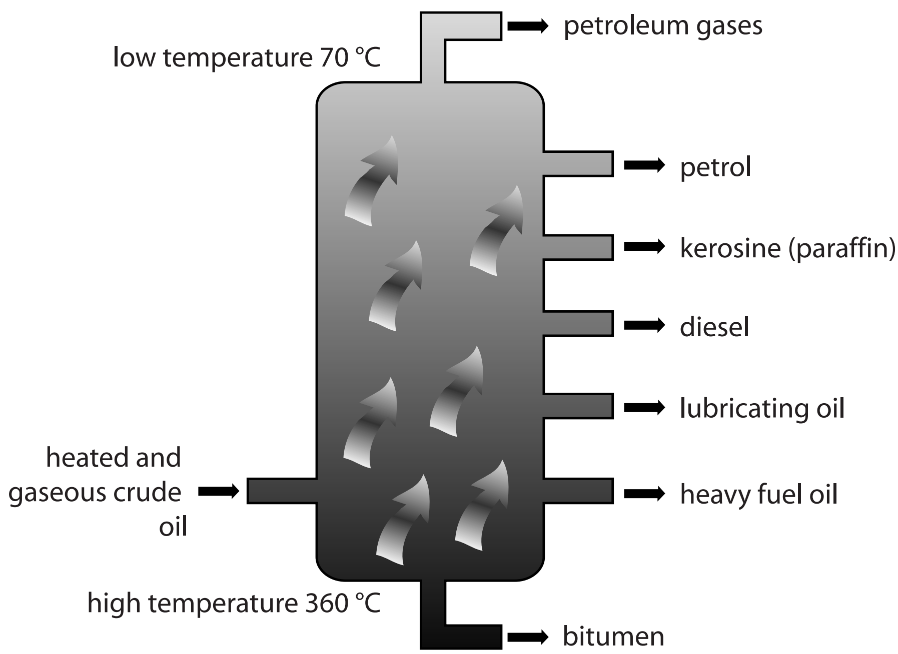
Source: http://www.bydesign.com/fossilfuels/links/html/oil.html

For simplied reason the term “petroleum” and “oil” or “crude oil” is used interchangeable.

(B.J. Skinner defines as follows: “Oil and gas are the two chief kinds of petroleum. We define petroleum as gaseous, liquid, and semisolid substances, occurring naturally and consisting chiefly by chemical compounds of carbon and hydrogen.”)

Skinner: 1987, p. 597

To use crude oil as a fuel it hat to be separated into compounds with similar boiling points. This process is called “fractional distillation” and takes place in “fractionating columns”.



TASK 3

Describe the distillation process and separation into the different fractions.

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TASK 4

Fill in: “biodegraded organic material”, “crude oil”, “generation of electricity”, “natural gas”, “pressure” and “viscosities”.

Petroleum

Petroleum, or „❶ ________________,“ is a liquid fuel that is present in various locations throughout the world. It has many uses, from the ❷ ________________ to the manufacture of medicines, plastics, and other commercial items.
Much like coal, petroleum is formed from the remains of ❸ ________________. When animals that lived in the sea millions of years ago died underwater, their remains were gradually covered by layers of very fine dirt known as „silt“ on the ocean floor. Then, as the years passed, ❹ ________________ from the layers built up and compressed the organic material, forming the oil.
Petroleum has many different „❺ ________________,“ or thicknesses. The viscosity depends on the amount of gases and solids that are present in the oil. Often, ❻ ________________ is dissolved in the liquid and can be extracted for other uses. Petroleum takes three main forms: paraffin, asphaltic, and mixed-base. These forms are based upon the chemical makeup of the hydrocarbon-based oil.

Source: after: http://www.bydesign.com/fossilfuels/links/html/petroleum.html

TASK 5

Discuss the role of oil as an energy resource and its environmental impact. Keywords to help:

- limitation as a natural resource;
- dependence on foreign oil (political aspects)
- controlling prices
- environmental aspect: shipping the oil, oil spills

Natural gas

Natural gas is a highly flammable hydrocarbon gas consisting chiefly of methane (CH_4). Although methane is always the chief component, it may also include other gases such as oxygen, hydrogen, nitrogen, ethane, ethylene, propane, and even some helium.

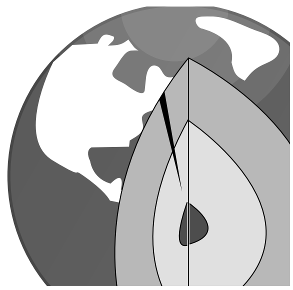
The gas is found entrapped in the earth's crust at varying depths beneath impervious strata, such as limestone, and may or may not be in association with oil. If oil is present it is called wet gas, else dry gas. The gas is drawn from wells, similar to oil wells, and is usually transported by pipelines, sometimes a thousand miles or more.

As a fuel, natural gas is convenient and efficient. It is used primarily for heat, in industrial, commercial and residential settings. In many homes the house and water are heated by gas, the food is cooked with it and clothes dried. It is also used to produce electricity, in many cases using gas fired turbines that are similar to jet engines. Gas has the great advantage of producing no smoke or ash on burning, although it is usually much more expensive than coal as a fuel.

Source: http://www.bydesign.com/fossilfuels/links/html/natural_gas.html

Unit 23 Energy Sources II

Geothermal Energy - Energy from the interior of the Earth



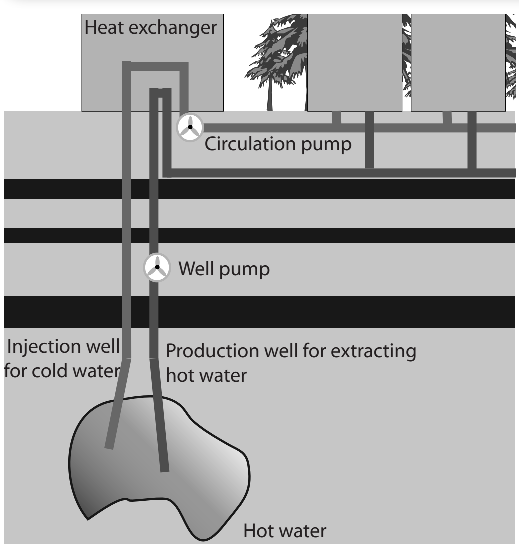
An immense energy story

Utilisation of geothermal energy is becoming more important

The energy stores in the Earth in the form of heat could meet the current world energy requirements for 30 million years - if only it were so simple to put it to work. Various technologies make it possible to apply more and more energy from geothermal sources to everyday life. Temperatures of 3,000 to 6,000 degrees Celsius prevail in the Earth's inner core; in the Earth's upper mantle, temperatures range between 900 and 1,400 degrees. Temperatures of between eight and 12 degrees are found in the 100 metres closest to the surface

Source: RAG Magazine 3/2006; p. 51

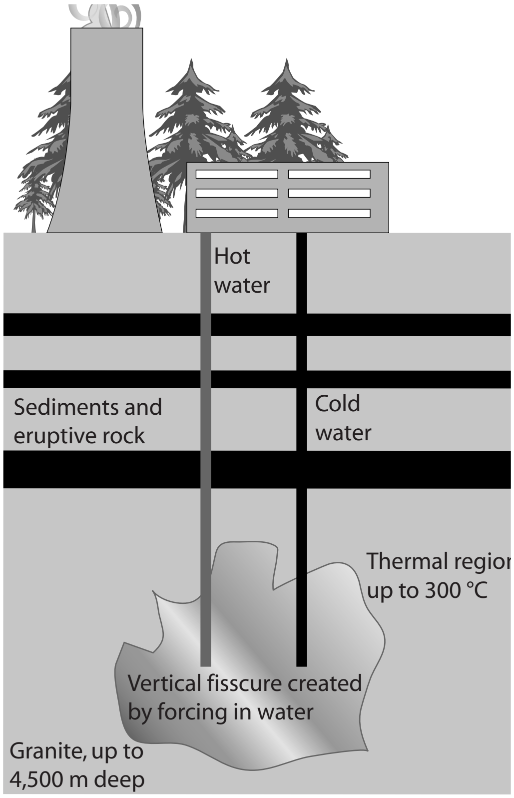
Two methods to use geothermal energy to supply power are described.



1. Hydrothermal geothermal energy

In the case of hydrothermal geothermal energy, you drill into layers that contain the water - the aquifers - and pump the hot water to the surface. This water heats industrial facilities and households via a ramified pipeline network - known as district heating.

A second pipeline, the injection well, then returns the cooled water back underground. That way the hydraulic equilibrium is maintained in the rocks, so that the underground reservoir is not depleted. Drinking water supplies are also fed by the aquifers.



2. Petrothermal geothermal energy

The petrothermal system is also called Hot Dry Rock (HDR).

Here the engineers drill into hot rock deep below the surface, and force water into the Earth's interior under high pressure - 150 bar - thereby creating cracks and fissures underground. These spaces then act as natural heat exchangers, through which water is channelled, heated and extracted again by a second well. At pressure of above six bar, water remains liquid even at temperatures of 170 degrees Celsius and doesn't evaporate as it usually would at 100 degrees. With the HDR process, drilling is conducted to depths of 4,000 to 5,000 metres, where the rock temperatures can be 200 to 300 degrees Celsius, depending on the location.

Source: RAG Magazine 3/2006; p. 51

TASK 1

Fill in the missing words: "crust", "formation", "originates", "radioactive decay" and "solar radiation".

What makes the Earth so hot?

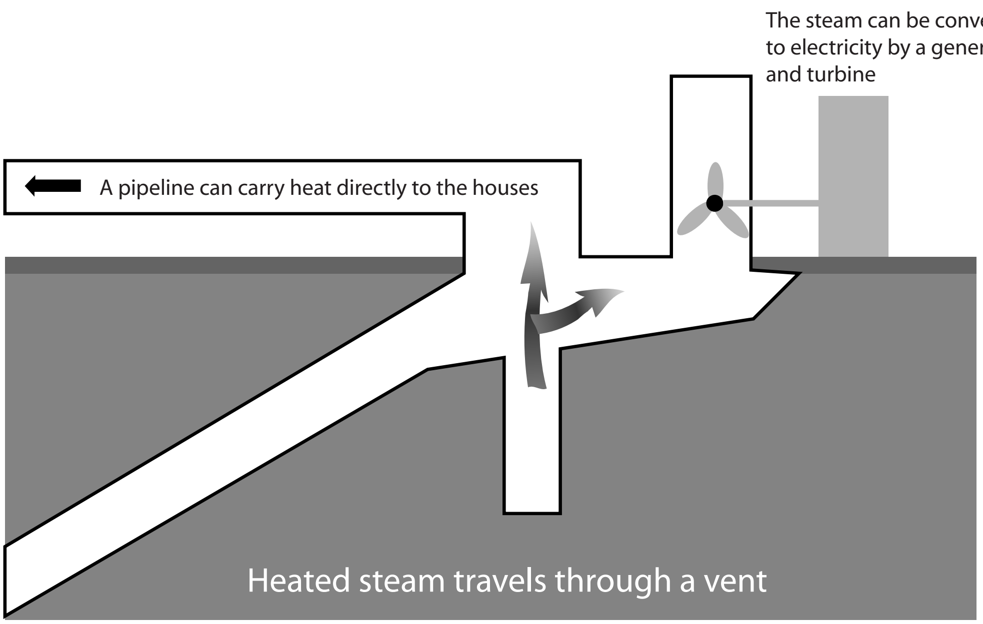
Thirty to 50 per cent of the Earth's heat originated as residual heat dating back to the Earth's ❶ _______________. Most of the rest is a result of natural ❷ _______________, which has been taking place for millions of years, producing heat in a process that continues today. In addition, a further part of heat comes from the ❸ _______________ that warms the Earth's surface. The temperature in the Earth's inner core are estimated variously to be at between 4,500 to 6,500 degrees Celsius. Approximately 40 per cent of the heat flux that reaches the Earth's surface ❹ _______________ in the Earth's interior; the remaining 60 per cent comes from the Earth's ❺ _______________.

Source: Information taken from: RAG - Magazin 3/2006

The Theory behind Geothermal Power

The earth‘s crust is heated by the decay of radioactive elements. The heat is carried by magma or water beneath the earth‘s surface. Some of the heat reaches the surface and manifests itself in geysers and hot springs throughout the world.

Geothermal power can be used to directly heat buildings. Further, the pressurized steam from superheated water beneath the earth‘s surface can be used to power turbines and thus generate electricity.



Although geothermal power seems ideal in that it is naturally occurring and does not require structures to trap or collect the energy (as in solar panels or windmills), it does have limitations. The greatest drawback is that naturally occurring geothermal vents are not widely available. Artificial vents have been successfully drilled in the ground to reach the hot rocks below and then injected with water for the production of steam. However, oftentimes the source of heat is far too deep for this method to work well.

Nor can geothermal power realistically generate enough electricity for the entire United States or any other large industrialized nation. A good-sized hot spring can power at most a moderate sized city of around 50,000 people. And there just aren‘t enough viable hot springs to power all the cities in any large country.

Source: http://library.thinkquest.org/20331/types/geotherm/theory.html

TASK 2

Name advantages and disadvantages of geothermal power given in the text.

Advantages	Disadvantages
no pollution	

Geothermal Energy as a Natural Resource

Geothermal energy is present everywhere beneath the Earth's surface, although the highest temperature, and thus the most desirable, resources are concentrated in regions of active or geologically young volcanoes. Though the resource is thermal energy rather than a physical substance such as gold or coal, many aspects of geothermal energy are analogous to characteristics of mineral and fossil-fuel resources. Geothermal energy also has some unique, desirable attributes.

Global Distribution

Measurements made in drill holes, mines, and other excavations demonstrate that temperature increases downward within the Earth. The rate at which the temperature increases (temperature gradient or geothermal gradient) is proportional to the rate at which heat is escaping to the surface through the Earth's crust (heat flow). Thus, zones of higher-than-average heat flow are the most likely places for encountering high temperatures at shallow depth, perhaps shallow enough to favor exploitation of geothermal energy. The average rate at which heat escapes through the Earth's crust accounts for a prodigious amount each year, but local heat flow can vary widely from region to region.

Large quantities of heat that are economically extractable tend to be concentrated in places where hot or even molten rock (magma) exists at relatively shallow depths in the Earth's outermost layer (the crust). Such "hot" zones generally are near the boundaries of the dozen or so slabs of rigid rock (called plates) that form the Earth's lithosphere, which is composed of the Earth's crust and the uppermost, solid part of the underlying denser, hotter layer (the mantle). According to the now widely accepted theory of plate tectonics, these large, rigid lithospheric plates move relative to one another, at average rates of several centimeters per year, above hotter, mobile mantle material (the asthenosphere). High heat flow also is associated with the Earth's "hot spots" (also called melting anomalies or thermal plumes), whose origins are somehow related to the narrowly focused upward flow of extremely hot mantle material from very deep within the Earth. Hot spots can occur at plate boundaries (for example, beneath Iceland) or in plate interiors thou-sands of kilometers from the nearest boundary (for example, the Hawaiian hot spot in the middle of the Pacific Plate). Regions of stretched and fault-broken rocks (rift valleys) within plates, like those in East Africa and along the Rio Grande River in Colorado and New Mexico, also are favorable target areas for high concentrations of the Earth's heat at relatively shallow depths.

Zones of high heat flow near plate boundaries are also where most volcanic eruptions and earthquakes occur. The magma that feeds volcanoes originates in the mantle, and considerable heat accompanies the rising magma as it intrudes into volcanoes. Much of this intruding magma remains in the crust, beneath volcanoes, and constitutes an intense, high-temperature geothermal heat source for periods of thousands to millions of years, depending on the depth, volume, and frequency of intrusion. In addition, frequent earthquakes—produced as the tectonic plates grind against each other—fracture rocks, thus allowing water to circulate at depth and to transport heat toward the Earth's surface. Together, the rise of magma from depth and the circulation of hot water (hydrothermal convection) maintain the high heat flow that is prevalent along plate boundaries.

Accordingly, the plate-boundary zones and hot spot regions are prime target areas for the discovery and development of high-temperature hydrothermal-convection systems capable of producing steam that can drive turbines to generate electricity. Even though such zones constitute less than 10 percent of the Earth's surface, their potential to affect the world energy mix and related political and socioeconomic consequences is substantial, mainly because these zones include many developing nations. An excellent example is the boundary zone rimming the Pacific Plate—called the "Ring of Fire" because of its abundance of active volcanoes—that contains many high-temperature hydrothermal-convection systems. For the developing countries within this zone, the occurrence of an indigenous energy source, such as geothermal, could substantially bolster their national economies by reducing or eliminating the need to import hydro-carbon fuels for energy. The Philippines, Indonesia, and several countries in Central America already benefit greatly from geothermally generated electricity; additional projects are underway and planned. Of course, the use of geothermal energy already contributes to the economies of industrialized nations along the circum-Pacific Ring of Fire, such as the United States, Japan, New Zealand, and Mexico.

Source: http://energy.usgs.gov/other/geothermal/geothermal_learn.html

Unit 24 Energy Resources III

Other renewable energy sources for power generation

Power for the nation. How it all works

1. Conventional power stations

In the main, conventional power stations burn fossil fuels to boil water and raise steam. The high-pressure, high-temperature steam is then directed into the blades of a steam turbine - and makes them rotate.

Often, there are a number of stages in a steam turbine, each using the steam at a slightly lower pressure. Finally, the steam is condensed back into water and recycled into the system.

2. Hydroelectric power

The production of hydroelectricity usually requires the construction of a dam across a river, generally in a deep valley. A large mass of water builds up behind the dam. The water is conducted through pipes at the bottom of the dam and its potential energy is used to drive water turbines. The turbines drive generators to produce electricity.

3. Tidal and wave power

Sometimes, where there is sufficient difference in water level between low and high tide, it may be possible to build a barrier, or barrage, across an inlet of water. Gates in the barrage are opened on a rising tide to allow the basin behind to fill with water. The gates are then closed before the tide begins to fall. Once a usable head of water has built up between the basin and the sea outside, the trapped water is released through large turbine/generator units.

Generating electricity from the power of the waves is also being investigated. The oscillating water column (illustrated inside) is one way of harnessing this energy. Another method uses floating booms and hinged flaps which move up and down with the motion of the waves.

4. Wind power

There is a plentiful, free supply of wind -though it is rather spread around, or diffuse. This means that large machines have only small power outputs. Machines with outputs of about 300 kW are currently favoured but even these are large. They may be 40 m to the tip of the blade-just about as tall as a modern electricity pylon.

5. Solar power

Direct generation of electricity using photovoltaic cells is now an established technology. A silicon cell generates a voltage of about 0.6 V and a normal module of cells produces 12 V. Solar cells should not be confused with solar panels, used to heat hot water in some modern houses.

6. Biomass

When organic materials decompose under the action of naturally occurring bacteria, methane gas is produced. This gas can be burned to generate heat and drive electricity-generating turbines as one form of biomass energy.

7. Geothermal power

There is considerable heat trapped in the rocks beneath the Earth‘s surface- heat generated when the Earth was formed and from the continuing radioactive decay of the rocks. (s. Unit 24)

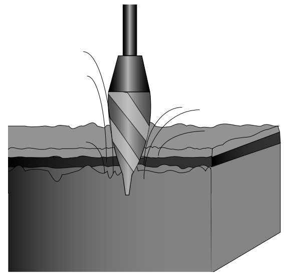
Source: National Power; leaflet; GB

TASK 1

Discuss the contribution of alternative (renewable) energy sources for electricity generation and energy mix. Take into account: technical, environmental, and economic aspects.

Unit 25 Drilling Techniques

From hand augers to rotary core barrel drills



The term „drilling“ defines operations from boring relatively small holes into a wall up to boring larger holes in the ground mainly for prospecting or extracting oil, gas or water. It can also mean the operation of tunnelling or stoping. Drilling can be percussive or rotary.

For soil studies relatively simple and practical hand auger equipment is often sufficient...

Hand auger equipment

Description of various auger types Edelman augers

Edelman augers

This type of soil auger is by far the most used auger. The typical design of the Edelman auger allows for a minimum of friction during penetration into the soil, and the extraction of the auger from the soil, which means less physical effort. To achieve optimal results, the auger type should be chosen in respect of the soil type in question. There are 4 types: the clay-, sand-, coarse sand- as well as a combination type.

- Clay soils are very cohesive. Therefore the blades of the clay auger can be narrow, having the advantage that they meet with little resistance.
- Sandy soils are not cohesive. To keep the sample inside the auger, this type has broad blades.
- Coarse sand soils and extremely dry sand soils have little or no cohesion at all. The blades of this auger are extended with extra wings, thus forming an almost closed auger
- The combination auger type gets a reasonably good hold of sandy material while clayey material can be fairly easily removed from the auger body.

Riverside auger

This design is very suitable for augerings in hard, stiff soils, mixed with fine gravel both above and below the groundwater level. The very sharp extremities of the auger bits point at an angle downwards. This design makes the auger go through the soil easily.

Stony soil auger

For soils with a large gravel content. The auger body for stony soils consists of a heavy steel strip, vaulted all along, which is bent double by forging. The pointed cutting bits of the strip are bent outward, thus creating a hole somewhat wider than the average body diameter. The stony soil auger is used when the Riverside auger is not yielding adequate results in coarse gravel soils.

Source: Eijkelkamps: Catalogue for Agrisearch Equipment; p.8

TASK 1

Match the sentence parts.

Hand auger equipment is extremely **1**

With hand augers **2**

The maximum boring depth **3**

The equipment should be strong and solid **4**

As a little manpower is generally available for field soil research **5**

and made of high quality steel to be wear-resistant. **A**

it is important that equipment is light and easy to handle. **B**

suitable for soil research. **C**

a depth of 8-10 meters can be achieved. **D**

depends on various factors such as soil profile or characteristics of materials. **E**

see source from text above

1__ 2__ 3__ 4__ 5__

> ... whereas for rock studies - especially for oceanic research - and core drilling special drilling equipment is required.

Rotary Core Barrel

Scientific Application

The Rotary Core Barrel (RCB) is a rotary coring system designed to recover core samples from firm to hard sediments and igneous basement. The RCB is crucial for oceanic crustal hard rock studies.

Tool Operation

The RCB inner core barrel free falls (and is pumped) through the drill string and latches into the RCB bottom-hole assembly (BHA). The main RCB bit trims the 2.312 in. core. The BHA, including the bit and outer core barrel, is rotated with the drill string while bearings allow the inner core barrel to remain stationary. The inner core barrel can hold a 9.5 m core and is retrieved by wireline. A wireline packoff at the top of the drill string permits rotation and circulation of the drill string to continue while using the wireline to retrieve the core.

Design Features

1. Rugged Design

The RCB BHA, bit, and inner core barrel assembly have a rugged design for use in abrasive and fractured hard sediments and igneous basement.
Benefit: Increases operating time of the bit and improves penetration of hard formations.

2. Drilling with Center Bit

A center bit can be used to drill a hole without attempting to recover core. The center bit is used to drill ahead in hard rock and is run on a special inner barrel sub to lock it into the outer barrel for rotation. The center-bit assembly is configured to allow circulation through the center bit;
Benefit: The center bit can be interchanged with a standard RCB core barrel for „spot“ coring.

3. Wireline Logging with Bit Release

A Mechanical Bit Release (MBR) can be operated by wireline to drop a bit in the hole or on the seafloor to provide a fully open BHA for logging.
Benefit: Wireline logs can be run after coring with the RCB system without making a pipe trip to install a logging bit.

RCB Specifications

1. Inner Core Barrel Length : 9.5 m (31.16 ft)
2. RCB Bit Throat (Core Diameter): 5.87 cm (2.312 in.)

Typical Operating Range

1. Formation: Firm to very hard sediments and igneous basement
2. Depth Range: Seafloor through igneous basement
3. Mean Recovery: 20% to 55%
4. Quantity of Cores on Deck: 0.3 to 2 cores/hr depending on water depth and formation hardness
5. Rate of Penetration: Depends on rock properties, but averages 4.0 to 9.8 m/hr

Limitation

Does not recover soft sediments or granular formations (such as sand, fractured rock, or rubble)

Source: http://www-odp.tamu.edu/publications/tnotes/tn31/rcb/main.htm

TASK 2

Answer the questions to the text.

1. What kind of application is especially useful for rotary coring system?

2. What is specific for the tool operation of a RCB regarding the outer and inner core barrel?

3. How can the core be retrieved?

4. Name some benefits of the RCB system.

5. What are the limitations?

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TASK 3

Important words for drilling. Give a definition or description of the following terms.

derrick

framework over an oil well or borehole to hold the drilling machinery

drilling rig

____

drill string

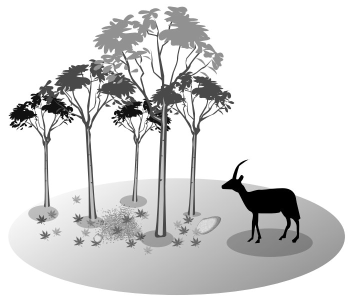
____

drill bit

____

Unit 26 Rehabilitation

Restoration of landscape as a sustainable development



The most visible environmental aspects occur in quarries and mines. Nowadays quarry and mine management does not only involve a „cap and close" mentality, however, a more active approach towards environmental management and rehabilitation practices is needed. Nature conservation and more useful and sustainable landforms for further generations have become a need.

What is rehabilitation?

Rehabilitation of a pit or quarry involves the management of all of the property's natural resources during the aggregate extraction process.

Topsoil, including the seed sources that it contains, and overburden are managed carefully (i.e. stripped and placed separately in a manner that reflects the original profile) throughout the life of the operation to ensure that they can be used to progressively create a new landscape and land use for the pit or quarry.

Rehabilitation sequences are carefully planned during the preliminary licensing process, and become a legal requirement when the site is first licensed. As the aggregate extraction progresses through the site, the topsoil and overburden are sequentially replaced to ensure that the property is properly prepared for its future land use.

Rehabilitation activities commonly include wildlife habitat restoration and forestry management activities, proper soil enhancement to ensure agricultural productivity, landform creation to support recreational activities, and many other state of the art techniques designed to ensure the next land use for the property is productive and sensitive to local land use patterns.

Source: OSSGA, Ontario Stone, Sand & Gravel Association; brochure: Rehabilitation of Pits and Quarries

TASK 1

Fill in the gaps: “biodiversity”, “habitats”, “protect”, “quarry” and “wetland”

Rehabilitation

Quarries can be restored to create new ❶ ________________ and recreational facilities. Many restored gravel quarries are now used as water sports facilities, while new wetland areas may enhance ❷ ________________. Elsewhere, large areas of floodplains from which minerals have been extracted have been left as ‚washlands‘, areas that can store water during periods of intense rain to ❸ ________________ inhabited areas from inundation. If a ❹ ________________ is intended for restoration to a ❺ ________________ after use, consideration needs to be taken of the potential for birds attracted by water to cause a hazard to aircraft. Specific design criteria may be needed to ensure that certain species of bird are not encouraged.

after: http://www.mineralsuk.com/britmin/mm11.pdf

Distinction between progressive and final rehabilitation

Progressive rehabilitation means to rehabilitate sequentially, in a reasonable period of time, while the aggregate is being excavated. With good planning, the extraction of aggregate proceeds in a logical sequence so that depleted areas can be rehabilitated while extraction continues in other areas of the pit or quarry. Planned stripping and replacement of topsoil, subsoil and overburden materials allows the licensee or permittee to establish vegetation in as much area as possible, and a start can be made towards developing the site for a particular after use.

Final rehabilitation is the rehabilitation that is performed, as set out by the site plan, after the site is depleted of all aggregate material. During final rehabilitation, all equipment, stockpiles and buildings (in most cases) have been removed and there may be additional vegetation (e.g. trees) to be established on the areas that have already been progressively rehabilitated.

Source: Ministry of Natural Resources, Canada; http://www.mnr.gov.on.ca/MNR/aggregates/rehab,html

TASK 2

Match the sentence parts.

Aggregate producers should perform rehabilitation 1	must be completed where aggregate reserves have been exhausted. A
Progressive rehabilitation means 2	as they extract the sites. B
The maximum boring depth 3	rehabilitation done sequentially within a reasonable time after extraction. C

1__ 2__ 3__

TASK 3

Complete the sentence parts to form statements about rehabilitation.

1. Rehabilitation means restoration

____

____

2. Rehabilitation means compatibility with

____

____

3. Rehabilitation means encouraging biodiversity because

____

____

4. Rehabilitation is beneficial because

____

____

TASK 4

Name productive forms of rehabilitation.

Example: wildlife habitats; ______________________________

____

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Biodiversity refers to the number and relative abundance of different species in a defined area

In the summit declaration of the G8 Summit 2007 in Heiligendamm the participating politician stressed the importance of biodiversity for the ecosystem. They declared in part 61 of the summit declaration: „We emphasise the crucial importance of the conversation and the sustainable use of biodiversity as an indispensable basis for the provision of vital ecosystem services and the long term provision of natural resources for the global economy ... (We) will increase our efforts for the protection and sustainable use of biological diversity to achieve our agreed goal of significantly reducing the rate of loss of biodiversity by 2110.“

Source: (G8 Summit Declaration on Growth and Responsibility in the World Economy, June 2007)

TASK 5

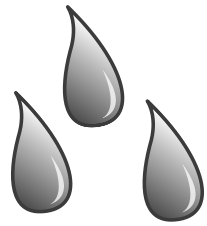
Why is biodiversity an important factor to the functioning of our natural ecosystem?

TASK 6

Explain or give examples why the extinction one species can have great impacts on the balance of our ecosystem.

Unit 27 Hydrogeology

Water as a source of life



TASK 1

Read the following text and match the titles to the paragraphs.

- Chemical salts (Sulphates , Carbonates, Calcium, Magnesium, Iron)
- Water quality
- Groundwater
- Micro-organisms
- Saline water
- Metals (Zinc, Copper, Chromium, Borates)
- Sources of water for agriculture
- Piped supply
- Lakes and reservoirs
- Suspended particles (Sand, Clay, Humus, Iron)

A dependable supply of good quality water is essential for the success of any agricultural project. Both the quantity and quality of the water required will depend on the activity involved.

For example, sprinkler irrigation requires large amounts of water of high quality. Approximately 100,000 litres of water are needed to apply 20 mm of water over one hectare. If the water is high in calcium (hardness) or contains particles then the sprinklers may become blocked or corroded.

❶ ______________________________

In many areas rivers are often the most convenient source of water. However, the flow of the river is dependent on the rainfall in the catchment area. Consequently, during dry seasons, when most water is required, the flow will be lowest. If too many users abstract water from the river, the flow may be reduced to such an extent that it silts up. The quality of river water is often poor since domestic and industrial sewage is frequently discharged directly into the water course.

❷ ______________________________

Natural lakes accumulate water when it rains and so provide a source which can be used at other times of the year. Similarly, dam or reservoir projects store water from the wet season for use in the dry season. This overcomes the problem of naturally fluctuating flow. Because a lake or reservoir is a closed system, nutrients and pollutants can accumulate and sometimes reach toxic levels. If there is a build-up of nitrates and phosphates then eutrophication may occur which will furtner lower the quality of the water.

❸ ______________________________

Groundwater is obtained from boreholes sunk into water bearing rocks or aquifers. This water is often of great age and so. providing it is not saline, it is often of very good quality. Aquifers normally recharge naturally through time by the slow infiltration of water through the soil and rock from the surface. However, if abstraction rates are high then eventually the water table may fall and the aquifer dry up.

❹ ______________________________

The capacity of many piped water supplies is often insufficient for irrigation purposes although it may be adequate for general farm or plantation use. Due to this storage tanks are often used. These are filled up overnight so that pumped supplies can be delivered during the day. Piped water is often treated to a high standard to make it suitable for human consumption. Where water resources are limited, lower quality supplies can be used for irrigation.

❺ ______________________________

No natural water is actually pure since it contains a variety of materials, either dissolved or in suspension, as well as micro-organisms (many of these are harmless to humans, plants and animals).

However, it is normally difficult to determine visually whether a water sample is safe to drink or suitable for irrigation. During drought conditions it becomes acceptable to use water of lower quality, particularly for non-essential uses. Under these circumstances it is even more important to regularly check the water quality since contamination frequently increases during long dry periods.

6 ______________________

Suspended solids may clog the filters and nozzles of irrigation equipment. Sand particles are abrasive and can cause excessive wear in pumps. When dry these particles may cause an unattractive deposit on crops and flowers so lowering their commercial value.

7 ______________________

These are present in most water supplies but are not normally found in concentrations high enough to affect crop growth. However, if used for irrigation, water containing these salts can increase the alkalinity of the soil. Excessive hardness of water can lead to pipe and sprinkler blockages. Iron salts can also cause blockages, as well as leading to pipe corrosion, through the growth of iron bacteria.

8 ______________________

Natural water sometimes contains raised levels of metals but they are more commonly associated with sewage sludge or the pollution of other water sources with industrial effluent. These metals sometimes cause direct damage to crop plants but are also often accumulated in the leaves. In this way humans or animals may be subjected to a higher than normal intake of these when the crops are eaten.

9 ______________________

Few crops (and even fewer animals) are able to tolerate saline water. Many commercial crops are extremely sensitive to saline water and will either be damaged or produce reduced yields. Irrigation with saline water is also likely to damage the soil.

10 ______________________

Plant, animal and human diseases can be spread by water contaminated by bacteria, viruses and other micro-organisms. Contamination of water supplies with domestic sewage is one of the main problems. Water which is used to irrigate crops which are likely to be eaten raw should be checked for biological contamination before it is used.

Adapted from: ELE Agronomics Catalogue, 2003

TASK 2

Answer the questions.

1. What is the main water problem in rivers?

____

____

____

____

2. In contrast to rivers lakes and reservoirs are closed systems. What does that mean for water quality?

____

____

____

____

3. Naturally occurring groundwater normally is of good water quality. What happens when taking-up rates are rising?

____

____

____

____

4. What are the advantages of piped water supplies?

____

____

TASK 3

Find questions for the other paragraphs.

5. ____

6. ____

7. ____

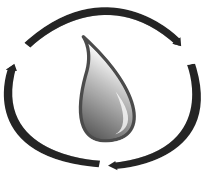
8. ____

9. ____

10. ____

Unit 28 The Water Cycle

A model about the supply of water



Hydrogeology is the scientific study of water movements on and below the Earth's surface. These water movements can be illustrated and described in a **water** or **hydrological cycle.**

TASK 1

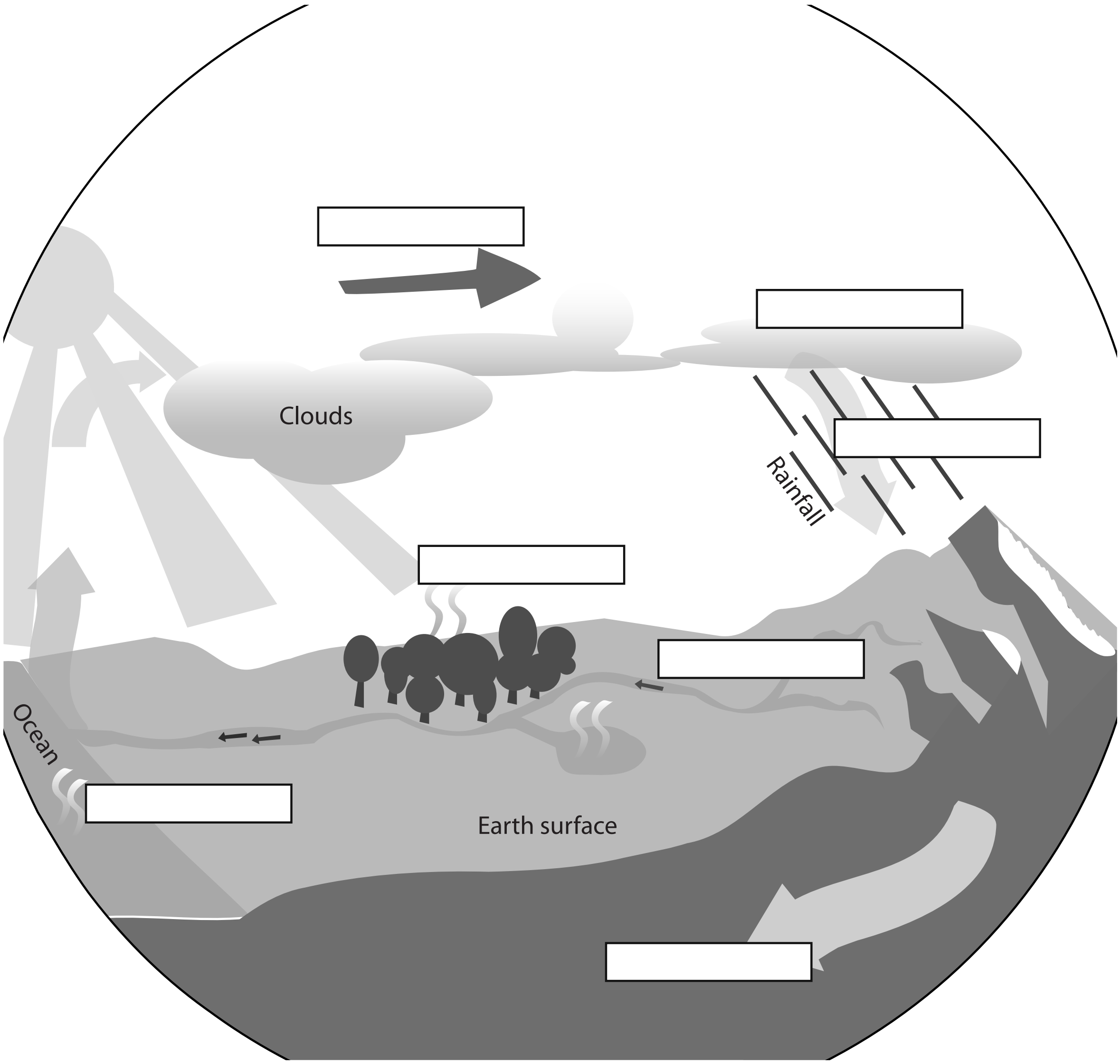
Match the definitions to the terms.

Term		Definition	
Condensation	1	From the smallest streams to rivers etc. that move water from land to the oceans.	A
Evaporation	2	The transformation of water from gas into a liquid.	B
Groundwater	3	Transfer of water to the atmosphere by plants and vegetation.	C
Precipitation	4	The transfer of water from the atmosphere to land. Rain, snow, hail, sleet, and freezing rain are different types of it.	D
Runoff	5	The movement of water through the atmosphere.	E
Transpiration	6	The transformation of water from a liquid into a gas.	F
Transport	7	Water below the surface and its location in different soil layers and gaps.	G

1__ 2__ 3__ 4__ 5__ 6__ 7__

TASK 2

Label the simplified version of a water cycle with the above mentioned terms of task 1.



TASK 3

Form three separate sentences from the sentence parts.

to evaporate from oceans	produces clouds of	causes water
condensation	remains constant	heat from the sun
tiny droplets of water	on earth	the amount of water

1. ____

____

2. ____

____

3. ____

____

TASK 4

Fill in the missing words into the text about water cycle (nouns and verbs).

The ❶ ______________ cycle begins with the ❷ ______________ of water from the surface of the ocean. As moist air is lifted, it cools and water vapor ❸ ______________ to form clouds. Moisture is ❹ ______________ around the globe until it returns to the surface as ❺ ______________. Once the water reaches the ground, one of two processes may occur; first some of the water may evaporate back into the atmosphere or second the water may penetrate the surface and become ❻ ______________. Groundwater either seeps its way to into the oceans, rivers, and streams, or is released back into the atmosphere through ❼ ______________. The balance of water that remains on the earth‘s surface is ❽ ______________, which empties into lakes, rivers and streams and is carried back to the oceans, where the cycle begins again.

Information taken from: http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml

The following text gives us a summary of the water cycle.

The Hydrologic Cycle

Water on or beneath Earth‘s surface cycles among the various reservoirs: the oceans, the atmosphere, and the land. The cyclical movement of water - from the ocean to the atmosphere by evaporation, to the surface through rain, to streams through runoff and groundwater, and back to the ocean - is the hydrologic cycle. A simplified illustration of the circulation of water and the amounts moved. Because organisms use water, it is also stored in the biosphere - for example, within the trees of rain forests.

Within the range of temperatures found at Earth‘s surface, water shifts among the three states of matter: liquid (water), gas (water vapor), and solid (ice). These transformations power some of the main flows from one reservoir to another in the hydrologic cycle. Earth‘s external heat engine, powered by the Sun, drives the hydrologic cycle, mainly by evaporating water from the oceans and transporting it as water vapor in the atmosphere. Under the right conditions of temperature and humidity, water vapor condenses to the tiny droplets of water that form clouds and eventually falls as rain or snow - together known as precipitation - over the oceans and continents. Some of the water that falls on land soaks into the ground by infiltration, the process by which water enters rock or soil through joints or small pore spaces between particles. Part of this groundwater evaporates through the soil surface. Another part is absorbed by the biosphere in plant roots, carried up to the leaves, and returned to the atmosphere by transpiration - the release of water vapor from plants. Other groundwater may return to the surface in springs that empty into rivers and lakes.

The rainwater that does not infiltrate the ground runs off the surface, gradually collecting into streams and rivers. The sum of all rainwater that flows over the surface, including the fraction that may temporarily infiltrate near-surface formations and then flow back to the surface, is called runoff. Some runoff may later seep into the ground or evaporate from rivers and lakes, but most of it flows into the oceans.

Snowfall may be converted into ice in glaciers, which return water to the oceans by melting and runoff and to the atmosphere by sublimation, the transformation from a solid (ice) directly into a gas (water vapor). Most of the water that evaporates from the oceans returns to them as precipitation. The remainder falls over the land and either evaporates or returns to the ocean as runoff.

The land surface gains water from precipitation and loses the same amount of water by evaporation and runoff. The ocean gains water from runoff and precipitation and loses the same amount by evaporation, more water evaporates from the oceans than falls on them as rain. This loss is balanced by the water returned as runoff from the continents. Thus, the size of each reservoir stays constant.

Source: Grotzinger, J. u.a.: Understanding Earth; W.H. Freeman and Company, New York 2007; p. 402-403

TASK 5

Discuss the water cycle in connection with climate change. How would the hydrological cycle be altered by global warming? What would be the effects on our ecosystem?

Unit 29 The Groundwater System

How geologists locate groundwater

Groundwater is an important part of the water cycle. Groundwater is the part of precipitation that seeps down through the soil until it reaches rock material that is saturated with water. Water in the ground is stored in the spaces between rock particles. Groundwater slowly moves underground, generally at a downward angle because of gravity and may eventually seep into streams, lakes, and oceans.

How Do Hydrogeologist Locate Groundwater?

Using scientific methods to locate water

To locate groundwater accurately and to determine the depth, quantity, and quality of the water, several techniques must be used, and a target area must be thoroughly tested and studied to identify hydrologic and geologic features important to the planning and management of the resource. The landscape may offer clues to the hydrologist about the occurrence of shallow groundwater. Conditions for large quantities of shallow groundwater are more favorable under valleys than under hills. In some regions--in parts of the arid Southwest, for example--the presence of „water-loving“ plants, such as cottonwoods or willows, indicates groundwater at shallow to moderate depth. Areas where water is at the surface as springs, seeps, swamps, or lakes reflect the presence of groundwater, although not necessarily in large quantities or of usable quality.

Geology is the key

Rocks are the most valuable clues of all. As a first step in locating favorable conditions for ground-water development, the hydrologist prepares geologic maps and cross sections showing the distribution and positions of the different kinds of rocks, both on the surface and underground. Some sedimentary rocks may extend many miles as aquifers of fairly uniform permeability. Other types of rocks may be cracked and broken and contain openings large enough to carry water. Types and orientation of joints or other fractures may be clues to obtaining useful amounts of groundwater. Some rocks may be so folded and displaced that it is difficult to trace them underground.

<u>Existing wells provide clues</u>

Next, a hydrologist obtains information on the wells in the target area. The locations, depth to water, amount of water pumped, and types of rocks penetrated by wells also provide information on groundwater. Wells are tested to determine the amount of water moving through the aquifer, the volume of water that can enter a well, and the effects of pumping on water levels in the area. Chemical analysis of water from wells provides information on quality of water in the aquifer.

How groundwater occurs in rocks

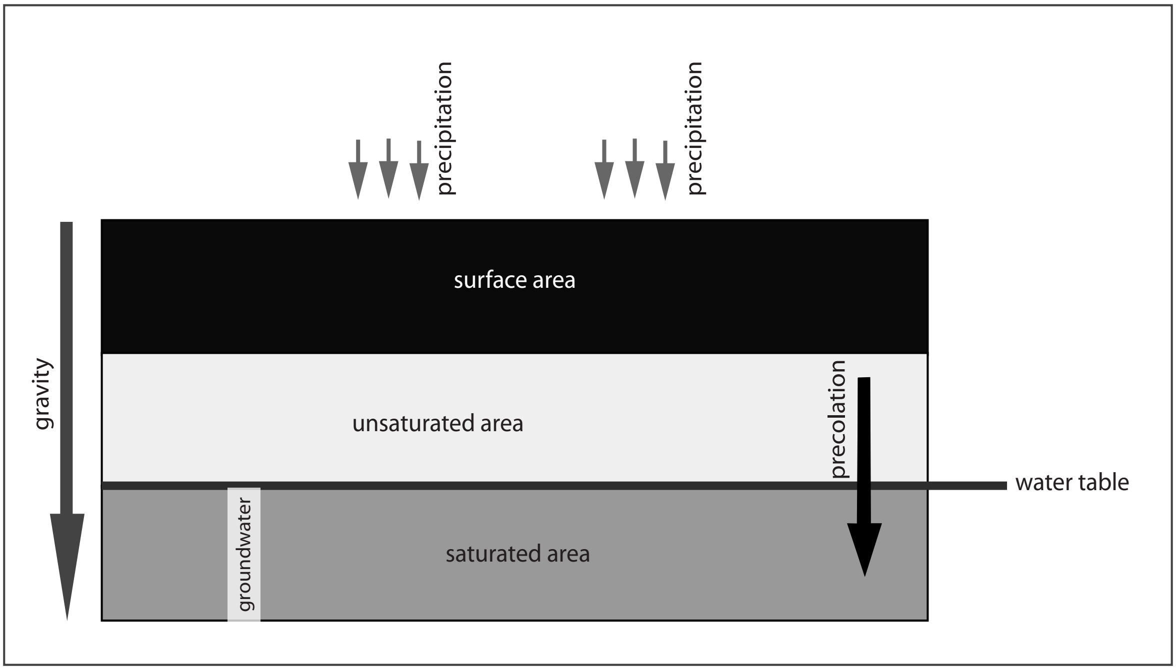
Groundwater is simply the subsurface water that fully saturates pores or cracks in soils and rocks. Aquifers are replenished by the seepage of precipitation that falls on the land, although they can be artificially replenished by people, also. There are many geologic, meteorologic, topographic, and human factors that determine the extent and rate to which aquifers are refilled with water.

From: http://ga.water.usgs.gov/edu/swhowtofind.html

TASK 1

Decide if the following statements are true or false. If false, correct.

	True	False
1. Most of the Earth‘s water is stored as groundwater.	☐	☐
2. The water table is below the saturated zone.	☐	☐
3. Groundwater flows mainly through percolation.	☐	☐
4. Velocity of groundwater increases as the slope of the water table increases.	☐	☐
5. Groundwater dissolves mineral matter from rock.	☐	☐
6. Water constantly cycles from one reservoir to another.	☐	☐



Simplified diagram of the groundwater system

TASK 2

Explain how underground storage of hazardous waste can disturb the groundwater system severely and discuss methods of preventing damage.

Unit 30 Groundwater Modelling System

A geoengineering groundwater software program

Who is GGU?

GGU is an international company working both as an engineering consultancy and as a software development firm. The software development branch has been in operation since 1988 and employs full-time programmers who are constantly upgrading existing programs and developing new ones. The consultancy utilizes the programs on a daily basis. Feedback from the consultancy and the wide client base ensures that the programs are always maintained, relevant and regularly updated.

Geoengineering Software Suite

The geoengineering software suite developed by GGU comprises 43 programs covering a wide range of applications in geotechnical design, site investigation and laboratory analysis. The programs are used by geotechnical, structural and general consultants, site investigation firms, design offices, government agencies and universities.

Familiarization with the programs is very quick because of the consistent and user-friendly Windows interface of all programs. Each program is provided with easy-to-understand user manuals. A support hotline is also available for technical assistance.

All programs are WYSIWYG (What You See is What You Get), ensuring sophisticated report quality output in Windows true-type fonts. Colour output and bitmap graphics are supported. Output from all GGU programs can be „cut and paste“ into other Windows programs such as word processors and spreadsheets.

Testing software

You can evaluate GGU software before you buy programs. Fully-functional 21 day test versions of all software programs are available on our website. You can even print from the demonstration versions.

Source: Brochure of GGU Software International; http://www.ggsu-software.com

TASK 1

Answer the questions.

1. What services does GGU offer?

2. Who are the clients of GGU?

3. Give examples why the programs are so user-friendly?

GROUNDWATER package - solves groundwater flow and contaminant transport problems

The package consists of the 5 GGU programs GGU-SS FLOW2D, GGU-SS FLOW3D, GGU-TRANSIENT, GGU-CONTAM FE and GGU-CONTAM RW

GGU-SS FLOW2D

Calculates steady-state groundwater flow in horizontal,vertical and axi-symmetric groundwater systems using the finite element method.

GGU-TRANSIENT

Calculates transient groundwater flow in horizontal, vertical and axi-symetric groundwater systems using the finite element method.

GGU-CONTAM FE

Calculation of pollutant transport using the finite element method on the basis of a horizontal, vertical or axi-symmetric groundwater system calculated with SS FLOW2D. Convection, diffusion, dispersion, sorption and decomposition are taken into account. A user-friendly boundary condition generator and analysis program is included.

GGU-CONTAM RW

Calculates pollutant transport using the random-walk method on the basis of a groundwater system calculated with SS FLOW2D.

GGU-SS FLOW3D

Calculates steady-state groundwater flow in three dimensional groundwater systems using the finite element method.

Summary of capabilities:

- Computation of seepage lines and unsaturated zones
- Powerful grid generator with grid concentration and grid optimisation contaminant transport problems
- Easily implemented analysis routines
- Colour support (e.g. filled contour plans, 3-D graphics,sections, water quantities, flow lines, etc.).

GGU-DRAWDOWN - Optimisation of multiple well installations

The GGU-DRAWDOWN program allows the design of multiple well installations. Excavations with rectangular or irregular plan shape can be analyzed. The influence of bodies of water and cut-off walls can be taken into consideration. The program has optimisation routines for well numbers, well radius and well depth. After input of the excavation dimensions you can invoke the optimisation routines to automatically design an optimised groundwater management system. Graphic output includes drawdown sections, system sections, plans and isographs with system legends and summaries, all in colour. This output is available on screen and as printout.

Source: Brochure of GGU Software International; http://www.ggsu-software.com

TASK 2

Further questions:

1. What is the difference between the GGU-SS Flow2D and GGU-Transient package?

2. What is the difference between the GGU-Contam FE and the GGU-Contam RW program?

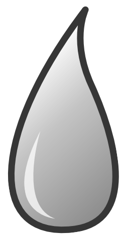
3. What additional advantage does GGU-SS Flow 3D have?

4. What services does the GGU groundwater package offer for well installation?

5. Why is the GGU software program an optimized groundwater management system?

Unit 31 Water Quality

Testing equipment



What do we mean by „water quality“?

Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. To determine water quality, scientists first measure and analyze characteristics of the water such as temperature, dissolved mineral content, and number of bacteria. Selected characteristics are then compared to numeric standards and guidelines to decide if the water is suitable for a particular use.

How is water quality measured?

Some aspects of water quality can be determined right in the stream or at the well. These include temperature, acidity (pH), dissolved oxygen, and electrical conductance (an indirect indicator of dissolved minerals in the water). Analyses of individual chemicals generally are done at a laboratory.

Source: http://www.usgs.gov/fs/fs-027-01

TASK 1

Fill in the gaps: “bacteria”, “climate”, “evaporates”, “mineral”, “muddy”, “percolate”, “processes” and “silt”

How do natural processes affect water quality?

Natural water quality varies from place to place, with the seasons, with ❶ ________________, and with the types of soils and rocks through which water moves. When water from rain or snow moves over the land and through the ground, the water may dissolve ❷ ________________ in rocks and soil, ❸ ________________ through organic material such as roots and leaves, and react with algae, ❹ ________________, and other microscopic organisms. Water may also carry plant , debris and sand, ❺ ________________, and clay to rivers and streams making the water appear „❻ ________________" or turbid. When water ❼ ________________ from lakes and streams, dissolved minerals are more concentrated in the water that remains. Each of these natural ❽ ________________ changes the water quality and potentially the water use.

after: see source from text above

TASK 2

How do human activities affect water quality?

____

____

____

____

____

____

____

To measure temperature, acidity, oxygen and electrical conductance multimeters can be used for field measurements.

Why are pH, redox, EC and 0_2 measured directly in the field?

1. The release or sorption of carbon dioxide causes the **pH** (= acidity) of groundwater to change.
2. Precipitation of hydroxides changes the conductivity of groundwater
3. When sampling groundwater the oxygen content rapidly increases.
4. The availability of oxygen causes the redox potential to shift rapidly.
5. Direct availability of results.
6. Less costly than when carried out in a laboratory.

The interaction of various acids, bases and salts determines the **pH**. The pH of soil and groundwater are important criteria in the selection of plant material, the amount of fertilizer to apply, or the environmental measures to be taken.

Redox is short for Reduction-Oxidation potential. Oxidation stands for an increase of bound oxygen. Reduction indicates lower oxidation levels in a medium. Better; the Redox potential is a measure of the capacity of a substance to absorb or release electrons. **EC** is an indication of the amount of salts dissolved in water. As the concentration of salt may be a limiting or stimulating growth factor, or an indication of soil pollution, it is essential to establish the electrical conductivity.

The measurement of $\mathbf{O_2}$ refers to the amount of oxygen dissolved in water. It is measured in mg/l of water or indicated as a percentage of saturation. The presence of oxygen is not only of crucial importance to the open water flora and fauna but also to aerobic processes of degradation in the soil.

Source: Brochure: Eijkelkamp Agrisearch Equipment; p. 209

TASK 3

Complete the sentences.

1. Field analysis and measurements of water quality might be more efficient than measurements in a laboratory because

___

2. To know the pH value

___

3. Redox means

___

4. If you want to know the amount of salts

___

5. O_2 refers to

___

Multimeters

- Watertight ABS housing.
- Simultaneous measurement of several parameters possible.
- Display of measurements, temperature and battery status.
- Automatic adjustion.
- Polarisation time not required (0_2).
- Programmable automatic switch-off.
- Complete in case.
- Optional: rechargeable batteries and AC adapter, 12 V car connection.

pH/mV/EC/T meter

Standard meter measuring acidity, redox, conductivity and temperature.

- **Measuring range:**
  - pH 0-14 pH
  - mV +/- 1200 mV
  - °C 0-100°C
  - EC 0-100 mS/cm
- Resolution: 0.01 pH, 0.1°C, 0.1 µS.
- No memory.

ph/mV/O2/T meter

Meter measuring oxygen, acidity, redox and the temperature.

- **Measuring range:**
  - pH 0-14 pH
  - mV ±1200mV
  - °C 0-100°C
  - 02 0-20 mg/l, 0-200%
- Resolution: 0.01 pH, 1 mV, 0.1°C, 0.01 mg/l, 0.1%.
- Memory: 200 values.
- No polarisation time required (0_2).
- Calibrates only to air (0_2).

Source: Brochure: Eijkelkamp Agrisearch Equipment; p. 209

Unit 32 Waste Water Treatment

How do waste water treatment plants work?

TASK 1

Before you read the text about waste water treatment match the technical terms, which are important for waste water treatment, to their definitions and translate. Put them into the table.

English: “aeration”, “digester”, “landfill”, “sewer/sewerage”, “sludge” and “scum”

English	Translation	Definition
		thick mud, a slime produced by the precipitation of solid matters from liquid sewage in sedimentation tanks
		to add oxygen
		layer of dirt, forming at the top of a liquid
		kind of fermentation tank
		network of underground pipes that collect and deliver waste water to treatment plants or streams
		area of ground for disposing of rubbish etc.

How do waste water treatment plants work?
The following text will give you an overview of the primary treatment of waste water. The step-by-step guide describes what happens at each stage of the treatment process to keep our water clean.

The Primary Treatment Process

1. Screening

Waste water entering the treatment plant includes items like wood, rocks, and even dead animals. Unless they are removed, they could cause problems later in the treatment process. Most of these materials are sent to a landfill.

2. Pumping

The waste water system relies on the force of gravity to move sewage from your home to the treatment plant. So waste water-treatment plants are located on low ground, often near a river into which treated water can be released. If the plant is built above the ground level, the waste water has to be pumped up to the aeration tanks. From here on, gravity takes over to move the waste water through the treatment process.

3. Aerating

One of the first steps that a water treatment facility can do is to just shake up the sewage and expose it to air. This causes some of the dissolved gases (such as hydrogen sulfide, which smells like rotten eggs) that taste and smell bad to be released from the water. Waste water enters a series of long, parallel concrete tanks. Each tank is divided into two sections. In the first section, air is pumped through the water.

As organic matter decays, it uses up oxygen. Aeration replenishes the oxygen. Bubbling oxygen through the water also keeps the organic material suspended while it forces ‚grit‘ (coffeegrounds, sand and other small, dense particles) to settle out. Grit is pumped out of the tanks and taken to landfills.

4. Removing sludge

Waste water then enters the second section or sedimentation tanks. Here, the sludge (the organic portion of the sewage) settles out of the waste water and is pumped out of the tanks. Some of the water is removed in a step called thickening and then the sludge is processed in large tanks called digesters.

5. Removing scum

As sludge is settling to the bottom of the sedimentation tanks, lighter materials are floating to the surface. This ‚scum‘ includes grease, oils, plastics, and soap. Slow-moving rakes skim the scum off the surface of the waste water. Scum is thickened and pumped to the digesters along with the sludge.

Many cities also use filtration in sewage treatment. After the solids are removed, the liquid sewage is filtered through a substance, usually sand, by the action of gravity. This method gets rid of almost all bacteria, reduces turbidity and color, removes odors, reduces the amount of iron, and removes most other solid particles that remained in the water. Water is sometimes filtered through carbon particles, which removes organic particles. This method is used in some homes, too.

6. Killing bacteria

Finally, the waste water flows into a ‚chlorine contact' tank, where the chemical chlorine is added to kill bacteria, which could pose a health risk, just as is done in swimming pools. The chlorine is mostly eliminated as the bacteria are destroyed, but sometimes it must be neutralized by adding other chemicals. This protects fish and other marine organisms, which can be harmed by the smallest amounts of chlorine.
The treated water (called effluent) is then discharged to a local river or the ocean.

Source: http://ga.water.usgs.gov/edu/wwvisit.html

TASK 2

Fill in: "bacteria", "biological process", "chemical/physical methods", "floating", "removes", "sludge", "stage" and "suspended"

secondary waste water treatment - treatment (following primary waste water treatment) involving the ❶ ____________________ of reducing suspended, colloidal, and dissolved organic matter in effluent from primary treatment systems and which generally ❷ ____________________ 80 to 95 per cent of the Biochemical Oxygen Demand (BOD) and suspended matter. Secondary waste water treatment may be accomplished by biological or ❸ ____________________. Activated ❹ ____________________ and trickling filters are two of the most common means of secondary treatment. It is accomplished by bringing together waste, ❺ ____________________, and oxygen in trickling filters or in the activated sludge process. This treatment removes ❻ ____________________ and settleable solids and about 90 per cent of the oxygen-demanding substances and ❼ ____________________ solids. Desinfection is the final ❽ ____________________ of secondary treatment.

after: http://ga.water.usgs.gov/edu/dictionary.html

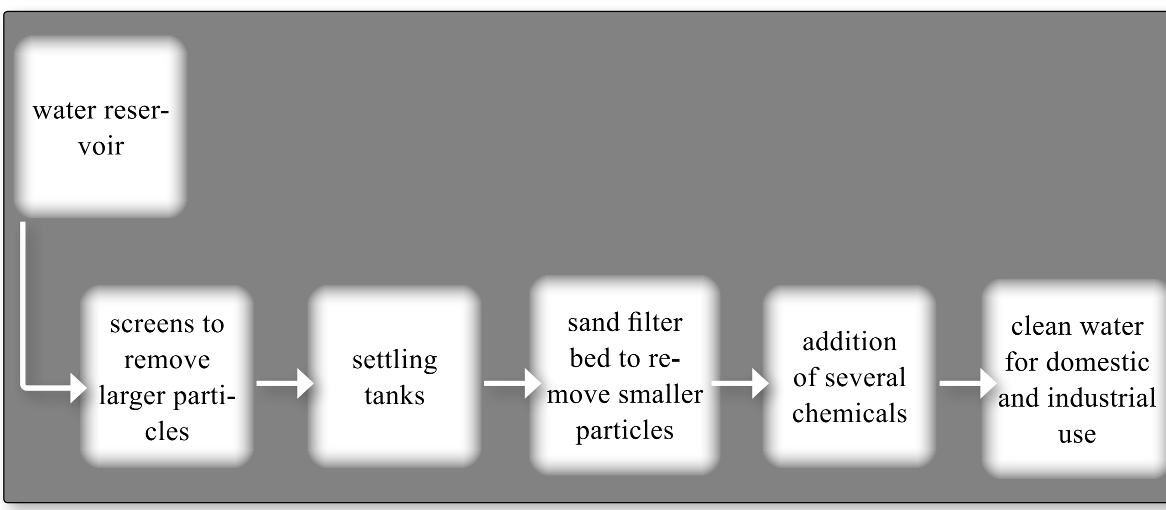
TASK 3

Fill in: “aeration”, “basins”, “chlorine”, “conventional”, “inorganic”, “quality”, “screens” and “solid”

tertiary waste water treatment - selected biological, physical, and chemical separation processes to remove organic and ❶ ________________ substances that resist ❷ ________________ treatment practices; the additional treatment of effluent beyond that of primary and secondary treatment methods to obtain a very high ❸ ________________ of effluent. The complete waste water treatment process typically involves a three-phase process: (1) First, in the primary waste water treatment process, which incorporates physical aspects, untreated water is passed through a series of ❹ ________________ to remove ❺ ________________ wastes; (2) Second, in the secondary waste water treatment process, typically involving biological and chemical processes, screened waste water is then passed a series of holding and ❻ ________________ tanks and ponds; and (3) Third, the tertiary waste water treatment process consists of flocculation ❼ ________________, clarifiers, filters, and ❽ ________________ basins or ozone or ultraviolet radiation processes.

after: http://ga.water.usgs.gov/edu/dictionary.html

Diagram of the simplified waste water treatment process



TASK 4

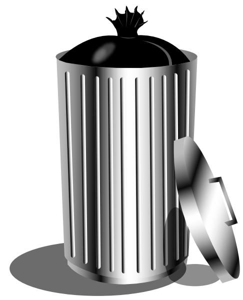
Simplified one can summarize the water treatment process to produce drinking water in five stages. Match the description to the stages.

1. Screening (1)	A: At this stage of the treatment process a flocculant, e.g. aluminium sulphate is filled into the water. Due to this treatment smaller particles flock together into bigger lumps and drop / settle to the bottom of the water tank.
2. Settling (2)	B: At this stage the water flows through meshes or screens and the coarser floating material is collected.
3. Filtration (3)	C: Here a chemical is added to prevent tooth decay. This method is discussed controversially in many countries. However, at this stage the pH value of the water is tested. If the level is too low, some lime is added. If it is too high, then dilute acid is mixed into the water.
4. Chlorination (4)	D: The water flows through sand beds. At this stage of the treatment process any remaining insoluble particles are cleared away. Visually the water might be clear, but it may still contain bacteria.
5. Fluoridation (5)	E: Now a chemical is added to kill any bacteria left. The addition must be carefully monitored because too little of this chemical may not kill all the bacteria and too much causes a bad smell and taste of the water.

1__ 2__ 3__ 4__ 5__

Unit 33 Waste Disposal

Waste management and geoengineering



TASK 1

Brainstorming for words. Fill in the empty bubbles.

waste material

trash

rubbish

dump

disposal site

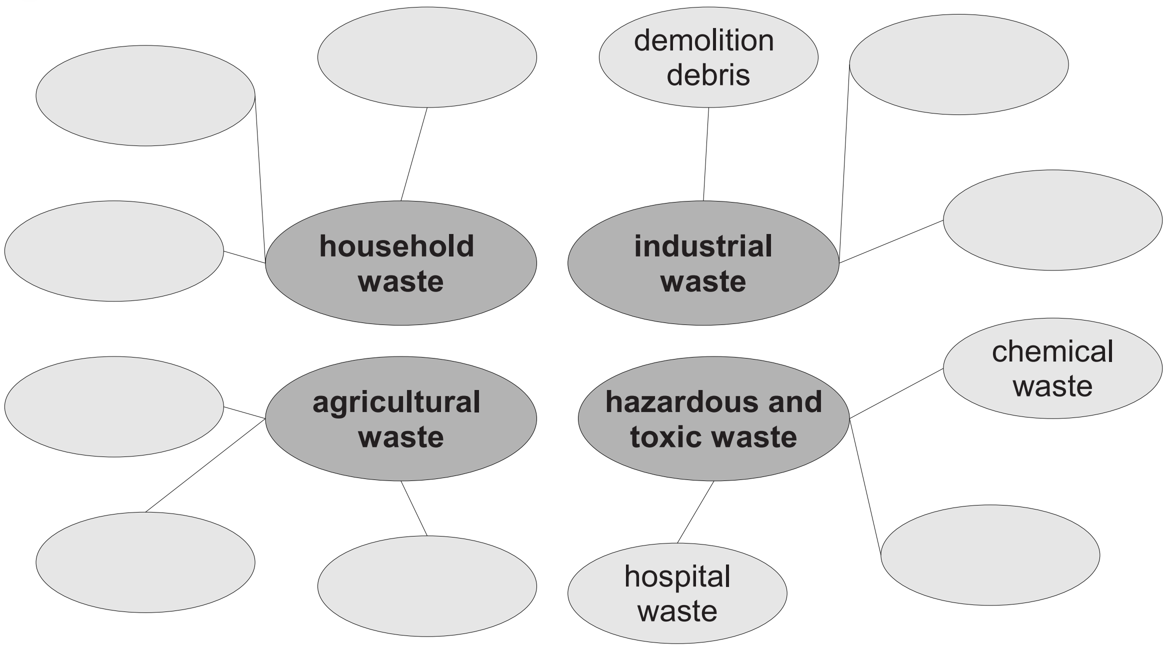
rubbish heap

garbage

landfill

TASK 2

Types of waste – complete.



Introduction

Modern landfills are highly engineered containment systems, designed to minimize the impact of solid waste (refuse, trash, and garbage) on the environment and human health. In modern landfills, the waste is contained by a liner system. The primary purpose of the liner system is to isolate the landfill contents from the environment and, therefore, to protect the soil and groundwater from pollution originating in the landfill.

The greatest threat to groundwater posed by modern landfills is leachate. Leachate consists of water and water-soluble compounds in the refuse that accumulate as water moves through the landfill. This water may be from rainfall or from the waste itself. Leachate may migrate from the landfill and contaminate soil and groundwater, thus presenting a risk to human and environmental health.

Landfill liners are designed and constructed to create a barrier between the waste and the environment and to drain the leachate to collection and treatment facilities. This is done to prevent the uncontrolled release of leachate into the environment.

Society produces many different solid wastes that pose different threats to the environment and to community health. Different disposal sites are available for these different types of waste. The potential threat posed by the waste determines the type of liner system required for each type of landfill. Liners may be described as single composite, or double liners.

From: Hughes, L. u.a.: Landfill Types and Liner System; OSU Extension Sheets; http://ohioline.osu.edu/cd-fact/0138.html

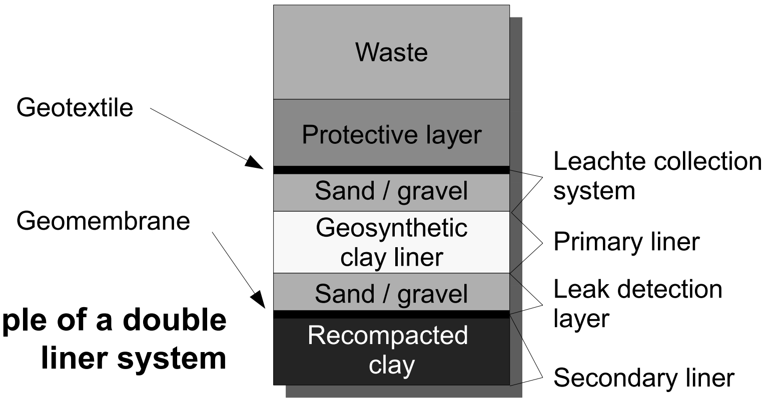
Waste management means…

1. finding the right location for a landfill site;
2. finding measures for protecting the environment;
3. finding techniques to prevent percolation of contaminants into soil, groundwater or sewerage;
4. finding stability methods for a landfill;
5. finding methods to manage landfill gas
6. etc.

TASK 3

Explain each point, think of problems which may arise and discuss.

How is a landfill roughly designed?



Example of a double liner system

TASK 4

Explain the figure.

Liner Components

Clay: To protect the groundwater from landfill contaminants, clay liners are constructed as a simple liner that is two- to five-feet thick. In composite and double liners, the compacted clay layers are usually between two- and five-feet thick, depending on the characteristics of the underlying geology and the type of liner to be installed. Regulations specify that the clay used can only allow water to penetrate at a rate of less than 1.2 inches per year. The effectiveness of clay liners can be reduced by fractures induced by freeze-thaw cycles, drying out, and the presence of some chemicals.

In theory, one foot of clay is enough to contain the leachate. The reason for the additional clay is to safeguard the environment in the event of some loss of effectiveness in , part of the clay layer. The efficiency of clay liners can be maximized by laying the clay down in four- to six-inch layers and then compacting each layer with a heavy roller.

The efficiency of clay liners is impaired if they are allowed to dry out during placement. Desiccation of the clay during construction results in cracks that reduce the liner efficiency. In addition, clays compacted at low moisture contents are less effective barriers to contaminants than clays compacted at higher moisture contents. Liners that are made of a single type of clay perform better than liners constructed using several different types.

Geomembranes: Geomembranes are also called flexible membrane liners (FML). These liners are constructed from various plastic materials, including polyvinyl chloride (PVC) and high-density polyethylene (HDPE).

Geotextiles: In landfill liners, geotextiles are used to prevent the movement of small soil and refuse particles into the leachate collection layers and to protect geomembranes from punctures. These materials allow the movement of water but trap particles to reduce clogging in the leachate collection system.

Geosynthetic Clay Liner (GCL): Geosynthetic clay liners are becoming more common in landfill liner designs. These liners consist of a thin clay layer (four to six millimeters) between two layers of a geotextile. These liners can be installed more quickly than traditional compacted clay liners, and the efficiency of these liners is impacted less by freeze-thaw cycles.

Geonet: A geonet is a plastic net-like drainage blanket which may be used in landfill liners in place of sand or gravel for the leachate collection layer. Sand and gravel are usually used due to cost considerations, and because geonets are more susceptible to clogging by small particles. This clogging would impair the performance of the leachate collection system. Geonets do, however, convey liquid more rapidly than sand and gravel.

From: Hughes, L. u.a.: Landfill Types and Liner System; OSU Extension Sheets; http://ohioline.osu.edu/cd-fact/0138.html

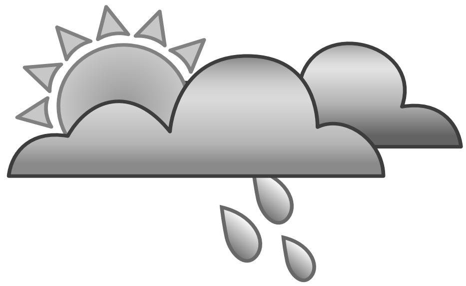
TASK 5

Think of other ways to treat waste. Give examples, explain and discuss.

Words to help: “to dump”, “to decompose”, “to reuse”, “to recycle”, “to incinerate”, “to convert into biodegradable products”,…

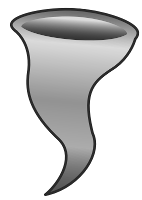
Unit 34 Meteorology and Climatology

An introduction to weather and climate phenomena



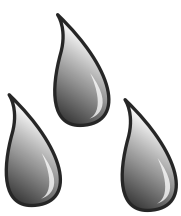
Meteorology

Meteorology is an interdisciplinary field of study of the Earth's atmosphere in relation to its movements and its changes. Meteorology especially centres on weather processes and makes weather forecasts.



Climatology

Climatology is the scientific study of the climate which means the regular patterns of weather conditions. Climatologists study our average weather conditions and variations over longer periods of time.



The difference between "weather" and "climate" should be absolutely clear.

TASK 1

Fill in the terms “weather” or “climate” to complete the sentences.

1. ________________ is all around us.
2. ________________ describes the total of all weather occurring over a period of years in a given place.
3. ________________ is what happens from minute to minute.
4. ________________ is what we hear about on TV or radio news.
5. ________________ includes average weather conditions, regular weather sequences and special weather events.
6. ________________ includes daily changes in temperature, rainfall, barometric pressure, and wind and sun conditions.
7. ________________ tells us what it is usually like in the place where you live.
8. ________________ gives us information about the area or region with certain weather conditions.

information adapted from: http://epa.gov/climatechange/kids/climateweather.html

TASK 2

Fill in the table about “weather” and “climate” with the following words. Add information into the last column about general topics on meteorology and climatology.

“atmospheric pressure“, “autumn”, “air pollution”, “blizzard”, ”cloudburst”, “drizzle”, “dry”, “fall/rise of the barometer“, “fog”, “freezing rain”, “frostiness”, “global warming”, “greenhouse effect”, “hail”, “humidity“, “hurricane”, “hygrometer“,“lightning”, “rain”, “showers”, “spring”, “snow”, “summer”, “tornado”, “thunderstorm”, “wet”, “winter”, “weather forecast”

moderate, temperate, mid-latitude season	tropic season	types of precipitation	types of storm	weather conditions	meteorology climatology - general topics

TASK 3

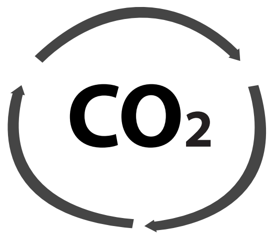
In which climate region do you live?

Do you live in a mild, string, humid or dry, snowy or rainy climate?

Describe the seasons, give temperature and precipitation data.

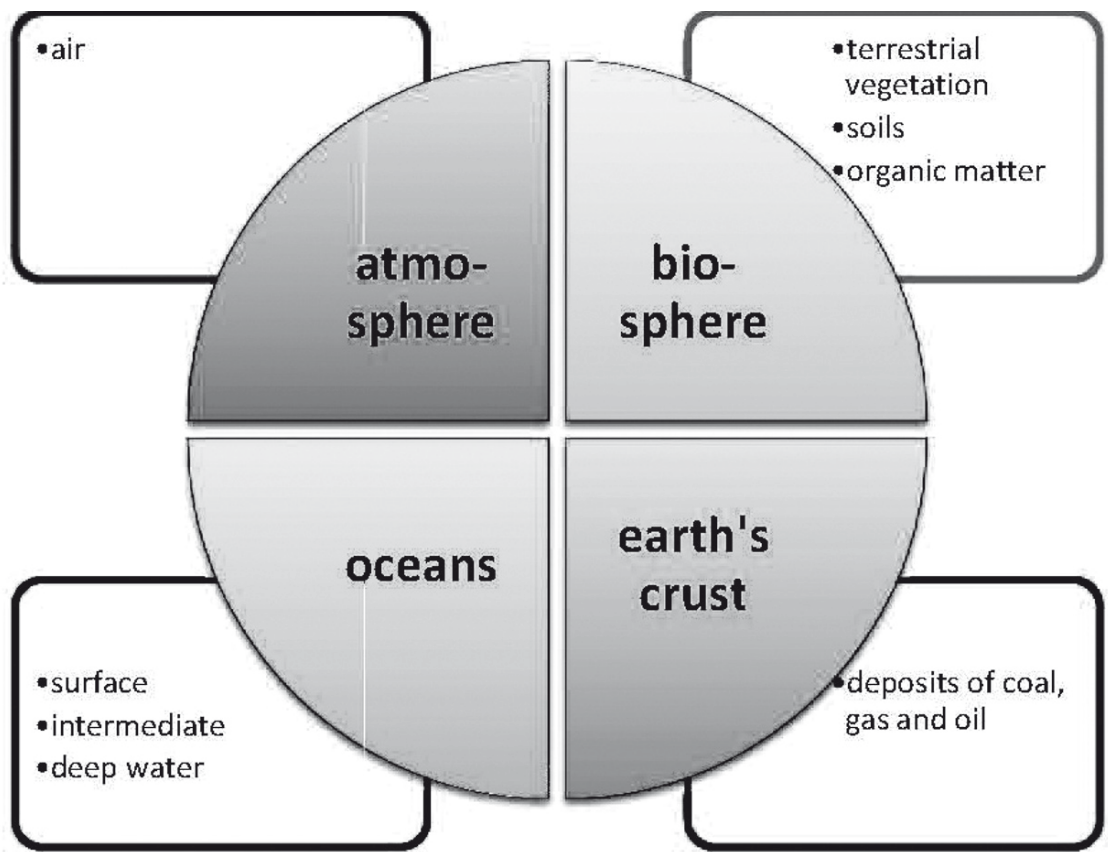
Unit 35 The Carbon Cycle

The natural transfer of carbon dioxide

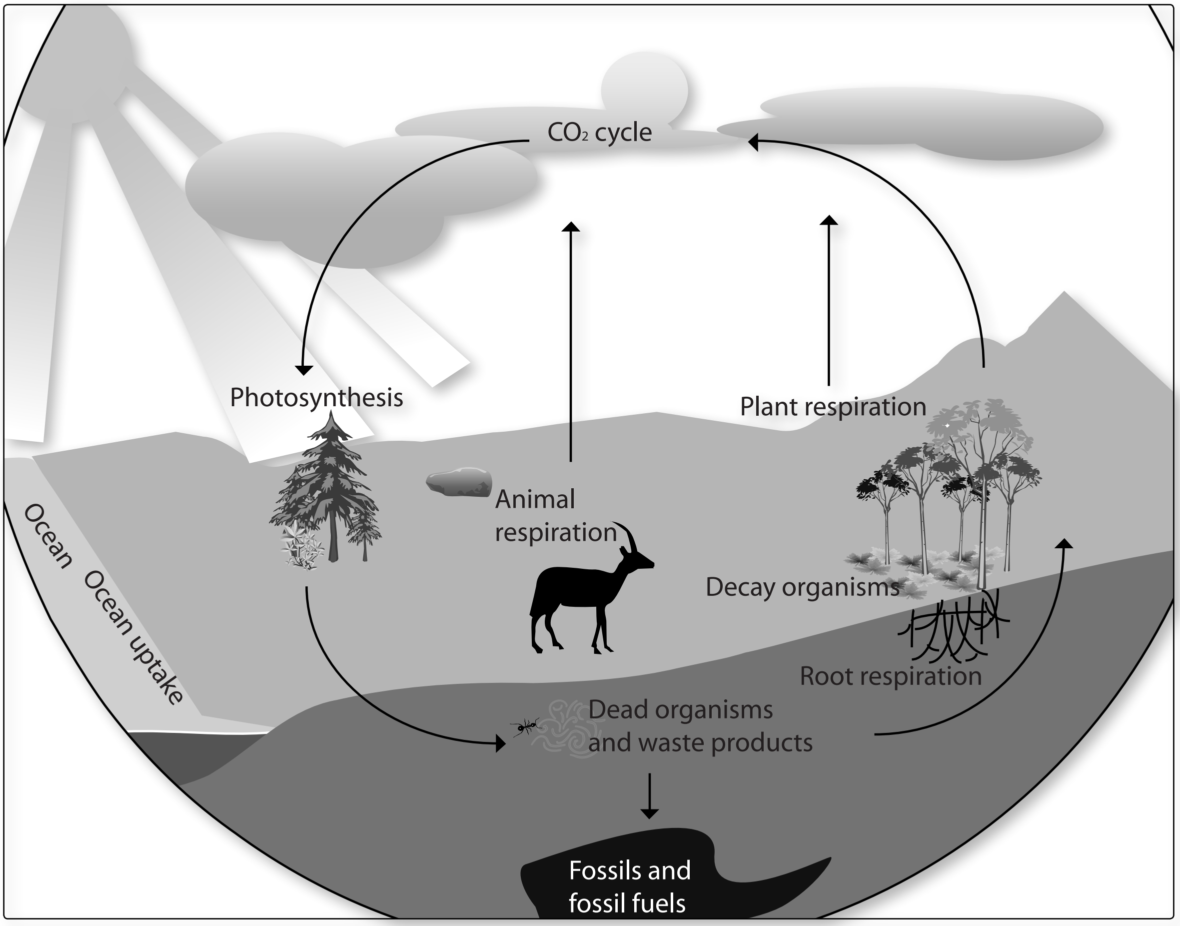


All living things and matter are made from carbon. Carbon exists in non-living environments as well. If carbon is attached to some oxygen, it is called carbon dioxide.

The biggest reservoirs of carbon are



Between these reservoirs there is a permanent natural exchange explained in a complex series of processes ideally described in the carbon cycle (here: simplified version)



TASK 1

Describe the processes of the carbon cycle and the natural transfer of carbon dioxide in your own words.

____

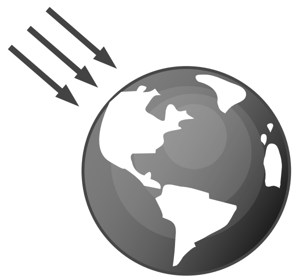
TASK 2

Discuss.

What happens if the carbon cycle comes out of balance, if the uptake and return of carbon is not in equilibrium? Think of the fact that carbon dioxide is a greenhouse gas.

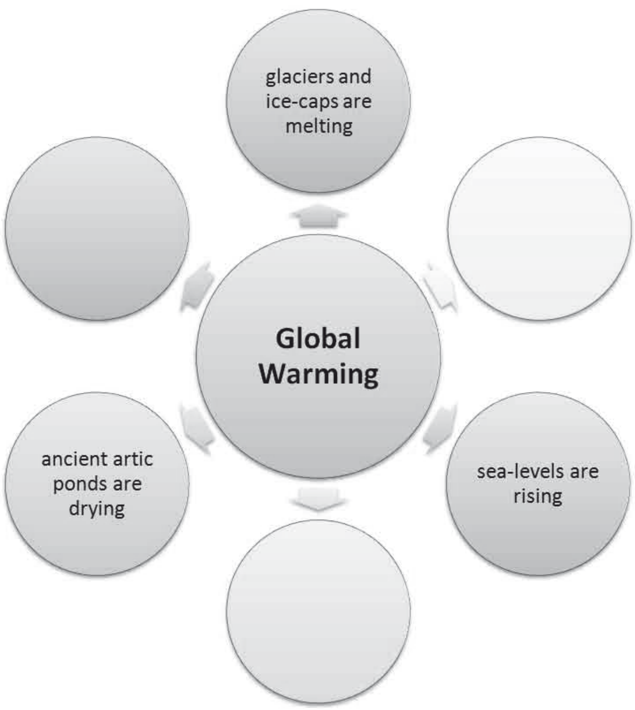
Unit 36 Global Warming and Climate Change

The human impact on the environment



TASK 1

Complete the diagram.



Climate has always changes from natural causes, but it is becoming clear that human activities have caused most of the past century's warming by releasing heat-trapping gases – called greenhouse gases – into the atmosphere.

The Greenhouse Effect

The „greenhouse effect" is the warming that happens when certain gases in Earth's atmosphere trap heat. These gases let in light but keep heat from escaping, like the glass walls of a greenhouse.

First, sunlight shines onto the Earth's surface, where it is absorbed and then radiates back into the atmosphere as heat. In the atmosphere, „greenhouse" gases trap some of this heat, and the rest escapes into space. The more greenhouse gases are in the atmosphere, the more heat gets trapped.

Scientists have known about the greenhouse effect since 1824, when Joseph Fourier calculated that the Earth would be much colder if it had no atmosphere. This greenhouse effect is what keeps the Earth's climate livable. Without it, the Earth's surface would be an average of about 60 degrees Fahrenheit cooler. In 1895, the Swedish chemist Svante Arrhenius discovered that humans could enhance the greenhouse effect by making carbon dioxide, a greenhouse gas. He kicked off 100 years of climate research that has given us a sophisticated understanding of global warming.
Levels of greenhouse gases (GHGs) have gone up and down over the Earth's history, but they have been fairly constant for the past few thousand years. Global average temperatures have stayed fairly constant over that time as well, until recently. Through the burning of fossil fuels and other GHp emissions, humans are enhancing the greenhouse effect and warming Earth.

Global warming and climate change

Scientists often use the term „climate change" instead of global warming. This is because as the Earth's average temperature climbs, winds and ocean currents move heat around the globe in ways that can cool some areas, warm others, and change the amount of rain and snow falling. As a result, the climate changes differently in different areas.

Aren't temperature changes natural?

The average global temperature and concentrations of carbon dioxide (one of the major greenhouse gases) have fluctuated on a cycle of hundreds of thousands of years as the Earth's position relative to the sun has varied. As a result, ice ages have come and gone.
However, for thousands of years now, emissions of GHGs to the atmosphere have been balanced out by GHGs that are naturally absorbed. As a result, GHG concentrations and temperature have been fairly stable. This stability has allowed human civilization to develop within a consistent climate.

Occasionally, other factors briefly influence global temperatures. Volcanic eruptions, for example emit particles that temporarily cool the Earth's surface. But these have no lasting effect beyond few years. Other cycles, such as El Nino, also work on fairly short and predictable cycles.

Now, humans have increased the amount of carbon dioxide in the atmosphere by more than a third since the industrial revolution. Changes this large have historically taken thousands of years but are now happening over the course of decades.

Why is this a concern?

The rapid rise in greenhouse gases is a problem because it is changing the climate faster than some living things may be able to adapt. Also, a new and more unpredictable climate poses unique challenges to all life.

Historically, Earth's climate has regularly shifted back and forth between temperatures like those we see today and temperatures cold enough that large sheets of ice covered much of North America and Europe. The difference between average global temperatures today and during those ice ages is only about 5 degrees Celsius (9 degrees Fahrenheit), and these swings happen slowly, over hundreds of thousands of years.

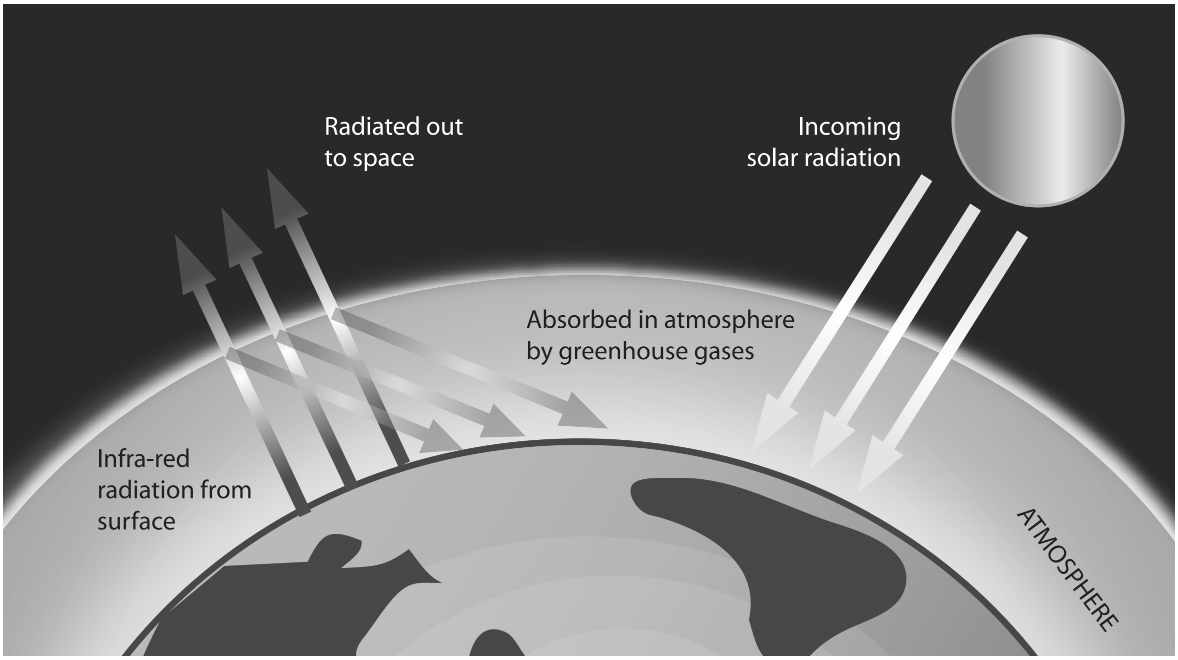
Now, with concentrations of greenhouse gases rising, Earth's remaining ice sheets (such as Greenland and Antarctica) are starting to melt too. The extra water could potentially raise sea levels significantly.

As the mercury rises, the climate can change in unexpected ways. In addition to sea levels rising weather can become more extreme. This means more intense major storms, more rain followed by longer and drier droughts (a challenge for growing crops), changes in the ranges in which plants and animals can live, and loss of water supplies that have historically come from glaciers.

Scientists are already seeing some of these changes occurring more quickly than they had expected. According to the Intergovernmental Panel on Climate Change, eleven of the twelve hottest years since thermometer readings became available occurred between 1995 and 2006.

Source: http://green.nationalgeographic.com/environment/global-warming/gw-overview.html

The Greenhouse Effect



The Greenhouse Effect

TASK 2

Describe the diagram.

TASK 3

Fill in the missing words: “atmosphere”, “greenhouse gases”, “infrared radiation”, “ozone”, “solar radiation”, “surface”, “temperature” and “water vapour”

The Earth has a natural ❶ ________________ control system. Certain atmospheric gases are critical to this system and are known as ❷ ________________ . On average, about one third of the ❸ ________________ that hits the earth is reflected back to space. Of the remainder, some is absorbed by the ❹ ________________ but most is absorbed by the land and oceans. The Earth‘s ❺ ________________ becomes warm and as a result emits ❻ ________________ . The greenhouse gases trap the infrared radiation, thus warming the atmosphere. Naturally occurring greenhouse gases include ❼ ________________ , carbon dioxide, ❽ ________________, methane and nitrous oxide, and together create a natural greenhouse effect. However, human activities are causing greenhouse gas levels in the atmosphere to increase.

Source: information taken from: UNEP; United Nations Environment Programme

Table of Main Greenhouse Gases

Gases	Chemical formula	resulting from / composition of
Carbon dioxide	CO_2	fossil fuels (oil, gas, coal, etc.) deforestation ________________, ________________
Chlorofluorocarbons	CFC	aerosols refrigerants ________________, ________________
Methane	CH_4	biomass cattle and other farm animals paddy fields ________________, ________________ ________________, ________________
Nitrous oxide	N_2O	soils fertilisers ________________, ________________ ________________, ________________
Ozone		by-product of nitrous oxide and hydrocarbons ________________, ________________ ________________, ________________

TASK 4

Complete the table by filling in more causes for the rising of greenhouse gases.

The Results of Global Warming

TASK 5

Match the sentence parts.

Researchers have evidence that **1**	have broken off in the past decade. **A**
Scientists say the rise in sea levels around the world caused by the melting of ice **2**	global warming is melting the ice in Antarctica faster than had previously been thought. **B**
Over the past years, scientists have found that melting Antarctic ice caps contribute **3**	should not be under-estimated. **C**
Several major sections of Antarctic ice **4**	at least 15% to the current global sea level rise of 2 mm a year. **D**

1__ 2__ 3__ 4__

Unit 37 Global Response to Climate Change

Statements and conclusions

The following text gives a good overview about the problems involved with climate change due to global warming and gives scientific advice on how to react to climate changes and to reduce the causes.

Joint science academies' statement: Global response to climate change

Climate change is real

There will always be uncertainty in understanding a system as complex as the world's climate. However there is now strong evidence that significant global warming is occurring

1. The evidence comes from direct measurements of rising surface air temperatures and subsurface ocean temperatures and from phenomena such as increases in average global sea levels, retreating glaciers, and changes to many physical and biological systems. It is likely that most of the warming in recent decades can be attributed to human activities (IPCC 2001)

2. This warming has already led to changes in the Earth's climate.

The existence of greenhouse gases in the atmosphere is vital to life on Earth - in their absence average temperatures would be about 30 centigrade degrees lower than they are today. But human activities are now causing atmospheric concentrations of greenhouse gases -including carbon dioxide, methane, tropospheric ozone, and nitrous oxide - to rise well above pre-industrial levels. Carbon dioxide levels have increased from 280 ppm in 1750 to over 375 ppm today-higher than any previous levels that can be reliably measured (i.e. in the last 420,000 years). Increasing greenhouse gases are causing

temperatures to rise; the Earth's surface warmed by approximately 0.6 centigrade degrees over the twentieth century. The Intergovernmental Panel on Climate Change (IPCC) projected that the average global surface temperatures will continue to increase to between 1.4 centigrade degrees and 5.8 centigrade degrees above 1990 levels, by 2100.

Source: http://nationalacademies.org/onpi/06072005.pdf

TASK 1

Questions, remarks and comments.

1. How do we know that global warming is evident?

2. Why is the existence of a certain amount of greenhouse gases imperative to our lives?

3. Why do increasing greenhouse gases become a problem?

Reduce the causes of climate change

The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action. It is vital that all nations identify cost-effective steps that they can take now, to contribute to substantial and long-term reduction in net global greenhouse gas emissions.

Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change. As the United Nations Framework Convention on Climate Change (UNFCCC) recognises, a lack of full scientific certainty about some aspects of climate change is not a reason for delaying an immediate response that will, at a reasonable cost, prevent dangerous anthropogenic interference with the climate system.

As nations and economies develop over the next 25 years, world primary energy demand is estimated to increase by almost 60%. Fossil fuels, which are responsible for the majority of carbon dioxide emissions produced by human activities, provide valuable resources for many nations and are projected to provide 85% of this demand (IEA 2004)3. Minimising the amount of this carbon dioxide reaching the atmosphere presents a huge challenge. There are many potentially cost-effective technological options that could contribute to stabilising greenhouse gas concentrations. These are at various stages of research and development. However barriers to their broad deployment still need to be overcome.

Carbon dioxide can remain in the atmosphere for many decades. Even with possible lowered emission rates we will be experiencing the impacts of climate change throughout the 21st century and beyond. Failure to implement significant reductions in net greenhouse gas emissions now, will make the job much harder in the future.

Source: http://nationalacademies.org/onpi/06072005.pdf

TASK 1

4. The text claims that over the next 25 year, world primary energy demand is estimated to increase by almost 60%. If that is true what does that mean for technology development?

5. The text goes on: “There are many potentially cost-effective technological options that could contribute to stabilising greenhouse gas concentrations.” Comment.

Prepare for the consequences of climate change

Major parts of the climate system respond slowly to changes in greenhouse gas concentrations. Even if greenhouse gas emissions were stabilised instantly at today‘s levels, the climate would still continue to change as it adapts to the increased emission of recent decades. Further changes in climate are therefore unavoidable. Nations must prepare for them.

The projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources, agriculture, natural ecosystems and human health. The larger and faster the changes in climate, the more likely it is that adverse effects will dominate. Increasing temperatures are likely to increase the frequency and severity of weather events such as heat waves and heavy rainfall. Increasing temperatures could lead to large-scale effects such as melting of large ice sheets (with major impacts on low-lying regions throughout the world). The IPCC estimates that the combined effects of ice melting and sea water expansion from ocean warming are projected to cause the global mean sea-level to rise by between 0.1 and 0.9 metres between 1990 and 2100. In Bangladesh alone, a 0.5 metre sea-level rise would place about 6 million people at risk from flooding.

Developing nations that lack the infrastructure or resources to respond to the impacts of climate change will be particularly affected. It is clear that many of the world‘s poorest people are likely to suffer the most from climate change. Long-term global efforts to create a more healthy, prosperous and sustainable world may be severely hindered by changes in the climate.

The task of devising and implementing strategies to adapt to the consequences of climate change will require worldwide collaborative inputs from a wide range of experts, including physical and natural scientists, engineers, social scientists, medical scientists, those in the humanities, business leaders and economists.

Source: http://nationalacademies.org/onpi/06072005.pdf

TASK 1

6. Why are low-lying regions primarily affected by climate changes? Give examples.

7. “Developing nations that lack the infrastructure or resources to respond to the impacts of climate change will be particularly affected.” Comment.

8. Why is scientific and technological collaboration with developing nations crucial to give response to climate change?

Conclusion

- We urge all nations, in the line with the UNFCCC principles, to take prompt action to reduce the causes of climate change, adapt to its impacts and ensure that the issue is included in all relevant national and international strategies. As national science academies, we commit to working with governments to help develop and implement the national and international response to the challenge of climate change.
- G8 nations have been responsible for much of the past greenhouse gas emissions. As parties to the UNFCCC, G8 nations are committed to showing leadership in addressing climate change and assisting developing nations to meet the challenges of adaptation and mitigation.
- We call on world leaders, including those meeting at the Gleneagles G8 Summit in July 2005, to:
- Acknowledge that the threat of climate change is clear and increasing.
- Launch an international study5 to explore scientifically-informed targets for atmospheric greenhouse gas concentrations, and their associated emissions scenarios, that will enable nations to avoid impacts deemed unacceptable.
- Identify cost-effective steps that can be taken now to contribute to substantial and long-term reduction in net global greenhouse gas emissions. Recognise that delayed action will increase the risk of adverse environmental effects and will likely incur a greater cost.

- Work with developing nations to build a scientific and technological capacity best suited to their circumstances, enabling them to develop innovative solutions to mitigate and adapt to the adverse effects of climate change, while explicitly recognising their legitimate development rights.
- Show leadership in developing and deploying clean energy technologies and approaches to energy efficiency, and share this knowledge with all other nations.
- Mobilise the science and technology community to enhance research and development efforts, which can better inform climate change decisions.

Source: http://nationalacademies.org/onpi/06072005.pdf

TASK 1

9. How can political decisions "mobilise the science and technology community to enhance research and development efforts" e.g. concerning the reduction of greenhouse gases.

10. Can you think of other conclusions to be drawn?

Unit 38 Glossary

Creation of one's own geology glossary

TASK 1

Skim the book for geology-related terms and create your own glossary. Examples are given:

A ash

particles blasted into the air due to volcanic eruptions; less than 2mm in diameter

A

A

A

B

B basalt

an extrusive igneous rock

B

B

C

C

C continental drift

continents are moving over the Earth's surface

C

D

D

D

D

E

E earthquake

a motion or trembling of the Earth's ground or crust caused by seismic waves or displacements along a fault

E

E

F

F

F fossil fuel

an energy resource from the remains of plants and animals such as coal, oil or natural gas

F

G granite

an intrusive igneous rock

G

G

G

H

H

H

H

I

I iron

the metallic element FE; it occurs in a vast range of ores; it is magnetic and oxidizes easily when exposed to air

I

I

J

J

J

J

K

K

K

K

L

L

L

L

M magma

molten rock material; it is formed by melting deep down inside the Earth

M

M

M

N

N

N

N

O

O

O

O

P

P pyroclast

fragments or particles ejected due to volcanic eruptions

P

P

Q quartz

a silicate with the chemical formula SiO_2; it has a hardness of 7 on Mohs' hardness scale

Q

Q

Q

R recycling

the collection and separation of materials that have reached the end of their useful lives

R

R

R

S

S

S

S

T

T transpiration

the transfer of water to the atmosphere by plants and vegetation

T

T

U

U

U

U

V

V

V

V

W weathering

any of the chemical or mechanical processes by which rocks exposed to the weather undergo changes in structure and break down.

W

W

W

X

X

X

X

Y

Y

Y

Y

Z

Z

Z

Z zinc

a lustrous bluish-white metal with the formula Zn

Index

G

H

I

L

M

N

O

U

V

W

Z

Solution

Unit 1 Applied Geology

Task 2

1. follow text in stage 1-3
2. s. stage 2
3. career opportunities are numerous; additional fields, which are not explicitly mentioned in the texts, are: the construction industry and landfill/ waste management
4. up to students, open discussion

Task 3

For help compare websites / module description of different universities. Students can compare the core and optional modules of their own university with the modules given in the text. The modules are usually known to the students otherwise they can be easily found on universities homepages etc. Due to bachelor's and master's degree courses, the study courses should be roughly the same and comparable.

Unit 2 Geotechnology

Task 2

1E - 2C - 3D - 4B - 5A

Unit 3 Geotechnical Engineering

Task 2

1. s. paragraph 1
2. s. paragraph 1
3. s. paragraph 2

Task 3

1. s. Unit 1, task 3

Task 4

Applied Geology: more fundamental knowledge about Earth history, mineralogy, resources, tectonics etc. is taught;
Geotechnical Engineering: practical, engineering knowledge via laboratory work; knowledge of rock/ soil mechanics, ground movements, soil stability with regard to construction work is provided.

Solution

Unit 4 Geoengineering

Task 1

For the steps follow l. 51ff

step 4 completing of a geological survey by petrographical surface analysis; relation between underground and surface

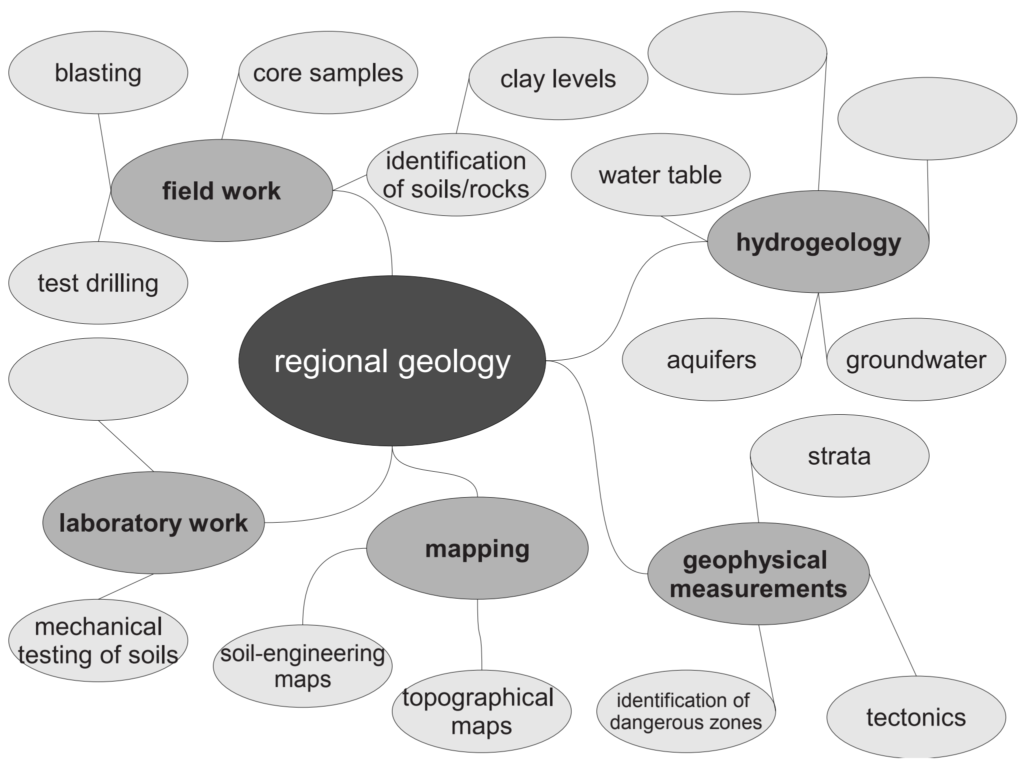
step 3 first physical data must be obtained by test drilling; soil tests in the laboratory

step 2 regional knowledge from field trips and site visiting; aerial photos and topographical observation

step 1 regional knowledge from scientific literature; from topographical and mining maps

Task 2

For the mind map: solution provided gives only examples; students may have a totally different way of brainstorming and structuring according to their knowledge



Task 4

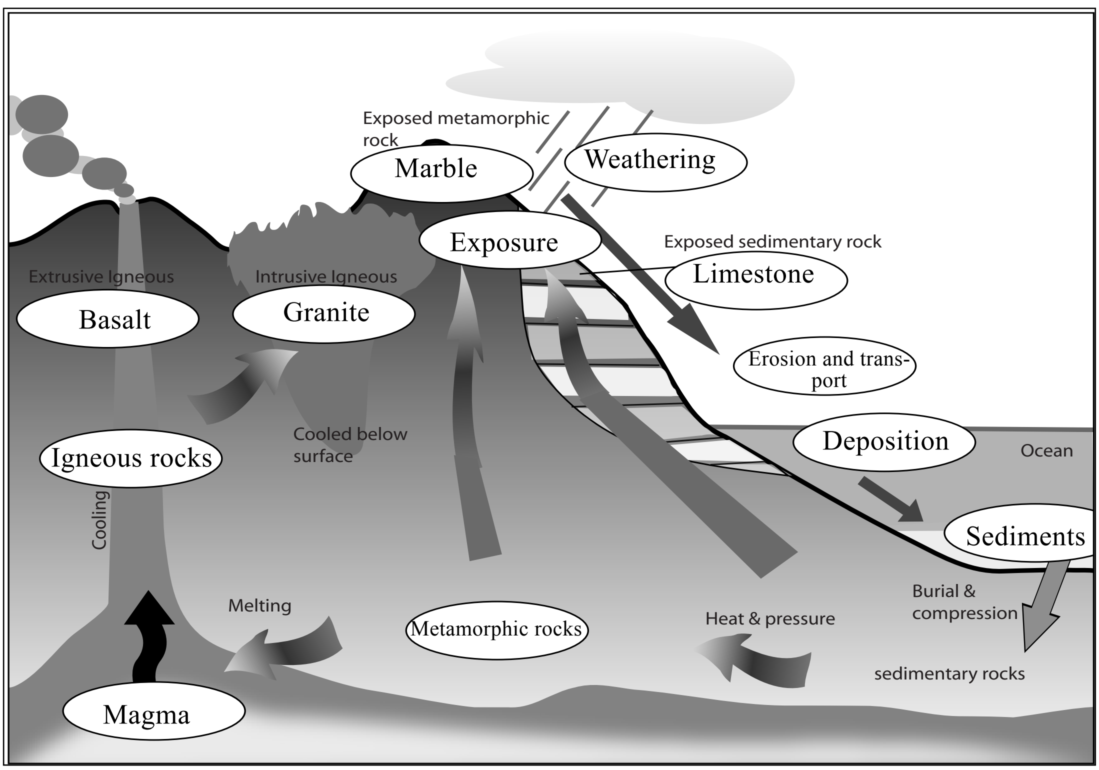
1. l. 1-2
2. l. 15 ff
3. l. 23 ff

Unit 5 The Rock Cycle

Task 1

Types	Definition	Example
sedimentary	They are formed from the crushed together remains of animals, plants and other rocks.	shale, sandstone, limestone, coal
igneous	They were formed when hot, molten volcanic material cooled and became solid.	basalt, granite, lava
metamorphic	They were once igneous or sedimentary, which were changend by great heat or pressure.	slate, marble

Task 2



Task 3
Intrusive igneous rocks cool slowly and have large crystals. Extrusive igneous rocks cool quickly and have small crystals.

Unit 6 Rocks and Rock Mechanics

Task 1
1E - 2D - 3A - 4F - 5B - 6C

Task 2
1) strength 2) deflects 3) sites 4) information 5) mapping

Task 3

Testing Equipment	Complete
hand tools	rock hammers, rock picks, chisels, saws, ...
devices	for splitting, cutting rocks, for grinding rocks, for polishing rocks, ...
machines	for testing strength, compression, deformation, ...

Unit 7 Plate Tectonics, Tectonics and Faultings

Task 1
1B - 2C - 3A

Task 2
When plates separate, they must come together, i.e. must converge somewhere else; they collide and form convergent boundaries.

Task 3
Possible Answers

1. Matching rocks are found on continents that are thousands of kilometres apart; matching fossils are found in regions where the continents were once joined together; edges of continents fit together like pieces in a puzzle
2. ..., because of the existence of mind-ocean ridges; varying ages of sea floor; the age of the sea floor is youngest where new rocks are formed along mid-ocean ridges and oldest along continental edges; glacial deposits of similar types are found in locations where continents were attached.

Unit 8 Earthquakes

Task 1

1) not felt 2) very weak 3) weak 4) observed 5) strong 6) slightly damaging 7) damaging 8) very damaging 9) destructive 10) very destructive 11) devastating 12) catastrophic

Task 2

Example:

1. The "Richter Magnitude Scale" and the "Moment Magnitude Scale" are scales for measuring the strength of an earthquake.
2. A seismogram is the record of ground movements.
3. Hz is the unit of frequency.

Task 3

1) P-waves 2) S-waves 3) L-waves 4) S-waves

Task 4

1) mantle 2) shakes 3) surface 4) crust 5) fault lines 6) damage

Task 5

1) severe 2) movements 3) rocks 4) plates 5) strength 6) waves

Task 6

For description s. unit 7 about "plate tectonics"

Task 7

1) Richter Magnitude 2) Modified Mercalli Magnitude 3) Moment Magnitude

Task 8

For discussion s. "Geohazards and engineering-services" in unit 4;
For further information s. "http://www.scec.org"

Task 9

1) fifth 2) third 3) four 4) iron nickel 5) 5000 6) liquid 7) outer 8) mantle 9) crust 10) continental

Unit 9 Volcanoes

Task 1

1) vent/pipe 2) crater 3) cone

Task 2

for solution see task 5 as well.

Task 4

1) dust 2) ash 3) bomb 4) block 5) cinder 6) pumice

Solution

Task 5

A large eruption can be extremely dangerous for people living near a volcano. Flows of searing lava, which can reach 2,000 degrees Fahrenheit (1,250 degrees Celsius) or more, can be released, burning everything in its path, including whole towns. Boulders of hardening lava can rain down on villages. Mud flows from rapidly melting snow can strip mountains and valleys bare and bury towns. Ash and toxic gases can cause lung damage and other problems, particularly for infants and the elderly. Scientists estimate that more than 260,000 people have died in the past 300 years from volcanic eruptions and their aftermath.
(s. http://green.nationalgeographic.com/environment/natural-disasters/volcano-profile.html)

Task 6

Volcanic eruptions can be a benefit because they may add nutrients to soil which assist the growth of vegetation. Volcanic eruptions can also create new islands when magma cools and solidifies.

Unit 10 Tsunamis

Task 1

1. l. 5ff
2. l. 13 ff
3. l. 24-27
4. l. 33ff
5. l. 45ff
6. l. 70ff

Task 2

Difference between volcanic eruptions and submarine earthquakes should be made.

Task 4

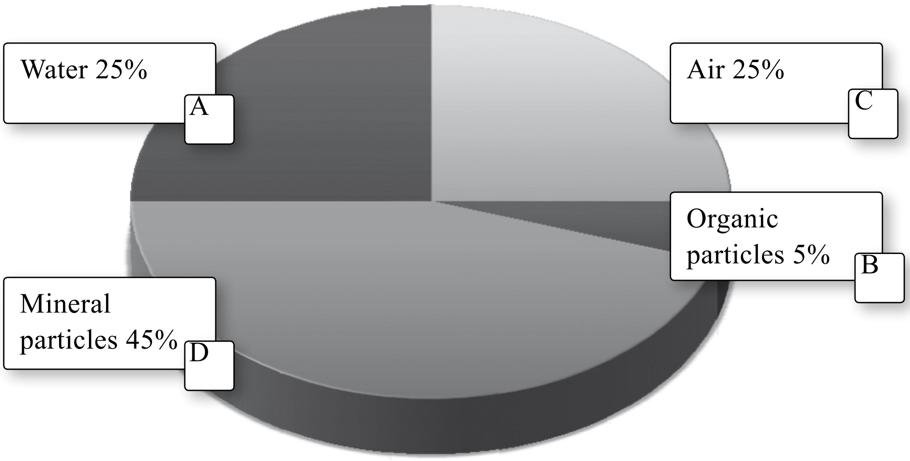
1. Recorder on sea bed monitors sea pressure and activity every few minutes; in case of unusual results readings are triggered more often
2. Surface buoy monitors upper level sea conditions and relays these plus data from sea bed monitors to satellite
3. Satellite receives data and relays them to ground stations.

Unit 11 Soil Sciences and Soil Studies

Task 1

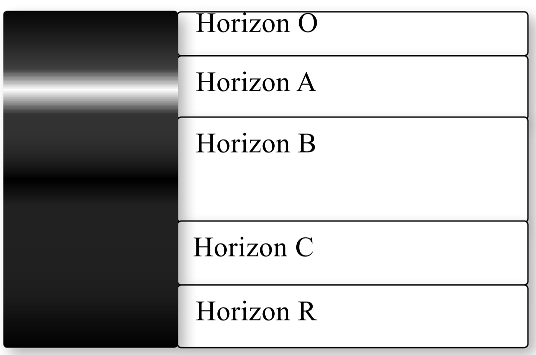
1. l. 1ff
2. l. 17ff
3. l. 23ff
4. l. 28ff
5. l. 57ff and figure 1

Task 2



Task 3

The horizons are ordered in this sequence (from top to bottom): O; A; B; C; R
Thus: 2; 4; 1; 5; 3



Task 4

1) eluviation 2) illuviation

Unit 12 Soil Testing Equipment I

Task 1

For all earthwork and construction work where foundation stability and bearing capacities must be calculated.

Task 2

1B - 2A - 3D - 4C

Solution

Task 3

1) total weight 2) drop weight 3) max. impact force 4) duration of impact 5) spring element 6) diameter 7) thickness of plate 8) total weight 9) dimensions 10) measurement range of settlement 11) temperature range 12) power supply

Unit 13 Soil Testing Equipment II

Task 1

consolidated: former loosely aggregated material which have become firm or coherent rocks.
unconsolidated: soil material in a loosely aggregated form
drained: dry; emptied
undrained: not dry; not emptied

Task 2

1) do not cause changes 2) cause changes

Unit 14 Mineralogy I

Task 1

1C - 2A - 3B

Task 2

1) physical 2) chemical 3) coarse- 4) fine- 5) crystals

Task 3

Mineral: A mineral is a naturally occurring substance with a crystalline structure. Minerals are generally inorganic with a specific chemical composition; they are homogeneous
Crystal structure: In minerals the atoms are arranged in a crystalline structure, i.e. in an ordered 3-dimensional arrangement. Crystal structure means a specific regular structure.

Task 4

Group:	Silicates	Oxides	Sulfides	Carbonates	Sulfates	Phosphates
	Quartz	Magnetite	Galena	Dolomite	Gypsum	Apatite
	Clays	Hematite	Pyrite	Calcite	Anhydrite	
	Feldspar	Rutile		Aragonite		

Task 5

1) false: approx. 3000 or more 2) false: approx. 30 minerals 3) false: s. task 4 4) true 5) true

Task 6

keywords are given

Task 7

s. Unit 17 "Minerals in Industry and Economy"

Unit 15 Mineralogy II

Task 1

1) fracture 2) hardness 3) luster 4) transparency 5) colour 6) crystal form 7) cleavage 8) streak 9) density 10) magnetism

Task 2

1) luster 2) hardness 3) colourless 4) cleavage 5) crystal form 6) pyramid 7) grains 8) glass

Unit 16 Mineralogy III

Task 2

1) hardness 2) clarity 3) thermal conductivity 4) melting point 5) lattice density

Task 4

hard	soft
insulator	conductor
abrasive	lubricant
transparent	opaque
isometric system	hexagonal system

1) hard 2) soft 3) insulator 4) conductor 5) abrasive 6) lubricant 7) transparent 8) opaque 9) isometric system 10) hexagonal system

Unit 17 Minerals in Industry and Economy

Task 2

1) economic development 2) raw materials 3) self-sufficiency 4) prospectivity 5) minerals testing 6) hydrocarbons 7) reservoir geology 8) state-of-the-art laboratories 9) exploration 10) rehabilitation

Task 3

construction:

Petrographical character of surface formations of roads etc. must be known; relations between surface formations and those situated below them etc.; for handling landslides; soil stability etc.

manufacturing:

ex. zinc; s. unit 18; task 1

Solution

agriculture:
s. unit 11 about the composition of soils; also minerals as fertilizers.

Unit 18 Tara Mines I

Task 1
1) galvanizing 2) alloys 3) sulphur 4) iron 5) oxide

Task 2
See also text in task 1.

Task 3
1. l. 20ff
2. l. 35ff

Task 4
1. l. 36ff
2. l. 27ff
3. l. 55ff; s. also task 1, unit 19

Unit 19 Tara Mines II

Task 1
1) resources 2) resource 3) reserve 4) resource 5) reserve 6) reserves 7) reserves 8) reserves 9) reserves 10) reserves

Task 2
Use English dictionaries, if necessary. Example:
footwall:
In geology or mining: The lower wall of country rock in contact with a vein or lode.
faults:
A discrete surface or zone of discrete surfaces separating two rock masses across which one mass has slid past the other.
hanging wall:
The upper wall in contrast to the footwall which is the lower wall.
blasting:
The destruction or breaking apart (esp. rocks) using explosives.
hoisting:
The way of transporting most by an engine with a drum, used for winding up a load from a shaft or underground passage; mostly used in mine extraction; raising or hauling up by means of ropes and pulleys.

Unit 20 Tara Mines III

Task 1

1) true 2) true 3) false: 67% lead; 56% zinc 4) false: some residue is left 5) false: tailings are pumped to tailings ponds or stored in sand tanks 6) true

Task 2

Step 1	Step 2	Step 3	Step 4	Step 5
Comminution	Flotation	Dewatering	Tailings and Backfills	Transportation and Monitoring
agitating agent blasting crushing grinding milling reducing size computer control-led	air bubbles dispersion of froth chemical additives water sprays	filtration moisture residue	recirculation refilling suspension waste	computer control-led shipping

Task 3

step 5 The by-product materials are transported to other processing plants.

step 4 The waste by-product materials are transported away or pumped back into the stopes.

step 3 The thickening and pressure filtration process of lead and zinc dewatering takes place.

step 2 The process of adding different chemicals to collect valuable minerals that float on top of the liquid takes place.

step 1 The blasting, crushing, grinding and milling process takes place to get smaller sizes.

Unit 21 Minerals Recycling

Task 2

1) demolition 2) labour 3) environmental 4) dismantling 5) to dispose of 6) landfill 7) balance

Task 3

1B - 2C - 3A

Solution

Unit 22 Energy Sources I

Task 1

1C - 2A - 3D - 4E - 5F - 6B

Task 2

Open discussion; Keywords are given; environmental problems like CO_2 emission, ozone depletion and contribution of fossil fuels can be better discussed after reading the chapter about climate change.

The burning of fossil fuels is blamed for emissions that contribute to global climate change, but there are new technologies developed that make burning fossil fuels much more efficient and cleaner. This is mostly discussed on "clean coal technologies".

Task 3

The hydrocarbon molecules of crude oil are mixed in different amounts and are of different sizes. Thus: The hydrocarbons boil at different temperatures, meaning they have different boiling points. In a fractionating column crude oil is separated into the different fractions. The larger the hydrocarbon molecules size, the higher its boiling point and the less volatile they are.

Task 4

1) crude oil 2) generation of electricity 3) biodegraded organic material 4) pressure 5) viscosities 6) natural gas

Task 5

Open discussion.

Unit 23 Energy Sources II

Task 1

1) formation 2) radioactive decay 3) solar radiation 4) originates 5) crust

Task 2

Advantages	Disadvantages
No pollution	Not available in many locations
Theoretically inexhaustible energy source	Not much power per vent
Often an excellent supplement to other renewable sources	Not enough hot springs
Does not require structures such as solar panels or windmills to collect the energy; can be directly used to heat or produce electricity (thus very cheap)	

Unit 24 Energy Resources III

Task 1

1. fossil fuels: high power output; emissions: greenhouse gases but: “clean” technologies as well
2. hydroelectric power: relatively high output; suitable areas needed
3. tidal power: depending on water tides; level
4. wind power: suitable area needed; noise-shadow problems
5. solar power: only in suitable regions with enough sun
6. biomass: methane produced = greenhouse gas
7. geothermal: power output?; suitable areas

None of the methods is entirely problem-free.

Unit 25 Drilling Techniques

Task 1

1C - 2D - 3E - 4A - 5B

Task 2

Follow text.

Task 3

Use dictionaries, if necessary.

drilling rig:
A term for the general equipment necessary in rotary or other drilling; in oilfield exploration the surface equipment and related structures.

drill string:
A term used in rotary drilling for assemblage in a bore hole of drill pipe, drill bit, core barrel etc.

drill bit:
A device for making circular holes in rock or earth material; the actual cutting or boring tool in a drill.

Unit 26 Rehabilitation

Task 1

1) habitats 2) biodiversity 3) protect 4) quarry 5) wetland

Task 2

1B - 2C - 3A

Solution

Task 3

Example:

1. ... of open areas within a quarry or pit.
2. ... with landscape and biodiversity .
3. ... it creates new habitats.
4. ... it reduces soil erosion potential.

Task 4

Example: wetlands, recreational parks, forestry, agricultural land, grape vinegars etc.

Task 5 and Task 6

Answers from general knowledge.

Unit 27 Hydrogeology

Task 1

1) rivers 2) lakes and reservoirs 3) groundwater 4) piped supply 5) water quality 6) suspended particles 7) chemical salts 8) metals 9) saline water 10) micro-organisms

Task 2

Follow text.

Task 3

Example:

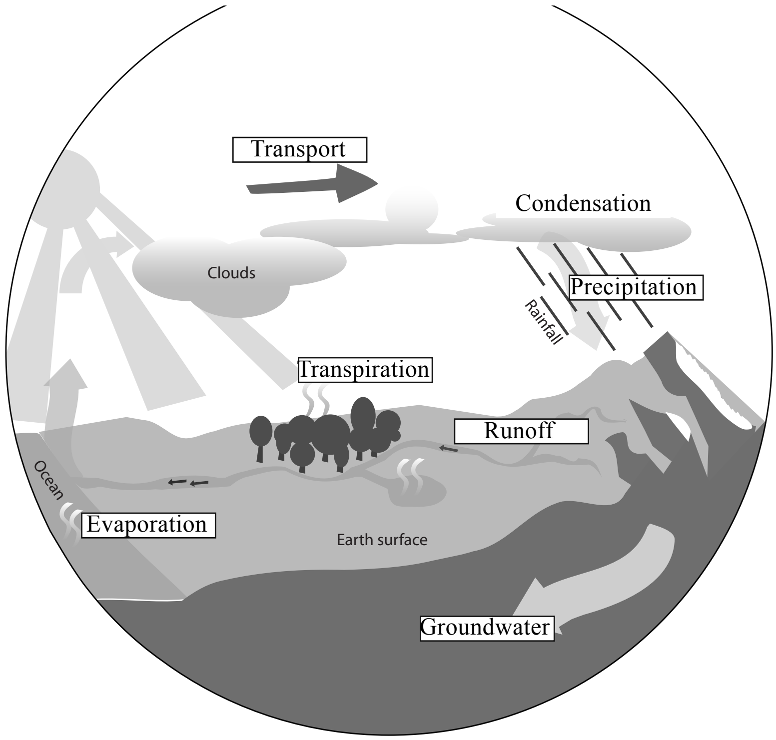
5. water quality: Can you judge if water is safe to drink just by examing a water sample visually?
6. etc.

Unit 28 The Water Cycle

Task 1

1B - 2F - 3G - 4D - 5A - 6C - 7E

Task 2



Task 3

1. The amount of water (on earth) remains constant (on earth)
2. Heat from the sun causes water to evaporate from oceans.
3. Condensation produces clouds of tiny droplets of water.

Task 4

1) evaporation 2) condenses 3) transported 4) precipitation 5) groundwater 6) transportation 7) runoff

Task 5

discussion might be more fruitful after reading unit 34

Unit 29 The Groundwater System

Task 1

1) false: stored in the oceans 2) false: is below the unsaturated zone 3) true 4) true 5) true 6) true

Task 2

For discussion s. unit 33 about waste disposal.

Solution

Unit 30 Groundwater Modelling System

Task 1

Follow text.

Task 2

Follow text.

Unit 31 Water Quality

Task 1

1) climate 2) minerals 3) precolate 4) bacteria 5) silt 6) muddy 7) evaporates 8) processes

Task 2

Different activities in industry, households and service sectors should be mentioned

Task 3

1. ... because of their direct availability of results.
2. ... is important for the selection of plants, fertilizers etc.
3. ... the reduction-oxidation potential.
4. ... you have to measure the EC value.
5. ... the amount of oxygen dissolved in water.

Unit 32 Waste Water Treatment

Task 1

English	...	Definition
sludge		thick mud, a slime produced by the precipitation of solid matters from liquid sewage in sedimentation tanks
aeration		to add oxygen
scum		layer of dirt, forming at the top of a liquid
digester		kind of fermentation tank
sewer / sewerage		network of underground pipes that collect and deliver waste water to treatment plants or streams
landfill		area of ground for disposing of rubbish etc.

Task 2

1) biological process 2) removes 3) chemical / physical methods 4) sludge 5) bacteria 6) floating 7) suspended 8) stage

Task 3

1) inorganic 2) conventional 3) quality 4) screens 5) solid 6) aeration 7) basins 8) chlorine

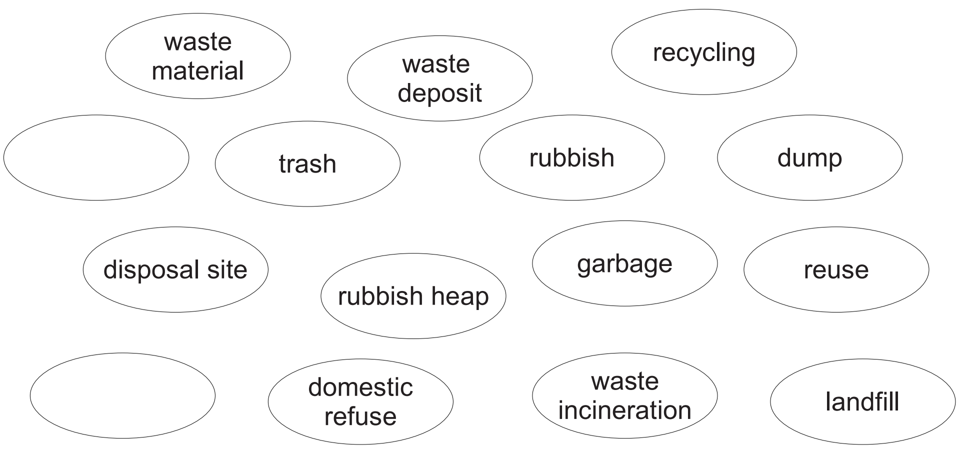
Task 4

1B - 2A - 3D - 4E - 5C

Unit 33 Waste Disposal

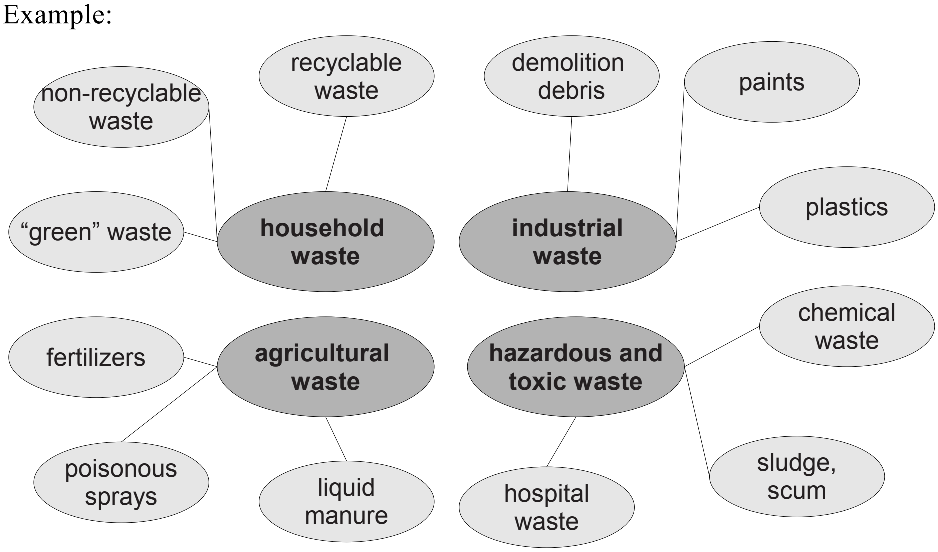
Task 1

Example:



Task 2

Example:



Solution

Task 3

Problems should be discussed seeing the relationship between the natural (e.g. wildlife habitats etc.) and the built environment (e.g. neighbourhoods etc.)

Unit 34 Meteorology and Climatology

Task 1

1) weather 2) climate 3) weather 4) weather 5) climate 6) weather 7) climate 8) climate

Task 2

moderate, temperate, mid-latitude season	tropic season	types of precipitation	types of storm	weather conditions	meteorology climatology - general topics
▪ spring ▪ summer ▪ autumn ▪ winter	▪ dry ▪ wet	▪ rain ▪ fog ▪ drizzle ▪ sleet ▪ snow ▪ freezing rain	▪ thunderstorm ▪ tornado ▪ hurricane ▪ blizzard	▪ cloudburst ▪ frostiness ▪ lightning ▪ shower	▪ air pollution ▪ atmospheric pressure ▪ global warming ▪ greenhouse effect ▪ humidity ▪ hygrometer ▪ rise / fall of the barometer ▪ weather forecast

Unit 35 The Carbon Cycle

Task 2

s. unit 36 (esp. about the “greenhouse gases”)

Unit 36 Global Warming and Climate Change

Task 1

Task 3

1) temperature 2) greenhouse gases 3) solar radiation 4) atmosphere 5) surface 6) infrared radiation 7) water vapour 8) ozone

Solution

Task 4

Gases	Chemical formula	resulting from / composition of
Carbon dioxide	CO_2	fossil fuels (oil, gas, coal, etc.) deforestation vehicles cement or concrete production
Chlorofluorocarbons	CFC	aerosols refrigerants foams coolants
Methane	CH_4	biomass cattle and other farm animals paddy fields uncontrolled gas leakages fossil fuels waste dumps
Nitrous oxide	N_2O	soils fertilisers biomass fossil fuels
Ozone		by-product of nitrous oxide and hydro-carbons vehicles

Task 5

1B - 2C - 3D - 4A

Unit 37 Global Response to Climate Change

Task 1

1-10 follow text

Selected Reference List

The selected reference list – for those who wish to study a subject further – is by no means representative. Older classic textbooks which seem to be still informative are named as well.

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For a first overview the following Internet websites of the English and American Geological Surveys might be quite useful and informative; especially the education pages:
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