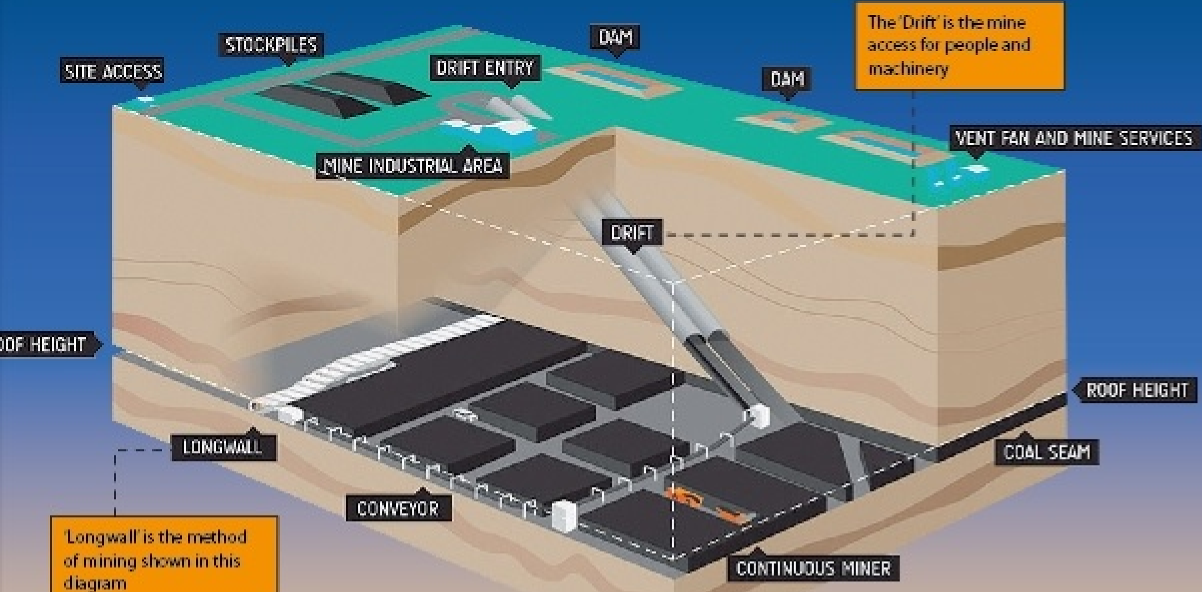
BASIC CONCEPTS OF MINING TECHNOLOGY



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State Higher
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ОСНОВИ ТЕХНОЛОГІЇ ВИДОБУВАННЯ КОРИСНИХ КОПАЛИН

навчальний посібник

State Higher
Educational Institution
National
Mining University

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BASIC CONCEPTS OF MINING TECHNOLOGY

tutorial

for students, masters and postgraduates
of higher educational establishments
studying "Mining" with learning
of professional English language

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The materials concerning global importance of mineral resources in the society life, their amount, origin, classification of deposits and economical aspects are presented. Opening and development technologies, mining methods during minerals mining are described. Nontraditional mining methods are educed. The material given in the tutorial is based on scientific and practical experience.

The tutorial is dedicated for students, masters and postgraduates of higher educational establishments studying "Mining" with learning of professional English language.

Викладені матеріали глобального значення мінеральних ресурсів у житті суспільства, їх запаси, походження, класифікації розробки родовищ та економічні аспекти. Описані технології розкриття, підготовки і систем розробки при видобуванні корисних копалин. Наведено нетрадиційні способи видобутку вугілля. Матеріал, що викладений у навчальному посібнику, базується на науковому і практичному досвіді.

Навчальний посібник призначений для студентів, магістрів і аспірантів вищих навчальних закладів, які навчаються за напрямом підготовки «Гірництво» з поглибленим вивченням професійної англійської мови.

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Поповича Игоря Николаевича

Выражаем искреннюю благодарность
за содействие в подготовке горных инженеров
высокого профессионального уровня –
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Popovych Igor Mykolayovych

We express sincere gratitude for assistance
in training of high professional level mining engineers –
potential for Ukraine's coal industry

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Chapter 1

1.1 IMPORTANCE OF MINERAL RESOURCES AND THEIR USE IN SOCIETY

Natural mineral resources serve as a basis for the economic development of civilization.

Mineral resources are all the physical materials that we **extract** from the earth for our use. Modern society is dependent on a huge **amount** and variety of mineral resources.

Mineral resources are classified as *metallic* or *non-metallic*. As **measured** by total **consumption**, the most important metallic resources are: iron, aluminum, copper, zinc and lead. The most important non-metallic resources are: crushed stone, sand, gravel, cement, clays, salt and phosphate.

So what is a mineral?

A mineral is a naturally **occurring** solid chemical **substance** that is formed through geological processes and that has a characteristic **chemical composition**, a highly ordered atomic structure, and specific physical **properties**. By comparison, a rock is an **aggregate** of minerals and does not have a specific chemical composition.

Minerals around us

Every segment of society uses minerals and mineral resources every day. The roads we drive, and the buildings we live, learn and work in, all contain minerals.

Some metals and minerals are used in modern society

COPPER	Copper is used for electrical *conductors*, motors, *appliances*, *piping* and in metal *alloys*.
GOLD	*Gold* has many high tech *applications* including computers and many scientific instruments, is used in electrical conductors. It is used in medical and dental equipment, and jewellery.
ZINC	ZnO is used to prevent sunburn; zinc is used for protective coatings for *steel*, casting alloys and extensively in medicine.
NICKEL	*Nickel* is *primarily* used to *manufacture stainless steel*.
SILVER	*Silver* is used in electrical conductors, photography, chemical manufacturing, dental and medical uses.
ALUMINUM	*Aluminum* is used in shipbuilding, for production airplanes, doors, windows, roofing, insulation, domestic utensils.
IRON	*Iron* is used in steel manufacturing, magnets, medicines, paints, printing *inks*, plastics, *dyes*. Iron is used in volume, about 20 times more than any other metal in our society.
BORAX	*Borax* is used to make *fiberglass*, high temperature *glass*, cleaning agents, ceramics, corrosion inhibitors and *fertilizers*.
TITANIUM	*Titanium* is used in paint manufacture as pigments, and in plastic manufacture. It has high *strength* and low weight metal alloys.
TALC	*Talc* is used in paper manufacture, in paint manufacture and in plastics and the cosmetic industry.
CLAY	*Clay* is used to make cement and *concrete*, which is used to build roads, buildings and housing foundations.
COAL	Coal is used in *steel making* and to provide the LOWEST cost electricity in the world (except for hydro generated). *Slag* (the residue left when coal is burned) from coal *power plants* is used for *paving additives*, for abrasives in *sandblasting* and to manufacture roofing materials.
PHOSPHATE	Phosphate is used to *produce* phosphoric *acid* for fertilizers, feed additives for livestock, chemicals, and in consumer home products.
POTASH	Carbonate of *potassium*, is used in fertilizers, medicines and the chemical industry.
RARE EARTH ELEMENTS	*Cerium*, *Neodymium*, *Europium*, etc., are used in *petroleum refining*, computers, televisions, magnetic industry, metallurgical *applications*, ceramics and lighting.

There are lots of minerals around your home. Look around your home. Minerals are used in lots of everyday objects in your house. Here are just a few household items made from minerals.

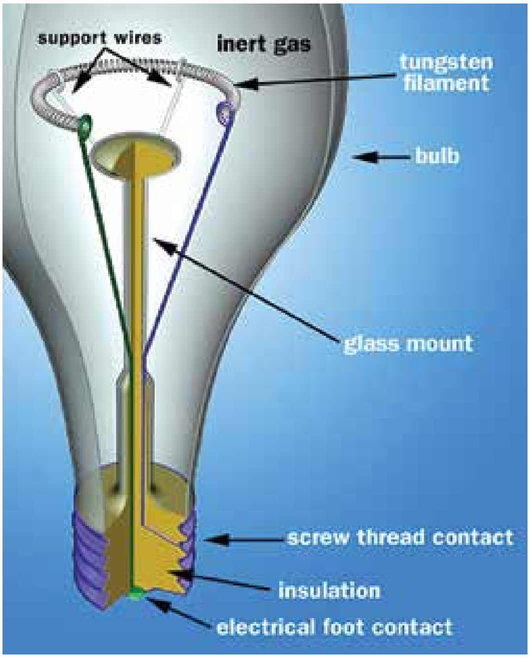
Light bulb

Where would we be without light bulbs? In the dark!

Tungsten has the highest melting point of all metals. Light bulbs can be very hot, so tungsten is a good metal to use to make the filaments in light bulbs. **Wolframite** and **scheelite** are the main **ores** of tungsten.

Think about the properties of tungsten:

- strong;
- very high melting point;
- rigid;
- impermeable.



Bulb (glass bulb) – колба (стеклянная колба);
Support wire – проволочное крепление;
Inert gas – инертный газ;
Tungsten filament – вольфрамовая нить;
Glass mount – стеклянная опора;
Screw thread contact – винтовой соединительный контакт;
Insulation – изоляция;
Electrical foot contact – подножный электрический контакт;

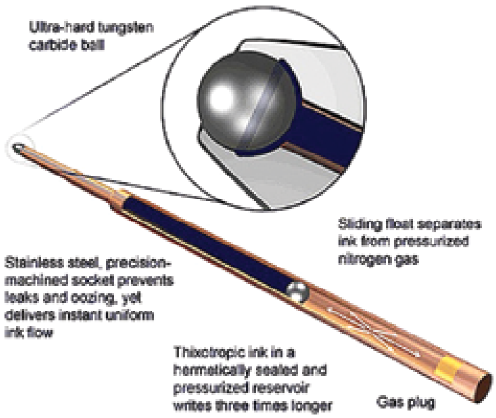
Pen, pencil and paper

Without minerals you could not use pen, pencil ore paper. The points of most ballpoint pens are made out of **brass**, which is an alloy of copper and zinc. This material is used because of its strength, resistance to corrosion, and **ability** to be easily formed. **Precious metals** such as gold, silver, or **platinum** are plated onto more expensive pens.

Also the writing tips of pens are made with strong metal called tungsten.

Paper is usually made of wood pulp mixed with minerals like clay, **mica**, talc and **baryte**.

Look at the picture of a pen structure:



Ultra-hard tungsten carbide ball – сверх прочный вольфрамовый карбидный шарик;

Sliding float separates ink from pressurized nitrogen gas – скользящий поплавок отделяет чернила от находящегося под давлением азотистого газа;

Stainless steel, precision-machined socket prevents leaks and oozing, yet delivers instant uniform ink flow – обработанный на станке с высокой точностью разъем из нержавеющей стали, предотвращающий утечки и просачивания, еще обеспечивает мгновенный равномерный поток чернил;

Thixotropic ink in a hermetically sealed and pressurized reservoir writes three times longer – тиксотропные чернила в герметичном резервуаре под давлением пишут в три раза дольше;

Gas plug – газовая пробка;

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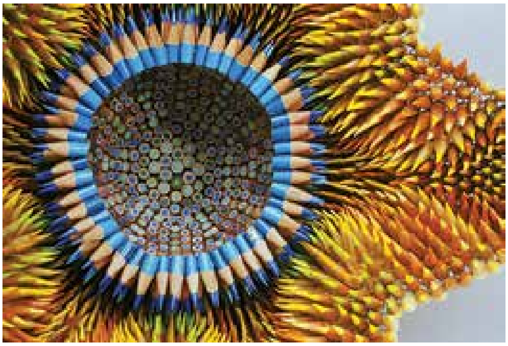


Most pencil cores are made of **graphite**, leaving grey or black marks that can be easily erased.

Film and battery

To take a photo, cameras have to have a film in them. Photographic films are coated with different mineral salts. Silver, **argentite** and other silver minerals are often used in photography.

Cameras also need batteries to work. Nickel is used in **rechargeable** batteries.

Let's look at the picture of cylindrical lithium-ion battery structure:

Anode – анод;

Anode tab – положительный контакт;

Cathode – катод;

Cathode tab – отрицательный контакт;

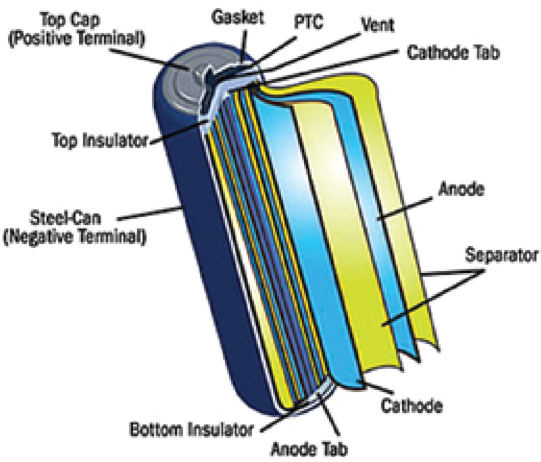
Separator – разделитель;

Vent – отвод;

PTC – полимерный герметик;

Gasket – прокладка;

Top insulator – верхняя изоляция;



Bottom insulator – нижняя изоляция;

Top cap (positive terminal) – верхняя крышка (положительный вывод);

Steel can (negative terminal) – покрытый сталью (отрицательный вывод).

Computer and monitor

Computer screens contain a variety of materials, some of them hazardous. Computer monitors contain raw and treated materials like metal semiconductors, phosphor, lead and mercury. Semiconductors are typically made of some kind of silicone crystal.

Here is what a laptop is made of (also refers to a desktop computer):

Polyvinyl chloride – поливинилхлорид;

Lead – свинец;

Antimony – сурьма;

Chromium, cadmium and lithium – хром, кадмий и литий;

Beryllium – бериллий;

Phosphor – фосфор;

Liquid crystal display – жидкокристаллический дисплей.

Conclusion

In science, a mineral is a natural substance, characterized by its **distinctive** composition, atomic structure and physical and chemical properties. In economic context, a mineral is any solid or fluid substance that can be extracted from the Earth **interior** for **profit**.

Generally, all minerals can be divided into four classes:

Metals – copper in electrical **wiring**, aluminum in beverage cans; iron in cars.

Energy minerals – used in the production of electricity, as fuel for transportation, for heating homes and offices, etc. (coal, oil and natural gas).

Industrial minerals – salt, china clay and limestone that are used for a range of specific industrial applications such as the manufacture of chemicals, glass, fertilisers and paper.

Construction minerals – sand, gravel, brick clay and crushed stone. Its are used for making concrete, bricks and surfacing roads.

Questions

1. What are mineral resources?

2. What classes of minerals do you know?

3. Give a definition to a mineral.

4. What is a rock?

5. What precious metals do you know?

Vocabulary

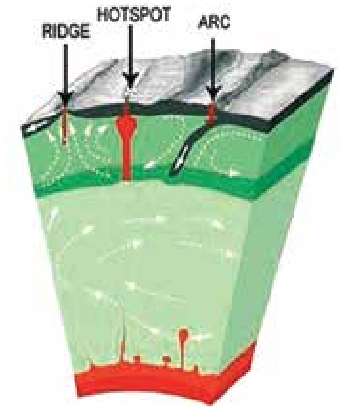
(to) extract	[ikˈstrækt]	извлекать
amount	[əˈmaunt]	количество, величина
(to) measure	[ˈmeʒə]	измерять
consumption	[kənˈsʌm(p)ʃən]	потребление
(to) occur	[oˈkə:]	происходить, возникать
substance	[ˈsʌbstən(t)s]	вещество
chemical composition	[ˈkemik(ə)l kompoˈziʃ(ə)n]	химический состав
property	[ˈpropə(r)ti]	свойство
aggregate	[ˈəgrigeit]	совокупность
conductor	[kənˈdʌktə(r)]	проводник
appliance	[əˈplaiən(t)s]	прибор
piping	[ˈpaipiŋ]	трубопровод
application	[æpliˈkeiʃ(ə)n]	применение, использование
primarily	[praiˈmer(ə)li]	главным образом
manufacture	[mænjuˈfæktʃə]	производство
manufacturing	[mænjuˈfæktʃəriŋ]	производство
ink	[iŋk]	чернило
dye	[dai]	краска
fertilizer	[ˈfə:tilaizə(r)]	удобрение
strength	[strenΘ]	прочность
steel making	[sti:l ˈmeikiŋ]	производство стали
power plant	[ˈpauə pla:nt]	электростанция
paving additive	[ˈpeiviŋ ˈæditiv]	добавка к дорожному покрытию
(to) produce	[ˈprodju:s]	производить
(to) refine	[riˈfain]	перерабатывать, очищать
ability	[əˈbiliti]	способность
rechargeable	[ri:ˈtʃa:dʒəbl]	перезаряжаемый, аккумуляторный
hazardous	[ˈhæzədəs]	опасный
raw	[ro:]	необработанный
treated	[ˈtri:tid]	обработанный
semiconductor	[səmikənˈdʌktə(r)]	полупроводник
distinctive	[diˈstiŋktiv]	отличительный, характерный
interior	[inˈtiriə]	недра
profit	[ˈprofit]	выгода, польза
wiring	[ˈwaiəriŋ]	проводка
beverage can	[ˈbeveridʒ kæn]	банка с безалкогольным напитком

surfacing road	[ˈsə:fesiŋ rəud]	дорога с твердым покрытием
iron	[ˈairon]	железо
aluminium	[əˈlu:minəm]	алюминий
copper	[ˈkopə]	медь
zinc	[zink]	цинк
lead	[led]	свинец
crushed stone	[krʌʃt stəun]	щебень
sand	[sænd]	песок
gravel	[græv(ə)l]	гравий
cement	[səˈmənt]	цемент
clay	[klei]	глина
salt	[so:lt]	соль
phosphate	[ˈfosfeit]	фосфат
rock	[rok]	горная порода
alloy	[ˈæloi]	сплав
gold	[geuld]	золото
steel	[sti:l]	сталь
nickel	[ˈnikl]	никель
stainless steel	[ˈsteinləs sti:l]	нержавеющая сталь
silver	[ˈsilvə]	серебро
borax	[ˈbo:ræks]	бура
fiberglass	[ˈfaibəgla:s]	стекловолокно
glass	[gla:s]	стекло
titanium	[taiˈteinium]	титан
talc	[tælk]	тальк
concrete	[ˈkonkri:t]	бетон
coal	[kəul]	уголь
slag	[slæg]	шлак
acid	[ˈeisid]	кислота
potash	[ˈpotæʃ]	углекислый калий, поташ
potassium	[pəˈtæsiəm]	калий
cerium	[ˈsiriəm]	церий
neodymium	[ni:oˈdimiəm]	неодим
europium	[juˈropiəm]	европий
petroleum	[pəˈtroliəm]	нефть
oil	[oil]	нефть
tungsten	[ˈtʌnstən]	вольфрам
wolframite	[ˈwulfrəmʌit]	вольфрамит
scheelite	[ˈʃi:lait]	шеелит
ore	[o:]	руда

brass	[bra:s]	латунь
precious metal	[ˈprəʃəs ˈmət(ə)l]	драгоценный метал
platinum	[ˈplætinəm]	платина
mica	[ˈmaikə]	слюда
barite	[bəˈrait]	барит
graphite	[ˈgræfait]	графит
argentite	[ˈa:dʒentait]	аргенит, сернистое серебро
phosphor	[ˈfosfə]	фосфор
mercury	[ˈmə:kjuri]	ртуть
silicon	[ˈsilikən]	кремний
polyvinyl chloride	[poli:ˈvainil ˈklo:raid]	поливинилхлорид
antimony	[ˈæntiməni]	сурьма
chromium	[ˈkromiəm]	хром
cadmium	[ˈkædmiəm]	кадмий
lithium	[ˈliΘiem]	литий
beryllium	[beˈriliəm]	бериллий
fuel	[ˈfju: əl]	топливо
natural gas	[ˈnætʃ(ə)r(ə)l gæs]	природный газ
china clay	[ˈtʃainə klei]	фарфоровая глина
limestone	[ˈlaimstəun]	известняк
brick clay	[brik klei]	кирпичная глина
brick	[brik]	кирпич
peat	[pi:t]	торф
chalk	[tʃo: k]	мел
sandstone	[ˈsæn(d) stəun]	песчаник
shale	[ʃeil]	глинистый сланец
uranium	[juˈreiniəm]	уран
diamond	[ˈdaiəmənd]	алмаз
bauxite	[ˈbo:ksait]	боксит
tin	[tin]	олово
brown coal	[braun kəul]	бурый уголь
anthracite	[ˈænΘrəsait]	антрацит
amethyst	[ˈæməΘist]	аметист
fluorite	[ˈfluərait]	флюорит
malachite	[ˈmæləkait]	малахит
calcite	[ˈkælsait]	кальцит
manganese	[ˈmængəni:ʒ]	марганец
solder	[ˈsəuldə(r)]	припой (сплав с низкой температурой плавления)
nitrogen	[ˈnaitrədʒən]	азот

marble	[ˈma:bl]	мрамор
zirconium	[zə:ˈkoniəm]	цирконий
sulfur	[ˈs/\lfə]	сера
kaolin	[ˈkeiəlin]	каолин, белая глина
granite	[ˈgrænit]	гранит
marl	[ma:l]	мергель, известковая глина

1.2 MINERAL RESOURCES AND MINERAL RESERVES



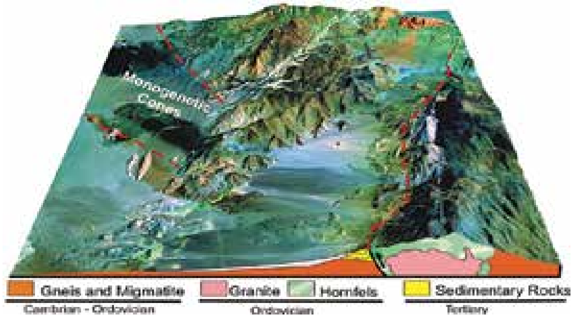
What is a mineral deposit?

Mineral deposit is a concentration of minerals and geological materials that have economic or po-tentially economic importance.

Origin of mineral deposits

Various geological processes cause particular minerals to be concentrated to form mineral deposits. The main types of these processes are as follows:

1. Igneous processes
2. Sedimentary processes
3. Weathering processes
4. Metamorphic processes



Igneous processes (magmatic processes) are called all processes with which formation of magma and magmatic rocks, and also phenomena conditioned by activity of magma, are related.

Magma repre-sents natural, more often silicate, **incandescent** liquid composition occurring in the **Earth crust** or in **upper mantle** at big depths and forming magmatic rocks when **cooling down**.

Magma that comes on the surface is called lava.

Igneous rocks are formed through the cooling and **solidification** of magma or lava.

Sedimentation is the collective name for processes that cause mineral and/or organic **particles** (detritus) to settle and accumulate. Particles that form sedimentary rocks are called sediment.

Sedimentary rocks are formed one of the three main ways:

- by the **deposition** of the weathered remains of other rocks;
- by the deposition of the results of biogenic activity;
- by deposition from solutions.

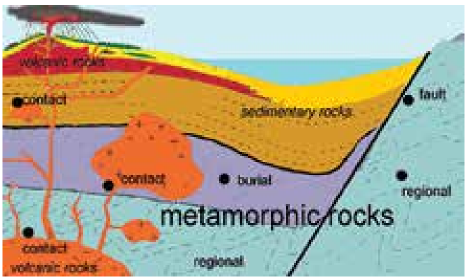
Sedimentary rocks include common types such as *chalk*, limestone, *sandstone* and *shale*.

Weathering is the breaking down of rocks, **soils** and minerals as well as artificial materials through contact with the Earth's atmosphere, biota and water. Three main types of weathering processes exist – physical, chemical and biological weathering.

Physical weathering is the gradual **destruction** of larger rocks into smaller rocks right where they stand. Physical weathering loosens and crumbles surface minerals of rocks so that they can be more easily transported by wind and water in the erosion process.

Chemical weathering is the process by which rocks are destruction, dissolved or loosened by chemical processes to form residual materials.

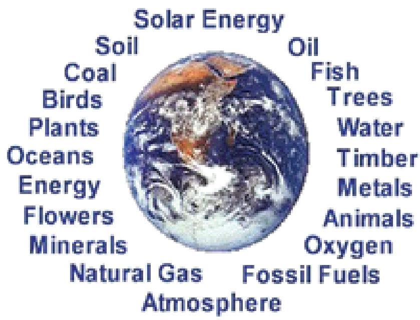
In *biological weathering* take part living organisms, such as plants and animals, cause rocks to de-struction.



Metamorphism is a process of re-crystallization of pre-existing rocks due to changes in physical and chemical conditions, primarily temperature, pres-sure, and the introduction of chemically active fluids. Mineralogical, chemical and crystallographic changes of rocks can occur during this process.

Natural resources and tectonic processes

Many natural resources have been formed along the ancient boundaries of tectonic plates. Metallic minerals, such as gold, silver, copper, lead and zinc, are found at **subduction zones** – place where oceanic crust into the mantle. Metallic minerals are formed and near **magma chambers** and so mineral deposits are often located near volcanoes.

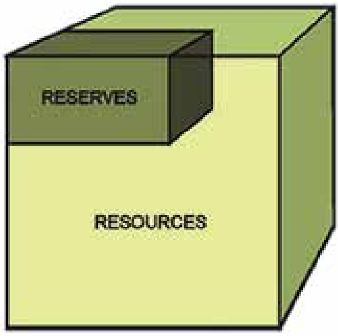


Some of the magma bodies do not reach the surface. Ore deposits form around these magma bod-ies in veins or disseminated through the rock.

Ancient ocean crust can contain mineral resources. Iron, nickel, zinc and other metals can accu-mulate at mid-ocean ridges.

What are a mineral resources and mineral reserves?

Mineral resources are defined as natural concentrations of minerals or bodies of rock that are, or may represent, of potential economic interest due to their valuable properties.



That part of a mineral resource, which can be economically profitable extracted, is called a **mineral reserve**.

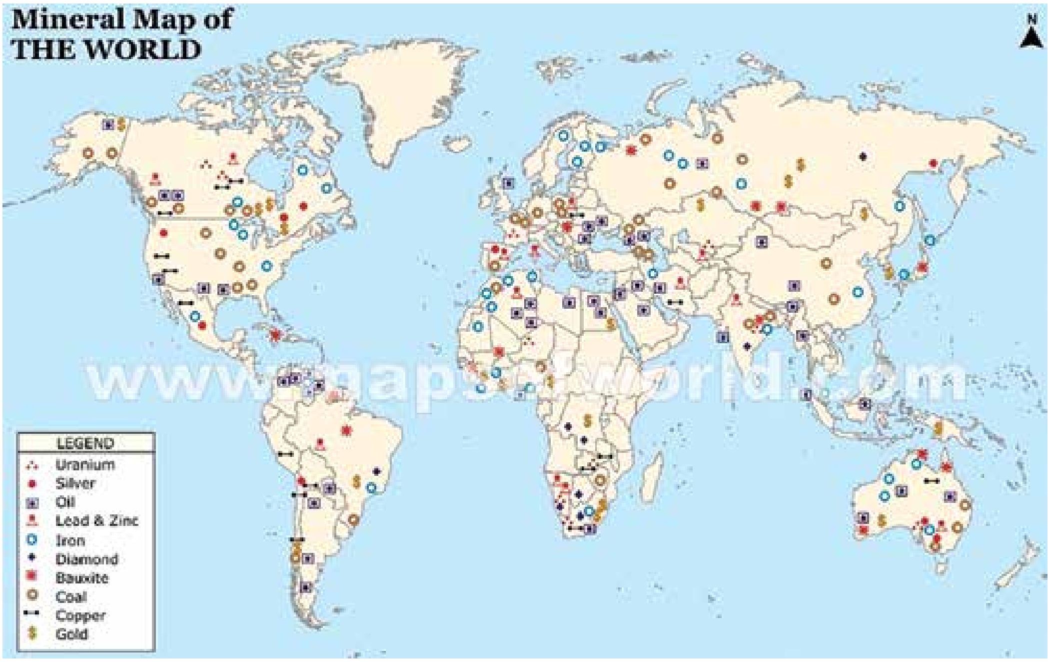
Exploitation of mineral resources

The exploitation of natural resources started in the 19th century. During the 20th century, energy consumption rapidly increased. Today, about 80% of the world's energy consumption is sustained by the extraction of **fossil fuels**, which consists of oil, coal and natural gas. Other **non-renewable** resources are exploited in the production of industrial **commodities**.

The stocks of minerals **available** in defined territory cannot be increased by human effort. It is not also possible to replace the minerals once mined. The existing minerals have accumulated over millions of years of past geological periods. Therefore natural replacement of minerals is an extremely slow process.

The world map of minerals

World mineral map shows availability of minerals in various part of the world.



Australia is the continent with the world's largest **uranium** reserves. Canada is the largest exporter of uranium ore.

Mexico is the largest silver exporter in the world.

Earlier **diamonds** were found only in alluvial deposits of Southern India. At present diamond deposits are also found in Africa, South Africa, Namibia, Botswana, the Democratic Republic of Congo, and Tanzania.

The most common element found on earth is iron. The five largest producers of iron ore are China, Brazil, Australia, Russia and India.

South Africa, Canada, United States and Western Australia are major producers of gold. Oil reserves can be found in Canada, United States, Mexico, Saudi Arabia, Iran, Iraq, United Arab Emirates and Kuwait.

Mineral reserves some minerals

Mineral	Uses	World Reserves Major Producing Resources (Tons)	Countries
Bauxite	Ore of aluminum	21.559.000	Australia, Jamaica, Brazil
Chromium	Alloys, electroplating	418.900	India, South Africa, Turkey
Copper	Alloys, electric wires	3.21.000	Chile, USA, Canada
Gold	Jewellery	42.000	South Africa, USA, Australia
Iron Ore	Iron and steel	64.648.000	Brazil, Australia, China, Canada and Venezuela
Lead	Solder, pipings	70.440	USA, Mexico, Canada
Manganese	Iron and steel	812.800	South Africa, Gabon, Australia and France
Nickel	Stainless steel	48.660	Canada, Norway and Dominican Republic
Silver	Jewellery	78.000	Mexico, USA, Peru, Canada
Tin	Tin cans, alloys	5.930	China, Brazil, Indonesia
Zinc	Iron and steel	143.910	Canada, Australia, China

Questions

1. Please, give the definition to a mineral deposit.

2. What types of geological processes do you know?

3. What are the main tree ways of formation of sedimentary rocks?

4. What types of weathering do you know?

5. Where are usually natural resources formed?

6. What is the difference between mineral reserves and resources?

7. Where are the world's largest reserves of uranium, diamonds and gold situated?

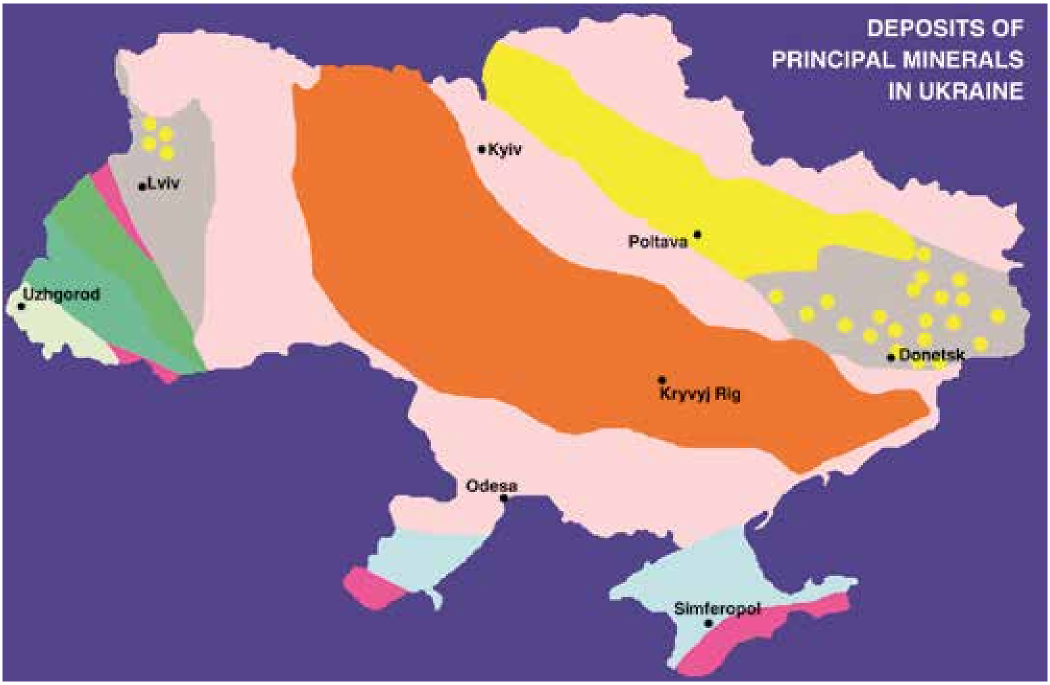
Vocabulary

mineral deposit	[ˈmin(ə)r(ə)l diˈpozit]	месторождение полезных ископаемых
particular	[peˈtikjulə]	отдельный, специфический
igneous	[ˈignies]	магматический, изверженный
sedimentary	[sediˈment(ə)ri]	осадочный
weathering	[ˈweΘ(ə)riŋ]	выветривание
metamorphic	[metəˈmo:fik]	метаморфический
incandescent	[inkænˈdes(ə)nt]	раскаленный
Earth crust	[ə:Θ kr/\st]	земная кора
upper mantle	[/\pə ˈmantl]	верхняя мантия
(to) cool down	[ku:l daun]	охлаждать, остывать
solidification	[səlidifiˈkeiʃ(ə)n]	затвердевание
particle	[ˈpa:tikl]	частица
deposition	[depəˈziʃ(ə)n]	осаждение, отложение
soil	[soil]	почва, грунт
destruction	[diˈstr/\kʃ(ə)n]	разрушение
subduction zone	[səbˈd/\kʃ(ə)n zəun]	зона субдукции
magma chamber	[ˈmægmə ˈtʃəimbə(r)]	магматический очаг
mid-ocean ridge	[midˈəuʃ(ə)n ridʒ]	срединно-океанический хребет
(to) define	[diˈfain]	определять
valuable	[ˈvæljuəbl]	полезный, ценный
fossil fuel	[ˈfos(ə)l fju:əl]	ископаемое топливо
renewable	[riˈnju:əbl]	возобновляемый
commodity	[kəˈmodəti]	предмет потребления, товар
available	[əˈveiləbl]	доступный

1.3 UKRAINIAN RESOURCES

Mineral Potential of Ukraine

The Geological Survey of Ukraine has built up a powerful mineral potential which *enabled* Ukraine to enter the community of leading countries with developed mineral industry. Explored reserves of some mineral commodities are estimated at 7.0-7.5 trillion US dollars ($ US 150,000 per capita), and Ukraine is high on the list of European countries. Taking into account per capita consumption of minerals, Ukraine can be *placed* alongside with the developed countries of the world.



Ukraine has practically all kinds of raw minerals that ensure stable operation and development of the country economy. That is why the mineral sector of economy is one of the main factors that *ensure* independence and national security of the state. Nowadays mineral resources are considered to be a great hope of our economy. This mineral potential (over 200 types of minerals) includes about 10000 deposits and *manifestations*, 7667 deposits (94 types of mineral commodities) of which are of commercial value and are recorded in the State Balance for Reserves.

Geographical location and economic conditions of the deposits are *favourable* for *intense* growth of mining and processing enterprises. By now, the industry exploits 3295 deposits which form a mineral base for more than two thousand mining and processing enterprises.

Occupying 0.4% of the world land with population *estimated* at 0.8% of the world total, Ukraine produces 5% of world mineral raw materials and products of their processing. Ukraine accounts for 6.2% of the world output. Ukraine mines 3% of coal, 1.0% of iron, 20% of manganese ores from world *output* figures.

Ukraine ranks the leading place among the developed world countries for 16 types of mineral com-modities (coal, iron and manganese ores, titanium, zirconium, mercury, uranium, sulfur, graphite, kaolin and other minerals).

Explored reserves of Ukraine cover 30% of iron ore reserves of the CIS countries, 75% of manganese ore, 70% of kaolin, 90% of crystalline graphite, the greatest part of titanium and zirconium reserves. They comprise a considerable part of CIS reserves of coal, mercury, uranium, beryllium, non-metallic raw materials for metallurgy, different stones.

Mineral raw materials that are mined in Ukraine *constitute* 2.9-3.8 per cent of the world total ($ US 14.5-20.0 billion). Exported mineral raw materials cover over one-third of the total Ukrainian export.

Losses of mineral commodities due to insufficient mining and extraction make 70% for oil, 40% for coal, 25% for metallic ores and 50% for salt. This mineral *wealth* remains in the Earth's interior and is considered to be lost.

Now the import of mineral commodities in Ukraine is higher than the country export. Import is 3.5 times greater than export nowadays. This gap is due both to a large list of imported mineral commodities and to low prices for exported minerals.

Specific features of the mineral base of Ukraine favour the growth of trade and economic relations with neighboring countries. For instance, Russia has no mineral base of manganese, titanium, zirconium and some other minerals that occur in Ukraine. As to iron, manganese, kaolin, graphite, titanium and some other minerals, European countries cover their demands at the expense of Ukraine.

Methane

Almost all mine fields of Donbass, except Eastern anthracite regions, have high rate methane con-tent – over 10 m^3/t and can be the objects of its extraction.

According to Geological Survey, in 140 mines with high methane rate about 2.5 billion m^3 methane gas is recovered *annually*, and till 550 mln m^3 is *gained* by the *degasification system* with average 31.7 % methane content.

Building materials

Ukraine is rich in building materials (granite, marble, labradorite, chalk, marl, sandstone). The largest reserves of granite and labradorite are found in Zhitomir oblast.

Mining of gem stone deposits is considered to be an effective activity. Ukraine played an important role in the former USSR as to the output of ornamental (decorative) stones.

As a matter of fact, stone mining and processing requires different tools, machines and equipment to be used. As to Ukraine, its industry does not produce stone-mining equipment for quarries with the ex-ception of several types of pneumatic drill bits.

Dnipropetrovs'k region is unique among other regions of Ukraine for its variety of mineral deposits. In its depths there were found 302 deposits and about 950 ore manifestations. In the region about 39 kinds of minerals are extracted. Kryvorizhsky basin with explored reserves of iron ores equal to 15 mln tons and annual volume of extraction equal to 87 mln tons takes the first place in Ukraine.

Available reserves make it possible to supply *ferrous metallurgy* with raw material for quite a long time into the third millenium. Nikopol deposit of mangane-se, on the basis of which two mining and con-centration plants are working, will be working up to the years 2025-2026.

Types of minerals in the region	Total quantity of deposits	Quantity of deposits that are worked
Ore	27	22
Manganese	2	2
Coal	77	11
Rare metals ore	2	1
Kaolin	2	1
Cladding stone	13	3
Building stone	47	32
Brick and tile raw material	53	16
Building sand	14	3
Oil-gas-condensate raw material	14	12
Mineral water	18	8
Brown coal	20	—

Fresh underground water

The large quantity of water is at beneath ours feet in underground. It honor in 40 times more, than in all rivers, lakes and world bogs. Water which is in the top part of crust called as underground.

For the person underground waters are the real wealth. Such waters, filtering deep into, pass through a number of natural filters – layers of rocks of various density and by that are perfectly cleared.

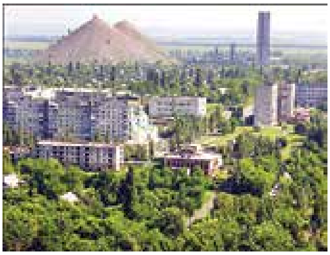
Underground waters share on fresh and mineralized.

Mineral water

On the territory of the region 18 deposits of the mineral medicinal, medicinal-and-table water are discovered, and they are used both for internal and external consumption, and also for industrial bottling.

Drinking mineral water is characterized with wide variety both in mineralization and iron-salt composition, which makes it possible to use these waters for treating various diseases, among waters for external consumption there are highly mineralized chloride, sodium, *bromine brine*, radon water and so on.

Conclusion



Ukraine is rich in natural resources: coal, iron ore, manganese, nickel and uranium, and others. The reserves of sulfur are the largest in the world, the reserves of mercury ore are the second largest. Also more than 5% of world reserves of iron ore are concentrated in Ukraine.

Ukraine is rich in building materials (granite, marble, labradorite, chalk, marl, sandstone). The largest reserves of granite and labradorite are found in Zhitomir oblast.

In the volume of Ukrainian industrial production mining industry accounts for 11.1%.

And being among the leading countries of the world in supply of mineral primary resources Ukraine has to develop new deposits and improve its technologies to follow the changes of the world.

Questions

1. What minerals can be found on Ukraine's territory?

2. According to the world output figures, what mineral reserves does Ukraine have?

3. Resources of what mineral are most abundant in Ukraine?

4. Except minerals recovered by mining, what other examples of minerals do you know?

5. What building materials do you know?

Vocabulary

(to) enable	[enˈeibl]	давать возможность, позволять
(to) place	[pleis]	занимать (место)
(to) ensure	[inˈʃuə]	обеспечивать
manifestation	[mænifesˈteiʃ(ə)n]	проявление
favourable	[ˈfeiv(ə)rəbl]	благоприятный, удобный
processing enterprise	[ˈprəusesiŋ ˈentəpraiz]	перерабатывающее предприятие
intense	[inˈten(t)s]	значительный, интенсивный
(to) estimate	[ˈestimeit]	оценивать
output	[ˈautput]	добыча
CIS (Commonwealth of Independent States)	[ˈkomənwelθ]	СНГ
(to) constitute	[ˈkon(t)stitju:t]	составлять
wealth	[welθ]	богатство
(to) favour	[ˈfeivə]	благоприятствовать
relation	[riˈleiʃ(ə)n]	отношение
according to	[əˈko:diŋ tu:]	соответственно с
annually	[ˈænjuəli]	ежегодно
(to) gain	[gein]	получать
degasification system	[degæsifiˈkeiʃ(ə)n]	система дегазации
gem stone	[dʒem stəun]	драгоценные камни
equipment	[iˈkwipmənt]	оборудование
quarry	[ˈkwori]	карьер
pneumatic drill bit	[nju:ˈmætik]	пневматическая буровая коронка
hole	[həul]	скважина
well	[wel]	колодец
intake	[ˈinteik]	приток
bottling	[ˈbotliŋ]	разлив по бутылкам
medicinal	[məˈdis(ə)n(ə)l]	лекарственный, целебный
table water	[ˈteibl ˈwo:tə]	столовая минеральная вода
bromine brine	[ˈbrəumi:n]	соляной раствор бора

1.4 MAJOR SOURCES OF ENERGY

COAL

Coal – is a *readily combustible* black or brownish-black sedimentary rocknormally occurring in *rock strata* or veins called *coal beds* or *coal seams*. Coal is the largest source of energy for the generation of electricity worldwide, as well as one of the largest worldwide anthropogenic sources of carbon dioxide releases.

Formation

About 300 million years ago, the Earth had dense forests in low-lying *wetland areas*. Due to natural processes such as *flooding*, these forests were buried under the soil. As more and more soil deposited over them, they were compressed. The temperature also rose as they sank deeper and deeper. For the process to continue, the plant matter was protected from *biodegradation* and *oxidization*, usually by mud or acidic water. This trapped the carbon in immense peat bogs that were eventually covered and deeply buried by sediments. Under high pressure and high temperature dead vegetation were slowly converted to coal. As coal contains mainly carbon, the conversion of dead vegetation into coal is called *carbonization*.

Classification

As geological processes apply pressure to dead biotic material over time, under suitable conditions it is transformed *successively* into:

Peat – considered as a precursor of coal, has industrial importance as a fuel in some countries. In its *dehydrated* form, peat is a highly effective absorbent for fuel and *oil spills* on land and water. It is also used as a conditioner for soil to make it more able to retain and slowly release water.

Lignite– this is a brownish-black coal with high *moisture* and *ash* content, which has the lowest heating value of the all types of coal. It is considered an “*immature*” coal that is still soft. It is used for generating electricity.

Subbituminous coal – this is a black coal with a higher heating value than lignite, and is used principally for electricity and space heating.

Hard coal or **Bituminous coal** – it is the most commonly used type of coal for electric power generation. It is a dark coal that has a higher heating value than lignite and subbituminous coal, but a lower heating value than anthracite.

Anthracite– this is coal that was formed from bituminous coal under increased pressures in rock strata during the creation of mountain ranges. This type of coal is the most compact and therefore, has the highest energy content of the all levels of coal. It is used for space heating and generating electricity.

The classification of coal is generally based on the content of volatile matter. However, the exact classification varies between countries.

Extracting

Coal mining has had a lot of developments over the recent years, from the early days of men tunneling, digging and manually extracting the coal on carts to large *open cuts* and *long walls* mines. Mining at this scale requires the use of *draglines*, *trucks*, *conveyors*, *jacks* and *shearers*. Coal mining can have a large environmental impact and needs to be managed.

Many mines are required by government to rehabilitate the area that was mined. Coal is extracted from the ground by underground mining either surface mining.

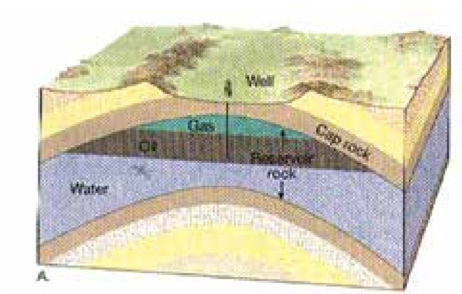
Uses of coal

Coal is used primarily as an energy source, either for heat or electricity. It was once heavily used to heat homes and power locomotives and factories. Bituminous coal is also used to produce coke for making steel and other industrial process heating. Coal *gasification* and coal *liquefaction* (coal-to-liquids) are also possible uses of coal for producing synthetic fuel.

PETROLEUM

Petroleum or crude oil is a naturally occurring liquid found in formations in the Earth consisting of a complex mixture of *hydrocarbons* (mostly alkanes) of various lengths. Petroleum literally means «rock oil»; oil that comes from rock. Oil is a hydrocarbon-based liquid which is sometimes present in *porous* rocks beneath the earth's surface.

Formation



Petroleum is formed by the slow *alteration* of organic remains over time. It consists of a mixture of liquid hydrocarbon *compounds* and varies widely in composition, color, *density*, and viscosity. From this liquid after distillation yields a range of combustible fuels, petrochemicals, and lubricants. Compounds and mixtures of compounds separated from crude petroleum by distillation include gasoline, diesel fuel, kerosene, fuel oil, some types of alcohol, benzene, different grades of lubricating oils.

Classification

Petroleum is usually classified according to the predominance of paraffin or asphalted compounds and accordingly is said to have a paraffin base, an intermediate base, or an asphalt base.

Extracting

Oil wells are drilled as deep as tenkilometers into the Earth to search for petroleum. These wells can cost millions of dollars to drill, drilling is done because petroleum is a valuable natural resource. Although the major use of petroleum is as a fuel it often use to generate electricity, there are many other uses as well.

Uses of petroleum

Here are some of the ways petroleum is used in our everyday lives. All plastic is made from petroleum and plastic is used almost everywhere, in cars, houses, toys, computers and clothing. Asphalt used in road construction is a petroleum product as is the *synthetic rubber* in the tires.

Paraffin wax comes from petroleum, as do fertilizers, pesticides, herbicides, *detergents*, phonograph records, photographic film, furniture, packaging materials, surfboards, paints and *artificial fibers* used in clothing, upholstery, and carpets. Petroleum is used principally as a source of fuel and lubricating oils. Only when these reserves of oil are restricted or threatened does the average person begin to realize their importance.

NATURAL GAS

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, with up to 20% of other hydrocarbons as well as impurities in varying amounts such as carbon dioxide.

Formation

Most natural gas was created over time by two mechanisms: biogenic and thermogenic. Biogenic gas is created by methanogens in bogs and sediments. Deeper in the earth, at greater temperature and pressure, thermogenic gas is created from buried organic material.

Natural gas is found in deep underground natural rock formations or associated with other hydrocarbon reservoirs, in coal beds, and as methane clathrates (or methane hydrate). Often petroleum is also found near natural gas deposits.

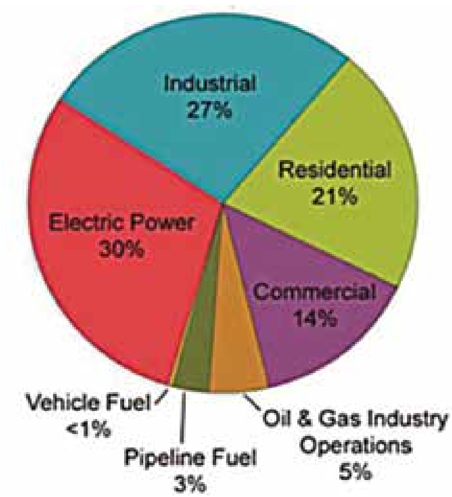
Typical Composition of Natural Gas

Methane	CH_4	70-90%
Ethane	C_2H_6	0-20%
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8%
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5%
Hydrogen sulphide	H_2S	0-5%
Rare gases	A, He, Ne, Xe	trace

Extracting

Before natural gas can be used as a fuel, it must undergo processing to clean the gas and remove impurities including water in order to meet the specifications of marketable natural gas. The by-products of processing include ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, hydrogen sulphide (which may be converted into pure sulfur), carbon dioxide, water vapor, and sometimes helium and nitrogen.

Natural gas is often informally referred to simply as gas, especially when compared to other energy sources such as oil or coal.



Uses of natural gas

Natural gas is widely used as an important energy source in many applications including heating buildings, generating electricity, providing heat and power to industry, as fuel for vehicles and as a chemical feedstock in the manufacture of products such as plastics and other commercially important organic chemicals.

Questions

1. Give a definition to a coal.
2. What types of coal do you know?
3. How oil is formed?
4. Where petroleum can be used?
5. What is a natural gas?
6. What gases can be found in a natural gas?

Vocabulary

combustible	[kəmˈb/\stəbl]	возгораемый, воспламеняемый
rock strata	[rok ˈstra:tə]	толща пород
coal bed	[kəul bed]	угольный пласт
coal seam	[kəul si:m]	угольный пласт
wetland area	[ˈwetlənd ˈɛəriə]	заболоченное место, территория
flooding	[ˈfl/\diŋ]	наводнение
biodegradation	[baieudegrəˈdeiʃ(ə)n]	деструкция
oxidization	[oksidaiˈzeiʃ(ə)n]	окисление
peat bog	[pi:t bog]	торфяное болото
vegetation	[vedʒiˈteiʃ(ə)n]	растительность
carbonization	[ka:b(ə)naiˈzeiʃ(ə)n]	насыщение углеродом
suitable	[ˈsju:təbl]	подходящий, пригодный
successively	[səkˈsesivli]	последовательно
dehydrated	[di:haiˈdreitid]	обезвоженный
oil spill	[oil spil]	разлив нефти
moisture	[ˈmoistʃə]	влажность
immature	[iməˈtjuə]	незрелый
ash	[æʃ]	зольность
open cut	[ˈəup(ə)n k/\t]	разрез
longwall	[loŋ wo:l]	лава
dragline	[ˈdræglain]	экскаватор, драглайн
jack	[dʒæk]	подъемник, домкрат
gasification	[gæsifiˈkeiʃ(ə)n]	газификация
liquefaction	[likwiˈfækʃ(ə)n]	сжижение
hydrocarbon	[haidrəuˈka:b(ə)n]	углеводород
porous	[ˈpo:rəs]	пористый
alteration	[o:lt(ə)ˈreiʃ(ə)n]	преобразование, изменение
compound	[ˈkompaund]	соединение
density	[ˈden(t)siti]	плотность
synthetic rubber	[sinˈthetik]	синтетический каучук
detergent	[diˈtə:dʒ(ə)nt]	моющее средство
artificial fiber	[a:tiˈfiʃ(ə)l]	искусственное волокно
impurity	[imˈpjuərəti]	примесь
methanogen	[mi:ˈθenodʒən]	метанобразующий организм
methane hydrate	[ˈmi:θein ˈhaidreit]	метановый гидрат
hydrogen sulphide	[ˈhaidrədʒən ˈs/\lfaid]	сероводород

1.5 COMMON AND RARE MINERALS

COMMON MINERALS

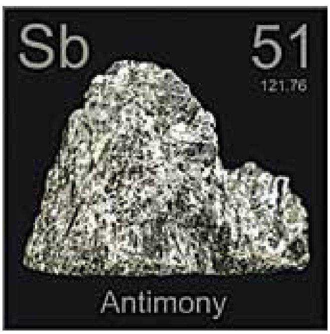
Aluminum

Is the most *abundant* metal element in the Earth's crust. Bauxite is the main source of aluminum. Aluminum is used in the United States in packaging, transportation, and building. Guinea and Australia have about one-half of the world's reserves. Other countries with major reserves include Brazil, Jamaica, and India

Bauxite

A general term for a rock composed of hydrated aluminum oxide. It is the main ore of *alumina* to make aluminum. Also used in the production of synthetic *corundum* and aluminous refractories.

Corundum is a white, grey, blue, green, red, yellow, or brown mineral, found in metamorphosed shales and limestones, in veins, and in some igneous rocks. It is used as an abrasive and as gemstone; the red variety is *ruby*, the blue is sapphire. Composition: aluminum oxide.



Antimony

A native element is extracted from stibnite – a soft greyish mineral that consists of antimony sulphide, – and other minerals.

Antimony is used as a *hardening* alloy for lead. Also used in *bearing metal*, *type metal* – it is an alloy of tin, lead and antimony; solder – an alloy for joining two metal surfaces by *melting* the alloy so that it forms a thin layer between the surfaces; collapsible tubes and *foil*, pipes, and semiconductor technology.

Stibnite

Stibnite – the main ore of Antimony. It is the most important ore of antimony. Stibnite is used for metal antifriction alloys, type metal, batteries, in the manufacture of fireworks. Antimony salts are used in the rubber and textile industries, in medicine, and glassmaking.

Asbestos

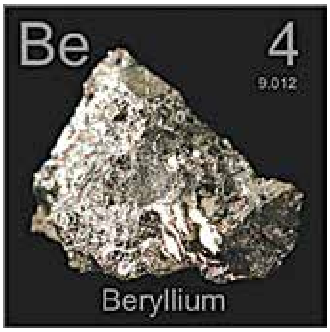
This group of silicate minerals can be readily separated into such kind as:

- thin fibers;
- strong fibers that are flexible;
- *heat resistant* fibers;
- chemically inert fibers;

Asbestos minerals are suitable for use in *fireproof* fabrics, yarn, cloth, paper, paint *filler*, roofing composition, reinforcing agent in rubber and plastics, brake linings, *tiles*, electrical and heat insulation, cement, and chemical filters

Barium

Used as an additive in oil-well-drilling mud during oil extraction , in the paper and rubber industries, as a filler or *extender* in production of cloth, ink, and plastics products, in radiography, as deoxidizer for copper, lubricant for anode rotors in X-ray tubes and spark-plugs. Also used to make an expensive white pigment.



Beryllium

Beryllium alloys are used mostly in applications in aerospace, automobiles, computers, oil and gas drilling equipment, and for telecommunications. Beryllium salts are used in fluorescent lamps, in X-ray tubes and as a deoxidizer in bronze metallurgy. Beryllium is the source of the gem stones <u>*emerald*</u> and aquamarine.

Chromite

Chromite (chromium): about 99 percent of the world's chromite is found in southern Africa and Zimbabwe. Chemical and metallurgical industries use about 85% of the chromite consumed in the United States.

Cobalt

Used in alloys for jet engines, chemicals (paint, catalysts, magnetic coatings, pigments, rechargeable batteries), magnets, and cemented carbides for cutting tools.

Principal cobalt producing countries include Democratic Republic of the Congo, Zambia, Canada, Cuba, Australia, and Russia.

The United States uses about one-third of total world consumption. Cobalt resources in the United States are low grade and production from these deposits is usually not economically feasible.

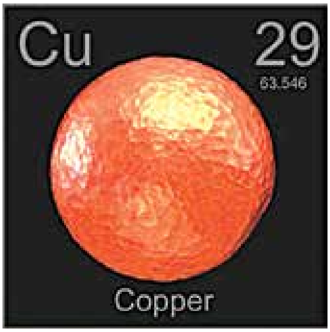
Columbite

Columbite: tantalite group (columbium is another name for niobium). Columbite is a natural oxide of niobium, tantalum, *ferrous iron* and manganese. Some quantity of tin and tungsten may be present in the mineral.

Columbite, in the form of ferrocolumbium, is used mostly as an additive in steel making and for such applications as heat-resisting and combustion equipment, *jet engine* components, and rocket, in cemented carbides and in superconductors.

Brazil and Canada are the world's leading producers of columbite.

Copper



Copper used in electric cables and wires, switches, plumbing, heating, roofing and building construction, chemical and pharmaceutical machinery, alloys (brass, bronze, and a new alloy with 3% beryllium that is particularly vibration resistant), alloy castings, electroplated protective coatings and undercoats for nickel, chromium, zinc, etc., and cooking utensils.

The leading producer is Chile, followed by the U.S.A. and Indonesia.

Feldspar

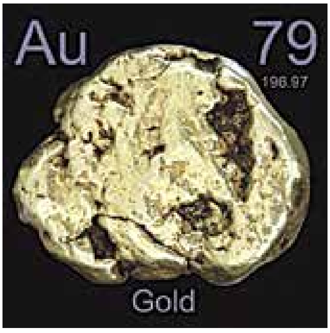
A rock-forming mineral, industrially important in glass and ceramic industries, pottery and enamelware, soaps, abrasives, bond for abrasive wheels, cements and concretes, insulating compositions, fertilizer, tarred roofing materials, and as a filler in textiles and paper.

Albite is a *feldspar* mineral and is a sodium aluminum silicate. This form of feldspar is used as a glaze in ceramics.

Flourite

Fluorite (fluorspar) used in production of hydrofluoric acid, which is used in the electroplating, stainless steel, refrigerant, and plastics industries; in production of aluminum fluoride, which is used in aluminum smelting, as a flux in ceramics and glass, and in steel furnaces, and in emery wheels, optics, and welding rods

Gold



Used in dentistry and medicine, in jewelry and arts, in medallions and coins, in ingots as a store of value, for scientific and electronic instruments, as an electrolyte in the electro-plating industry.

South Africa has about half of the world's resources. Significant quantities are also present in the U.S., Australia, Brazil, Canada, China, and Russia.

Gypsum

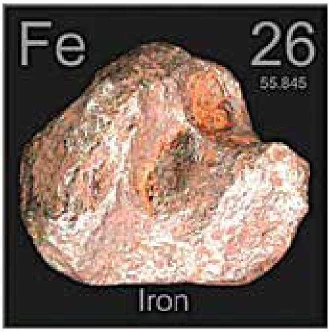
Gypsum is a colourless or white mineral sometimes tinted by impurities. It is used in the manufacture of building plaster, cement, paint, school chalk, glass, fertilizers, agriculture and other uses.

Halite

Halite (Sodium chloride-Salt): Used in human and animal diet, food seasoning and food preservation, used to prepare sodium hydroxide, soda ash, caustic soda, hydrochloric acid, chlorine, metallic sodium. Used in ceramic glazes, metallurgy, curing of hides, mineral waters, soap manufacture, home water softeners, highway de-icing, photography, herbicide, fire extinguishing, nuclear reactors, mouthwash, in scientific equipment for optical parts.

Single crystals used for spectroscopy, ultraviolet and infrared transmission.

Iron ore



About 98% of iron ore is used to make steel – one of the greatest inventions and most useful materials ever created. While the other uses for iron ore and iron are only a very small amount of the consumption, they provide excellent examples of the ingenuity and the multitude of uses that man can create from our natural resources.

Powdered iron

Used in metallurgy products, magnets, high-frequency cores, auto parts, catalyst.

Radioactive iron (iron 59): in medicine, tracer element in biochemical and metallurgical research.

Iron blue: in paints, printing inks, plastics, cosmetics (eye shadow), artist colors, paper dyeing, fertilizer ingredient, baked enamel finishes for autos and appliances, industrial finishes.

Black iron oxide: as pigment, in polishing compounds, metallurgy, medicine, magnetic inks, in ferrites for electronics industry.

Major producers of iron ore include Australia, Brazil, China, Russia, and India.

Kaolin

Also known as “china clay” is a white, aluminosilicate mineral widely used in paints, *refractories*, plastics, sanitary wares, fiberglass, adhesives, ceramics, and rubber products.

Lead

Used in lead batteries, *gasoline tanks*, and solders, *seals*, used in electrical and electronic applications, TV tubes, TV glass, construction, communications, protective coatings, ceramics or *crystal glass*, tubes or containers, type metal, foil or wire, X-ray and gamma radiation shielding, soundproofing material in construction industry, and ammunition.

The U.S.A. is the world’s largest producer and consumer of refined lead metal. Major producers of lead other than the U.S.A. include Australia, Canada, China, Peru, and Kazakhstan.

Galena

A lead sulfide, the commonest ore of lead. This a grey mineral, found in hydrothermal veins. Galena is mainly used in making lead-acid batteries; however, significant amounts are also used to make lead sheets and *shot*.

Limestone

A sedimentary rock is composed mostly of the mineral calcite. Uses are numerous. Limestone is a basic building block of the construction industry and the chief material from which cement, lime, and building stone are made.

71% of all crushed stone produced in the U.S.A. Limestone is used as a source for lime. It is used to make paper, plastics, glass, paint, steel, cement; used in water treatment and *purification plants*, in the processing of various foods and household items (including medicines).

Lithium

It is a soft, silver-white metal belonging to the alkali metal group of chemical elements. Under standard conditions it is the lightest metal and the least dense solid element. Like all alkali metals, lithium is highly reactive and flammable.

Lithium compounds are used in ceramics and glass, in the manufacture of lubricants and *greases*, rocket propellants, vitamin A synthesis, silver solders, underwater devices, batteries.

Manganese

Manganese makes up about 0.1% of the Earth's crust, making it the 12th most abundant element there. Land-based resources are large but irregularly distributed. About 80% of the known world manganese resources are found in South Africa; other important manganese deposits are in Ukraine, Australia, India, China, Gabon and Brazil.

Manganese is essential to iron and steel production by virtue of its deoxidizing and alloying properties.

Mica

The mica group of sheet silicate (phyllosilicate) minerals includes several closely related materials having close to perfect *cleavage*.

Mica commonly occur as *flakes* or sheets. Sheets *muscovite mica* (white) is used in electronic insulators (mainly in vacuum tubes), in paints, as joint cement, as a dusting agent, in well-drilling muds, and in plastic, roofing, rubber, and welding rods.

Molybdenum

The two largest uses of molybdenum are as an alloy in stainless steels and in alloy steels – these two uses consume about 60% of the molybdenum needs in the United States. Stainless steels include the strength and corrosion-resistant requirements for *water distribution systems*, food handling equipment, chemical processing equipment, home, hospital, and laboratory requirements. Alloy steels include the stronger and tougher steels needed to make automotive parts, construction equipment, gas transmission pipes. Other major uses an alloy include tool steels, for things like bearings, dies, machining components, cast irons, for steel mill rolls, auto parts, crusher parts, super alloys for use in furnace parts, gas turbine parts, chemical processing equipment.

Molybdenum also is an important material for the chemicals and lubricant industries. Moly has uses as catalysts, paint pigments, corrosion inhibitors, dry lubricant on space vehicles and resistant to high loads and temperatures. As a pure metal, molybdenum is used because of its high melting temperatures as filament supports in light bulbs, metal-working dies and furnace parts. Major producing countries are China, Chile, and the U.S.A.

Nickel

Nickel as an alloying constituent of stainless steel, plays key role in the chemical and aerospace industries.

Leading producers include Australia, Canada, Norway and Russia. Large reserves are found in Australia, Cuba, New Caledonia, Canada, Indonesia, the Philippines, and Russia.

Platinum group metals

Platinum group metals include platinum, palladium, rhodium, iridium, osmium and ruthenium. They commonly occur together in nature and are among the most *scarce* of the metallic elements. Platinum is used principally as catalysts for the control of automobile and industrial plant emissions, as catalysts to produce acids, organic chemicals and pharmaceuticals. PGMs are used for making glass fibers used in fiber-reinforced plastic and other advanced materials, in electrical contacts, in capacitors, in conductive and resistive films used in electronic circuits, in dental alloys used for making crowns and bridges, in jewelry. Russia and South Africa have nearly all the world's reserves.

Potash

Usually chloride of potassium. Used as a fertilizer, in medicine, in the chemical industry and is used to produce decorative color effects on brass, bronze and nickel. Can also be potassium sulfate, potassium-magnesium sulfate, and potassium nitrate. Is an essential mineral for vegetable and animal life.

Pyrite

Used in the manufacture of sulfuric acid and sulfur dioxide. Pellets of pressed pyrite dust are used to recover iron, gold, copper, cobalt, nickel. Also used to make inexpensive jewelry.

Quartz (silica)

As a crystal, quartz is used as a semiprecious stone. Cryptocrystalline forms may also be gem stones: agate, *jasper*, onyx, carnelian, chalcedony, etc. Crystalline gem varieties include amethyst, citrine, rose quartz, smoky quartz, etc. Because of its piezoelectric properties quartz is used for *pressure gauges*, resonators and wave stabilizers. Because of its ability to rotate the plane of polarization of light and its *transparency* in ultraviolet rays, prism and spectrographic lenses. Used in the manufacture of glass, paints, abrasives, and precision instruments.

Rare minerals and their uses

Industrial consumption of *rare earth* ores is primarily in petroleum fluid, metallurgical additives, ceramics and polishing compounds, permanent magnets and phosphors.

Rare earth elements are lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.

Silicon

Silicon (commonly called quartz). Used in manufacture of special steels and cast iron, aluminum alloys, glass and refractory materials, ceramics, abrasives, for water filtration, component of hydraulic cements, in cosmetics, pharmaceuticals and paper manufacturing, as anti-caking agent in foods, flatting agent in paints, thermal insulator.

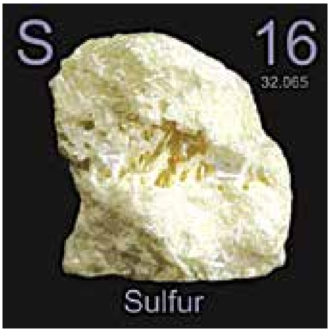
Fused silica is used as an ablative material in rocket engines and spacecraft. Silica fibers used in reinforced plastics.

Silver

Used in photography, jewelry, in electronics because of its very high conductivity, as currency – generally in some form of an alloy, in lining *vats* and other equipment for chemical reaction vessels, water distillation, etc.; catalyst in manufacture of ethylene, mirrors, electric conductors, batteries, silver plating, table cutlery, dental, medical and scientific equipment, electrical contacts, bearing metal, magnet windings, brazing alloys, solder. Silver is mined in approximately 56 countries. Nevada produces over one-third of the U.S.A. silver. Largest silver reserves are found in the U.S.A., Canada, Mexico, Peru and China.

Sodium carbonate

Sodium carbonate (soda ash or trona): used in glass container manufacture, in fiber glass and specialty glass, also used in production of flat glass, in powdered detergents, in medicine, as a food additive, photography, cleaning and boiler compounds, pH control of water.



Sulfur

Used in the manufacture of sulfuric acid, fertilizers, chemicals, *explosives*, dyestuffs, petroleum refining, vulcanization of rubber, fungicides.

Tantalum

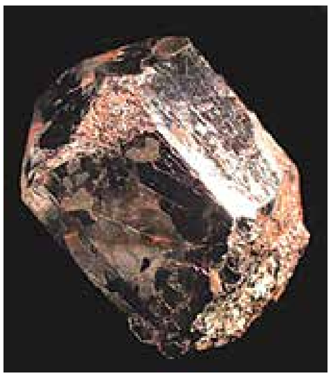
A refractory metal with unique electrical, chemical and physical properties that is used mostly as tantalum metal powder in the production of electronic components, mainly tantalum capacitors. Alloyed with other metals, tantalum is also used in making cemented carbide tools for metal working equipment, and in the production of superalloys for jet engine components.

Australia, Brazil, Canada, Congo, Ethiopia and Rwanda are leading tantalum ore producers.

Titanium

Titanium is a strong lightweight metal often used in airplanes. When titanium combines with oxygen, it forms titanium dioxide (TiO_2), a brilliant white pigment used in paint, paper and plastics. Major deposits of titanium minerals are found in Australia, Canada, India, Norway, South Africa, Ukraine and the United States.

Rutile



Rutile is a mineral composed primarily of titanium dioxide, TiO_2.

Rutile has among the highest *refractive indices* of any known mineral and also exhibits high dispersion. Natural rutile may contain up to 10% iron and significant amounts of niobium and tantalum.

Used in alloys, for electrodes in arc lights, to give a yellow color to porcelain and false teeth.

Tungsten

Used in metalworking, construction and electrical machinery and equipment, in transportation equipment, as filament in lightbulbs, as a carbide in drilling equipment, in heat and radiation shielding, textile dyes, enamels, paints, and for coloring glass. Major producers are China, Korea and Russia. Large reserves are also found in the U.S.A., Bolivia, Canada, Germany.

Vanadium

Used in metal alloys, important in the production of aerospace titanium alloys, as a catalyst for production of maleic anhydride and sulfuric acid, in dyes and mordants, as target material for X-rays. Russia and South Africa are the world's largest producers of vanadium. Large reserves are also found in the U.S.A., Canada and China.

Zeolites

Used in aquaculture (fish hatcheries for removing ammonia from the water), water softener, in catalysts, odor control, and for removing radioactive ions from effluent.

Zinc

Used as protective coating on steel, as an alloying metal with copper to make brass, as chemical compounds in rubber and paints, in metal spraying, automotive parts, electrical fuses, anodes, fungicides, nutrition (essential growth element), chemicals, in catalysts and in additives to lubricating oils.

Zinc oxide: in medicine, in paints, as an activator and accelerator in vulcanizing rubber, as an electrostatic and photoconductive agent in photocopying.

Zinc dust: for primers, paints, precipitation of noble metals, removal of impurities from solution in zinc electrowinning.

Zinc is mined in about 40 countries with China the leading producer, followed by Australia, Peru, Canada and the United States.

Questions

1. Give the definition to a mineral.

2. Why is it so important for each country to have mineral resources?

3. Where and how do we use minerals in our life?

4. What is the difference between mineral resources and mineral reserves?

5. Name geological processes that cause particular minerals to be concentrated to form mineral deposit.

6. Name categories of mineral reserves.

7. What are the metallic and non-metallic minerals? What is the difference between them?

8. What do we use coal for?

9. What common minerals do you know? Show their deposits on the mineral map of the world.

10. Name the countries that have significant mineral resources. And name the type of minerals each country possesses.

Vocabulary

abundant	[ə’bʌndənt]	широко распространенный, часто встречающийся
alumina	[əlu:ʌnd(ə)ns]]	оксид алюминия
corundum	[kə’rʌndəm]	корунд
ruby	[’ru:bi]	рубин (ярко-красный)
sapphire	[’sæfaiə]	сапфир (темно-синий)
harden	[’ha:d(ə)n]	становится или делать твердым, твердеть
bearing metal	[’beərin ’met(ə)l)	подшипниковый металл
type metal	[’taip ’met(ə)l]	типографский сплав
melting	[’meltin]	плавление
foil	[foil]	фольга
heat resistant	[hi:t ri’zist(ə)n]	термостойкий
fireproof	[’faiepru:f]	огнеупорный
tile	[tail]	черепица
filler	[’filə]	наполнитель
extender	[ik’stendə]	добавка, наполнитель
emerald	[’em(ə)r(ə)ld]	изумруд
ferrous iron	[’ferəs ’aiən]	двухвалентный феррум
jet engine	[dʒet ’endʒin]	реактивный двигатель
feldspar	[feldspar:]	полевой шпат
reflactories	[ri’frækt(ə)riz:]	огнеупорная керамика
gasoline tank	[gæs(ə)li:n tænk]	бензобак
seal	[si:l]	изолирующий материал
crystal glass	[krist(ə)l gla:s]	хрусталь
shot	[ʃot]	шпур
purification plant	[pjuəridi’keiʃ(ə)n pla:nt]	очистное сооружение
grease	[gri:s]	жир, смазочное вещество
cleavage	[’kli:vidʒ]	отслоение (горных пород)
flake	[fleik]	чешуйка
muscovite mica	[mʌskəvait ’maikə]	белая слюда, московит
water distribution system	[’wotə: distri’bju:ʃ(ə)n ’sistəm]	система водоснабжения
automotive parts	[o:tə’məutiv pa:ts]	автозапчасти
cast iron	[ka:st ’aiən]	чугун
scarce	[skeəs]	дефицитный, редкий
jasper	[dʒæspə]	яшма

pressure gauge	[’preʃə geidʒ]	манометр
transparency	[træn’spær(ə)n(t)si]	прозрачность
rare earth	[reə e:Ɵ]	редкоземельный
vat	[væt]	бак, цистерна
explosive	[ik’spləusiv]	взрывчатое вещество
refractive index	[ri’fræktive ’indeks]	показатель преломления

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Chapter 2

2.1 MINING. OVERVIEW

Process of extracting

Mining is the process of extracting useful minerals from the surface of the Earth (including sea extraction) usually from an ore body, vein or coal seam.

This term also includes the removal of soil. Materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, rock salt and potash. Mining is required to obtain any material that cannot be grown through agricultural processes, or created artificially in a laboratory or factory. Mining in a wider sense comprises extraction of any non-renewable resource (e.g., petroleum, natural gas, or even water).

Start of mining

Mining of stone and metal has been done since pre-historic times.

Modern mining is a costly and complicated business. It starts with the location of probably mineral veins. *Prospecting* and *exploration* require a great

deal of knowledge in the Earth sciences to find likely mining locations.

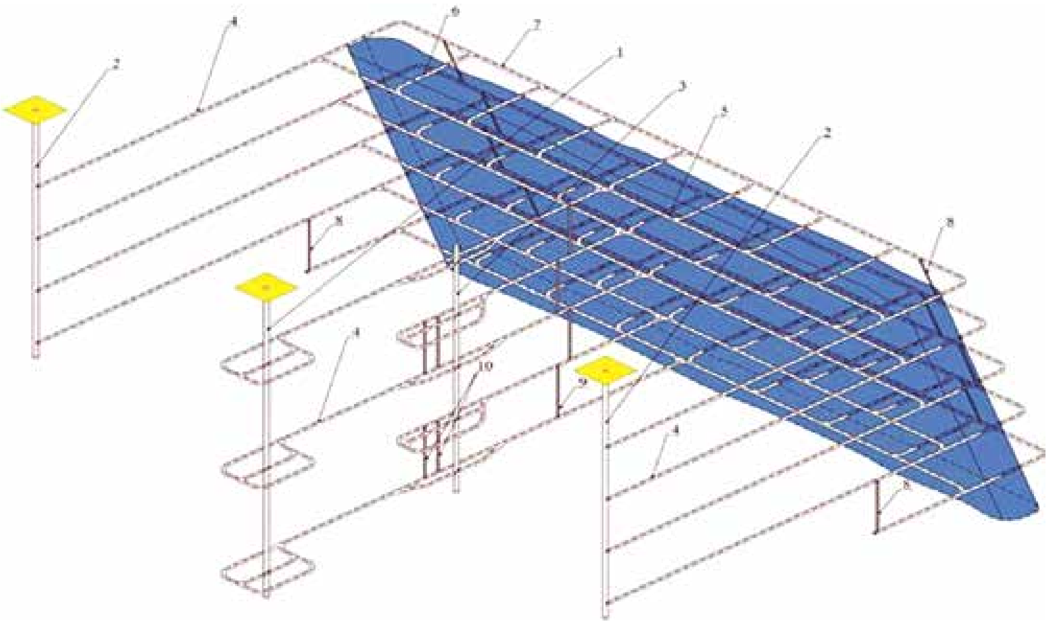
Once the location is determined, mining engineers decide the best way to mine it. Mining can be done as a surface operation or it can be done by an underground method

Open pit

Sometimes a vein of ore runs from the surface deep into the ground. Ore that is found at the surface is mined from the open pit. More than two-thirds of the world's annual mineral production is extracted by surface mining.

Scheme of underground mine workings

The openings made in the process of extracting ore are called stopes. There are two steps involved in stoping: development (preparing the ore blocks for mining) and production (stoping itself).



1 – main vertical shaft; 2 – flange air shaft; 3 – vertical blind shaft;
4 – cross-cut; 5 – drift of foot wall; 6 – ort; 7 – drift of hanging wall;
8 – air rise; 9 –foot way rise; 10 – orepass and rockpass rises

Fig. 2.1 Scheme of underground mine workings location

Mining processes

Modern mining processes involve:

1. Prospecting for ore bodies

2. Analysis of the profit potential of a proposed mine

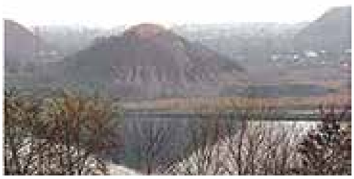
3. Extraction of the desired materials

4. Finally reclamation of the land to prepare it for other uses once the mine is closed.

Negative impact

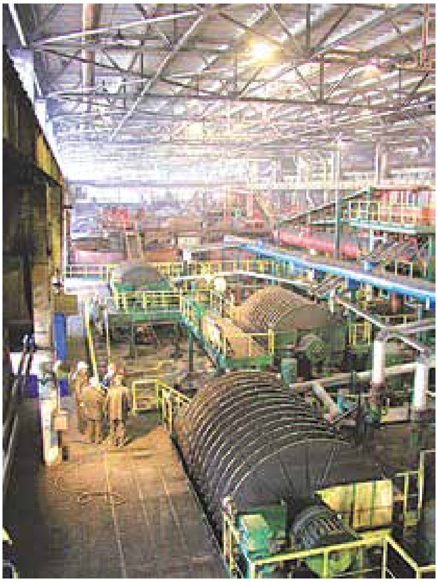
The nature of mining processes creates a potential negative impact on the environment both during the mining operations and for years after the mine is closed. This impact has led to most of the world's nations adopting regulations to moderate the negative effects of mining operations.

Safety has long been a concern as well, though modern practices have improved safety in mines significantly.



Engineering discipline

Mining engineering is an engineering discipline that involves the practice, the theory, the science, the technology, and application of extracting and processing minerals from a naturally occurring environment. Mining engineering also includes processing minerals for additional value.



Questions

1. Mining is the process	a) a surface operation or it can be done by an underground method
2. Mining is required	b) comprises extraction of any non-renewable resource
3. Mining can be done as	c) a great deal of knowledge in the Earth sciences
4. Mining in a wider sense	d) are called stopes
5. The openings made in the process of extracting ore	e) of extraction useful minerals or other geological materials
6. Prospecting and exploration require	f) processing minerals for additional value
7. Mining engineering also includes	g) to obtain any material

Vocabulary

determine	[dɪˈtərmən]	устанавливать, определять
coal seam	[ˈkoʊl ˈsiːm]	угольный пласт
complicated	[ˈkɑmpləˌkeɪtəd]	затруднительный
comprise	[kəmˈpraɪz]	заключать в себе
created artificially	[kriːˈeɪtɪd [artificially]	созданный искусственно
extraction	[ɪkˈstrækʃən]	извлечение, добыча
impact	[ɪmˈpækt]	воздействие
involve	[ɪnˈvɑlv]	привлекать
limestone	[ˈlaɪmˌstoʊn]	известняк
non-renewable resource	[non-renewable] [ˈriːˌsɔrs]	невозобновляемый ресурс
obtain	[əbˈteɪn]	приобретать, получать
ore body	[ˈɔr ˈbɑdiː]	рудное тело
potash	[ˈpɑtˌæʃ]	калий
precious metals	[ˈpreʃəs ˈmetəlz]	цветные металлы
process	[ˈprɑˌses]	процесс
prospecting	[ˈprɑˌspektɪŋ]	поиск, разведка
reclamation	[ˌrekləˈmeɪʃən]	восстановление
recovered	[rɪˈkəvərd]	извлекаемый
removal	[rɪˈmuːvəl]	устранение, удаление
require	[rɪˈkwaɪr]	требовать
rock salt	[ˈrɑk ˈsɔlt]	каменная соль
soil	[ˈsɔɪl]	почва, вскрыша
stone	[ˈstoʊn]	камень
stope	[ˈstoʊp]	выработка
surface	[ˈsərfəs]	поверхность
vein	[ˈveɪn]	жила

2.2 HISTORY OF MINING

Archeological discoveries

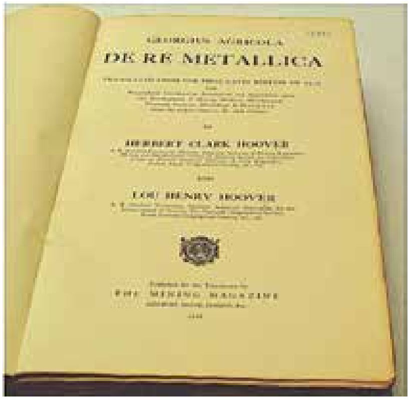
Mining is the process of extracting useful minerals from the surface of the Earth (including sea) usually from an ore body, vein or coal seam.

Archeological discoveries indicate that mining was known in prehistoric times. The first mineral found was flint, which could be broken to pieces that were useful as knives and arrowheads. Gold was one of the first metals utilized. Gold was mined from streambeds of sand and gravel. Copper was probably the second metal discovered and used. Silver was also found and was valued more highly than gold. Other hard rock mined or collected for axes included greenstone.

The oldest known underground mine in the world was run more than 40,000 years ago in Swaziland to mine ochre used in burial ceremonies and as body colouring.

Georgius Agricola

The book on mining "De re Metallica" (1556) by the German scholar



Georgius Agricola is the best source of information on early mining techniques, many of which are still used or were used until recently: picks and hammers, ventilation and pumping systems and cart-like "tricks" for hauling minerals to name a few. Agricola describes detailed methods of drilling, shafts and tunnels, timber support systems, etc.

Great progress

Great progress in mining was made when the secret of black powder reached the West, probably from China in the late Middle Ages. Gunpowder was replaced by dynamite in the mid-XIXth century. Since 1956 both ammonium nitrate and slurries (mixture of water, fuels and oxidizers) have come into use.

The invention of mechanical drills increased the capability to mine hard rock decreasing the cost and time for excavation by many times. The first rotary drill appeared in England in 1813. In Germany in 1853 a drill that resembled modern air drills invented. Pistol drills were followed by hammer drills run by compressed air.

Later advances included improvements in loading methods, usage of electric locomotives and conveyors, steam-driven pumps to remove water from the deep mines. In 1930s battery-powered cap lamps began entering mines...

Surface and underground methods

Modern mining is a costly and complicated business. It starts with the locating of probable mineral veins. Prospecting and exploration require a great deal of knowledge in the Earth sciences to find likely mining locations. Once the location is determined, mining engineers decide the best way to mine it. Mining can be done as a surface operation or it can be done by an underground method.

Sometimes a vein of ore runs from the surface deep into the ground. Ore that is found at the surface is mined from the open pit. More than two-thirds of the world's annual mineral production is extracted by surface mining.

The openings made in the process of extracting ore are called stopes. There are two steps involved in stoping: development (preparing the ore blocks for mining) and production (stoping itself).

Technology

Technology has developed to the point where gold is now mined underground at depths of 4000 m, and the deepest surface mines have been excavated to more than 700 m.

It is the machines that provide the strength and trained miners who provide the brains needed today to prevail in this highly competitive industry.

Questions

1. How is ore found at the surface mined ?

2. How many steps are there in stoping ?

3. How can mining be carried out ?

4. When was the great progress in mining made ?

5. What does Agricola describe ?

Vocabulary

battery powered cap lamp	[ˈbætri: powered ˈkæp ˈlæmp]	шахтерская лампа с батарейным питанием
competitive	[kəmˈpetətɪv]	конкурентоспособный, конкурентный
determine	[dɪˈtərmən]	определять, устанавливать, измерять, вычислять
discover	[dɪsˈkəvər]	открывать, обнаруживать (месторождение)
excavate; excavation	[excavate] [ˌekskəˈveɪʃən]	вынимать грунт, производить земляные работы разрабатывать открытым способом, выемка/разработка грунта, земляные/экскаваторные работы, открытая горная выработка
extracting	[ɪkˈstræktɪŋ]	добыча (минералов)
hammer	[ˈhæmər]	молот, кувалда, отбойный молоток
hard rock	[ˈhɑrd ˈrɑk]	крепкая/твердая/скальная порода
improvements in loading methods	[ɪmˈpruːvmənts ˈɪn ˈloʊdɪŋ ˈmeθədz]	модернизация методов погрузки
invention	[ɪnˈvenʃən]	изобретение, открытие
location of probable mineral veins	[loʊˈkeɪʃən əv ˈprɑbəbəl ˈmɪnrəl ˈveɪnz]	определение вероятного местоположения жил полезных ископаемых
open pit	[ˈoʊpən ˈpɪt]	карьер, открытая разработка (минералов)
ore body, vein or seam	[ˈɔr ˈbɑdiː, ˈveɪn ər ˈsiːm]	рудное тело, жила или пласт/прослоек
prospect	[ˈprɑˌspekt]	производить изыскания
prospecting	[ˈprɑˌspektɪŋ]	разведочные работы
explore	[ɪkˈsplɔr]	исследовать
exploration	[ˌekspləˈreɪʃən]	исследование месторождения
provide	[prəˈvaɪd]	обеспечивать, снабжать, предоставлять, оснащать
require	[rɪˈkwaɪr]	требовать(ся), нуждаться (в чем-либо)
shaft and tunnel	[ˈʃæft ənd ˈtənəl]	ствол шахты и штольня
source of information	[ˈsɔrs əv ˌɪnfərˈmeɪʃən]	источник информации
steam-driven pump	[steam-driven ˈpəmp]	паровой насос

stope	[ˈstoʊp]	выемочная камера
surface of the Earth	[ˈsərfəs əv ðə ˈərθ]	земная поверхность
surface operation	[ˈsərfəs ˌɑpəˈreɪʃən]	разработка открытым способом
timber support system	[ˈtɪmbər səˈpɔrt ˈsɪstəm]	система деревянной крепи
underground method	[ˌəndərˈgræʊnd ˈmeθəd]	разработка подземным способом
value	[ˈvæljuː]	значение, величина, цена, стоимость
ventilation and pumping system	[ˌventəˈleɪʃən ənd ˈpəmpɪŋ ˈsɪstəm]	вентиляционная и насосная установка

2.3 PROFESSIONAL FOREIGN LANGUAGE FOR MINING ENGINEERS IN THE NATIONAL MINING UNIVERSITY OF UKRAINE

National mining university

NMU is in the top of three best technical universities of Ukraine as to the quality of the scientific-pedagogical potential and the quality of teaching and for international recognition. He is ahead of such universities as:

Rise

The National Mining University was established in 1899.

The main task of the University was to train mining engineers and technicians, to popularize technological achievements among miners, to work on important problems of mining and metallurgical engineering.

The National Mining University introduced a new course in coal mining mechanization which provided the basis for the development of mining engineering.

The University established close contacts with the coal and ore mining industries. The scientists are carrying out scientific research and work on important mining problems.

The two scientists A.M. Terpigorev and M.M. Protodyakonov wrote the first textbook on machinery for mining layer deposits (minerals). The National Mining University is one of the best-known educational universities in Ukraine. It has well-equipped laboratories, demonstration rooms and a library which has many volumes of Ukrainian and foreign scientific books and journals.

National mining university today

Today the «National Mining University» is one of the leading educational establishments and the leading educational establishment of the country in **geological prospecting** and **mining sectors**.

There are **53 departments** in the University that are united in **9 faculties** of full time education, Institute of part-time and distance education, postgraduate and doctoral studies, Interdisciplinary institute of continuous education, developed science- research section, Ukrainian-American Linguistic Center, Center of Language Training, Ukrainian-German Cultural Center, Ukrainian-Hispanic-Latin American Center, Ukrainian-Polish Collaboration and Language Learning Center, Center of Energy Saving and Energy Management, Prydniprovs'k Scientific-Technical Center of Information Protection, Ukrainian-American Lyceum, Marganets'k college, Auto Transport College and Pavlograd technical vocational college. There are about **16000 students**, postgraduates and doctoral postgraduates in 27 modern specialities studying at the University. Studying process is provided by more than **600 teachers**, including more than **150 doctors of sciences**, professors and **350 PHDs**, professor associates. High quality of education is guaranteed by the developed infrastructure of the studying process, modern calculation equipment, local and global computer networks, library with fund of more than **1 million volumes**, strong material-technical base of the laboratories, Up-to-date educational technologies.

Mining faculty

The faculty was founded in 1899. It comprises 7 departments:

- Underground Mining;
- Surface Mining;
- Aerology and Labour Protection;
- Transport systems and technologies;
- Ecology;
- Military Service;
- Physical Training.

Mining faculty conducts preparation of the future specialists based on such areas and specialities:

- Mining of the deposits and extraction of minerals
- Underground mining of stratified deposits;
- Underground mining of ore deposits;
- Designing of mines and underground structures;
- Underground mining of minerals with profound learning of information technologies;
- Underground mining of minerals with profound learning of profession- oriented English language;
- Underground mining of minerals with profound learning of management in production field;
- Transport systems and logistics of mining enterprises;
- Gas accumulation and transport technologies; Surface mining;
- Labor protection in mining production.

At the mining faculty educational process is provided by 29 professors, 62 associate Professors, 26 research assistants.

Graduates' objects of activities:

- Underground and surface mining; labor protection at mining enterprises;
- Organization and exploitation of transport complexes at mining enterprises; environment safety of mining industry.

Educational process is organized by European Credit Transfer and Accumulation System (ECTS) using innovational technologies, high potential of material-technical and information-methodological personnel Graduates of the mining faculty are:

- Prime-minister of Ukraine;
- Minister of Coal Industry;
- Head of the Regional State Administration;
- 4 general directors of coal enterprises association;
- 20 directors of coal mines;
- 7 Laureates of State Prize of Ukraine;
- 10 honored workers of education of Ukraine;
- 7 honored figures of science and technology of Ukraine;
- 50 doctors and 400 PhD's.

Underground mining department

Underground Mining Department was established in 1900 in order to prepare specialists in underground mining. There are 54 people working at the department nowadays, among them there are 10 professors, 22 professor associates and 9 research assistants.

Underground mining department is engaged in the following research areas of mining industry:

- innovative technologies of opening, development and extraction of coal, iron-ore, uranium, copper and manganese deposits;
- methods of calculation of rational parameters of various types of support,
- management of strain and stress state of the massif;
- ventilation of mine openings;
- underground coal gasification technologies;
- research of ecological environment and geomechanical processes;
- economic aspects and investment-innovative ways of mining industry development and other important topics.

The department of Underground Mining during its existence has prepared more than 20,000 mining engineers.

Knowledge

Mining engineers with knowledge of general and professional English will always be competitive at world labor market.

Possibilities:

- Study and field practice in the leading Higher Education Establishments of mining profile in countries the European Union, Northern America, Australia and others;
- Diploma of an international standard;
- Employment at mining enterprises of Europe and rest of the world.

Importance and summary

The aim is clear:

- Integration with the European Society;
- Beginning of massive exchange of students, postgraduates and scientific- educational personnel;
- Mutual supervising of PhD and doctoral students, defense of theses;
- Invitation of Professors abroad to read lectures in English for advanced students;
- Implementation of mutual scientific projects using international financial programs.

Questions

Match the verbs from the list A with the corresponding nouns from the list B. Translate of the phrases.

A	B
1. to carry out	a) new courses
2. to direct	b) laboratories
3. to prospect for	c) experiments
4. to introduce	d) research
5. to equip	e) contacts
6. to establish	f) new deposits
7. college	g) vocational

In the right column you must find Russian equivalents of the following words combinations.

1) mining equipment	б) подготовка горных инженеров
2) to carry out research	в) разведка нефти
3) new course in	г) обработка цветных металлов
4) to direct scientific activity	д) техническое образование
5) to take an active part in	е) новый (учебный) курс по
6) prospecting for oil	ж) принимать активное участие
7) bedded deposit	з) проводить исследования
9) technical education	и) направлять научную деятельность
10) processing of non-ferrous metals	к) горное оборудование
11) the training of geologist and mining engineers	л) пластовые месторождения

Vocabulary

appear	[əˈpɪr]	появляться
acknowledgment	[ɪkˈnɑlɪdʒmənt]	признание, подтверждение
disappear	[ˌdɪsəˈpɪr]	исчезать
bed	[ˈbed]	пласт, слой
colliery	[ˈkɑljəriː]	каменноугольная шахта
comprise	[kəmˈpraɪz]	содержать, включать
get an education	[ˈget ən ˌedʒəˈkeɪʃən]	получать образование
graduate	[ˈgrædʒəwət]	выпускник ВУЗа
to be in need of	[tə ˈbiː ˈɪn ˈniːd əv]	нуждаться в
to take part in	[tə ˈteɪk ˈpɑrt ˈɪn]	участвовать в
concentration plant	[ˌkɑnsənˈtreɪʃən ˈplænt]	обогатительная фабрика
training	[ˈtreɪnɪŋ]	обучение; подготовка
technique	[tekˈniːk]	техника, способ, метод, технический прием
mining technique	[ˈmaɪnɪŋ tekˈniːk]	горная техника, методы ведения горных работ
research	[rɪˈsərtʃ]	научное исследование
process	[ˈprɑˌses]	обрабатывать
ore	[ˈɔr]	руда
ore mining	[ˈɔr ˈmaɪnɪŋ]	разработка рудных месторождений
open-cast mine	[open-cast] [ˈmaɪn]	открытая разработка
cast iron	[ˈkæst ˈaɪrn]	чугун, чугунная отливка
pig iron	[ˈpɪg ˈaɪrn]	чугун
establish	[ɪˈstæblɪʃ]	основывать, создавать
non-ferrous metals	[non-ferrous] [ˈmetəlz]	цветные металлы
ferrous metals	[ˈferəs ˈmetəlz]	черные металлы
carry out	[ˈkæriː ˈæʊt]	проводить *(исследование);* выполнять *(план)*
call for	[ˈkəl fər]	требовать

2.4 ADVANTAGE OF MINING EDUCATION

Variety of coures

As known young people who are in their last year at school are planning the next stage in their education. The variety of courses at universities and colleges is extensive but many young people don't have any clear idea about the career they wish to follow. Those who are primarily motivated by wealth tend to choose law, business administration, economics or accountancy. Those interested in fame may choose the arts, the stage, or the media.

Exception

Except perhaps in the countries with successful manufacturing industries such as Germany and Japan, where engineers tend to be held in higher regard, a career in engineering is not often recommended with any enthusiasm by school teachers, politicians, TV, newspapers or teenage magazines. Those influencing young people tend to be pop singers, TV actors and sports stars.

The difficulties

It is no wonder, therefore, that many engineering degree courses find it difficult to attract students, with the result that young graduate engineers in many fields are in short supply worldwide. Courses in mineral resource engineering — mining geology, rock mechanics, mining, quarrying, mineral processing, and petroleum engineering have special difficulties in recruitment.

Matter of choice

However, this is only part of the story. After graduation and the award of a degree, there is a strong wish to abandon the subject matter of the course and enter a career offering more reward: commerce, banking, accountancy or stock braking. This causes disappointment to the academy staff who wasted all their efforts to give useful practical knowledge to the students.

Practice

There is one more barrier to recruitment into the mining industry where management trainees should spend several years of practical training underground or in the mill. Modern mining and processing machinery, computer controlled and high in output capacity, cannot and should not be operated by young management trainees: nowadays operators are often highly skilled and from their ranks should come the line supervisors.

Knowledge

Management trainees, after a brief period to acquire general knowledge about the operation, would be better trained by working as assistants to managers and consulting engineers, and gain experience in planning surveying and ventilation departments, all areas where knowledge learned at a mining school can be utilized to good advantage.

Not only one

It should be noted that there are mineral engineering courses which must provide a wide and general tuition, covering not only mineral extraction and processing methods but also economics, business administration, computer studies, communication skills and basic civil and mechanical engineering which are vital for important career development to senior ranks.

Questions

1. What courses have difficulties in recruitment?

2. What causes disappointment of the academy staff?

3. What courses must provide a general and wide education?

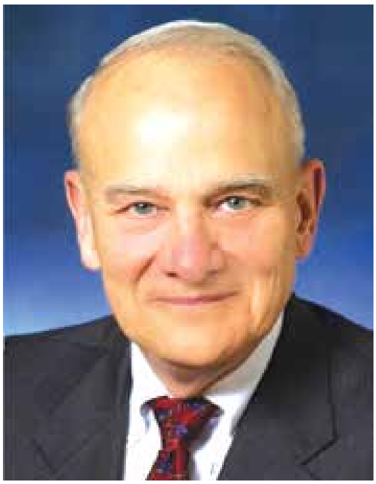
Vocabulary

accountancy	[əˈkæʊntənsiː]	бухгалтерский учет
to attract	[tə əˈtrækt]	привлекать
abandon	[əˈbændən]	покидать, оставлять; самовольно уходить
covering	[ˈkəvrɪŋ]	охватывать
efforts	[ˈefərts]	усилие, попытка
extensive	[ɪkˈstensɪv]	всесторонний, исчерпывающий
fame	[ˈfeɪm]	слава
higher regard	[higher] [rɪˈgɑrd]	высокое уважение
influence	[ˈɪnˌfluːəns]	влияние, действие, воздействие
maturity	[məˈtʊrətiː]	зрелость
mill	[ˈmɪl]	обогатительная фабрика
motivate	[ˈmoʊtəˌveɪt]	мотивировать
provide	[prəˈvaɪd]	обеспечивать, снабжать, предоставлять, оснащать
recruitment	[rɪˈkruːtmənt]	набор
reward	[rɪˈwɔrd]	вознаграждение
senior ranks	[ˈsiːnjər ˈræŋks]	вышестоящие руководители
skilled	[ˈskɪld]	квалифицированный
staff	[ˈstæf]	штат служащих, персонал
stage	[ˈsteɪdʒ]	эстрада
stock braking	[ˈstɑk ˈbreɪkɪŋ]	биржевые операции
supply	[səˈplaɪ]	снабжение, поставка
tend	[ˈtend]	иметь тенденцию
wealth tend	[ˈwelθ ˈtend]	стремление к богатству
wasted	[ˈweɪstɪd]	понапрасну потраченный

2.5 PROFESSIONAL ENGINEER'S ROLES AND RESPONSIBILITY

Abstract. This paper highlights the scope of engineering education and their relevant to engineering profession being globally practiced in various sectors of development. The main objective of this discussion is to create awareness on the importance of engineering education in terms of their contents in responding to the work place requirement. It is to know about engineering profession by and large and also their scope of works in relation to engineer's roles and responsibilities. The contents of engineering education and their dynamic development provide the tools for engineers to play their significant roles and responsibilities across a multidiscipline of engineering profession. The behavioral of professional engineers through a standard code of ethics should create engineers ability to troubleshoot problems under various circumstances and propose a solution through a number of approaches to the benefit of community, nation as well as global integration.

There are various definitions on what is engineering and how it relates with the teaching and learning environment. Some of those can be expressed as follows;



"Engineering is all around us, so people often take it for granted, like air and water. Ask yourself, is there anything I touch that is not engineered? Engineering develops and delivers consumer goods, builds the networks of highways, air and rail travel, and the internet, mass produced antibiotics, creates artificial heart valves, builds lasers, and offers such wonders an imaging technology and conveniences like microwave ovens and compact discs. In short, engineers make over quality of life possible" (William A.Wulf, President of the National Academy of Engineering)

"Engineering is the application of science to the common purpose of life" (Count Rumford)

Scientists study the world as it is, engineers create the world that never has been " (Theodore Von Karman)

From all these definitions, engineering contents can be further broken down into numerous details. Some of the following are relevant in one way or the other:

1. Engineering is an art. Aesthetics as well as function found in the Great Wall of China, Pyramids and other wonder of the world is truly an engineering genius in the form of art.

2. Engineering is an approximation. The mathematics of engineering system are often used to solve "Engineering problems are under-defined, there are many solutions, good, bad and indifferent. The art is to arrive at a good solution. This is creative activity involving imagination institution and deliberate choice" -(Ove Arup)

3. Engineering is measurement, estimation, forecast and projection. River flow, noise and vibration from transport system, earthquake, traffic volume, pollution and others.

4. Engineering is about modeling and simulation. Validation and verification of an analysis can be tested through modeling and computer simulation.

5. Engineering is a communication, technical report writing and presentation. Making presentations, producing technical manuals, co-ordinating team of large scale project are all fundamental to engineering practice.

6. Engineering is finance

Design, construction, operations, repair and maintenance costs, hiring, chartering and others determine the viability of the intended projects.

7. Engineering is an invention and design processes

New devices, material selection and viable processes are developed by engineers to meet the requirement that existing technology do not address. Engineers identify and apply the most suitable system to solve engineering related problems using appropriate decision making tools which were acquired through a number of circumstances.

In general, engineering is the art of applying scientific and mathematical principles, experience, judgement, and common sense. Engineering technologists use their knowledge to help design and make bridges, buildings, computers, electrical appliances, power plants, transport infrastructures, etc that we utilize at present. Engineering is also deal with the process of producing a technical product or system to meet a specific need to benefit mankind.

Who is Engineer

The following are some of the definitions on who is an engineer. Engineer is:

1. A person who were trained in the design, construction, and use of engines or machines, or in any of various branches of engineering: a mechanical engineer, civil engineer, electrical engineer, chemical engineer, etc.

2. A person who operates or is in charge of a power plant system in term of operation, repair and maintenance.

3. A consultant in their respective area of expertise.

4. A skillful manager who manages the implementation of the engineering related decision making processes. Etc.

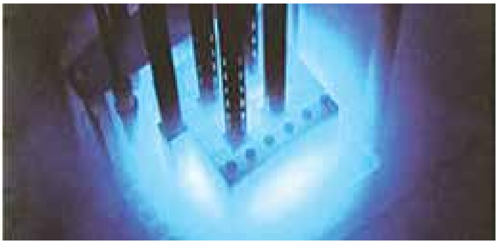
Greatest Engineering Achievements of the 20th Century

20th century have witnessed a great achievement in engineering technology in the field of design, information technology (IT), construction, manufacturing, robotic, advanced materials or even the engineering management techniques for problem solving. Some of the newly and enhanced technologies can be described and intepreted as the following.

Petroleum and gas technologies. Petroleum has been used to providing fuel for cars, home, and industries. Petrochemicals are used in products ranging from aspirin to zippers. Engineering in oil exploration and processing, petroleum products have an enormous impact on world economies, people, environment and politics.

Lasers and fiber optics. Pulses of light from lasers are used in industrial tools, surgical devices, satellites, and other products. In communications for instance, a single fiber-optic cable can transmit tens of millions of phone calls, data files, and video images.

Nuclear technologies. Nuclear technologies provide a new source of electric power and new capabilities in medical research and imaging as well as for unwarranted military use.



Health technologies. Medical professionals have an arsenal of diagnostic and treatment equipment at their disposal. Artificial organs, replacement joints, imaging technologies, and biomaterials are but a few of the engineered products that improve the quality of life for millions.

Imaging technologies. Imaging technologies have expanded the reach of our vision. Probing the human body, mapping ocean floors, tracking weather patterns are all the result of engineering advances in imaging technologies.

Agricultural mechanization. The machinery of farms; tractors, cultivators, combines, and hundreds of others; dramatically increased farm efficiency and productivity.

Electronics. Electronics provide the basis for countless innovations; CD players, TVs, and computers. From vacuum tubes to transistors, to integrated circuits, engineers have made electronics smaller, more powerful, and more efficient.

Aeronautics. Modern air travel transport goods and people quickly around the globe, facilitating personal, cultural and commercial interaction.

Space explorations. The development of spacecraft has expanded our knowledge base, and improved our capabilities. Thousands of useful products and services have resulted from the space program, including medical devices, wireless communications, etc.

Automobiles. The automobile may be the world' major transporter of people and goods, and a strong source of economic growth and stability. The automobile is a showcase of 20 century engineering ingenuity, with innovations made if design production & safety.

Electrification. Electrification powers has literally lighted the world and impacted countless areas of daily life, including food production and processing, air conditioning and heating, refrigeration, entertainment, transportation, communication, health care, and computers.

Training and advancement programmes. A strong technical knowledge is essential for engineering managers, who must understand and guide the work of their subordinates, and explain the work in nontechnical terms to senior management and potential customers. These management

positions usually require work experience and formal education.

In most cases to fill management positions, employers seek engineers who possess administrative and communications skills in addition to their technical knowhow. Engineers who prefer to manage in technical areas should get a Master degree in engineering management, while those interested in non-technical management should get an MBA.

Engineering managers may progressively advance to higher leadership positions within their discipline. Some may become managers in non-technical areas such as marketing, human resources, or sales. In high technology firms, managers in nontechnical areas often must possess the same specialized knowledge as do managers in technical areas. Employers in an engineering firm may prefer to hire experienced engineers as sale workers because the complex services can only be marketed by someone with specialized engineering knowledge.

Engineer's Roles and Responsibility

Engineering encompasses science and art, mathematics and creativity, models and approximations in solving real-world problems. Engineers integrate their knowledge of the physical sciences with more abstracts realms beyond the boundaries of current technology in all areas of life. Chemical and bioengineers are working on drug related systems that work inside cells at the molecular level. An environmental engineers quantify the particle flow of pollutants through soil to clean up abandoned industrial sites, oil spills, and other hazards.

Engineers have many different types of jobs to choose from, including research, design, analysis, development, testing, and sales positions. Engineering work is also organized by traditional academic fields of study. Engineers are problem solvers who search for quicker, better, less expensive ways to meet tough challenges.

Professional Engineer

A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering, notably in research, designing, construction, manufacturing, managing and in the education of the engineer. The work is predominantly intellectual and requires the exercise of original thought and judgment.

Engineers are capable of closely and continuously progressing in their branch of engineering through assimilation of various information and application. They are thus placed in a position to make contributions to the development of engineering and its application. The engineering education and training require a broad and general appreciation of the engineering sciences as well the special features of his own branch. He is able to give authoritative technical advice and to assume responsibility for the roles and his responsibility.

The majority of engineers fulfill the key characteristics of professional profession known as follows:

1. They are required to be expert in a particular area of activity for which an advanced and extended formation is necessary and practice in which requires a high level of theoretical foundation.

2. They have mastered in a clearly definable and valuable body of knowledge and understanding.

3. They accept responsibility and accountability for the decisions they make against standard conduct and values.

The range of activities covered by engineers is greater than for most other professions. Engineers have over many years formed themselves into associations, the number of which has grown enormously from the founding of the Institution of Civil Engineers (IEM) in 1818 to the present day through a process of initiation, division and amalgamation based sometimes on technical disciplines such as civil, mechanical, electrical and other engineering disciplines.

There are now over 80 national engineering Institutions. In 1962, 13 of the largest Institutions, each holding a Royal Charter, established the Engineering Institutions Joint Council to provide a single forum and representative voice for all professional engineers. This body changed its name to the Council of Engineering Institutions (CEI) on securing its own Royal Charter in 1965. The CEI now comprises 16 Chartered Institutions which are corporation members and another nine with affiliate status.

The major Institutions were originally formed mainly as learned societies for the exchange of views and the dissemination of information among people with a shared interest in a branch of engineering. The efforts was made to raise the quality of its practical training in terms of educational attainments, practical and their personal standing in the eyes of their professional peers. This was done through the establishment of membership criteria which specified minimum requirement for education training and experience and which also imposed a code of professional conduct.

Engineers held 1.5 million jobs in 2002. Over 190,000 engineers worked in the government sectors. About 55,000 were self employed.

Electrical engineers hold more jobs than any other engineer disciplines. Mining engineers hold fever jobs than any other type. The number of jobs for engineers is expected to increase more slowly but rather steadily. However, job opportunities in engineering are expected to be good in future simply because the number of people in engineering education is expected to grow due to forecasted rise of technological development in the country.

Benefit of Being a Professional Engineers

The reason for choosing engineering as a professional career largely attributed to the perception of the job security and market demand as Malaysia poised to become the industrialized nation by the year 2020. However, several other reasons as follows can also contribute to the phenomena namely;

1. Job satisfaction

Is important to find a career that provides ones with enjoyment and satisfaction. For numerous reasons, some engineering professions provide a very satisfying working environments.

2. Variety of career opportunities

An engineering degree offers a wide range of career opportunity. Within the practice of engineering, there is an enormous variety of job functions.

a. For an imaginative and creative, design engineering may be relevant.

b. For laboratories and experimental works, test engineering is relevant.

c. To organize and expedite projects, look into being a development engineer.

d. To be persuasive, consider a career in sales or service engineering.

The engineering analytical skills and technological expertise being developed can also be put to use in many other relevant fields. For example, an engineering knowledge and skills could be applied in the field of medicine or law. Similarly, engineers can also become a politician and use the knowledge of technology and science to set important policy. Ultimately, engineers could also become an entrepreneur in a related field such as in construction, manufacturing, or others businesses.

3. Challenging work

Generally, real engineering problems are quite different from most of the problems to be solved. In engineering work, virtually all problems has no readily answer to choose from. Engineers are required to devise a solution and make it applicable.

4. Intellectual development

An engineering education will develop the ability to think logically and to solve problems. These are skills that will be valuable throughout the life and not only when solving the engineering problems. For example, the problem-solving skills can help one to undertake tasks such as planning, finding, organizing and even purchasing.

5. Benefit society

Engineers benefit the society by developing clean and efficient transportation systems, finding new sources of energy, alleviating the world's hunger problems, and increasing the standard of living through the application of engineering technology.

6. Financial security

Financial security should not be the only reason for choosing a career in engineering, Engineering graduates receive the most highest starting salary in any discipline.

7. Prestige

Engineers play a prestigious role in sustaining our nation's international competitiveness, maintaining our standard of living, ensuring a strong national security, and protecting public safety.

8. Professional environment

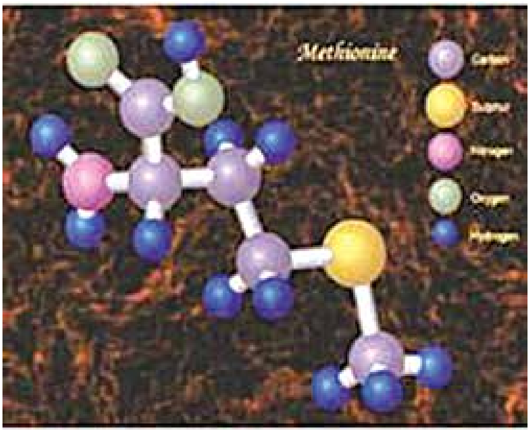
In most cases, engineers receive adequate work space and the tools you need to execute their work, including the latest computer hardware and software. Quite often engineers are judged on the productivity as well as quality and quantity of their work.

Engineers have the opportunity to learn and grow through both on-the-job and formal training. Often, the immediate supervisor will closely involved on some challenging tasks. Engineers are usually allowed to attend seminar, conferences and short course when necessary in enhancing their knowledge and skills. Some employers provide funds for engineers to enroll in higher education and training.

9. Technological and scientific discovery

An understanding of technology will provide engineers with a better understanding of many issues facing the society and determine the most viable ways in addressing the issue such as utilizing a zero-emission electric vehicles to reduce noise, vibration and pollution.

10. Creative thinking



Engineers develop solutions to a real world problems. They employ conscious and subconscious mental processing as well as divergent and convergent thinking. The need for engineers to think creatively is greater now than before. Through creativity, engineers cope with changes.

"Engineering is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings homes to men or women. Then it elevates the standard of living and adds to the comforts of life. This is engineer's high priviledge." (Herbert Clark Hoover, Engineer & President of the US from 1929-1932)

Conclusion

Engineering exist everywhere in a number of ways and circumstances. It is part of our lives and everything we touch and do, relate significantly to engineering matters in one way or the other. Engineering is about everything around us that are being utilized in a manner that is able to provide answers and solution to various problems that we are facing. Engineering and technology change hand in hand and closely integrated to complement each other.

In order to be meaningful, engineering education and training programme is designed taking into consideration of global requirement for problem solving tool with greater freedom of efficiency. In doing so, a standard have been formulated for such programmes to be accredited and recognized paving the ways for a formal acceptance as a norm for before putting it into practice.

Questions

1. Who is an engineer?
2. What is the agricultural mechanization?
3. What do nuclear technologies provide?
4. Where do pulses of light from lasers provide?
5. Where is petroleum used?

Vocabulary

amalgamation	[əmælgə'meɪʃ(ə)n]	слияние, объединение; смешение
appliance	[ə'plaɪəns]	аппарат, прибор; приспособление, устройство
artificial	[ɔ:tɪ'fɪʃ(ə)l]	искусственный
assume	[ə'sju:m]	принимать, брать на себя
awareness	[ə'weənɪs]	осведомлённость, компетентность
behavioral	[biˈhāvyərəl]	характерный
circumstances	['sɜ:kəmstænses]	обстоятельство; случай; условие
deliberate	[dɪˈlɪb(ə) rət]	неслучайный, тщательно спланированный, взвешенный
encompass	[in'kempəs]	охватывать; окружать
enhance	[in'hɔ:ns]	увеличивать, усиливать, улучшать
fascination	[fæsi'neiʃ(ə)n]	привлекательность, притягательность
figment	['figmənt]	вымысел, домысел, ложь, фикция
highlight	['hailait]	отводить главное место; выдвигать на первый план
judgement	['dʒedʒmənt]	судебное разбирательство, процесс
peer	[piə]	ровня, равный (по положению, способностям)
probing	['prəʊbiŋ]	прощупывание; зондирование
relevant	[reləv(ə)nt]	релевантный; значимый; существенный; важный
respond	[ri'spɔnd]	отвечать
scope	[skəʊp]	границы, рамки, пределы
significant	[sig'nifikənt]	значительный, важный, существенный; знаменательный
surgical	['sɜ:dʒik(ə)l]	хирургический
troubleshoot	['trvb(ə)ləu:t]	отыскивать повреждения; выявлять неисправности
unwarranted	[,en'wɔrəntid]	произвольный, неоправданный; незаконный; неуместный
validation	[,vælɪ'deɪə(ə)n]	ратификация, утверждение
viable	['vaɪəb(ə)l]	жизнеспособный
witness	[witnis]	свидетель, очевидец

2.6 JOBS IN MINING

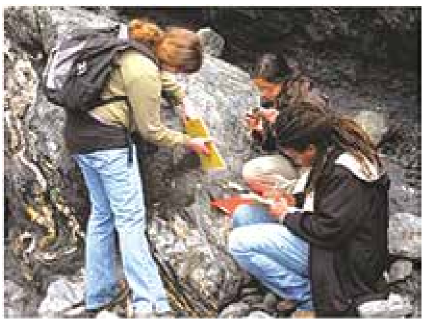
Have you considered a job in today's high tech minerals industry?

Sure the money is great, but working in mining also gives you the skills and experience to set you up for the rest of your life.

Gain access to specialist training and the latest tools and equipment that comes from working in one of the world's most technologically advanced industries.

Enjoy dynamic teamwork, safe working environments and flexible rosters that let you balance work with family and leisure.

Kind of professions



Geoscience – geoscientists may specialise as a Field/Exploration Geologist, Geochemist/Mineralogist, Geomorphologist, Hydrogeologist/Hydrologist, Mathematical Geologist, Mine Geologist, Palaeontologist, Stratigrapher or a Structural Geologist:

Exploration geologist – this essential role discovers and determines where minerals are likely to be found for future mining operations.

Geophysicist – studies the composition, structure and other physical attributes of the earth and locates minerals and ground water.

Mine geologist – working in a team of professionals to locate, map and define the grade of ore bodies for mining operations.

Resource Geologist – your skills involve planning and implementing resource development modelling and analysis of ore bodies for future development of mining operations.

GIS Technician – using GIS systems, provide professional support to find and analyze mineral ore bodies and samples.

Chemical – research and develop processes used in; extracting metals from their ores, casting, alloying, and heat treating.

Civil – your critical skills plan, design, organise and oversee the construction and operation of mining related projects.

Electrical / Electronics – develop, implement and supervise the installation and maintenance for the huge range of electrical systems found in the mining industry.

Mechanical – plan, design and oversee the assembly, operation and maintenance of highly specialised mechanical and process plant equipment.

Surveyor – work closely with engineering and geoscience professionals to plan, direct and/or conduct survey work used in open cut or underground operations.

Mining – an essential and versatile role, planning and directing the engineering aspects of locating and extracting minerals from the earth.

Miner – Underground – safely operate specialized equipment to excavate, load and transport coal, ore and rock in an underground mining operation; **Opencut** – safely operate specialized equipment to excavate, load and transport coal, ore and rock in an open-cut mining operation.

Driller – **Blasthole** – Operate a drilling rig and related equipment to extract ore in an open cut or underground operation; **Exploration** – assemble, position, operate and maintain a drilling rig and related equipment to extract ore for analysis by geologists for future mining operations.

Longwall / Continuous Miner Operator – underground coal miner operating and maintaing the specialist equipment for digging the coal out of the coal seams.

Trainee Operator / Miner – A role for the mechanically minded, to safely operate and maintain a broad range of specialised equipment.

Mobile Plant Operator / Driver – operate stationary and mobile cranes, hoists, lifts and winches to lift, move and place materials, equipment in a range of locations on mining operations.

Crane Operator – operate stationary and mobile cranes, hoists, lifts and winches to lift, move and place materials, equipment in a range of locations on mining operations.

Dragline Operator – senior operator and maintenance for an open pit coal mine - using the dragline to remove the overburden from the coal seams.

Shotfirer – a highly specialised position that assembles, positions and detonates explosives at a mining operation.

Laboratory Assistant – assisting with assessment, research and development of exploration and production of a mining operation.

Excavator / Shovel Operator – assist with the production of a mining operation by safely operating an excavator or shovel.

Grader Operator – grader operators are an essential part of any mining production team.

Haul Truck Operator – safely operate a highly specialised haul pac truck in this unique industry.

Loader Operator – loader operators are essential in a mining operation, using their skills to move and load rock, ore and soil.

Truck Driver – heavy vehicle drivers are used on a range of trucks in the diverse mining industry.

Questions

1. Give a simple definition of mining.
2. Name stages of modern mining process.
3. What is mining engineering?
4. What is the main purpose of mining engineers?

Vocabulary

advanced	[ədˈvɑ:nst]	передовой
alloying	[ə'lɔıŋ]	легирование
assembly	[əˈsemblı]	сборка, монтаж
assessment	[əˈsesmənt]	оценивание качества
casting	[ˈkɑ:stıŋ]	литье
composition	[ˌkɔmpəˈzıʃən]	состав
conduct	[kən'dʌkt]	управлять
define	[dıˈfaın]	давать определение
diverse	[daıˈvə:s]	разнообразный
drilling rig	[ˈdrılıŋ rıg]	буровая установка
essential role	[ıˈsenʃ(ə)l rəʊl]	значительная роль
experience	[ıksˈpıərıəns]	опыт
flexible rosters	[ˈfleksəbl ˈrəustəs]	гибкий график
gain access	[geın ˈækses]	получать доступ
geoscience	[ˌjeoˈsain(t)s]	геолог-ученый
GIS technician	[tekˈnıʃən]	специалист по ГИС-технологиям
heat treating	[hi:t tri:tıŋ]	термообработка
hoists	[hɔısts]	подъемник
huge range	[hju:dʒ reındʒ]	огромный диапазон
haul truck	[hɔ:l trʌk]	грузовик-буксир
implement	['ımplıment]	осуществлять
installation	[ˌınstəˈleıʃən]	монтаж
maintenance	[ˈmeıntənəns]	обслуживание
oversee	[ˈəuvəˈsi:]	надзор
skills	[[skıl]s]	навыки
structure	[ˈstrʌktʃə]	структура, строение
surveyor	[sə:ˈveıə]	геодезист
versatile	[ˈvə:sətaıl]	разносторонний, многогранный
winches to lift	[wıntʃes tu: lıft]	лебедка

2.7 FUNCTIONS OF MINING ENGINEERS

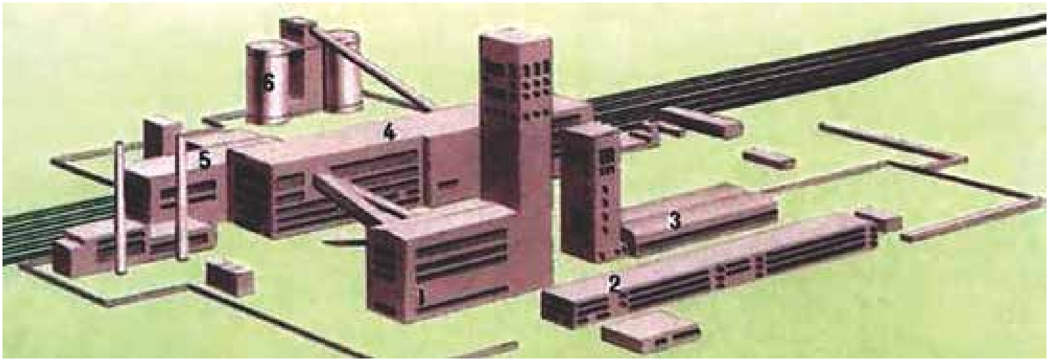
The mine plan is largely conceptual

The mine plan is largely conceptual. If it appears to have economic potential, then a detailed technical study will be undertaken by mining engineers to confirm the viability of the project. Some of these mining engineers should have specialist knowledge. For example, a geotechnical specialist will be required to determine the properties of the rockmass and to predict how it will respond to the various mining options. The specialist may recommend how wide to make the tunnels, how to support the excavations and what type of equipment is best suited. Other mining engineers could be required with specialist knowledge in areas such as environment, blasting and ground vibration, machinery design, training and marketing. Once the mining method is chosen, it is necessary to construct a 'life of mine' plan to determine the size and equipment...

A good knowledge of mining engineering practice

Once the mine layout has been generated, equipment chosen and coasted, schedules developed and production and sales rates determined, the mining engineer has to subject the project to a financial analysis to determine its economic viability. A good knowledge of mining engineering practice is required to ensure that realistic situ ations are being evaluated. Some mining engineers specialize in undertaking this type of financial analysis. Others specialize in auditing the outcomes on behalf of organizations such as banks...

The construction of a new mine



The construction of a new mine involves managing a large number of contractors and a large number of parallel tasks. Project management and contract management are critical to keeping the project on time and budget. Both the mine owner and the various contractors may employ mining engineers for these purposes. An increasing number of mining engineers are now involved in managing contracting companies at both a site level and a corporate level...

The options available

It is not feasible for an individual mine or even a very large mining company to employ all the mining engineers that are needed to undertake all the tasks. Therefore, they call upon consultants. The options available include:

Resource evaluation…	**Environmental assessment…**
Mine design and planning…	**Mine ventilation…**
Equipment selection and performance…	**Financial analysis…**
Human resource management...	**Management process…**

Numerous opportunities

The mining industry creates numerous opportunities for mining engineers to work in private and public companies. Many mining engineers are the founders and principal shareholder in these companies. In addition to consulting, the types of activities in these companies include:

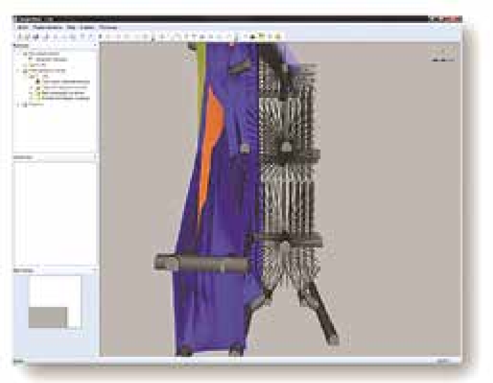
- Equipment design, manufacture, sales and service;
- Computer software development;
- Financial analysis;
- Technology commercialisation.

The role of mining engineers

It is the role of the mining engineers to ensure that the right amount of mineral is produced at the right quality and at the right time in a safe and cost effective manner in accordance with mining approval conditions. Numerous roles for mining engineers include:

Production manager	**Mine manager**
Drill and blast engineer	**Mine planning engineer**
Mine ventilation officer	**Environmental officer**
Mineral processing	**Marketing**
General mine manager	

Computer simulation



The exploration geologist finds a mineral deposit. The mining engineer must discuss with the geologist the shape, size and composition of the deposit. Thereafter, the mining engineer has to determine the grade (quality) and distribution of the minerals in the deposit. Quite often the deposit has to be visualized in three dimensions. Up until the late 1980s, physical models were built to help in understanding the nature of the deposit. More information was gained from drilling. Today this is done by computer simulation. Mining engineers are quite often involved in developing software packages.

Questions

1. What areas of knowledge should be covered by a mining engineer?

2. What tasks must be solved by mining engineer?

3.What professions can be occupied by mining engineers?

4. What a geologist must determine?

Vocabulary

accordance	[əˈkɔ:dəns]	согласие, соответствие, согласованность
approval	[əˈpru:vəl]	утверждение; санкция
competitive	[kəmˈpetɪtɪv]	конкурентоспособный, конкурентный
confirm	[kənˈfə:m]	подтверждать, одобрять
create	[kri:ˈeɪt]	порождать, производить; создавать, творить
determine	[dɪˈtə:mɪn]	определять, измерять, вычислять
dimension	[dɪˈmenʃən]	измерение
discover	[dɪsˈkʌvə]	открывать, обнаруживать (месторождение)
ensure	[ɪnˈʃuə]	гарантировать, обеспечивать
excavate;	[ˈɛkskəveɪt]	вынимать грунт разрабатывать открытым способом,
excavation	[ɛkskəˈveɪʃən]	выемка/разработка грунта, земляные/экскаваторные работы, открытая горная выработка
extracting	[ɪk'stræktɪŋ]	добыча (минералов)
explore	[ɪksˈplɔ:]	исследовать
exploration	[ˌeksplɔ:ˈreɪʃən]	исследование месторождения
feasible	[ˈfi:zəbl]	реальный, выполнимый
gain	[geɪn]	добывать, зарабатывать
invention	[ɪnˈvenʃ(ə)n]	изобретение, открытие
involve	[ɪnˈvɔlv]	привлекать, вовлекать, втягивать
largely conceptual	[ˈlɑ:dʒlɪ] [kənˈseptjuəl]	весьма концептуально
on behalf of	[ɔn] [bɪˈhɑ:f] [ɔv]	от чьего-либо лица
to predict	[tu:] [prɪˈdɪkt]	прогнозировать, предсказывать
properties	[ˈprɔpətɪs]	свойства
prospect	['prɔspekt]	производить изыскания
prospecting	[prə'spektɪŋ]	разведочные работы
provide	[prəˈvaɪd]	обеспечивать, снабжать, предоставлять
purpose	[ˈpə:pəs]	назначение, намерение,
require	[rɪˈkwaɪə]	требовать(ся), нуждаться (в чем-либо)
respond	[rɪsˈpɔnd]	отвечать, реагировать
sales rates	[seɪls] [reɪts]	темпы реализации
viability	[vaɪəˈbɪlɪtɪ]	жизнеспособность
value	[ˈvælju:]	значение, величина, цена, стоимость

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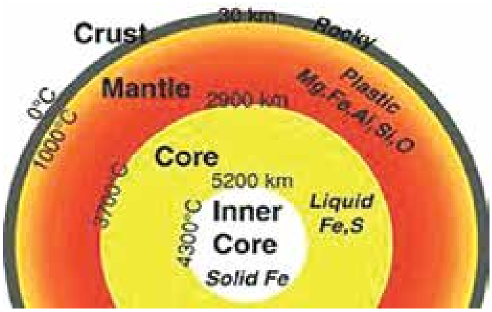
Chapter 3

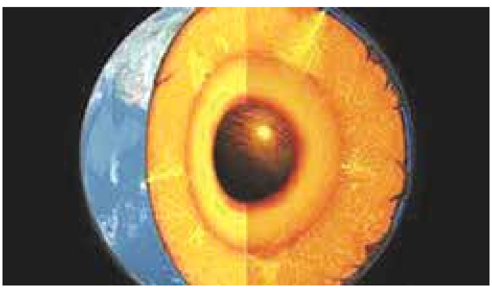
3.1 EARTH STRUCTURE

Earth structure

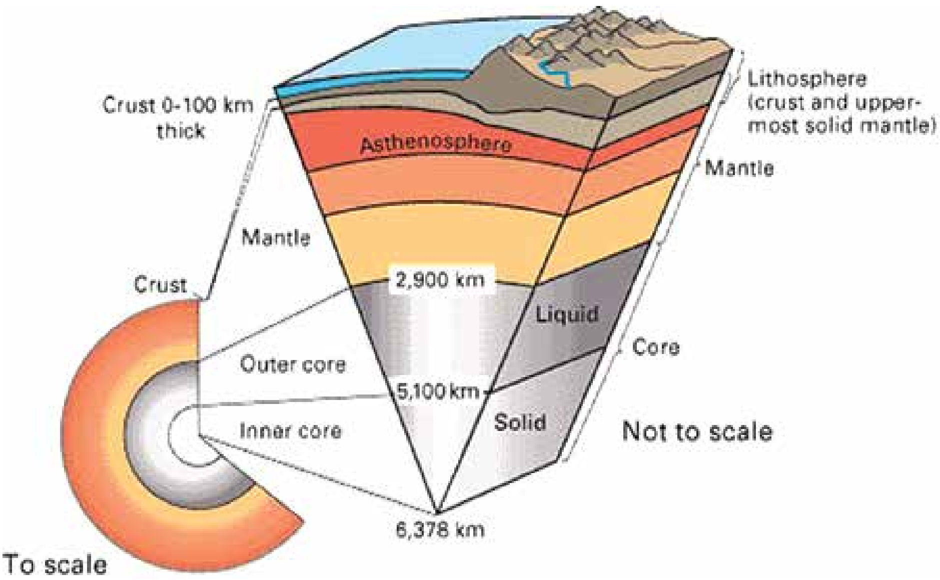
The interior structure of the Earth is layered in spherical shells, like an onion. These layers can be defined by either their chemical or their rheological properties. Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core.

The structure of Earth can be defined in two ways: by mechanical properties such as rheology, or chemically. Mechanically, it can be divided into lithosphere, asthenosphere, mesosphere mantle, outer core, and the inner core. The interior of Earth is divided into 5 important layers. Chemically, Earth can be divided into the crust, upper mantle, lower mantle, outer core, and inner core:

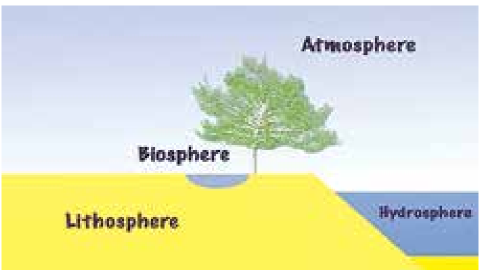


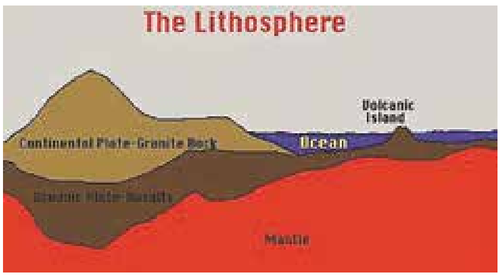


Lithosphere

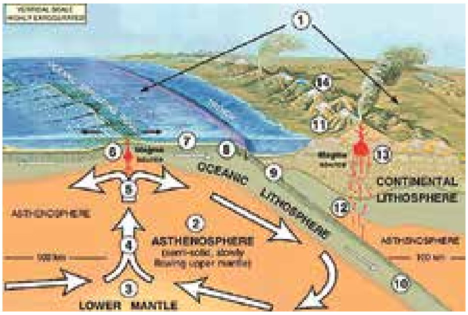


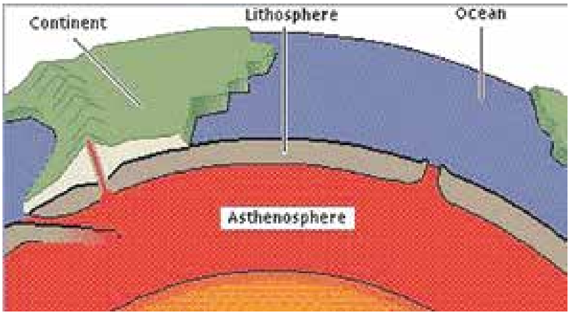
Lithosphere is the rigid outermost shell of a rocky planet. Here on Earth the lithosphere contains the crust and upper mantle. The Earth has two types of lithosphere: oceanic and continental. The lithosphere is broken up into tectonic plates.





Oceanic lithosphere consists mainly of mafic (rich in magnesium and iron) crust and ultramafic (over 90% mafic) mantle and is denser than continental lithosphere. It thickens as it ages and moves away from the mid-ocean ridge. This thickening occurs by conductive cooling, which converts hot asthenosphere into lithospheric mantle. It was less dense than the asthenosphere for tens of millions of years, but after this becomes increasingly denser.

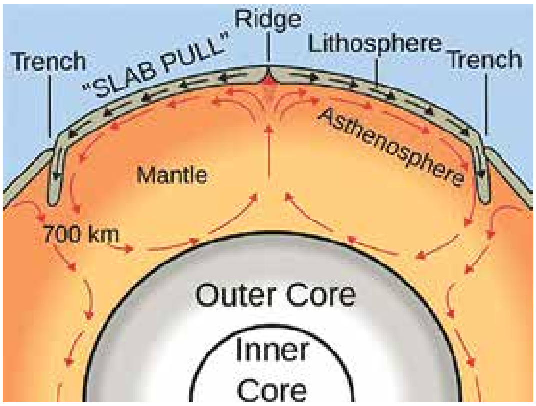


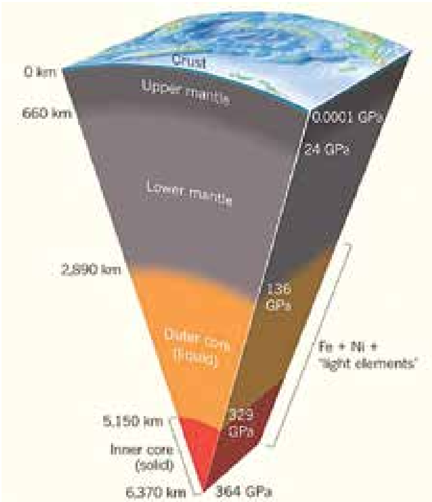


The gravitational instability of mature oceanic lithosphere has the effect that when tectonic plates come together, oceanic lithosphere invariably sinks underneath the overriding lithosphere. New oceanic lithosphere is constantly being produced at mid-ocean ridges and is recycled back to the mantle at subduction zones, so oceanic lithosphere is much younger than its continental counterpart. The oldest oceanic lithosphere is about 170 million years old compared to parts of the continental lithosphere which are billions of years old.

Mantle

The upper part of the Earth's mantle, extending from a depth of about 75 km to about 200 km. The asthenosphere lies beneath the lithosphere and consists of partially molten rock. Seismic waves passing through this layer are significantly slowed. Isostatic adjustments (the depression or uplift of continents by buoyancy) take place in the asthenosphere, and magma is believed to be generated there.

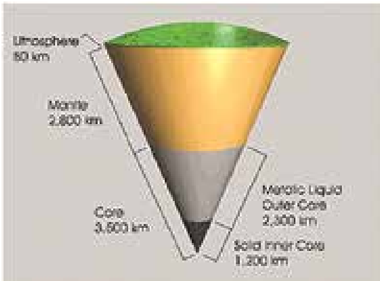




The mesosphere refers to the mantle in the region between the asthenosphere and the outer core. The upper boundary is defined as the sharp increase in seismic wave velocities and density at a depth of 660 km. As depth increases, pressure builds and forces atoms into a denser, more rigid structure; thus the difference between mesosphere and asthenosphere is likely due to density and rigidity differences, that is, physical factors, and not to any difference in chemical composition.

Outer core

The outer core of the Earth is a liquid layer about 2,266 km thick composed of iron and nickel which lies above the Earth's solid inner core and below its mantle. Its outer boundary lies 2,890 km beneath the Earth's surface. The transition between the inner core and outer core is located approximately 5,150 km beneath the Earth's surface.

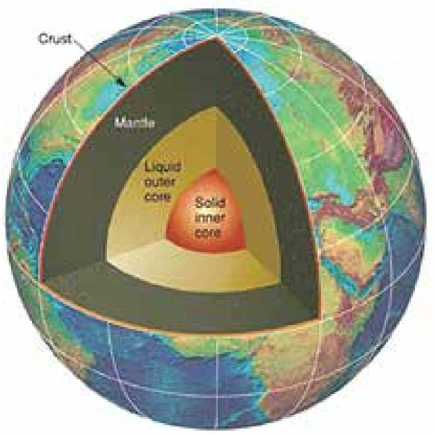


Properties

The temperature of the outer core ranges from 4400 °C (8000 °F) in the outer regions to 6100 °C (11000 °F) near the inner core. Because of its high temperature, modeling work has shown that the outer core is a low viscosity fluid (about ten times the viscosity of liquid metals at the surface) that converts turbulently. Eddy currents in the nickel iron fluid of the outer core are believed to influence the Earth's magnetic field. The average magnetic field strength in the Earth's outer core was measured to be 25 gauss, 50 times stronger than the magnetic field at the surface. The outer core is not under enough pressure to be solid, so it is liquid even though it has a composition similar to that of the inner core. Sulfur and oxygen could also be present in the outer core. As heat is transferred outward toward the mantle, the net trend is for the inner boundary of the liquid region to freeze, causing the solid inner core to grow. The growth rate of inner core is estimated to be 1 mm per year.

Inner core

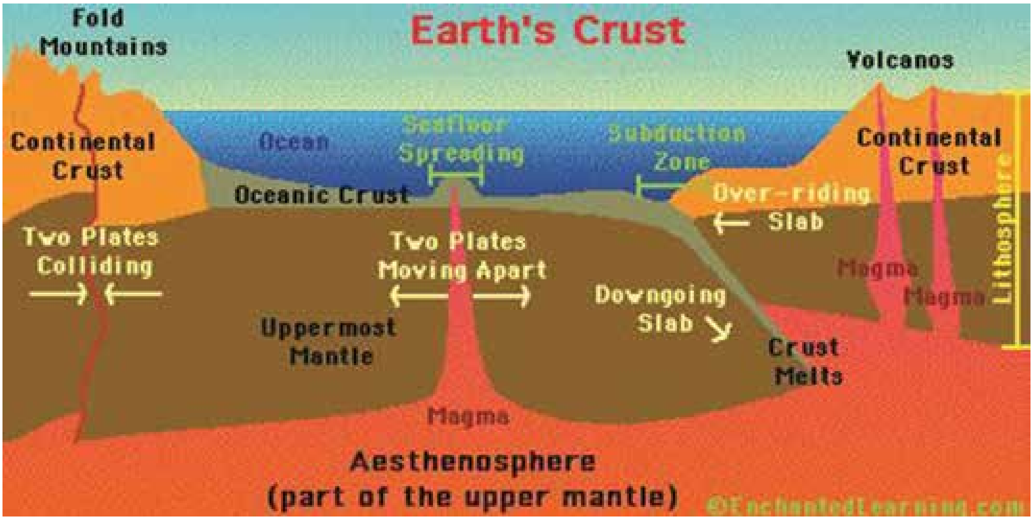
The inner core of the Earth, its innermost part, is a primarily solid ball with a radius of about 1,220 km, according to seismological studies (this is about 70% of the length of the Moon's radius). It is believed to consist primarily of an iron–nickel alloy, and to be about the same temperature as the surface of the Sun: approximately 5700 K (5430 °C).



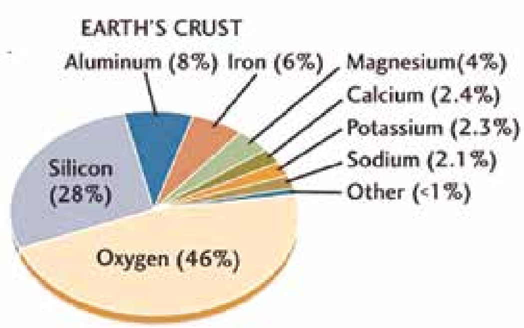
The inner core of the Earth has temperatures and pressures so great that the metals are squeezed together and are not able to move about like a liquid. The inner core begins about 6400 km beneath the crust and is about 1280 km thick. The temperatures may reach 9000 degrees F. and the pressures are 22,5 million kg per square inch. This is 3,000,000 times the air pressure on you at sea level.

Crust

The crust ranges from 5–70 km in depth and is the outermost layer. The thin parts are the oceanic crust, which underlie the ocean basins (5–10 km) and are composed of dense (mafic) iron magnesium silicate igneous rocks, like basalt. The thicker crust is continental crust, which is less dense and composed of sodium, potassium, aluminium silicate rocks, like granite.



The crust of the Earth is composed of a great variety of igneous, metamorphic, and sedimentary rocks. The crust is underlain by the mantle. The upper part of the mantle is composed mostly of peridotite, a rock denser than rocks common in the overlying crust. The boundary between the crust and mantle is conventionally placed at the discontinuity, a boundary defined by a contrast in seismic velocity. The crust occupies less than 1% of Earth's volume.



Depth of earth layers below the surface

Depth		Layer
Kilometres	**Miles**	
0–35	0–22	Crust (locally varies between 5 and 70 km)
35–60	22–37	Uppermost part of mantle
35–2,890	22–1,790	Lithosphere (locally varies between 5 and 200 km)
100–200	62–125	Asthenosphere
35–660	22–410	Upper mesosphere (upper mantle)
660–2,890	410–1,790	Lower mesosphere (lower mantle)
2,890–5,150	1,790–3,160	Outer core
5,150–6,360	3,160–3,954	Inner core

Questions

1. In what ways can earth structure be defined?
2. How many important layers does the Earth have?
3. What parts of lithosphere do you know?
4. What is the outer core of Earth?
5. What is the composition of Earth crust?

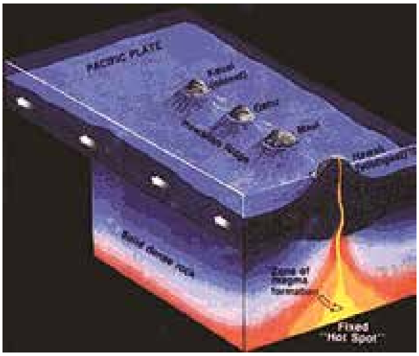
Vocabulary

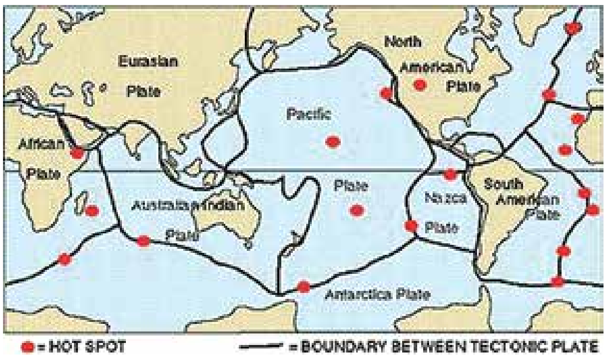
interior structure	[in'tiəriə strʌktʃə]	внутренняя структура
viscous	[ʻviskəs]	вязкий
liquid	[ʻlikwid]	жидкий
outer core	[autə kɔ:]	внешняя часть ядра
inner core	[ʻinə kɔ:]	внутренняя часть ядра
rheology	[ri'ɒlədʒi]	реология
lithosphere	[litosfiə]	литосфера
asthenosphere	[astinosfiə]	астеносфера
mesosphere	[mezosfiə]	мезосфера
earth crust	[ə:Θ krʌst]	кора земли
upper mantle	[ʻʌpə mæntl]	верхняя мантия
lower mantle	[ləuə mæntl]	нижняя мантия
rigid	[ʻridʒid]	жесткий
outermost	[ʻautəmaust]	наиболее удаленный от центра
mafic	[məfi:k]	темный
mid-ocean ridge	[mid ʻauʃ(ə)n ridʒ]	средне-океанический хребет
dense	[dens]	густой
instability	[instə'biliti]	неустойчивость
counterpart	[ʻkauntəpɔ:t]	копия, аналог
to extend	[iks'tend]	протягиваться
molten rock	[məult(ə)n rɔk]	расплавленная порода
seismic wave	[seismik weiv]	сейсмическая волна
buoyancy	[ʻbaiyo ənsi]	плавучесть
velocity	[vi'lɔsiti]	скорость, быстрота
eddy current	[ʻedi kʌr(ə)nt]	вихревой ток
influence	[ʻinflu əns]	влияние
approximately	[ə'prɔksimitli]	приблизительно
squeeze	[skwi:z]	сжатие
pressure	[ʻpreʃ ə]	давление
outermost layer	[ʻautəmaust ʻlei ə]	наружный слой
peridotite	[ʻpiridɔti:t]	перидотит
discontinuity	[ʻdiskən'tjuniti]	разрыв

3.2 HOT SPOTS

Hot spots

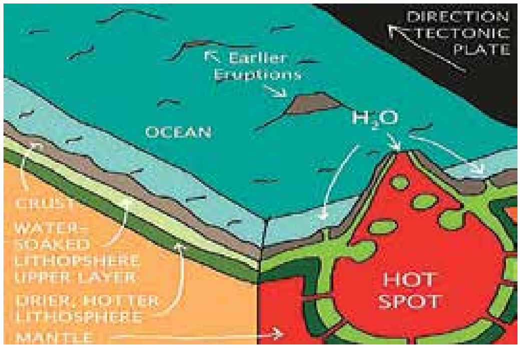
In geology, a hotspot is a location on the Earth's surface that has experienced active volcanism for a long period of time. They may be on, near to, or far from tectonic plate boundaries. There are two hypotheses to explain them. One suggests that they are due to hot mantle plumes that rise as thermal diapirs from the core-mantle boundary. The other hypothesis postulates that it is not high temperature that causes the volcanism, but lithospheric extension that permits the passive rising of melt from shallow depths. This hypothesis considers the term "hotspot" to be a misnomer, asserting that the mantle source beneath them is, in fact, not anomalously hot at all. Well known examples include Hawaii and Yellowstone.





A hot spot is a very hot region deep within the Earth. It is usually responsible for volcanic activity. Volcanic activity happens whenever red-hot material from the Earths thickest layer, the mantle, rises up and leaks through to the Earth’s surface, the crust. The red-hot material, called magma, sometimes erupts in the form of lava. Lava is the red-orange substance that spills out of a volcano onto the surface.

Hotspots were thought to remain in a fixed position with respect to the earth's lower mantle. Hotspots were therefore used to define a unique, absolute reference frame to quantify the displacement of lithospheric plates. Maps of absolute velocity vectors for the earth's plates relative to hotspots (first produced in the late 1970s) provide a visual representation of plate motion from which the sense of displacement and resulting style of deformation at plate margins can be deduced. Hotspot tracks define segments of small circles about a fixed pole of rotation for the plate (called the Euler pole).



Paleomagnetic studies of volcanic rocks formed above hotspots and detailed global plate reconstructions suggest that at least some hotspots may not have remained stationary. Rates of relative hotspot movement have been generally estimated at approximately 0.8-2 in (200 mm) per year. This implies that plumes may have moved with part of the mantle and displaced relative to each other. If the density distribution of the mantle changed in the past, the whole mantle may have rotated with respect to the earth's rotational axis to a new stable position (a process called true polar wander), systematically rotating all hotspots relative to the rotational axis.

Volcanoes

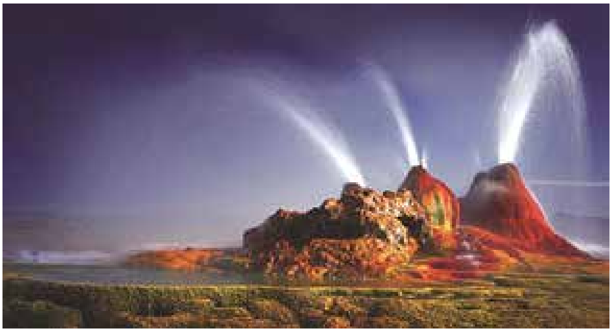
Most volcanoes occur near the Earth's plate boundaries, but some do not. For example, the Hawaiian islands have been formed over millions of years by volcanic eruptions thousands of miles from the edges of the Pacific plate. Island formation is still happening on Hawaii every time the shield volcanoes Kilauea and Mauna Loa erupt.

Hawaii islands

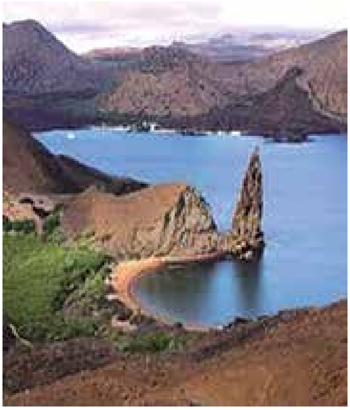
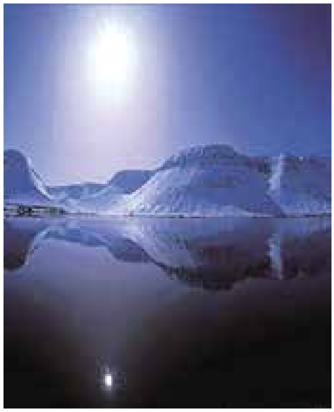
It is thought that a hotspot - a stationary plume of magma that rises from deep within the Earth - powers the volcanism on Hawaii. As the Pacific plate slowly moves over the hotspot, the islands in the Hawaiian-Emperor chain have been built one at a time by a numerous volcanic eruptions.

Geysers

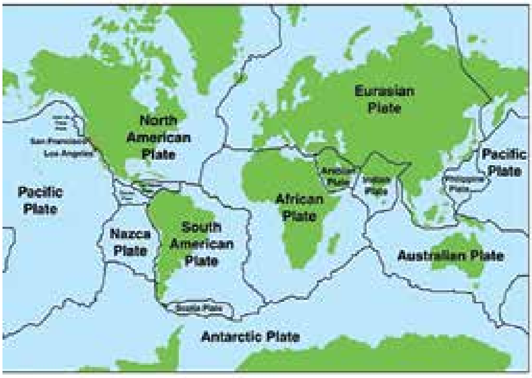
Hot spots don't always create volcanoes that spew rivers of lava. Sometimes, the magma heats up groundwater under the Earth's surface, which causes water and steam to erupt like a volcano. These eruptions are called geysers. A famous geyser is Old Faithful in Yellowstone National Park in the U.S. state of Wyoming. When it erupts, the water is 95.6 degrees Celsius and can reach more than 55 meters high.



There are 40 to 50 hot spots around the world, including near the Galapagos Islands and Iceland. Hot spots can create entire chains of islands, like the U.S. state of Hawaii. Hawaii is on the Pacific plate, an enormous section of the Earth in the Pacific Ocean that is constantly moving, but very, very slowly. Although the plate is always moving, the hot spot underneath it stays still. These islands were created right after the plate moved, almost like an island factory.

Earth plates



Scientists use hot spots to track the movement of the Earths plates. The Pacific plate is just one of many tectonic plates that make up the Earth: the North American plate, the Caribbean plate, the South American plate, the Scotia plate (beneath South America), the African plate, the Eurasian plate, the Arabian plate, the Indian plate, the Australian plate, the Filipino plate, the Pacific plate, the Cocos plate (west of South America), the Juan deFuca plate (west of the U.S. state of Washington), and the Antarctic plate.

Questions

1. What is a hot spot?
2. Please tell us the definition of lava?
3. How are the Hawaiian islands formed?
4. How many hot spots are there around the world?
5. How do scientists use hot spots?

Vocabulary

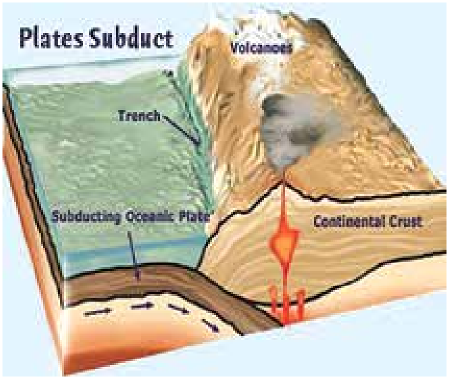
surface	[sə:fis]	поверхность
mantle plume	[mæntl plu:m]	магматический выброс
diapir	[daiəpi:]	диапир (куполо- или валообразные антиклинальные складки с интенсивно смятым ядром)
mantle boundary	[mæntl baund(ə)ri]	граница мантии
misnomer	[misnɔ:umʌ]	неправильное название
volcanic activity	[vɔl'kenik æk'tiviti]	вулканическая активность
magma	[məgmʌ]	магма
to remain	[ri'mein]	оставаться
to define, determine	[di'fain] [di'tə:min]	определять
fixed position	[fikst pə'ziʃ(ə)n]	фиксированное, неподвижное положение
unique	[ju:'ni:k]	уникальный, своеобразный
to erupt	[i'rʌpt]	извергать
displacement	[dis'pleismənt]	перемещение
to spills out	[spilz aut]	переполняться
visual representation	[viʒjual reprizen'teiʃ(ə)n]	зрительное представление, визуализация
plate motion	[pleit 'məuʃ(ə)n]]	движение плиты
circle	['sə:kl]	круг
rotation	[rəu'teiʃ(ə)n]	вращение
paleomagnetic	[paleomæg'netik]	палеомагнитный
distribution	[distri'ju:ʃ(ə)n]	распространение, распределение
axis	['æksis]	координатная ось
shield	[ʃi:ld]	щит
numerous	['nju:m(ə)rəs]	многочисленный
plume	[plu:m]	плюм, твердый восходящий поток в мантии, мантийная струя
enormous	['inɔ:məs]	огромный, невероятный
to spew	[spju:]	выплескивать, выбрасывать
chain of islands	[tʃein of 'ailands]	цепь островов
wander	[wɔndə]	отклонение, дрейф
to imply	[im'plai]	подразумевать, предполагать

3.3 TECTONIC PROCESSES

Tectonic processes are the structural forces affecting the deformation, uplift, and movement of the earth's crust. The main force that shapes our planet's surface over long amounts of time is the movement of Earth's outer layer by the process of plate tectonics.

Plates

The surface of the Earth is not a stationary solid surface. This outer layer of the Earth is the lithosphere. It is actually broken up into pieces like a giant puzzle. These broken pieces are called plates. The Earth's surface is actually broken into about a dozen large plates and several smaller plates. These plates are constantly on the move. This is called plate tectonics or continental drift.



Movement

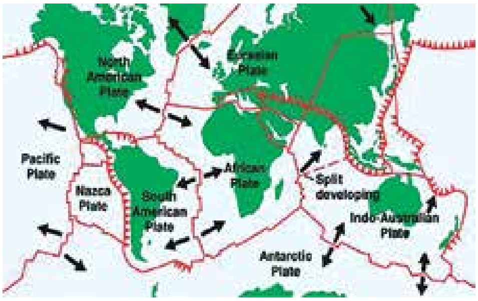
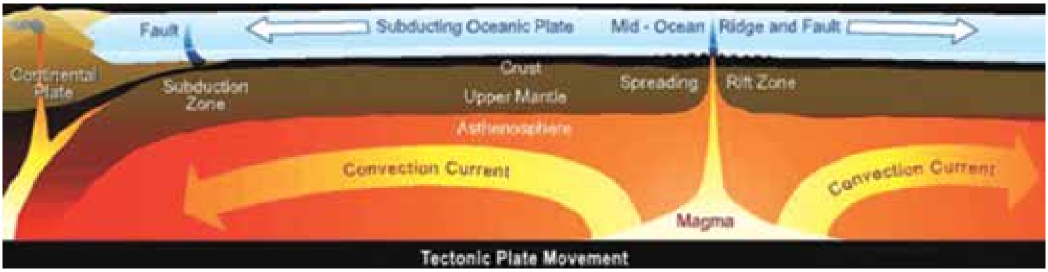
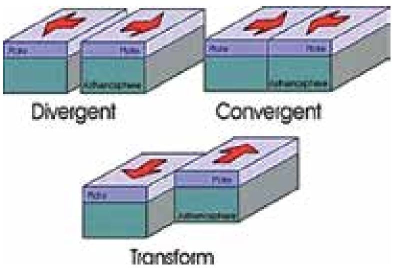


Plate tectonics are the mechanics behind the movement of the plates. According to the US Geological Survey, "The fastest plate races along at 15 centimeters (6 inches) per year while the slowest plates crawl at less than 2.5 centimeters (1 inch) per year." To humans this is incredibly slow, but in geological time it is movement on a massive scale. In one million years the fastest plates will have moved 6 million inches or 500,000 feet. This means that this plate could move a little over 94 miles. This would move Los Angeles north to where Santa Barbara is located. So in about 30 million years Hawaii will be part of Alaska.

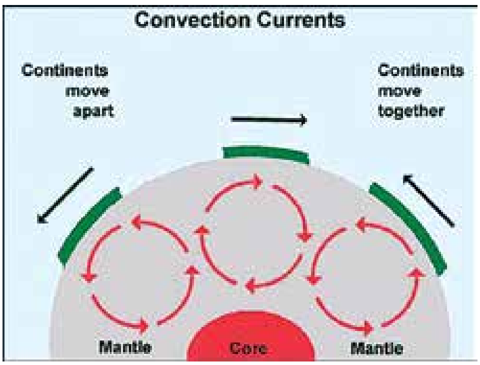




The movement of the plates creates three types of tectonic boundaries: convergent, where plates move into one another; divergent, where plates move apart; and transform, where plates move sideways in relation to each other.

Currents

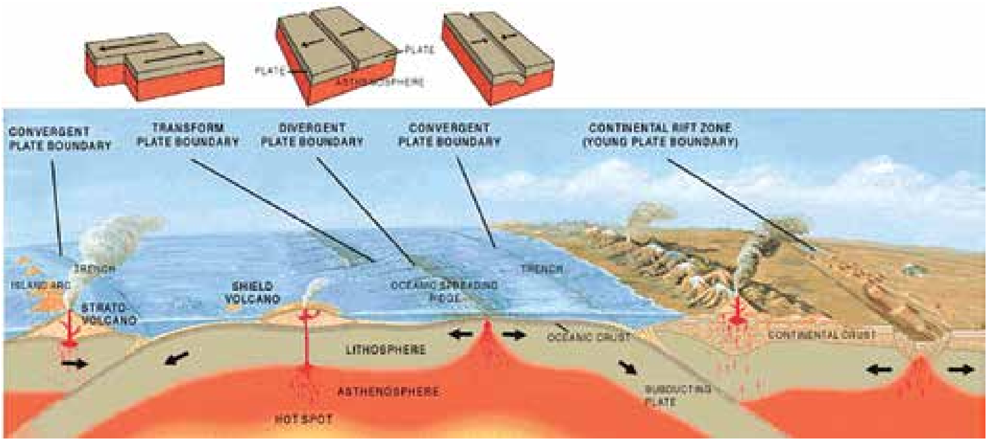
The movement of the plates is a simple concept. Under the crust of the Earth is the mantle. It is a hot area with semi-solid liquid. The magma closest to the Earth's core is super-hot and rises on currents of heat towards the upper levels of the mantle. As it rises, the liquid cools and becomes more solid. It also becomes heavier. These semi-solids sink and reheat on the way down



towards the core. Imagine giant circles of heat driven movement. This may go on below the surface, but it affects the surface. The tectonic plates of the Earth are riding on these convection currents. These convection currents shift the plates.

Plate Boundaries

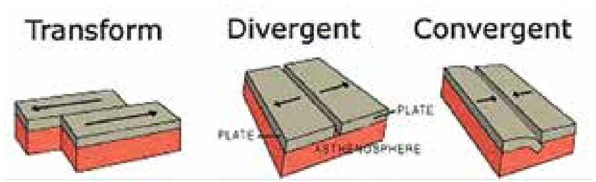
With this massive movement the plates move in different ways. The surface cycle consists of plates moving, their edges being pulled under to join the material in the mantle, and the mantle welling up on the other side of the plate as a form of regeneration. The boundaries of the plates grind against each other and cause friction. This friction is released as energy in the form of earthquakes. When a divergent plate boundary is formed, the plates move away from each other. In these areas, the boundary area pushes the continents away from each other as magma moves to the surface. When a convergent plate boundary is formed, one plate rises over the top of another.

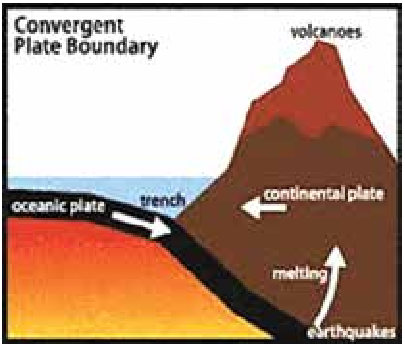


One plate is pushed under the other plate to become part of the mantle. When a transformed plate boundary is formed, the plates slide against each other in opposite directions. These boundary types are fault lines like the San Andreas Fault. They don't have spectacular features like mountains or oceans, but the halting motion often triggers large earthquakes, such as the 1906 one that devastated San Francisco.

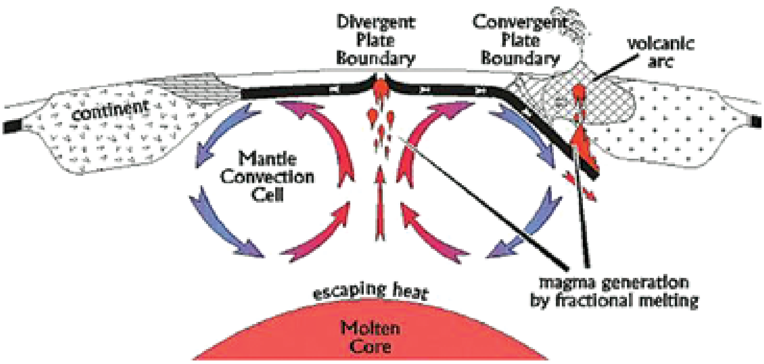
Convergent Boundaries

India and Asia crashed about 55 million years ago, slowly giving rise to the Himalaya, the highest mountain system on Earth. As the mash-up continues, the mountains get higher. Mount Everest, the highest point on Earth, may be a tiny bit taller tomorrow than it is today.





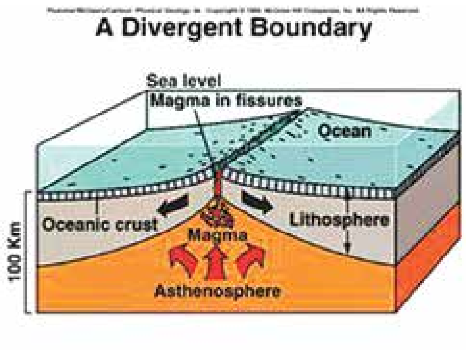
These convergent boundaries also occur where a plate of ocean dives, in a process called subduction, under a landmass. As the overlying plate lifts up, it also forms mountain ranges. In addition, the diving plate melts and is often spewed out in volcanic eruptions such as those that formed some of the mountains in the Andes of South America.

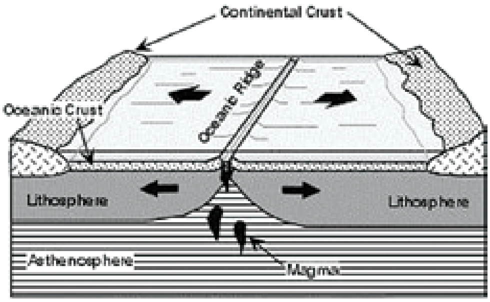


At ocean convergences, one plate usually dives beneath the other, forming deep trenches like the Mariana Trench in the North Pacific Ocean, the deepest point on Earth. These types of collisions can also lead to underwater volcanoes that eventually build up into island arcs like Japan.

Divergent Boundaries

At divergent boundaries in the oceans, magma from deep in the Earth's mantle rises toward the surface and pushes apart two or more plates. Mountains and volcanoes rise along the seam. The process renews the ocean floor and widens the giant basins. A single mid-ocean ridge system connects the world's oceans, making the ridge the longest mountain range in the world.





Diverging Plate Boundary
Oceanic Ridge - Spreading Center

On land, giant troughs such as the Great Rift Valley in Africa form where plates are tugged apart. If the plates there continue to diverge, millions of years from now eastern Africa will split from the continent to form a new landmass. A mid-ocean ridge would then mark the boundary between the plates.

Questions

1. What is a tectonic process?

2. Please give the definition of a tectonic plate.

3. What is the speed of the slowest and the fastest tectonic plates movement?

4. How many types of tectonic boundaries do you know?

5. What is the deepest point on the planet?

Vocabulary

force	[fɔ:s]	сила
giant	[‘dʒaiənt]	громадный, огромный
puzzle	[‘pʌzl]	мозаика
continental drift	[,kɔnti’nentl drift]	дрейф континентов
crawl	[krɔ:l]	ползание, медленное движение
incredibly	[inkrɔ:diblli]	невероятно
inch	[intʃ]	дюйм
convergent	[kanvirgənt]	ссужающийся
divergent	[dai’və:dʒ(ə)nt]	расходящийся
transform	[træns’fɔ:m]	преобразование
massive scale	[‘mæsiv skeil]	крупный масштаб
sideway	[‘saidwei]	боковая дорожка, боком к чему-либо
semi-solid liquid	[səmi sɔlid ‘likwid]	полутвердая жидкость
sink	[si:nk]	выемка, раковина
reheat	[rəhit]	подогрев, перегрев
to affect	[a’fekt]	влиять, задевать
convection current	[kən’venʃ(ə)nt ‘kʌr(ə)nt]	конвекционный поток
welling up	[wellin: ʌp]	выжимание
earthquake	[‘ə Ɵkweik]	землетрясение
fault line	[fɔlt lain]	линия тектонического нарушения
landmass	[‘lændma:s]	суша
trench	[trentʃ]	впадина, траншея
collision	[kə;liʒ(ə)n]	столкновение

3.4 ROCK DEFINITION. ENGINEERING GEOLOGY

Rock

What is a 'rock'? In Geology, 'Rock' is defined as the solid material forming the outer rocky shell or crust of the earth. There are *three* major groups of rocks by its origin:

(1)

(2)

(3)

1)Igneous rocks: cooled from a molten state; e.g., *granite*, *basalt...*;

2)Sedimentary rocks: deposited from fluid medium; the products of weathering of other rocks in water; e.g., sandstone, mudston;

3)Metamorphic rocks: formed from preexisting rocks by the action of heat and pressure. e.g., dolomite, marble.

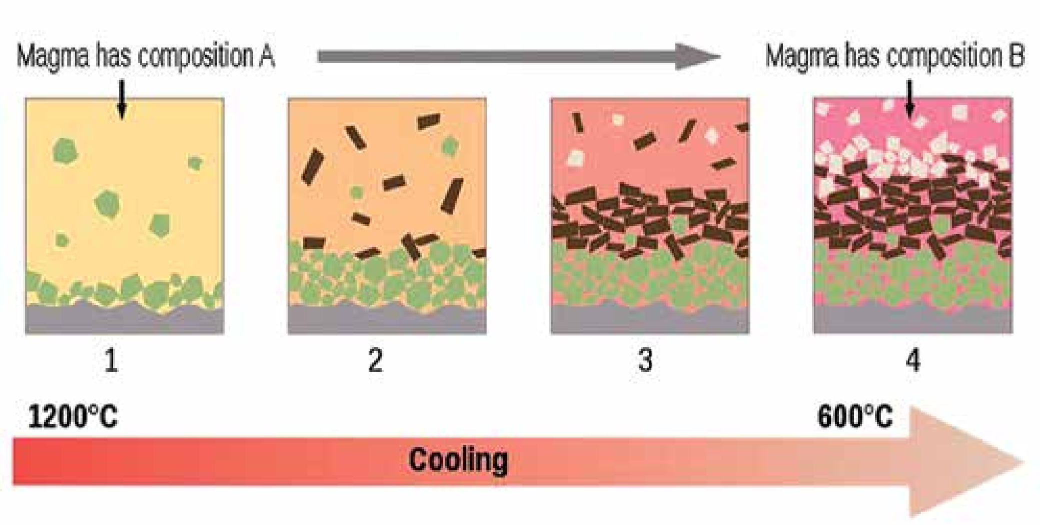
Igneous rock is one of the three main rock types. Igneous rock is formed by magma (molten rock) cooling and becoming solid. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks.. Typically, the melting is caused by one or more of three processes: an increase in temperature, a decrease in pressure, or a change in composition. Over 700 types of igneous rocks have been described, most of them having formed beneath the surface of Earth's crust.

Igneous rocks make up approximately 90% of the upper part of the Earth's crust, but their great abundance is hidden on the Earth's surface by a relatively thin but widespread layer of sedimentary and metamorphic rocks.

Intrusive igneous rocks are formed from magma that cools and solidifies within the crust of a planet. Surrounded by pre-existing rock, called country rock, the magma cools slowly, and as a result these rocks are coarse grained. The mineral grains in such rocks can generally be identified with the naked eye.

Extrusive igneous rocks are formed at the crust's surface as a result of the partial melting of rocks within the mantle and crust. Extrusive Igneous rocks cool and solidify quicker than intrusive igneous rocks. Since the rocks cool very quickly they are fine grained.

The melt with or without suspended crystals and gas bubbles is called magma. Magma rises because it is less dense than the rock from which it was created. When it reaches the surface, magma extruded onto the surface, then it is called lava.



Schematic diagrams showing the principles behind fractional crystallisation in a magma. While cooling, the magma evolves in composition because different minerals crystallize from the melt. 1: olivine -crystallizes; 2: olivine and pyroxene; 3: pyroxene and plagioclase crystallize; 4: plagioclase crystallizes.

As magma cools, minerals typically crystallize from the melt at different temperatures (fractional crystallization). Magmas of different compositions can mix with one another.

Classification

Igneous rocks are classified according to mode of occurrence, texture, mineralogy, chemical composition, and the geometry of the igneous body.

The classification of the many types of different igneous rocks can provide us with important information about the conditions under which they formed. Two important variables used for the classification of igneous rocks are particle size, which largely depends upon the cooling history, and the mineral composition of the rock.

In a simplified classification, igneous rock types are separated on the basis of the type of feldspar present, the presence or absence of quartz.

Igneous rocks which have crystals large enough to be seen by the naked eye are called phaneritic; those with crystals too small to be seen are called aphanitic. Generally speaking, phaneritic implies an intrusive origin; aphanitic - an extrusive one.

Texture and chemical composition

Texture is an important criterion for the naming of volcanic rocks. The texture of volcanic rocks, includes the size, shape, orientation, and distribution of mineral grains and the intergrain relationships.

Textural criteria are less critical in classifying intrusive rocks where the majority of minerals will be visible to the naked eye or at least using a hand lens, magnifying glass or microscope. Mineralogical classification is used most often to classify plutonic rocks.

Igneous rocks can be classified according to chemical or mineralogical parameters:

Chemical: total alkali-silica content:

- acid igneous rocks containing a high silica content, greater than 63% SiO_2 (example granite)
- intermediate igneous rocks containing between 52 - 63% SiO_2 (example andesite)

- basic igneous rocks have low silica 45 - 52% and typically high iron - magnesium content (example gabbro and basalt)

Mafic magmas produce dark colored rocks made of dark minerals (such as Basalt), intermediate magmas - intermediate colored rocks (e.g. Diorite) and felsic magmas -light colored rocks (e.g. Granite).

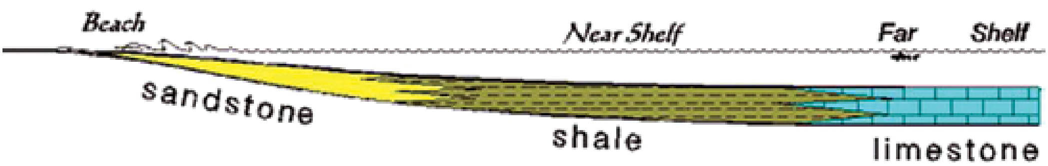
Because of these conditions it is natural to classify igneous rock on color and texture.

The following table is a simple subdivision of igneous rocks according both to their composition and mode of occurrence.

	Composition			
Mode of occurrence	Felsic	Intermediate	Mafic	Ultramafic
Intrusive	Granite	Diorite	Gabbro	Peridotite
Extrusive	Rhyolite	Andesite	Basalt	Komatiite

Sedimentary rocks

The simple scheme for the evolution of sedimentary rocks says there are three end products that all sedimentary processes are working to reach - quartz sandstone, shale, and limestone.



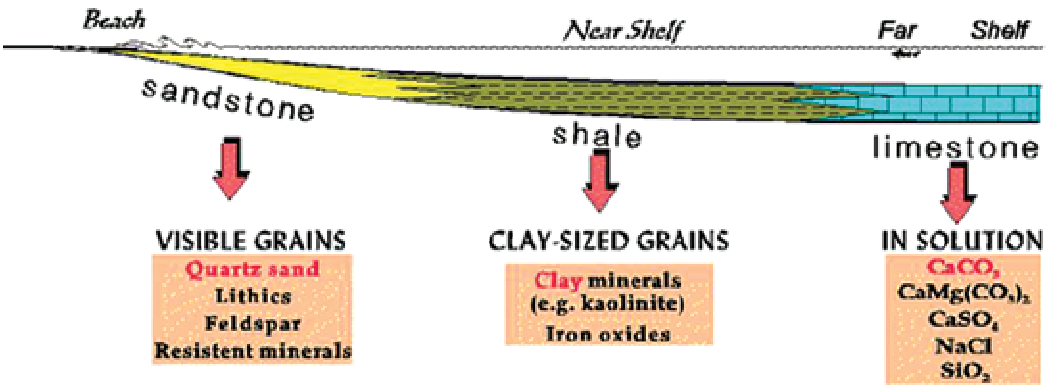
The three attractors in the simple ideal model are not isolated, however; each one stands for a class of weathering products. For example:

Quartz sandstone = ***all visible grains.***

Shale – all clay sized grains (clay is a generic name; there are many kinds of clay minerals as well as other minerals that are clay sized).

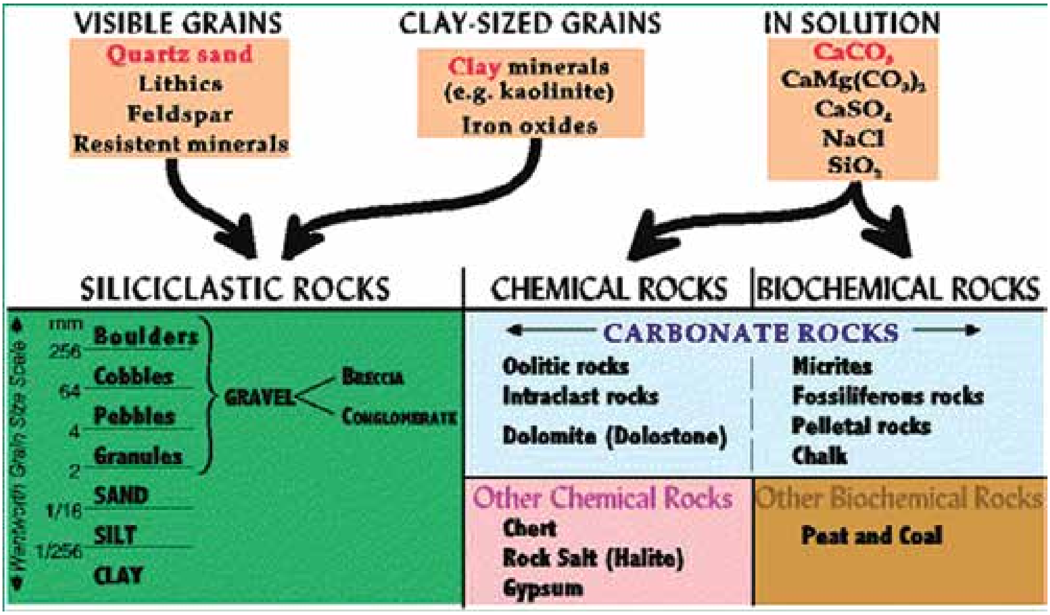
Limestone – all dissolved minerals, including not only calcite $CaCO_3$, but also halite (table salt; NaCl), and gypsum ($CaSO_4 . H_2O$) among others.

On the chart below we can see these additional weathering products.



From now on, sedimentary rocks are generally divided into three great categories, siliciclastic (or simply, clastic) rocks, chemical rocks and biochemical rocks. Their relationships are shown in the figure below. Observe how visible grains and clay sized grains mix together to form clastic rocks, while minerals in solution split to form chemical and biochemical rocks.

Clastic rocks are composed of weathering products that do not dissolved into water and have silica (SiO_2) as one of their major components, and are transported either by rolling along the bottom, or in suspension. Because of this the *visible grain* and *clay sized grain* weathering products in the chart above tend to be mixed, and deposited together. So we group them together as *siliciclastic* rocks.



Minerals *in solution* are not generally deposited in the presence of siliciclastic rocks. Indeed, these rocks are so different from clastic rocks that geologists often specialize in studying either one group or the other.

To deposit minerals that are in solution, they must some how come out of solution and this happens two ways. Either they precipitate directly from sea water (usually because it is evaporating and concentrating the salts) - *chemical rocks*.

Or " plants" and " animals" or their skeletons eventually become part of the sediment as *biochemical rocks*.

Chemical/biochemical rocks fall into several groups, depending on how they form.

Carbonates: These are composed of the mineral calcite ($CaCO_3$ - calcium carbonate), and are thus all known as carbonates.

Other chemical rocks: These rocks fall into two categories. Chert is a siliceous rock that forms from the recrystalized skeletons of "animals "or single celled" plants. Rock salt (halite; NaCl) and gypsum ($CaSO_4 . H_2O$) originally are dissolved in the sea water, thus making the sea salty. When sea water evaporates in a closed area, such as a lagoon, the salt concentration becomes very high and precipitates out. The process is common in desert areas, with examples today in the Red Sea and Dead Sea in the Middle East, both highly saline.

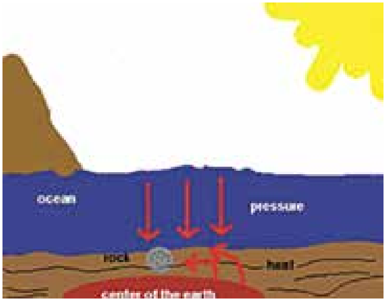
Other biochemical rocks: Peat and coal because they come from plant remains are biochemical rocks, but unlike all the other chemical/biochemical rocks peat and coal always form in the presence of clastic rocks – sandstones and shales.

Sedimentary rocks form in so many different ways, from so many different processes that coming up with one scheme that is inclusive and yet straight forward is not easy. There always seem to be exceptions to the rule that have to have to be explained individually.

Metamorphic rocks

Metamorphism is the recrystallization of pre-existing rocks due to changes in physical and chemical conditions, primarily heat, pressure, and the introduction of chemically active fluids.

The change in the particle size of the rock during the process of metamorphism is called recrystallization. For instance, the small calcite crystals in the sedimentary rock limestone change into larger crystals in the metamorphic rock marble, Both high temperatures and pressures contribute to recrystallization.



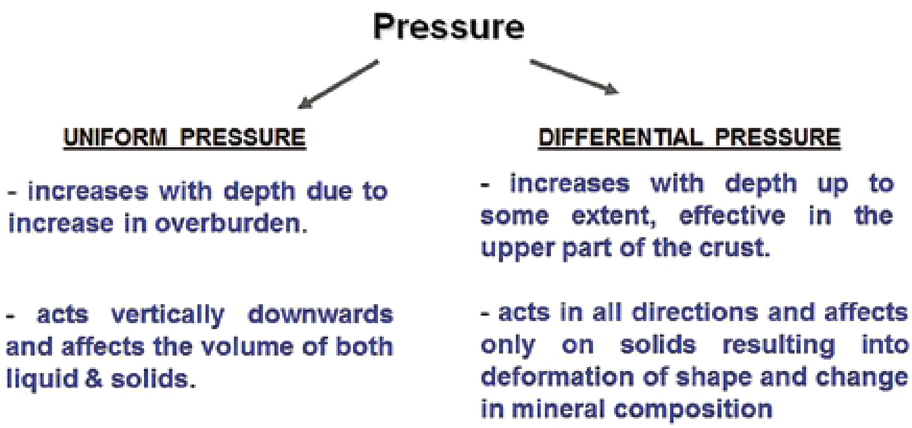
Conditions of formation: Metamorphic rock is the result of the transformation. They may be formed simply by being deep beneath the Earth's surface, subjected to high temperatures and the great pressure of the rock layers above it. They can form from tectonic processes such as continental collisions.

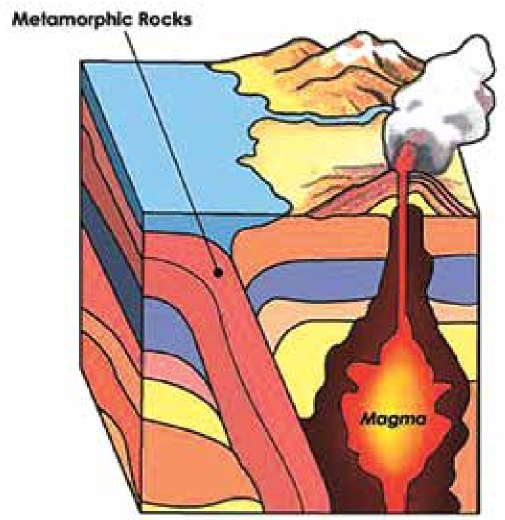
They are also formed when rock is heated up by the intrusion of hot molten rock called magma.

Metamorphic minerals are those that form only at the high temperatures and pressures associated with the process of metamorphism.

Metamorphism is the process that occur in rocks due to the effects of

- High temperature
- High pressure
- Chemically active fluids





Where does the heat come from? The heat comes from *magma*. Where does the pressure come from? The pressure comes from layers of rock piled on top of layers and layers of rock. The layers on the bottom get squeezed. The thicker the layers, the more pressure there is.

Heat and pressure usually work together, because both rise as you go deeper in the Earth. At high temperatures and pressures, most rocks break down and change into a different assemblage of minerals that are stable in the new conditions.

Fluids are an important agent of metamorphism. Every rock contains some water, but sedimentary rocks hold the most. That process, which changes a rock's chemistry rather than just its mineral assemblage, is called metasomatism.

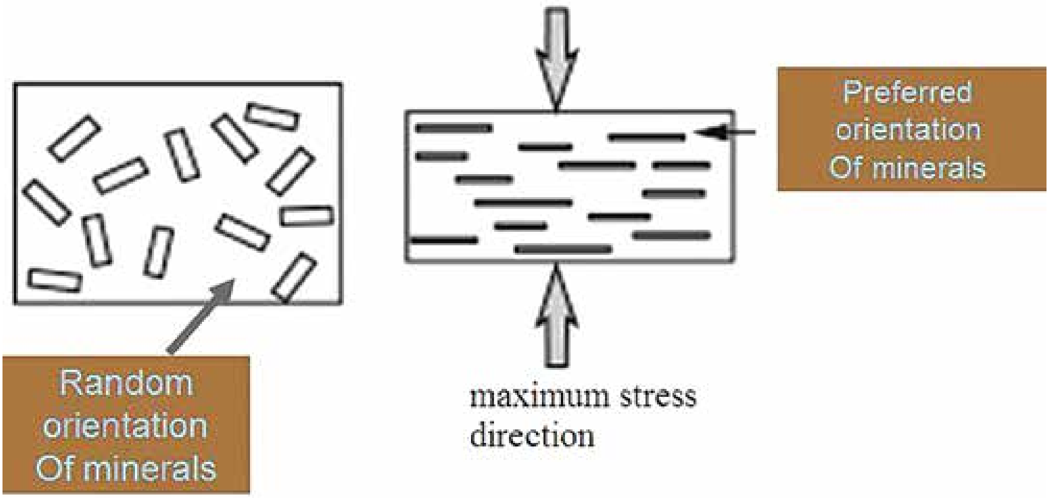
Metamorphic rocks form deep in the earth where high temperature, great pressure, and chemical reactions cause one type of rock to change into another one. Metamorphic rocks begin to form at 12-16 kilometers beneath the earth's surface. They begin changing at temperatures of 100 degrees Celsius to 800 degrees Celsius.

Some **Common** Metamorphic Rocks			
Name	**Image**	**Color**	**Texture**
Gneiss		Pink/Gray	Foliated
Marble		Light Colored	Unfoliated
Quartzite		Light Colored	Unfoliated
Slate		Dark Gray to Black	Foliated

Metamorphic Rocks Classification

Metamorphic rock is classified by texture and composition. The texture can be foliated or nonfoliated.

Foliation is the presence of mineral layers is called foliation.


Preferred
orientation
Of minerals
Random
orientation
Of minerals
maximum stress
direction


FOLIATED
NON-FOLIATED
The common foliated rocks in the order of increasing grain size are
SLATE – PHYLLITE – SCHIST – GNEISS
QUARTZITES and HORNFELS
0.5 mm

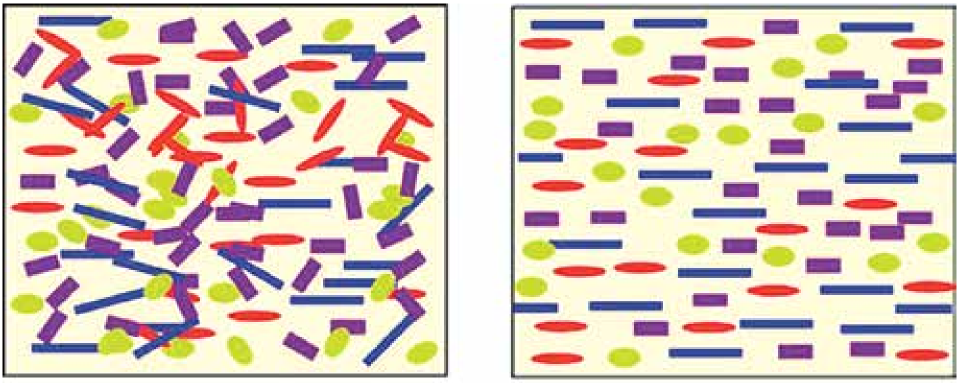


Image A Image B

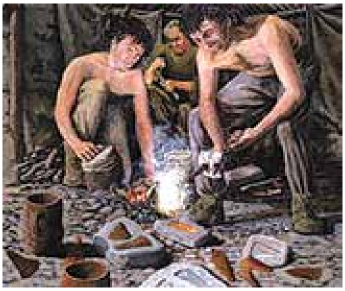
The mineral grains in rocks subjected to extreme pressure often rearrange themselves in a parallel fashion, creating a foliated texture (Image A - before metamorphism; Image B - after metamorphism).

Grain size is another characteristic of texture. It ranges from very fine to course.

Classification of Metamorphic Rocks				
Name of Rock	Parent Rock	Texture	Grain Size	Notes
Slate	Shale, mudstone, siltstone	Foliated	very fine	smooth dull surfaces
Phyllite	Slate		fine	glossy sheen
Gneiss	Shist, granite, volcanic rocks		medium to course	mineral banding
Marble	limestone	Nonfoliated	medium to course	Interlocking calcite or dolomite grains
Quartzite	quartz sandstone		medium to course	fused quartz grains
Anthracite	bituminous coal		fine	black, shiny, organic rock

Uses of rocks

The usage of rocks has had impact on cultural and technological growth of the human race. For more than two millions years, rocks have been used by humans and hominids. One of the primary factors for the human advancement is the mining of rocks, which has progressed at different rates in different places because of some kind of metals are available only in defined regions. Stone Age, Bronze Age, and Iron Age are the classifications of the prehistory and history of civilization.



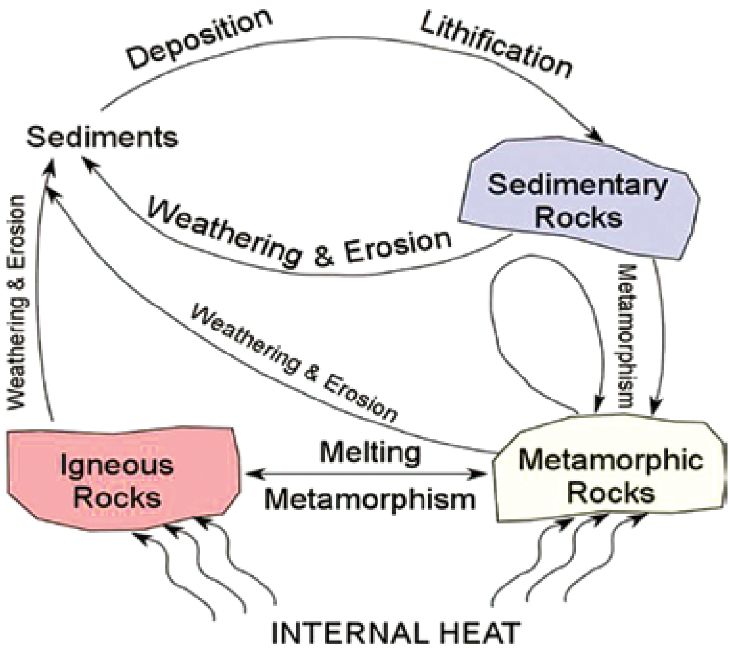
Geology is the study of the Earth from different perspectives, it studies:

- Composition –Mineralogy, petrology;
- Surface expression–Geomorphology;
- Structure–Structural geology;
- Internal activities–Global geophysics;
- Formation process–Stratigraphy, geochronology;
- Ancient Life-Paleontology;

The physical nature of the Earth and its interaction with engineering construction is called **Engineering Geology**.



The interrelationships between Earth's internal and exterior processes of rock formation and disintegration are described by the rock cycle.

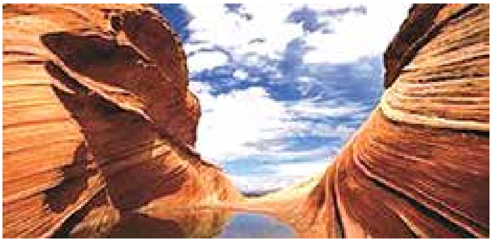


The rock cycle:

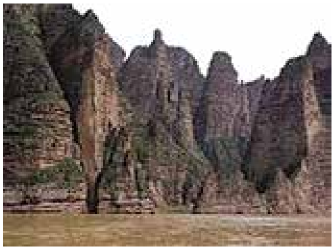
- relates the three rock types to each other
- shows surface processes such as weathering, transportation and deposition
- shows internal processes such as magma generation and metamorphism.

Movements in Earth's crust are the mechanisms responsible for recycling rock materials; they therefore drive the rock cycle.

Thus, in pure geological sense rock is defined as the essential part of the earth's crust. Geologists concern about the origin, classification, history, and the spatial aspects of rocks. So, geologically speaking, ice, sand, marble, coal, basalt, can be simply regarded as rocks. However, the Engineering Geologists have a different, and relatively narrower view of rocks. The Engineering Definition of Rocks - Rock is the hard and durable material.



By an excavation point of view, rocks are the earth materials that cannot be excavated without blasting. This definition clearly excludes other kinds of earth materials such as soils and glacial tills, etc. Here is another engineering definition of rocks: the earth materials that do not slake when soaked into water. For example, a thick loess deposit is regarded as rock geologically and regarded as soil in engineering.



Rock Identification

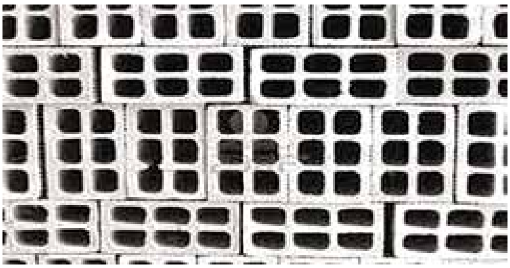
Rocks are identified mostly by its:

- texture;
- mineral composition;
- field relationships;
- color;
- hardness;
- specific weight;
- crystal form;
- magnetism.

Apparently, some techniques used in identifying minerals can also be used to classify the rock type.

Rock Properties for Engineering

Rock is significant for two major reasons in engineering:



1)As building materials for constructions;

2)As foundations on which the constructions are setting.

For the consideration of rocks as construction material the engineers concern about:

a)Density to some extent (for calculating the weight, load to the foundation, etc.);

b)Strength;

c)Durability;

For the consideration of rocks as the construction foundation the geological engineers concern about the rocks:

a)Density;

b)Strength;

c)Compressibility;

The Nathan Hale Monument in Coventry, Connecticut. Built in 1851 with granite blocks quarried from Quincy, MA.

Questions

1. What is a rock?
2. What major groups of rocks do you know?
3. Give the definition of engineering geology.
4. By what methods rocks can be identified?
5. What rock properties can you name?

Vocabulary

fluid medium	[‘flu(:)id ‘mi:djəm]	жидкая среда
weathering	[‘wezəri:n]	выветривание
preexisting	[prəeiq’zistin’]	предшествующий
impact	[impəkt]	влияние, воздействие
human race	[‘hju:mən reis]	человеческая раса
hominid	[hɔ:minid]	человекообразный
advancement	[əd’vansmənt]	прогресс, успех
prehistory	[pre’hist(ə)ri]	предыстория, доистория
interaction	[‘intəræk∫(ə)n]	взаимодействие, взаимосвязь
interrelationship	[‘intərri’lei∫(ə)n∫ip]	соотношение, взаимоотношение
disintegration	[dis’intigreiʃn]	распадение, разрушение
rock cycle	[rək ‘saikl]	цикл горных пород
magma generation	[mægmʌ dʒenə’rei∫(ə)n]	зарождение магмы
essential	[i’sen∫(ə)l]	неотъемлемый, обязательный
spatial aspect	[spæj∫l ‘æspekt]	пространственный аспект
narrow	[‘nærəu]	узкий
durable	[‘djuərəbl]	долговечный, прочный
blasting	[bla:sti:n’]	взрывные работы
to exclude	[iks’klu:d]	исключать
glacial tills	[‘gleisjal tils]	ледниковые отложения
to slake	[sleik]	набухать
loess	[les]	лёсс
to regard	[ri’ga:d]	относиться
apparently	[ə’pær(ə)ntli]	явно, очевидно
extent	[iks’tent]	степень, мера
compressibility	[kəm’pre∫∫ibiliti]	стягиваемость, сжимаемость

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Chapter 4

4.1 FORMULAS OF CHEMICAL COMPOUNDS AND REACTIONS

Chemical Formula

Understanding chemical equations is an important part of both basic and advanced chemistry. Instructors often spend an entire semester teaching their students how to read, interpret, write, and balance chemical equations. Likewise, chemical equations involve many factors including chemical symbols, reactants, products, and coefficients.

There are 3 parts to a chemical formula:

Molecule – 2 or more elements chemically bonded together. Can be the same element or different elements. Symbol with 2 letters have an upper case followed by a lower case letter. Example: Pb is lead, while PB would be phosphorus borine.

Coefficient – the big number in front of a compound or element. (Represent the amount of molecules).

Subscript – the small number after an element or molecule. (Represent the number of element within a molecule).

Reading a chemical formulas

Cl I Cl – C – Cl I Cl	C, C, L four Carbon Clorine 4
O = C = O	C, O 2
$4HCl + O_2 = 2Cl_2 + 2H_2O$	4 molecules of H, C, l plus O 2 give 2 molecules of C, l 2 plus 2 molecules of H 2, O 4 molecules of Hydrogen and Chlorine plus Oxygen two give 2 molecules of Chlorine 2 plus 2 molecules of Hydrogen 2 and Oxygen 4 molecules of Hydrochloric acid plus Oxygen gives 2 molecules of Chlorine and 2 molecules of water

There are features of an equation that is commonly used in the state of the substances involved: solid, liquid, gas or water solution.

- Solid – Is denoted by a subscript (s) after the formula of the substance, $CaO_{(s)}$.
- Liquid – Is denoted by a subscript (l) after the formula of the substance, $H2O_{(l)}$.
- Gas – Is denoted by a subscript (g) after the formula of the substance, $CO2_{(g)}$.
- Water solutions are called "aqueous solutions" and are denoted by the subscript (aq) after the formula of the substance, $NaCl_{(aq)}$.

The heating of lime thus becomes:	
Ca $CO_{3(s)}$ →Heat T°C→ $CaO_{(s)}$ + $CO_{2(g)}$	a unit of solid calcium carbonate breaks down on heating, to form a unit of solid calcium oxide and a molecule of gaseous carbon dioxide
The formation of water becomes:	
$2H_{2(g)} + O_{2(g)} = 2H_2O_{(l)}$	Two molecules of gaseous hydrogen and a molecule of gaseous oxygen react to form two molecules of liquid water

Numbers in chemical names

It is often necessary to distinguish between compounds in which the same elements are present in different proportions; carbon monoxide CO and carbon dioxide CO_2 are familiar to everyone.

Greek	**Latin**	**Значення**
mono- ['mɒnəʊ]	uni- [ju:ni]	один, одинарный
di- [dai]	bi- [bai]	два, двойной
tri- [trai]	ter- [tɜ:]	три, тройной, 3-х кратный
tetra- ['tetrə]	quadric- ['kwɒdri]	четыре, 4-х кратный
penta- ['pentə]	quindi- ['kwindi]	пять, 5-ти кратный
hexa- ['heksə]	sexton- ['sekstəʊ]	шесть, 6-ти кратный
hepta- ['heptə]	septo- ['septeʊ]	семь, 7-ми кратный
octa- [ɒktə]	octo- ['ɒktəʊ]	восемь, 8-ми кратный
nona- [nona]	nona- [nona]	девять 9-ти кратный
deca- [deka]	deca- [deka]	десять 10-ти кратный
poly- [pɒli]	multi- ['mʌlti]	много, многократный
hemi- ['hemi]	semi- ['semi]	половина

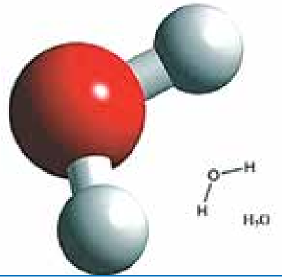
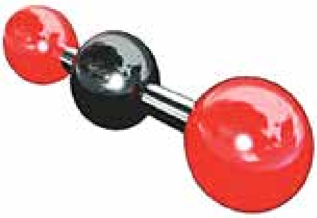
N_2O_4 – dinitrogen tetroxide (note the missing *a* preceding the vowel);
N_2O – dinitrogen oxide (more commonly, *nitrous oxide*);
SF_6 – sulfur hexafluoride;
P_4S_3 – tetraphosphorus trisulfide;
Na_2HPO_4 – disodium hydrogen phosphate
H_2S – hydrogen sulfide (we skip both the *di* and *mono*);
CO – carbon monoxide (*mono*- to distinguish it from the dioxide);
$CaSO_4 \cdot \frac{1}{2}H_2O$ – calcium sulfate hemihydrates.

Balancing chemical reaction

A chemical equation describes what happens in a chemical reaction. The equation identifies the reactants (starting materials) and products (resulting substance), the formulas of the participants, the phases of the participants (solid, liquid, gas), and the amount of each substance. Balancing a chemical equation refers to establishing the mathematical relationship between the quantity of reactants and products. The quantities are expressed as grams or moles.

Chemical equations must always be balanced. The law of conservation of mass states that the quantity of each element that is present at the beginning of a reaction must be equal to the quantity of each element that is present at the end of the reaction. Thus, each side of a chemical equation must symbolize an equal amount of any element that is present in the equation. Furthermore, balancing a chemical equation is the process used to determine how many molecules of each substance are present in the reactants and products of a reaction.

Equations are one of the most important aspects of chemistry, as it helps chemists understand what happens during a chemical reaction. Especially for engineering students, learning how to read, write, and balance chemical equations is the first step to understanding and predicting how various chemicals will react with one another. Therefore, it is important to memorize the chemical symbols on the scientific periodic table.

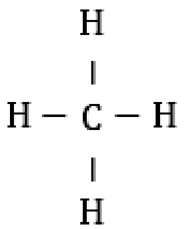
	$2H_2 + O_2 = 2H_2O$ (water) + 83 KJ/Mole $H_2+1/2O_2 = H_2O$ (water) + 242 KJ/Mole
	$C + 2H_2 = CH_4$ (methane) + 75,3 KJ/Mole
	$C + O_2 = CO_2$ (carbon dioxide) 221 KJ/Mole

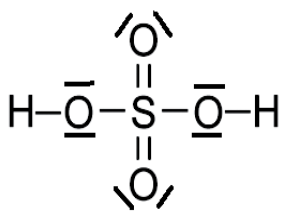
Questions

Make formulas:

- Carbon monoxide plus water give carbon dioxide plus hydrogen plus two hundred and five KJ per mole.
- Carbon plus two molecules of hydrogen two give methane plus seventy five point three KJ per mole.
- Zinc plus Copper Sulphur Oxygen four give Copper plus Zinc Sulphur Oxygen four.

Write down formulas:





- $CH_4 + 2O_2 = CO_2 + 2H_2O$ + 801 KJ/mole.
- $C_2H_5OH + HONO_2 \rightarrow C_2H_5ONO_2 + H_2O$
- $Cu(OH)Cl + HCl \rightarrow CuCl_2 + HOH$
- $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + HOH_{(l)}$

Vocabulary

infinity	[in'finiti]	бесконечность
asterisk	['æste(ə)risk]	звездочка, сноска
addition	[ə'diʃ(ə)n]	добавление
negligible	['neglidʒəbl]	незначительный
subtraction	[səb'trækʃ(ə)n]	вычитание
multiplication	[mʌltipli'keiʃ(ə)n]	умножение
multiplicand	[mʌltipli'kænd]	сомножитель
quotient	['kwouʃənt]	отношение
fractions	['frækʃ(ə)nz]	дроби
numerator	['nju:məreitə]	числитель
denominator	[di'nɔmineitə]	знаменатель
integer	['intidʒə]	целое число
decimal	['desiməl]	десятичный
exponent	[ik'spəʊnənt]	показатель
ratio	['reiʃiou]	отношение
proportion	[prə'pɔ:ʃən]	пропорция
magnitude	['mægnitju:d]	величина
determine	[di'təmin]	определять
inverse	[in'vɜ:s]	обратной
vary	['vεəri]	меняться, варьироваться
equation	[i'kweiʃən]	уравнение
value	['vælju:]	величина, значение
identity	[ai'dentiti]	тождество
valent	[vælent]	валентный
ion	['aiən]	ион
chemical bond	['kemik(ə)l bɒnd]	химическая связь
likewise	['laikwaiz]	таким же образом
involve	[in'vɒlv]	включать, вмещать
upper case	[upəʊə'keis]	прописной регистр
lower case	[ləʊə'keis]	строчный регистр
subscript	['sʌbskript]	нижний индекс
denote	[di'nəʊt]	помечать
aqueous solutions	['ækweiəs sə'luʃ(ə)n]	водяные растворы
conservation	[kɒnsə'veiʃ(ə)n]	сохранение

4.2 CHEMICAL COMPOSITION OF MINERALS

Common elements found in the Earth's rocks

Most rocks are composed of minerals. Minerals are defined by geologists as naturally occurring inorganic solids that have a crystalline structure and a individual chemical composition. Of course, the minerals found in the Earth's rocks are produced by a variety of different arrangements of chemical elements. A list of the eight most common elements making up the minerals found in the Earth's rocks is described in the Table.

Element	Transcription	Chemical Symbol	Percent Weight in Earth's Crust
Oxygen	['ɔksidʒ(ə)n]	O	46.60
Silicon	['silikən]	Si	27.72
Aluminum	[ə'lu:mɪnəm]	Al	8.13
Iron	[ai'ən]	Fe	5.00
Calcium	['kælsiəm]	Ca	3.63
Sodium	['səʊdiəm]	Na	2.83
Potassium	[pə'tæsiəm]	K	2.59
Magnesium	[mæg'ni:ziəm]	Mg	2.09

The average chemical composition of the earth's crust has been determined from tens of thousands of chemical analyses of rocks and minerals taken from the surface or drill holes. The most common elements in the crust by weight are oxygen (46.6%), silicon (27.7%), aluminum (8.1%), iron (5.0%), calcium (3.6%), sodium (2.8%), potassium (2.6%), and magnesium (2.1%).

These eight elements account for about 98.5 percent of the weight of the crust. The many other elements from the periodic table make up the remaining 1.5 percent. It may seem surprising that oxygen, which we normally associate with the atmosphere, is the most abundant element in rocks. It is an important part of most common minerals, such as quartz (SiO_2) and calcite ($CaCO_2$).

Differences between rocks and minerals

A mineral is a naturally occurring solid with a definite chemical composition and a specific crystalline structure. A rock is an aggregate of one or more minerals. Some rocks are predominantly composed of just one mineral. For example, limestone is a sedimentary rock composed almost entirely of the mineral calcite. Other rocks contain many minerals and the specific minerals in a rock can vary widely.

Some minerals, like quartz, mica or feldspar are common, while others have been found in only four or five locations worldwide.

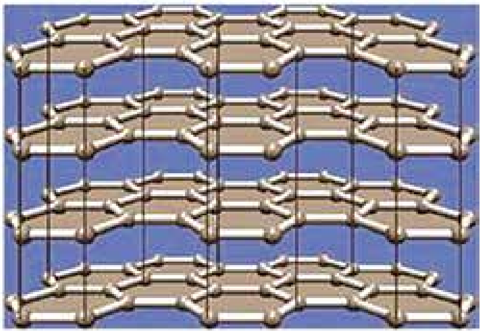
Commercially valuable minerals and rocks are referred to as industrial minerals. Rocks from which minerals are mined for economic purposes are referred to as ores (the rocks and minerals that remain, after the desired mineral has been separated from the ore, are referred to as tailings).

Minerals are the building blocks of the earth. So it is a combination of elements that forms an inorganic, naturally occurring solid of a definite chemical structure. For example, SiO_2 is always the mineral quartz. A rock is a solid material that is composed of various minerals.

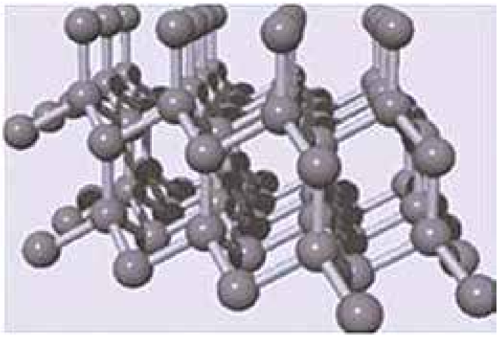
When the mineral grains are too small to see or are irregularly shaped, the underlying crystal structure can be determined by X-ray diffraction.

Chemistry and crystal structure together define a mineral. In fact, two or more minerals may have the same chemical composition, but differ in crystal structure.

Crystal structure greatly influences a mineral's physical properties. For example, though diamond and graphite have the same composition (both are pure carbon), graphite is very soft, while diamond is the hardest of all known minerals. This happens because the carbon atoms in graphite are arranged into sheets which can slide easily past each other, while the carbon atoms in diamond form a strong, interlocking three-dimensional network.



Graphite



Diamond

There are currently more than 4,000 known minerals, according to the International Mineralogical Association, which is responsible for the approval of and naming of new mineral species found in nature".

Mineral properties

It is often difficult to identify a mineral simply by looking at it, but each mineral has a set of distinctive characteristics that are easily tested in the field or laboratory.

Minerals can be only identified absolutely by x-ray analysis and chemical tests. The x-ray analysis determines the structure of the mineral, and the chemical tests determine the composition of the mineral. Structure and composition are the defining marks of a mineral.

Unfortunately for the average collector, these tests require expensive equipment. By the other way, both structure and composition affect certain physical properties. It is through the proper use of these properties that minerals can reliably be identified.

- Color
- Luster
- Transparency
- Crystal Systems
- Technical Crystal Habits
- Descriptive Crystal Habits
- Cleavage
- Fracture
- Hardness
- Specific Gravity
- Streak
- Associated Minerals
- Feel
- Taste

Chemical classification of the minerals

There are different grouping systems in use. So the minerals may be classified according to chemical composition. They are here categorized by anion group.

Class	Name	Description
I	Elements	Metals, alloys, semi-metals and non-metals
II	Sulfides	Sulfur is the principal anion
III	Halides	Halogen elements are anions: F, Cl, Br
IV	Oxides	Oxygen is the principal anion, includes hydroxides in which the hydroxyl radical (OH) acts as the anion
V	Carbonates	Carbonate radical (CO_3) is the principal anion
VI	Sulphates	Sulphate radical (SO_4) is the principal anion
VII	Phosphates	Anions are principally PO_4
VIII	Silicates	Silicate groups as anions combining with other elements: includes silica SiO_2
IX	Organic	Biogenic substances

Element class

The Elements class includes over one hundred known minerals. Many of the minerals in this class are composed of only one element. Most minerals are made up of combinations of chemical elements.

Geologists sometimes subdivide this group into metal and nonmetal categories.

Gold, silver, and copper are examples of metals.

The elements sulfur and carbon produce the minerals sulfur, diamonds, and graphite which are nonmetallic. This group also includes natural alloys, such as electrum (a natural alloy of gold and silver) and carbides.

Sulfide class

The Sulfide class are an economically important class of minerals.

Many of these minerals consist of metallic elements in chemical combination with the element sulfur. Many of the world's primary metal ores belong to this group.

Most ores of important metals such as mercury (cinnabar - HgS), iron (pyrite – FeS_2), and lead (galena - PbS) are extracted from sulfides. Many of the sulfide minerals are recognized by their metallic luster.

This group of minerals tend to be dense, brittle, and metallic in appearance.

Halide class

The Halide minerals are the group of minerals forming the natural salts and include fluorite (calcium fluoride), halite (sodium chloride). Halides, like sulfates, are commonly found in settings such as salt lakes and seas such as the Dead Sea and Great Salt Lake.

The Halides are a group of minerals whose principle chemical elements are fluorine, chlorine, iodine, and bromine. Many of them are very soluble in water. Halides also tend to have a highly ordered molecular structure and a high degree of symmetry. The most well-known mineral of this group is halite ($NaCl$) or rock salt and fluorite (CaF_2).

Oxide class

Oxide minerals are extremely important in mining as they form many of the ores from which valuable metals can be extracted. They commonly occur as close to the Earth's surface, oxidation products of other minerals in the near surface weathering zone, and as minerals in igneous rocks of the crust. Common oxides include hematite Fe_2O_3 (iron oxide) and magnetite Fe_3O_4 (iron oxide).

The Oxides are a group of minerals that are compounds of one or more metallic elements combined with oxygen, water, or hydroxyl (OH). The minerals in this mineral group show the greatest variations of physical properties. Some are hard, others soft. Some have a metallic luster, some are clear and transparent. Some representative oxide minerals include corundum, cuprite, and hematite.

Carbonate class

The Carbonate class consists of minerals which contain one or more metallic elements chemically associated with the compound CO_3. Most carbonates are lightly colored and transparent. All carbonates are soft and brittle. Carbonates also effervesce when exposed to warm hydrochloric acid. Most geologists considered the nitrates and borates as subcategories of the carbonates. Some common carbonate minerals include calcite, dolomite, and malachite.

Carbonates are usually deposited in marine settings when the shells of dead planktonic life settle and accumulate on the sea floor.

Sulfate class

The Sulfates are a mineral group that contain one or more metallic element in combination with the sulfate anion compound SO_4. Sulfates commonly form in settings where highly saline waters slowly evaporate.

All sulfates are transparent to translucent and soft. Most are heavy and some are soluble in water. Rarer sulfates exist containing replacement for the sulfate compound. For example, in the chromates SO_4 is replaced by the compound CrO_4 .

Two common sulfates are anhydrite and gypsum.

Phosphate class

The Phosphates are a group of minerals of one or more metallic elements chemically associated with the phosphate compound PO_4.

The phosphates are often classified together with the arsenate, tungstate, and molybdate minerals.

Most phosphates are heavy but soft. They are usually brittle and occur in small crystals or compact aggregates.

The most common phosphate is apatite which is an important biological mineral found in teeth and bones of many animals.

Silicate class

The Silicates are by far the largest group of minerals (most rocks are ≥ 95% silicates), which are composed largely of silicon and oxygen, with the addition of ions such as aluminium, magnesium, iron, and calcium.

Chemically, these minerals contain varying amounts of silicon and oxygen. It is easy to distinguish silicate minerals from other groups, but difficult to identify individual minerals within this group. None are completely transparence.

The construction component of all silicates is the tetrahedron. A tetrahedron is a chemical structure where a silicon atom is joined by four oxygen atoms (SiO_4). Some important rock-forming silicates include the feldspars, quartz, olivines, pyroxenes and micas.

Organic class

The Organic mineral class includes biogenic substances in which geological processes have been a part of the genesis the existing compound.

The Organic minerals are a rare group of minerals chemically containing hydrocarbons. Most geologists do not classify these substances as true minerals. Note that our original definition of a mineral excludes organic substances.

However, some organic substances that are found naturally on the Earth exist as crystals. These substances are called organic minerals. Amber is a good example of an organic mineral.

Common minerals

Group	Typical Minerals	Chemistry	Chemical name
Elements	**Gold** [gə ʊ ld]	**Au**	**Gold**
	Silver ['silvə]	**Ag**	**Silver**
	Copper ['kɔpə]	**Cu**	**Copper**
	Carbon ['ka:bən] **(Diamond, Graphite)** ['da ɪ əmənd], ['græfait]	**C**	**Carbon**
	Sulfur ['sʌlfə]	**S**	**Sulfur**
Sulfides [sʌlfa ɪ ds]	**Cinnabar** ['s ɪ nəbɑ:]	**HgS**	**Mercury Sulfide**
	Galena [gə'li:nə]	**PBS**	**Lead Sulfide**
	Pyrite ['pa ɪ ra ɪ t]	**FeS_2**	**Iron Sulfide**

Halides ['hælaidəs]	**Fluorite** ['flu(ə)rait]	CaF_2	**Calcium Fluoride**
	Halite ['hælait]	$NaCl$	**Sodium Chloride**
Oxides ['ɔksaids]	**Corundum** [kə'rendəm]	Al_2O_3	**Aluminum Oxide**
	Cuprite ['kju:prait]	Cu_2O	**Copper Oxide**
	Hematite ['hemətait,'hi:]	Fe_2O_3	**Iron Oxide**
Carbonates ['kɑ:bən(e)it]	**Calcite** ['kælsait]	$CaCO_3$	**Calcium Carbonate**
	Dolomite ['dɔləma ɪ t]	$CaMg(CO_3)_2$	**Calcium Magnesium Car-bonate**
	Malachite ['mæləkait]	$Cu_2(CO_3)(OH)_2$	**Copper Carbonate Hydrox-ide**
Sulfates ['sulfeites]	**Anhydrite** [æn'haidrait]	$CaSO_4$	**Calcium Sulfate**
	Gypsum ['dʒips(ə)m]	$CaSO_4^{-2}(H_2O)$	**Hydrated Calcium Sulfate**
Phosphates ['fɔsfeits]	**Apatite** ['æpəta ɪ t]	$Ca_5(F,Cl,OH)(PO_4)$	**Calcium (Fluoro, Chloro, Hydroxyl) Phosphate**
Silicates ['silik(e)its]	**Albite** ['ælba ɪ t]	$NaAlSi_3O_8$	**Sodium aluminum silicate**
	Beryl ['ber ɪ l]	$Be_3Al_2(SiO_3)_6$	**Beryllium Aluminum Sili-cate**
	Biotite ['ba ɪ əta ɪ t]	$K (FE, Mg)_3AlSi_3O_{10}(F, OH)_2$	**Potassium iron magnesium aluminum silicate hydrox-ide fluoride**
	Muscovite ['meskəvait]	$KAl_2(AlSi_3O_{10})(F, OH)_2$	**Potassium aluminum sili-cate hydroxide fluoride**
	Olivine ['ɔlivi:n]	$(Mg, Fe)_2SiO_4$	**Magnesium Iron Silicate**
	Orthoclase ['ɔ: θkleiz, -eis]	$KAlSi_3O_8$	**Potasium Aluminum Sili-cate**
	Quartz [kwɔ:ts]	SiO_2	**Silicon dioxide**
Organics [ɔ:'gæniks]	**Amber** ['æmbə]	$C_{10}H_{16}O$	**Succinic acid**

Elements

Gold
[gə ʊ ld]

Gold is a very stubborn element when it comes to reacting or combining with other elements. Many people have discovered this unique feature throughout the ages.

Silver
['silvə]

Silver has been mined for eons and has always been popular in jewelry and for coinage. Only in the past hundred years however, has the need for silver been so great. The reason for this need is the use of silver in the industry,

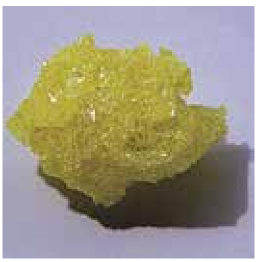
Copper
['kɔpə]

Native copper (copper found in a chemically uncombined state) has been mined for centuries and now is depleted as an economically viable ore. Native copper is still found in limited quantities in once-active mining regions.

Carbon (Diamond, Graphite)
['da ɪ əmənd],
['græfait]

Diamond is the ultimate gemstone. 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. Graphite is a polymorph of the element carbon.

Sulfur
['sʌlfə]



Major ore of sulfur is used for chemical production. It occurs when water (including humidity in the air) mixes with the sulfur and a small amount of hydrogen sulfide (H_2S) gas is produced and has the smell of rotten eggs.

Sulfides [sʌlfaɪds]

Cinnabar
['sɪnəbɑ:]

Cinnabar is a colorful mineral that adds a unique color to the mineral color palette. The scarlet red color can be very attractive in different kind of rocks.

Galena
[gə'li:nə]

Galena is a common and popular mineral for rock hounds. The structure of Galena is identical to that of halite, NaCl. The two minerals have the same crystal shapes, symmetry and cleavage. Some Galena may contain up to 1% silver in place of lead.

Pyrite
['paɪraɪt]

Pyrite's structure is analogous to galena's structure with a formula of PbS. Galena, though, has a higher symmetry. The difference between the two structures is that the single sulfur of galena is replaced by a pair of sulfurs in pyrite.

Halides ['hælaidəs]

Fluorite
['flu(ə)rait]

Fluorite is well known and for its glassy luster and rich variety of colors. Fluorite is the most popular mineral for mineral collectors in the world, second only to quartz. Fluorite is also rare gemstone.

Halite
['hælait]

Halite, better known as rock salt, can easily be known by its taste. It was found in many current evaporative deposits such as near Salt Lake City, Utah and Searles Lake, California in the U.S., where it crystallizes out after lakes evaporating.

Oxides ['ɔksaids]

Corundum
[kə'rendəm]

Corundum is the third hardest natural mineral known to science. The hardest mineral, diamond is still four times harder than corundum. Aluminium oxide is used as a gemstone like topaz and aquamarine [,ækwəmə'ri:n].

Cuprite
['kju:prait]

Cuprite has been a major ore of copper and is still mined in many places around the world. Copper oxide is rarely as a gemstone but not so expensive as a gold or silver.

Hematite
['hemətait,'hi:]

Hematite is an important ore of iron and its blood red color (in the powdered form) gives itself well to use as a pigmen. Iron oxide is very important ore of iron

Sulfates ['sulfeites]

Anhydrite
[æn'haidrait]

Anhydrite is a relatively common sedimentary mineral that forms massive rock layers. Anhydrite does not form directly, but is the result of the dewatering of the rock forming mineral Gypsum ($CaSO_4$-$2H_2O$).

Gypsum
['dʒips(ə)m]

Gypsum is one of the more common minerals in sedimentary environments. It is a major rock forming mineral that produces massive. Since it forms from saline water, gypsum can have many inclusions of other minerals and even bubbles of air and water.

Carbonates ['kɑ:bən(e)it]

Calcite
['kælsait]

It is one of the most common minerals on the face of the Earth, consists about 4% by weight of the Earth's crust and is formed in many different geological environments. Calcite is even a major component in the igneous rock called carbonatite and forms the major portion of many hydrothermal veins. Some of these rock types are composed of better than 99% calcite.

Dolomite
['dɔləmaɪt]

Dolomite is a common sedimentary rock-forming mineral. The rocks which consists dolomite are also called dolomitic limestone. Dolomite in addition to the sedimentary beds is also found in metamorphic marbles, hydrothermal veins and replacement deposits.

Malachite
['mæləkait]

Malachite is a famous and very popular semi-precious stone. Some malachite contains special combinations with other value minerals. Malachite is also popular in jewelry ['dʒu:əlrɪ].

Phosphates ['fɔsfeit]

Apatite
['æpətaɪt]

Apatite is actually three different minerals depending on the predominance of either fluorine, chlorine or the hydroxyl group Nevertheless it is called Calcium (Fluoro, Chloro, Hydroxyl) Phosphate. Apatite is widely distributed in all rock types; igneous, sedimentary and metamorphic.

Organics [ɔ:'gæniks]

Amber
['æmbə]

Amber is a beautiful stone that is cut and polished and used as a valuable gemstone and semi-precious stone. It is very light in weight which allows it to be used in a large jewelry piece without discomfort.

Silicates ['silik(e)its]

Albite
['ælbaɪt]

Albite by definition must contain no less than 90% sodium and no more than 10% of either potassium. Albite is the last stage of crystallize from molten rock. The process of crystallization from a molten rock body serves to isolate rarer elements in the last stages of crystallization. Thus albite is often found with some lovely rare and beautiful minerals

Augite
['ɔ:dʒaɪt]

Augite is an important rock-forming mineral in many igneous rocks, especially in gabbros and basalts, and is also found in some hydrothermal metamorphic rocks. Augite is a part of an important solid solution series of the pyroxene group.

Beryl
['berɪl]

Beryl is often unknown to the general public, even the gemstone-buying public. However, it is one of the most important gem minerals. Large crystals of aquamarine and izumrud are available on the open market and represent perhaps the largest raw gemstone specimens.

Biotite
['baɪətaɪt]

More generally, it refers to the dark mica series. Like other mica minerals, biotite has a highly perfect cleavage, and consists of flexible sheets. Biotite is found in a wide variety of igneous and metamorphic rocks.

Hornblende
['hɔ:nblend]

Hornblende is actually the name given to a series of minerals that are rather difficult to distinguish by ordinary means. Hornblende is not often a collection mineral because good crystals are somewhat difficult to find even though the mineral is widespread.

Muscovite
['mʌskəvait]

Muscovite is a common rock forming mineral and is found in igneous, metamorphic and sedimentary rocks. The sheets of muscovite also have high heat and electrical insulating properties and are used to make many electical components.

Olivine
['ɔlivi:n]

Olivine is found in ultramafic igneous rocks and marbles that formed from metamorphosed impure limestones. Mafic is a word that is used to define igneous rocks with a high iron and magnesium content.

Orthoclase
['ɔ: θkleiz, -eis]

Orthoclase is a polymorph of other minerals that have the same chemistry, but have different crystal structures. Orthoclase is extrusive igneous rock, forming when the rock cooled quickly.

Quartz
[kwɔ:ts]

Quartz is the most common mineral on the face of the Earth. It is found in nearly every geological environment and is at least a component of almost every rock type. It frequently is the primary mineral, >98%. Quartz can be uses for glass production, electrical components, optical lenses, gemstones, ornamental stone, building stone

Questions

1. Give a definition of mineral.
2. What is the most widespread chemical element that forms most of the minerals?
3. What are the differences between rocks and minerals?
4. Which minerals have the same chemical composition but differ in chemical structure?
5. How many minerals exist in the world?
6. What is the easy way to identify minerals?
7. How many chemical classes of minerals do you know? Name them.
8. What are the common representatives of the element class?
9. What is the hardest mineral?
10. Who are rock hounds?

Vocabulary

periodic	[pi(ə)ri'ɒdik]	периодически
remaining	[ri'mein]	остальной
abundant	[ə'bʌndənt]	распространенный
aggregate	['ægrigeit]	совокупность
predominantly	[pri'dɒmənəntli]	преимущественно
composed	[kəm'pəuzd]	складываться
feldspar	['feldspɒ:]	полевой шпат
referred	[ri'fɜ:]	относить
tailings	['teiliŋ]	отходы
diffraction	[di'frækʃ(e)n]	дифракция
pure	['pjʊə]	чистый, без примесей
slide	[slaid]	скользить
interlocking	[intə'lɒkiŋ]	взаимосвязанные
three-dimensional	[θri:-d(a)i'menʃ(e)nəl]	трехмерный
currently	['kʌrəntli]	в настоянный момент
species	['spi:ʃi:z]	виды
distinctive	[dis'tiŋ(k)tiv]	отличительные
determine	[di'tɜ:min]	определять
reliably	[ri'laiəbli]	надежно
luster	['lʌstər]	блеск
transparency	[træn'spærənsi]	прозрачность
cleavage	['kli:vidʒ]	кливаж, спайность
fracture	['fræktʃə]	трещиноватость
specific gravity	[spi'sifik,'græviti]	удельная плотность
streak	[stri:k]	черточка
anion	['ænaiən]	анион (отрицательно заряжен ион)
mercury	['mɜ:kjɒri]	ртуть
cinnabar	['sinəbɒ:]	киноварь, ртутная руда
lead	[li:d]	свинец
tend	[tend]	склонный
dense	[dens]	густой
brittle	['britl]	хрупкий
soluble	['ɒljub(ə)l]	растворимый
hydroxyl	[hai'drɒks(a)il]	гидроксил, водный остаток
effervesce	[efəves]	выделяться в виде пузырьков

exposed	[ik'spəʊz]	поддавать влиянию
marine settings	[mə'ri:η, 'setiη]	морские условия
shell	[ʃel]	ракушка
settle	['setl]	поселяться, падать на дно
saline	['seilain]	соляной
evaporate	[i'væpəreit]	испариться
translucent	[trænz'lu:s(ə)nt]	просвечивающий, полупрозрачный;
tungstate	['tʌηsteit]	вольфрамат
distinguish	[dis'tiηgwiʃ]	отличать
tetrahedron	[tetrə'hi:drən]	тетраэдр, четырехгранник;
mica	[mika]	слюда
stubborn	['stʌbən]	неподатливый
eons	[ions]	вечность
coinage	['kɔinidʒ]	производство монет
uncombined	[ʌn'kɒmbain]	не связанный (химически), свободный
depleted	[di'pli:tid]	исчерпанный
ultimate	['ʌltimeit]	более высокая степень
gemstone	['dʒemsteʊn]	драгоценный камень;
realize	['riəlize]	осознавать
humidity	[hju:'miditi]	влажность
palette	['pælit]	палитра
scarlet	['skɒ:lit]	багряный
rock hounds	['rɒkhaʊnd]	коллекционер минералов
dewatering	[de'wɔ:teriη]	осушать
semi-precious	['semi,'preʃəs]	полудрагоценный
polish	['pɒliʃ]	полировать
hornblende	['hɔ:nblend]	роговая обманка
insulate	['insjʊleit]	изолировать

4.3 CHEMICAL COMPOSITION OF ROCKS

Igneous Rocks

Intrusive and Extrusive Rock Types

Igneous rocks are formed from the solidification of molten rock material. There are two basic types:

1) intrusive igneous rocks such as diorite, gabbro, granite and pegmatite that solidify below Earth's surface;

2) extrusive igneous rocks such as andesite, basalt, obsidian, and peridotite that solidify on or above Earth's surface. Pictures and brief descriptions with chemical composition of some common igneous rock types are shown below.

Intrusive Igneous Rocks

Diorite ['daiərit] is a coarse-grained, intrusive igneous rock that contains a mixture of feldspar, pyroxene, hornblende and quartz SiO_2 52-65 %.

Gabbro ['gæbroʊ] is a coarse-grained, dark colored, intrusive igneous rock that contains feldspar and sometimes olivine and quartz less than 20 %. This rock is chemically equivalent to basalt.

Granite ['grænit] is a coarse-grained, light colored, intrusive igneous rock that contains mainly quartz (25-30 %) and feldspar minerals (60-65 %). It forms from the slow crystallization of magma below Earth's surface

Pegmatite ['pegmetait] is a light-colored, extremely coarse-grained intrusive igneous rock. It forms near the field of a magma chamber during the final phases of magma chamber crystallization. It often contains different rare minerals. SiO_2 composition is more than 75 %.

Extrusive Igneous Rocks

Andesite ['ændəsaɪt] is a fine-grained, extrusive igneous rock composed mainly of plagioclase ['pleidʒiəkləis] with other minerals such as hornblende, pyroxene and biotite. In a general sense, it is the rock which consist from silicon dioxide (SiO_2) in ranges from 57 to 63 %

Basalt ['bæsɒlt] is a fine-grained, dark-colored extrusive igneous rock composed mainly of plagioclase and pyroxene. By definition, basalt must be igneous rock with less than 20% quartz (SiO_2).

Obsidian [əb’sidiən] is a dark-colored volcanic glass that forms from the very rapid cooling of molten rock material. It cools so rapidly that crystals do not form. Obsidian consist from 70–75% SiO_2 and MgO, Fe_3O_4

Peridotite ['peridotait] is a coarse-grained intrusive igneous rock that is composed almost entirely of olivine $(Mg, Fe)_2$ $[SiO_4]$ (70-30 %). It may contain small amounts of feldspar or quartz (30-40 %).

Metamorphic Rocks

Foliated and Non-Foliated Rock Types

Metamorphic rocks have been modified by heat, pressure and chemical process usually below Earth's surface. According to these extreme conditions has different mineralogy, texture and chemical composition of the rocks.

There are two basic types of metamorphic rocks:

1) foliated metamorphic rocks such as gneiss, phyllite, schist and slate which have a layered or banded appearance that is produced by heat and directed pressure;

2) non-foliated metamorphic rocks such as amphibolites, hornfels, marble and quartzite which do not have a layered or banded appearance.

Foliated metamorphic rocks

Gneiss ['nais] is foliated metamorphic rock that has a banded appearance and is made up of granular mineral grains. It typically contains abundant quartz or feldspar minerals.

Phyllite ['filaıt] is a foliated metamorphic rock that is made up mainly of very fine-grained mica. The surface of phyllite is typically lustrous and sometimes wrinkled. It is intermediate in grade between slate and schist.

Schist [ʃi:st] is metamorphic rock with well developed foliation. It often contains significant amounts of mica which allow the rock to split into thin pieces. It is a rock of intermediate metamorphic grade between phyllite and gneiss.

Slate [sleit] is a foliated metamorphic rock that is formed through the metamorphism of shale. It is a low grade metamorphic rock that splits into thin pieces.

Non-foliated metamorphic rocks

Amphibolite [am'fibəlait] is a non-foliated metamorphic rock that forms through recrystallization under conditions of high viscosity and directed pressure. It is composed primarily of amphibole and plagioclase, usually with very little quartz.

Hornfels [hɔ:nfls] is a fine-grained nonfoliated metamorphic rock with no specific composition. It is produced by contact metamorphism. Hornfels is a rock that was "baked" while near a heat source such as a magma chamber.

Marble ['ma:b(ə)l] is a non-foliated metamorphic rock that is produced from the metamorphism of limestone. It is composed primarily of calcium carbonate.

Quartzite [kwɔ:tsit] is a non-foliated metamorphic rock that is produced by the metamorphism of sandstone. It is composed primarily of quartz.

Sedimentary Rocks

Sedimentary rocks are formed by the accumulation of sediments. There are three basic types of sedimentary rocks:

1) clastic sedimentary rocks such as conglomerate, sandstone, shale and siltstonethat are formed from mechanical weathering debris;

2) chemical sedimentary rocks such as iron ore, rock salt, dolomite and flint that form when dissolved materials precipitate from solution;

3) organic sedimentary rocks such as coal, limestone, oil sands and oil shale which form from the accumulation of plant or animal debris.

Clastic sedimentary rocks

Conglomerate [kən'glɒm(ə)rit] is a clastic sedimentary rock that contains large (greater than two millimeters in diameter) rounded particles. The space between the pebbles is generally filled with smaller particles and/or a chemical cement that bind the rock together.

Sandstone [sænd,stəʊn] is a clastic sedimentary rock made up mainly of sand-size (1/16 to 2 millimeter diameter) weathering debris. Environments where large amounts of sand can accumulate include beaches, deserts and deltas.

Shale [ʃeil] is a sedimentary rock that is made up of clay-size (less than 1/256 millimeter in diameter) weathering debris. It typically breaks into thin flat pieces. Some shales have special properties that make them important resources. It can be crushed and mixed with water to produce clays.

Siltstone [silt,stəʊn] is a clastic sedimentary rock that forms from size (between 1/256 and 1/16 millimeter diameter) weathering debris.

Chemical sedimentary rocks

Iron Ore ['aiənɔ:] is a chemical sedimentary rock that forms when iron and oxygen (and sometimes other substances) combine in solution and deposit as a sediment. Hematite is the most common sedimentary iron ore mineral.

Rock Salt [rɒk sɔ:lt] is a chemical sedimentary rock that forms from the evaporation of ocean or saline lake waters. It is also known by the mineral name "halite". It is rarely found at Earth's surface, except in areas of very arid climate. It is often mined for use in the chemical industry or for use as a winter highway treatment.

Dolomite ['dɒləmait] is a word that is used by geologists in two different ways: 1) as the name of the mineral dolomite; and, 2) as the name of a rock known as dolomite. Dolomite, also known as "dolostone" and "dolomite rock", is a sedimentary rock composed primarily of the mineral dolomite, $CaMg(CO_2)_3$.

Flint [fli:t] is a hard, tough chemical or biochemical sedimentary rock that breaks with a conchoidal fracture. It is a form of microcrystalline quartz. Flint as a source of fire.

Organic sedimentary rocks

Coal is an organic sedimentary rock that forms mainly from plant debris. The plant debris usually accumulates in a swamp environment. Coal is combustible and is often mined for use as a fuel.

Limestone ['laim,stəʊn] is a rock that is composed primarily of calcium carbonate. It can form organically from the accumulation of shells, corals, algals and debris. It can also form chemically from the precipitation of calcium carbonate from lake or ocean water. Limestone is used in many ways: production of cement, acid neutralization e.t.c.

Oil Sands [ɔil sænds] also known as "tar sands" are sedimentary rocks composed of sand, clay minerals, water and bitumen. The oil is in the form of bitumen, a very heavy liquid or sticky black solid with a low melting temperature. Bitumen typically makes up about 5 to 15% of the deposit.

Oil shale [ɔil ʃeil] is commonly defined as a fine-grained sedimentary rock containing organic matter that yields substantial amounts of oil and combustible gas. Some oil-shale deposits contain minerals and metals that add byproduct value such as sulfur, ammonium sulfate, vanadium, zinc, copper, and uranium.

Questions

1. What types of rocks do you know?

2. What types of igneous rocks do you know and what do you know about the way they were formed?

3. Give a definition to intrusive and extrusive rocks.

4. What types of metamorphic rocks do you know and what do you know about the way they were formed?

5. What types of sedimentary rocks do you know and the way they were formed?

6. Is coal a rock or a mineral? What is the basic difference between a rock and a mineral?

7. Please name some of the combustible rocks.

8. Explain what foliated and non foliated rocks are.

9. Which rock looks like a glass?

10. What is another name of hematite?

Vocabulary

solidification	[səldifi'keiʃ(e)n]	отвердение
molten	[meʊltn]	расплавленный
intrusive	[in'tru:siv]	интрузивный
extrusive	[ik'stru:siv]	экструзивный
extremely	[ik'stri:mli]	чрезвычайно
foliated	['fəʊlieitid]	слоистый
non-foliated	[non,'fəʊlieitid]	не слоистый
banded	['bændid]	полосатый
granular	['grænjʊlə]	гранулированный
lustrous	['lʌstrəs]	блестящий, глянцевый
wrinkled	['riŋk(ə)ld]	сморщенный, помятый
schist	[ʃi:st]	аспидный сланец
significant	[sig'nifikənt]	значащий
split	[split]	раскол
slate	[sleit]	аспидный (глинистый) сланец
recrystallization	[ri:krist(ə)lai'zeiʃ(ə)n]	рекристаллизация
viscosity	[vis'ksiti]	вязкость
hornfels	[hɔ:nfls]	роговик
baked	[beikt]	спеченный
marble	['ma:b(ə)l]	мрамор
quartzite	[kwɔ:tsit]	кварцит
clastic	['klæstik]	обломочный
dissolved	[di'zɒlvd]	растворенный
precipitate	[pri'sipiteit]	осадок, оседать
particle	['pa:tik(ə)l]	частица, фракция
pebbles	['peb(ə)l]	галька
bind	[baind]	связывать
sandstone	[sænd,stəʊn]	песчаник
shale	[ʃeil]	сланец глинистый
siltstone	[silt,stəʊn]	алевролит, тонкозернистый песчаник
arid	['ærid]	сухой
shell	[ʃel]	ракушка
coral	['kɒrəl]	коралл
algals	['ældʒi:]	водоросли
tar	[ta:]	смола, деготь

4.4 CHEMICAL COMPOSITION OF FOSSIL FUELS

COAL

Formation

Coal is a fossil fuel. It is a combustible, sedimentary, organic rock, which is composed mainly of carbon, hydrogen and oxygen. It is formed from vegetation by the combined effects of pressure and heat over millions of years to form coal seams.

Coal formation began during the Carboniferous Period – known as the first coal age – which spanned 360 million to 290 million years ago.

The quality of each coal deposit is determined by temperature and pressure and by the length of time in formation. Initially the peat is converted into lignite or 'brown coal' – these are coal types with low organic maturity. In comparison to other coals, lignite is quite soft and its colour can range from dark black to brown.

Peat → Lignite → Sub-bituminous → Bituminous → Antracite

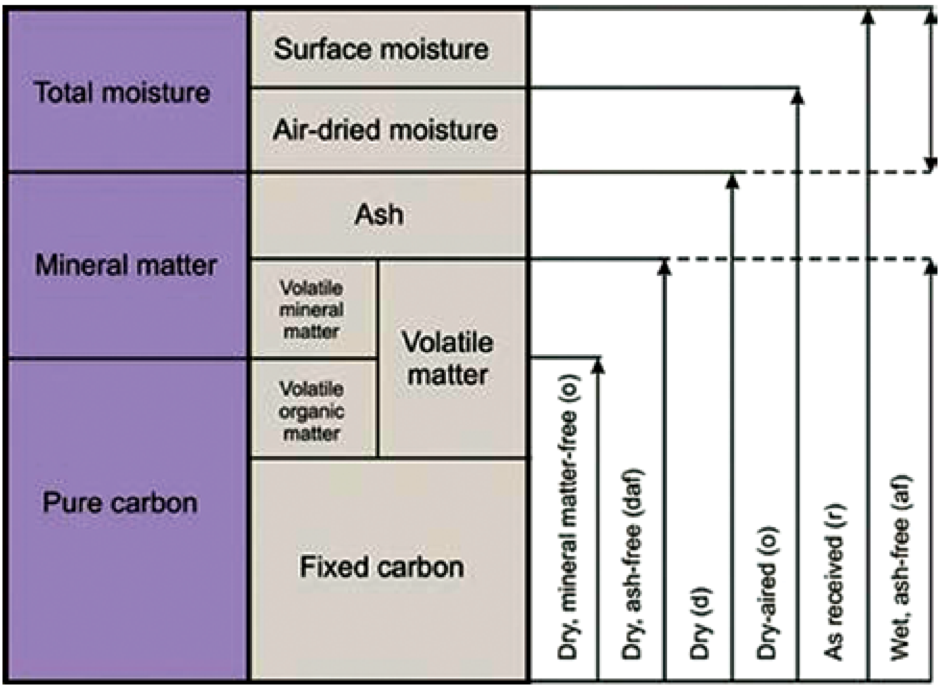
Over many more millions of years, the continuing effects of temperature and pressure produces further change in the lignite, progressively increasing its organic maturity and transforming it into the range known as 'sub-bituminous' coals.

Further chemical and physical changes occur, until these coals became harder and blacker, forming the 'bituminous' or 'hard coals'. Under the right conditions, the progressive increase in the organic maturity can continue, finally forming anthracite.

Basis of analytical data

Before proceeding to the analysis of the coal, it is important to understand how the moisture, ash, volatile matter and fixed carbon relate to one another. It is unfortunately a common problem that analyses are given, do not indicate on what basis they are presented. Indeed, they are often listed together on different bases.

Coal analyses may be reported as follows (see table).



The dates are expressed as percentages of coal:

As received (r) – includes total moisture.

Air dried (a) – includes air dried (inherent) moisture only.

Dry (d) – excludes all moisture (beside hydrate).

Dry, ash free (daf) – excludes total moisture and ash content.

Dry, mineral matter free (o) – excludes total moisture and mineral matter.

Wet, ash-free (af) – excludes ash content.

Components of coal reporting to different bases

Given result of coal	Wanted result of coal				
	As received (r)	Air dried (a)	Dry (d)	Dry, ash-free (daf)	Dry, mineral-matter-free (o)
As received (r)	–	$\frac{100-W^a}{100-W^r}$	$\frac{100}{100-W^r}$	$\frac{100}{100-W^r-A^r}$	$\frac{100}{100-W^r-M^r}$
Air dried (a)	$\frac{100-W^r}{100-W^a}$	–	$\frac{100}{100-W^a}$	$\frac{100}{100-W^a-A^a}$	$\frac{100}{100-W^a-M^a}$
Dry (d)	$\frac{100-W^r}{100}$	$\frac{100-W^a}{100}$	–	$\frac{100}{100-A^d}$	$\frac{100}{100-M^d}$
Dry, ash-free (daf)	$\frac{100-W^r-A^r}{100}$	$\frac{100-W^a-A^a}{100}$	$\frac{100-A^d}{100}$	–	$\frac{100-A^d}{100-M^d}$
Dry, mineral-matter-free (o)	$\frac{100-W^r-M^r}{100}$	$\frac{100-W^a-M^a}{100}$	$\frac{100-M^d}{100}$	$\frac{100-M^d}{100-A^d}$	–

W – moisture %; A – ash %; M – mineral matter.

In addition, the following countries have developed equations to calculate the mineral matter content of their coals.

North America:

$M = 1.08 \cdot A + 0.55 \cdot S$;

Modified formula: $M = 1.13 \cdot A + 0.47 \cdot Spyr + Cl$;

United Kingdom:

British Coal Utilization Research Association, BCURA formula:

$M = 1.10 \cdot A + 0.53 \cdot S + 0.74 \cdot CO_2 - 0.36$;

British Coal Association formula:

$M = 1.13 \cdot A + 0.5 \cdot Spyr + 0.8 \cdot CO_2 - 2.8 \cdot Sash + 2.8 \cdot S + 0.3 \cdot Cl$

Chemical analysis

Coal analyses are often reported as proximate analysis or ultimate analysis.

Proximate analysis is a broad analysis which determines the amount of moisture, volatile matter, fixed carbon and ash. This is the most fundamental of all coal analyses and is of great importance in the practical use of coal.

Ultimate analysis of coal consists of the determination of carbon and hydrogen as gaseous products of its complete combustion, the determination of sulphur, oxygen, nitrogen and trace elements.

Proximate analysis

- Volatile matter, moisture, ash, fixed carbon

Volatile matter (VM)	Fixed carbon (C_{fix})	Ash (A)	Total moisture (W)

Ultimate Analysis

- Carbon, hydrogen, nitrogen, sulphur (combustible & total), oxygen, trace elements

N	S	H	O	C	Trace

Moisture is an important property of coal, as all coals are mined wet. The terminology used in describing the moisture content of coals can be confusing and needs to be clarified. The most confusing term is inherent moisture, which has many different definitions and should be avoided if at all possible. If used in any tests it is necessary to ascertain the exact definition.

The coal industry has therefore developed a set of empirically determined definitions as follows:

1. Surface moisture. This is adventitious moisture which can be removed by low temperature air drying (40°C). This drying step is usually the first in any analysis and the moisture remaining after this step is known as air-dried moisture.

2. Total moisture. This is all the moisture which can be removed by aggressive drying (150˚C in vacuum or nitrogen atmosphere).

3. Air dried moisture. This is the moisture remaining after air drying and which can be removed by aggressive drying.

High moisture is undesirable in coals as it is chemically inert and absorbs heat during combustion. It lowers the calorific value in steam coals and lowers the amount of carbon in coking coals.

Ash of coal is that inorganic residue that remains after combustion. It should be remembered that the determined ash content is not equivalent to the mineral matter content of the coal. An analysis of coal ash may also be carried out to determine not only the composition of coal ash, but also to determine the levels at which trace elements occur in ash.

In a steam coal, high ash content will effectively reduce its calorific value. Recommended maximum ash content for steam coals for use as pulverized fuels are around 20% (a), but for some stoker-fired boilers, much lower value are desirable. In coking coals, a maximum of 10-20% (a) is recommended, as higher ash reduce the efficiency in the blast furnace.

Volatile matter represents that component of the coal except for moisture that is liberated at high temperature in the absence of air. This is usually a mixture of short and long chain hydrocarbons, aromatic hydrocarbons and some sulfur. Volatile matters usually subdivide into volatile mineral matter and volatile organic matter.

For electricity generation, most boilers are designed for a minimum volatile matter of 20-25% (daf). For electricity generation, the volatile matter limits recommended are 25-40% (daf). There is virtually no limit for the volatile matter for coals used in the production of cement. In coke production, high volatile matter content will give a lower coke yield so that the best quality coking coals have a volatile matter 20-35% (a).

Fixed carbon content of the coal is the carbon found in the material which is left after volatile materials are driven off. This differs from the ultimate carbon content of the coal because some carbon is lost in hydrocarbons with the volatiles. Fixed carbon is used as an estimate of the amount of coke that will be yielded from a sample of coal. Fixed carbon is determined by removing the mass of volatiles from the original mass of the coal sample.

Nitrogen content of coal made influence to atmospheric pollution. Upon combustion of the coal, nitrogen helps to form oxides and pollute the atmosphere; as a result, coals which are low in nitrogen are preferred in industry.

Coal should not as a rule have nitrogen contents of more than 1.5-2.0% (daf) because of the NO_x emission.

Oxygen is a component of many of the organic and inorganic compounds in coal as well as the moisture content.

It should be remembered that oxygen is an important indicator of rank in coal.

Oxygen is traditionally determined by subtracting the amount of the other elements, carbon, hydrogen, nitrogen and sulphur from 100%,

Sulphur content of coals presents problems with utilization and resultant pollution. Sulphur causes corrosion and atmospheric pollution.

Sulphur can be present in three forms:

1. Organic sulphur, present in the organic compounds of the coal.

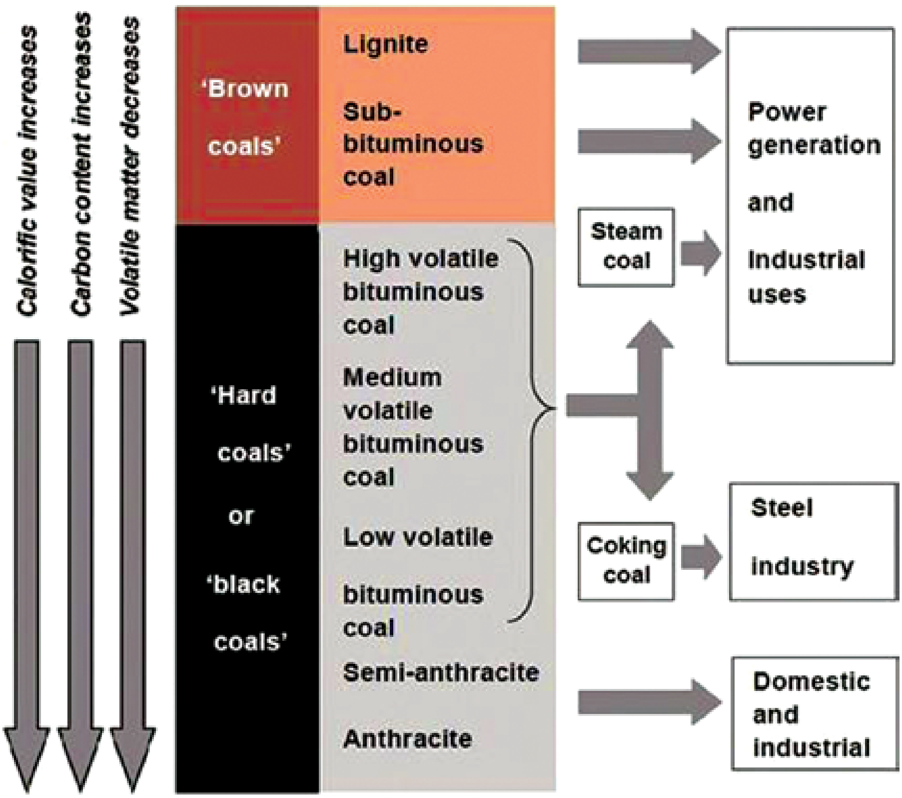
2. Pyritic sulphur, present as sulphide minerals in the coal, principally iron pyrite.

3. Sulphate minerals, usually hydrous iron or calcium sulphate.

The total sulphur content in steam coals used for electricity generation should not exceed 0.8-1.0% (a). In the cement industry, a total sulphur content of up to 2.0% (a) is acceptable but a maximum of 0.8% (a) is required in coking coals, because higher values affect the quality of steel.

Coal rank

The degree of change of coal from peat to anthracite – known as coalification that has an important physical and chemical properties and is referred to as the 'rank' of the coal. Low rank coals, such as lignite and subbituminous coals are typically softer. They are characterised by high moisture levels and low carbon content, and therefore a low energy content. Higher rank coals are generally harder and stronger and often have a black, vitreous lustre. They contain more carbon, have lower moisture content, and produce more energy. Anthracite is at the top of the rank scale and has a correspondingly higher carbon and energy content and a lower level of moisture (see diagrams).



Volatiles in wt – %	Ukraine	USA & UK	UN-ECE	Germany	Carbon in wt – % (daf)	Hydrogen in wt – % (daf)	Oxygen in wt – %(daf)	Total moisture in wt – % (r)	Calorific value MJ/kg
80	Wood	Wood	Wood	Holz	< 50	> 6	> 40	–	8 – 12,4
70	Peat	Peat	Peat	Torf	50 – 63	> 6	35 – 40	65 – 90	7 – 14,5
60	Brown (B1)	Lignite	Ortho-lignite Meta-lignite	Weich-braunkohle	60 – 67,5	6,0 > 5,8	35 – 25,5	30 – 65	12 – 17,5
	Brown (B2)	Sub-bituminous	bitumi-nous	Hart-braunkohle	67,5 – 75	6,0 > 5,8	25,5 – 17	10 – 30	
50	Flame	High volatile bituminous	Bituminous	Flamme-kohle	75 – 82	6,0 > 5,8	17 – 9,8	3 – 10	17 – 23,5
40	Gas flame			Gas-flamkohle	82 – 85	5,8 > 5,6	9,8 – 7,3	3 – 10	
	Gas	Medium volatile bituminous		Gaskohle	85 – 87,5	5,6 > 5,0	7,3 – 4,5	3 – 10	
30	Fat			Fettkohle	87,5 – 89,5	5,0 > 4,5	4,5 – 3,2	3 – 8	
20	Forge	Low volatile bituminous		Esskohle	89,5 – 90,5	4,5-4,0	3,2 – 2,8	2 – 6	25,7 – 31,5
	Nonbaking	Semi-anthracite	Anthracite	Me-gercohle	90,5 – 91,5	4,0-3,75	2,8 – 2,5	1 – 5	
10	Anthracite	Anthracite		Anthrazit	> 91,5	< 3,75	< 2,5	1 – 2	29 – 34

Mineralogy

Geologists also classify coal types according to the organic debris, called macerals[1], from which the coal is formed. Macerals are identified (microscopically) by reflected light – the reflective or translucent properties of the coal indicating the individual component macerals and the way they have combined to form the coal.

Coal are typified as either humic[2] or sapropelic[3]. Humic coals are divided into the lithological types: vitrain, clarain, durain and fusian, which differ in their maceral content, texture and fracture characteristics. Sapropelic coals are typically fine-grained. They include types known as cannel coal and boghead coal. The composition of the mineral content of coal varies; however 60 to 80 per cent of the total mineral content is usually made up of clay minerals (commonly kaolin). Other significant constituents may include; iron disulphide (pyrite), calcium sulphate (gypsum), calcium carbonate (calcite) and sodium chloride (halite).

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1 The basic organic constituent of coal made up of the remains of dehydrogenate plant material

2 Predominantly composed of the woody remains of mixed plant debris

3 Predominantly composed of the wax-rich remains of plant spores and algae

OIL

Crude oil – is a naturally occurring flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights and other liquid organic compounds that are found in geologic formations under the Earth's surface.

A fossil fuel is formed from large quantities of dead organisms. The chemical composition varies widely depending where and how the petroleum was formed. In fact, a chemical analysis can be used for determination of the source of the petroleum.

Elemental Composition

Although there is considerable variation between the ratios of organic molecules, the elemental composition of petroleum is well-defined:

- Carbon – 83 to 87%;
- Hydrogen – 10 to 14%;
- Nitrogen – 0,1 to 2%;
- Oxygen – 0,05 to 1,5%;
- Sulfur – 0,05 to 6,0%;
- Metals – < 0,1%.

The most common metals are vanadium, iron, nickel and copper.

Hydrocarbons in Crude Oil

There are four main types of hydrocarbons found in crude oil.

- Paraffins C_nH_{2n+2} (15-60%);
- Naphthenes C_nH_{2ni} (30-60%);
- Aromatics C_nH_{2n-6} (3-30%);
- Asphaltics (remainder).

Paraffin is a waxy substance made up of a mixture of alkanes with a total number of carbon atoms between 20 and 40.

Naphthenes are a class of hydrocarbons received from petroleum. Naphthenes have the general formula CnH_2n.

An aromatic compound is an organic molecule containing a benzene ring.

Asphaltic is a term which refers to asphalts, a class of solid to semi-solid hydrocarbons from petroleum.

NATURAL GAS

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly includes varying amounts of other higher alkenes and even a lesser percentage of carbon dioxide, nitrogen, and hydrogen sulfide. Natural gas is an energy source often used for heating, coking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals.

Chemical composition

<table>
<tr><th></th><th>Formula</th><th>Volume, %</th><th>LHV, MJ/kg</th></tr>
<tr><td>Methane ['mi:θein]</td><td>CH_4</td><td>70 – 90</td><td>50,1</td></tr>
<tr><td>Ethane ['eθeɪn]</td><td>C_2H_6</td><td rowspan="3">0 – 20</td><td>48,0</td></tr>
<tr><td>Propane ['prəʊpein]</td><td>C_3H_8</td><td>47,5</td></tr>
<tr><td>Butane [bju:tein]</td><td>C_4H_{10}</td><td>45,8</td></tr>
<tr><td>Carbon Dioxide</td><td>CO_2</td><td>0 – 8</td><td>incombustible</td></tr>
<tr><td>Hydrogen sulfide</td><td>H_2S</td><td>0 – 5</td><td>17,4</td></tr>
<tr><td>Hydrogen</td><td>H_2</td><td>0 – 5</td><td>120,9</td></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>0 – 5</td><td>incombustible</td></tr>
<tr><td>Oxygen</td><td>O_2</td><td>0 – 0,2</td><td>incombustible</td></tr>
<tr><td>Rare gases</td><td>A, He, Ne, Xe</td><td>traces</td><td>incombustibles</td></tr>
</table>

Natural gas is found in deep underground natural rock formations or associated with other hydrocarbon reservoirs in coal beds. Petroleum is also another resource found with natural gas.

Classification

1) Sour natural gas and sweet natural gas:

- Contains sour components in problematic concentration;
- Carbon dioxide: tolerable until 2 vol.-%;
- Hydrogen sulfide: highly toxic, corrosion, only trace tolerable (ppm);

2) Dry natural gas and wet natural gas:

- Dry natural gas (predominantly methane);
- Wet natural gas (in addition to methane, the gas contains compounds like ethane and butane);

3) “H” and “L” natural gas:

- LHV of “H” natural gas between 46 and 53 MJ/m^3;
- LHV of “L” natural gas between 39 and 46 MJ/m^3;

4) Special natural gases;

- Amount of inert gas: more than 3 – 5 vol.-%.

Associated petroleum gas (APG)

Definition:

- By-product from the petroleum extraction industry;
- Occurrence: directly above oil field or diluted in oil;
- Gas factor between 3 and 250 m^3/t of crude oil;
- Composed of methane, propane, ethane, butane, smaller amount of CO_2 H_2S (different quality);
- Composition depends on crude oil composition, geological formation and kind oil field;

Types:

- APG with high amount of hydrocarbons (95-100 vol.-%);
- Hydrocarbon-APG with CO_2 (4-20 vol.-%);
- Hydrocarbon-APG with N_2 (3-15 vol.-%);
- Hydrocarbon-nitrogen APG (up to 50 vol.-% N_2).

Questions

1. Give a definition of coal.
2. What is surface, air dried and total moisture?
3. Name the basis of analytical data.
4. What is the difference between proximate and ultimate analysis?
5. Name basic chemical elements of coal.
6. What coalification means?
7. What are the differences between steam coal and coking coal?
8. What is the equivalent of forge coal in UN-ECE, USA and UK coal industry?
9. Does the calorific value increase when volatile matter decreases?
10. Name basic chemical elements of crude oil.
11. Name basic chemical elements of natural gas.
12. What do LHV and APG mean?

Vocabulary

vegetation	[vedʒi'teiʃ(e)n]	растительность, вегетация
Carboniferous Period	[ka:bə'nif(ə)rəs, 'pi(ə)riəd]	каменноугольный период
spanned	[spæned]	образованный
maturity	[mə'tʃʊ(ə)riti]	дозревание
moisture	['mɔistʃə]	влажность
ash	[æʃ]	зола
volatile matter	['vɒlətail 'mætə]	летучие вещества
fixed carbon	[fiksed 'ka:bən]	химически связан углерод
indeed	[in'di:d]	более того
reported	[ri'pɔ:tid]	описаний
percentages	[pə'sentidʒ]	процентное содержание
as received	[æs ri'si:vd]	рабочая (при получении)
air dried	['eə draid]	аналитическая (высушенная воздухом)
dry	[drai]	сухая
dry, ash free	[drai, æʃ fri:]	сухая беззольная
dry, mineral matter free	[drai, 'min(ə)rəl fri:]	органическая (без мин. веществ)
wet, ash-free	[wet, æʃ fri:]]	влага беззольная
proximate analysis	['prɒksimit ə'nælisis]	технический анализ
ultimate analysis	['ʌltimeit ə'nælisis]	элементный анализ
property	['prɒpəti]	свойство
confusing	[kən'fju:ziŋ]	запутанный
inherent moisture	[in'hi(ə)rənt 'mɔistʃə]	естественная влага
avoid	[ə'vɔid]	избегать
adventitious moisture	[ædvən'tiʃes 'mɔistʃə]	внутренняя влага
absorb	[əb'zɔ:b]	поглощать, абсорбировать
steam coal	[sti:m kəʊl]	энергетический уголь
coking coal	['kəʊkiŋ kəʊl]	коксовый уголь
residue	['rezidju:]	остаток
trace	[treis]	ничтожно малое количество
pulverized fuels	['pʌlvəraiz fjʊel]	пылеугольное топливо
stoker-fired boilers	['stəʊkə-'faiə 'bɔilə]	котел с механической топкой
blast furnace	['blɑ:stfɜ:nis]	доменная печь
liberate	['libəreit]	выделять, освобождать
chain hydrocarbons	[tʃein 'haidrəʊ'ka:bən]	цепные углеводороды

aromatic hydrocarbons	[ærəmætik 'haidrəʊ'ka:bən]	ароматические углеводороды
virtually	['wɜ:tʃʊəli]	фактически
sample	['sɑ:mp(ə)l]	проба, керн
corrosion	[kə'rəʊʒ(ə)n]	коррозия
exceed	[ik'si:d]	превышать
acceptable	[ək'septəb(ə)l]	подходящий, допустимый
coalification	[kəʊlifi'keiʃ(ə)n]	углефикация
vitreous	['vitriəs]	стеклянный
correspondingly	[kɔris'pɔndiηli]	соответственно
maceral	[ma:cerl]	мацерал
identified	[ai'dentiai]	идентифицируются
microscopically	[maikrəs'kɔpikli]	с помощью микроскопа
reflected	[ri'flekt]	отбивать (светло, тепло, звук)
humic	['hju:mik]	гумусовый
sapropelic	[saprɔp'elik]	сапропельный
vitrain	[vit'rein]	витрин
clarain	[kla'rein]	кларен
durain	[dju'rein]	дюрен
fusian	[fju'zein]	фюзен
cannel coal	['kænl kəʊl]	кеннельский уголь
boghead coal	['bɑghed kəʊl]	богхедовый уголь
kaolinite	[kə:ɔlin]	каолин (белая глина)
constituent	[kən'stitʃʊənt]	составляющая
considerable	[kən'sid(ə)rəb(ə)l]	значительное количество
paraffins	['pærəfins]	парафины
naphthenes	['naftənes]	нафталины
aromatics	[ærə'mætik]	ароматические соединения
asphaltics	['æsfæltik]	асфальтены
benzene ring	['benzɒl riη]	бензольное кольцо
vehicles	[v'i:ik(ə)l]	транспортное средство
sour natural gas	['saʊə 'nætʃ(ə)rəl gæs]	высокосернистый природный газ
sweet natural gas	[swi:t 'nætʃ(ə)rəl gæs]	малосернистый природный газ
associated petroleum gas	[ə'səʊʃiəit pə'trəʊliəm gæs]	попутный нефтяной газ

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Chapter 5

5.1 METHODS OF MINING

The minerals are mined by the following methods:

- surface or 'opencast' mining;
- underground or 'deep' mining;
- in-situ leaching;
- borehole underground coal gasification (BUCG);
- sea deep mining.

The choice of mining method is *largely determined* by the **geology** of the coal deposit. Anyway, **underground mining** currently accounts for a bigger share of world coal production than opencast; although in several important coal producing countries surface mining is more common. For example, surface mining accounts for around 80% of production in Australia; while in the USA it is used for about 67% of production.

Surface Mining

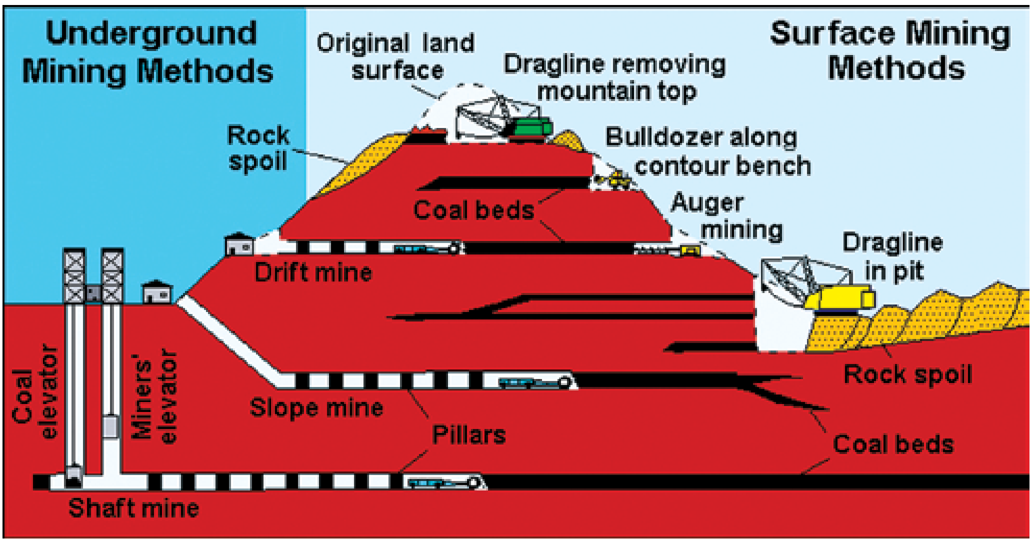
Surface mining - also known as *opencast* or *opencut* mining - is only economic when the coal seam is near the surface. This method recovers a higher proportion of the coal deposit than underground mining as all coal seams are exploited - 90% or more of the coal can be *recovered*.

Large opencast mines can cover an area of many square kilometers and use very large pieces of equipment, including: ***draglines*,** which remove the ***overburden***; ***power shovels***; **large trucks**, which transport overburden and coal; ***bucket wheel excavators***; **conveyors**. . In open pit mine up to 90-95% of the ore body can be removed.

The overburden of *soil* and rock is first broken up by explosives; it is then removed by draglines or by shovel and truck. Once the coal seam is exposed, it is drilled, *fractured* and systematically mined, the coal is loaded on to large trucks or conveyors for transport to either the coal preparation plant or direct to where it will be used.

Underground Mining

Under certain circumstances surface mining can become *prohibitively* expensive and underground mining may be considered. A major factor in the decision to operate by means of underground mining rather than surface mining is the number of units of *waste material* in a surface mine that must be removed in order to extract one unit of ore. Once this ratio becomes large, surface mining is no longer *attractive*. The objective of underground mining is to extract the mineral below the surface of the earth safely, economically, and with the removal of as little waste as possible



In underground mining generally more mineral has to be left behind as it is used *to support* the *mine roof*. The entry from the surface to an underground mine may be through an ***adit***, or horizontal tunnel, a ***shaft*** or a ***declined shaft***. A typical underground mine has a number of roughly horizontal levels at various depths below the surface and they spread out from the access to the surface. Ore is mined in ***stopes***, or ***rooms***. Material left in place to support the ceiling is called a ***pillar*** and can sometimes be recovered afterward. A vertical internal connection between two levels of a mine is called a ***winze*** if it was made by driving downward and a ***raise*** if it was made by driving upward.

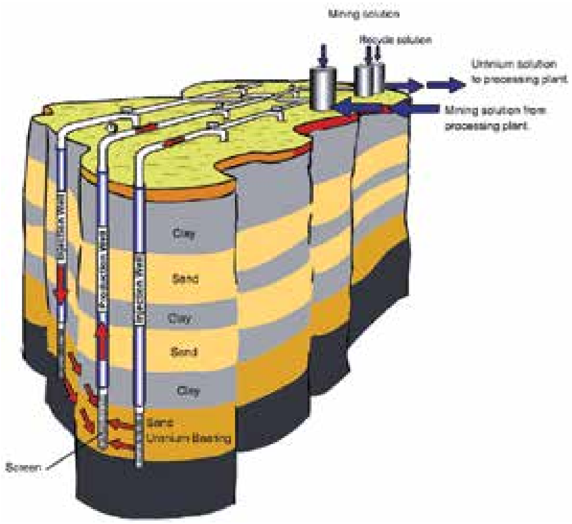
A modern underground mine is a highly mechanized operation requiring little work with *pick* and *shovel*. *Rubber-tired vehicles*, *rail haulage* and multiple drill units are commonplace. In order to protect miners and their equipment much attention is paid to mine safety. Mine ventilation provides fresh air underground and at the same time removes ***noxious gases*** as well as dangerous dusts that might cause lung disease, e.g. silicosis. Roof support is accomplished with *timber*, concrete or steel supports or, most commonly, with ***roof bolts***, which are long steel rods used *to bind* the exposed roof surface to the rock behind it.

Shafts, which are generally vertical, but may be inclined depending on the orientation of the mineral, can be distinguished from *adits* and *tunnels*, which are horizontal. Shafts and adits are the main access routes through which men, supplies, ore and waste are transported. They are the chief *service openings* during the development and operation of a mine, and provide space for *compressed-air pipes* or *electric cables*. By law at least two access points to the ore body are required for adequate ventilation and safety concerns.

In-situ leaching

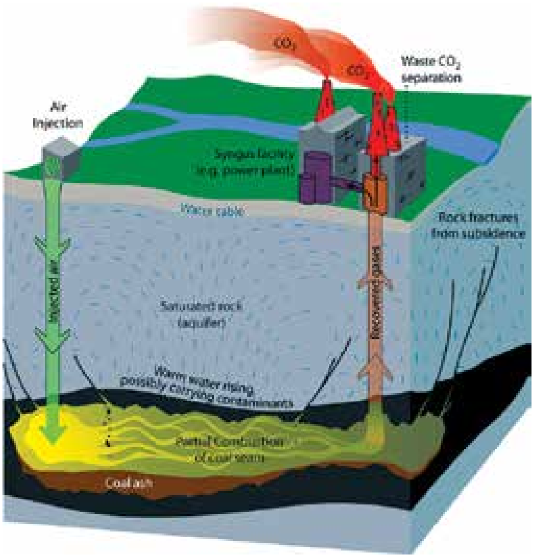
(ISL), also called **in-situ recovery** (ISR) or **solution mining**, is a mining process used to recover minerals such as copper and uranium through boreholes drilled into a deposit.

The process initially involves drilling of holes into the ore deposit. Explosive or ***hydraulic fracturing*** may be used to create open pathways in the deposit for solution ***to penetrate***. In-situ leach mining involves pumping of a *leaching* solution into the ore body *via* a borehole, which circulates through the porous rock dissolving the ore and is extracted via a second borehole.



The solution bearing the dissolved ore content is then pumped to the surface and processed. This process allows the extraction of metals and salts from an ore body without the need for conventional mining involving *drill-and-blast*, open-cut or underground mining.

Underground Coal Gasification (UCG) is the gasification of coal in-situ, which is achieved by drilling boreholes into the coal and *injecting* water/air or water/oxygen mixtures. It is both an extraction process (like coal mining) and a conversion process (gasification) in one step producing a high quality, affordable synthetic gas that can be processed to provide fuels for *power generation*, diesel fuels, *jet fuels*, hydrogen, fertilisers and chemical *feedstock*.



The technique offers many financial and social *benefits* over traditional extraction methods, most notably **lower emissions**, as no coal is brought to the surface and the gas can be processed to remove its CO_2 content. It can be used for heating, power generation, hydrogen production, or the manufacturer of key liquid fuels such as diesel fuel or methanol.

Proponents of UCG cite the carbon capture and storage prospects of

UCG, in which the resulting CO_2 would be pumped back into the cavity left underground after burning the coal.

Financial Benefits

- Capital and operating costs are lower than in traditional mining;
- Reduced cost of plant installation - No Surface Gasifier;
- Syngas can be piped directly to the end-user, reducing the need for rail / road infrastructure.

Environmental Benefits

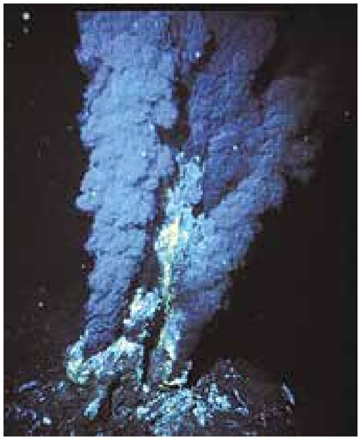
- UCG may not require an external water source to operate, a major environmental advantage over water-intensive coal mining operations;
- Lower emissions, because gasification in UCG is underground thereby reducing environmental management costs;
- Lower ***fugitive dust***, noise, ***visual impact*** on the surface;
- Low risk of surface water pollution;
- Reduced methane emissions - coal seam *gas is recovered* in the process, rather than lost in the atmosphere as in most conventional mining;
- No coal washing and fines disposal at mine sites.

Ocean potential

- Rich metallic sulfide deposits on the seabed form when super-heated water from volcanic hydrothermal vents reacts with rock;
- 350 vent fields have been found so far. Mining companies Nautilus and Neptune are exploring the possibility of extraction;
- Vent sites are biodiverse areas of fascination to marine scientists;
- The United Nations plans to regulate prospecting and exploration in international waters.

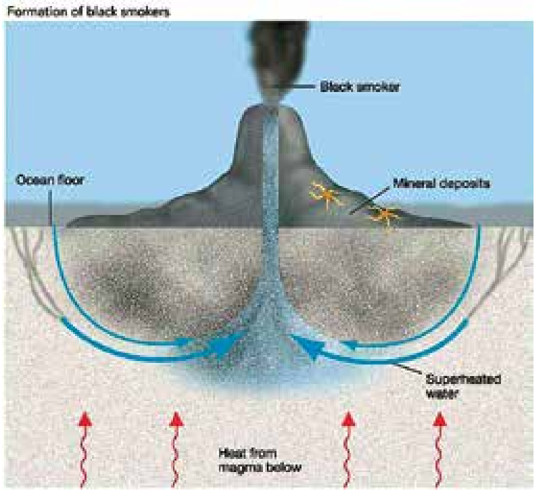
Some of the minerals like *metalliferous* oxides and metalliferous sulfides occur in the deep ocean. Metalliferous oxides contain manganese, copper, nickel and cobalt. Metalliferous sulfides contain copper, lead, zinc, chromium and gold.

Despite the rather dismal mineral market conditions, we will become more dependent on the oceans as a mineral resource reservoir in the future.



A plume of hot water and minerals venting through the seabed to form a 'black smoker'

A **hydrothermal vent** is *a fissure* in a planet's surface from which geothermally heated water issues. This water is rich in dissolved minerals from the crust, most notably sulfides. When it comes in contact with cold ocean water, many minerals precipitate, forming a black chimney-like structure around each vent. The metal sulfides that are deposited can become massive sulfide ore deposits in time. Hydrothermal vents are commonly found near volcanically active places, areas where tectonic plates are moving apart, ocean basins, and hotspots.



Extraction methods of sea deep mining

Recent technological advancements have given rise to the use remotely operated vehicles (ROVs) to collect mineral samples from prospective mine

sites. Using drills and other cutting tools, the ROVs obtain samples to be analyzed for precious materials. Once a site has been located, a mining ship or station is set up to mine the area.

Hydraulic suction mining lowers a pipe to the seafloor which transfers *nodules* up to the mining ship. Another pipe from the ship to the seafloor returns the tailings to the area of the mining site.

Questions:

1.How many methods of mining do you know? Name them.

2. What factors influence the choice of mining?

3. What is surface mining? What equipment does it involve?

4. What is underground mining? What is its difference from surface mining?

5. What is used to support mine roof underground?

6. What equipment is used to transport coal and rock underground?

7. When is in-situ leaching is used? What minerals are extracted using this technology?

8. What is BUCG used for? What benefits does it have?

9. How can we use ocean potential? How do minerals form at the ocean's bottom?

Vocabulary

in-situ leaching	[ˈɪn situ ˈliːtʃɪŋ]	выщелачивание на месте
borehole underground coal gasification	[ˈbɔrˌhoʊl ˌəndərˈgræʊnd ˈkoʊl ˌgæsəfəˈkeɪʃənˈsiː ˈdiːp ˈmaɪnɪŋ]	скважинная подземная газификация
sea deep mining	[ˈsiː ˈdiːp ˈmaɪnɪŋ]	глубоководная добыча
dragline	[ˈdrægˌlaɪn]	драглайн, канатный
overburden	[ˌəʊ.vəˈbɜː.dən]	вскрыша
power shovel	[ˈpaʊə(r) ˈʃʌv.əl]	одноковшовый экскаватор
bucket wheel excavator	[ˈbəkət ˈwiːl ˈekskəˌveɪtər]	роторный экскаватор
soil	[ˈsɔɪl]	почва
fracture	[ˈfræktʃər]	ломать, дробить
prohibitively	[prəˈhɪb.ɪ.tɪv]	запрещающий, препятствующий
attractive	[əˈtræktɪv]	привлекательный
support	[səˈpɔrt]	поддерживать (крепью)
mine roof	[ˈmaɪn ˈruːf]	кровля выработки
adit	[ˈædət]	штольня
shaft	[ˈʃæft]	ствол
declined shaft	[dɪˈklaɪnd ˈʃæft]	наклонный ствол
stope	[ˈstoʊp]	очистная выработка, очистной забой
room	[ˈruːm]	камера
pillar	[ˈpɪlər]	целик
winze	[ˈwɪnz]	гезенк
raise	[ˈreɪz]	восстающий
pick and shovel	[ˈpɪk ənd ˈʃəvəl]	подымание и загрузка
rail haulage	[ˈreɪl ˈhɔlɪdʒ]	рельсовая откатка
drill units	[ˈdrɪl ˈjuːnəts]	буровой агрегат
noxious gases	[ˈnɑkʃəs ˈgæsɪz]	ядовитый газ, вредный газ
silicosis	[ˌsɪləˈkoʊsəs]	силикоз
timber	[ˈtɪmbər]	дерево, лес
roof support	[ˈruːf səˈpɔrt]	поддержание кровли
concrete	[kɑnˈkriːt]	бетон
roof bolt	[ˈruːf ˈboʊlt]	анкер
rod	[ˈrɑd]	прут, брус, стержень
to bind	[tə ˈbaɪnd]	связывать
compressed-air pipes	[kəmˈpres eə(r) paɪp]	трубы с сжатым воздухом
electric cables	[ɪˈlektrɪk ˈkeɪbəlz]	электрический кабель
solution mining	[səˈluːʃən ˈmaɪnɪŋ]	добыча растворением
hydraulic fracturing	[haɪˈdrɔlɪk ˈfræktʃərɪŋ]	гидроразрыв

drill-and-blast	[drɪl ənd blɑːst]	буровзрывные работы
injection	[ɪnˈdʒekʃən]	ввод, инъекция
conversion	[kənˈvərʒən]	переход, превращение
power generation	[ˈpæʊr ˌdʒenəˈreɪʃən]	выработка (производство) энергии
jet fuel	[ˈdʒet ˈfjuːl]	реактивное топливо
benefit	[ˈbenəˌfɪt]	выгода, прибыль, польза
notably	[ˈnoʊtəbliː]	исключительно, особенно
cavity	[ˈkævətiː]	полость
capital cost	[ˈkæpətəl ˈkɔst]	капитальная стоимость
operating cost	[ˈɑpəˌreɪtɪŋ ˈkɔst]	стоимость эксплуатации
reduced	[rɪˈduːst]	уменьшенный
fugitive dust	[ˈfjuːdʒətɪv ˈdəst]	выходящие газы
visual impact	[ˈvɪʒəwəl ɪmˈpækt]	визуальный урон
fascination	[ˌfæsəˈneɪʃən]	очарование, привлекательность
fines disposal	[ˈfaɪnz dɪˈspoʊzəl]	ликвидация мелких фракций
biodiverse	[biodiverse]	биологически разнообразный
metalliferous	[ˌmetəlˈɪfrəs]	содержащий металл
hydrothermal vent	[ˌhaɪdrəˈθərməl ˈvent]	гидротермальный источник
fissure	[ˈfɪʃər]	трещина
hotspot	[ˈhɒt.spɒt]	горячая точка
ROV	[row]	телеуправляемый подводный апарат
nodule	[ˈnɑdʒuːl]	конкреция, галька, узелок

5.2 COMPONENTS OF MINING PRODUCTION

Increase of mineral resources demands contributes to development of mining sectors. **Mineral resources** reflect specific form of accumulation in lithosphere of mineral matters that are the sources of energy, materials, chemical elements and compounds, that meet technical possibilities and profitability of the gain, processing and usage.

Mineral raw materials is the subject of labour (ore, coal, oil, gas, minerals, stones) for other industry sectors and requires following processing in order to extract useful components located in it.

Remnants of mineral matters during processing and enrichment create mining wastes.

Terminology

Mine field (ore field) is part of a deposit at which a mining enterprise extracts minerals.

Mine allotment (mine take) is an area of a surface allocated for agricultural needs and is given to a mining enterprise.

Mining sector – basic source of fuel, raw material for ferrous and non-ferrous industry, chemical industry, fertilizers, building materials for buildings and roads.

Mining industry – complex of sectors engaged in prospecting of minerals, their extraction and initial processing – enrichment. Its basic groups are: oil, gas, fuel (coal, peat), ore, non-metallic minerals, local building materials, mining-chemical and hydromineral sectors.

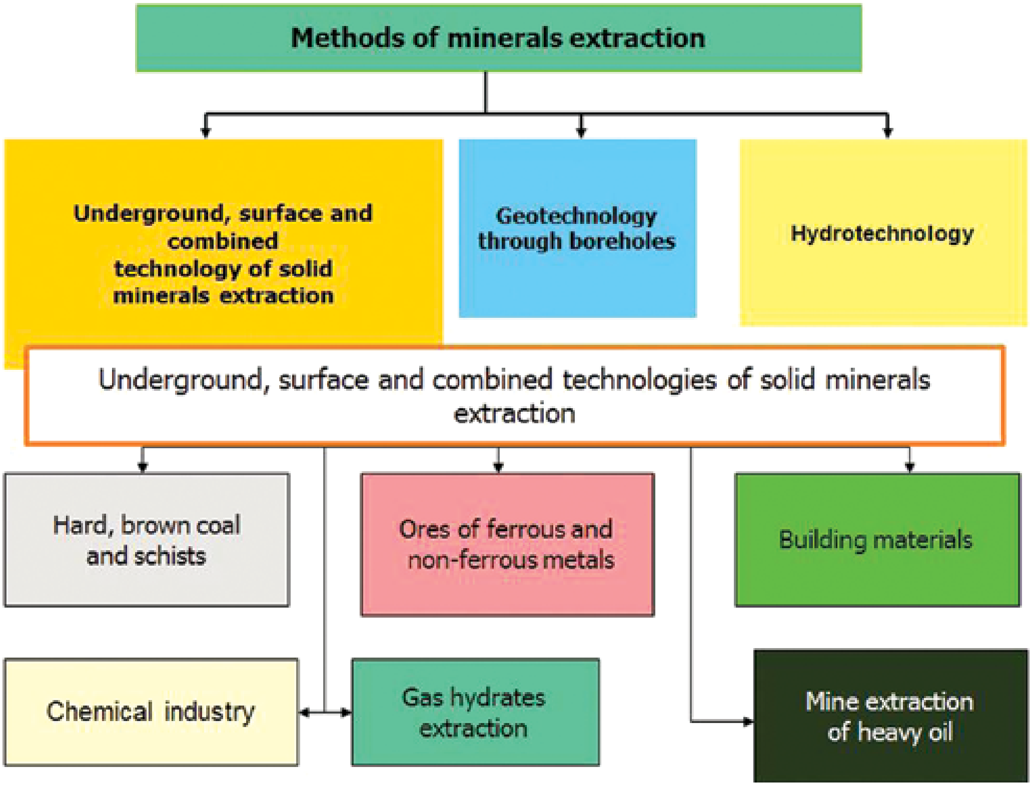
Method of mining production – method of minerals extraction with unification of production forces and relationships.

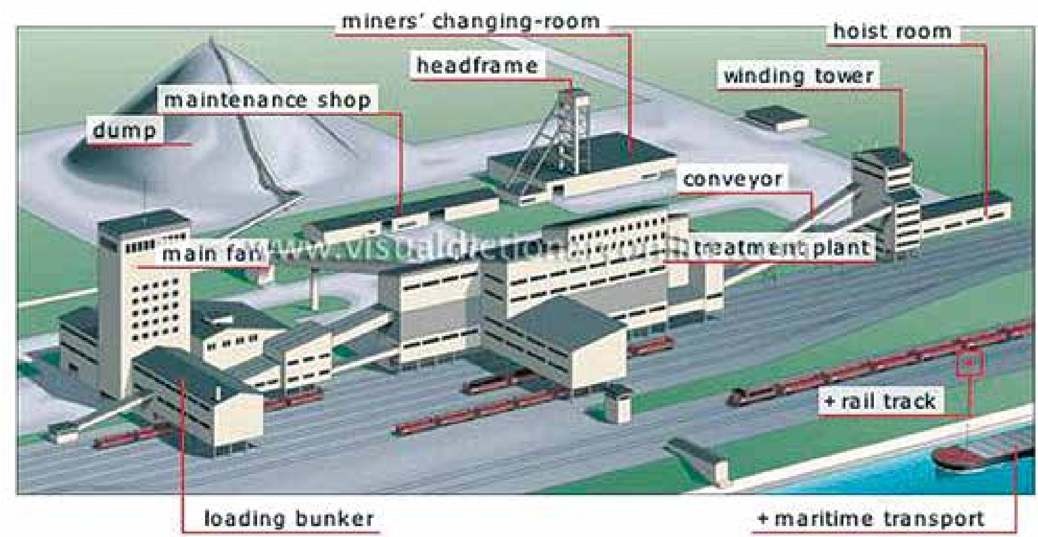
Extraction of minerals – processes of extraction of solid, liquid and gaseous minerals from Earth's interior with help of technical means.

Mining enterprise – technically and organizationally separated complex of means and resources for minerals extraction, building and exploitation of the objects with use of mining technologies (mines, open-cuts, quarries, processing plants and so on)

Mining – branch of science and technique that embraces complex of processes focused on extraction of minerals and their original processing.

Mining operations - complex of operations directed to drivage, support and maintenance of the mine workings and extraction of rocks under conditions of natural balance disturbance, possibility of dangerous and harmful factors manifestation.


Methods of minerals extraction
Underground, surface and combined technology of solid minerals extraction
Geotechnology through boreholes
Hydrotechnology
Underground, surface and combined technologies of solid minerals extraction
Hard, brown coal and schists
Ores of ferrous and non-ferrous metals
Building materials
Chemical industry
Gas hydrates extraction
Mine extraction of heavy oil


miners' changing-room
hoist room
headframe
winding tower
maintenance shop
dump
conveyor
main fan
treatment plant
+ rail track
loading bunker
+ maritime transport

Dump – pile that is made up of residue from mining operations.

Maintenance shop – work area where machinery is maintained and repaired.

Maritime transport – means of transport that uses barges to transport coal over water.

Hoist room – area that houses the hoist (cylinder) on which the hoisting cables are wound; it controls movement of the elevators and skip hoists in the shaft.

Winding tower – building that houses the shaft's hoisting equipment (including motors and hoisting cables); it provides communication between the surface and the mine galleries.

Conveyor – materials-handling device that consists of a conveyor belt (sturdy belt on rollers); it is used to carry coal to the treatment plant.

Treatment plant – place where all processing activities (including crushing and washing) are carried out to prepare the coal for market.

Miners' changing-room – area with sanitary facilities (showers, toilets) where miners can go mainly to change their clothes.

Loading bunker – reservoir where processed coal is stored before being loaded onto freight cars to be transported by rail to the power plant.

Main fan – Device that ensures air exchange in the mine; air is drawn through one shaft and exits through another.

Coal preparation plant

A coal preparation plant (CPP) is a facility that washes coal of soil and rock, preparing it for transport to market. A CPP may also be called a "coal handling and preparation plant", "prep plant," "tipple," or "wash plant".

Use of coal in the world

Coal has four major markets: *electric utilities*, industrial/retail users, the *steel industry* and exports.

In an *electric power plant*, coal, like oil and natural gas, is burned to produce heat. The heat is used to change water into steam. *The steam* then turns the *blades of a turbine, spinning* the generator, producing electricity. Before the coal is burned it is crushed and pulverized to the consistency of face powder.

Coal's second largest market is industrial and retail users. Among the industries using coal, the largest consumers are *chemical manufacturers*, users of stone, clay and glass, *paper mills*, primary metal industries and the food industry. Industry uses coal as a chemical *feedstock* to make *dyes, insecticides*, fertilizers, explosives, synthetic fibers, food preservatives, *ammonia*, synthetic rubber, fingernail polish, medicines, etc.

The third largest market is the iron and steel industry, where coal is used to be made into coke. Coke is derived from *bituminous coal* through heating in *airtight ovens*. The lack of air prevents the coal from burning and converts some of the solids to gases leaving coke.

The fourth market segment is exports. The top five foreign markets are Canada, Japan, Italy, Netherlands and Brazil.

Questions:

1. What is mining industry?
2. What is mining sector?
3. Name methods of mineral extraction?
4. What are the main facilities of a mine?
5. Coal preparation plant – what does it serve for?
6. How does the world use coal?

Vocabulary

mineral matters	[ˈmɪnər(ə)l ˈmætə(r)s]	минеральное вещество
gain	[ɡeɪn]	добыча, польза, выгода
mineral raw materials	[ˈmɪnər(ə)l rɔː məˈtɪərɪəls]	минеральное сырье
mining wastes	[ˈmaɪnɪŋ weɪst]	отходы горного производства
mining sector	[ˈmaɪnɪŋ ˈsektə(r)]	горная отрасль
mining industry	[ˈmaɪnɪŋ ˈɪndəstrɪ]	горная промышленность
mining production	[ˈmaɪnɪŋ prəˈdʌkʃ(ə)n]	горное производство
method of mining production	[ˈmeθəd ɒv ˈmaɪnɪŋ prəˈdʌkʃ(ə)n]	способ горного производства
extraction of minerals	[ɪksˈtrækʃən ɒv ˈmɪnərəl]	извлечение полезных ископаемых
mining enterprise	[ˈmaɪnɪŋ ˈentəpraɪz]	горное предприятие
mining	[ˈmaɪnɪŋ]	горное дело
mining operations	[ˈmaɪnɪŋ ɒpəˈreɪʃ(ə)n]	горные работы
underground mining	[ˈʌndəgraʊnd ˈmaɪnɪŋ]	подземные горные работы
surface mining	[ˈsəːfɪs ˈmaɪnɪŋ]	открытые горные работы
hard coal, black coal	[hɑːd kəʊl] [blæk kəʊl]	каменный уголь
brown coal	[braʊn kəʊl]	бурый уголь
ferrous and non-ferrous metals	[ˈferəs ænd non-ferəs ˈmetls]	черный и цветные металлы
gas hydrate	[gæs haɪdreɪt]	газовый гидрат
heavy oil	[ˈhevɪ ɔɪl]	тяжелая нефть
maintenance shop	[ˈmeɪntənəns ʃɒp]	ремонтный цех, ремонтная мастерская
main fan	[ˈmeɪn fæn]	главный вентилятор, вентиляционная установка
treatment plant	[ˈtriːtmənt plɑːnt]	перерабатывающий цех
headframe	[hedfreɪm]	надшахтный копер
miner's changing room	[ˈmaɪneˈs tʃeɪndʒɪŋ ruːm]	раздевалка для шахтеров
hoist room	[hɔɪst ruːm]	помещение подъемной машины
loading bunker	[ləʊdɪŋ ˈbʌŋkə(r)]	загрузочный бункер
shaft	[ʃɑːft]	ствол
galleries	[ˈgælərɪs]	штрек, выработка
electric utilities	[ɪˈlektrɪk juːˈtɪlɪtɪs]	электроэнергетика
electric power plant	[ɪˈlektrɪk ˈpaʊə(r) plɑːnt]	электростанция
blades of a turbine	[bleɪds ɒv æ ˈtəːbaɪn]	лезвия турбины
chemical manufacturers	[ˈkemɪk(ə)l	производители химических

	mænjʊˈfæktʃərə(r)s]	продуктов
paper mills	[ˈpeɪpə(r) mɪls]	бумажная фабрика
dyes	[daɪs]	краска, красители
insecticides	[ɪnˈsektɪsaɪds]	средства от насекомых
fertilizers	[ˈfəːtɪlaɪzə(r)s]	удобрения
explosives	[ɪkˈspləʊsɪvs]	взрывчатые вещества
bituminous coal	[bɪˈt juːmɪnəs kəʊl]	битуминозный уголь
airtight ovens	[eə(r)tɪŋ ˈʌv(ə)ns]	герметичные печи

5.3 MINE WORKINGS

Mine working (excavation, driftage, mine roadway, drivage, entry, opening, road, tunnel, heading) – artificially made cavity in Earth's crust that are formed due to mining operations and is used for deposits mining.

A mine working is restricted by the surfaces: top – roof, lower – bottom, side – sides of the opening.

Face (advance heading, mine face, breast, working face, bottomhole – скважины) – surface that restricting mine working and moving as a result of mining operations.

Face in rocks is called **drifting face**

Face in a mineral is called **stoping face (longwall face, face).**

Part of a working's area adjacent to a face is called **face space (face area).**

Depending on deep angle, there are horizontal, inclined and vertical openings.

Horizontal openings

Adit – horizontal or inclined opening that has an exit to the surface and usually is designed for extraction of minerals or service of mine workings. Adit is a basic main opening (вск. выработка) for deposits mining in mountainous areas.

Drift (drive, road, roadway, coal heading, entry, gateway, gateroad, head) – underground mine working that does not have direct exit to the surface and serves for ventilation and transportation.

Cross-cut (cross-entry, crossdrift, crossway, cross gallery, cross-tunnel) - permanent working that does not have a direct exit to the surface and is driven along a host rock (more often perpendicular) to the ore body. It is designed for a mineral opening, transportation, also for people movement, ventilation, water sewage.

Gain – орт (cross drift, ort, breakthrough, cross adit) – horizontal mine working that does not have a direct exit to the surface and driven to the roof or to the bottom of a seam or from the roof to the bottom. It is designed for accumulation and transportation of extracted minerals to the main transport working.

Vertical openings

Shaft – vertical main working that has direct exit on the surface and is designed for servicing of underground mining operations. Shafts are used for lowering and hoisting up the minerals, rock, materials, equipment, people and ventilation of the mine. Depending on the main purpose, mine shafts are divided into main and auxiliary. Main shaft is used for lifting the minerals to the surface. Auxiliary shaft – for lifting of the people, ventilation (incoming air stream).

Top part of the shaft that exits on the surface is called a **collar**. Lowest part of the shaft is called **sump** (sunk basin, dibhole). Diameter of the shafts reaches 9 meters, depth – 3-3.5 meters (the world's deepest mine in 3.9 km long – in South Africa).

Pit-hole (delve, exploratory shaft, prospecting shaft) – vertical (sometimes inclined) working that is driven from the surface for exploration of minerals, ventilation, dewatering (pumping), materials transportation, lifting of people and for other purposes.

Blind shaft (way shaft, dummy shaft) - vertical mine working that does not have exit to the surface and is designed for transportation of minerals, people, loads from underlying levels to the above situated ones, also for ventilation.

Winze – underground vertical or inclined mine working that does not have a direct exit to the surface. It connects different levels in a mine. It is used for transportation of the mineral to the underlying level by its gravity weight, ventilation. Usually it is equipped with a stair case.

Inclined workings

Incline (ramp, dipping drift, sloping tunnel) – inclined underground mine working that does not have a direct exit to the surface, driven downdip of a mineral. During mineral extraction is used for lifting of the loads from lower to upper level.

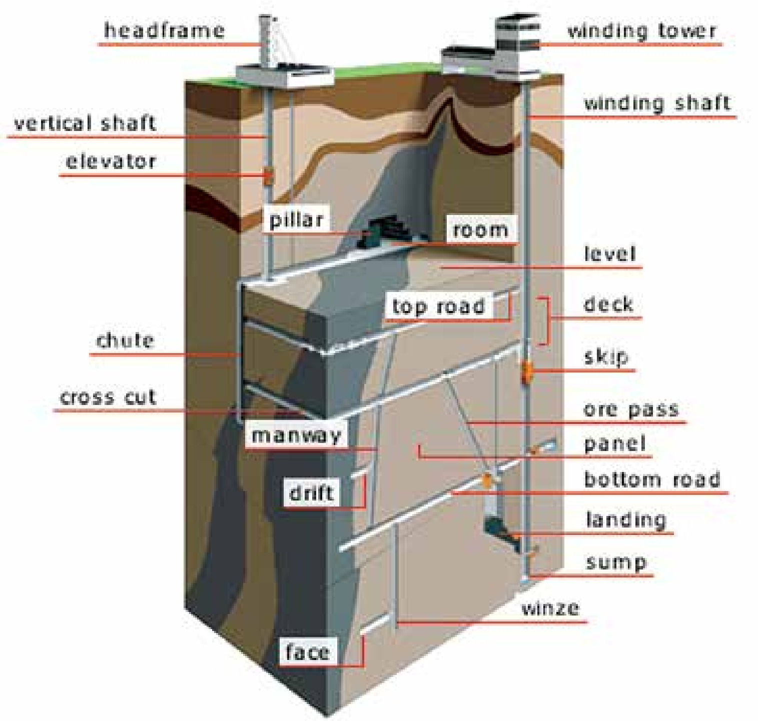
Inclined winze (drift) – (бремсберг), (dukeway, rope incline, **gravity incline**, brake incline – underground inclined mine working that does not have a direct exit to the surface, as a rule is driven along the seam (along deep line) and serves for lowering of minerals in mine trolleys from overlying to underlying levels. If a gravity incline is driven along the rock it is called **rock incline** (полевой).

Raise – an opening that does not have an exit to the surface and driven bottom-upwards at any angle.

Inclined shaft – an inclined underground mine working that has a direct exit to the surface and has the same purposes as the vertical shaft. Usually it is driven along a seam, rarely along a rock.

Usually equipped with rails, conveyors (depending on the incline angle), cable hoist.

Drop, chute, **ramp**, millhole, downward slope, descent (скат), – an inclined underground mine working that does not have a direct exit on the surface, driven along a seam or rock and designed for transportation of a mineral by its own weight.



Manway (pass, traveling way) – mine working driven parallel to an inclined winze (бремсберг) or to an incline and used for people movement and transportation of loads, ventilation. Depending on its purpose, there are people and freight manways.

Rise entry, set-up entry, raise – an inclined underground mine working driven along a seam and designed for coal, freight transportation, ventilation, people movement.

Rise entry driven along a mineral between **haulage and ventilation (air) drifts** for a longwall development is called **face entry** (разрезная печь).

Other mine workings

Longwall (long face) – underground mine working of a significant length (up to hundreds of meters), one side of which is formed by a coal massif (longwall face) and the other one – by a **backfill** and caved rock of a **goaf**. It has exits on haulage and air drifts.

Borehole – mine working of a circular shape, drilled from the surface or from an underground working without access of a man to the face, with diameter not bigger than 2 meters.

Cross slit (connection) – underground mine working (horizontal or inclined), that connects two adjacent workings, for example, drifts.

Chamber (room, stall) – mine working that is not very long (compared to its cross-section) and is designed for equipment and materials placement.

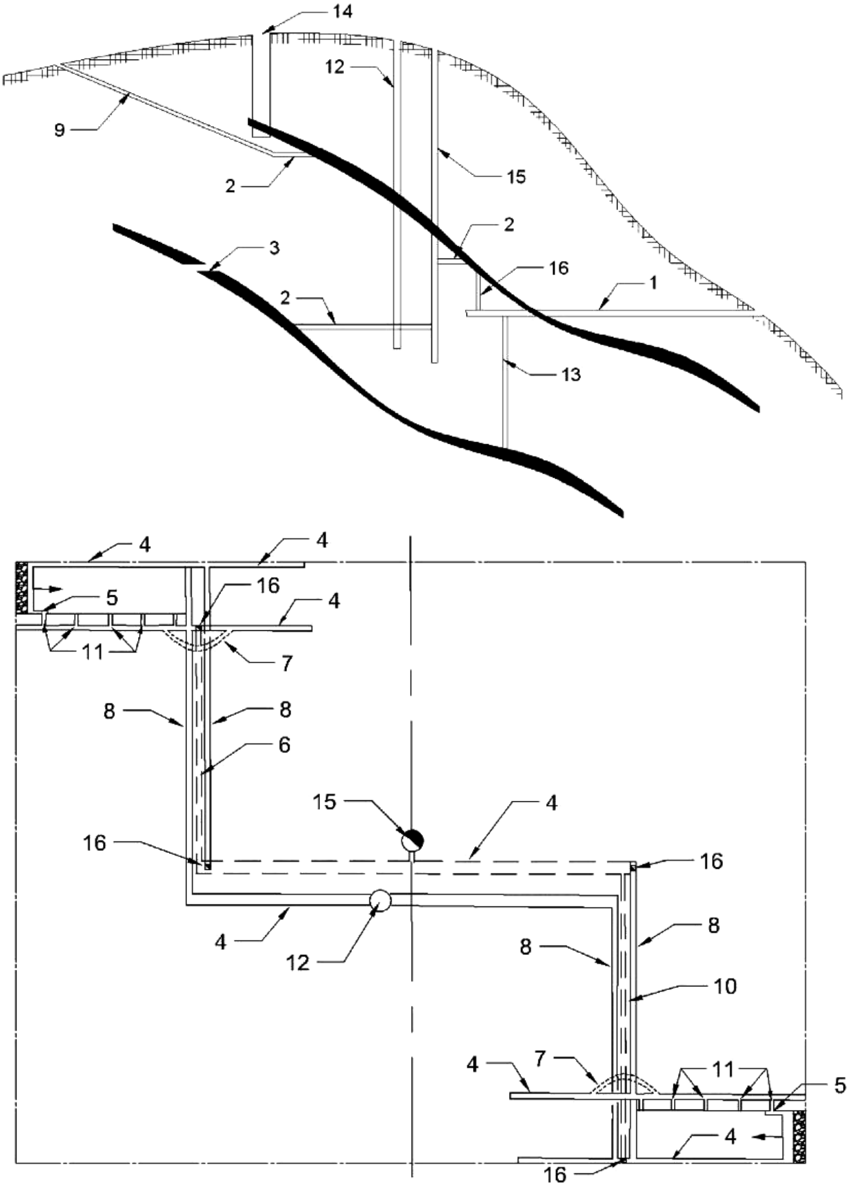
Shaft bottom (pit bottom) – aggregate of openings serving for connection of the shaft with all the rest mine workings and for placement of some mine facilities (water sewage system, power substations, electric locomotive garage, storage of fire-prevention tools).

Level: All of the horizontal openings which connect to a shaft at a specific point

Ramp: An inclined rubber wheeled access opening between horizontal openings at different elevations.

Sub-Level: A set of horizontal openings immediately above the main horizontal access openings.

Sump: An excavation for the purpose of collecting water so that it may be transferred to a pump. This often is the bottom most portion of a shaft.



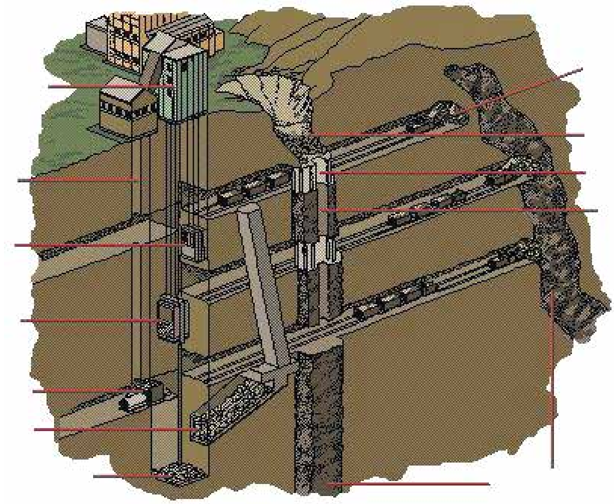
1 – Adit; 2 – Crosscut; 3 – Crossdrift; 4 – Drift; 5 – Gain; 6 – Incline Brake slope; 7 – Crossheading; 8 – Cundy; 9 – Incline shaft; 10 – Slope; 11 – Stenton; 12 – Airshaft; 13 – Blind pit; 14 – Prospect hole (shaft); 15 – Shaft; 16 – Winze

Fig. 5.1 Scheme of underground mine workings location

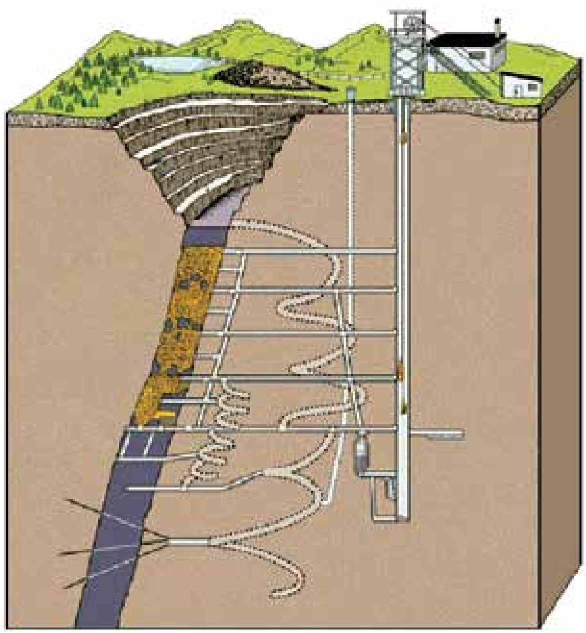
Questions

Fill in the gaps in the picture

1.



2.



Vocabulary

adit	['ædɪt]	штольня
crosscut	['krôsˌkət]	квершлаг
crossdrift	[krôs drɪft]	орт
drift	[drɪft]	штрек
gain	[geɪn]	просек
brake slope	[breɪk sləup]	бремсберг
crossheading	['krɔsˌhedɪŋ]	сбойка
cundy	[kundɪ]	ходок
incline shaft	[ɪn'klaɪn ʃɑːf t]	наклонный ствол
ramp	[ræmp]	скат
slope	[sləup]	уклон
stenton	[stʌnton]	печь
entry	[entrɪ]	разрезная печь
airshaft	[ɛə ʃɑːft]	вентиляционный ствол
blind pit	[blaɪnd pɪt]	слепой ствол
prospect hole (shaft)	[prɔspekt həul]	шурф
raise	[reɪz]	восстающий
shaft	[ʃɑːft]	ствол (главный ствол)
winze	[wɪnz]	гезенк

5.4 MINERAL PROSPECTING AND EXPLORING, EVALUATION OF THE DEPOSITS

Introduction

Mineral explorat ion is the process undertaken by companies in the endeavor of finding ore (commercially viable concentrations of minerals) to mine.

Objectives

The principal objective of mineral exploration is to find an economic mineral deposit that will appreciably increase the value of the company's stock on a continuing basis.

The exploration program should be designed to find and acquire a maximum number of acceptable mineral deposits at a minimum cost and within a minimum time period.

Area selection

Area selection is a crucial step in professional mineral exploration. Selection of the best, most prospective, area in a mineral field, geological region or terrain will assist in making it not only possible to find ore deposits, but to find them easily, cheaply and quickly.

Area selection is based on applying the theories behind ore genesis, the knowledge of known ore occurrences and the method of their formation, to known geological regions via the study of geological maps, to determine potential areas where the particular class of ore deposit being sought may exist.

Area selection is also influenced by the commodity being sought.

Often a company wishing to enter mineral exploration may conduct market research to determine, if a resource in a particular commodity is found, whether or not the resource will be worth mining based on projected commodity prices and demand growth.

Methods of exploration

Geophysical methods

The most effective and widespread method of gathering geophysical data is via flying **airborne geophysics.**

The basic concept remaining the same: collecting data from equipment aboard a low flying 80m above ground aircraft.

Geiger counters are used to determine the amount of radioactivity.

Airborne magnetometers are used to search for magnetic anomalies in the Earth's magnetic field.

Ground-based geophysical prospecting in the target selection stage is more limited, due to the time and cost. The most widespread use of ground-based geophysics is electromagnetic geophysics which detects conductive minerals such as sulfide minerals within more resistive **host rocks.**

Remote sensing

Aerial photography gives the explorer orientation information - location of tracks, roads, fences, habitation etc. Aerial photography was first used post World War II and was adopted in the 1960s onwards.

Geochemical methods

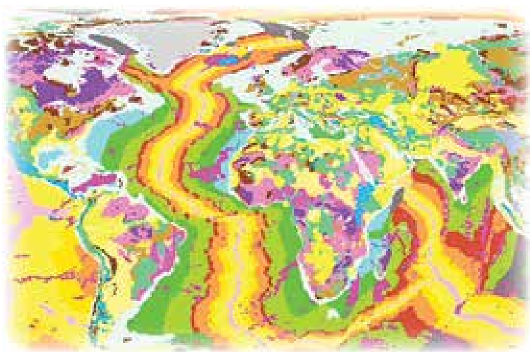
Involve studying of chemical elements' distribution in Earth's crust. Special attention is paid to detection of increased and decreased concentrations of separate chemical elements and boundaries that have abrupt differences of these concentrations.

Once the geochemical analyses are returned, the data is investigated for anomalies (single or multiple elements) that may be related to the presence of mineralisation.

The presence of some chemical elements may indicate the presence of a certain mineral. Chemical analysis of rocks and plants may indicate the presence of an underground deposit.

Geological Methods

Geological maps provide exploration agencies or companies with regional geological and geophysical information so that target areas that are considered to have a better prospect in terms of mineral deposits may be identified.



Geological methods rely on the identification of rocks and minerals and an understanding of the environment in which they formed. These surveys aim to find what rock types occur at or close to the surface and how these rock types are related to each other i.e. their boundaries, ages, and structure.

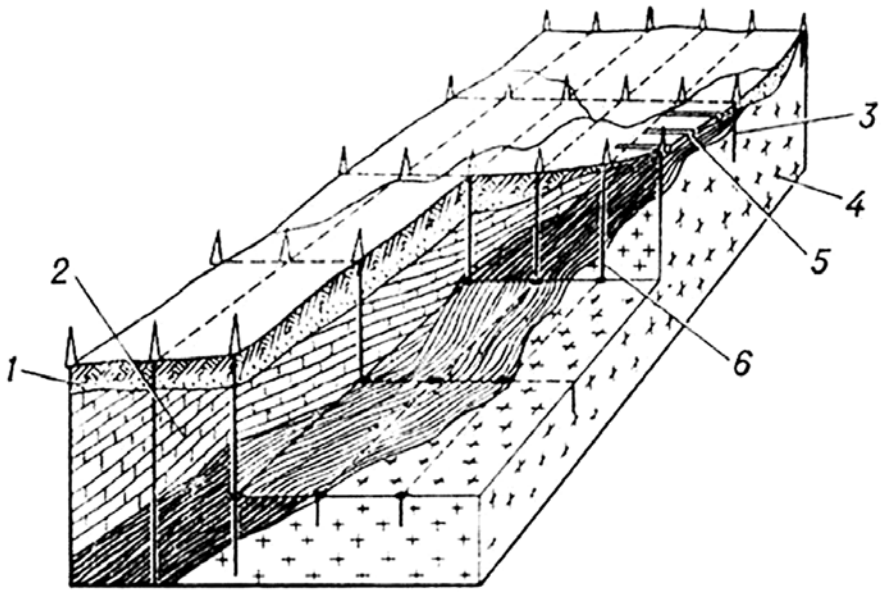
Drilling

Drilling is used to obtain very detailed information about rock types, mineral content, **rock fabric** and the relationships between rock layers close to the surface and at depth.

Applicability

Investigators can drill into only the **uppermost crust,** and the high cost of drilling severely limits the number of holes that can be dug. In recent years data returned by Earth satellites have led to several notable discoveries. The main methods of mineral exploration and their applicability (whether surface or subsurface) are listed hereunder:

METHOD	APPLICABILITY
Geological Mapping	Surface (sometimes in underground mines also)
Remote sensing	Surface
Geophysical methods	Surface
a) Gravity	Surface
b) Magnetic	Surface and subsurface
c) Electrical and Electromagnetic	Surface and subsurface
d) Seismic	Surface and subsurface
e) Radiometric	Surface and subsurface
Geochemical	Surface and subsurface
Drilling	Subsurface



1 – layers of loose sediments; 2 – limestone; 3 - ore deposit; 4 – granites;
5 – exploring channels; 6 – exploring boreholes

Fig. 5.2 Scheme of mineral exploration

Questions

1. What is mineral exploration and what is its purpose?
2. Why is area selection so important?
3. Name all the methods of exploration?
4. Describe the geophysical method of exploration.
5. What is remote sensing?
6. Describe geochemical method?
7. What is geological method used for?
8. What is drilling used for?

Vocabulary

prospecting	['prɔspektɪŋ]	разведка, разведочные работы
development	[dɪ'veləpmənt]	подготовительные работы
sinking of shaft	['sɪŋkɪŋ ɔv ʃɑːft]	углубка или проходка ствола
drainage	['dreɪnɪʤ]	дренаж, осушение, водосбор, слив
metallic ores	[mə'tælɪk ɔː]	металлсодержащие руды
blasting	['blɑːstɪŋ]	взрывные работы
loading	['ləudɪŋ]	погрузка, погрузочные работы
transportation	[ˌtræn(t)spɔː'teɪʃ(ə)n]	транспортирование
hoisting	[hɔɪst]	подъем груза
power transmission	['pauə trænz'mɪʃ(ə)n]	силовая передача, передача энергии
pumping	['pʌmpɪŋ]	откачка воды, подача насосом
storage	['stɔːrɪʤ]	хранение, сохранение
air contaminants	[ɛə kən'tæmɪnənt]	вещества, загрязняющие воздух
flooding	['flʌdɪŋ]	затопление, обводнение
explosion	[ɪk'spləuʒ(ə)n]	взрыв, взрывание
convenience	[kən'viːnɪən(t)s]	удобство, преимущество
stability	[stə'bɪlətɪ	стабильность, устойчивость
assembled	[ə'sembl]	собранный, составной
production rate	[prə'dʌkʃ(ə)n reɪt]	производительность
to gain	[tuː geɪn]	получать, добывать
underground mining	['ʌndəgraund 'maɪnɪŋ]	подземная разработка
strength	[streŋθ	крепость, прочность
wall rock	[wɔːl rɔk]	боковая порода
exploitation	[ˌeksplɔɪ'teɪʃ(ə)n]	эксплуатация (ресурсов)
aerial photography	['ɛərɪəl fə'tɔgrəfɪ]	аэрофотосъемка

5.5 DEVELOPMENT MINING

Development of underground mine consists of three main stages: the opening, preparation and extraction of ore. During the construction of the mine, these steps are performed sequentially, and after the introduction of the mine in operation - in parallel.

The autopsy reveals the deposit is being workings; their conduct is called the mining works. The scheme of the autopsy should provide a rational execution of the following operations:

- The rise of ores and rocks;
- Launching and recovery of people and equipment;
- Descent of materials and supply a bookmark (if applicable system development with mined-out space);
- Ventilation, water drainage, power supply and other mine.

It reveals the workings include vertical and inclined shafts, adits, crosscuts, pit bottom, capital ore passes, the main drifts connecting revealing production; pits; and ramps serving the main horizons, etc.

Revealing production by position relative to the surface are divided into two groups:

- Basic (have direct access to the surface - vertical and inclined trunks for any purpose, galleries);
- Underground (have no direct access to the surface).

By function revealing production are divided into:

- The main serving for transport and lifting of ore;

- Auxiliary (all other output).

Funds are also revealing a group of additional developments. They are blind vertical and inclined shafts, providing lifting ore from the lower to the upper horizons.

The following basic layout revealing the workings.

1. Central, in which all of the major revealing production are located in the middle of the field or across the middle. This scheme can be performed in two ways:

- Approaches to Central location revealing the workings of the mine at a production site or mine;

- Referred to the central location of revealing the workings in which they are located on two industrial sites on opposite sides of the field.

Central location Approaches revealing the workings widely used in the development of horizontal and gently sloping fields, and the development of lean ore production in the middle of a mine field (Fig. 5.3).

In developing this scheme steep deposits is less common: usually with a small stretch of the deposit (less than 1 km) and the possibility of applying the reverse order of its mining (Fig. 5.4).

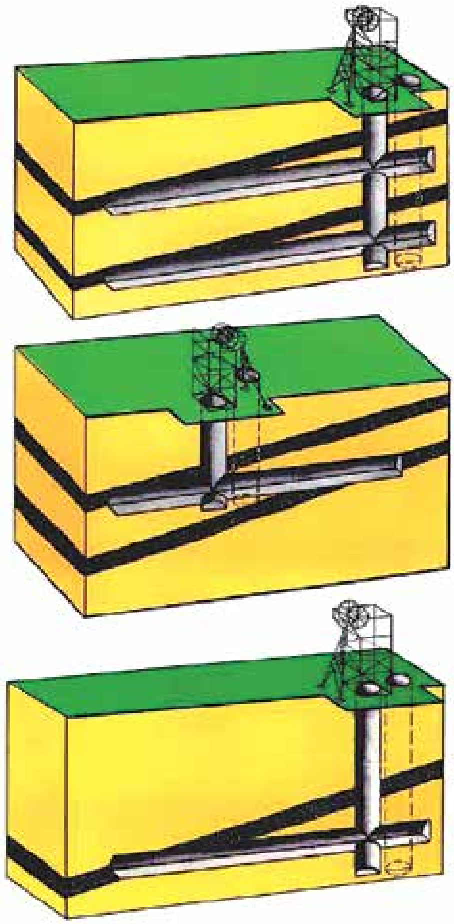


Fig. 5.3 Central location approaches trunks in the development of horizontal

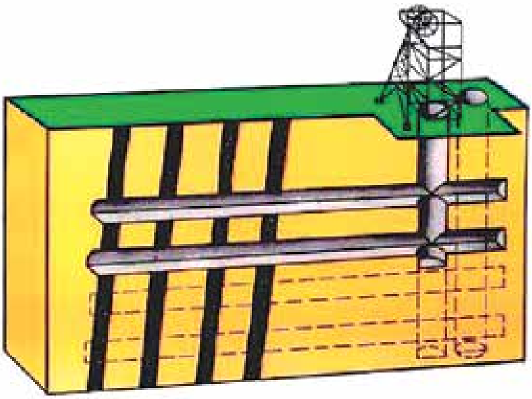


Fig. 5.4 Central location approaches trunks in the development of steep deposits

The obvious disadvantage of the central location of the main-approach is the difficulty in revealing the workings airing remote mining sites. Somewhat simplified, but the process is quite complex ventilation in Central attribution of the scheme, in which the air supply and ventilation shafts are located on opposite sides of the field (Fig. 5.5).

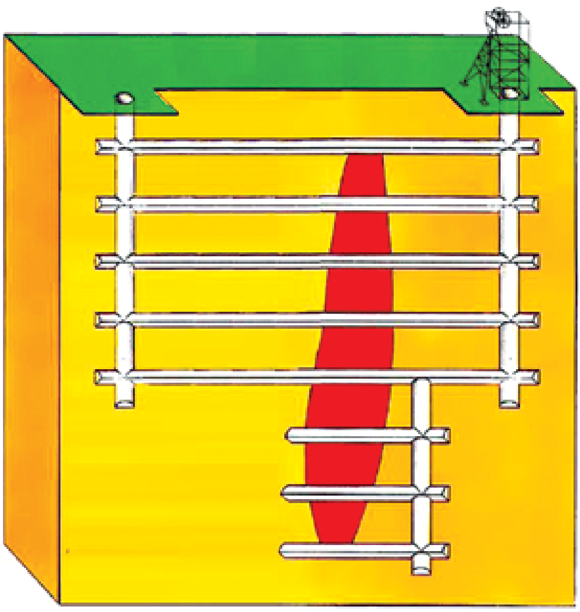


Fig. 5.5 Central location otherwise trunks in the development of steep deposits

2. Flank, where the main revealing production are located on different flanks of the deposit (Fig. 5.6).

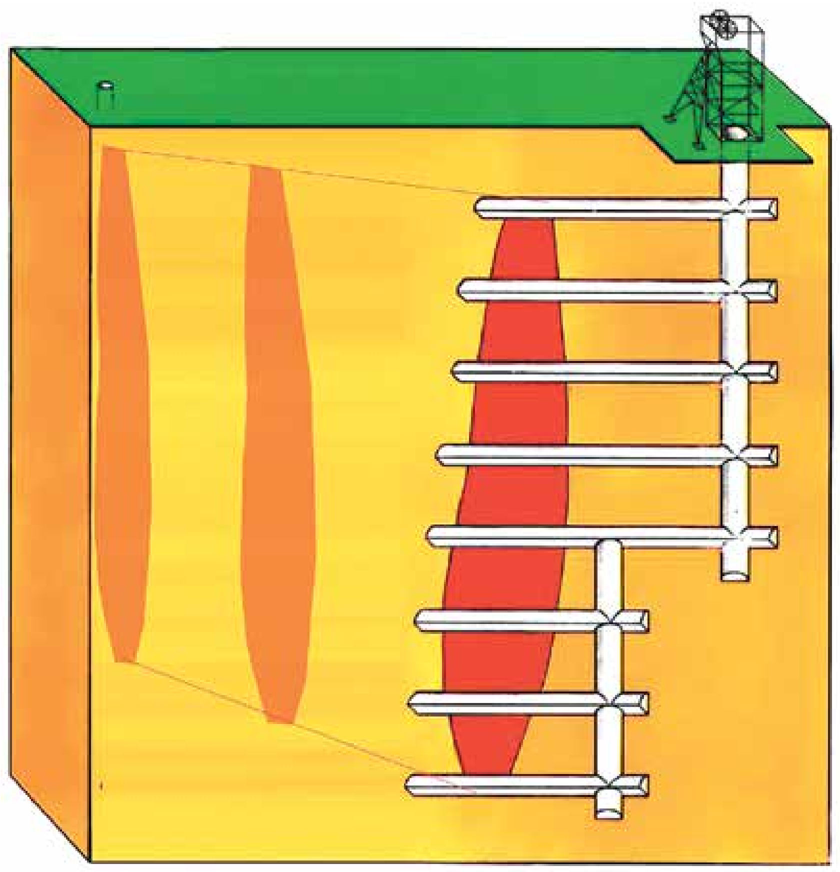


Fig. 5.6 Flank openings revealing the location of the development of steep deposits

When flank simplified scheme airing of all mining sites and power, but significantly increased (almost doubled) the cost of underground transport ore to the main trunk, which is not in the middle of the field or in front of the middle, and on its flank. This scheme is often used in the development of steep deposits at low productivity of the mine. This increases the cost of underground transport, but eliminates the need for the sinking of the barrel in front of the middle third of the deposit. Application flank scheme (Fig. 5.7), unlike the central, it is advisable for the development of flat dipping ore deposits, since in this case not needed leaving protective pillar.

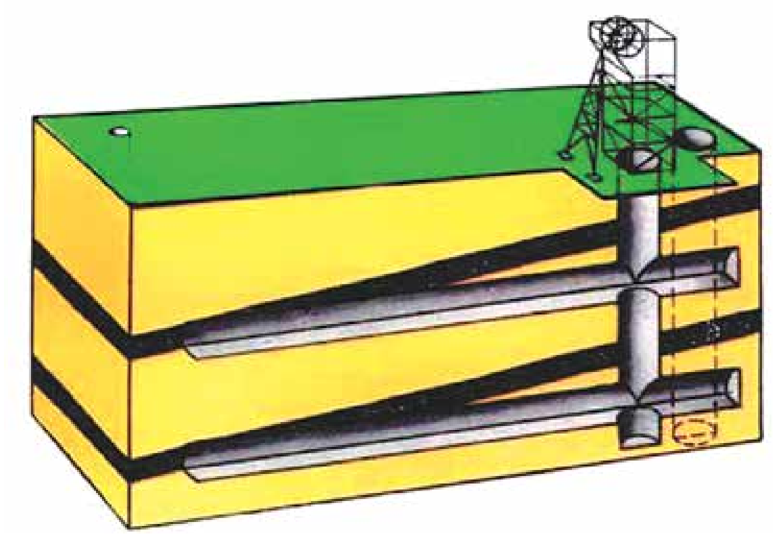


Fig. 5.7 Flank openings revealing the location of the development of gently sloping fields

3. Combined, in which reveals the main production center is located in front of the field, and on each side are placed ventilation generation (Fig. 5.8).

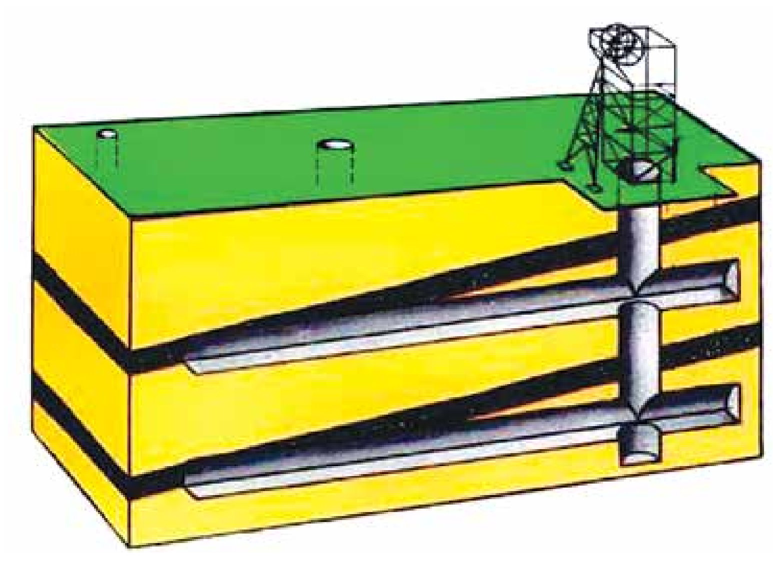


Fig. 5.8 Combined location revealing the workings

This scheme provides a minimum cost of underground transportation and creates favorable conditions for the ventilation of mining blocks and parcels. However, unlike the above-described scheme in which required at least two revealing output, combined with their arrangement must be at least three.

Often the number of the basic workings revealing than the above values. The reasons for increasing the number of openings can be:

♦ for top revealing the workings:

- Large production capacity of the mine;
- The need for the issuance of ore from several horizons;
- The need to issue several types of ore skip hoists, etc.;

♦ support for revealing the workings:

- The need for tunneling near the skip shaft auxiliary shaft for lowering and lifting people and fresh air;
- The need for additional air intake and sinking air revealing the workings at the mine using a self-propelled diesel-powered equipment;
- The need for penetration inclined or vertical shafts, equipped with overhead cranes for lowering and lifting of bulky mobile equipment;
- The need for sinking shafts for launching special backfill material;
- Excavation at major mines dedicated trunk to work independently mine sinking organization.

Thus, the large number of major mines revealing the workings may be 10 or more.

Revealing the location of the excavation must meet the following requirements:

- Revealing the production need to have outside the displacement of rocks that can be generated after the full development of the deposit;

- Will address the development of air intake must be located on the windward side of the dusty roads, dumps, steel mills, etc.;

- Will address the main production at the central or combined scheme for sustained opening circuits of the ore deposit should be placed in the center of the field or in front of its center, and with unrestrained - in front of the center of gravity of the field for the lowest cost on the underground transport of ore;

- The development of steep deposits revealing the workings, as a rule, have a footwall of the deposit, which significantly reduces the length of crosscuts. Inability to revealing the workings of such an arrangement may be due to the presence of nearby bodies of water, settlements, nature reserves, etc.

By revealing the location of the mouths of mines to meet the following requirements:

- In the mountainous terrain mouth revealing the workings must be located above the maximum water elevation in the rivers and in the landslide risk areas.

- A platform for placement of buildings and structures should be comfortable, with a slope surface within it no more than 5 - 6 degrees.

It is generally classified methods of opening ore deposits in their underground development by revealing the main type of production (which is to the issuance of the ore to the surface). If an autopsy is carried out excavations of the same type, it refers to a group of simple ways, as if to lift ore from the lower levels used by the blind trunks - then the group combined. The rise of the trunks of the ore and its transport to the galleries can be done in different ways.

Classification opening methods is as follows.

I. Simple ways of opening:

1) vertical shafts :

- A lift cage ore ;
- With skip lifting of ore;
- With conveyor lift ore;

2) inclined shaft :

- With the rise of ore into the car ;
- With skip lifting of ore;
- With conveyor lift ore;
- With the rise of ore dump;

3) galleries :

- For electric vehicles with the ore;
- With conveyor transport of ore;
- To transport the ore dump.

II. Combined methods of opening:

1) vertical blind and vertical shafts;

2) the vertical and inclined shafts blind;

3) galleries and blind vertical shaft;

4) galleries and blind inclined shaft;

5) inclined and vertical shafts blind.

Questions

1. Name basic stages in a mine development.

2. What is underground mining? Its purpose?

3. What is surface mining? Its purpose?

4. Explain how you understand what mine development is.

Vocabulary

prospecting	['prɔspektıŋ]	разведка, разведочные работы
development	[dı'veləpmənt]	подготовительные работы
sinking of shaft	['sıŋkıŋ ɔv ʃɑːft]	углубка или проходка ствола
drainage	['dreınıʤ]	дренаж, осушение, водосбор, слив
blasting	['blɑːstıŋ]	взрывные работы
loading	['ləudıŋ]	погрузка, погрузочные работы
transportation	[ˌtræn(t)spɔː'teıʃ(ə)n]	транспортирование
hoisting	[hɔıst]	подъем груза
underground mining	['ʌndəgraund 'maınıŋ]	подземная разработка
mining method	['maınıŋ 'meθəd]	система разработки
strength	[streŋθ]	крепость, прочность
wall rock	[wɔːl rɔk]	боковая порода

5.6 MINE DEVELOPMENT

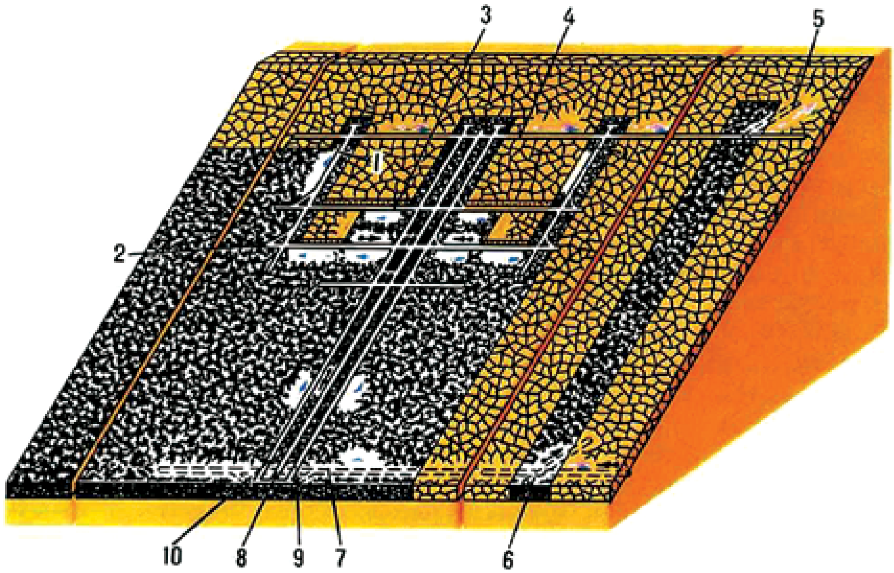
Mine development is drivage of mine working after opening of mine or its part that provides possibility of stoping execution. At development of coal (shale) deposits differs panel, horizon and level methods of mine development, and also combinations. Basic factors that determine choice of rational method of mine development are following: dip angle, water abundance of seam situation of developed part of mine towards hoisting horizon (tabl. 1).

Table 1. Characteristic of mine development methods

Rational method of mine development		**Application conditions**		
Inclined drift stair of mine	Slope stair of mine	Dip angle	Seam thickness	Water abundance of seam
Horizon with coal extraction down dip	Horizon with coal extraction upwall	3 – 12	Less than 2	Non water abundant
Panel	Horizon with coal extraction upwall			Water abundant
Horizon with coal extraction down dip	Horizon with coal extraction down dip		More than 2	Non water abundant
Panel Panel	Panel Panel	10 – 25	Anyone	Water abundant
Level	Level	More than 25		Anyone

The basic preparatory workings at mine development method are the main and level drifts; main inclined and panel drifts, slopes and footways.

At panel development method mine in the range of horizon stair divides on sequence developed districts – panels with length along the strike 800-3000 m. Each panel prepared with help of main transport and ventilation drifts and also panel inclined drifts or slopes with footways that drives from main drifts in the middle of panel or on its wings (Fig. 5.9).



1 – wing footway; 2 – deck transport drift; 3 – deck ventilation drift; 4 – main ventilation drift; 5 – main ventilation inclined drift; 6 – main transport inclined drift; 7 – main transport drift; 8 – conveyor inclined drift; 9 – manway; 10 – footway.

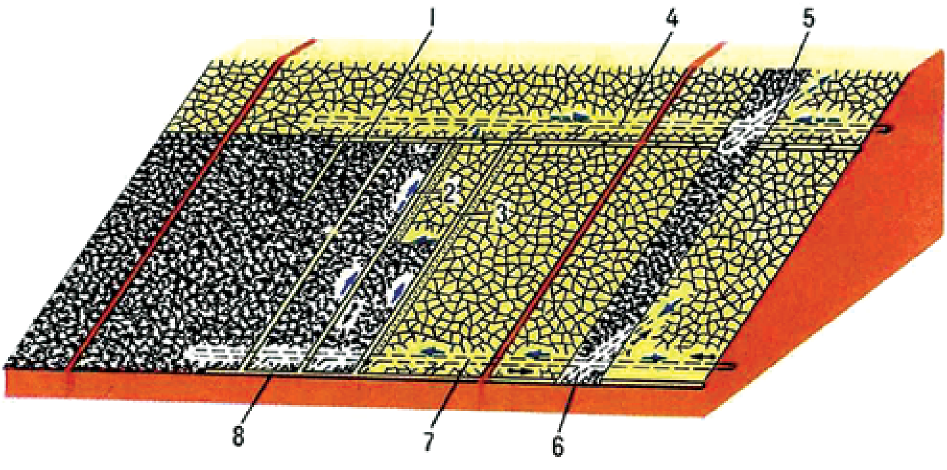
Fig. 5.9 Panel development method of inclined drift part of mine field

Panel divides on consistently developed decks 120-250 m that prepared by means of drivage of panel inclined drifts (slopes) of deck transport and ventilation drifts on coal seam.

For panel development is significant pillar mining method with reuse of deck drifts (at steady site rocks), straight-through arrangement ventilation of extraction face, position of main preparatory workings in rocks of seam soil. At non gas-bearing seams development wing gains not drives and apply U-ventilation of extraction face. If adjacent rocks unsteady, decks preparing by means of decks drifts drivage with cutting to work-out area. In panels with extended length along the strike, when drivage of deck drifts of great length by end cut is inconveniently (gas-bearing seams, poor adjacent rocks) and foresees intermediate footway for next decks preparation.

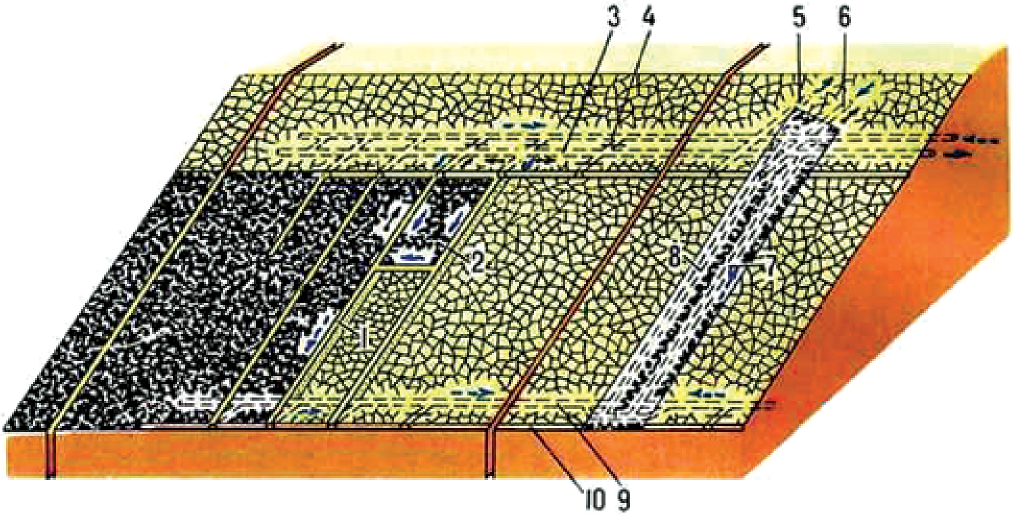
At development of self-ignition seams for avoidance of great air losses in worked-out area, usage of panel with length along the strike equal to 1000-1200 m is recommended. Panel mine development applies in all coal basins of country during thin seams development, i.e. in conditions that are favourable for belt conveyors working in panel inclined drifts (slopes). Advantage of panel development is possibility of supplying high level of stoping concentrations by means of simultaneous development of several panels on seam and few decks in each panel. Disadvantages: complexity of mine workings arrangement in mine field due to presence in transport system intermediate link, such as panel inclined drifts (slopes). Also difficulty of execution simultaneously with stoping, great volume of preparatory workings in panel, especially inclined.

Application of horizon development method caused by specialties of long pillars seam development with longwall advance upwall or down dip. At this method mine field within stair (horizon) of inclined workings 800-1200 m is divided into sequentially developed extraction pillars with width 120-250 m (Fig. 5.10, 5.11)



1 – adjusting drift; 2 – conveyor inclined drift; 3 – ventilation drift; 4 – main ventilation drift; 5 – main ventilation cross-cut; 6 – main transport cross-cut; 7 – main transport drift; 8 – dismantling chamber

Fig. 5.10 Horizon development method of inclined drift part of mine field during seam development by longwalls down dip



1 – conveyor slope; 2 – ventilation slope; 3- main transport drift; 4 – main ventilation drift; 5 - main ventilation cross-cut; 6 – main transport – cross-cut; 7 – supportive footway; 8 – manway; 9 – drainage drift; 10 – adjusting drift.

Fig. 5.11 Horizon development method of slope part of mine field during seam development upwall

The last one prepared with help of transport and ventilation slopes (inclined drifts). Extraction pillars developed, as a rule, by advance mining in inclined drift part and backward in slope part of mine field. The most simple and reliable arrangement of preparatory workings achieved in inclined drift part of mine field during seam extraction by longwalls down dip and in incline part during extraction by longwalls upwall. In these cases creates more favourable conditions for from stoping face along adjoining to it transport inclined drift (slope) immediately on the hoisting horizon of mine to shaft. For providing direct flow ventilation of extraction faces transport incline drift (slope) protects behind stoping face by artificial constructions (breaker rows, strips from cube spar, phosphogypsum and concrete blocks). During development of seams with high gas content variants of horizon development with backward ventilation of extraction face and position of main ventilation drift on one level with main transport drift are the most rational. In all cases of horizon development with seam extraction by longwalls upwall constructs drainage horizon with pump station. Fringe or sheet drainage drift connects with hoisting horizon by supportive slopes (Fig. 5.11).

On practice well-known variants of horizon development that differs by main drifts position towards seam (fringes or sheets), scheme of extraction faces preparation (with reuse of conveyor inclined drifts and slopes or it drivage with cutting to worked out area).

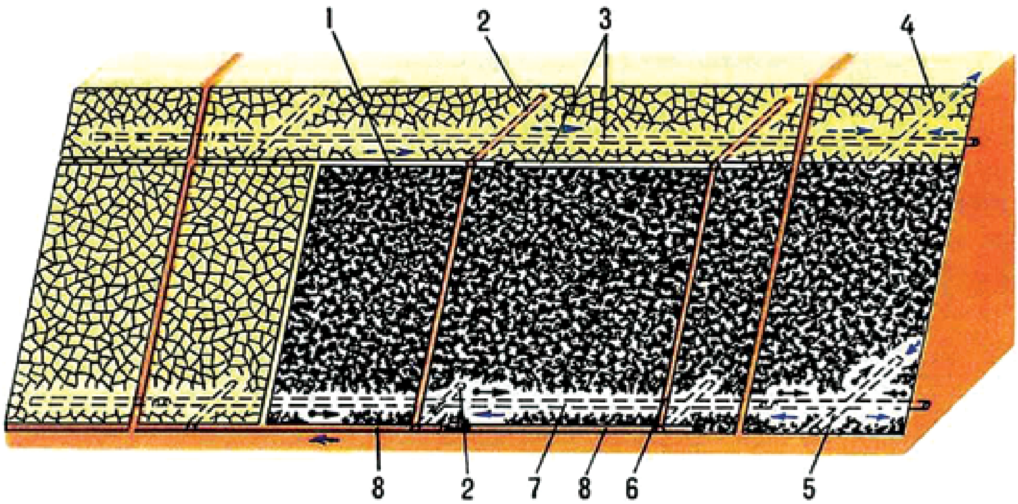
Horizon method of mine development is more widespread during thin seams development in Donetsk, Karaganda and Pechorsk coal basins. On work conditions of complex mechanization equipments in horizontal stoping face area of its usage is limited by seam dip angle 0 - 12°. Horizon method of mine development with longwall advance upwall applies on seams with thickness to 2 m (at higher thickness coal drawing intensifies and increases danger of people work in face). But with longwall advance down dip on non-water-abundant seams (presence of congregate water in longwall complicates work of mechanized support).

Basic advantages of horizon method of mine development are less than at other methods specific volume (on 1000 tone of extracted coal) of works on drivage of preparatory workings, possibility of providing stable length of longwall for all time of extraction pillar development. Disadvantages: difficulties of supportive transport implementation on long (800-1200 m) inclined mine workings; impossibility of reaching high level of mine works concentration (all mine field wing must have one stoping face).

At level development method mine field within the stair (horizon) is divided into sequentially developed strips-levels of incline height equal to 100 m and more, that prepared with help of level transport and ventilation drifts that drivage from level cross-cuts or main inclined drift (slope). On practice well-known different variants of constructive execution of this method of mine development depending on dip angle and sizes of mine field.

For development of flat seams level method of mine development with subdividing into 2-3 sublevel is more significant. In level creates one-wing extraction fields with length along the strike 300-1200 m, These wings prepared with help of district inclined drift with footway. In cases of great sizes of mine field stair down dip (400-600 m) on seam or bearing rocks drives main inclined drift (slope) with footways. These mine workings supposed for coal drawing from levels on hoisting mine horizon, also for ventilation and supportive operations.

Level development method is more significant for development of inclined and vertical (edge) seams. Levels of inclined extraction have length 100-150 m and developed by longwalls that advance along the strike of down dip. On practice applies mine development without subdividing level into sub-levels with grouping of several seams on sheet or group fringe level drifts (variant “longwall-level”, Fig. 5.12).



1 – ventilation sheet drift; 2 - interbedded cross-cut; 3 – group level ventilation drift; 4 – level ventilation cross-cut; 5 – level transport cross-cut; 6 – footway (ventilation) face entry; 7 – group level transport drift; 8 – transport sheet drift

Fig. 5.12 Level development method of coal field during development of vertical (edge) seams

Stoping on seam conducted in extraction field with length along the strike of 400-600 m that prepared with help of transport and ventilation sheet drifts.

Level method of mine development applies everywhere during development of inclined and steep seams and in particular cases during extractions of flat seams on mines of Donbass, Karaganda and Kusnetsk basins with less (3-4 km) sizes of mine field along the strike. The main advantage of this method is simple of arrangement of mine workings, Disadvantages: difficulty of providing high concentration of stoping on mine, increased exploitation expenses on drivage and supporting of mine workings.

In practice of coal deposits exploitation is not a common, when within mine field one seam or group of seams developed with application of different development methods. Combinations of panel and level, panel and horizon, level and horizon methods applies on Donetsk and Karaganda basins during extraction of flat seam with changing mine-geological conditions of occurrence within mine field.

Mine development of ore deposits includes drivage of transport preparatory workings (ore drift and cross gates) and upwall. Intersected ore deposits are separated into on levels (or panel). Development methods agree with relevant development systems and ore transport methods.

Transport by preparatory mine workings along the strike are divided on levels with height, usually 100 m (primarily 50-80 m) In the depending of dip angle and thickness of ore bodies, deposit can be prepared one (without-level) mine development or few (2 and more) levels. By transport preparatory workings upwall or along the strike deposit is subdivided on blocks and panels at flat occurrence of ore bodies. Length of blocks along the strike is 100 m and more.

Preparation of horizontal deposits realizes by main or main and panel drifts: flat, inclined and steep deposits, level drifts or level drifts and cross gates.

Questions

1. What is the mine development?
2. Name the basic preparatory mine workings
3. Where is horizon method of mine development more widespread?
4. What combinations of mine methods do you know?
5. What is advantage of panel development method?

Vocabulary

shale	[ʃəi:l]	сланец
water abundance	[’w ɔtə əbʌnd(ə)ns]]	водообильность
preparatory working	[pri’pær ət(ə)ri ’ wəkin]	подготовительная выработка
reuse	[ri’ju:z]	повторное использование
gas-bearing	[gæs biri:n]	газоносный
adjacent rock	[ə’dʒeis(ə)nt rɔk]	вмещающая порода
u-ventilation	[ju’ venti’leiʃ(ə)n]]	возвратноточная схема проветривания
intermediate link	[intə(:)mi:djət link]	промежуточное звено
cross-cut	[krɔs kʌt]	квершлаг
backward	[‘bækwəd]	обратным ходом
coal drawing	[kəul ‘drɔin]	отжим угля
breaker row	[breikə rəu]	органный ряд
drainage horizon	[‘dreinidʒ hə’raizn]	дренажный горизонт
pump station	[pʌmp steiʃ(ə)n]	водоотливная установка
widespread	[waidspred]	распространенный
flat seam	[flæt si:m]	пологий пласт
interbedded	[intebədded]	промежуточный
cross gate	[krɔs geit]	орт
steep seam	[sti:p si:m]	крутопадающий пласт
stair	[steə]	ступень
wing	[win]	крыло
straight-through arrangement	[streit θru: ə’reidʒm ənt]	схема подготовки
end cut	[end kʌt]	тупиковая выработка
dismantling chamber	[dis’mæn tlin ’tʃeim-bə]	демонтажная камера
cube spar	[kju:b spa:]	ангидрид
phosphogypsum	[‘fɔsf(ə)’ dʒipsəm]	фосфогипс
congregate	[’kɔngrigeit]	скопляться
specific volume	[spi’sifik vɔljum]	удельный объём
intersect	[intə:sekt]	пересекать, вскрывать
relevant	[’relivənt]	соответствующий

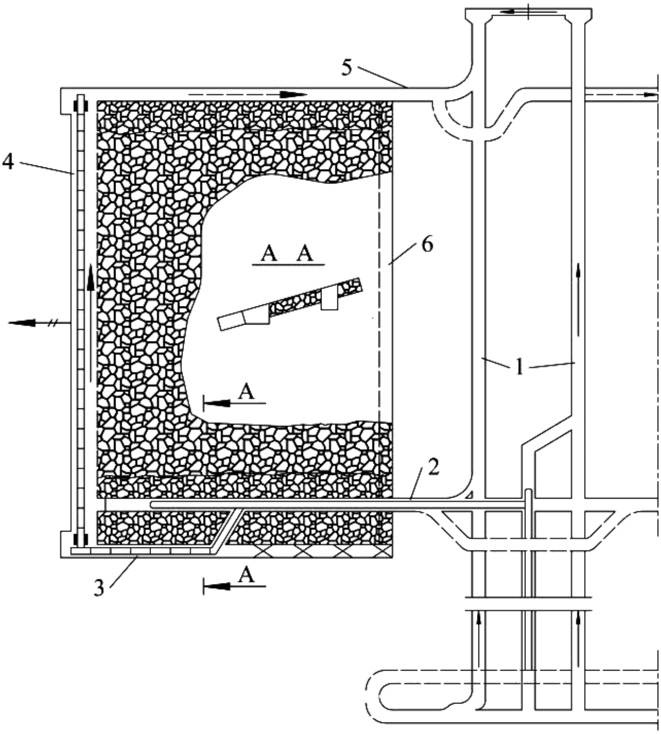
5.7 DEVELOPMENT OF COAL DEPOSITS

Mode of occurrence of coal seams differs by great variety. This, and also economic reasons determine appliance of different mining technologies. As a rule, for coal breaking use mechanical items or explosives. More rarely, hydraulic (hydraulic coal mining) and chemical (underground coal gasification). Stoping technology assumes from one side continuous presence of miners in longwall or on the other side manless mining. There are different methods of coal extraction: by shearers, ploughs, pick hammers and explosives. The most perspective method of extraction is usage of shearers or ploughs in combination with mechanized supports.

Mining methods can be with long or short faces.

Mining method with long face can be longwork, pillar and combined. Each of these mining methods has variants in terms of direction of longwall advance towards elements of seam occurrence (along the strike, down dip and upwall), preparation method of level or deck to stoping, but during thick seams mining from method of its extraction: with and without division into layers (incline, horizontal, cross-incline).

Longwall mining method. Synchronism of preparatory workings drivage and stoping in level or panel is significant for this mining method. Preparation of stoping face is realized (Fig. 5.13) at distance not less than 25-50 m from inclined (inclined drift, slope, shaft with footway) or horizontal mine workings by means of transport and ventilation workings drivage and face entry between them. Mechanized equipment is installed in face entry to begin coal stoping. Stoping face moves from inclined (horizontal) mine working boundaries of level (deck). Behind the face in worked-out area drives all adjacent mine workings. Also other variants are applied that depend upon dip angle and differs by development methods, drive of mine workings, etc. Longwall mining method is characterized by less primary volume of drivage of workings during preparing of new longwall. Its main disadvantages are as followes: hard conditions of drifts supporting, great air losses through worked-out area, possibility of unforeseen faulting and longwall stops for this reason. Longwall mining method embarrasses using of high-productivity complexes and devices. That is why its usage must be limited by thin seams that bedded on big depths and single unguarded seams, which are dangerous on sudden coal and gas outbursts or pressure bursts.

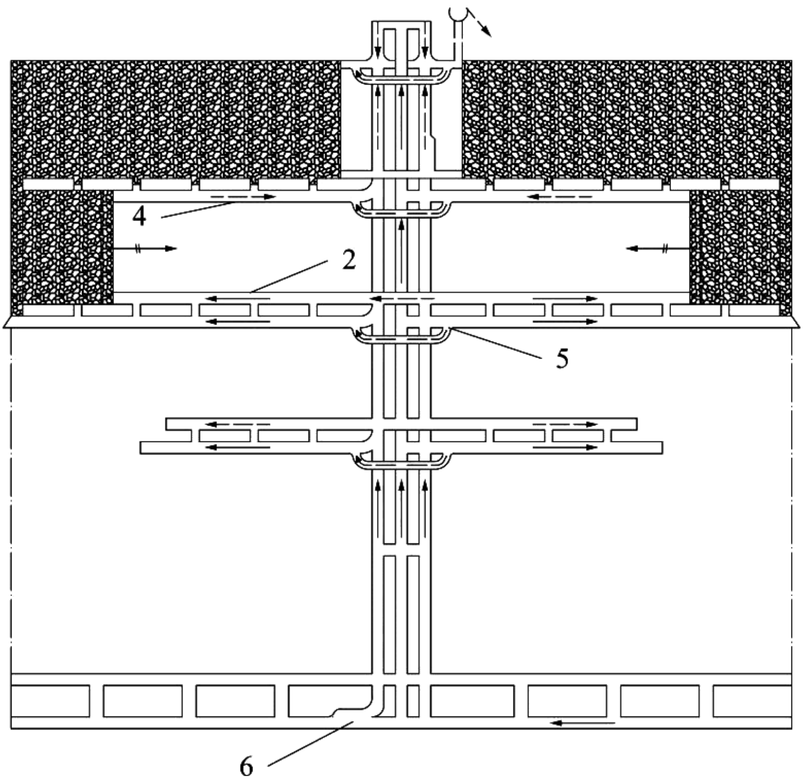


1 — inclined mine workings; 2 — level belt drift; 3 — gain; 4 — stoping face (longwall); 5 — level ventilation drift; 6 — face entry.

Fig. 5.13 Longwall mining method «longwall—level»

Pillar mining method. For pillar mining method is significant drivage of preparatory workings before start of stoping. These mine workings square up coal deposits within level, deck, extraction pillar.

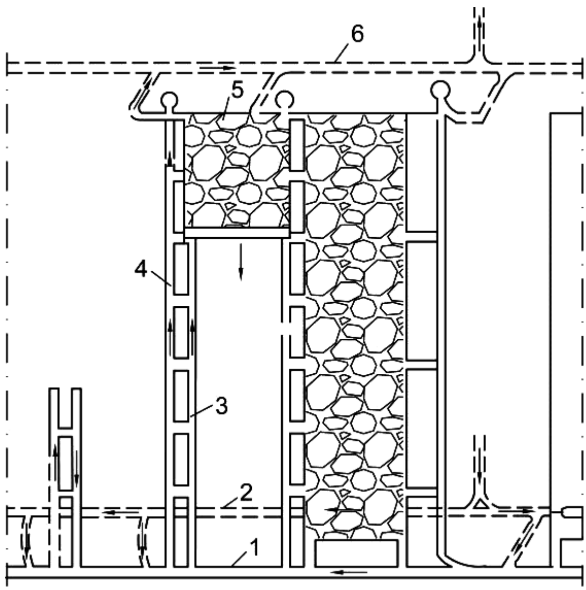
Variant of pillar mining method along the strike at panel development method represented on Fig. 5.14. Near main haulage drift at incline mine workings constructs acceptance-sending bay that provides acceptance and forwarding of loads from shaft bottom to stoping faces and vice versa. From bay to upper (or lower) panel boundary drives inclined mine workings: inclined drift (slope) and gains that uses for air delivery, relieving transport, descend-hoist of people. Coal transported by belt conveyors on inclined drift (slope). From inclined mine workings on both sides drives deck drifts (transport and ventilation) with service mine workings (cross slits). According to development, prepares next deck and drives new drifts. Pillar mining method removes disadvantages that longwall mining method has. However, it significant by great losses (on 5-7%) of coal in pillars and increased primary volume of preparatory mine workings drivage. It usage allows to increase load on stoping face and improve basic technical-economic indices.



1 — haulage drift; 2 — conveyor deck drift 3 — face entry; 4 — ventilation deck drift; 5 — provisional acceptance-sending bay; 6 — lower acceptance-sending bay

Fig. 5.14 Mining method with long pillars along the strike

Expansion receives mining method by long pillars with stoping face advancing down dip (Fig. 5.15) or upwall. From mine working that intersecting seam drives main fringe haulage drift. Parallely to fringe drift drives sheet drift and two inclined mine workings to ventilation horizon where connects them with face entry. Mining method with face displacement down dip allows to providing decreasing specific volume of drivage and supporting mine workings; steadying length of longwall in the range of extraction pillar (that especially necessary during fitting of stoping face by mechanized complex of equipment or device); simple and reliable scheme of underground transport; straight-through arrangement of ventilation with air delivery to methane emission source (stoping face, coal on conveyor, preparatory mine working). Disadvantages: great volume of inclined mine workings. It drives and exploitation is more expensive than horizontal. At high water abundance uses analog mining method with stoping face displacement upwall. Both variants of mining methods thanks to technical economic advantages are more progressive for extraction of thin and average thickness seams with dip angle to 12—15°.

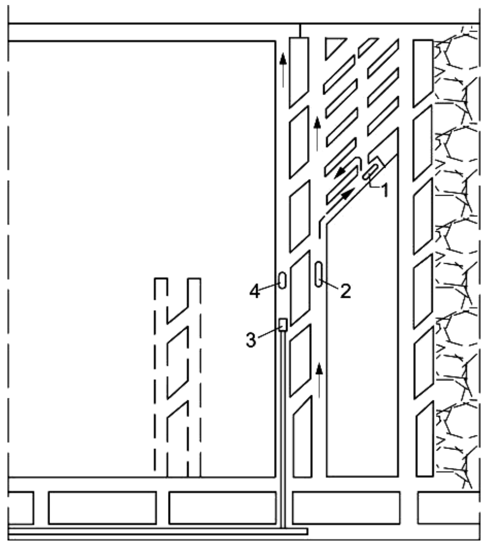


1 — sheet drift; 2 — main haulage fringe drift; 3 — conveyor inclined drift; 4 — ventilation gain; 5 — face entry; 6 — main ventilation fringe drift.

Fig. 5.15 Mining method by long pillars down dip

Mining method with short faces divided on chamber and chamber-pillar. At chamber mining methods length of chambers can be 200 – 300m; width 4 – 15m, rib pillars from 2 to 6m, zonal – 5 – 10 m. Collapse of roof must had place after its development, so sizes of face on thin seams equal to 50 – 150 m.

Chamber-and-pillar method differs from chamber by that rib pillars partially reclamates (Fig. 5.16) whereby increases efficiency of coal extraction. Between conveyor and ventilation drifts drives one or two chambers with width 3,5 – 5 m, after that filling rib pillar with width 15 – 20 m. Rib pillars filling by entry ways on 3,5 – 7 m with technological pillars leaving between them with width 0,6-1 m. Drifts and chambers supporting by anchor support; entry ways do not supporting. Basic conditions of usage technology with short faces are following: low quality of coal (usually energetic with increased ash content); seam thickness 0,8 – 3,5 m; dip angle of seam to 15° (determines by possibility of mobile equipment work); rocks of medium and above-medium steadiness; volume of gas to 15 m3 on 1 tone of extraction; depth of mine works to 300 m (as with depth distinctly increases losses of coal in deposits), etc.



1 — shearer; 2 — shuttle car; 3 — telescope conveyor; 4 — mechanically wagon drill

Fig. 5.16. Chamber-and-pillar mining method with pillar extraction by entry ways

In European countries primary expansion receives mining methods with long stoping faces. On mines of USA, Canada and Australia uses mining methods with short faces. It’s connected with favourable geological conditions.

Questions

1. What mining methods do you know?

2. Name the disadvantages of pillar mining method

3. Mining method with long face can be…

4. What is the difference between chamber and chamber-pillar methods?

5. In what countries mining methods with short faces are use?

Vocabulary

Acceptance-sending bay	[ək'septəns sendin' bei]	Приёмно-отправительная площадка
Cross slit	[krɔs slit]]	Сбойка
Chamber-and-pillar method	['tʃeimbə ənd 'pilə meΘəd]	Камерно- столбовая система разработки
Dip angle	[dip ængl]	Угол падения
Along the strike	[ælɔn straik]	По простиранию
Down dip	[daun dip]	По падению
Upwall	[ʌpwəl]]	По восстанию
Stoping face	[stɔpin' feis]	Очистной забой
Shearer	['ʃi əre]	Очистной комбайн
Plough	[plau]	Струг
Pillar mining method	['pilə 'mainin meΘəd]	Столбовая система разработки
Longwall mining method	[lɔnwɔl meΘəd]	Сплошная система разработки
Mining method with long face	['mainin meΘəd wiʃ lɔ n feis]	Система разработки с длинным забоем
Mode of occurrence	[məud of ə'kʌr(ə)ns]	Условия залегания
Level	['levl]	Этаж
Deck	[dek]	Ярус
Face entry	[feis 'entri]	Разрезная печь
Inclined drift	[in'klaind drift]	Бремсберг
Haulage drift	[hɔ:ledʒ drift]	Откаточный штрек
Footway	[futwei]	Ходок
Pillar	['pilə]	Целик, столб
Sheet drift	[ʃi:t drift]	Пластовый штрек
Fringe drift	[frin dʒ drift]	Полевой штрек
Methane emission	[meΘən əmiʃ(ə)n]	Выделение метана
Outburst	['autb ə:st]	Выброс
Rib pillar	[rib 'pilə]]	Междукамерный целик
Shaft bottom	[ʃa:ft 'bɔtəm]	Околоствольный двор
Square up	[skweə ʌp]	Оконтуривать
Worked-out area	[wə:kd ʌut eəriə]	Выработанное пространство
Filling	['filin]	Погашение

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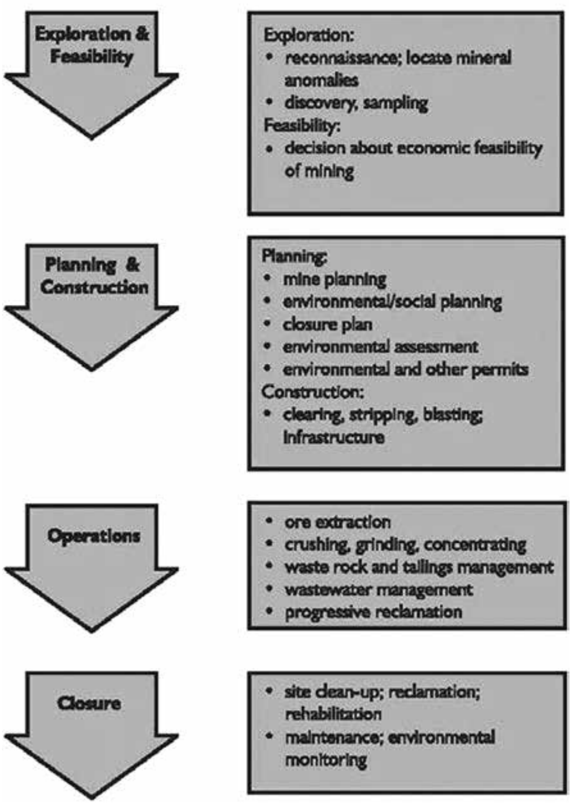
Chapter 6

6.1 STAGES IN THE LIFE OF A MINE

The overall sequence of activities in modern mining is often compared with the five stages in the life of a mine:

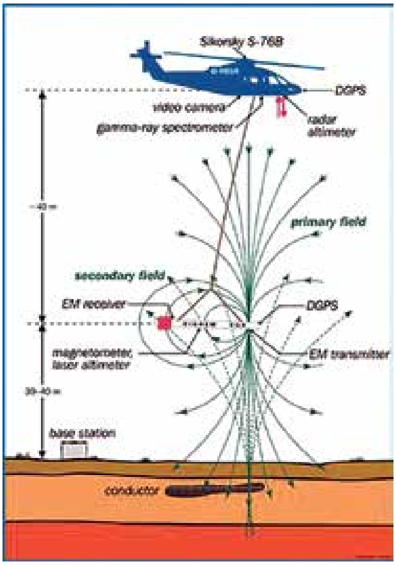
- prospecting;
- exploration;
- development;
- exploitation;
- reclamation.



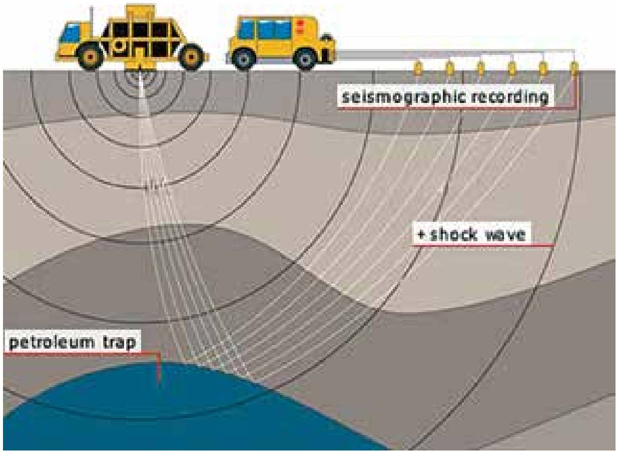
Prospecting and exploration, precursors to actual mining, are linked and sometimes combined. Geologists and mining engineers often share responsibility for these two stages. Likewise, development and exploitation are closely related stages; they are usually considered to constitute mining proper and are the main province of the mining engineer. Reclamation has been added to these stages since the first edition, Closure and reclamation of the mine site has become a necessary part of the mine life cycle because of the demands of society for a cleaner environment and stricter laws regulating the abandonment of a mine. The overall process of developing a mine with the future uses of the land in mind is termed sustainable development.

Prospecting

Prospecting, the first stage in the utilization of a mineral deposit. It is the search for ores or other valuable minerals (coal or non-metallic). Because mineral deposits may be located either at or below the surface of the earth, both direct and indirect prospecting techniques are employed.



Air : aerial photography, airborne geophysics, satellite



Surface : ground geophysics, geology

The direct method of discovery, normally limited to surface deposits, consists of visual examination of either the exposure (outcrop) of the deposit or the loose fragments that have weathered away from the outcrop. Geologic studies of the entire area augment this simple, direct technique. By means of aerial photography, geologic maps, and structural assessment of an area, the geologist gat hers evidence by direct methods to locate mineral deposits. Precise mapping and structural analysis plus microscopic studies of samples also enable the geologist to locate the hidden as well as surface mineralization.

Exploration

The second stage in the life of a mine, exploration, determines as accurately as possible the size and value of a mineral deposit, utilizing techniques similar to but more deeply than those used in prospecting. The line of demarcation between prospecting and exploration is not sharp; in fact, a distinction may not be possible in some cases. Exploration generally shifts to surface and subsurface locations, using a variety of measurements to obtain a more positive picture of the extent and grade of the ore body.

Representative samples may be subjected to chemical, metallurgical, X ray, spectrographic or radiometric evaluation techniques that are meant to enhance the investigator's knowledge of the mineral deposit. Samples are obtained by chipping outcrops, trenching, tunneling and drilling; in addition, borehole logs may be provided to study the geologic and structural makeup of the deposit.

The feasibility study includes an economic analysis of the rate of return that can be expected from the mine at a certain production rate

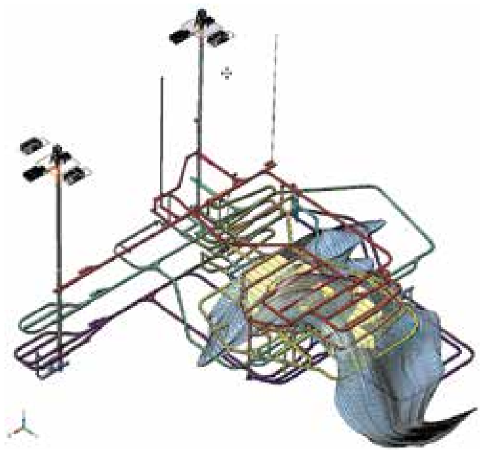
After suitable deposits have been found and their worth proved, development, or preparation for mining is necessary. It requires careful planning and layout of access openings for convenience, safety, and stability. For underground mining, the sinking of shafts, driving of adits and various other underground openings, and providing for drainage and ventilation. For all this, equipment must be provided for such purposes as blasting, loading, transporting, hoisting, power transmission, pumping, ventilation and storage.

Development

In the third stage, development, the work of opening a mineral deposit for exploitation is performed. With it begins the actual mining of the deposit, now called the ore. Access to the deposit must be gained either:

1. By stripping the overburden, which is the soil and/or rock covering the deposit, to expose the near-surface ore for mining or

2. By excavating openings from the surface to access more deeply buried deposits to prepare for underground mining.



In either case, certain preliminary development work, such as acquiring water and mineral rights, buying surface lands, preparing permit applications and an environmental impact statement (EIS), will generally be required before any development takes place. When these steps have been achieved, the provision of a number of requirements such as access of roads, power sources, mineral transportation systems, mineral processing facilities, waste disposal areas, offices, and other support facilities must precede actual mining in most cases.

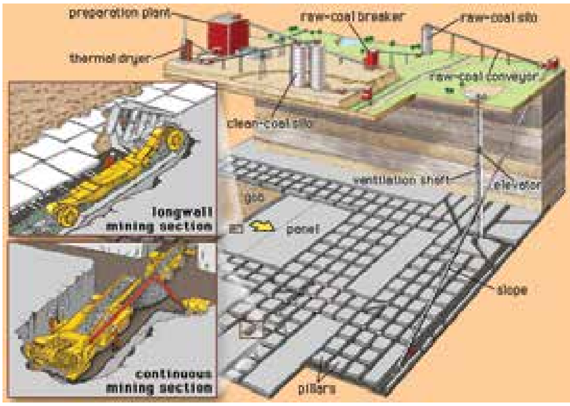
Some nonmetallic mines have no overburden to remove; the mineral is simply excavated at the surface. Development for underground mining is generally more complex and expensive. It requires careful planning and layout of access openings for efficient mining, safety, and permanence. The principal openings may be shafts, slopes, or adits; each must be planned to allow passage of workers, machines, ore, waste, air, water and utilities. Many metal mines are located along steeply dipping deposits and thus are opened from shafts, while drifts, winze and raises serve the production areas. Many coal and nonmetallic mines are found in nearly horizontal deposits. Their primary openings may be drifts or entries, which may be distinctly different from those of metal mines.

Exploitation

Exploitation, the fourth stage of mining, is associated with the actual recovery of minerals from the earth in quantity. Although development may continue, the emphasis in the production stage is on production. Usually, only enough development is done prior to exploitation to ensure that production, once started, can continue uninterrupted throughout the life of the mine. The mining method selected for exploitation is determined mainly by the characteristics of the mineral deposit and the limits imposed by safety, technology, environmental concerns, and economics. Geologic conditions, such as the dip, shape, and strength of the ore and the surrounding rock, play a key role in selecting the method. Traditional exploitation methods fall into two broad categories based on locale: surface or underground.

Surface mining includes mechanical excavation methods such as open pit and open cast (strip mining) and aqueous methods such as placer and solution mining. Underground mining is usually classified in three categories of methods: unsupported, supported, and caving.

Exploitation is associated with the actual recovery in quantity of minerals from the earth.



The mining method selected for exploitation is determined mainly by the characteristics of the mineral deposit and the limits imposed by safety, technology, and economics.

Geologic conditions, such as deposit dip and shape and strength of the ore and wall rock, play a key role in selecting the method.

The safety, health and welfare of people engaged in work or employment is crucial. The goal of all occupational health and safety actions is to develop a safe work environment.

Protection of the health and safety of employees from excessive or undesirable stresses in the occupational environment is all important. These hazards include reduced natural ventilation and light, difficult and limited access and exits, exposure to air contaminants, fire, flooding, and explosion.

Reclamation

Mine reclamation is the process of restoring land that has been mined to a natural or economically usable purpose. Although the process of mine reclamation occurs once mining is completed; the preparation and planning of mine reclamation activities occur prior to a mine being permitted or started. Mine reclamation creates useful landscapes that meet a variety of goals ranging from the restoration of productive ecosystems to the creation of industrial and municipal resources. In the United States, mine reclamation is a regular part of modern mining practices. Modern mine reclamation minimizes and mitigates the environmental effects of mining.

Closing and liquidation of mines is only possible when their balance coal reserves are exhausted and mining operations are executed on beyond-the-balance reserves with very low labour productivity and technologic and economic results.

The purpose of the land reclamation is to:

- Stabilize abandoned mined areas to decrease erosion and sedimentation, support desirable vegetation and improve offsite water quality and or quantity;
- Maintain or improve landscape visual and functional quality;
- Protect public health, safety and general welfare.

Questions

1. Name basic stages in a mine development.
2. What is geological prospecting? Its purpose?
3. Explain how you understand what feasibility study is.
4. What do development and building of a mine incorporate?
5. By what parameters is mining method defined?
6. Why is health protection of the workers so important? What are the main dangers that a miner can encounter?
7. When should a mining enterprise be closed? What is land reclamation? Its purpose?

Vocabulary

prospecting	['prɔspektɪŋ]	разведка, разведочные работы
stages in the life	[steɪʤ ɪn ðə laɪf]	стадии срока службы
development	[dɪ'veləpmənt]	подготовительные работы
metallic ores	[mə'tælɪk ɔː]	металлсодержащие руды
blasting	['blɑːstɪŋ]	взрывные работы
loading	['ləudɪŋ]	погрузка, погрузочные работы
layout	['leɪaut]	схема, план, разработка

6.2 PROSPECTING

Prospecting is the first stage of the territory geological analysis (second - exploration): physical search for minerals, fossils, precious metals or mineral specimens.

Prospecting is a small-scale form of mineral exploration which is an organized, large scale effort undertaken by mineral resource companies to find commercially viable ore deposits.

Prospecting is physical labour, involving traversing (traditionally on foot or on horseback), panning, sifting and outcrop investigation, looking for signs of mineralisation. A prospector must also make claims, meaning they must erect posts with the appropriate placards on all four corners of a desired land they wish to prospect and register this claim before they may take samples.

Prospecting is the first stage in the utilization of a mineral deposit. It is the search for ores or other valuable minerals (coal or non-metallic). Because mineral deposits may be located either at or below the surface of the earth, both direct and indirect prospecting techniques are employed.

The direct method of discovery, normally limited to surface deposits, consists of visual examination of either the exposure (outcrop) of the deposit or the loose fragments that have weathered away from the outcrop. Geologic studies of the entire area augment this simple, direct technique. By means of aerial photography, geologic maps, and structural assessment of an area, the geologist gets evidence by direct methods to locate mineral deposits. Precise mapping and structural analysis plus microscopic studies of samples also enable the geologist to locate the hidden as well as surface mineralization.

Geophysical prospecting

Geophysical prospecting combines the sciences of physics and geology to locate ore deposits. Familiar examples of geophysical prospecting include the use of geiger counters for detecting radioactive uranium deposits and magnetic surveys to find iron deposits.

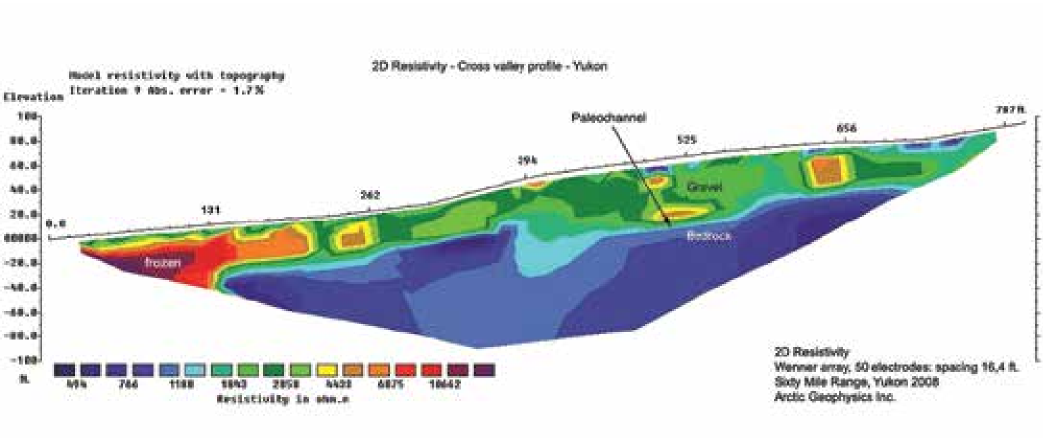
Five major geophysical methods—magnetic, gravimetric, electrical, radiometric, and seismic—are successfully utilized in mineral exploration. Some of these methods require complex and costly instruments and highly trained operators. Others, however, are relatively simple and inexpensive.

The purpose is to locate favorable locations by means of:

Air : aerial photography, airborne geophysics, satellite

Surface : ground geophysics, geology

Geophysical prospecting is the process of investigating geological formations with the use of various observational tools to collect data about their composition, size, and nature. Geologists use specialized equipment to look into the earth and learn more about petroleum deposits, rock, soils, and other objects that may be present. Mining and petroleum companies rely on this process to identify sites of interest and evaluate them to determine if they are worth further exploration.



In geophysical prospecting, people can use a variety of sensors above and below the ground for data collection. This can include flying in planes over the site to snap aerial photos, taking samples to collect data, using sonar to map out underground formations, and measuring the electrical conductivity and other physical characteristics of the soil. The goal is to collect as much information as possible to help people determine whether the site contains useful materials, so they do not have to invest in development of the site only to find that it is not useful.

Geologists focus on searches for specific materials of interest at a site, although they will document incidental findings along the way. Specialists working for a diamond company, for example, want to find diamonds or indicator minerals commonly associated with diamonds. The site may have other materials of use, and geologists could determine if the site should be sold to another company for resource exploitation in the event that it does not contain minerals of interest to their employers.

Exploration

The second stage in the life of a mine, exploration, determines as accurately as possible the size and value of a mineral deposit, utilizing techniques similar to but more deeply than those used in prospecting. The line of demarcation between prospecting and exploration is not sharp; in fact, a distinction may not be possible in some cases. Exploration generally shifts to surface and subsurface locations, using a variety of measurements to obtain a more positive picture of the extent and grade of the ore body.

Representative samples may be subjected to chemical, metallurgical, X ray, spectrographic or radiometric evaluation techniques that are meant to enhance the investigator's knowledge of the mineral deposit. Samples are obtained by chipping outcrops, trenching, tunneling and drilling; in addition, borehole logs may be provided to study the geologic and structural makeup of the deposit.

The feasibility study includes an economic analysis of the rate of return that can be expected from the mine at a certain production rate.

After suitable deposits have been found and their worth proved, development, or preparation for mining is necessary. It requires careful planning and layout of access openings for convenience, safety, and stability. For underground mining, the sinking of shafts, driving of adits and various other underground openings, and providing for drainage and ventilation. For all this, equipment must be provided for such purposes as blasting, loading, transporting, hoisting, power transmission, pumping, ventilation and storage.

Questions

1. What types of prospecting do you know ?

2. What is geological prospecting? Its purpose?

3. Explain how you understand what aerial photography is.

4. Explain how you understand what airborne geophysics is.

5. Explain how you understand what ground geophysics is.

Vocabulary

sinking of shaft	['sɪŋkɪŋ ɔv ʃɑːft]	углубка или проходка ствола
drainage	['dreɪnɪʤ]	дренаж, осушение, водосбор, слив
damage	['dæmɪʤ]	повреждение, ущерб, убыток
transportation	[ˌtræn(t)spɔː'teɪʃ(ə)n]	транспортирование
hoisting	[hɔɪst]	подъем груза
wall rock	[wɔːl rɔk]	боковая порода

6.3 METHODS OF MINING

Surface mining (also commonly called strip mining) is a type of mining in which soil and rock overlying the mineral deposit (the overburden) are removed. It is the opposite of underground mining, in which the overlying rock is left in place, and the mineral removed through shafts or tunnels.

Surface mining is used when deposits of commercially useful minerals or rock are found near the surface; that is, where the overburden is relatively thin or the material of interest is structurally unsuitable for tunneling.

To expose and mine the ore, it is generally necessary to excavate and relocate large quantities of waste rock. The main objective in any commercial mining operation is the exploitation of the mineral deposit at the lowest possible cost with a view of maximizing profits. It is generally conceded that surface mining is more advantageous than underground mining in terms of recovery, grade control, economy, flexibility of operation, safety, and the working environment.

Open pit terminology

The following are terms that commonly occur in open pit mine planning and are used throughout this chapter. These terms are illustrated in Figure 1, which shows a pit section through an idealized ore body.

A bench may be defined as a ledge that forms a single level of operation above which mineral or waste materials are mined in a bench face. The mineral or waste is removed in successive layers, each of which is a bench. Several benches may be in operation simultaneously in different parts of the open pit mine. The bench height is the vertical distance between the highest point of the bench, or the bench crest, and the bottom of the bench.

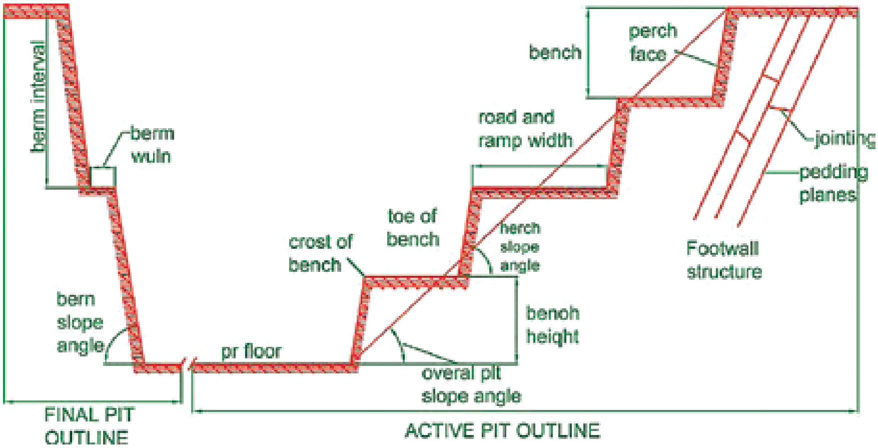


Fig. 6.1 Pit section through an idealized tabular ore body

The bench slope is the angle, measured in degrees, between the horizontal and an imaginary line joining the bench toe and crest.

Pit limits are the vertical and lateral extent to which the open pit mining may be economically conducted.

In order to enhance the stability of a slope within the pit and for safety reasons berms may be left. A berm is a horizontal shelf or ledge within the ultimate pit wall slope. The berm interval,

berm slope angle, and berm width are governed by the geotechnical configuration of the slope.

For the duration of open pit mining, a haul road must be maintained into the pit. A spiral system is an arrangement whereby the haul road is arranged spirally along the perimeter walls of the pit so that the gradient of the road is more or less uniform from the top to the bottom of the pit.

Haul road width is governed by the required capacity of the road and type of haulage unit.

The angle of repose or angle of rest is the maximum slope at which a heap of loose material will stand without sliding.

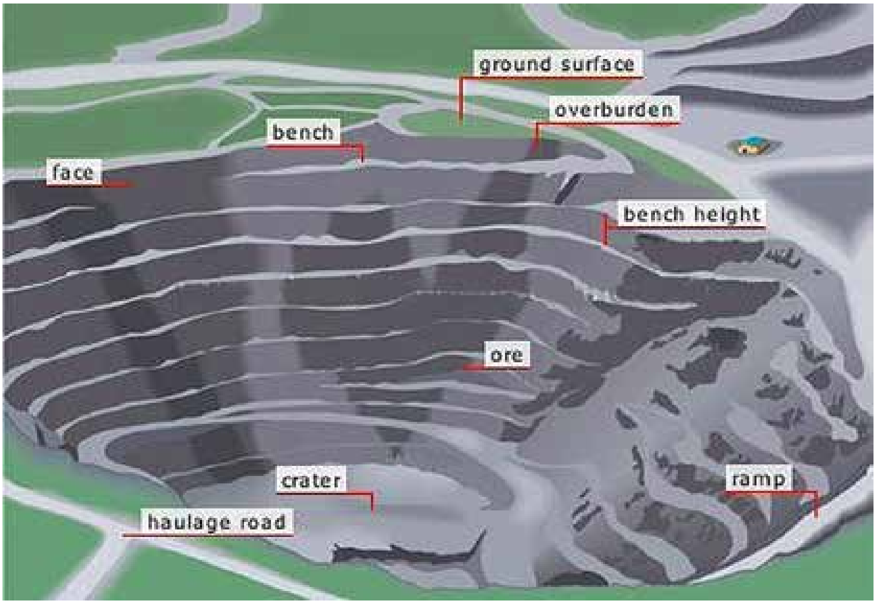


Fig. 6.2 Component of an open-pit

Fig. 6.3 Photo of a quarry

Geotechnical investigations

The behavior and stabilities of rock masses are controlled mainly by the nature and orientation of the discontinuities. A successful exploration program culminates in drilling and sampling information, useful in establishing mine operation parameters, geotechnical design, geohydrologic conditions, and mineral processing or metallurgical extraction.

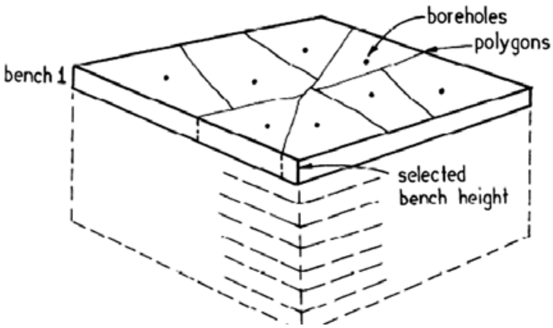


Fig. 6.4 Block model of an ore body

Drilling must be supervised by an experienced exploration geologist to record hole depths, core losses, and any other significant aspects (e.g., water losses) during drilling. Continuous liaison between the exploration geologist and the mine planning engineer is important to ensure that all mining-related data are collected.

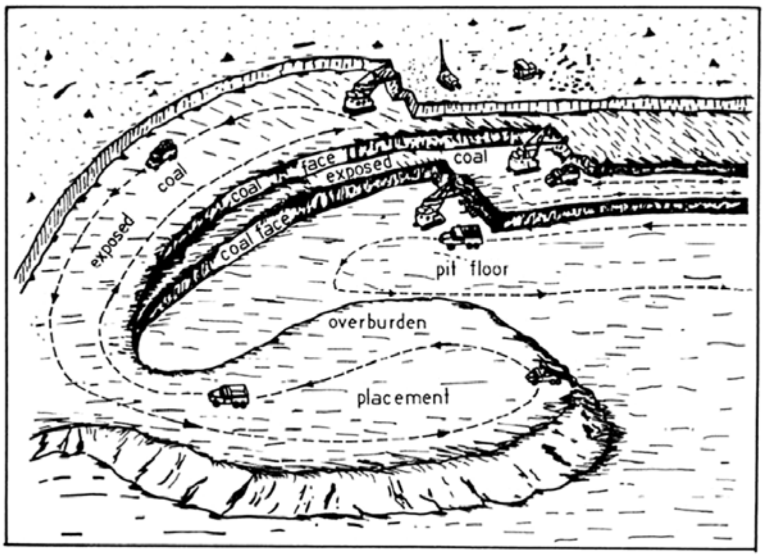


Fig. 6.5 Open-pit: flat-lying seams

Geohydrologic investigations

By far, the most important effect of the presence of groundwater is the reduction in stability resulting from water pressures within discontinuities in the rock mass.

Open pit feasibility studies

After a mineral deposit has been discovered and evaluated sufficiently to be considered an ore deposit, the problem then becomes how to mine and process that ore body in a way that maximizes the net present value (NPV) within a practical operating format.

Pit Development

Clearing and grubbing. This involves clearing the property of trees and shrubs and then removing the stumps and roots to insure a homogeneous topsoil. Grubbing is often done with rake-like grubbing attachments on agricultural tractors or dozers.

Topsoil removal. Regulations dictate that the topsoil be removed and ultimately replaced upon graded spoils. Topsoil can either be stockpiled at the side of the pit area for later redistribution or hauled immediately to the graded area for redistribution.

Selection and sizing of excavating equipment

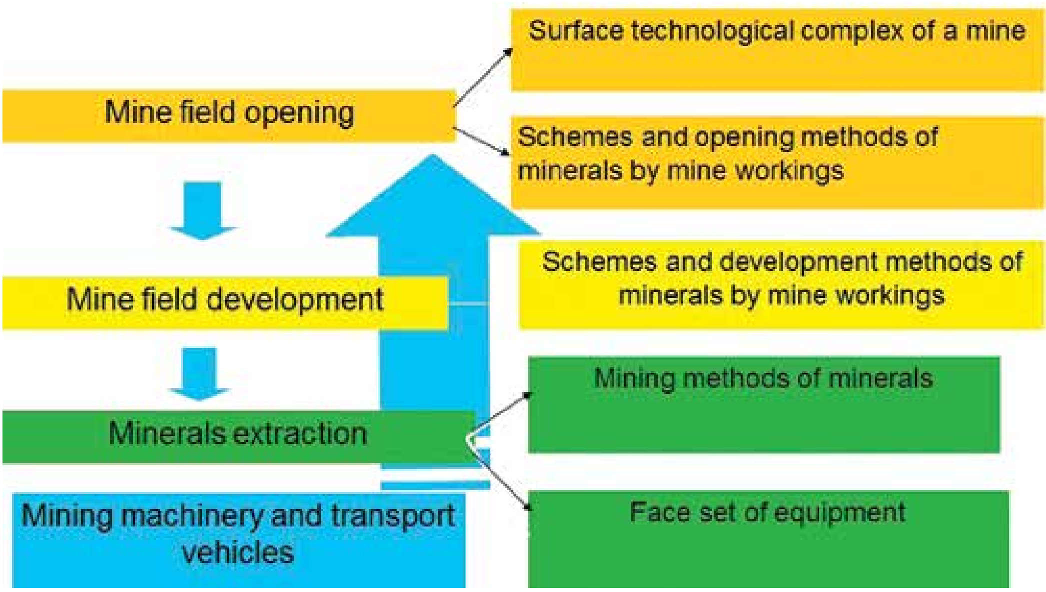
The main operations in a surface mine - ground preparation, excavation and loading, transport, and mineral treatment are interdependent, and the optimum cost per ton may not be obtained by attempting to minimize each of the individual operational costs.

The selection of the excavator or loader is of prime importance because it largely determines the other equipment required and the mode of operation; it is the key to low-cost production but is not usually the starting point in planning.

Environmental and health issues

Mining companies are required by Federal, State, and local laws to restore the mined land after surface mining is completed; as a result, the overburden and topsoil are stored after removal so that they can be replaced and native vegetation replanted.

Structure of underground mining technology



Basic conception of mineral deposits underground mining

Underground mining – extraction of the minerals in the Earth's interior without damage of the land surface by way of drivage the system of mine workings.

Materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, oil shale, rock salt and potash.

Modern mining processes involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials and finally reclamation of the land to prepare it for other uses once the mine is closed.

The overall sequence of activities involved in modern mining can be expressed as stages in the life of a mine.

There are three stages in underground mining: **opening, development and extraction.**

Extraction of the minerals by underground method is carried out by mining enterprises at allocated for them deposits or areas.

Mine field (ore field) is part of a deposit at which a mining enterprise extracts minerals.

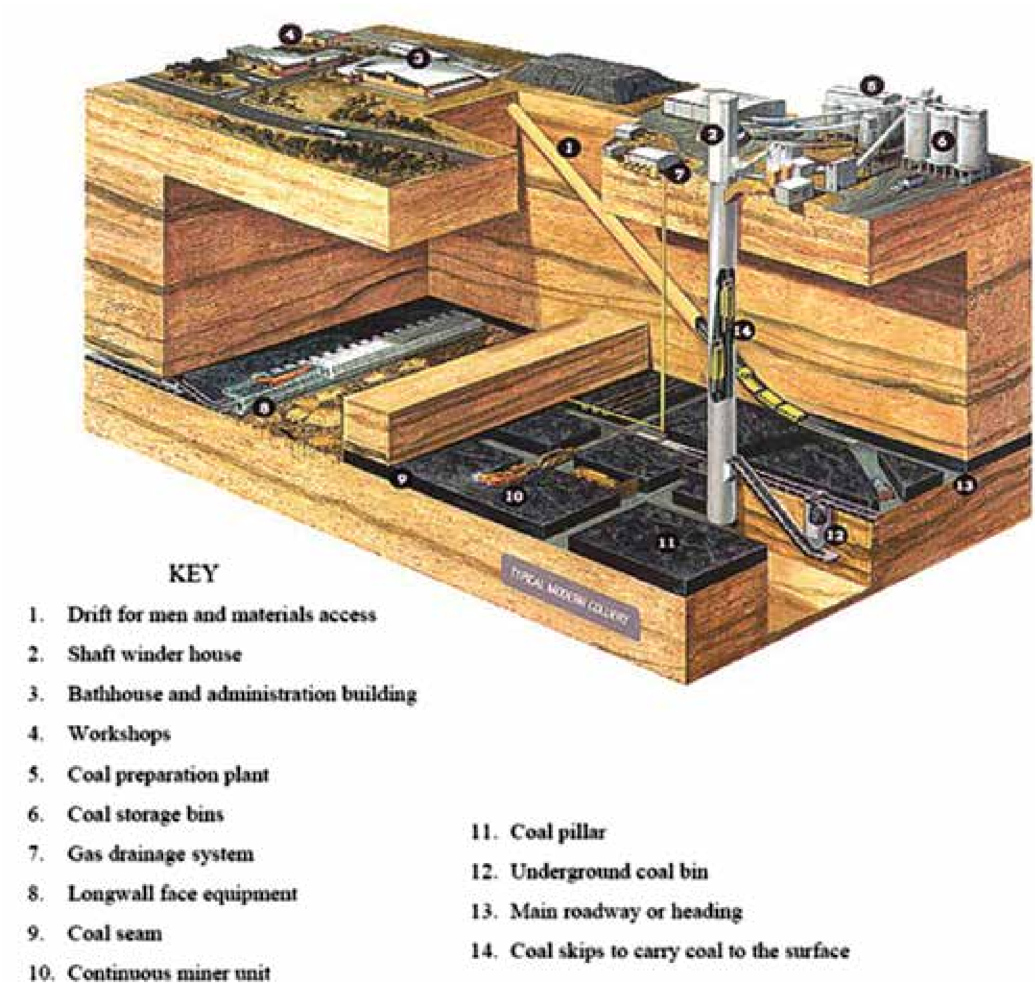
Mine allotment (mine take) is an area of a surface allocated for agricultural needs and is given to a mining enterprise.

Mine is a mining enterprise that mines a deposit by underground method or its part and that is consist of one or several mines, adits or other production units.

Structure of mining

Underground mining is something that is carried out when the mineral deposit is located deep down under the surface of the earth. Most coal seams are too deep underground for opencast mining and require underground mining, which method currently accounts for about 60% of world coal production.

When an underground mine is in development, miners start out by first digging two or more openings, or tunnels, deep inside the earth close to the place where they think the precious minerals are situated.



Depending on where the vein of ore is in relation to the surface, tunnels can either be vertical, horizontal, or in some cases even slope. An opening allows the miners to move around the mine and in and out with the tools they use and these openings can also be utilized as a path for carrying the rock that has been mined by conveyor belts to the outside.

Principal methods of underground mining (technologies of stoping)

Technology of stoping – aggregate of production processes, operations and actions that are carried out in a definite consequence in space and time and directed to gaining of marketable coal.

Longwall mining accounts for about 50% of underground production. The longwall shearer has a face of 300 m or more. It is a sophisticated machine with a rotating drum that moves mechanically back and forth across a wide coal seam. The loosened coal falls on to a pan line that takes the coal to the conveyor belt for removal from the work area. Longwall systems have their own hydraulic roof supports which advance with the machine as mining progresses. As the longwall mining equipment moves forward, overlying rock that is no longer supported by coal is allowed to fall behind the operation in a controlled manner. Once the coal is removed the roof is allowed to collapse in a safe manner.

Continuous mining utilizes a machine with a large rotating steel drum equipped with tungsten carbide teeth that scrape coal from the seam. Operating in a “room and pillar” (also known as “bord and pillar”) system – it can mine as much as five tons of coal a minute. Conveyors transport the removed coal from the seam. Remote-controlled continuous miners are used to work in a variety of difficult seams and conditions, and robotic versions controlled by computers are becoming increasingly common.

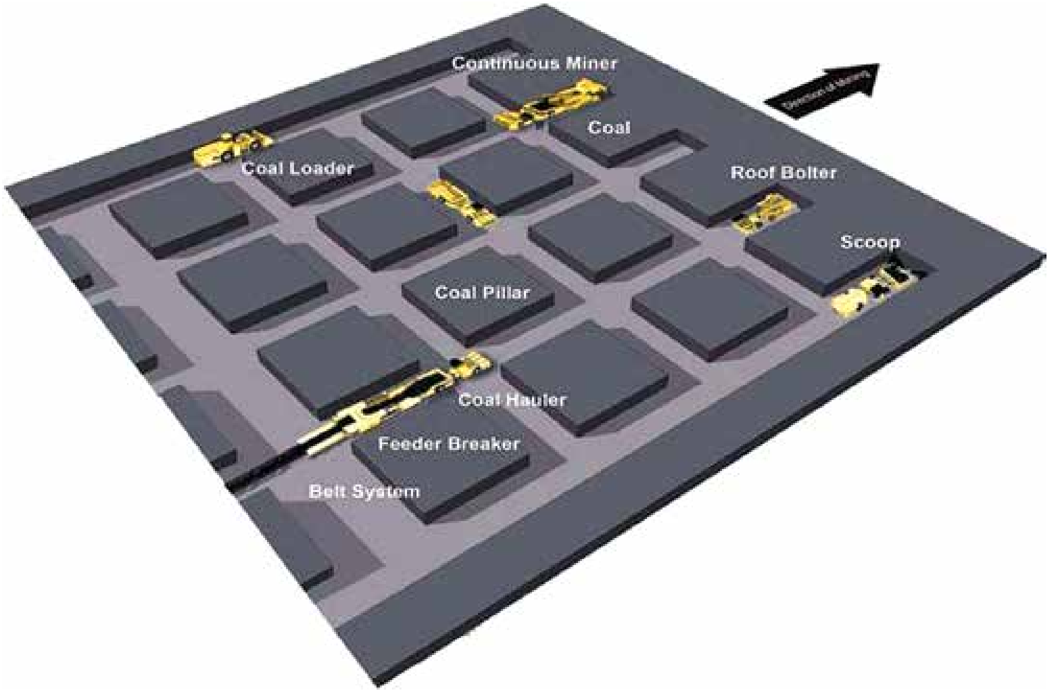
Shortwall mining, a method currently accounting for less than 1% of deep coal production, involves the use of a continuous mining machine with movable roof supports, similar to longwall. The continuous miner shears coal panels 40–60 m wide and more than 1 km long, having regard to factors such as geological strata.

Retreat mining is a method in which the pillars used to hold up the mine roof are extracted; allowing the mine roof to collapse as the mining works back towards the entrance. This is one of the most dangerous forms of mining owing to imperfect predictability of when the ceiling will collapse and possibly crush or trap workers in the mine.

There are two main methods of underground mining: room-and-pillar and longwall mining.

Room & Pillar Mining

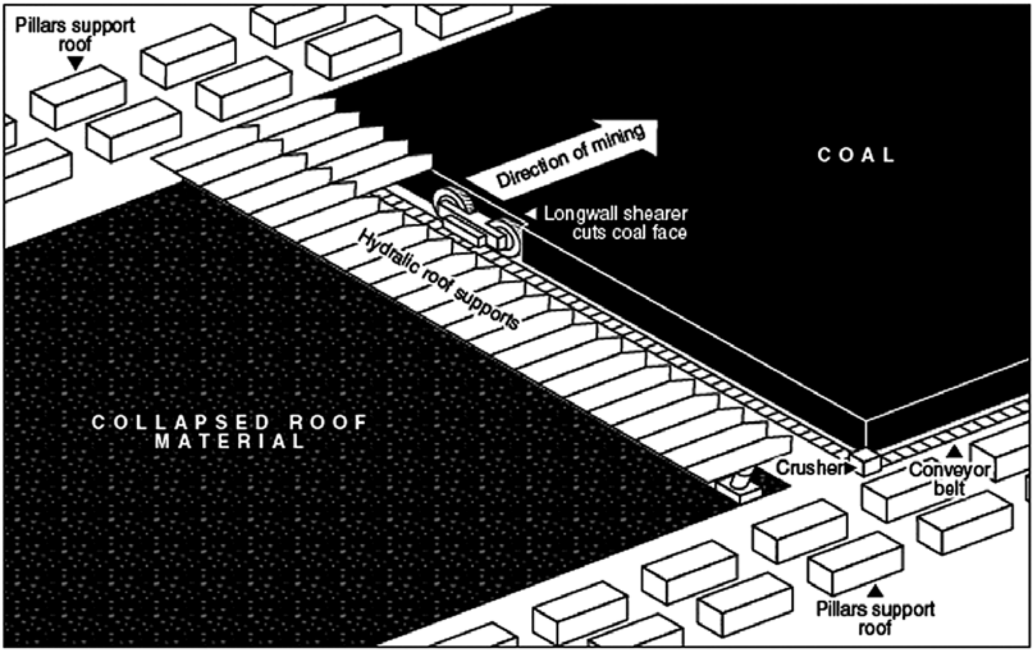
In room-and-pillar mining, coal deposits are mined by cutting a network of “rooms” into the coal seam and leaving behind “pillars” of coal to support the roof of the mine. These pillars can be up to 40% of the total coal in the seam – although this coal can sometimes be recovered at a later stage. In room and pillar mining coal seams are mined by a “continuous miner” that cuts a network of “rooms” into the seam. As the rooms are cut, the continuous miner simultaneously loads the coal onto a shuttle or ram car where it will eventually be placed on a conveyor belt that will move it to the surface. “Pillars” composed of coal are left behind to support the roof of the mine. Under special circumstances, pillars may sometimes be removed or “pulled” toward the end of mining in a process called “retreat mining”. Removing support during retreat mining can lead to roof falls, so the pillars are removed in the opposite direction from which the mine advanced: hence the term “retreat mining”.



The key to the successful room and pillar mining is selecting the optimum pillar size. If the pillars are too small the mine will collapse. If the pillars are too large then significant quantities of valuable material will be left behind reducing the profitability of the mine.

Longwall Mining

Longwall mining involves the full extraction of coal from a section of the seam, or "face" using mechanical shearers. The coal "face" can vary in length from 100 – 350m. Self-advancing, hydraulically-powered supports temporarily hold up the roof while coal is extracted. When coal has been extracted from the area, the roof is allowed to collapse. Over 75% of the coal in the deposit can be extracted from panels of coal that can extend 3km through the coal seam.



Questions

1. What is a bench?
2. Describe how would you measure a bench height?
3. What is a safety berm made for?
4. What is a bench face?
5. What is a haul road used for?
6. How do you understand what an overburden is?
7. How would you measure a haul road width?

Vocabulary

power transmission	['pauə trænz'mɪʃ(ə)n]	силовая передача, передача энергии
storage	['stɔːrɪʤ]	хранение, сохранение
air contaminants	[εə kən'tæmɪnənt]	вещества, загрязняющие воздух
flooding	['flʌdɪŋ]	затопление, обводнение
stability	[stə'bɪlətɪ	стабильность, устойчивость
feasibility study	[ˌfiːzə'bɪlɪtɪ 'stʌdɪ]	технико-эконом. обоснование
rate of return	[reɪt ɔv rɪ'tɜːn]	норма прибыли, доход
pumping	['pʌmpɪŋ]	откачка воды, подача насосом
explosion	[ɪk'spləuʒ(ə)n]	взрыв, взрывание
employ	[ɪm'plɔɪ]	применять, употреблять
expected	[ɪk'spekted]	ожидаемый
flow	[fləu]	поток

6.4 PROCESSES ASSOCIATED WITH COAL EXTRACTION, LOADING AND TRANSPORTATION

General information

Coal extraction can be carried out by the following ways:

Mechanically – shearers, plows, pick hammers, drilling methods, drilling-and-blasting operations;

Hydraulic method – using hydraulic monitors that have high-pressure nozzles installed on them to disperse water jet on a seam, destroying it. The pulp which is thus formed moves to shaft on special trenches by chute.

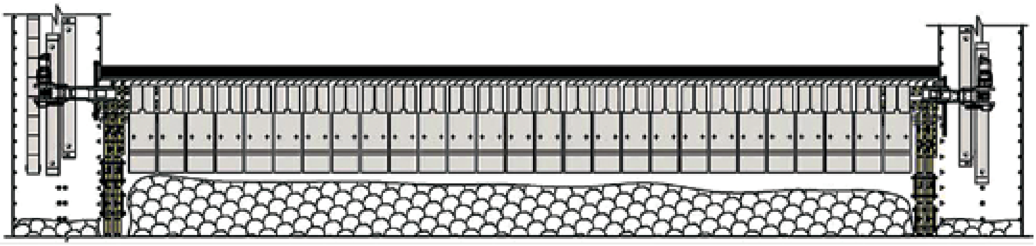
Extraction process includes **not only seam** destruction, but also loading of a **broken mineral**. (*On steep seams there is no* **necessity for loading** *operations).*

Coal extraction schemes

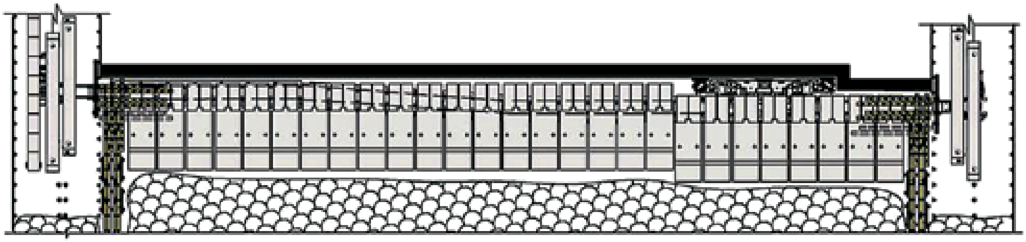
There are wide-web and a narrow-web types of mining.

Sheares with a web width more than **1 m** are classified as **wide-web shearer**, less than **1 m – narrow-web shearer.**

The extraction type during which the cutting member processes all surface of working face, and a coal extraction direction coincides with a longwall advance direction, is called as **frontal**.



The extraction type during which destruction of a coal strip is made by the shearer moving along the working face perpendicularly to its advancing direction is called as **flank**.



The narrow-web shearers working under the flunk scheme, can extract coal using the **one-way scheme** with **cleanup** after a strip extraction, and under **shuttle scheme**, extracting in both directions.

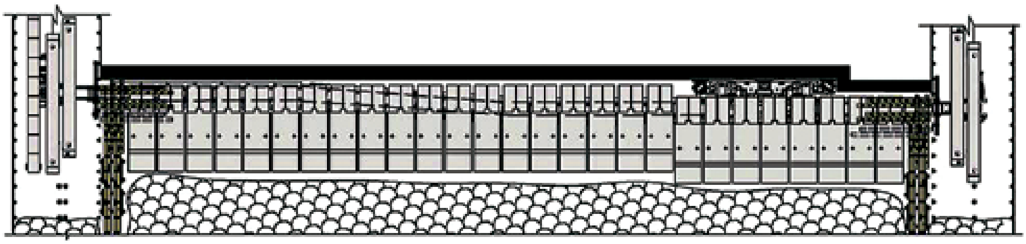
Characteristics of shearer

Shearers with screw (auger, worm) cutting member, such as 1K101, ГШ68, K103, K105, K120, РКУ10, РКУ13, ГШ-600, УКД-300 etc. They are quite simple by construction and capable of separating the coal off the massive at various thickness. Such shearers have simple adjustment system of cutting members position, high efficiency,

can self-cut in a coal seam and load bigger part of the broken coal on a face conveyor. However the disadvantage of these shearers is that they can effectively be applied only on seams with resistibility to cutting not more than 300 kN/m, produce big-size cuttings with size of 0 – 6 mm.

Strong and viscous coals with resistibility to cutting more than 400 kN/m and are capable to be destroyed by the shearers that have **drum-type cutting members with a vertical rotation axis.** Shearers KA80, KA90, KA200 separate coal from the massive with less energy consumption, can improve extracted coal quality, quite stable on the conveyor. The main disadvantage is a complex adjustment system of the cutting member along the seam thickness fluctuations.

Shuttle scheme of coal extraction



Using shuttle scheme of coal extraction the coal is extracted from the haulage drift to ventilation drift and in a reverse direction.

The main **advantages:** the best use of a shearer in terms of consumed time due to reduction of cycle duration; higher efficiency of the stope.

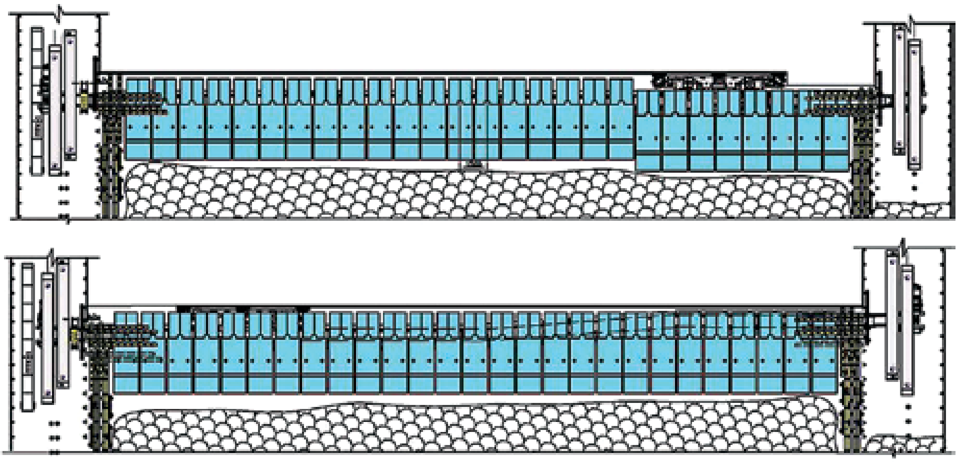
The main **disadvantages:**

1. Considerable volume of unloaded coal behind a shearer;

2. The workers performing operations connected with the conveyor advancing, longwall supporting, cleanup of coal during movement of shearer against an air current are exposed to extremely unfavorable dust circumstances;

3. The shuttle scheme of coal extraction is **prohibited** at coal mines developing seams prone to sudden outbursts of coal and gas;

One-way scheme of coal extraction



At **one-way scheme of coal extraction** the coal is extracted during movement of shearer towards ventilation drift (bottom-up) and the loading of the broken rock mass onto conveyor is implemented during movement of the shearer towards haulage drift (top-down). Conveyor is moved behind the shearer.

The reasons of using the one-way scheme are as follows: unfavorable dust conditions during shearing, caving of “false” roof, intensive coal sloughing, high gas content in the rock seams which are prone to sudden outbursts, changeable thickness of coal seam, viscous and strong coal, soft and prone to heaving bottom, high water content.

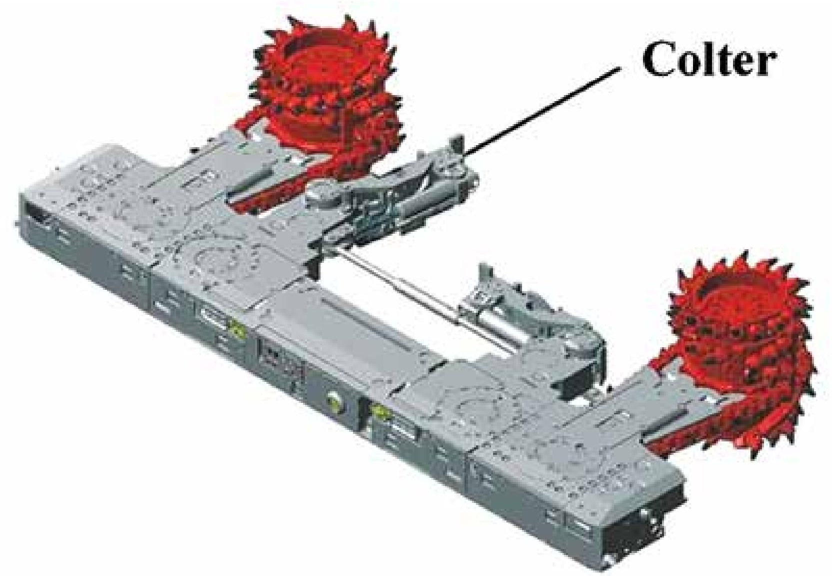
Disadvantages of the one-way scheme of the coal extraction are as follows: regrinding of coal during its loading onto the conveyor and low coefficient of shearer usage when extracting.

Coal loading on the conveyor

For improvement of loading the coal on the conveyor, the cutting members of narrow-web shearers are supplied with additional loading devices.

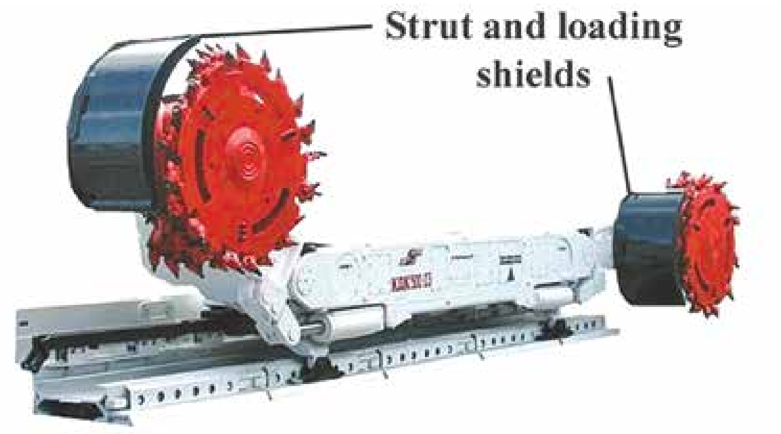
All loading devices are divided into the aggregated with a shearer (colters, strut and loading shields) and aggregated with a conveyor (static loaders).

Colters are used for loading the coal over the conveyor edge.



The colter is located at a considerable distance from cutting heads - from 0.3 m and more. In some case.

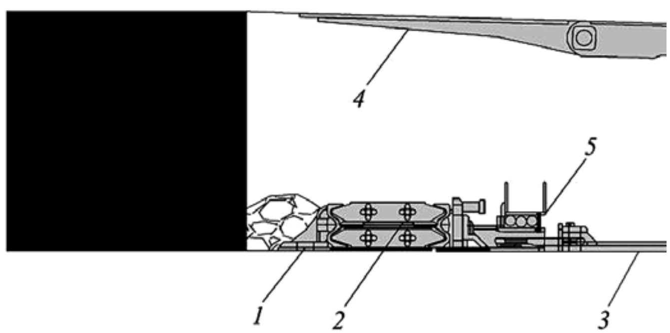
Strut and loading shields also reduce a part of unloaded coal on the conveyor creating the closed space around a screw that allows to load coal better on the conveyor.



Shields and colters are applied in longwalls with stable roof rocks and with an insignificant coal sloughing. Thus, colters and shields have limited scope of usage and do not provide mechanized loading under all conditions.

Static colters are installed on the conveyor and provide bottom cleanup between a face and the conveyor. These loaders are simple in design, reliable during usage, do not demand reinstallation at preparation of a shearer for extracting the new strip of coal, and the coal sloughing does not restrict their application.

Static colters are successfully applied in the longwalls with even and strong bottom.



1 – static colter; 2 – face conveyor; 3 – advancing thruster (jack);
4 – powered support console

Fig. 6.6 Structure of the static colter

Questions

1. What equipment is used for coal extraction?

2. What coal extraction schemes do you know?

3. What shape of a cuting tool does a shearer have?

4. What is the difference between one-way extraction scheme from shuttle scheme?

5. How is coal loaded onto the face conveyor?

Vocabulary

hydraulic monitor	[haɪˈdrɔːlɪk ˈmɔnɪtə]	гидравлический монитор
high-pressure nozzles	[ˈhaɪprɛʃə ˈnɔzl]	высоконапорные форсунки
water jet	[ˈwɔːtə dʒɛt]	водяная струя
wide-web shearer	[waɪd wɛb ʃɪə]	широкозахватный комбайн
narrow-web shearer	[ˈnærəu wɛb ʃɪrə]	узкозахватный комбайн
web width	[wɛb wɪdθ]	ширина захвата
coal strip	[kəul strɪp]	полоса угля
cutting tool	[ˈkʌtɪŋ tuːl]	режущий инструмент
self-cut	[sɛlf kʌt]	самозарубка
viscous	[ˈvɪskəs]	вязкий, тягучий
drum	[drʌm]	барабан
rotation axis	[rəuˈteɪʃən ˈæksɪs]	ось вращения
air current	[ɛəʳ ˈkʌrnt]	струя воздуха
prone to sudden outbursts of coal	[prəun tuː ˈsʌdn ˈautbəːst ɔv kəul]	склонный к внезапным выбросам угля
one-way extraction scheme	[ˈwʌnweɪ ɪksˈtrækʃən skiːm]	односторонняя схема выемки
shuttle extraction scheme	[ˈʃʌtl ɪksˈtrækʃən skiːm]	двусторонняя схема выемки
coal sloughing	[kəul]	отжим угля
bottom heaving	[ˈbɔtəm hiːv]	пучение почвы
colter	[kəult]	лемех
scope of usage	[skəup ɔv ˈjuːzɪdʒ]	диапазон использования
to restrict	[tuː rɪsˈtrɪkt]	ограничивать
even	[ˈiːvn]	ровный

6.5 BASICS OF LABOUR PROTECTION

Protection of the health and safety of employees from excessive or undesirable stresses in the occupational environment is all important. These hazards include reduced natural ventilation and light, difficult and limited access and egress, exposure to air contaminants, fire, flooding, and explosion.

Ventilation is an important common denominator in most health and safety design considerations in mines. In addition to the supply of fresh air to the miners, the overall control of gas, dust, heat, and humidity problems is achieved through the proper design of the ventilation system. Fresh air must be supplied to all underground work areas in sufficient amounts to prevent any dangerous or harmful accumulation of dusts, fumes, mists, vapors, or gases. If natural ventilation does not provide the necessary air quality through sufficient air volume and air flow, the employer must provide mechanical ventilation to ensure that each employee working underground has at least 5.7m^3 of fresh air per minute.

Open flames and fires are prohibited in underground construction areas except as permitted for welding, cutting, or other hot work operations. Smoking is prohibited unless an area is free of fire and explosion hazards.

Special air monitoring requirements

The employer must assign a "competent person" to perform air monitoring. If this individual determines that air contaminants may present a danger to life at any time, the employer must immediately take all necessary precautions and post a notice at all entrances to the underground site about the hazardous condition.

Test for oxygen first

The competent person charged with air monitoring must test for oxygen content before testing for air contaminants. All underground work areas must be tested as often as necessary to verify that the atmosphere at normal atmospheric pressure remains within the acceptable parameters of 19.5 and 22 percent oxygen.

Problems of noise and illumination, always a matter of concern in underground workings, are being addressed through the identification, development, and incorporation of specific design requirements for mine machinery and mining environment.

Ground support of underground areas

A competent person must inspect the roof, face, and walls of the work areas at the beginning of each shift and as often as necessary to ensure ground stability. The ground conditions along all haulage ways and travel ways must also be inspected as frequently as necessary to ensure safe passage and loose ground considered to be hazardous to employees must be scaled, supported, or taken down.

Employees involved in installing ground support systems must be adequately protected from the hazards of loose ground. Any dislodged or damaged ground supports that create a hazardous condition must be promptly repaired or replaced. The new supports must be installed before removing the damaged supports.

Hazards, accidents, and disasters

The term hazard is used here to describe an unsafe situation in a mine. This may be an unsafe physical condition or unsafe acts of miners. For example, methane is a source of hazard.

An accident is the realization of a hazard. If a large number of people are in fact killed, it is deemed a disaster.

Hazard control approaches

As distinct from practices in many other industries, the mine working environment cannot be precisely controlled. Also the environment is constantly changing. It is virtually impossible to foresee all the possible hazards and therefore, to take precautions against each of them.

Medical examinations

Pre-employment physical examinations and periodic continuing examinations are required to assure that employees' health and physical conditions are routinely monitored and documented. These examinations may reveal physical problems such as hearing loss, loss of vision, heart problems, arthritic conditions, lung impairment, etc.

Miner training must emphasize both general and job-specific health and safety aspects and improvement of production and maintenance skills.

The enhancement of personnel health and safety in mines requires an understanding of the hazards and the requirements for their control. In addition to the learning experience from the lamentable history of accidents and disasters in mines, there is a critical need to reduce the risks of mine hazards and resulting accidents through the application of such proactive analysis techniques as systems safety analysis and disaster simulations for the identification of new hazards.

Personal protective equipment

All underground workers must wear special equipment which is: head protection – caps or hats, cap lamps, eye and face protection – safety spectacles or facepiece respirators; respiratory protection (against dust); hearing protection – ear plugs; foot protection – boots; clothing – cotton overalls (sometimes with strips of reflective material); belts – to carry lamp battery, self-rescuer – respiratory protection which will help the miner escape dangerous place in case of a mine fire; gloves.

Fig 6.7 Self-rescuer

Fig. 6.8 Respirator

Fig. 6.9 Cap-lamp

Fig. 6.10 Ear-plugs

Threats to life and health

Threats to a miner's safety may arise from many sources: from falls of roof, face, or side; from haulage or other machinery; from electrical equipment, explosives, or ignitions or explosions of gases and dust; from sudden inundations of water and gas; or from mine fires.

Consequences of inadequate control can be sudden and catastrophic – such as injuries and loss of life through suffocation, heat strokes, and explosions or slow and long-enduring such as lung diseases including coal worker's pneumoconiosis (CWP) or black lung.

Diseases such as silicosis, asbestosis, and pneumoconiosis are associated with long-term exposure to high concentrations of silica, asbestos, and coal dust, respectively. Bad water quality and the lack of adequate lighting have also been associated with such diseases as dermatitis.

Training requirements

All employees involved in underground construction must be trained to recognize and respond to hazards associated with this type of work. The following topics should be part of an underground construction employee training program:

1. Air monitoring and ventilation;

2. Illumination;

3. Communications;

4. Flood control;

5. Personal protective equipment;

6. Emergency procedures, including evacuation plans;

7. Check-in/check-out procedures;

8. Explosives;

9. Fire prevention and protection;

10. Mechanical equipment.

Questions

1. What is ventilation?
2. Explaine what a “hazard” is?
3. What kind of protection do underground workers have to wear?

Vocabulary

labour protection	['leɪbə prə'tekʃ(ə)n]	охрана труда
convenience	[kən'viːnɪən(t)s]	удобство, преимущество
safety	['seɪftɪ]	безопасность, надежность
assembled	[ə'sembl]	собранный, составной
evaluation	[ɪˌvælju'eɪʃ(ə)n]	оценка, определение(качества)
production rate	[prə'dʌkʃ(ə)n reɪt]	производительность
to gain	[tuː geɪn]	получать, добывать
aerial photography	['ɛərɪəl fə'tɔgrəfɪ]	аэрофотосъемка
sufficient	[sə'fɪʃ(ə)nt]	достаточный, адекватный
dilute	[daɪ'luːt]	разбавлять
remove noxious gases	[rɪ'muːv nɔkʃəs gæses]	удалять (устранять) вредные газы
eons	[ions]	вечность
rate of return	[reɪt ɔv rɪ'tɜːn]	доход, рентабельность

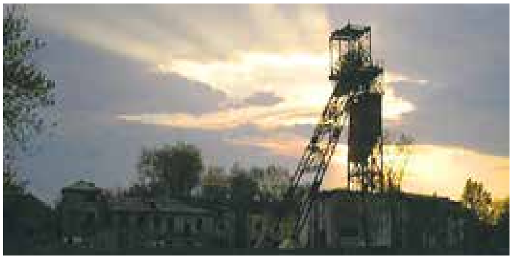
6.6 MINE ABANDONMENT

Mine, like other companies, has these periods of development: design, building an-TSS, development of design capacity, maintenance, fade-outs, pit closure and liquidation. All periods of activity followed by mine design. Almost every period developed relevant project documentation. In practice, often use the notion of "pit closure" and "mine abandonment", understanding one and the same meaning. But these are different concepts.

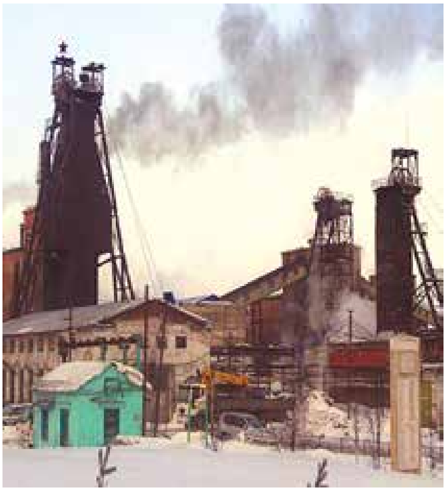
Define the concept of closed and abandonment mine

Closed mine – stop any processes that ensure coal. Depending on the machinery, equipment, cables and piping dismantle or leave them in the workings. Isolates near wellbore yard all revealing and development workings concrete bridges. Works during the closure of the mine – a preparatory work for the elimination of the mine shafts or create near wellbore in the workings of the court facilities freelance destination if defined project. Some surface objects can be reconstructed to create a production of the relevant products. Other objects are eliminated, and free the industrial area of mine ordered.

Abandonment mine – is completely eliminated all mine workings, including shafts and surface mine sites and industrial area orderly and can be used to construct other objects.



The decision to close the mine develop pre-feasibility study “On the feasibility of further work mine” or FS “further development of the mine”. In doing feasibility analysis of residual coal reserves, technical and economic performance of mine for the last 2 – 3 years, the strength of all the workers at the mine qualifications. Identify measures to granulated residual inflammation sat coal and negative impact of the mine on the environment.



Structure and Content of supplying and making design decisions standing orders relevant regulations, “Safety in Coal Mines” (SCM), Standard ministries project to the coal mines of Ukraine. “Structure and content of the project” (REB), “Rules for the elimination of barrels of coal mines” (instruction) (SPLM), “of ensuring explosion while filling barrels of coal mines” (Manual) (Sv). Following along with the full name of the instrument will use the abbreviations listed in parentheses.

Basic terms and concepts adopted in the regulations

1. Mine abandonment companies involves measures to stopping economic activity , bringing its assets to a state that guarantees the safety of people, property and the environment, social protection of displaced workers, as well as addressing other social and economic issues.

2. The waiting period – the period of construction (expansion)

dewatering the mine. During this period the mine liquidation objects that are not work-related low tide.

3. Abandonment pit shaft – of the work of filling the free volume of logs or backfill material, construction of bridges (slabs), jumper, other means to stop the drag due to the existing mine workings, as well as ensuring long-term stability of underground structures and designs (attachment) to prevent dangerous strains the earth's surface.

4. Physical elimination of mining companies involves performing work on deinstallation of machinery and equipment, power lines and communication technology, backfilling shafts, pits and down hole and other mining, demolition of buildings, structures and the implementation of measures aimed at solving the problems of drainage.

5. Assessment of environmental impact (AEI) – scoping and decision impact on the environment and economic activity that is planned , and developing measures to prevent or mitigate the identified impacts design decisions in terms of security environment.

6. Dangerous deformation of the earth surface – a sudden draft, failures at the earth's surface around the collar of the liquidated pit shaft to form the bell-pit (crater), which was formed as a result of the destruction of underground facilities and structures barrel, which eliminated.

7. Area of permanent control – part surface in the placement eliminated collar, which over time can cause a dangerous strain of the earth's surface.

8. Backfill material – dry, lumpy (250 mm) nonflammable material, which is used to fill the collar (non-flammable rock piles, rubbly material, grit of building materials, concrete structures).

9. The jetty (board) ceiling barrel – solid concrete unattended design (diaphragm), which is constructed in vertical and steep shafts and relies on bedrock or barrel mounting and is designed to provide long-term quasi-static equilibrium overlying rocks and underground structures.

10. The platform (board) ceilings orifice barrel – solid concrete slab with an angle of inclination of more than 35^{o}, which is built on the mouths of the barrel to isolation and exclusion of access to abandonment mines. At the collar of the platform floor Barrel establish permanent signs, rappers, discharge, and vapor pipes.

11. Isolation Maintenance-free jumper – tubular air no penetrating structure that is erected in the barrel at an angle up to 60^{o}, completely covers the roadway cross-section and is designed to prevent displacement backfill material and aerodynamic connection with the termination of the current workings of the mine or abandonment.

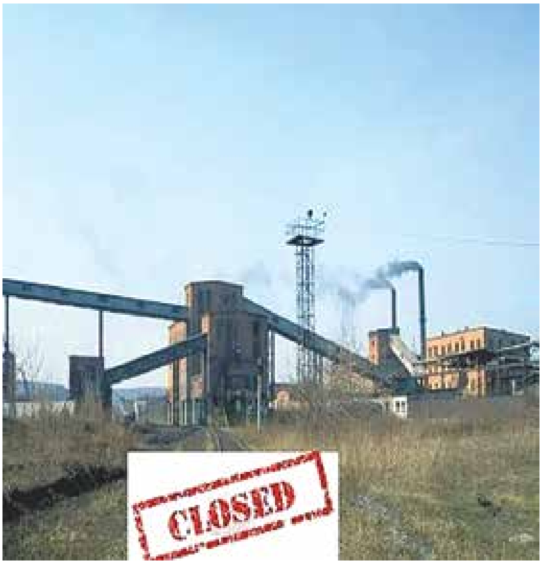
12. Area gas mode – the mines, hazardous gas, plot the surface of the earth within a radius of at least 25m from the center of the liquidated barrel. Equipment, machinery and mechanisms that operate in the area of sleep logs should be explosion-proof.

These terms and their meaning defined regulations that use the development of project documentation. The project developed after the appropriate authority decided to eliminate mine. The project not only developing technical solutions and measures to reduce social and economic tensions owing to elimination mine. The elimination of the mine causes social and moral and psychological stress in the surrounding population, and especially in the former mine workers. Therefore, the feasibility

study "On the feasibility of further work-you mine" to develop measures to mitigate the tension between collective mine and the surrounding population. Therefore, these activities after approval of feasibility study, but necessary to bring employees to the mine, and they will form the basis for further expansion of and justification for the project. In addition, after approval of the project, prior to the liquidation of the mine to the mine site and other public places to show a larger scale master plan for orderly industrial area drop-out mine. In addition, you must publish the draft measures designed to mitigate the social and psychological stress in the mine workers and the surrounding population.

Developed based on research design solutions and rigorous execution of their significantly reduce the negative effects of the elimination of the mine.

To develop the project closure and liquidation of specific designers you learn detailed mining and hydro-geological conditions of existing adjacent mines, a system of mine workings of each mine and the relationship between them, the values of barrier pillars between mine territory fields, inspect the surface structure and buildings and equipment which they have placed. Based on the analysis made determine the type of mine that closed.



The first type. Mine wound up completely: all abandonment mining, construction and liquidated building industrial site of mine;

Second type. Mine wound up partially disposed shafts, one shaft sump fitted as water storage tank, mounted two pipelines, which are artesian pumps for pumping mine water, removed the buildings and building industrial site other than those intended for maintenance of pumping mine water;

A third type. Mine is on the dry conservation (with or without reconstruction reconstruction and excavation equipment): industrial mining process stopped nearwellbore workings isolated from all revealing and development workings, as well as those nearwellbore developments that are designed for long-term or short-term pumping of mine water. Objects mine surface eliminated except those served by the water pump system.

Type the mine closed establish on the basis of analysis of the impact of full elimination of mines adjacent to existing mines, establish the possibility of receiving the flow of water abandonment mines adjacent applicable. In this case, determine the need for reconstruction of the relevant groundwater and surface pumping units.

The first step is to prepare the liquidation of mine to eliminate revealing and development workings.

Eliminate revealing and narrow roadway

From excavation equipment dismantled for re-uses after repair or sit in the scrap. Economic calculation established that this type of formulation is not reasonably repay, they should be left in the condition in which they are at the time of liquidation of the mine. Therefore, the estimate of supplying not expected savings from the sale of metal coal mines.

Eliminate pit workings

Eliminate pit excavation begins construction of concrete bridges that protect wellbore yard of excavation combined with it. Hardened jumpers constructed of reinforced of concrete or concrete blocks to high-strength solution for combinations revealing the workings of the mine field excavations wellbore court.

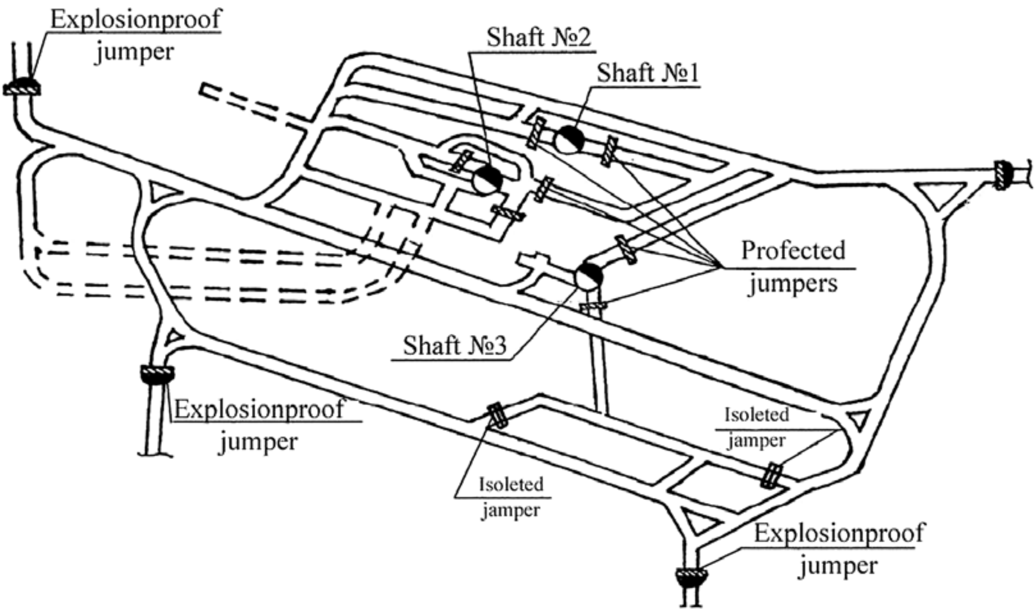


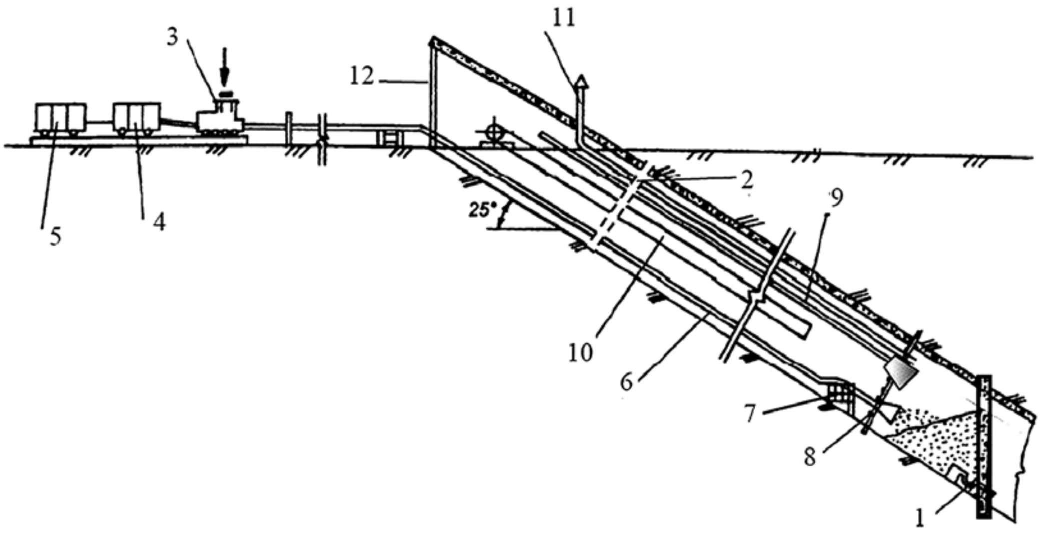
Fig. 6.11 Location of concrete jumpers at liquidation pit-bottom the pit shaft

Layout of plan mine abandonment pit shafts

In the “Rules of Safety in Coal Mines” indicates that vertical and cragged pit-shafts and boreholes with a diameter of 200 mm or more, which have access to the surface must fully backfilled non-combustible, non-toxic materials. One of the important problems of elimination pit shaft – is to ensure their long-term sustainability. Ways to eliminate barrels should ensure their safe long-term resistance to impact processes that occur during deboning rocks across the mine field.

Eliminate day-eye

In accordance with slanted and horizontal excavations that have exits to the surface, removed in the construction of insulating formulation of two abutments (brick, stone or concrete) and the space between them is filled with rock.



1 – jumper in day-eye, 2 – place the construction of day-eye in the collar of the pit shaft; 3 – burr mill and classifier rock 4 – compressor or air blast, 5 – electrical distribution point, 6 – ducting to transport fragmentary roche, 7 – a device for determining the direction of ore laying, 8 – brush guard, 9 - ducting and installation for irrigation dispersed crushed breeds, 10 – vent ducting, 11 – ducting drainage of gas, 12 – concrete floor estuary

Fig. 6.12 Technological scheme the elimination day-eye trunk with the use complex manufacture "Titan"

The first jumper constructed at depths of Earth's surface to the hanging layer of roadway at least ten times the height of the rough workings, and the second - at 10m from the collar of the roadway. After the construction of the first bridge roadway feed breed presented in the surface. Fixing day-eye trunk between the ridges and the surface is not dismantled, and in some cases strengthen.

The elimination of day-eye

With the elimination of day-eye trunk have the option of full control over the quality of foundation roche roadway. With the liquidation of day-eye the process of filling his breed almost uncontrollable.

In the regulations provides for the possibility of use of two methods of elimination pit shaft of concrete, reinforced concrete and circular closed support: complete filling of free volume pit shaft and incomplete filling – just between the pit shaft and the collar of the pit shaft. According to the “Rules of elimination pit shafts of coal mines” states that the decision by the method of elimination of pit shaft received a committee based on assessment of the actual state of pit shaft and lasting stability pit-bottom solid.

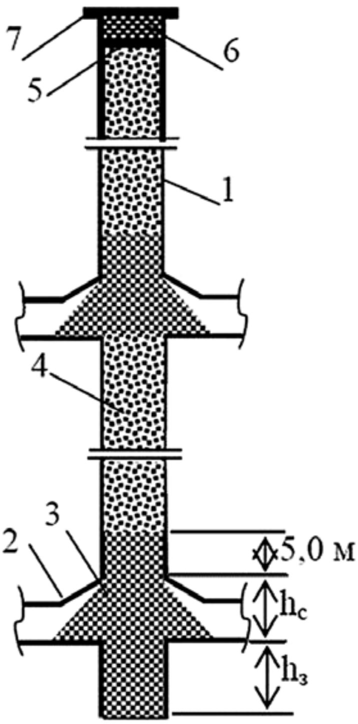
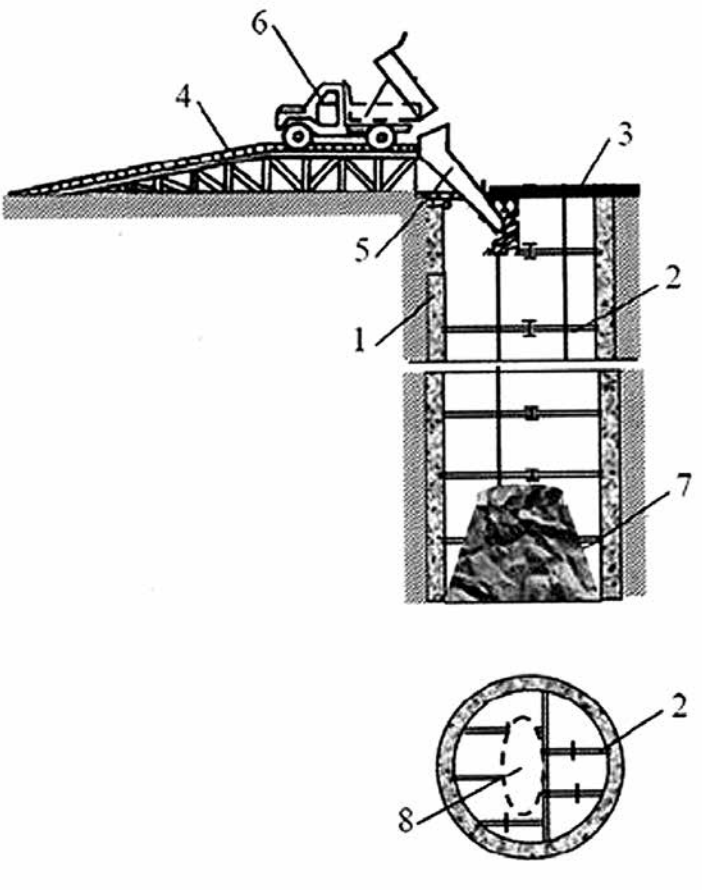


Fig. 6.13 Model of liquidated pit shaft

According to the current norms we consider a model with a full pit shaft liquidated his sleep free volume (Fig. 6.13). For flowing free volume pit shaft 1 is recommended to apply loose, lumpy (250 mm) non-flammable material, grit piece construction materials and concrete structures. When falling asleep pit shaft rules stipulated in the zone of conjugate 2 with horizontal and crut generate thrust gravel layer 3 of the strength of not less than 20 MPa, and the battle of building materials lumps up to 250 mm. The purpose of thrust bed - preventing the spread of the filling material in the excavation that filling with the barrel. Bearing layer – is the amount of material which fills pit shaft in the zone interface, and material that fills in the fall of conjugation. Height anchor layer as the sum of the depth of dib-hole h3 lower horizon, high coupling HC plus 5m over it. At intermediate horizons sole thrust layer is created on the material plane 4, which poured all the free volume of pit shaft in addition to the zone interface. As the regulations are not defined a way to monitor compliance with the above values and whether to exercise such control.

Floor slab pit shaft 5 – a reinforced concrete structure, which should provide a perception of a uniformly distributed static load weight material. Between the floor slab pit shaft 5 and collar 7 covered with material 6 fraction less than 10 cm after backfilling material is desirable to make tamping cavity cement-sand mortar. In calculating the parameters of plates taken factor of 2 for the mass of material. After filling pit shaft of the floor slab to construct collar iron-concrete slab floor hatch for 7 fill up to backfill material in the event of subsidence.

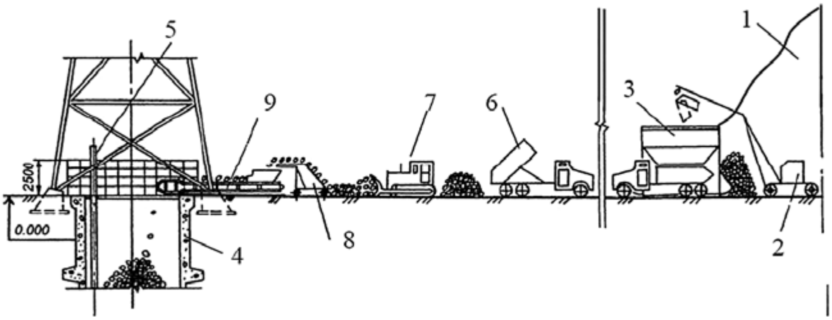


1 – Pit shaft; 2 – equipping; 3 – platform of overlaping collar; 4 – dolly way; 5 – flow defile; 6 – hauler; 7 – drift material; 8 – de-stressed zone

Fig. 6.14 Design of pit shaft

When designing slabs collar 7 calculations performed on uniformly distributed load of at least 10 kPa.

As mine liquidation projects used mainly two ways to sleep pit shafts. Transportation prepared material (selected from large lumps) of the flyovers dump dump in pit shaft (Fig. 6.15);



1 – natural spoil dump 2 – bucket excavator 3 – point training rocks, 4 – pit shaft, 5 – Gas-pipe, 6 – dump 7 – bulldozer, 8 – rock loader machine; 9 – transport pan.

Fig. 6.15. Backfill technology using pit shaft assembly.

Eliminate pit shafts without full filling

The elimination process pit shaft without fully laying consists of the construction of reinforced concrete slabs pit shaft at around bedrock, fill backfill material free volume of the slab erected to day surface and construction of reinforced concrete slabs mouth of the barrel.

The decision on how to eliminate pit shaft without fully sealing adopts special commission, which examines pre barrel. According to a survey commission is an act that project developers have the original data to make technical decisions in the development of the project.

Design liquidation of objects surface mine complex

Type closed mine determines appropriate solutions to eliminate objects as the industrial area and beyond. Depending on the condition and maintenance of the project structures of defined sequence and how to eliminate them: Partial disassembly, collapse or explosion.

With buildings dismantled equipment, and then eliminate them.

Surface buildings and facilities planning dismantled following markings industrial area of at least 0.3 meters from the industrial area located underground concrete or reinforced concrete channel blocking off construction, dismantle or leave them in the pipes and cables, and then they fall asleep (Fig. 6.16, 6.17).

After the elimination of all surface facilities site ordering and transfer to local authorities for further use.

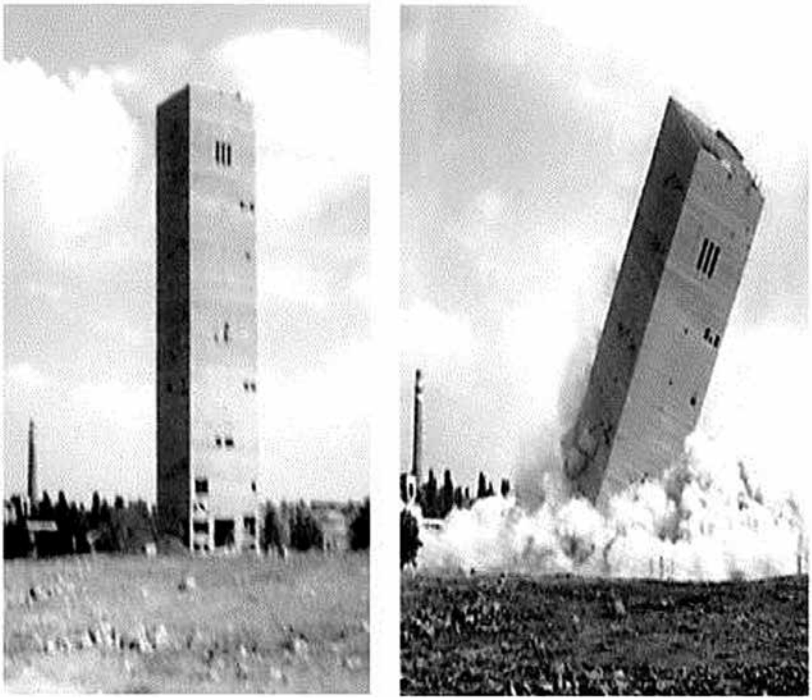


Fig. 6.16. Headframe elimination of mine "Kocheharka"

Fig. 6.17. Dilapidated buildings remaining on the abandoned mines

Questions

1. Explain the concept of closing a mine.
2. What is the procedure for liquidation of a mine?
3. What is the main reason of mining companies liquidation?
4. Explain the concept of physical abandonment of mining companies.
5. Explain what dangerous deformation of the earth surface is.
6. Expand the concept of zone control.
7. Expand the concept of backfill material.

Vocabulary

Pit shaft	[pɪt] [ʃɑːft]	ствол
equipping	[ɪˈkwɪping]	армирование
platform	[ˈplætfɔːm]	помост
dolly way	[ˈdɒl.i] [weɪ]	естакада
flow defile	[fləʊ] [dɪˈfaɪl]	направляющий желоб
hauler	[ˈhɔː.li.ər]	откатчик
drift material	[drɪft] [məˈtɪəriəl]	засыпанный материал
de-stressed zone	[distrest] [zəʊn]	зона разгрузки
transport pan	[ˈtrænspɔːt] [pæn]	скребковый конвейер
backfill	[`bækfil]	закладка
day-eye	[deɪ aɪ]	наклонный ствол
ducting	[`dΛktɪŋ]	трубопровод
narrow	[ˈnærəʊ]	сужать
case off	[keɪs] [ɒf]	изолировать
abutment	[ə`bΛtmənt]	перемычка

6.7 LAND RECOVERY

The development of the mining industry, as well as reclamation of disturbed areas and re-use them, on the one hand depends on the natural conditions, and on the other side – from a modern technology state ,technology, the level of knowledge in the field of environmental management, ecology and mining. Influence of the mining industry on the environment depends from the level of science and equipment, public regulations, and other natural conditions. In addition, the results of mining operations should be separated in space and time.

Impact of the adoption of the mining method of development on the atmosphere and hydrosphere essentially depends on the area of the surface outcrop slopes and ledges, i.e. the parameters of the space generated during the operation of a career, and consequently the residual gob after the development of the field, which depends on the applied equipment, his parameters and the accepted mining method.

In liquidation, reorganization or conservation, the general provisions, consistent with the economic state of the state, as well as the following features open-pit mining:

- Mining refers to the base because all the final products, translational coming to the consumer is directly used or modified form products processing industries;

- The object of labor mining industry is by design, regardless of the people and was not created by their labor as opposed to manufacturing and other industries;
- Minerals are not reproducible, mineral deposits other than large variety of nature and their position in space, are initially uncontrollable factor in the sense that it cannot be altered by man, and he is forced to adapt to them.

The above gives reason to believe that the termination of the mine (closing it) can occur under the following conditions:

- Depletion of mineral resources;
- Technical difficulties of operation, leading to a significant deterioration of economic results of the company for a long time;
- The lack of demand for the products of a career now and the foreseeable future;
- The appearance on the market of cheaper products for the same purpose and the quality (or a high-quality) and the inability to make their products more competitive;
- The emergence of substitute products (substitutes), so that the products of a company is losing market;
- The negative impact on the environment, which cannot be prevented or significantly mitigated by known methods, or their

implementation is associated with very large costs;

- The deterioration of the natural qualities of the mineral, which causes it to uncompetitive, and the production makes ineffective.

The reason for the suspension of a career (conservation reserves) may be the following circumstances:

- Technical difficulties and quarrying (as long as it will be found effective means to overcome or mitigate to acceptable limits);

- A temporary lack of demand for manufactured goods, when there is reason to believe that such demand will resume;

- The negative impact on the environment, provided that a certain time, it can be neutralized or mitigated to acceptable limits;

- The deterioration of the quality of natural mineral if there is reason to hope for the emergence of new technologies of production, processing or use of minerals that will raise its in the effective production.

Duration of conservation of stocks depends on the specific conditions of each company: the current situation and the degree of influence of the factors that determine the closing of quarries.

Socio-economic and environmental impacts of conservation and closing career

Closure of the business must be preceded comparing the socio-economic and technological options assessment closing with opportunities to continue working for the selected payment reference period – the minimum length of time over which can take into account all the main features of the options under consideration. In particular, the current period should include of time on the performance of all work and organizational measures to close a career, as well as events that require significant or have a significant impact on the amount of current investment costs. For example, if it turns out that the extension of the mine requires replacement of major equipment, a large amount of overburden removal or will occur in the changed mining activities conditions, etc. The calculation period have to be selected so as to be able to assess these factors. At the same time the reliability of events considerably distant in time is reduced, it is desirable for practical reasons to establish the duration of the calculation period in the range 10 – 15 years and only under especially difficult and abruptly dynamic process, this time can be increased to 20 – 25.

In the feasibility study is to be determined the value of all work related to the closure of career, according to the above list. And if necessary, it cannot reasonably be changed, including the cost of the time (within the billing period), when the quarry virtually will not work, such as environmental monitoring, benefits, etc., as well as the main technical and economic performance of the Company if it will continue.

After the approval of feasibility studies are developed to the extent necessary working drawings and construction documents.

The term "preservation stock" is not sufficiently unique, it requires verification, as well as its relation with the closing of mines. The suspension of operations of the mine pit or may occur for a variety of reasons, including, for example, due to a drop in demand for the products. In the conventional understanding stopping short of the mine or mines do not consider conservation reserves, but the boundary between the "short-lived" and "long" length of time is highly conditional and uncertain.

But suppose that it was equal to five years, then it turns out that if the mining in the quarry suspended for 5.5 years, it is – conservation reserves, and 4.5 years if it stops working, not preservation. To exclude these different interpretations should be possible to distinguish between the close of his career and conservation reserves. Obviously, the most distinctive feature of delimiting – the renewal or non-renewal of the mine. This is a necessary condition but not sufficient. If we imagine that pit stops for two days, according to the above condition is that it "preserves" their holdings at the same time, with what can hardly be accepted. Preservation of stocks involves their reactivation, that is, the performance of two work packages aimed respectively at making careers prepare to stay in working order, and then bring it back to working condition, and not necessarily in the form of a replica of the enterprise, which was suspended.

Reclamation planning framework

Earth mining sites in mining are subject to change on the structure of the relief, ecological state of soils, parent material and are subject to reclamation.

Areas of land reclamation depends on the types of future land use. Is divided in six main areas:

- Agricultural land areas – arable land, hayfields, pastures, perennial planted by the Board;

- Forest land areas – afforestation general economic and climbed the protective purpose;
- Ground water management areas – ponds for domestic, industrial purposes, irrigation and ponds;
- Recreational land areas – recreation and sports, parks and forest parks, ponds long recreational purposes, hunting grounds, tourist centers and sports facilities;

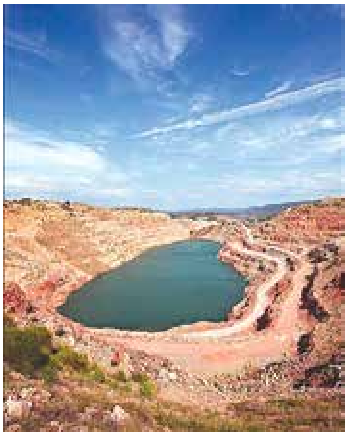
- Land conservation and sanitary areas – or sodded areas of floods, erosion forest stands, enshrined or preserved by technical means, overgrowth areas – especially not being landscaped for use in commercial or recreational purposes;
- Building land areas – areas for industrial, civil and other construction, including the placement of waste dumps (rocks, building the dirt, tailings, etc.).

In line with its strategy of sustainable development, the Laws "On Land" and "On the natural-reserve fund" and other laws of Ukraine disturbed land, are not suitable for traditional agricultural use (if they are translated into this category requires a lot of site restoration costs) should be phased out as intended and are classified as land for the restoration of other land uses.

It disturbed lands are no longer in the original value, all of the land with the removed or blocked off humus horizon, not suitable for use without restoring fertility.

Process industries	Types of Violations (man-made objects)
I. Excavation	Career Trench Dish Interceptor ditch Utility lines (piping, road i.e.)
II. Storage of minerals, day lighting breeds and enrichment waste	Warehouse minerals Conditional ore dumps Overburden dumps Tailing and sludge depository Enrichment waste / processing of minerals Disposal area Dumps placer working off dredges

By the nature of the disturbance by mining the upper layers of the Earth's crust can be divided into three main types:



- A career, a variety of trenches and pits, ditches and other open-pit expression processing , as well as the collapse, cracks, etc.;

- With the bulk soil – dry waste dumps, disposal area, tailings dams, expensive-gi, areas covered with overburden or waste rock production;

- Flooded by groundwater – septic tanks and reservoirs for various purposes, axial trough Denmark, as well as the residual space developed with subsea.

Quantify the degree of disturbance of the surface can be characterized by the volume of seizures, Dumping per unit area, as well as the size of the area of violation, the depth of excavation or subsidence, soil descents, linear violations – the length and width of disturbed area.

The main influencing factors are: the method of production, the system design, physical and mechanical properties of rocks, angle, power and depth of mineral resources; terrain within the career field, etc.

Reclamation objects in the quarries are:

- Developed space mining;
- Internal and external waste dumps;
- Embankments, dams, drainage ditches and upland;
- Septic tanks and tailings processing plants;
- Areas of land occupied by railways and roads, highways and pipelines, etc.;
- Industrial sites and other facilities that after the liquidation of the mining enterprise cannot be used in the national economy.

Strategic directions reclamation

The main strategic directions of mining companies in the reclamation areas disturbed by mining, they are:

- Science-based transformation of recovery patterns of land disturbed by mining activities in order to create a balanced relationship between different types of land (ecosystems) and environmental safety;

- Increasing the proportion of farmland extensive use (hay and pasture) with respect to evidence-based indicators and taking into account regional and local singularities;

- Expansion of the area of forest shelter belts and other loess protective plantings with respect to evidence-based indicators and taking into account the livelihoods and health of the population in the region;

- The creation of new areas and the expansion of existing areas, objects of nature reserve fund;

- Creation of conditions for the continuity of natural areas and the formation of environmental corridors;

- The creation of ecologically balanced living space near human settlements by increasing the share of public green space (at least 20 m^2 per resident);

- Ensure the development and diffusion of new environmentally sustainable land management technologies;
- Development and implementation of economic instruments promoting subsoil users to conduct environmentally sustainable activities at all stages of the life cycle of birth – place operation.

When addressing these issues, special attention should be paid to the soil as important a resource for everyday life, as well as the need to convince the public that the soil needs for the Protection and careful use.

Questions

1. What disturbed areas reclamation depends on?

2. What lands are called disturbed?

3. What are main directions of reclamation?

4. What are objects of reclamation in an open-pit?

Vocabulary

pit shaft	[pɪt] [ʃɑːft]	ствол
equipping	[ɪˈkwɪping]	армирования
platform	[ˈplætfɔːm]	помост
dolly way	[ˈdɒl.i weɪ]	эстакада
flow defile	[fləʊ dɪˈfaɪl]	направляющий желоб
hauler	[ˈhɔː.li.ər]	самосвал
drift material	[drɪft məˈtɪəriəl]	засыпанный материал
de-stressed zone	[distrest zəʊn]	зона разгрузки
transport pan	[ˈtrænspɔːt pæn]	ленточный конвейер
backfill	[`bækfil]	закладка
day-eye	[deɪ aɪ]	наклонный ствол
ducting	[`dΛktɪŋ]	трубопровод
narrow	[ˈnærəʊ]	сужать
case off	[keɪs] [ɒf]	изолировать
abutment	[ə`bΛtmənt]	перемычка

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Chapter 7

7.1 DRILLING

Drilling is a *cutting process* that uses a *drill bit* to cut or enlarge a hole in solid materials. The drill bit cuts by applying pressure and rotation to the *workpiece*, which forms *chips* at the *cutting edge*.

Rock drilling, in the field of blasting, is the first operation carried out and its purpose is to open holes, with the adequate geometry and distribution within the rock masses, where the *explosive charges* will be placed along with their initiating devices.

The systems of rock drilling that have been developed and classified according to their order of present day applicability are:

- *Mechanical:* Percussion, rotary, rotary-percussion.
- *Thermal:* Flame, plasma, hot fluid. Freezing.
- *Hydraulic:* Jet. erosion, cavitation.
- *Sonic:* High frequency vibration.
- *Chemical:* microblast, dissolution.
- *Electrical:* Electric arc, magnetic induction.
- *Seismic:* Laser ray.
- *Nuclear:* Fusion, fission.

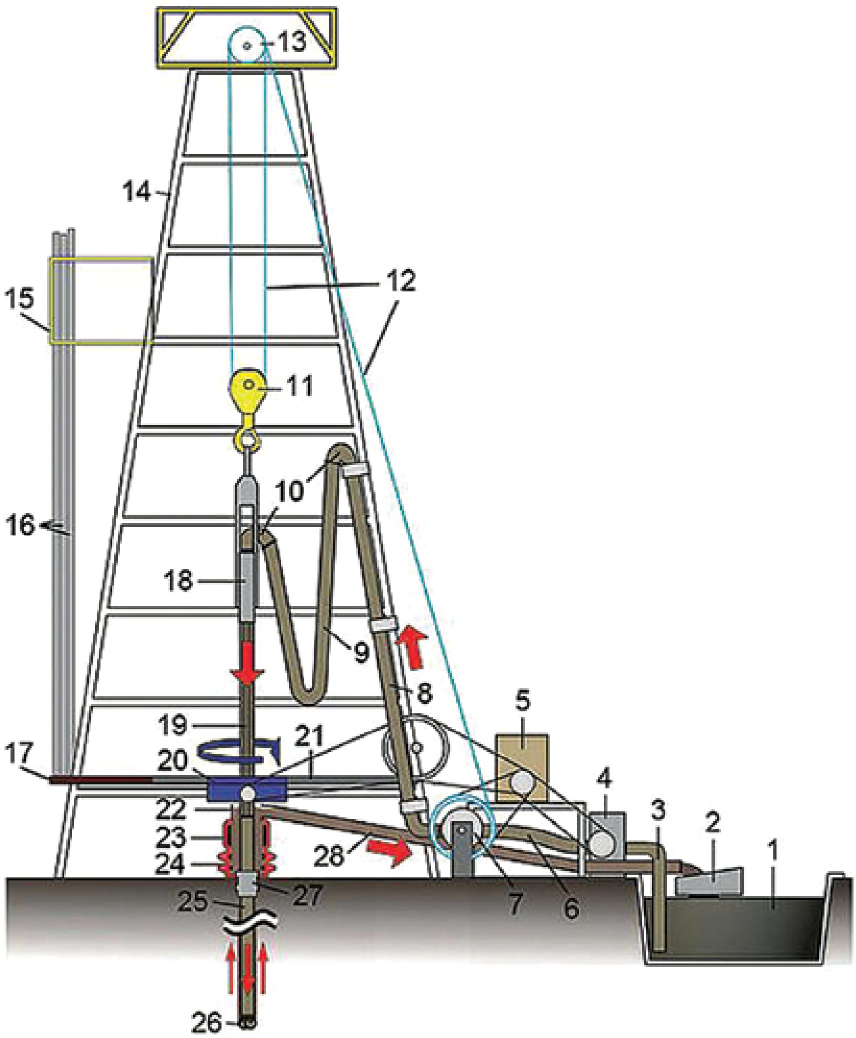
One of the most used method for drilling of deep boreholes, i.e. mechacical: rotary.

The main components of a drilling system of this type are: the *drilling rig* which is the source of mechanical energy, the *drill steel* which is the means of transmitting that energy, the *bit* which is the tool that exercises that energy upon the rock, and *the flushing air* that cleans out and evacuates the *drilling cuttings* and waste produced.

The principal physical rock properties that have influence upon penetration mechanisms and, *as a consequence*, on choice of the drilling method are:

- *hardness*
- *strength*
- *elasticity*
- *plasticity*
- *abrasiveness*
- *texture*
- *structure*

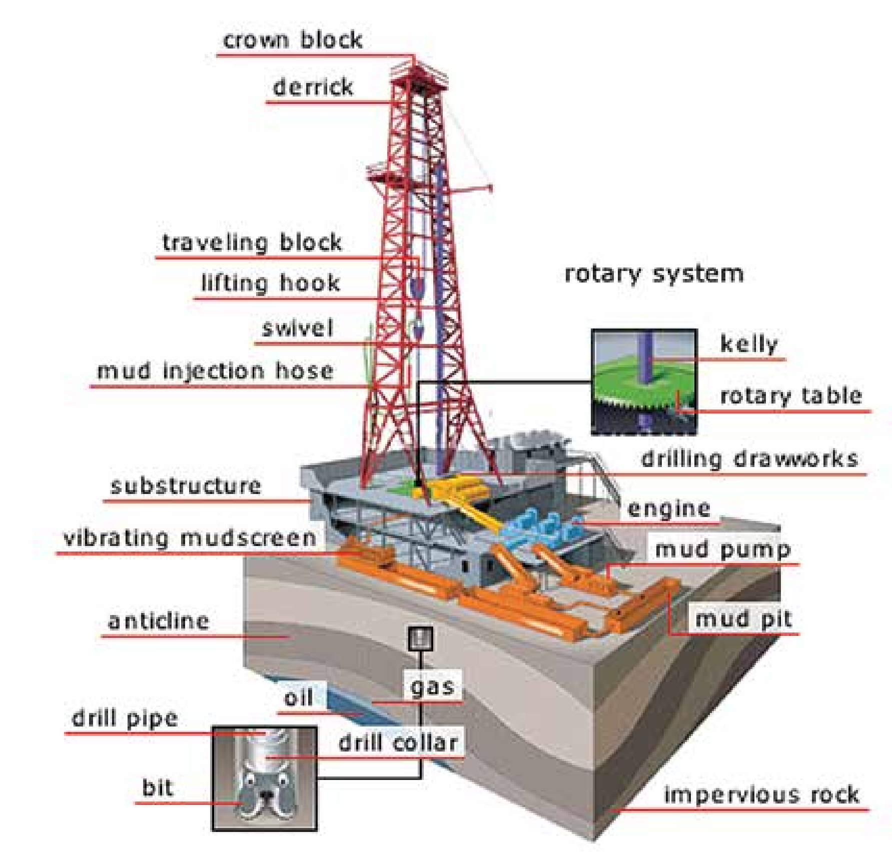
A **drilling rig** is a machine which creates holes (usually called *bore-holes*) and/or shafts in the ground. They sample sub-surface mineral deposits, test rock, soil and groundwater physical properties, and also can be used to install sub-surface fabrications, such as *underground utilities*, instrumentation, tunnels or wells. Drilling rigs can be mobile equipment mounted on trucks, tracks or trailers, or more permanent land or *marine-based structures* (such as *oil platforms*, commonly called 'offshore oil rigs' even if they don't contain a drilling rig). The term "rig" therefore generally refers to the complex of equipment that is used to penetrate the surface of the Earth's *crust*.



1 – Mud tank; 2 – Shale shakers; 3 – Suction line (mud pump); 4 – Mud pump; 5 – Motor or power source; 6 – Vibrating hose; 7 – Draw-works; 8 – Standpipe; 9 – Kelly hose; 10 – Goose-neck; 11 – Traveling block; 12 – Drill line; 13 – Crown block; 14 – Derrick; 15 – Monkey board; 16 – Stand (of drill pipe); 17 – Pipe rack (floor); 18 – Swivel (On newer rigs this may be replaced by a top drive); 19 – Kelly drive; 20 – Rotary table; 21 – Drill floor; 22 – Bell nipple; 23 – Blowout preventer (BOP) Annular; 24 – Blowout preventers (BOPs) pipe ram & shear ram; 25 – Drill string; 26 – Drill bit; 27 – Casing head; 28 – Flow line.

Fig 7.1 Drilling rig

Drill rig with basic structural components



Mud injection hose. *Flexible hose* that introduces the drilling mud into the swivel.

Anticline. Geologic stratum that results from the convex folding of rock formations; large pools of oil often accumulate in it.

Impervious rock. Layer of *impermeable rock* that covers and protects the oil deposit; it prevents hydrocarbons from migrating into other rocks.

Oil. *Flammable*, relatively viscous oily liquid that is used as an energy source; it is made up of various hydrocarbons resulting from the *decomposition* of plant life over millions of year.

Gas. Mixture of gaseous hydrocarbons (mainly methane) that are found in underground deposits, which sometimes also contain *crude oil*; it is used mainly as a fuel.

Engine. Device *converting* the combustion of fuel and air into mechanical energy.

Substructure. Metal infrastructure that supports the derrick, engines and *auxiliary equipment*.

Traveling block. Movable mechanical device with pulleys; it is attached by cable to the crown block and fitted with a lifting hook.

Drill pipe. Hollow steel rods that are joined together according to the depth of the excavation; their rotation activates the bit.

Drill collar. Heavy steel tube immediately above the bit that applies a certain weight to the bit to help it cut into the rock.

Bit. Rotating drill bit with toothed steel or diamond wheels; it bores into rock to break it up and drill a hole.

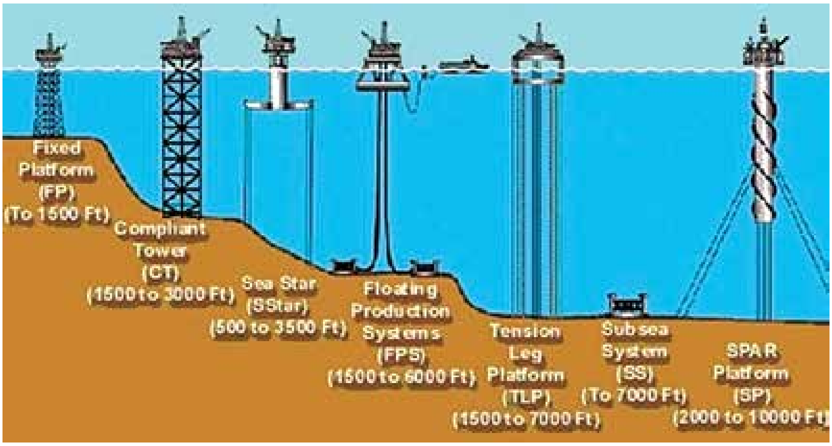
Rotary system. Drilling device in which a kelly is attached to a *rotary table*; with the help of powerful motors, it transmits the *rotative movement* to the kellies.

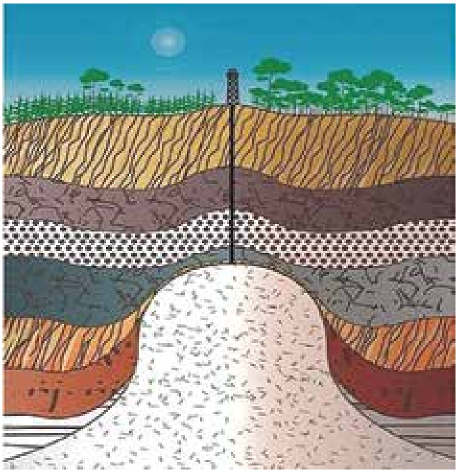
Rotary table. Circular table that is moved by powerful motors; it transmits its rotative movement to the drill pipes by means of the kelly.

Kelly. Special square rod that is screwed to the top of the drill pipes and driven by the rotary table.

Offshore drilling

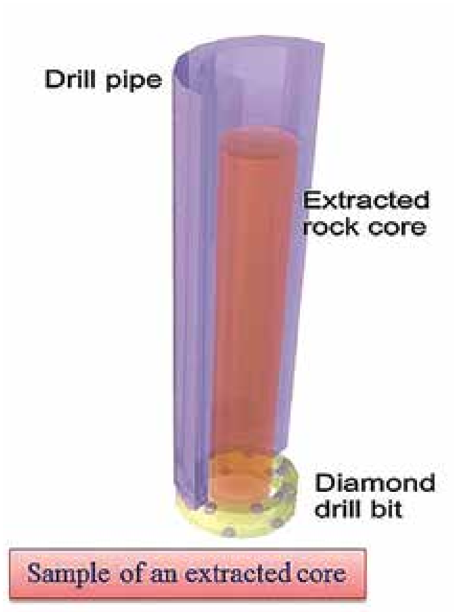
In a broad sense, operators drill two basic types of wells—exploratory (to find new oil or gas deposits) and development (to prepare the discovery for production)

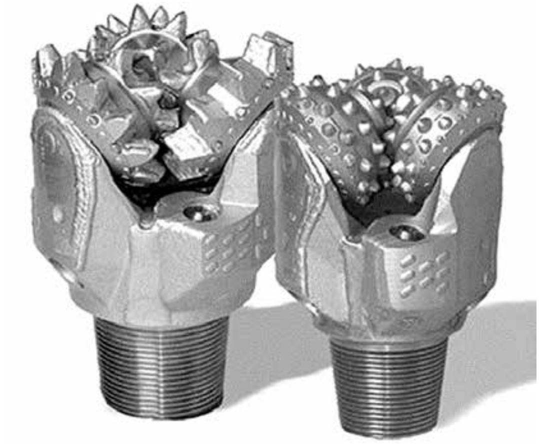




Before drilling an exploratory well, an operator will conduct geologic surveys of an area to determine the potential for oil or gas deposits and to identify specific targets. The oil company chooses the location and supervises the operation, which may take as little as 15 days or as long as 12 months, of *round-the-clock*, seven-days-per-week operation to drill a single well depending on the complexity of the project.

Exploration diamond drilling is used in the mining industry *to probe* the contents of known *ore* deposits and potential sites. By *withdrawing* a small diameter *core of rock* from the orebody, *geologists* can analyze the core by *chemical assay* and conduct petroilogic, *structural* and *mineralogic* studies of the rock.





The effectiveness of a drill bit varies by *formation type*. There are three types of formations: *soft, medium and hard*. A soft formation includes *unconsolidated* sands, clays, soft limestones, *red beds* and shale. Medium formations include calcites, dolomites, limestones, and hard shale. Hard formations include hard shale, calcites, mudstones, *cherty* limestones and hard and abrasive formations.

Questions

1. What is drilling?
2. What types of drilling do you know?
3. What is the most widespread drilling method?
4. Name major properties of rocks.
5. What is a drill rig?
6. Explain the meaning of an impervious rock.
7. What is gas?
8. What is bit used for?
9. What is exploration diamond drilling used for?
10. Explain what core of rock is.

Vocabulary

cutting process	[ˈkʌtɪŋ ˈprəusɛs]	процесс резания, рубки
drill bit	[drɪl bɪt]	буровое сверло (буровая коронка, долото), головка бура
work piece	[wəːk piːs]	заготовка, обрабатываемая деталь,
chips	[tʃɪps]	буровая стружка (syn. drilling cuttings)
cutting edge	[ˈkʌtɪŋ ɛdʒ]	режущая кромка, край
explosive charge	[ɪksˈpləusɪv tʃɑːdʒ]	заряд взрывчатого вещества
percussion drilling	[pəˈkʌʃən ˈdrɪlɪŋ]	ударное бурение
rotary drilling	[ˈrəutərɪ ˈdrɪlɪŋ]	вращательное бурение
rotary-percussion drilling	[ˈrəutərɪ pəˈkʌʃən ˈdrɪlɪŋ]	ударно-вращательное бурение, вращательно-ударное бурение
mechanical	[mɪˈkænɪkl]	механический
thermal	[ˈθəːml]	тепловой, термический
flame	[fleɪm]	пламя
hydraulic	[haɪˈdrɔːlɪk]	гидравлический
jet	[dʒɛt]	струя
sonic	[ˈsɔnɪk]	акустический, звуковой
high frequency vibration	[haɪ ˈfriːkwənsɪ vaɪˈbreɪʃən]	высокочастотная вибрация
chemical	[ˈkɛmɪkl]	химический
micro blast	[blɑːst]	микробласт
dissolution	[dɪsəˈluːʃən]	растворение, разложение
electrical	[ɪˈlɛktrɪkl]	электрический
electric arc	[ɪˈlɛktrɪk ɑːk]	электрическая дуга
magnetic induction	[mægˈnɛtɪk] [ɪnˈdʌkʃən]	магнитная индукция
seismic	[ˈsaɪzmɪk]	сейсмический
laser ray	[ˈleɪzər reɪ]	лазерный луч
nuclear	[ˈnjuːklɪər]	ядерный
fusion	[ˈfjuːʒən]	плавление, плавка
fission	[ˈfɪʃən]	расщепление, деление (ядра)
drilling rig	[ˈdrɪlɪŋ rɪg]	буровая установка, карета
drill steel	[drɪl stiːl]	буровая штанга
bit	[bɪt]	коронка
flushing air	[flʌʃ ɛər]	продувочный воздух
drilling cuttings	[ˈdrɪlɪŋ ˈkʌtɪŋ]	буровая стружка
as a consequence	[æz ə ˈkɔnsɪkwəns]	в результате

hard ness	[hɑːd]	твердость, крепость
strength	[strɛŋθ]	прочность
elasticity	[ɪlæsˈtɪsɪtɪ]	упругость
plasticity	[plæsˈtɪsɪtɪ]	пластичность
abrasiveness	[əˈbreɪsɪvnəs]	абразивность
texture	[ˈtɛkstʃər]	текстура
structure	[ˈstrʌktʃər]	структура
bore hole	[bɔːr həul]	скважина (syn. hole; well – буровая скважина, используемая при добыче нефти)
fabrications	[fæbrɪˈkeɪʃəns]	конструкции
underground utilities	[ˈʌndəgraund] [juːˈtɪlɪtɪ]	подземное оборудование, устройства
marine-based structure	[məˈriːn beɪs] [ˈstrʌktʃər]	платформа на воде (нефтяные вышки)
oil platforms	[ɔɪl ˈplætfɔːms]	нефтяные платформы, вышки
flexible hose	[ˈflɛksəbl həuz]	гибкий шланг
extensive dimensions	[ɪksˈtɛnsɪv] [daɪˈmɛnʃəns]	обширные/широкие размеры
to expose	[tuː ɪksˈpəuz]	обнажать
conventional	[kənˈvɛnʃənl]	стандартный, общепринятый
to penetrate	[tuː ˈpɛnɪtreɪt]	проникать, пронизывать
down hole instrument	[daun həul ˈɪnstrumənt]	забойный инструмент
to transmit	[tuː trænzˈmɪt]	передавать, посылать
assembly	[əˈsɛmblɪ]	монтаж, сборка, агрегат, устройство
rotational torque	[rəʊˈteɪʃənl tɔːk]	крутящий момент
wire line	[ˈwaɪər laɪn]	проводная линия, вспомогательный канат
logging	[ˈlɔgɪŋ]	каротаж, геофизическое исследование в скважине
to steer	[tuː stɪər]	управлять, руководить
employment	[ɪmˈplɔɪmənt]	применять, употреблять
to obtain	[tuː əbˈteɪn]	получать, добывать, приобретать
down hole motor	[daun həul ˈməutər]	забойный двигатель
Mud tank	[mʌd tæŋk]	резервуар для бурового раствора
Shale shaker	[ʃeɪl ʃeɪk]	вибрационное сито для бурового раствора
Suction line	[ˈsʌkʃən laɪn]	всасывающий трубопровод
mud pump	[mʌd pʌmp]	шламовый насос, буровой

		насос, грязевой насос
vibrating mud screen	[vaɪˈbreɪtɪŋ mʌd skriːn]	вибрационное сито
debris	[ˈdɛbriː]	обломки пород, обломочный материал
swivel	[ˈswɪvl]	шарнирное соединение, промывочный сальник
derrick	[ˈdɛrɪk]	мачтовый кран
pipe rack	[paɪp ræk]	стеллаж для труб
drill line	[drɪl laɪn]	буровой канат, рабочий канат
crown block	[kraun blɔk]	крон-блок
standpipe	[ˈstændpaɪp]	водонапорная труба
pulley	[ˈpulɪ]	ролик
goose-neck	[guːs nɛk]	колено
mud pit	[mʌd pɪt]	отстойник, амбар для бурового раствора
Kelly drive	[ˈkælɪ draɪv]	передача вращения буровому снаряду при помощи ведущей буровой трубы
Drill floor	[drɪl flɔːr]	буровая площадка
Blow out preventer	[bləu aut prɪˈvɛntɛ]	противовыбросовый превентор
Drill string	[drɪl strɪŋ]	бурильная колонна, колонна бурильных труб
Casing head	[ˈkeɪsɪŋ hɛd]	головка обсадной колонны
Rotary system	[ˈrəutərɪ ˈsɪstəm]	роторный способ бурения
drawworks	[ˈdrɔːwɜːks]	буровая лебедка
kelly	[ˈkælɪ]	ведущая бурильная труба
traveling block	[ˈtrævəlɪŋ blɔk]	талевый блок
drill collar	[drɪl ˈkɔlər]	воротник бура, утяжеленная бурильная труба (штанга)
rotary table	[ˈrəutərɪ ˈteɪbl]	буровой ротор/стол
rotative movement	[ˈmuːvmənt]	вращательное движение
round-the-clock	[raund ðə klɔk]	«круглые сутки»
to probe	[tuː prəub]	брать пробу, исследовать
withdrawing	[wɪθˈdrɔː]	– вынимание (to withdraw – отдергивать, вынимать, отводить)
core of rock	[kɔːr ɔv rɔk]	керн породы
chemical assay	[ˈkɛmɪkl əˈseɪ]	химический анализ
formation type	[fɔːˈmeɪʃən taɪp]	тип образования (тип пород)
unconsolidated	[ʌn kənˈsɔlɪdeɪtɪd]	рыхлый, неуплотненный
red beds	[rɛd bedz]	красный глинистый песчаник
impermeable rock	[ɪmˈpɜːmjəbl rɔk]	плотная порода

flammable	[ˈflæməbl]	опасный, легковоспламеняющийся
decomposition	[diːkɔmpəˈzɪʃən]	распад, разложение
red bed	[rɛd bɛd]	глинистый красный песчаник
cherty		кремнистый
crude oil	[kruːd ɔɪl]	необработанная (сырая) нефть
converting	[ˈkɔnvəːtən]	преобразование, превращение
auxiliary equipment	[ɔːgˈzɪlɪərɪ ɪˈkwɪpmənt]	вспомогательное оборудование
directional drilling	[dɪˈrɛkʃənl ˈdrɪlɪŋ]	направленное бурение
kickoff point	[ˈkɪkɔf pɔɪnt]	начальная точка
entry point	[ˈɛntrɪ pɔɪnt]	точка входа
Hydraulic fracturing	[haɪˈdrɔːlɪk ˈfræktʃər]	гидроразрыв
Fracture	[ˈfræktʃər]	трещина, разрыв
Ultimate	[ˈʌltɪmət]	полныйа, окончательный
To prevent	[tuː prɪˈvɛnt]	предотвращать
Porosity	[pɔːˈrɔsɪtɪ]	пористость, пористая среда
Permeability	[pɜːmjəˈbɪlɪtɪ]	проницаемость, проходимость

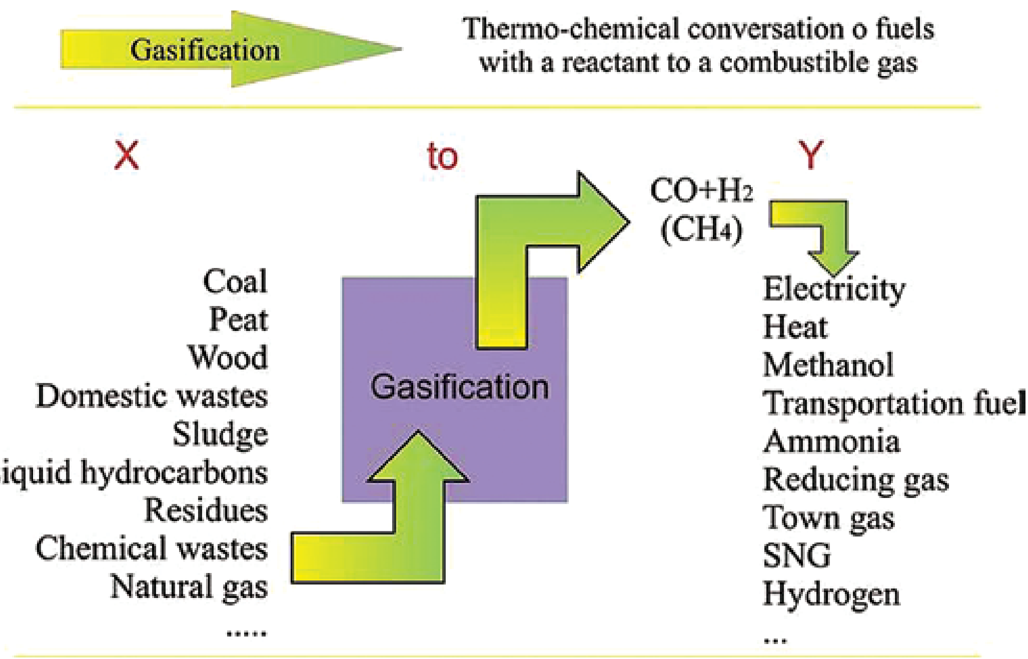
7.2 UNDERGROUND COAL GASIFICATION

Underground coal gasification

1. Gasification

Definition

Gasification is a process that converts organic or fossil carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and / or steam. The resulting gas mixture is called syngas (from synthesis gas or synthetic gas) or producer gas and is itself a fuel.



Application

Fuel gas for power and / or heat generation:

- fuel gas for industrial processes, e.g. hard coal coking;
- town gas and SNG for local heat supply;
- fuel gas for turbines and engines for power generation or for driving of motor vehicles.

Synthesis gas for different syntheses (e.g. of ammonia, methanol, transport fuels, alcohols).

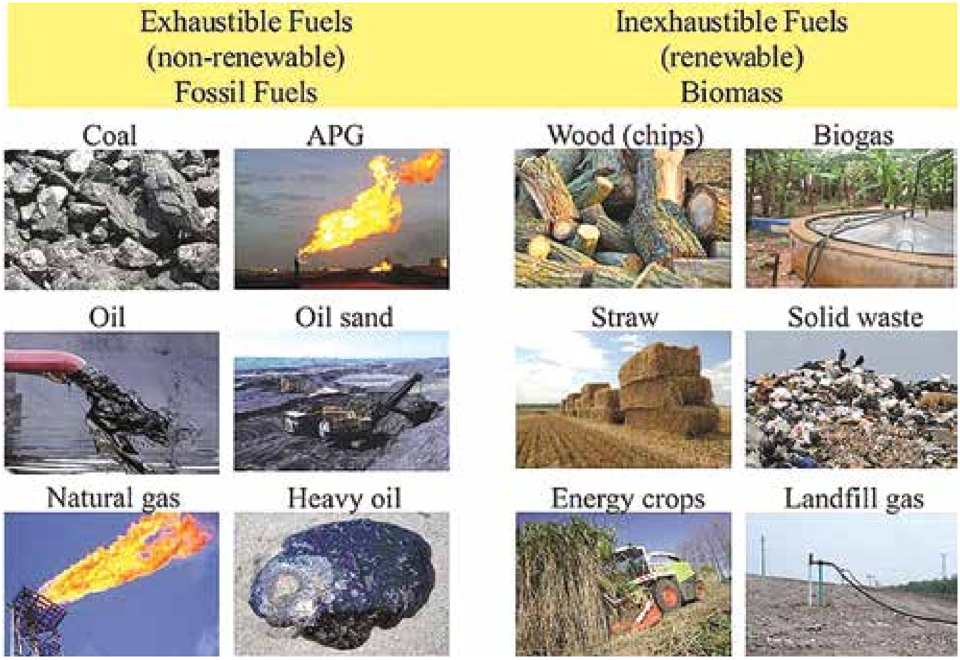
Hydrogen for hydrogenation processes (e.g. in petrochemical industries) or for fuel cells.

Reducing gas for metallurgical processes (e.g. in blast furnaces to produce iron).

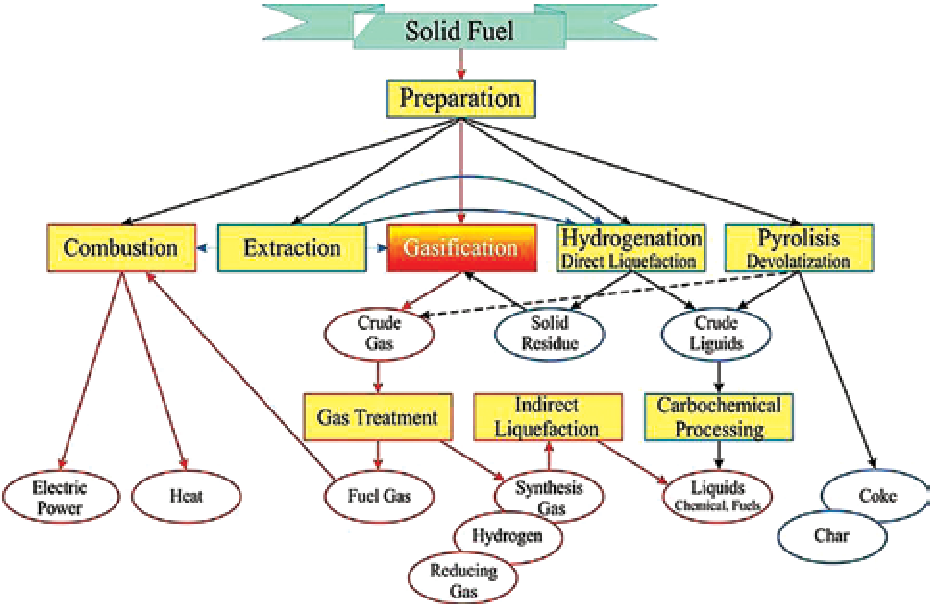
Further applications:

- energetic and non-energetic use of wastes and residues;
- recycling of chemical raw materials;
- Gasification as sub-process:
- in use in reduction processes in the metallurgy;
- for the production of carbonaceous adsorbents, activated carbon.

Fuels for gasification process



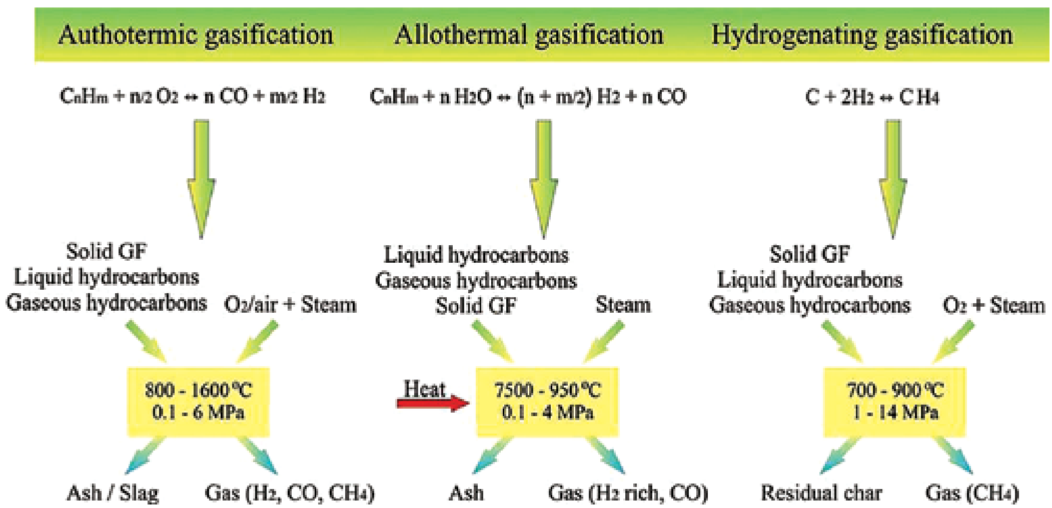
Conversion routs



Delimitation against other thermo-chemical processes

	Pyrolysis		Hydrogenation	Gasification	Combustion
	(HT) Cook-ing	(LT) Car-boni-sation			
Feedstock	coal, biomass, waste, liquid/gas hydrocarbons		coal, plastic waste, liquid hydrocarbons	coal, biomass, waste, char, liquid hydrocarbons	coal, biomass, waste, coke, liquid/gas hydrocarbons
Reactant	without		H_2	O_2/air (sub-stoichiometric)	air (hyper-stoichiometric) (O_2)
Chemical process	decomposition by heat		catalytic hydrogenation	partial oxidation	complete oxidation
Temperature °C	700-1100	400-700	350-500	700-1600	800-2200
Pressure, MPa	0.1		20-70	0.1-8	0.1-2.5
Product	coke (fuel gas)	tar/oil (char)	low/medium hydrocarbons	H_2, CO, CH_4	heat
By-products	tar/oil, BTX, NH_3, S, H_2	fuel gas, phenols S	liquid gas, phenols, NH_3, S	ash/slag, tar	ash/slag, flue gas
Examples	Hard coal coking,	Lurgi process	liquid-phase hydrogenation	- entrained flow gasification; - fluidized bed gasification; - fixed bed gasification	- pulverized coal combustion; - fluidized bed combustion; - grate combustion

Classification of gasification



Fundamental terms

Gasification feedstock (GF)	- solid (ash < 30wt%) - liquid - gaseous	- coal, coke, biomass, wastes - liquid hydrocarbons, refinery residues - natural gas, refinery gas
Gasification agent (GA)	- with exothermic reaction: O_2, H_2 - with endothermic reaction: H_2O, CO_2	technically greatest importance: - H_2O/O_2, H_2O/air, technical O_2, air
Gasification gas (GG) Synthetic gas (Syngas)	components - combustible gases - diluents - trace gases (pollutant components)	 - CO, H_2, CH_4, C_xH_x - N_2, CO_2, H_2O - S-, N-, Cl- compound,...
	by-products/impurities	tar/oil, phenol, benzene, naphthalene, organic acids, organic sulphur, soot, dust, ammonium salts, volatile metals,...
	designation - raw gas/purified gas - sour gas/sweet gas	 - until gas purification/after gas purification - until H_2S removal/after H_2S removal
	application - fuel gas low calorific value (lean gas) medium calorific value (town gas) high calorific value (rich gas)	 LHV < 8 MJ/m^3 LHV = 8-25 MJ/m^3 LHV > 25 MJ/m^3
	- synthesis gas	Methanol $CO/H_2 = {}^1/_2$, $CO_2/H_2 = {}^1/_3$ Fisher-Tropsch synthesis CO/H2 = ${}^1/_{1,7...2,5}$ Methanation (SNG) $CO/H_2 = {}^1/_1$ Oxo-alcohol synthesis $CO/H_2 = {}^1/_1$
	- hydrogen	ammonia synthesis hydrogenation process (fuel cells)
	- reducing gas	for blast furnace process $CO + H_2 > 90$ vol%
Gasification residue (GR)	- ash (bed ash, fly ash) - slag - residual char	- not molten - solidify - carbon-containing ash (incomplete gasification)

2. Coal gasification

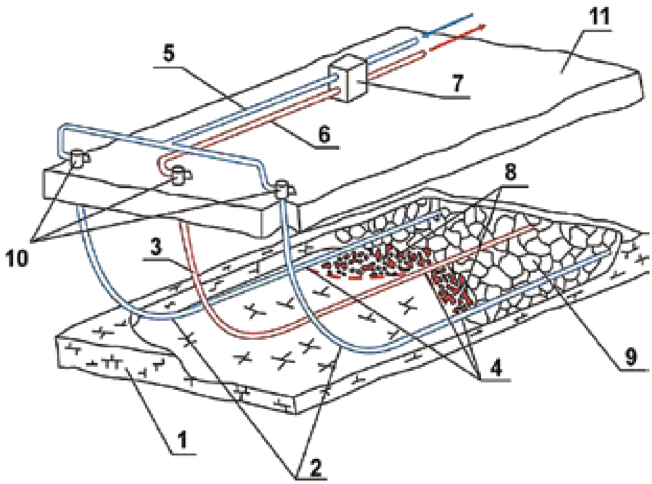
What is Underground Coal Gasification

Underground Coal Gasification (UCG) is a process by which coal is converted in-situ to a combustible gas.

UCG can provide energy from coal seams where traditional mining methods are either impossible or uneconomical.

In order to carry out this technology we need two boreholes. One of them is an injection well, the other one is production. Boreholes are bored towards the coal seam. It is an in-seam directional drilling.

UCG gases can be used for industrial heating, power generation, hydrogen production and chemicals like sodium, ammonia, char and other raw materials, because coal is a source of rare chemical elements. From coal we can also produce petroleum in the large volumes.



1 – coal seam; 2 – injection (inlet) boreholes; 3 – production (outlet) borehole; 4 – controlled retracting injection point; 5 – air injection pipeline; 6 – gas production pipeline; 7 – heat exchange utilizator; 8 – combustion face (reaction channel); 9 – goaf; 10 – pipeline sitting.

Fig. 7.2 The principle flow sheet of underground gas generator

Why Underground Coal Gasification

1. Lower operational costs then in conventional mining:

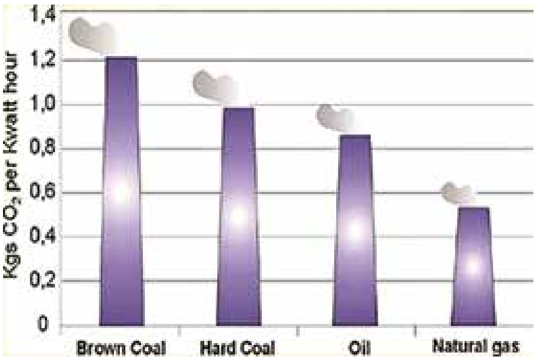
- Mining cost;
- Surface area;
- Transportation and storage;
- No surface gasification;

2. It can be used to exploit the offshore coal reserve which is unsuitable for utilization by conventional mining:

- Safety in mining;
- Unminable coal deposits;
- Dip coal seams;
- Thin coal seams;
- Coal seams with disjunctive and plicative geological dislocations

3. Environment advantages:

- controlled greenhouse gas emission GHG (CO2, NOx, SOx);
- carbon capture and storage CCS.



Environmental degradation is becoming a national priority.

The history of Underground Coal Gasification

The idea of underground coal gasification was proposed by Dmytro Mendelejev in 1880.

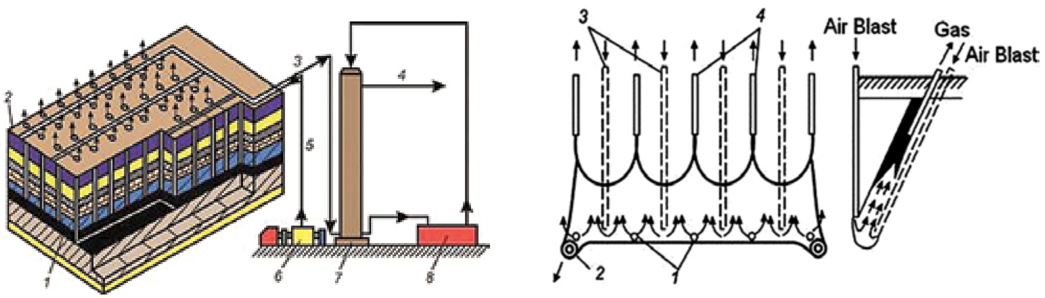
Underground coal gasification is a technology that has been discussed and experimented with for over 150 years. It was used at several sites in the former USSR, including a facility in present-day Uzbekistan that has been in operation since 1961. Interest in UCG was high after World War II, and a number of pilot projects were started across Europe. Most of these projects were abandoned in the 1960s due to falling energy prices.

The first project was offered by W. Ramsen in 1912 (not realized). The project of the station of «Pidzemgaz» was developed by I.P. Kirichenko in 1928.

I. Korobchanski, V. Matveev, V Skafa and other developed first industrial installation "Pidzmgaz", Lisichansk coal basin in Donbas (1933).

In Ukraine

Lisichansk station UCG had operated from 1933 till 1966 with annually productivity nearly 1,7 billion m3, (loses of coal reserves nearly 18%).



a) 1 – coal seam; 2 – daylight surface, 3 – gas outlet direction; 4 – syngas outlet; 5 – air supply direction;
b) 1, 3 – air blast wells; 2 – grid point; 4 – gas outlet wells;

Fig. 7.3 Flow sheets of UCG:

In Gorlovsk experimental station «Pidzemgas» (1935 – 1941) the method of gasification on coal seams with the angle of incidence 70-75° and thickness 1-1,9 m was tested.

In Sinelnikov experimental station “Pidzemgas” research with gas transporting goaf was conducted.

Flow sheets of UCG

During last years in Ukraine was determinate the parameters and developed project documents for experimental area of the BUCG station «Pivdeno-Sinelnikovska». Project document was developed by the employees of NMU and project institute of Dniprodiproshakht. A project was realized to the stage of generator gases reception, but from economic confusions, the station did not go out on the level of production.

Two building project for the stations of "Pidzemgaz" was developed for the stock company "Pavlogradcoal", Western-Donbas coal deposits and Tarnavsk brown coal deposit. A project was stopped on the stage of introduction because the absence of financing.

Flow sheets of experimental gas generator was developed for the conditions of Barbara mine during implementation the general project of «HUGE». Financing carries out the European fund of «Coal and steel».

Abroad

The first experiments of UCG were conducted after the Second World War. After World War II, the shortage in energy and the diffusion of the Soviets' results provoked new interest in Western Europe and the United States. In the United States, tests were conducted in 1947–1960 in Gorgas, Alabama. From 1973–1989, an extensive test was carried out. The United States Department of Energy and several large oil and gas companies conducted several tests. Lawrence Livermore National Laboratory conducted three tests in 1976–1979 at the Hoe Creek test site, Hanna, Rock Hill.

In Europe, the stream method was tested at Bois-la-Dame, Belgium, in

1948 and in Jerada, Morocco, in 1949. The borehole method was tested at Newman Spinney and Bayton, United Kingdom, in 1949–1950. A few years later, a first attempt was made to develop a commercial pilot plan, the P5 Trial, at Newman Spinney in 1958–1959. During the 1960s, European work stopped, due to an abundance of energy and low oil prices, but recommenced in the 1980s. Field tests were conducted in 1981 at Bruay-en-Artois and in 1983–1984 at La Haute Deule, France, in 1982–1985 at Thulin, Belgium, and in 1992–1999 the El Tremedal site, Province of Teruel, Spain.

Last time UCG has been tested and investigated in:

- China (12 experimental station);
- Australia pilot (Linc Energy, Carbon Energy, Cougar Energy);
- South Africa (Escom and Sasol);
- Hungary, Poland, Belgium, Canada, GB, NZ, USA.

The first major plant was at the Yerosticaz facility in Angren, in

Uzbekistan, which started in 1961, works a brown coal deposit and is now run by Linc Energy. The plant produced 35 million cu ft of synthetic gas a day, which is fed into the local power plant.

Difference between gasification and combustion

Gasification is a process by which coal is converted in-situ to a combustible gas primarily carbon monoxide (CO) and hydrogen (H_2).

Combustion is a conversation of coal into carbon dioxide (CO_2) and water (H_2O).

Gasification $(C_mH_m) + 1/2O_2 \rightarrow CO + H_2$

Combustion $(CmHm) + O_2 \rightarrow CO_2 + H_2O$

Combustion is the total oxidation of carbon, hydrogen and other elements, which releases thermal energy. Combustion is generally less thermally efficient than gasification. As shown by the typical combustion reactions below, combustion (as carried out in incinerators) produces higher concentration of pollutant gasses such as SO_x and NO_x.

Combustion (Oxidation) Reactions

$C + O_2 \longleftrightarrow CO_2$	Oxidation of carbon
$½ O2 + H_2 \leftrightarrow H_2O$	Oxidation of hydrogen
$N + O_2 \longleftrightarrow NO_2$ (NOx)	Oxidation of Nitrogen
$S + O_2 \longleftrightarrow SO_2$ (SOx)	Oxidation of Sulfur

Gasification is a much cleaner process than combustion (incineration) for converting carbonaceous materials to energy. In gasification, the fuel is first converted to a clean-burning gas (syngas) at high temperatures. This gas can be used as a clean fuel or converted to chemicals such as ammonia for industrial or agricultiral use.

The differences between gasification and combustion are best understood by comparing the chemical reactions involved in each process.

Gasification Reactions

$C + \frac{1}{2} O_2 \longleftrightarrow CO$ (Gasification with Oxygen)

$C + CO_2 \longleftrightarrow 2CO$ (Gasification with Carbon Dioxide)

$C + H_2O \longleftrightarrow CO + H_2$ (Gasification with Steam)

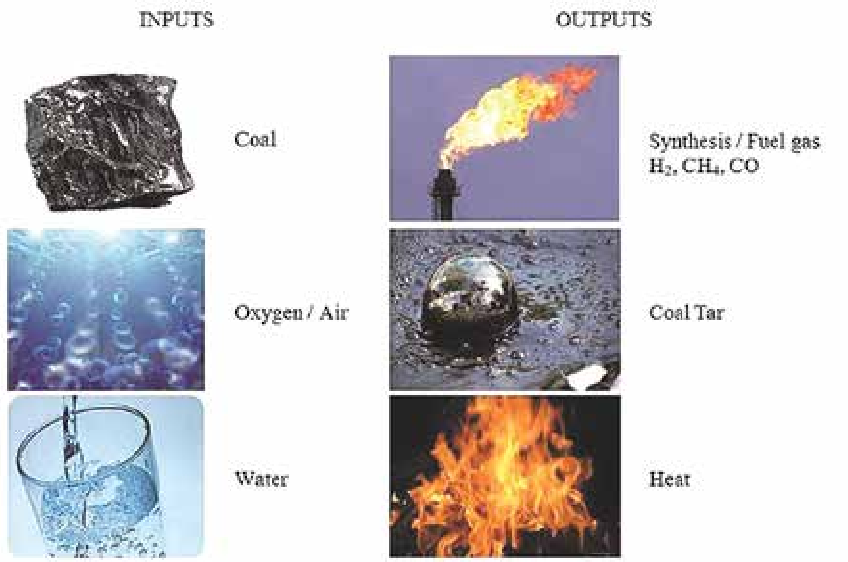
$C + 2H_2 \longleftrightarrow CH_4$ (Gasification with Hydrogen)

$CO + H_2O \longleftrightarrow H_2 + CO_2$ (Water-Gas Shift Reaction)

$S + H_2 \longleftrightarrow H_2S$ (Sulfur forms H_2S - not SO_x)

Fundamentals of coal gasification & chemical reactions

«Gasification» is a general term used for various reactions, besides combustion, that result primarily in a gaseous mixture of CO, H_2 and CH_4. In both conventional and underground gasification processes, the chemical and physical changes are similar; however, the in-situ coal naturally has higher methane and moisture contents.



The combustion gases generated from in-situ coal under specific conditions and according to the following reactions:

Drying: Wet Coal → Dry Coal + H_2O + 394 kJ/mol

Pyrolysis: Dry Coal → Char + Volatile matter ~ 0 kJ/mol

COMBUSTION

1). $C + O_2 = CO_2$ + 394 kJ/mol

2). $2C + O_2 = 2CO$ + 221 kJ/mol

GASIFICATION

3). $CO_2 + C = 2CO$ – 173 kJ/mol

4). $H_2O + C = CO + H_2$ – 130 kJ/mol

5). $2H_2O + C = CO_2 + H_2$ – 80 kJ/mol

6). $CO + 3H_2 = CH_4 + H_2O$ + 205 kJ/mol

7). $C + 2H_2 = CH_4$ +75 kJ/mol

The water-gas reaction is the most important for generating the gas fuel mixture of mainly H_2 and CO, known also as 'water-gas' product. Note that the enthalpy of reaction is positive, which means that this reaction is endothermic. As a result, the preparation of the water-gas reaction typically involves alternating blasts of steam and either oxygen or air through a heated coal seam.

The exothermic reactions between coal and oxygen to produce CO and CO_2 provide enough energy to drive the reaction between steam and coal. Additional steam in the injection blast generally lowers the temperature of the reaction zones and thus improves the efficiency of the gasification. Too much steam, however, can stop the gasification process, then it is need to provide a new coal ignitionn.

Factors affecting UCG Designs

1. Coal seam geology:

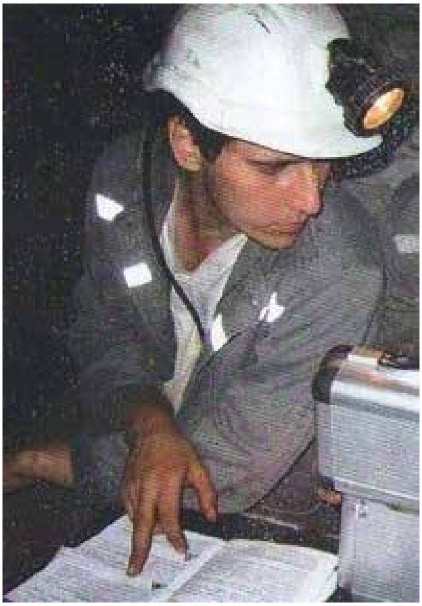
- Thickness and depth;
- Permeability to gas, liquid;

2. Coal properties:

- Rank (ash, volatile, carbon content);
- Chemical composition (hydrogen, sulphur, oxygen);

3. Strata / overburden properties:

- Geology;
- Hydrogeology;
- Geomechanics;
- Drilling properties;



4. Product gas:

- Required volume;
- Composition, calorific value;

5. Process efficiency:

- Thermal;
- Chemical;
- Resources recovery;

6. Interaction with the environment:

- Subsidence effects;
- Water contamination.

Advantages of UCG over conventional mining and surface gasification

Nowadays classic mining methods are expensive and have economic and environmental disadvantages. Problems in traditional technology promote creation of a new technology. Such technology is underground coal gasification. Why?

- Process of mining is eliminated;
- Lower capital costs;
- No human labor underground;
- Lower surface distraction;
- Much higher coal extraction up to 95 %;
- Loss of methane during mining and transporting is avoided;
- No ash of coal and solid wastes at the surface;
- Direct use of groundwater;
- Cavities formed as a result of UCG can be used for CO2 capture and storage;

- The economics of UCG look promising as capital expenses should be considerably less than surface gasification;
- Generator gas suitable for high-efficiency power generation;
- Syngas is source of hydrogen, liquid fuel and chemicals;
- Positivities of transport of medium calorific value gas over a distance of 100 km;
- Safer;

Disadvantages and potential problems of UCG

- Difficulties in linking the injection and production wells;
- Variation of product gas composition;
- Lower heating value of the produced gas;
- Groundwater pollution;
- Subsidence and rock mass deformation;
- Public concerns about potential loss of controllability of the reaction.

Environmental Impact

- Ground water contamination is preventable;
- UCG leaves environment largely untouched;
- Piping is removed and boreholes are cut off and filled;
- Only trace elements of contaminants are left underground ;
- Air is used not only once, instead of using air for mining ventilation;
- In comparison to conventional CTL process it is safer technology.

Compared to traditional coal mining and processing, the underground coal gasification eliminates surface damage and solid waste discharge, and reduces sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions. For comparison, the ash content of UCG syngas is estimated to be approximately 10 mg/m³ compared to smoke from traditional coal burning where ash content may be up to 70 mg/m³. However, UCG operations cannot be controlled as surface gasifiers. Variables include the rate of water influx, the distribution of reactants in the gasification zone, and the growth rate of the cavity. These can only be estimated from temperature measurements, and analyzing product gas quality and quantity.

Subsidence is a common issue with all forms of extractive industry but UCG leaves the ash behind reaction channel in goaf.

Underground combustion produces NO_x and SO_2 lowers emissions, including acid rain. The process has advantages for geologic carbon storage. Combining UCG with CCS technology allows re-injecting some of the CO2 on-site into the highly permeable rock created during the burning process. Contaminants, such as ammonia and hydrogen sulfide, can be removed from product gas at a relatively low cost.

Aquifer contamination is a potential environmental concerns. Organic and often toxic materials (such as phenol) remain in the underground chamber after gasification and, therefore, are likely to leach into ground water. Phenol leachate is the most significant environmental hazard due to its high water solubility and high reactiveness to gasification. Some research has shown that the persistence of such substances in the water is short and that ground water recovers within two years.

Criteria for UCG

A wide variety of coals are amenable to the UCG process. Coal grades from lignite through to bituminous may be successfully gasified. A great many factors are taken into account in selecting appropriate locations for UCG, including surface conditions, hydrogeology, lithoglogy, coal quantity, and quality.

Also UCG requires other special properties of coal seam:

- Coal seam lays underground between 100 and 1400 meters (preferably more than 300 meters);
- Thickness is more than 0,8 meters;
- Ash content is less than 60 %;
- Minimum geological dislocation;

- No good water aquifers;
- Minimum distance of 1,6 km from rivers;
- Minimum distance of 1,6 km from abundant mines and minimum distance;
- of 3,2 km from active mines;
- Floor and roof conditions need be examined.

How does UCG work

Step 1: Finding the coal

Step 2: Drilling boreholes

Step 3: Linking the boreholes underground

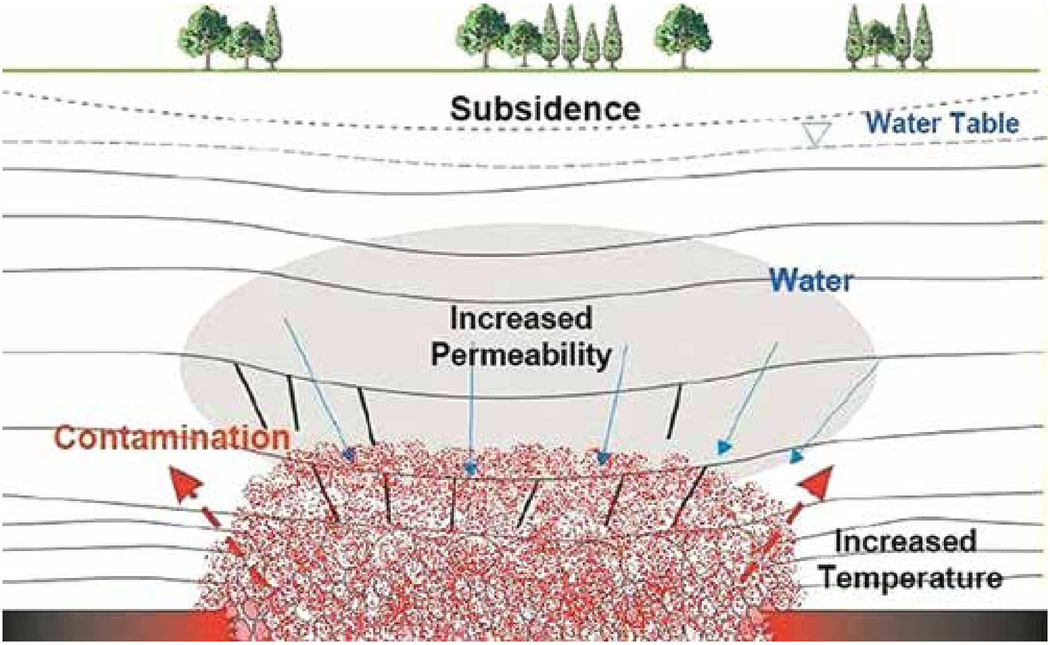
Step 4: Igniting the coal

Step 5: Injecting the O_2 and steam

Step 6: Extracting the syngas

Rock mass deformation

The most important factor in this process is rock mass behavior at underground coal gasification. It is known that the mechanism of rock mass behavior at underground coal gasification is in a great extent alike the processes which accompany the wallface coal extraction in mining. Therefore it is necessary to conduct research for determination the deformed state of rock mass moving around an underground gas generator in the mine conditions.



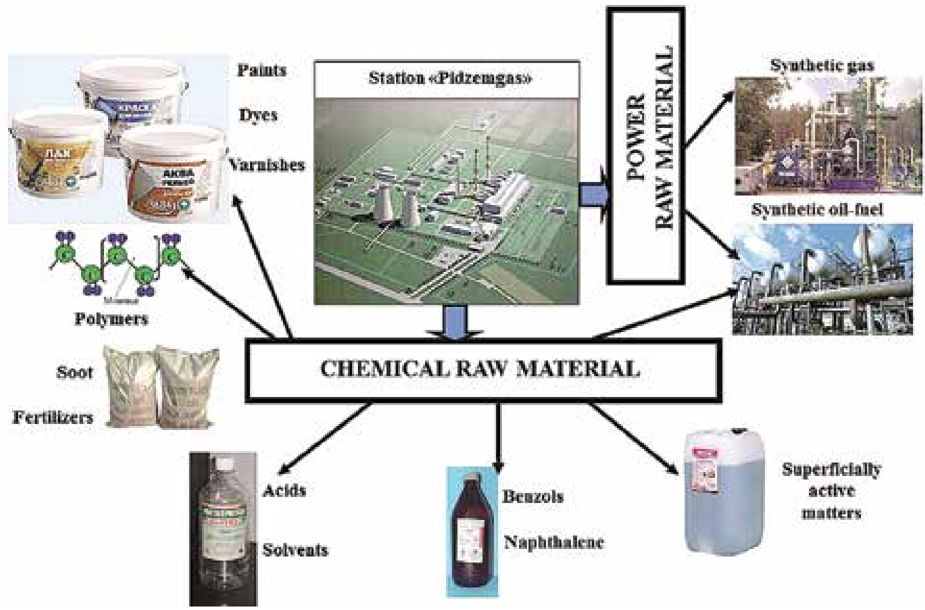
Nevertheless we cannot stop deformation, and if impacts cannot be managed, we must abandon the site for UCG.

Products of UCG

UCG product gas is used to fire combined cycle gas turbine (CCGT) power plants, with a combined UCG/CCGT process efficiency of up to 43%. CCGT power plants using UCG product gas instead of natural gas can achieve higher outputs than pulverized-coal-fired power stations (and associated upstream processes, resulting in a large decrease in greenhouse gas emissions. It can be also used in IGCC power plant.

UCG product gas can also be used for:

- Synthesis of liquid fuels;
- Manufacture of chemicals, such as ammonia and fertilizers;
- Production of synthetic natural gas;
- Production of hydrogen.



In addition, carbon dioxide produced as a by-product of underground coal gasification may be re-directed and used for enhanced oil recovery.

Underground product gas is an alternative to natural gas and potentially offers cost savings by eliminating mining, transport, and solid wastes. The expected cost savings could increase given higher coal prices driven by emissions trading, taxes, and other emissions reduction policies.

Questions

1. Give a definition of gasification.
2. Name the renewable and non renewable fuels for gasification.
3. What is the temperature regime of gasification process?
4. What does partial and complete oxidation mean?
5. What types of gas according to heating value do you know?
6. Give a definition of underground coal gasification.
7. What are the main parts of UCG flow sheet?
8. What was the first UCG station?
9. What is the UCG station that is now run since 1961?
10. Name the main reactant of UCG process.
11. What is the difference between exothermic and endothermic chemical reactions?
12. What are the main products of UCG power plant?
13. Expalain the following abbreviations: CCT, SNG, IGCT, CTL, CRIP, GF, LHV, BUCG, GHG and CCS?

Vocabulary

gasification	[gæsifi'keiʃ(ə)n]	газификация
syngas	['singæs]	синтез-газ
thermo-chemical	[ðermo'kemik(ə)l]	термохимический
conversion	[kən'vɜ:ʃ(ə)b]	конверсия, переработка
reactant	[ri'æktənt]	реагент
combustible gas	[kəm'bʌstəb(ə)l gæs]	горючий
sludge	[slʌdʒ]	шлам
residues	['rezidju:]	остатки нефтепродуктов
methanol	['məθənɒl]	метанол, метиловый спирт
reducing gas	[ri'dju:siŋ gæs]	восстановительный газ
engine	['engʒin]	механизм, машина
vehicle	['vi:k(ə)l]	автотранспорт
alcohol	['ælkəhɒl]	спирт
hydrogenation	[haidrɒdʒi'neiʃ(ə)n]	гидрогенизация
fuel cell	['fjʊlsel]	топливный элемент, ТВЭЛ
blast furnaces	['bla:stfɜ:nis]	доменная печь
recycling	[ri:'saikliŋ]	переработка отходов, повторное использование
chemical raw materials	['kemik(əl) rɔ: mə'ti(ə)riəl]	химическое сырье
heavy oil	['hevi ɔil]	тяжелая нефть
biomass	['baiə(ʊ)mæs]	биомасса
chips	[tʃips]	стружка
straw	[strɔ:]	солома
energy crops	['enədʒi krɒp]	энергетическая культура
landfill gas	['lændfil gæs]	свалочний газ
rout	[ru:t]	метод, путь, способ
liquefaction	[likwi'fækʃ(ə)n]	сжижение, разжижение
pyrolisis	[pi'rəlizis]	пиролиз
crude gas	[kru:d gæs]	сырой нефтяной газ
gas treatment	[gæs 'tri:tment]	очистка газа
coke	[kəʊk]	кокс
char	[tʃa:]	коксовый остаток
delimitation	[dilimi'tiʃ(ə)n]	разграничение
against	[ə'ge(i)nst]	по сравнению
feedstock	['fi:dstɒk]	сырье
substoichiometric	[substɔikiəʊ'metric]	субстехиометрический

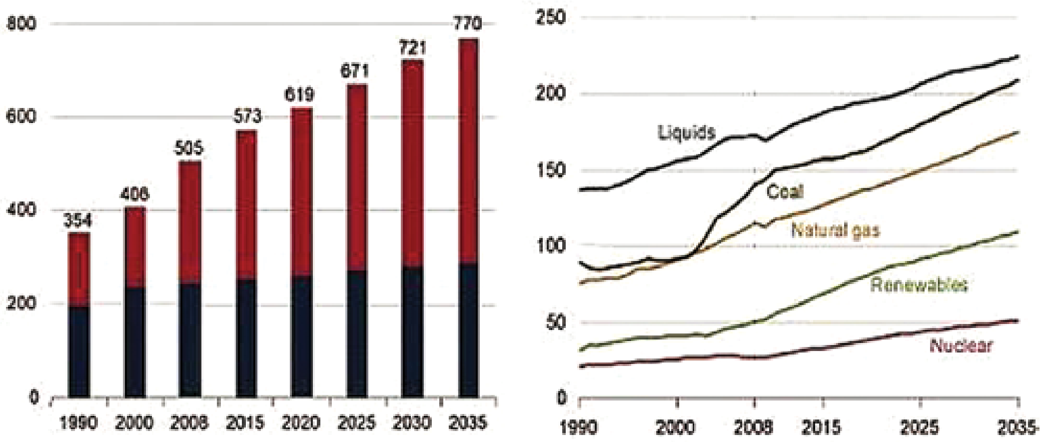
hyperstoichometric	['haipərstɔikiəʊ'metric]	гиперстехиометрический
decomposition	[di:kɒmpə'ziʃ(ə)n]	разложение
catalytic	[kætə'litil]	каталитический
tar	[tɒ:]	смола
phenols	['fi:nɒls]	фенолы
slag	[slæg]	шлак
flue gas	[flu: gæs]	дымовой газ
entrained flow gasifiction	[in'trein fleʊ gæsifi'keiʃ(ə)n]	поточная газификация
fluidized bed gasification	['flu:idaizid bed gæsi-fi'keiʃ(ə)n]	газификация в псевдо-ожиженном слое
fixed bed gasification	[fikst bed gæsifi'keiʃ(ə)n]	слоевая газификация
pulverized coal combus-tion	['pʌlvəraiz kəʊl kəm'bʌstʃ(ə)n]	сжигание угольной пыли
fluidized bed combustion	['flu:idaizid bed kəm'bʌstʃ(ə)n]	сжигание в псевдоожи-женном слое
grate combustion	[greit kəm'bʌstʃ(ə)n]	сгорание на решетке
refinery	[ri'fain(ə)ri]	нефтеперерабатывающий завод
exothermic	[eksə(ʊ)'θɜ:mik]	экзотермический
endothermic	[endə(ʊ)θ'ɜ:mik]	эндотермический
diluents	['diljʊəns]	уменьхающие концентра-цию, растворители
impurities	[im'pjuritis]	примеси
soot	[sʊt]	сажа
raw gas	[rɔ: gæs]	необработанный генера-торный газ
purified gas	['pjʊ(ə)rifaid gæs]	очищен газ
sour gas	['saʊə gæs]	высокосернистый газ
sweet gas	[swi:t gæs]	малосернистый газ
lean gas	[li:n]	бедный газ
bed ash	[bed æʃ]	зольный остаток
fly ash	[flai æʃ]	золовынес
injection well	[in'dʒekʃ(ə)n wel]	дутьевая скважина
production well	[prə'dʌkʃ(ə)n wel]	газоотводная скважина
borehole	['bɔ:həʊl]	скважина
directional drilling	[d(a)i'rekʃənl 'driliŋ]	наклонно направлено бу-рение
flow sheet	['fləʊʃi:t]	технологическая схема
combustion face	[kəm'bʌstʃ(ə)n feis]	огненный забой
goaf	[gəʊf]	выработано пространство

disjunctive	[dis'dʒʌŋ(k)tiv]	дизюнктив
plicative	[pli:kativ]	пликатив
implementation	[implimən'teiʃ(ə)n]	выполнение, внедрение
shortage	['ʃɔ:tidʒ]	нехватка
diffusion	[di'fju:ʒ(ə)n]	диффузия
extensive	[ik'stensiv]	обширный
stream method	[stri:m 'meθəd]	поточный метод
abundance	[ə'bʌndəns]	избыток
recommence	[rikə'mens]	возобновлять
primarily	['praim(ə)rəli]	в первую очередь
release	[ri'li:s]	высвобождать
incinerator	[in'sinəreitə]	печь для сжигания
alternating	['ɔ:ltəneitiŋ]	переменный, периодический
blasts	[blɒ:st]	потек, струя
ignition	[ig'niʃ(ə)n]	розжиг
permeability	[pɜ:miə'biliti]	проницаемость, коэффициент фильтрации
resources recovery	[ri'zɔ:s ri'kʌv(ə)ri]	степень добычи полезных ископаемых
interaction	[intə'rækʃ(ə)n]	взаимодействие
subsidence	[səb'said(ə)ns]	оседание, проседание
eliminate	[i'limineit]	устранять
linking	['liŋkiŋ]	сбойка (скважин)
controllability	[kəntrəʊə'biliti]	управляемость
discharge	[dis'tʃɒ:dʒ]	выделение, утечка
smoke	[sməʊk]	дым
gasifier	['gæsifaiə]	газогенератор
relatively	['relətivil]	относительно
leach	[li:tʃ]	вымывать, промывать
amenable	[ə'mi:nəb(ə)l]	пригодный
appropriate	[ə'prəʊprieit]	целесообразный
accompany	[ə'kʌmp(ə)ni]	сопровождать
instead	[in'sted]	вместо
fertilizer	['fɜ:tilaizə]	удобрение
enhanced	[in'hɒ:ns]	усиливать
tax	[tæks]	налог

7.3 GAS HYDRATES AS AN ALTERNATIVE SOURCE OF ENERGY

1. Relevance of gas hydrates and their essence

The nature for millions of years has accumulated a huge amount of mineral deposits that are successfully used by the humanity as energy sources during many centuries. But recently there is an acute question rises concerning the period of time which such resources as coal, oil and natural gas will be enough for. According to various scientists' calculations, their amount will be enough for 250-300 years at current consumption rates: oil – for 40 years, natural gas – 70 years, coal – 200 years, uranium – 85 years (Makogon 2010) (Fig.7.4)



a) b)

a) The dynamics of using the energy, 1990-2035, quadrillion Btu (1 Btu ≈ 1055 J);
b) Volume of world fuel consumption, 1990-2035, quadrillion Btu

Fig. 7.4 Energy resources consumption:

One of the perspective, and, according to most scientists, the most perspective alternative source of energy on the planet is gas hydrates. Gas hydrates represent specific combination of two widely spread matters –

water and natural gas. Gas hydrate is a crystalline compound-clathrate in which gas molecules are trapped in cavities that are located in so-called "carcasses" formed by water molecules and connected between each other by firm hydrogen bonds. Water molecules in such compounds are called "hosts" and molecules of other matters stabilizing the crystalline lattice – "guests" (hydrate formers). Gas molecules (guests) are located in internal cavities of crystalline lattice of water and are held by Van der Waals forces (Fig. 7.5).

Molecules-guests stabilize the system, since the crystalline lattice itself, if it is not filled with minimal number of gas molecules, is thermodynamically metastable.

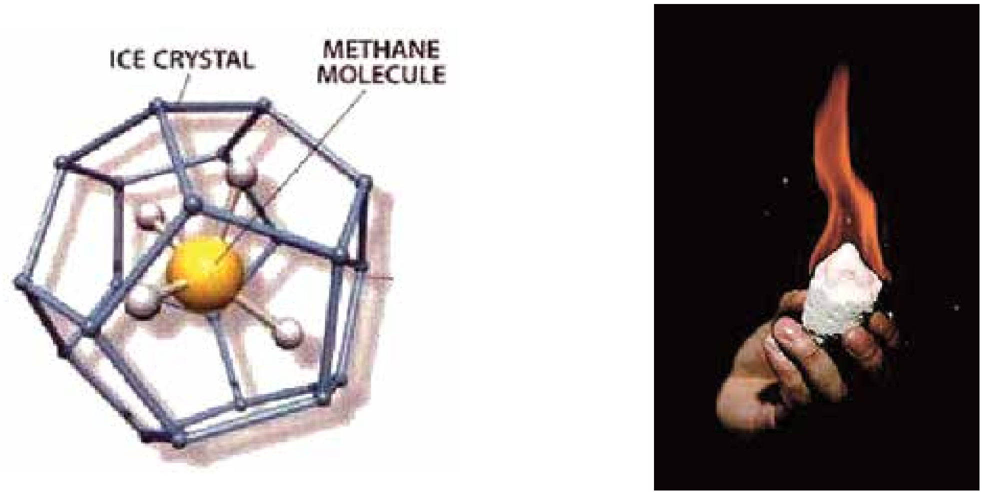
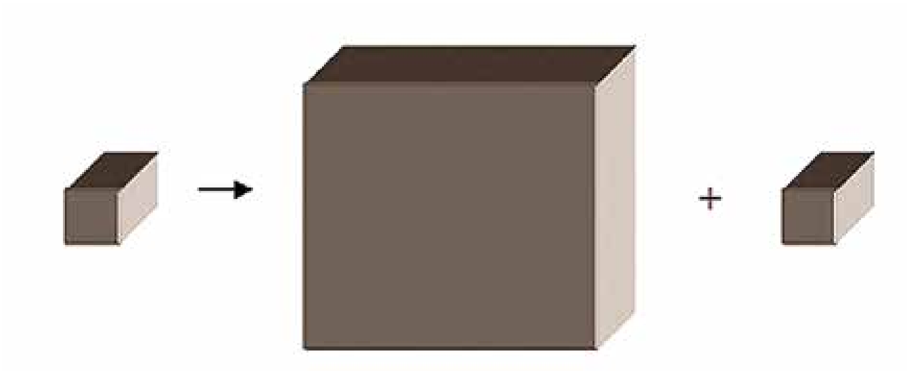


Fig. 7.5 Gas hydrates structure: molecule of methane in "carcass" formed by water molecules by means of hydrogen connections

General formula of gas hydrates – , where – gas molecule, – water molecules number per one included gas molecule. As a result of molecules compaction, 1 m^3 of natural methane hydrate in solid state contains 175 m^3 of methane! (Fig. 7.6)



1 м³ of methane hydrate — 164 м³ of methane — 0.8 м³ water

Fig. 7.6 Content of water and gas in gas hydrate

2. Conditions of formation and dissociation

The first discovered gas hydrates were created with help of people although not intentionally. Gas industry workers know hydrates because of their property to create plugs in pipelines decreasing pipes cross-section needed for gas movement (Leksakov and Kudryavtseva 2010).

In order to have natural gas hydrates formed, the following conditions are re-quired: pressure – from 1 to 200 atm. and temperature – from -30°C to +40°C depending on formation conditions and composition of a hydrate.

On the planet gas hydrates form in continental shelf zones, since 90% of all organic matter in the ocean is concentrated exactly in those areas, decomposition products of this matter is the source for methane creation.

Also, gas hydrates form in permafrost areas where rocks temperature does not rise above 0 °C. Percentage of gas hydrates content in marine sediments is 95% and in permafrost zones – only 5% (Fig. 7.7).

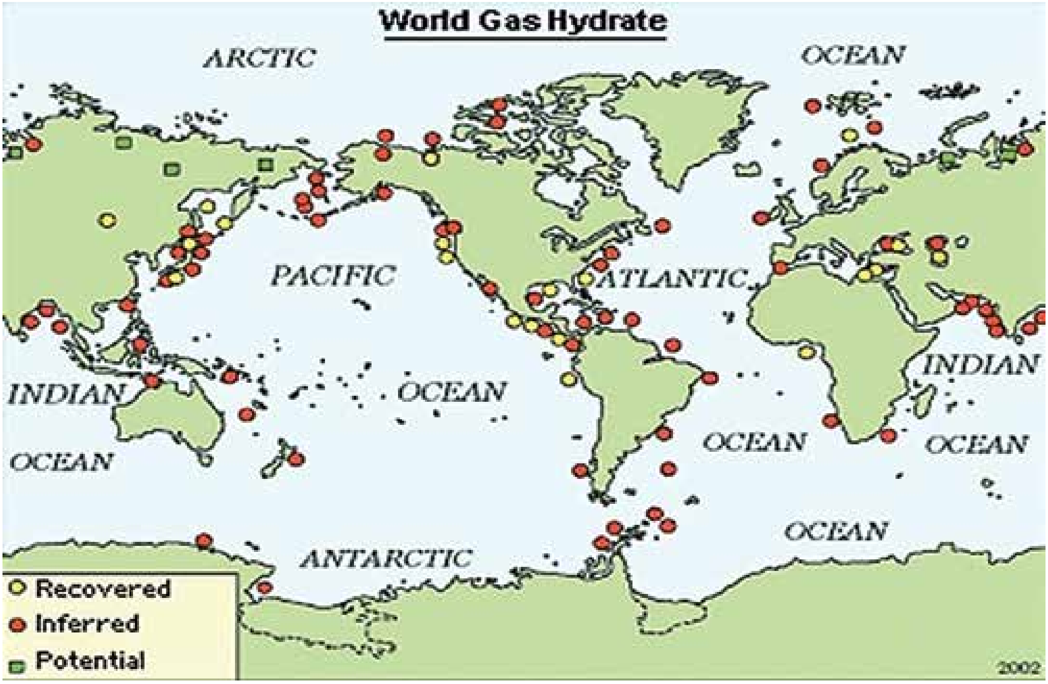


Fig. 7.7 Deposits of gas hydrates located in marine sediments and permafrost areas

Gas hydrates formation conditions, in particular, pressure and temperature, have wide range. Gas hydrates form in sea water at depths of more than 500 meters in low and middle latitudes, and in more than 150-200 meter-depth in high latitudes. Also they can form under the sea bottom creating layers from dozens to hundreds meters thick. Range of stability zone fluctuates depending on temperature, pressure, hydrate-forming gas composition, geological conditions (porosity, density of hydrate-containing rock), depth and other factors (Fig. 7.8).

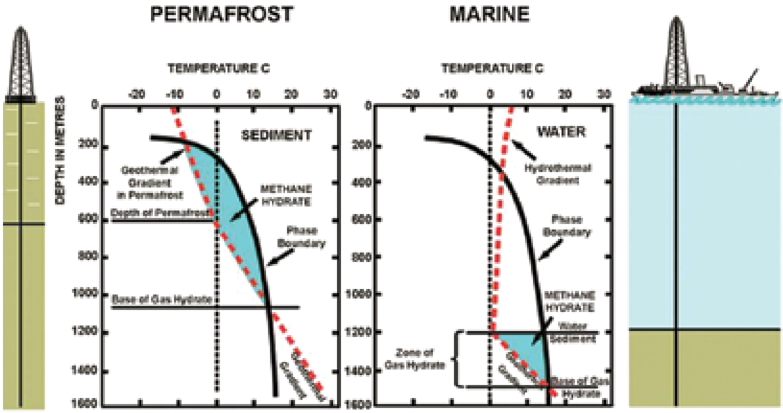


Fig. 7.8 Conditions of hydrates formation in marine environment and permafrost areas

It is worth mentioning that insignificant concentrations of other gases, for example, 5% of propane, can decrease gas hydrate formation pressure in two times (Deaton and Frost 1964). This is an extremely important fact which should be taken into account during further research of gas hydrates.

3. Amount of gas hydrates in the black sea

In 2002 the studies conducted by Bulgarian scientists showed that the average depth at which the hydrates begin to form is 620 m embracing territory of about 288100 km^2 that presents near 68.5% of the Black sea total area.

Based upon the research of the same scientists, thickness of the hydrate stability zone (HSZ) in the Black sea reaches 160 m at depth of 1000 m. At depth of 1500 m the layer thickness makes up 260 m in average (from 110 to 650 m) and at 2000m-depth – 350 m. If to calculate the amount of gas contained in gas hydrates of the Black sea (volume of gas hydrates makes up about 0.35 ×1012 m^3) then this number would make 40-50 × 1012 m^3 of methane!

Based upon the expeditions conducted in the 90’s in the USSR, the amount of methane in the whole Black sea resulting from drilling and lifting samples of the sea bottom soil in more than 400 cores is not less than 100 trillion m^3. With that, regions of the Sea of Azov still remain to be unexplored.

4. Formation conditions of gas hydrates in the black sea

When talking about formation conditions of gas hydrates the attention should be paid to composition of gas forming the hydrate, temperature and pressure of the forming media, sediment porosity and other.

Usually, hydrates form under temperature below +30°C and high pressure. For example, at 0˚ C methane hydrate forms at pressure of 3 MPa, and carbon dioxide at 1 MPa. If the temperature is +25°C, methane hydrate forms at pressure of 40 MPa. Density of the Black sea's gas hydrates is within 0.9-1.1 g/cm^3.

Water temperature in the Black sea below the seasonal temperature variations increases with depth and consequently the water surface temperature grows from 8.7 to 8.8°C at sea depth being 400-500 m; and at sea depth of 2100-2200 m - to 9.05-9.1°C. It allows to make a conclusion that in bot-tom sediments at sea depth of 620-650 m, favorable thermobaric conditions exist all over the place for formation and stable existence of methane hydrates (Fig. 7.9)

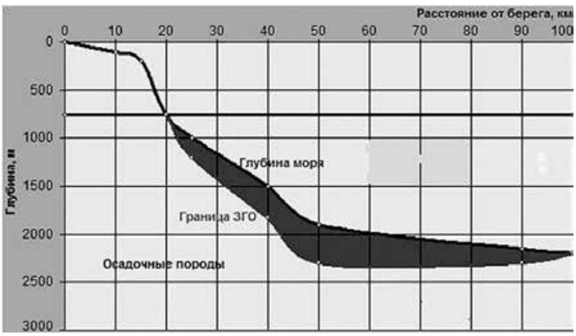


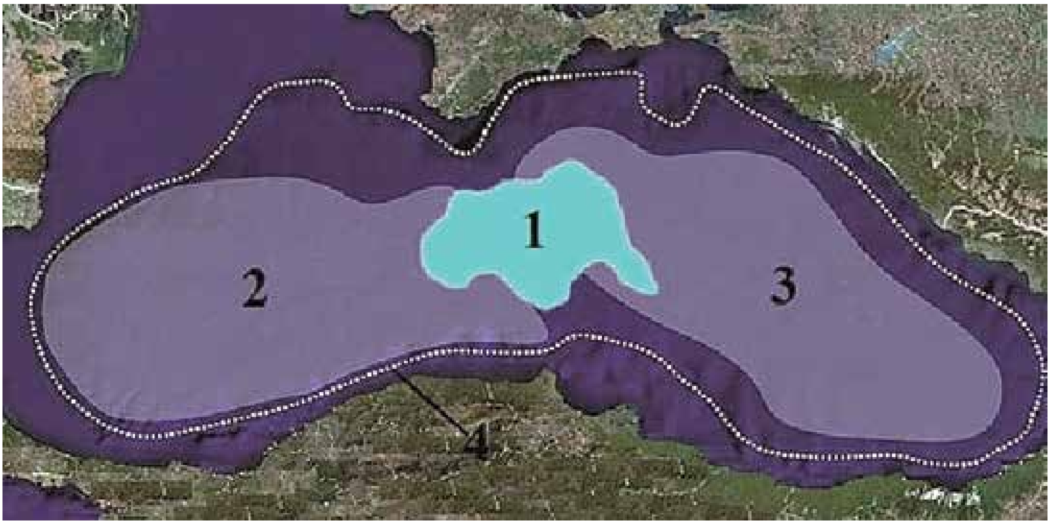
Fig. 7.9 Stable zone of gas hydrates formation in the Black Sea

It is seen from this picture that gas hydrate formation within the shown zone of the Black Sea begins from the depth of about 750 m under the water surface and ends at the depth of about 2350 m. At this maximal thickness of the layers reaches around 400m.

The Black sea water, especially in shallow layers is far less salty than the oceans water. In average, 1000 grams of the Black sea water contains 18 grams of salt. Whereas, in Atlantic Ocean 1000 grams of water contains 35 grams of salt, Red sea water contains 39 grams of salt. So, exactly relatively low content of salt in the Black sea has a favorable influence on gas hydrates formation.

Basic amount of these deposits are allocated to Ukraine and Romania, less – to Turkey, Bulgaria, Russia and Georgia.

Fig. 7.10 shows one of the most perspective gas hydrate deposits. Its depth is around 2000 m.

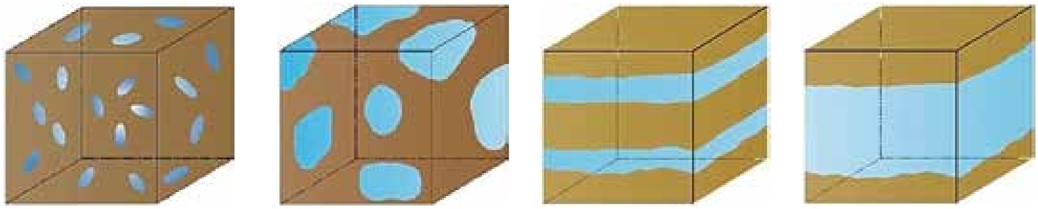


1 – highly perspective zone of gas hydrate formation; 2 – Western Black Sea trough; 3 –Eastern Black Sea trough; 4 – outline of the Black Sea trough

Fig. 7.10 Map-scheme of gas-bearing zones suitable for hydrates formation in the Black Sea trough

5. Types of gas hydrate deposits

There are four possible ways of gas hydrate formations in sea sediments: scattered cement components, thin interlayers (nods), veins and massive solid layers (Fig. 7.11).



dispersed cement nods veins massive layers

Fig. 7.11 Possible forms of gas hydrate.

And, in addition, there are two mechanisms of gas hydrates creation in the pore space of sediments. First, gas hydrates are formed at the contacts of rock grains. In that case, hydrates play cementing role in sediments. According to the second mechanism, the formation of gas hydrates occurs in pores outside contacts between grains, and hydrates have practically no effect or no effect at all on rock particles cohesion which reduces porosity of sediment.

6. Existing technologies

The selection of suitable technology of gas extraction is fully based on the geological conditions and properties of gas hydrate deposits. At present there are three basic methods for gas extraction from a hydrate layer are taken into account: heating hydrate-bearing formations above equilibrium temperature, artificial pressure decrease withing the layer and inhibitors introduction. They are all based on dissociation – process during which a compound decomposes into more simple components: gas and water.

Heat carrier introduction method is based on heat delivery inside the gas hydrate crystal lattice to increase temperature and speed up dissociation process. During the heating process an exothermal catalytic reaction occurs with specific heat liberation exceeding solid gas hydrate dissociation heat (Equation 7.1).

$$CH_4\left(H_2O\right)_n \rightarrow CH_4 + n \cdot H_2O \cdot \Delta H_f = 54.49 \text{ KJ/mole} \qquad (7.1)$$

But, as the study's results show, heat influence through the borehole face is low efficient.

It is connected with the fact that gas hydrate dissociation process is followed by heat absorption with high specific enthalpy 0.5 MJ/kg (for example, ice melting heat makes up 0.34 MJ/kg). As the dissociation front moves away from the borehole face more and more energy is spent to heat up host rocks hence heat influence zone on hydrate is calculated by the first meters.

When an inhibitor is introduced inside the gas hydrate its composition changes. In multiple works it is established that a definite concentration inhibitor injection into gas hydrate leads to hydrates formation equilibrium conditions shift, notably to equilibrium temperature shift leading to dissociation and methane release. The notion "inhibitor" here denotes to not only a matter that slows down any process but also a matter that can actually speed it up. Concentration is what plays the major role in establishing an inhibitor influence behavior.

Use of inhibitors has a line of disadvantages: high toxicity (during vapors influence, contact with skin and internal body organs), high flammability risk.

Questions

1) Gas hydrate is … .

2) Basic conditions for gas hydrates formation are … .

3) The main components of a gas hydrate are … .

4) What does the composition of a gas hydrate influence on?

5) Give an approximate value of gas that can be recovered from 1 m^3 of gas hydrate.

6) What are the places on the planet that can be suitable for gas hydrates for-mation?

7) What is the relation between pressure and temperature during formation of a gas hydrate?

8) Why is the Black Sea very favorable for the formation of gas hydrates?

9) What are the main types of gas hydrate formations?

10) Briefly describe existing technologies for gas hydrates extraction.

11) Why do you think CO_2 injection into the hydrate layer is considered to be the most perspective extraction technology?

Vocabulary

natural gas	[’nætʃərəl gæs]	природный газ
methane	[ˈmiː.θeɪn]	метан
gas hydrate	[ˈgæs ˈhaɪˌdreɪt]	газовый гидрат
layer	[ˈleɪə(r)]	слой
pores	[pɔːr]	поры
molecule	[ˈmɒl.ɪ.kjuːl]	молекула
cage	[keɪdʒ]	клеть
entrap	[ɪnˈtræp]	включать в себя, захватывать
carcass	[ˈkɑː.kəs]	каркас
crystalline compound	[ˈkrɪstəlaɪn ˈkɒm.paʊnd]	кристаллическое соединение
clathrate	[ˈklæˌθreɪt]	клатрат
hydrogen bond	[ˈhaɪ.drodʒən bɑːnd]	водородная связь
host	[həʊst]	хозяин
stabilize	[ˈsteɪbɪlaɪz]	стабилизировать
lattice	[ˈlætəs]	решетка
metastable	[metastable]	метастабильный
compaction	[kəmˈpækʃən]	уплотнение
dissociation	[dɪˈsəʊʃieɪt]	диссоциация, разложение, распад
pipeline	[ˈpaɪplaɪn]	трубопровод
plug	[plʌg]	пробка, заглушка
continental shelf zones	[ˈkɒntɪnənt ʃelf zəʊn]	континентальные шельфовые зоны
decomposition	[ˌdiːkəmˈpəʊz]	разложение, распад
permafrost areas	[ˈpɜːməfrɒst ˈeəriə]	зоны вечной мерзлоты
content	[ˈkɑːntent]	содержание
marine sediments	[məˈriːn ˈsedɪmənt]	морские осадки
high latitudes	[haɪ ˈlætɪtjuːd]	высокие широты
to fluctuate	[tə ˈflʌktjueɪt]	варьироваться, колебаться
scattered	[ˈskætəd]	рассеянный, разбросанный
interlayer	[interlayer]	прослойка, промежуточный слой
particles cohesion	[ˈpɑːtɪkl kəʊˈhiːʒən]	сцепление частичек
specific heat liberation	[spəˈsɪfɪk hiːt ˌlɪbəˈreɪʃən]	выделение удельной теплоты
heat absorption	[hiːt əbˈzɔːpʃən]	поглощение теплоты
high toxicity	[haɪ ˈtɒksɪk]	высокая токсичность
high flammability risk	[haɪ ˈflæməbiliti rɪsk]	высокий риск возгорания
molar mass	[ˈməʊlər mæs]	молярная масса
reactionary capability	[riˈækʃənəri] [ˌkeipəˈbɪlɪti]	реакционная способность

7.4 MINERAL PROCESSING

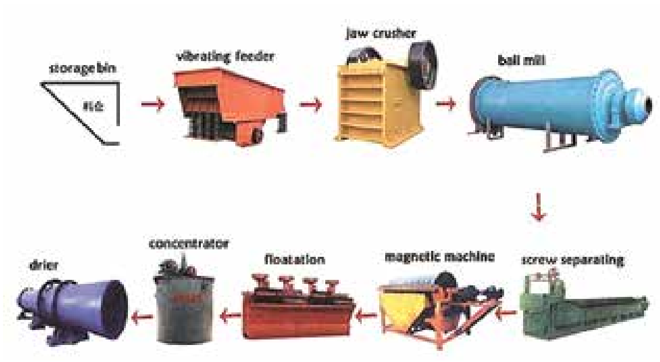
Digging ore from the earth is only half the battle. Often just as challenging and costly is the processing of the ore, which takes place in *mills, smelters and refineries*.

Mineral processing methods are critical to the *profitability* of a mine operation, particularly as customers demand higher production, *reliability*, efficiency and new features from processing equipment. The term ***mineral processing*** is used to analyze and describe the operations involved in *upgrading* and *recovering* minerals or metals from ores.

Goals and basics of mineral processing

In the traditional sense, mineral processing is regarded as the processing of ores or other materials *to yield* concentrated products. Most of the processes involve physical concentration procedures during which the chemical nature of the mineral(s) does not change.

The ultimate goal in the production of metals is to yield minerals in their *purest* form, that is, to recover the valuable minerals locked up in the ore. Mineral processing plays an integral part in *achieving* this objective.



Flow process

Fig. 7.12 shows a generalized flow diagram for metals extraction from mining (step 1) through *chemical processing*. Steps 2 and 3 involve physical processing and steps 5 and 7 involve low-temperature chemical processing (hydrometallurgy). All four steps are considered part of mineral processing. High-temperature *smelting* and *refining*, steps 4 and 6, are not included under the heading of mineral processing.

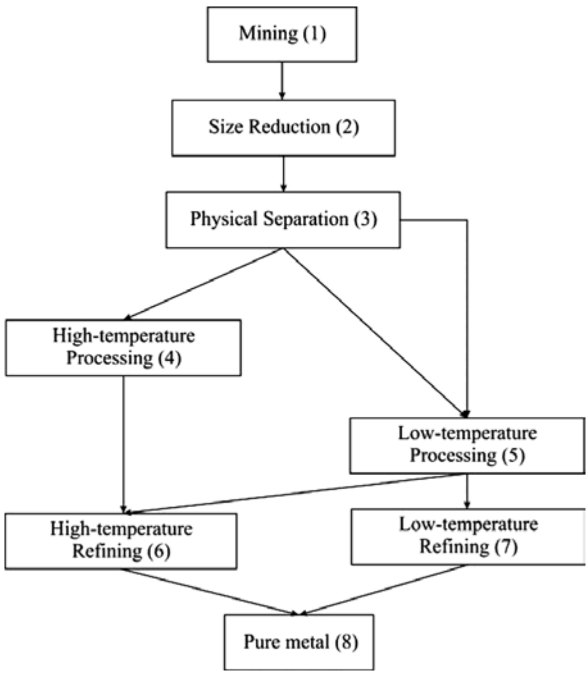


Fig. 7.12 Generalized flowchart of extraction of metals

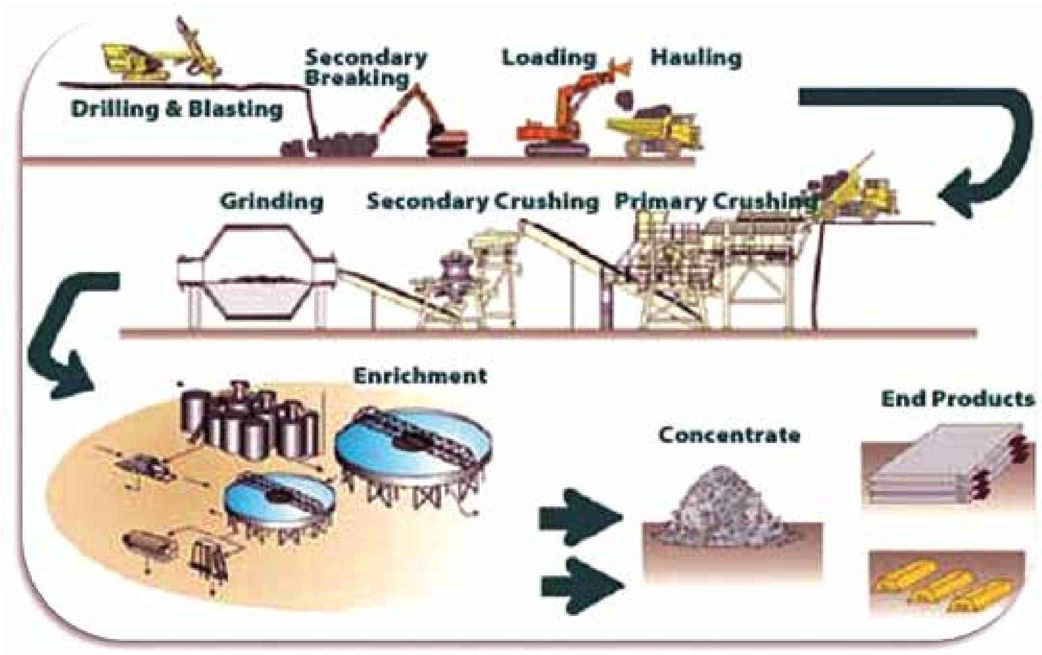


Fig. 7.13 Coal processing plant

Unit operations

Mineral processing can involve four general types of unit operation:

- *comminution* – particle size reduction;
- *sizing* – separation of particle sizes by screening or classification;
- *concentration* by taking advantage of physical and surface chemical properties; and

- *dewatering* – solid/liquid separation.

Comminution is particle size reduction of materials. Comminution may be carried out on either dry materials or *slurries*. *Crushing* and *grinding* are the two primary comminution processes.

Sizing is the general term for separation of particles according to their size. The simplest sizing process is screening, or passing the particles to be sized through a screen or number of screens.

There are a number of ways to increase **the concentration** of the wanted minerals: in any particular case the method chosen will depend on the relative physical and surface chemical properties of the mineral and the *gangue*.

Historically the earliest method used, particles can be classified based on their *specific gravity*.

Separation by ***froth flotation*** relies on the differing surface potentials of the particles.

Electrostatic separation: *Non-conducting particles* maintain an electrostatic charge induced electrically, and so remain pinned to a *charged drum*. *Conducting particles* do not maintain the electrostatic charge and so fall off the drum.

Magnetic separation: Minerals such as magnetite is naturally magnetic, and so can be separated from non-magnetic particles using strong magnets.

Dewatering: since many size reduction and separation processes involve the use of water, solid-liquid separation processes are also a subject of mineral processing.

Efficiency

One of the most important and basic *concepts* in mineral processing is *efficiency*. *Two terms* are commonly used *to describe* the efficiency of processes: *recovery* and *grade*. Note that *obtaining* the highest possible recovery is not necessarily the best approach in a concentration process. High recovery without acceptable grade will *lead* to an *unsalable* product and is therefore *unsatisfactory*.

Economic concerns

Most metals are present in extremely small concentrations in nature, and none of these metals can be recovered economically at these concentrations. An average copper ore, for example, may contain 0.3% to 0.5% copper.

Questions

1. What is mineral processing done for?
2. Briefly describe the flow process.
3. Describe what comminution, sizing, concentration and dewatering are.

Vocabulary

mills	[mɪls]	мельница, дробилка, обогатительная фабрика,
smelters	[smelters]	плавильная печь, плавильщик
refinery	[rɪˈfaɪnərɪ]	очистительный завод
profitability	[prɒfɪtəˈbɪlɪtɪ]	рентабельность, прибыльность
reliability	[rɪlaɪəˈbɪlɪtɪ]	надежность
upgrading	[ʌp'greɪdɪŋ]	обогащение, повышение качества
recovering	[rɪ'kʌvəɪŋ]	извлечение (руды)
to yield	[ji:ld]	добывать, извлекать
pure	[pjuə]	чистый, беспримесный
achieving	[əˈtʃi:vɪŋ]	достижение
chemical pro-cessing	[ˈkemɪk(ə)l prə(u)'sesɪŋ]	химическая обработка
smelting	[smeltɪŋ]	плавка, выплавка, плавление
refining	[rɪˈfaɪnɪŋ]	очистка, облагораживание
comminution	[ˌkɔmɪˈnju:ʃən]	раздробление, размельчение
sizing	[saɪzɪŋ]	сортировка по крупности, размеру
dewatering	[dewɔ:tərɪŋ]	осушение, дегидратация
slurries	[ˈslə:rɪes]	гидросмесь, жидкий раствор
crushing	[krʌʃɪŋ]	дробление, измельчение
grinding	[graɪndɪŋ]	перемалывание, измельчение
screening	[skri:nɪŋ]	грохочение, отсеивание
gangue	[gæŋə]	пустая порода, породный примеси
gravity	[ˈgrævɪtɪ]	вес, сила тяжести
froth flotation	[frɔθ fləuˈteɪʃən]	пенная флотация
non-conducting	[non kən'dʌkt]	непроводящий
charged drum	[tʃɑ:dʒd drʌm]	заряженный барабан
efficiency	[ɪˈfɪʃənsɪ]	эффективность, результативность
concepts	[ˈkɔnsept]	понятие, представление, идея
grade	[greɪd]	качество, сорт
to obtain	[əbˈteɪn]	получать, добывать
unsatisfactory	[ˈʌnˌsætɪsˈfæktərɪ]	неудовлетворительный
unsalable	[ˈʌnˌseɪləbl]	непригодный к продаже, не пользующийся спросом

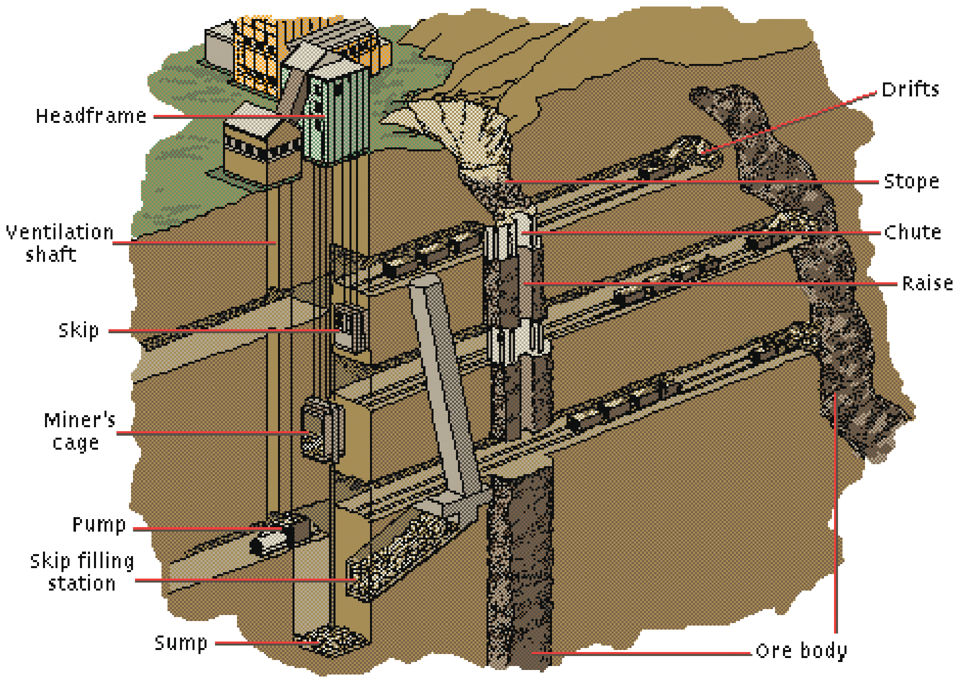
7.5 LABOUR PROTECTION

Basics of labour protection

Protection of the health and safety of employees from excessive or undesirable stresses in the occupational environment is all important. These hazards include reduced natural ventilation and light, difficult and limited access and egress, exposure to air contaminants, fire, flooding, and explosion.

Ventilation is an important common denominator in most health and safety design considerations in mines. In addition to the supply of fresh air to the miners, the overall control of gas, dust, heat, and humidity problems is achieved through the proper design of the ventilation system.

Fresh air must be supplied to all underground work areas in sufficient amounts to prevent any dangerous or harmful accumulation of dusts, fumes, mists, vapors, or gases. If natural ventilation does not provide the necessary air quality through sufficient air volume and air flow, the employer must provide mechanical ventilation to ensure that each employee working underground has at least 5.7m3 of fresh air per minute.



Open flames and fires are prohibited in underground construction areas except as permitted for welding, cutting, or other hot work operations. Smoking is prohibited unless an area is free of fire and explosion hazards.

Special air monitoring requirements

The employer must assign a “competent person” to perform air monitoring. If this individual determines that air contaminants may present a danger to life at any time, the employer must immediately take all necessary precautions and post a notice at all entrances to the underground site about the hazardous condition.

Test for oxygen first

The competent person charged with air monitoring must test for oxygen content before testing for air contaminants. All underground work areas must be tested as often as necessary to verify that the atmosphere at normal atmospheric pressure remains within the acceptable parameters of 19.5 and 22 percent oxygen.

Problems of noise and illumination, always a matter of concern in underground workings, are being addressed through the identification, development, and incorporation of specific design requirements for mine machinery and mining environment.

Ground support of underground areas

A competent person must inspect the roof, face, and walls of the work areas at the beginning of each shift and as often as necessary to ensure ground stability. The ground conditions along all haulage ways and travel ways must also be inspected as frequently as necessary to ensure safe passage and loose ground considered to be hazardous to employees must be scaled, supported, or taken down.

Employees involved in installing ground support systems must be adequately protected from the hazards of loose ground. Any dislodged or damaged ground supports that create a hazardous condition must be promptly repaired or replaced. The new supports must be installed before removing the damaged supports.

Hazards, accidents, and disasters

The term hazard is used here to describe an unsafe situation in a mine. This may be an unsafe physical condition or unsafe acts of miners. For example, methane is a source of hazard.

An accident is the realization of a hazard. If a large number of people are in fact killed, it is deemed a disaster.

Hazard control approaches

As distinct from practices in many other industries, the mine working environment cannot be precisely controlled. Also the environment is constantly changing. It is virtually impossible to foresee all the possible hazards and therefore, to take precautions against each of them.

Medical examinations

Pre-employment physical examinations and periodic continuing examinations are required to assure that employees' health and physical conditions are routinely monitored and documented. These examinations may reveal physical problems such as hearing loss, loss of vision, heart problems, arthritic conditions, lung impairment, etc.

Miner training must emphasize both general and job-specific health and safety aspects and improvement of production and maintenance skills.

The enhancement of personnel health and safety in mines requires an understanding of the hazards and the requirements for their control. In addition to the learning experience from the lamentable history of accidents and disasters in mines, there is a critical need to reduce the risks of mine hazards and resulting accidents through the application of such proactive analysis techniques as systems safety analysis and disaster simulations for the identification of new hazards.

Personal protective equipment

All underground workers must wear special equipment which is: head protection – caps or hats, cap lamps, eye and face protection – safety spectacles or facepiece respirators; respiratory protection (against dust); hearing protection – ear plugs; foot protection – boots; clothing – cotton overalls (sometimes with strips of reflective material); belts - to carry lamp battery, self-rescuer – respiratory protection which will help the miner escape dangerous place in case of a mine fire; gloves.

Threats to life and health

Threats to a miner's safety may arise from many sources: from falls of roof, face, or side; from haulage or other machinery; from electrical equipment, explosives, or ignitions or explosions of gases and dust; from sudden inundations of water and gas; or from mine fires.

Consequences of inadequate control can be sudden and catastrophic - such as injuries and loss of life through suffocation, heat strokes, and explosions—or slow and long-enduring - such as lung diseases including coal worker's pneumoconiosis (CWP) or black lung.

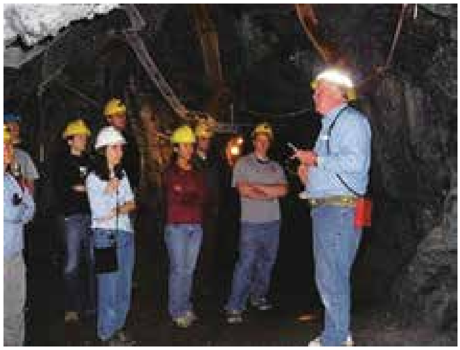
Diseases such as silicosis, asbestosis, and pneumoconiosis are associated with long-term exposure to high concentrations of silica, asbestos, and coal dust, respectively. Bad water quality and the lack of adequate lighting have also been associated with such diseases as dermatitis.

Training requirements

All employees involved in underground construction must be trained to recognize and respond to hazards associated with this type of work. The following topics should be part of an underground construction employee training program:

1. Air monitoring and ventilation;
2. Illumination;

3. Communications;
4. Flood control;
5. Personal protective equipment;
6. Emergency procedures, including evacuation plans;
7. Check-in/check-out procedures;
8 Explosives;
9. Fire prevention and protection;
10. Mechanical equipment.



Questions

1. What hazards underground do you know?
2. What is underground ventilation provided for?
3. What happens if there are too much noxious gases present underground?
4. What is the minimum amount of a fresh air that should be present underground?
5. In what cases an open fire is allowed underground?
6. Why is smoking prohibited underground?
7. Why is air monitoring should be carried out on a constant basis?
8. What percentage of oxygen must be present underground for miners breathing?
9. How can an excessive noise cause troubles to miners?
10. Why should a mine roof be supported and how is it conducted?
11. How can you define a disaster?
12. Why medical examination is so important for the miners?
13. What personal protective equipment do you know? Briefly describe the purpose of each item.
14. Miners training – what is it carried out for? And what activities does it include?

Vocabulary

health and safety	[ˈhelθ ənd ˈseɪftiː]	здоровье и безопасность
excessive	[ɪkˈsesɪv]	чрезмерный
undesirable	[ʌndɪˈzaɪərəb(ə)l]	нежелательный
ventilation and light	[ˌventəˈleɪʃən ənd ˈlaɪt]	вентиляция и освещение
egress	[ˈiːˌgres]	выход, средство эвакуации
exposure to something	[ɪkˈspoʊʒər tə ˈsəm(p)θɪŋ]	подвергание чему-либо
flooding	[ˈflədɪŋ]	затопление, обводнение
explosion	[ɪkˈsploʊʒən]	взрыв
falls of roof	[ˈfɔlz əv ˈruːf]	обрушение почвы
face	[ˈfeɪs]	забой выработки
side	[ˈsaɪd]	бок выработки
haulage	[ˈhɔlɪdʒ]	откатка, транспортировка, перевозка
ignitions	[ɪgˈnɪʃənz]	воспламенение, зажигание
dust	[ˈdəst]	пыль
inundations of water	[ˌɪnənˈdeɪʃənz əv ˈwɔtər]	наводнение, затопление
injuries	[ˈɪndʒriːz]	повреждение, травма, ущерб
suffocation	[ˌsəfəˈkeɪʃən]	удушье, удушение
heat strokes	[ˈhiːt ˈstroʊks]	тепловой удар
lung diseases	[ˈləŋ dɪˈziːzɪz]	заболевание легких
pneumoconiosis	[ˌnuːmoʊˌkoʊniːˈoʊsəs]	пневмокониоз
dermatitis	[ˌdərməˈtaɪtəs]	дерматит
common denominator	[ˈkɑmən dɪˈnɑməˌneɪtər]	общий знаменатель
in sufficient amounts	[ˈɪn səˈfɪʃənt əˈmæʊnts]	в достаточных количествах
fumes	[ˈfjuːmz]	дым, газы, испарение
mist	[ˈmɪst]	туман
vapors	[ˈveɪpərz]	испарения, пар
to be prohibited	[tə ˈbiː proʊˈhɪbətɪd]	быть запрещенным
permitted	[pərˈmɪtɪd]	разрешенный

7.6 WORKING ENVIRONMENT

Mining environment

Mining *by its very nature* requires land, air and water systems be disturbed. Digging a hole in the ground to gather mineral resources means that various aspects of the environment, such as land, water and ecosystems, will *be affected*.

Environmental issues can include *erosion*, formation of *sinkholes*, loss of *biodiversity*, and *contamination* of soil, groundwater and surface water by chemicals from mining processes. Besides creating environmental damage, the contamination resulting from *leakage* of chemicals also affect the health of the local population.

Erosion of exposed *hillsides*, *mine dumps*, tailings dams and resultant *siltation* of drainages, creeks and rivers can significantly impact the surrounding areas. In areas of wilderness mining may cause destruction and disturbance of ecosystems and habitats. In urbanized environments mining may produce noise pollution, dust pollution and visual pollution.

The metals and *industrial minerals* that mining produces can find their way into the environment and become *pollutants*. The *byproducts* that occur with the metals, such as sulphur and *arsenic*, can be dangerous to the environment if they are released. Mining creates and employs hazardous substances that must be handled with a lot of care. The challenge for industries is to find, extract and process mineral resources with the least possible environmental disruption.

Environmental geology relates the science of the Earth to the activities of human beings.

It is concerned with geological processes influence on the human environment, both through slow processes such as the influence on landscape, and through hazardous events such as earthquakes or landslides.

Among possible threats to the health of miners are the following: exposure to *toxic gases* and dusts, exposure to *excessive* heat and humidity, inadequate *illumination*, noise and vibration problems, and oxygen-deficient atmospheres. Some of these environmental stresses may *interact* to produce a greater overall effect.

The components of environmental geology used as a basis for this book

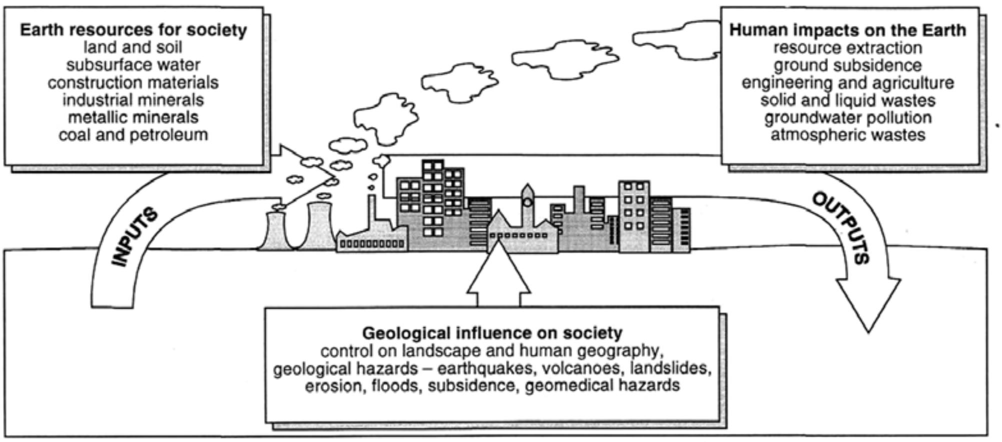


Fig. 7.14 Components of environmental geology

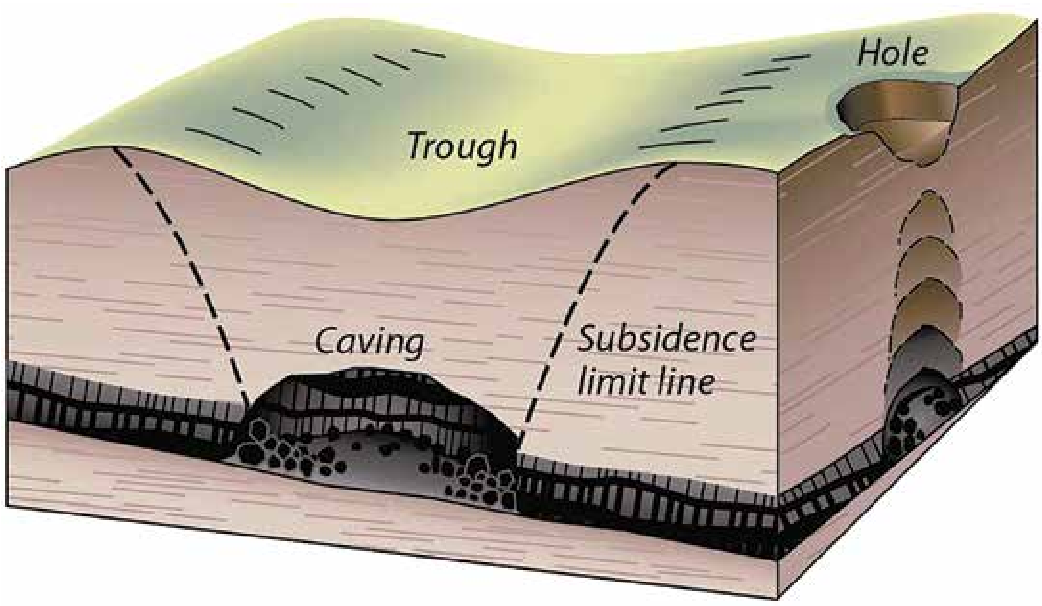


Fig. 7.15 Surface subsidence

Environmental geology focuses not only on the inputs but on its outputs wastes and environmental degradation.

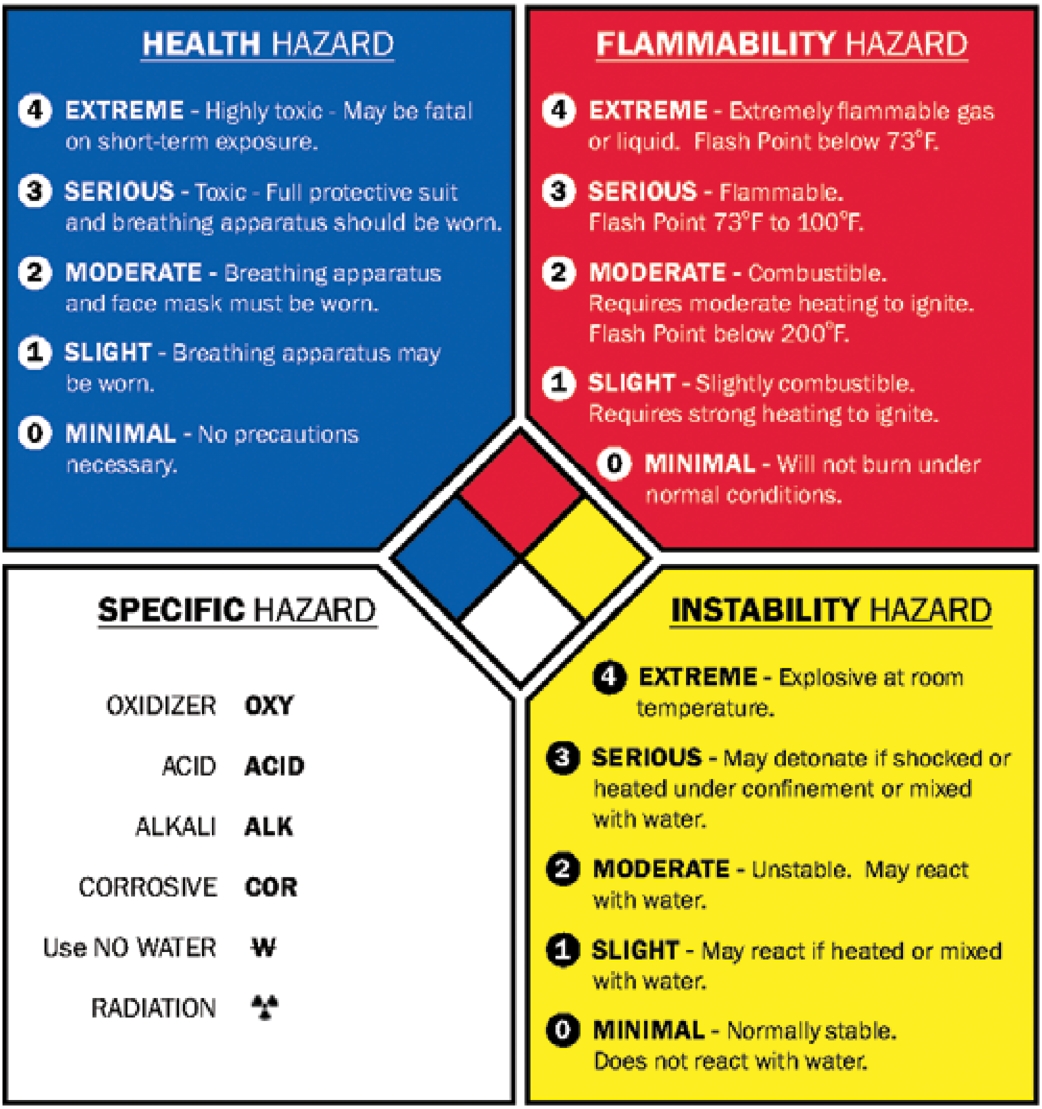
Geological influences on society covers the natural geological processes that influence the environment and its use irrespective of human activities, although some human actions may trigger or accelerate natural processes such as floods, ground subsidence or earthquakes.

Earth resources for society describes the subsurface resources that geologists *are called upon* to find. These include land, water and industrial minerals as well as coal, petroleum and metallic minerals.

Human impacts on the Earth. This part also covers the deliberate impacts of engineering and agriculture, and the unplanned pollution of land, water and air by the wastes from society.

Hazard type and assessment

Landslides, subsidence, earthquakes, coastal erosion - these are some **geological hazards.** Together with **technological, biological, meteorological** and **hydrological** hazards, they form a spectrum of natural threats.



Technological hazards are due to human activity rather than natural processes: landslides and the emission of greenhouse gases threaten climate change.

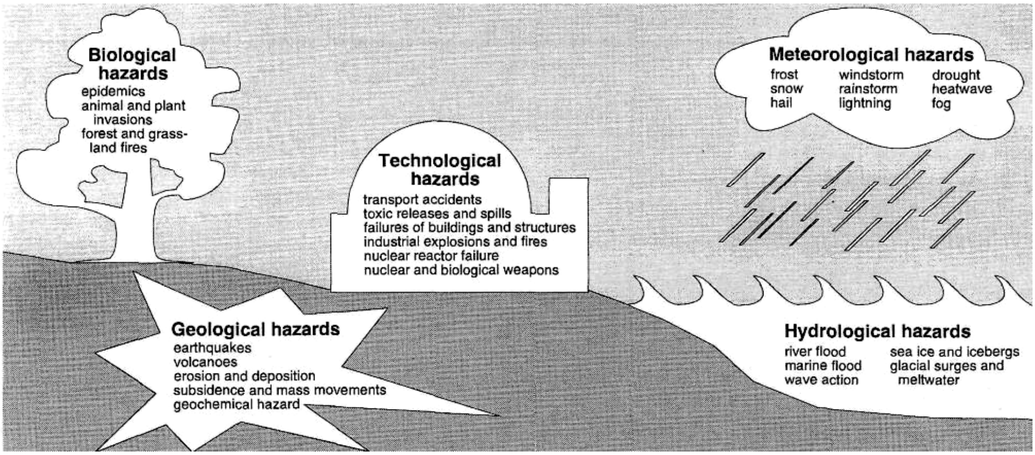


Fig. 7.16 Geological hazards in the context of other natural and human-induced hazards

Mining companies in some countries are required to follow environmental and rehabilitation codes, ensuring the area mined is returned to close to its original state. ***Some environmental matters that mining laws may incorporate into specific schedules or regulations include:***

- safety of structures and operations; limiting exposure to chemicals; explosive hazards;
- establishment of wastewater *retention* and treatment techniques, safe management of contaminated *runoff*, and groundwater contamination;
- soil erosion control and *revegetation* procedures during the operation as well as afterwards;
- *requirements* to prepare plans for mine waste disposal;

- *reclamation and restoration* of sites and disturbed areas, and removal of all unused structures and machinery. (UNEP UNDESA).

Questions

1. What environmental issues do you know?
2. What can erosion lead to?
3. What are pollutants?
4. Name threats to the health of miners.
5. What a surface subsidence is caused by and can lead to?
6. Name 4 types of hazards presenting natural threats
7. What goals does the mining law include?

Vocabulary

by its very nature	[baɪ ɪts ˈverɪ ˈneɪtʃə(r)]	в сущности, по своей натуре, природе
to affect	[tuː əˈfekt]	оказывать влияние, воздейст-вие,затрагивать, влиять
sinkhole	['sɪŋkhəul]	карстовая воронка, яма, коло-дец
biodiversity	[,baɪəudaɪ'vɜ:sɪtɪ]	биоразноообразие
contamination	[kən,tæmɪ'nɪʃ(ə)n]	загрязнение, заражение
leakage	[ˈliːkɪdʒ]	протечка, течь, просачивание
hillside	['hɪlsaɪd]	склон горы, холма
mine dump	[maɪn dʌmp]	шахтный отвал
erosion	[ɪ'rəuʒ(ə)n]	эрозия, разрушение, размывание
siltation	[siltʌti:ɔn]	заиление, отложение наносов
Industrial mineral	[ɪn'dʌstrɪəl ['mɪn(ə)r(ə)l]	промышленные минералы
pollutants	[pə'lu:t(ə)nt]	пустая порода, загрязняющий агент/вещество
byproduct	['baɪ,prɔdʌkt]	побочный продукт
arsenic	[ɑ:s(ə)nɪk]	мышьяк
illumination	[ɪˌI(j)u:mɪ'neɪʃ(ə)n]	освещение
toxic gas	['tɔksɪk [gæs]	токсичный газ
excessive	[ɪk'sesɪv]	чрезмерный
interact	[ˌɪntər'ækt]	взаимодействовать, влиять друг на друга
to call upon	[tu: kɔ:l ə'pɔn]	призывать
retention	[rɪ'ten(t)ʃ(ə)n]	удержание, задержание, сохранение
runoff	[ru: nɔf]	слив, сток, спуск (жидкости)
revegetation	[revegə:tei ʃ(ə)n]	восстановление растительности, рекультивация
requirement	[rɪkwaɪəmənt]	требования, необходимые условия
restoration	[rest(ə)'reɪʃ(ə)n]	восстановление
reclamation	[,reklə'meɪʃ(ə)n]	повторное использование, восстановление, рекультивация

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BASIC CONCEPTS OF MINING TECHNOLOGY

tutorial

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Основи технології видобування корисних копалин

навчальний посібник

англійською мовою

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Issues concerning global importance of mineral resources in the society life, their amount, origin and classification are given. Mine development stages and economical aspects are considered. Opening and development schemes, mining methods during coal seams mining are described. Nontraditional mining methods are educed. The reviewed material is based on great scientific and practical experience.

Tutorial is dedicated for students, masters and postgraduates of higher educational institutions studying "Mining" with profound learning of professional English.