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English for Oil Geologists

Учебно-методическое пособие

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УДК
ББК
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Данное пособие предназначено для студентов 4-5 курсов Института нефти и газа по специальности «Геология нефти и газа». Пособие может быть использовано преподавателями для проведения практических занятий по иностранному языку, предполагает самостоятельную подготовку студентов к занятию и представляет интерес для желающих развить коммуникативные способности по специальности на иностранном языке. Учебно-методическое пособие представляет интерес для студентов магистратуры на основе ФГОС по специальности «Прикладная геология».

Пособие включает в себя тексты для изучения по тематике «Геология нефти и газа», задания, направленные на закрепление словарного запаса, отработку грамматических навыков и навыков говорения.

УДК
ББК

Оглавление

ПРЕДИСЛОВИЕ

Дорогой друг! Ты держишь в руках учебно-методическое пособие, которое представляет собой материал для углубленного изучения геологии нефти и газа на английском языке и может использоваться на практических занятиях по дисциплине «Профессиональный иностранный язык» или «Иностранный язык в сфере профессиональной коммуникации» (английский язык). Его главная задача – предложить тебе пути развития коммуникативных навыков, которые необходимо сформировать для успешной реализации процесса обучения иностранного языка в рамках высшего учебного заведения. Развитие коммуникативных навыков включает в себя не только свободное владение языковыми единицами данного иностранного языка, но и правильное построение предложений в соответствии с грамматическими нормами изучаемого языка, распознавание грамматических формул и их использование при говорении.

Данное методическое пособие рассчитано на студентов, обладающих грамматическими и первоначальными лексическими знаниями по тематике «Геология нефти и газа» и содержит более детальную информацию по профилю на иностранном языке. Пособие состоит из следующих разделов: Introduction, Nature of oil, Nature of gas, The Earth crust – where we find it. Тексты заданной тематики сопровождаются списком новой лексики, а также упражнениями к ним, направленными на закрепление лексического и грамматического материала, отраженного в текстах**.**

Материал в пособии расположен таким образом, что новая лексика, которая закрепляется на последующих занятиях, расположена перед текстами, что позволяет возвращаться к ней на протяжении всего курса.

С помощью представленных в работе видов коммуникативной деятельности удается сформировать необходимые навыки языковой и грамматической компетенции, универсальные компетенции на повышенном уровне, которыми должен обладать выпускник:

- обладает навыками социокультурной и межкультурной коммуникации, обеспечивающими адекватность социальных и профессиональных контактов (ОК-3);
- владеет культурой мышления, способен к анализу, обобщению информации, постановке целей и выбору путей их достижения, владеет культурой устной и письменной речи (ОК-7);
- умеет применять методы и средства познания, обучения и самоконтроля для своего интеллектуального развития, повышения культурного уровня, профессиональной компетенции, сохранения своего здоровья, нравственного и физического самосовершенствования (ОК-8);
- стремлением к постоянному саморазвитию, повышению своей квалификации и мастерства; может критически оценить свои достоинства и недостатки, наметить пути и выбрать средства саморазвития (ОК-11);

• понимает социальную значимость своей будущей профессии, обладает высокой мотивацией к выполнению профессиональной деятельности (ОК-12).

В связи с переходом на новый уровень образования повысились требования к языковой подготовке студентов, владению языка в сфере профессиональной коммуникации. В отсутствии учебной литературы по данной тематике пособие, как представляется, способно заполнить пробел. Учитывая тот факт, что материалы пособия выстроены с учетом требований ФГОС, а содержание соответствует тематике основного курса по специальности «Геология нефти и газа», пособие может быть востребовано не только на практических занятиях и для самостоятельной работы студентов, но и на разных этапах деятельности в дальнейшем: при подготовке к экзаменам, научно-исследовательской деятельности, написании курсовых работ или диплома.

Учебно-методическое пособие основано на книге Hyne N.J. Nontechnical guide to petroleum geology, exploration, drilling and production (2nd Edition). Также использована информация со следующих сайтов:

Мир нефти. Роснефть. – Режим доступа: http://www.mirnefti.ru/index.php?id=9

Гуру энциклопедия. – Режим доступа: http://enc.guru.ua/index.php?title_id=100

Википедия - свободная энциклопедия. – Режим доступа: http://ru.wikipedia.org/wiki/

Planete Energies En – Planète Energies. – Режим доступа: http://www.planete-energies.com/

Geology Wiki.. – Режим доступа: http://geology.wikia.com/

The Schlumberger Oilfield Glossary. – Режим доступа: http://www.glossary.oilfield.slb.com/

United Nations Conference on Trade and Development. – Режим доступа: http://www.unctad.org/

San Joaquin Valley Geology. – Режим доступа: http://www.sjvgeology.org/

Пособие может быть рекомендовано студентам Института Нефти и Газа, получающим второе высшее образование по специальности «Переводчик в сфере профессиональной коммуникации».

Надеемся, пособие поможет тебе не только повторить пройденный материал, но и узнать что-то новое. Если ты захочешь расширить свое представление о материале, можешь обратиться к источникам, указанным выше, а также к периодическим изданиям: Oil and gas journal. – Режим доступа: http://www.ogj.com/index.html

Journal of Petroleum geology. – Режим доступа: http://www.jpg.co.uk/

Russian Journal of Pacific Geology. – Режим доступа: http://www.springer.com/earth+sciences+and+geography/geology/journal/11720

Unit 1: Introduction

Mind the definitions

Bit	долото	A drill bit is attached to the end of the first drill rod.
Caprock	покрывающая порода	Cap rock is needed to form a barrier above the reservoir rock.
Density	плотность	Increasing the pressure on an object decreases the volume of the object and therefore increase its density.
Drillstring	бурильная колонна	The drillstring (and the drill bit), is slowly and carefully lowered until it touches bottom.
Fracture	трещина; разлом; разрыв	Fractures can provide permeability for fluid movement, such as water or hydrocarbons.
Generate	создавать; формировать	They tend to generate mostly gas with associated light oils.
Limestone	известняк	Limestone makes up about 10% of the total volume of all sedimentary rocks.
Migration	миграция	Migration is a slow process i.e. perhaps a few kilometres over a period of millions of years.
Occur	залегать	Radon occurs naturally in rocks such as granite.
Permeability	проницаемость	The concept of permeability is of importance in determining the flow characteristics of hydrocarbons in oil and gas reservoirs.
Pore	пора	Pore is one of many small openings in a solid substance of any kind that contribute to the substance's porosity.
Reservoir	коллектор	Reservoir rocks are potentially filled with gas or oil.
Rotary drilling rig	установка для роторного бурения	Rotary drilling rigs can be massive structures housing equipment used to drill water wells, oil wells, or natural gas extraction wells.
Sandstone	песчаник	Sandstone may be any colour, but the most common colours are tan, brown, yellow, red, gray, pink, white and black.
Sedimentary rock	осадочная порода	Sedimentary rocks are also important sources of natural resources like coal, fossil fuels, drinking water or ores.

Shale	сланец	Shales are typically deposited in very slow moving water and are often found in lakes and lagoonal deposits, in river deltas, on floodplains and offshore from beach sands.
Source rock	нефтематеринская порода	Source rocks can be formed from marine planktonic and bacterial remains.
Trap	ловушка	When hydrocarbons are concentrated in a trap, an oil field forms.
Viscous	вязкий	The less viscous the fluid is, the greater its ease of movement.

Oil has been used for lighting purposes for many thousand years. In areas where oil is found in shallow reservoirs, seeps of crude oil or gas may naturally develop, and some oil could simply be collected from **seepage** or tar ponds. Historically, we know of tales of eternal fires where oil and gas seeps would **ignite** and burn. One example 1000 B.C. is the site where the famous oracle of Delphi would be built, and 500 B.C. Chinese were using natural gas to boil water.

But it was not until 1859 that "Colonel" Edwin Drake drilled the first successful oil well, for the sole purpose of finding oil.

The Drake Well was located in the middle of quiet farm country in north-western Pennsylvania, and began the international search for and industrial use of petroleum.

These wells were **shallow** by modern standards, often less than 50 meters, but could give quite large production. For example, the Phillips well was flowing initially at 4000 barrels per day in October 1861, and the Woodford well came in at 1500 barrels per day in July, 1862.

The oil was collected in the wooden tank. At this time, barrel size was not yet standardized, which made

Seepage – поверхност
ные признаки нефтепроявления

Ignite – возгораться, воспламеняться

Shallow – мелкий, мелководный

Overproduction – перепроизводство

Issue –исход, результат, плод

Complete – заканчивать (скважину бурением)

Plummet = plummet down – быстро и отвесно падать

Replace – заменять, замещать

Adopt – принимать

Aircraft – самолёт,

terms like "Oil is selling at $5 per barrel" very confusing (today a barrel is 159 liters). But even in those days, **overproduction** was an **issue** to be avoided. When the "Empire well" was **completed** in September 1861, it gave 3,000 barrels per day, flooding the market, and the price of oil **plummeted** to 10 cents a barrel.

Soon, oil had **replaced** most other fuels for mobile use. The automobile industry developed at the end of the 19th century, and quickly **adopted** the fuel. Gasoline engines were essential for designing successful **aircraft**. Ships **driven** by oil could move up to twice as fast as their coal fired **counterparts**, a vital military advantage. Gas was burned off or left in the ground.

Despite attempts at gas transportation as far back as 1821, it was not until after the World War II that **welding** techniques, pipe rolling, and metallurgical advances allowed for the construction of reliable long distance pipelines, resulting in a natural gas industry **boom**. At the same time the petrochemical industry with its new plastic materials quickly increased production. Even now gas production is **gaining** market share as LNG provides an economical way of transporting the gas from even the remotest sites.

With oil prices of 50 dollars per barrel or more, even more difficult to access **sources** become economically interesting. Such sources include tar sands in Venezuela and Canada as well as oil shales. Synthetic diesel (syndiesel) from natural gas and biological sources (biodiesel, ethanol) have also become commercially **viable**. These sources may eventually more than triple the potential reserves of hydrocarbon fuels.

воздушное судно, летательный аппарат

Drive – запускать; приводить в действие

Counterpart – аналог

Welding – сварка, сваривание || сварочный

Boom – бум, резкий подъём деловой активности

Gain – извлекать пользу, выгоду; улучшаться

Pipe rolling – трубопрокатное производство

Source – источник, ключ

Viable – жизнеспособный.

Answer the questions:

1. How was oil used in ancient times? 2. When did the international search for and industrial use of petroleum begin? 3. Could the shallow wells give quite large production? 4. What was oil collected in? 5. Why was the statement "Oil is selling at $5 per barrel" very confusing? 6. What was an issue to be avoided and why? 7. What could ships driven by oil do? 8. What resulted in a natural gas industry boom? 9. Why is gas production gaining market share? 10. What sources may eventually more than triple the potential reserves of hydrocarbon fuels?

General characteristic of oil and gas

Both crude oil and natural gas are **mixtures** of molecules formed by carbon and hydrogen atoms. There are many different types of crude oils and natural gases, some more **valuable** than others. Heavy crude oils are very **thick** and viscous and are difficult or impossible to produce, whereas **light** crude oils are very **fluid** and relatively easy to produce. Less valuable are sour crude oils that contain **sulfur** and **sour** natural gasses that contain hydrogen sulfide. Some natural gases burn with more heat than others, contain natural gas liquids and gasoline, and are more valuable.

In order to have a commercial deposit of gas or oil, three geological conditions must have been **met**. First, there must be a source rock in the subsurface of that area that generated the gas or oil at some time in the geological past. Second, there must be a separate, subsurface reservoir rock to hold the gas or oil. Third, there must be a trap on the reservoir rock to concentrate the gas or oil into commercial quantities.

The uppermost crust of the earth in oil- and gas-producing areas is composed of sedimentary rock layers. Sedimentary rocks are the source and reservoir rocks for gas and oil. These rocks are called sedimentary rocks because they are composed of sediments. Sediments are 1) particles such as sand **grains** that were formed by the **breakdown** of pre-existing rocks and transported, 2) seashells, or 3) salt that **precipitated** from of water. The sedimentary rocks that make up the earth's crust are millions and sometimes billions of years old. During the vast expanse of geological time, sea level has not been constant. Many times in the past, the seas have risen to cover the land and then fallen to **expose** the land. During these times, sediments were deposited. These sediments are relatively simple materials such as sands deposited along beaches, mud on the sea bottom, and beds of seashells. These ancient sediments, **piled** layer upon layer, form the sedimentary rocks that are drilled to find and produce oil and gas.

Mixture - смесь
Valuable - ценный
Thick - плотный; густой, мощный (о слое, пласте)
Light - легкий
Fluid - флюид
Sulfur - сера
Sour – высокосернистый
Meet - удовлетворять, соответствовать
Grain – зерно
Breakdown – разрушение
Precipitate – осаждаться
Expose – обнажать
Pile – накапливаться

Answer the questions:

1.What are oil and gas? 2. What type of oil is more valuable and why? 3. What gases are valuable? 4. Are heavy crude oils easy to produce? 5. What are three geo-

logical conditions that must be met? 6. Why are some rocks called sedimentary? 7. How were sediments deposited? 8. What forms the sedimentary rocks?

Generation of hydrocarbons

The source of gas and oil is the organic matter that is **buried** and **preserved** in the ancient sedimentary rocks. These rocks contain not only inorganic particles such as sand grains and **mud**, but also dead plant and animal material. The most common organic-rich sedimentary rock (the source rock for most of the gas and oil) is black shale. It was deposited as organic-rich mud on an ancient ocean bottom. In the subsurface, temperature is the most important factor in turning organic matter into oil. As the source rock is covered with more sediments and buried deeper in the earth, it becomes hotter and hotter. The minimum temperature for the formation of oil, about 150°F (65°C), occurs at a depth of about 7000 ft (2130 m) below the surface (Fig. 1-1). Oil is generated from there and down to about 300°F (150°C) at about 18,000 fit (5500 m). The reactions that change organic matter into oil are complex and take a long time. If the source rock is buried deeper where the temperatures are above 300°F (150°C), the **remaining** organic matter will generate natural gas.

Gas and oil are relatively light in density compared to water that also occurs in the subsurface sedimentary rocks. After oil and gas have been generated, they rise due to buoyancy through fractures in the subsurface rocks. The rising gas and oil can **intersect** a layer of reservoir rock. A reservoir rock is a sedimentary rock that contains billions of **tiny** spaces called pores. A common sedimentary rock is sandstone composed of sand grains similar to the sand grains on a beach or in a river channel. Sand grains are like spheres, and there is no way the grains will **fit** together perfectly. There are pore spaces between the sand grains on a beach and in a sandstone rock. Limestone, another common sedimentary rock, is deposited as shell beds or **reefs**, and there are pores between the shells and corals. The gas and oil flow into the pores of the reservoir rock layer.

Bury – погружаться

Preserve – сохраняться

Mud – ил, тина

Remaining – оставшиеся

Intersect – пересекать

Tiny – крошечный

Fit – подходить

Reef – риф

Answer the questions:

1.What particles do rocks contain? 2. What conditions are necessary for oil and gas to be generated? 3. What happens after oil and gas have been generated? 4. What is sandstone composed of? 5. Why and where do pore spaces occur? 6. How is limestone deposited?

Migration of oil

Any fluid (water, gas, or oil), either on the surface or in the subsurface, will always flow along the path of least **resistance**, the easiest **route**. In the subsurface, the path of least resistance is along a reservoir rock layer. This is because most of the **pore spaces interconnect**, and the fluid can **flow** from pore to pore to pore up the angle of the rock layer toward the surface. The ease in which the fluid can flow through the rock is called permeability, and the movement of the gas and oil up the angle of the reservoir rock toward the surface is called migration. Because of migration, the gas and oil can end up a considerable distance, both vertically and horizontally, from where it was originally formed. (Fig. 1-1).

As the gas and oil migrates up along the reservoir rock, it can **encounter** a trap. A trap is a high point in the reservoir rock where the gas or oil is stopped and concentrated. Because the pores in the reservoir rock are filled with water, the gas and oil will flow to the highest part of the reservoir rock.

One type of trap is a natural arch in the reservoir rock (Fig. 1—2) called a **dome** or **anticline**.
In the trap, the fluids separate according to their density. The gas is the lightest and goes to the top of the trap to form the free gas cap. The oil goes to the middle to form the oil reservoir. The salt water, the heaviest goes to the bottom.

To complete the trap, a caprock must **overlie** the reservoir rock. The caprock is a **seal** and doesn't allow fluids to flow through it. Without a caprock, the oil and gas would leak up to the surface of the ground. Two common sedimentary rocks that can be seals are shale and salt.

Resistance - сопротивление

Route – путь, дорога

Pore space – поровое пространство

Interconnect – взаимодействовать

Flow – течь

Encounter – встречать

Dome – купол

Anticline – антиклиналь

Overlie – перекрывать (залегать выше)

Seal – изолирующий слой

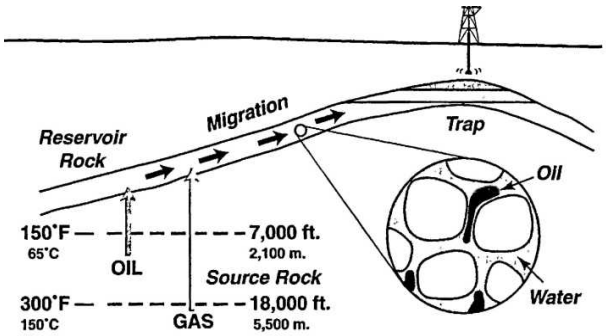


Fig. I–1 Generation and migration of gas and oil

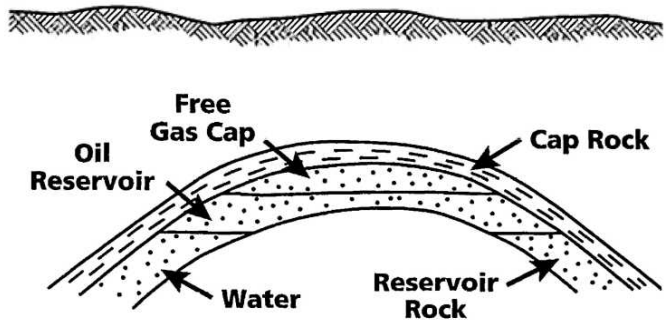


Fig. I–2 Petroleum trap

Answer the questions:

1.Why can the fluid flow from pore to pore? 2. What is permeability? 3. What is migration? 4. How do the fluids separate in the trap? 5. Why must a caprock overlie the reservoir rock?

Oil detection

How are subsurface deposits of gas and oil **located**? During the early days of drilling, it was thought that there were large, flowing underground rivers and subsurface **pools** of oil. Early drillers, however, had some success because many subsurface traps are **leaky**. There are small fractures in the caprock, and some of the oil and gas leaks up and seeps onto the surface. The early drillers located their wells on the **seeps**.

By the early 1900s, the principles of subsurface gas and oil deposits were becoming better known. Oil companies realized that by **mapping** how the sedimentary rock layers **crop out** on the surface of the ground, the rock lay-

Locate – определять место

Pool – резервуар; бассейн

Leaky – имеющий течь; протекающий

Seep – выход, проявление

ers could be projected into the subsurface, and traps could be located (Fig. 1—3). Geologists were hired to map rock outcrops.

Mapping – нанесение на карту

Later, **seismic method** was developed to **detect hidden** traps in the subsurface. Seismic exploration uses a **source** and **detector** (Fig. 1-4).

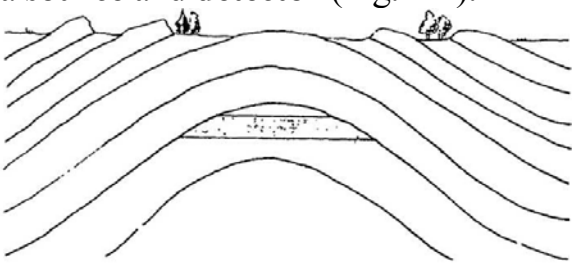


Fig. I–3 Rock outcrops

Crop out – обнажаться, выходить на поверхность

Seismic method – сейсмический метод

Detect – обнаруживать

Hidden – скрытый, спрятанный

The source, such as dynamite, is located on or near the surface and gives off an impulse of sound energy into the subsurface. The sound energy **bounces** off sedimentary rock layers and returns to the surface to be recorded by the detector. Sound echoes are used to make an image of the subsurface rock layers.

Source – взрывной источник

Detector – сейсмоприёмник

Bounce – отскакивать

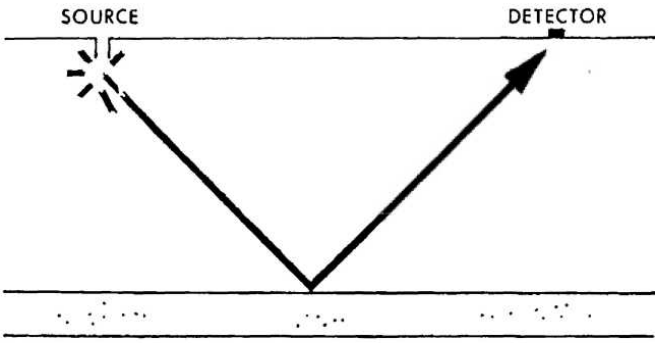


Fig. I–4 The seismic method

Answer the questions:

1.What was thought during the early days of drilling? 2. Why does some of the oil and gas leak up? 3. How could the rock layers be projected? 4. What is the main principle of seismic method? 5. What are sound echoes used for?

Drilling a well

The only way to know for sure if a trap contains commercial amounts of gas and oil is to drill a well. A well drilled to find a new gas or oil field is called a **wildcat** well. Most wildcat wells are **dry holes** with no commercial amounts of gas or oil. The well is drilled using a rotary drilling rig (Fig. 1-5). There can be thousands of feet of **drillpipe** with a bit on the end, called the drillstring, **suspended** in the well. By rotating the drillstring from the surface, the bit on the bottom is turned and cuts the hole. As the well is drilled deeper, more drillpipe is **added**. The power is supplied by diesel engines. A steel **tower** above the well, the derrick, is used to raise and lower equipment. The well can be drilled either almost straight down as a straight hole or out at an angle as a **deviated well**.

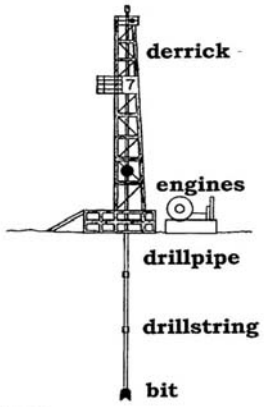


Fig. 1–5 Rotary drilling rig

Wildcat – разведочная скважина

Dry hole – непродук
тивная скважина

Drillpipe – бурильная колонна

Suspend – подвешивать

Add – наращивать

Tower – вышка, башня

Deviated well – наклонная скважина

Answer the questions:

1.What is the only way to know about the commercial amounts of oil and gas? 2. What is a drillstring? 3. How is bit rotated? 4. What types of well do you know? 5. What is derrick?

Drilling mud

An important system on the rig is the circulating mud system. The drilling mud is pumped down the inside of the drillpipe where it **jets** out from **nozzles** in the bit and returns up the outside of the drillpipe to the surface (Fig. 1—6). The drilling mud **removes** the rock **chips** made by the bit, called well **cuttings**, from the bottom of the hole. This prevents them from **clogging** up the bottom of the well. The well is always kept

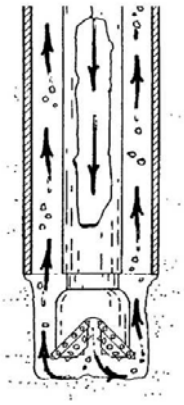


Fig. 1-6 *Well-cutting removal by circulating drilling mud*

Jet – бить струёй

Nozzle – промывочная насадка

Remove – удалять

Chips, Cuttings – буровой шлам

Clogging – забивание загрязнение; засорение;

Prevent – предотвращать

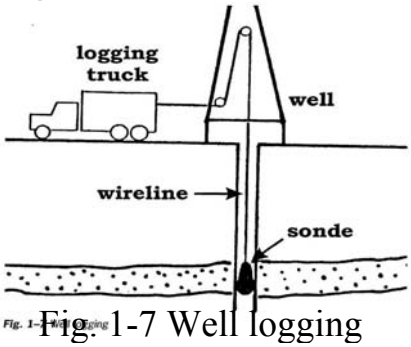
filled to the top with heavy drilling mud as it is being drilled. This **prevents** any fluids such as water, gas, and oil from flowing out of the subsurface rocks and into the well. If gas and oil flowed up onto the floor of the drilling rig, it could catch fire. Even if only water flowed out of the surrounding rock into the well, the sides of the well could **cave** in and the well could be lost. The drilling mud keeps the fluids back in the surrounding rocks. Offshore wells are drilled the same as on land. For offshore wildcat wells, the rig is **mounted** on a barge, floating platform, or ship that can be moved. Once an offshore field is located, a production platform is then installed to drill the rest of the wells and produce the gas and oil.

Answer the questions:

1.What are the functions of the drilling mud? 2. Why could the sides of well cave? 3. How are offshore wells drilled?

Well evaluation

Because the drilling mud keeps gas and oil back in the rocks, a subsurface deposit of gas or oil can be drilled without any **indication** of the gas or oil. To **evaluate** the well, a service company runs a **wireline** well log. A **logging truck** is driven out to the well.



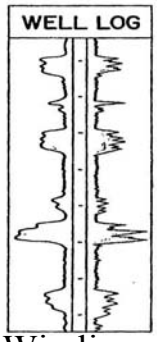


Fig. 1-7 Well logging Fig. 1-8 Wireline well log

A long cylinder containing instruments called a **sonde** is unloaded from the truck and lowered down the well on a wireline (Fig. 1-7).As the sonde is brought back up the well, the instruments remotely **sense** the electrical, sonic, and radioactive properties of the surrounding rocks and their fluids. These measurements are recorded on a long strip of paper called a **well log** (Fig. 1-8).

It is used to determine the composition of each rock layer, whether the rock layer has pores, and what fluid (water, gas, or oil) is in the pores.

Indication – признак

Evaluate – оценивать

Wireline – талевый канат

Logging truck – передвижная каротажная станция

Sonde – 1) зонд 2) каротажный заряд (спускаемый в скважину)

Sense – зондировать, измерять

Well log – каротажная диаграмма

Answer the questions:

1.Why is evaluation necessary? 2. How is evaluation conducted? 3. What is well log used for?

Completing a well

Depending on the test results, the well can be **plugged** and **abandoned** as a dry hole or completed as a **producer**. Setting pipe is synonymous with completing a well. To set pipe, a long length of large diameter steel pipe (casing) is lowered down the hole. Wet cement is then pumped between the **casing** and the well walls and allowed to set (Fig. 1-9). This stabilizes the hole. In most wells, the casing is done in stages called a casing program during which the well is drilled, cased, drilled deeper, cased again, drilled deeper, and cased again.

In order for the gas or oil to flow into the well, the casing is shot with explosives to form holes called **perforations** (Fig. I—10). A long length of narrow diameter steel pipe (tubing) is then suspended down the center of the well. The produced fluids (water, gas, and oil) are brought up the tubing string to the surface to prevent them from touching and corroding the casing that is harder to repair. The tubing is relatively easy to repair during a **workover**.

In a gas well, gas flows to the surface by itself. There are some oil wells, early in the development of the oilfield, in which the oil has enough pressure to flow up to the surface. Gas wells and flowing oil wells are completed with a series of **fittings** and **valves** called a Christmas tree on the surface to control the flow (Fig. I—11).

Most oil wells, however, do not have enough pressure for the oil to flow to the surface and **artificial lift** must be used. A common artificial lift system is a **sucker-rod pump** (Fig. 1-11). A **downhole pump** on the bottom of the **tubing string** is driven by a **beam-pumping unit** on the surface. The pump lifts the oil up the tubing to the surface.

Plug – ставить пробку

Abandon – ликвидировать

Producer – эксплуатационная скважина

Casing - обсадные трубы, обсадная колонна

Perforation – перфорация

Workover – ремонт, ре монтные работы; КРС

Fittings – арматура

Valve – клапан; вентиль; задвижка

Artificial lift – механизированная добыча, насосно-компрессорная добыча

Sucker-rod pump – шланговый скважинный насос

Downhole pump – забойный насос

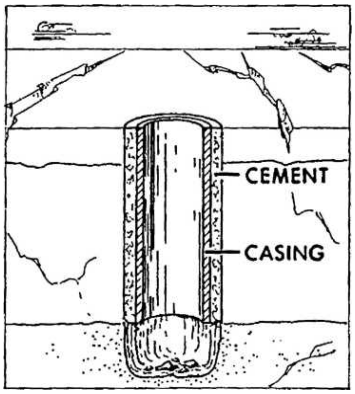


Fig. 1-9 *Casing a well*

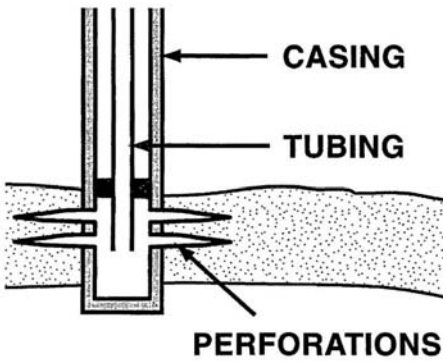


Fig. 1-10 *Perforations and tubing in a well*

Tubing string – колонна насосно-компрессорных труб

Beam-pumping unit – балансирный станок-качалка

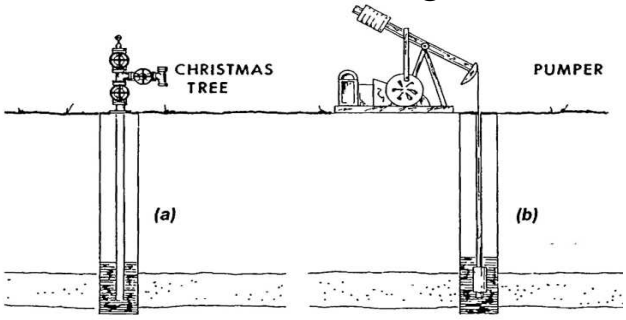


Fig. 1–11 *Gas (a) and oil well (b) completions*

Answer the questions:

1.What can be done depending on test results? 2. What is a casing program? 3. Why is casing shot? 4. Why is tubing necessary? 5. What is done if oil has enough pressure to flow up? 6. Why are pumps used?

Oil recovery

Production from wells can be increased by **acid** and **frac jobs**. Acid is pumped down a well to dissolve some of the reservoir rock adjacent to the wellbore during an acid job. During a frac job, the reservoir rock is hydraulically fractured with a liquid pumped under high pressure down the well. Periodically, production from the well must be **interrupted** for repairs or **remedial** work during a workover. As fluids are produced from the subsurface reservoir, the pressure on the remaining fluids drops. The production of oil and gas from a well or a field decreases with time on a **decline curve**. The shape

Acid – кислота

Frac job – гидравлический разрыв

Interrupt – прерывать

Remedial – ремонтный

Decline curve – кривая падения

of the decline curve and the ultimate amount of oil or gas produced depend on the **reservoir drive**, the natural energy that forces the oil or gas through the subsurface reservoir and into the well. Ultimate recovery of gas from a gas reservoir is often about 80% of the gas in the reservoir. Oil reservoirs, however, are far more variable and less efficient. They range from 5% to 80% recovery but average only 30% of the oil in the reservoir. This leaves 70% of the oil remaining in the pressure-depleted reservoir.

After the natural reservoir drive has been **depleted** in an oilfield, **water-flood**, and **enhanced oil recovery** can be attempted to produce some of the remaining oil.

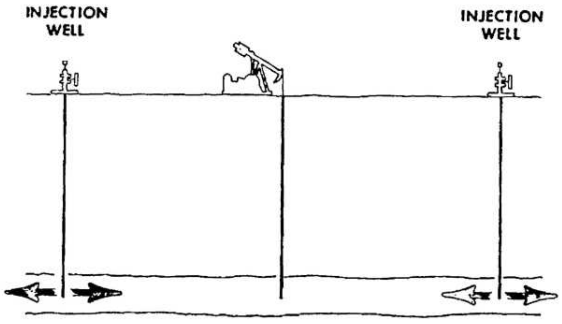


Fig. 1–12 Waterflood

During a water-flood, water is pumped under pressure down **injection wells** into the depleted reservoir to force some of the remaining oil through the reservoir toward producing wells (Fig. 1-12). Enhanced oil recovery involves pumping fluids that are not natural to the reservoir, such as **carbon dioxide** or **steam**, down injection wells to obtain more production.

After the well has been depleted, it is plugged and abandoned. Cement must be poured down the well to seal the depleted reservoir and to protect any subsurface fresh water reservoirs. A steel plate is then **welded** to the top of the well.

(добычи); кривая истощения (пласта)

Reservoir drive – пластовый режим

Deplete – истощать; исчерпывать

Water- flood – заводнение

Enhanced oil recovery (EOR) – добыча нефти вторичным методом

Injection well – нагнетательная скважина

Carbon dioxide – углекислый газ

Steam – пар

Weld – сваривать

Answer the questions:

1.How are acid and frac jobs used? 2. What is the percentage of oil recovered and left in the reservoir? 3. What methods are used when the natural reservoir drive has been depleted? 4. How is well depleted?

Exercise № 1. Match English words with their Russian equivalents.

sediments	плотность
shale	пересекать
generate	песчаник
density	разрыв
sandstone	образовывать
limestone	путь
intersect	сланец
fracture	проницаемость
path	купол
permeability	известняк
dome	просачиваться
leak	осадочные породы

Exercise № 2. Make up word combinations and translate them.

hydrogen	sulfide
sedimentary	rock
sand	grain
vast	expanse
organic	matter
inorganic	particles
source	rock
rock	layer
animal	material
ancient	sediments

Exercise № 3. Match English words with their Russian equivalents.

mapping	разведка
crop out	коммерческий объем
seep	звуковая энергия
exploration	долото
sound energy	картирование
commercial amount	двигатель
wildcat	удалять
bit	обнажаться
engine	закачивать
pump	предотвращать
remove	удалять
prevent	проявления
floor	плавучая платформа
cave	разведочная скважина

floating platform	обрушаться
install	основание

Exercise № 4. Make up word combinations and translate them.

pore	cap
natural	rivers
gas	trap
salt	arch
underground	outcrops
subsurface	exploration
give off	space
seismic	an image
rock	hole
diesel	water
straight	an impulse
make	engine
mud	cutting
well	system

Exercise № 5. Fill the gaps using the words given.

Shot	offshore	well log	to flow	a producer	less	
repairs	the well	detector	interrupted	more	filled	

1. The drilling mud removes the cuttings from … .
2. These measurements are recorded on a long strip of paper called … .
3. Most wells do not have enough pressure for oil … to the surface.
4. The well can be completed as … .
5. The casing is … with explosives.
6. Production from the well must be … for …
7. Oil reserves are far … valuable and … efficient.
8. The well is always kept … to the top as it is being drilled.
9. For … wildcat wells, the rig is mounted on a barge.
10. The sound energy returns to the surface to be recorded by…

Exercise № 6. Complete the sentences using the infinitive.

to lower	to produce	to complete	to detect	to concentrate	
to map	to flow	to hold	to expose	to cover	to raise.

1. Heavy crude oils are difficult … .
2. There must be a trap … the oil and the gas.
3. The seas have risen … the land and then fallen … the land.
4. Sedimentary rocks are drilled … and … oil and gas.
5. There must be a subsurface rock … the gas or oil.

6. … the trap, a caprock must overlie the reservoir the reservoir rock.
7. The geologists were hired … rock outcrops.
8. Seismic method was developed … hidden traps in the subsurface.
9. The caprock doesn't allow fluids … through it.
10. The derrick is used … and … equipment.

Exercise № 7. Match the words and definitions:

Migration	Complete	Occur	Density	Sediment	Fracturing	
Sourcerock	Perforations	Log	Fracture	Pore		
Casing	Viscous	Abandon	Outcrop	Permeability	EOR	

1. A crack or break in a hard object or material, typically a body of rock.
2. Exist or be found to be present in a place or under a particular set of conditions.
3. The movement of hydrocarbons from their source into reservoir rocks.
4. Degree of consistency measured by the quantity of mass per unit volume.
5. A minute opening in a surface through which gases, liquids, or microscopic particles can pass.
6. The unconsolidated grains of minerals, organic matter or preexisting rocks, that can be transported by water, ice or wind, and deposited.
7. A body of rock exposed at the surface of the Earth.
8. A sediment containing sufficient organic matter to be a future source of hydrocarbons.
9. The state or quality of a material or membrane that causes it to allow liquids or gases to pass through it.
10. Having a thick, sticky consistency between solid and liquid.
11. Large-diameter pipe lowered into an openhole and cemented in place.
12. The measurement versus depth or time, or both, of one or more physical quantities in or around a well.
13. To perform activities in the final stages of well construction to prepare a well for production. The well is completed once zones of interest have been identified.
14. A well stimulation technique in which fluids are pumped into a formation under extremely high pressure to create or enlarge fractures for oil and gas to flow through.
15. To stop producing because of unprofitability.
16. Method of recovery that uses sophisticated techniques that alter the original properties of oil.
17. The communication tunnel created from the casing or liner into the reservoir formation, through which oil or gas is produced.

Exercise № 8. Fill the gaps using the words given.

source	shallow	pipe rolling	issue	replace	seepage	
adopt	plummet	drive	overproduction	ignite	boom	

1. The industry's chemical … and waste have caused untold damage.

2. The bombs … a fire.

3. The water is quite … for some distance.

4. … of oil sank prices to rock bottom in 1959.

5. He hoped that his enterprise would have a prosperous ….

6. The prices … .

7. After workover operations bit … .

8. This approach … adopted by many big companies .

9. The current flows into electric motors that the wheels.

10. The popularity of oil products … in the last two decades.

11. Our range of pipe bending machines includes … machines.

12. Sandstone is a good … of oil.

Exercise № 9. Complete the definitions given.

1. Having little depth.

2. To perform activities in the final stages of well construction to prepare a well for production.

3. Decrease rapidly in value or amount.

4. Sedimentary rock consisting of sand or quartz grains cemented together, typically red, yellow, or brown in color.

5. A configuration of rocks suitable for containing hydrocarbons and sealed by a relatively impermeable formation through which hydrocarbons will not migrate.

6. Soft, finely stratified sedimentary rock that formed from consolidated mud or clay.

7. A relatively impermeable rock, commonly shale, anhydrite or salt, that forms a barrier or seal above and around reservoir rock so that fluids cannot migrate beyond the reservoir.

8. A hard sedimentary rock, composed mainly of calcium carbonate or dolomite, used as building material and in the making of cement.

9. The combination of the drillpipe, the bottomhole assembly and any other tools used to make the drill bit turn at the bottom of the wellbore.

10. The tool used to crush or cut rock.

11. A type of anticline that is circular or elliptical rather than elongate.

12. An exploration well.

13. Small pieces of rock that break away due to the action of the bit teeth.

14. Crude oil that has a high API gravity, usually more than 40^{o}.

15. The process of performing major maintenance or remedial treatments on an oil or gas well.

16. An artificial-lift pumping system using a surface power source to drive a downhole pump assembly.

17. An assembly of valves, gauges, and chokes mounted on a well casing head to control production and the flow of oil to the pipelines.

Exercise № 10. Write forms of adjectives:

Slow, cold, beautiful, easy, difficult, good, bad, many, high, light, interesting.

Exercise № 11. Insert the prepositions:

1. Oil has been used … lighting purposes for many thousand years.
2. Historically, we know … tales of eternal fires where oil and gas seeps would ignite and burn.
3. The Drake Well was located in the middle of quiet farm country … north-western Pennsylvania, and began the international search … and industrial use of petroleum.
4. These wells were shallow … modern standards.
5. For example, the Phillips well was flowing initially at 4000 barrels per day … October 1861.
6. Oil is selling … $5 per barrel.
7. Gasoline engines were essential … designing successful aircraft.
8. Ships driven … oil could move up … twice as fast as their coal fired counterparts, a vital military advantage.
9. Welding techniques, pipe rolling, and metallurgical advances allowed … the construction of reliable long distance pipelines, resulting … a natural gas industry boom.
10. With oil prices … 50 dollars per barrel or more, even more difficult to access sources become economically interesting.
11. Depending … the tests, the well can be plugged… .
12. The produced fluids are brought up the tubing string to the surface to prevent them … touching and corroding the casing.
13. Valuable natural gas liquids are removed … the gas.
14. Setting pipe is synonymous … completing a well.
15. Production must be interrupted … repairs.
16. Steel tank is used to separate natural gas and salt … the oil.
17. Gas is prepared … delivery … a pipeline.
18. The reservoir rock is hydraulically fractured … a liquid pumped … high pressure.
19. A steel plate is welded … the top of the well.
20. The oil is stored … steel stock tanks.

Exercise № 12. Translate the sentences into Russian.

1. Во время заводнения вода под давлением закачивается в нагнетательную скважину.
2. При формировании нефти и газа температура является самым важным фактором.

3. Добычу нефти можно увеличить при помощи методов вторичной добычи нефти.

4. По мере того, как увеличивается глубина, становится жарче.

5. Насос на забое скважины приводится в движение станком качалкой.

6. НКТ относительно легко отремонтировать.

7. Длинные трубы большого диаметра, называемые обсадными, опускаются в скважину.

8. Вещество с меньшей плотностью занимает самую верхнюю часть залежи.

9. Как только определяется шельфовое месторождение, устанавливается эксплуатационная платформа.

10. Любой флюид будет двигаться по пути наименьшего сопротивления, по самому легкому пути.

11. Чтобы наносить на карту обнажения горной породы, нефтяные компании нанимали геологов.

12. Сланец и соль – это осадочные породы, которые могут быть покрышками.

13. Легкость, с которой флюид может передвигаться по породе, называется проницаемостью.

14. Накапливаясь слой за слоем, эти осадочные породы образуют нефтематеринские породы.

15. Мигрируя, нефть и газ могли пересекать слой породы-коллектора.

16. Считалось, что под землей существуют подземные нефтяные реки.

17. Долото на забое вращается и разрезает породу.

18. Каротаж используется, чтобы определить есть ли поры в пласте, и какой флюид находятся в породе.

19. Фонтанирующие скважины оборудуются специальным оборудованием, которое называется елкой.

20. Около 70% нефти остается в пластах с пониженным давлением.

21. Первая скважина на нефть (разведочная) промышленным способом была пробурена на Абшеронском полуострове в 1847 году, первая эксплуатационная скважина пробурена на р. Кудако на Кубани в 1864 году.

22. В 347 год н. э. в Китае впервые пробурили скважины в земле для получения нефти.

23. В качестве труб использовались полые стволы бамбука.

24. В 1951 году впервые в истории США нефть стала главным источником энергии, оттеснив уголь на второе место.

25. К 1829 году в Баку 82 скважины давали 550 тонн нефти в год.

26. Самым первым способом добычи нефти был сбор с поверхности водоемов.

27. Из нефти производят эффективные моющие средства и другую бытовую химию.

28. Нефть служит сырьем для множества различных продуктов.

29. Самое распространенное топливо для транспорта – бензин, на который приходится 50% от общего объема производимых в мире нефтепродуктов.

30. Каждый год в мире производят около 180 миллионов тонн пластмассы.

Exercise № 13. Render the text using words from the unit.

В природе нефть располагается в пористых породах, в которых жидкость может накапливаться и перемещаться. Такие породы называют коллекторами. Важнейшими коллекторами нефти являются пески, песчаники, конгломераты и трещиноватые породы. Но чтобы образовалась залежь, необходимо присутствие так называемых покрышек – непроницаемых пород, которые препятствуют миграции. Обычно пласт-коллектор расположен под уклоном, поэтому нефть и газ просачиваются вверх. Если их выходу на поверхность мешают складки породы и другие препятствия, образуются ловушки. Верхнюю часть ловушки иногда занимает слой газа – «газовая шапка».

Таким образом, чтобы обнаружить месторождение нефти, необходимо найти возможные ловушки, в которых она могла скопиться. Сначала потенциально нефтеносный район исследовали визуально, научившись выявлять присутствие нефтяных залежей по многим косвенным признакам. Однако чтобы поиски были максимально успешными, необходимо уметь «видеть под землей». Это стало возможным благодаря геофизическим методам исследования. Наиболее эффективным инструментом оказался сейсмограф, который был предназначен для регистрации землетрясений. Его способность улавливать механические колебания пригодилась в геологоразведочном деле. Колебания от взрывов динамитных снарядов преломляются подземными структурами, и, регистрируя их, можно определить расположение и форму подземных пластов.

Итак, месторождение найдено, и решено начать его разработку. Бурение нефтяных скважин – это процесс, в ходе которого разрушаются горные породы, и раздробленные частицы выносятся на поверхность. Тяжелая буровая колонна, вращаясь, давит на долото, которое и разрушает породу. Скорость проходки при этом зависит и от характера породы, и от качества оборудования, и от мастерства бурильщика.

Очень важную роль играет буровой раствор, который не только выносит на поверхность частицы породы, но и работает в качестве смазки и охладителя буровых инструментов. Он же способствует образованию глинистой корки на стенках скважины. Буровой раствор может быть сделан на водной или даже нефтяной основе, в него часто добавляют различные реагенты и добавки.

Как же нефть извлекают из скважин? В материнских пластах она находится под давлением, и если это давление достаточно высокое, при вскрытии скважины нефть начинает естественным образом фонтанировать. Обычно этот эффект сохраняется в начальной стадии, а потом приходится прибегать к механизированному способу добычи – с помощью разного рода насосов или с помощью ввода в скважину сжатого газа (этот способ называют газлифтным). Чтобы повысить давление в пласте, в него закачивают воду, где она выполняет роль своего рода поршня. Сегодня для

повышения пластового давления применяют также одновременную закачку газа и воды.

На одном месторождении бурят от нескольких десятков до нескольких тысяч скважин – не только нефтяных, но и контрольных, и нагнетательных – для закачивания воды или газа.

После завершения эксплуатации месторождения нефтяные скважины консервируются или ликвидируются в зависимости от степени использования. Эти меры необходимы для того, чтобы обеспечить безопасность жизни и здоровья людей, а также, чтобы защитить окружающую среду.

Все, что выходит из скважин – нефть с попутным газом, водой и прочими примесями, например песчаными – замеряют, определяя процент воды и попутного газа. В специальных газонефтяных сепараторах нефть отделяют от газа, и она поступает в сборный трубопровод. Оттуда начинается путь нефти на нефтеперерабатывающий завод.

Do you know that? Oil Through the Ages

347 A.D. Oil wells are drilled in China up to 800 feet deep using bits attached to bamboo poles.

1264 Mining of seep oil in medieval Persia witnessed by Marco Polo on his travels through Baku.

1500s Seep oil collected in the Carpathian Mountains of Poland is used to light street lamps.

1594 Oil wells are hand dug at Baku, Persia up to 35 meters (115 feet) deep.

1735 Oil sands are mined and the oil extracted at Pechelbronn field in Alsace, France.

1802 A 58-ft well is drilled using a spring pole in the Kanawha Valley of West Virginia by the brothers David and Joseph Ruffner to produce brine. The well takes 18 months to drill.

1815 Oil is produced in United States as an undesirable by-product from brine wells in Pennsylvania.

1848 First modern oil well is drilled in Asia, on the Aspheron Peninsula north-east of Baku, by Russian engineer F.N. Semyenov.

1849 Distillation of kerosene from oil by Canadian geologist Dr. Abraham Gesner. Kerosene eventually replaces whale oil as the illuminant of choice and creates a new market for crude oil.

1850 Oil from hand-dug pits in California at Los Angeles is distilled to produce lamp oil by General Andreas Pico.

1854 First oil wells in Europe are drilled 30- to 50-meters deep at Bóbrka, Poland by Ignacy Lukasiewicz.

1854 Natural Gas from a water well in Stockton, California is used to light the Stockton courthouse.

1857 Michael Dietz invents a kerosene lamp that forces whale oil lamps off the market.

1858 First oil well in North America is drilled in Ontario, Canada.

1859 First oil well in United States is drilled 69 feet deep at Titusville, Pennsylvania by Colonel Edwin Drake.

Unit 2. Nature of oil.

Mind the definitions

Boiling point	точка кипения	The boiling point is dependent on the pressure.
Carbon	углерод	Carbon forms more compounds than any other element.
Chain	цепочка	Macromolecular structures have large numbers of atoms linked in chains.
Cloud point	температура помутнения	In crude or heavy oils, cloud point is synonymous with wax appearance temperature.
Composition	состав	The exact molecular composition varies widely from formation to formation.
Cracking	крекинг	Hydrocarbon cracking is the process of breaking long-chain hydrocarbons into short ones.
Cut	фракция; погон	All these cuts are processed further in subsequent refining processes.
Distilling column	дистилляционная колонна	Depending on their purpose, distillation columns may have liquid outlets at intervals up the length of the column.
Feedstock	сырьё	The crude oil feedstock has typically been processed by an oil production plant.
Fossil fuel	ископаемое топливо	Fossil fuels contain high percentages of carbon and include coal, petroleum, and natural gas.
Hydrocarbon	углеводород	A modern refinery will convert heavy hydrocarbons and lighter gaseous elements into these higher value products.
Hydrogen	водород	Hydrogen forms compounds with most elements.
Impurity	примесь	The removal of impurities is usually done chemically.
Molecule	молекула	The shortest molecules, those with four or fewer carbon atoms, are in a gaseous state at room temperature.
Nitrogen	азот	Organic compounds contain nitrogen, oxygen and sulfur.
Oxygen	кислород	Oxygen is produced industrially by fractional distillation of liquefied air.

Pour point	температура застывания	In crude oil a high pour point is generally associated with a high paraffin content.
Property	свойство	Each petroleum variety has a unique mix of molecules, which define its physical and chemical properties, like color and viscosity.
Refinery	НПЗ	In many ways, oil refineries use much of the technology of, and can be thought of, as types of chemical plants.
Saturated	насыщенный	Naphthenes are saturated hydrocarbons which have one or more carbon rings.
Sweet	десульфурированный; обессеренный	Crude oil may be referred to as sweet if it contains relatively little sulfur.
Vaporize	испаряться	Cold gasoline does not vaporize readily.
Wax	парафин, воск; твёрдые углеводороды	Paraffin wax is an alkane with approxi-mately 25 carbon atoms.

Petroleum, Chemical Composition, Properties

The word petroleum comes from the Greeks. Petro means rock, and oleum means oil. In it **strictest** sense, petroleum includes only crude oil. By usage, however, petroleum includes both crude oil and natural gas.

The chemical composition by weight of typical crude oil and natural gas is shown in Table 1-1.

The two most important elements in both crude oil and natural gas are carbon and hydrogen. Because of this, crude oil and natural gas are called hydrocarbons.

Strict – точный

Occur – встре-чаться, проявлять-ся

Range – колебать-ся, варьироваться

Side branch – бо-ковое ответвление

Table 1–1

The chemical composition of typical crude oil and natural gas

	crude oil	*natural gas*
Carbon	84–87%	65–80%
Hydrogen	11–14%	1–25%
Sulfur	0.06–2%	0–0.2%
Nitrogen	0.1–2%	1–15%
Oxygen	0.1–2%	0%

(modified from Levorsen, 1967)

The difference between crude oil and natural gas is the size of the hydrocarbon molecules. Under surface temperature and pressure, any hydrocarbon molecule that has one, two, three, or four carbon atoms **occurs** as a gas. Natural gas is composed of a mixture of the four short hydrocarbon molecules. Any hydrocarbon molecule with five or more carbon atoms occurs as a liquid. Crude oil is a mixture of more than 100 hydrocarbon molecules that **range** in size from 5 to more than 60 carbons in length. The hydrocarbon molecules in oil form straight chains, chains with **side branches**, and circles.

Sulfur is an undesirable impurity in fossil fuels such as crude oil, natural gas, and coal. When sulfur is burned, it forms sulfur dioxide, a gas that pollutes the air and forms acid rain. During the refining process, the refiner must remove the sulfur as the crude oil is being processed. If not, the sulfur will harm some of the chemical equipment in the refinery. Crude oils are classified as sweet and sour on the basis of their sulfur content. Sweet crudes have less than 1% sulfur by weight, whereas sour crudes have more than 1% sulfur. The refiner usually pays a US $1 to $3 per barrel premium for sweet crude. In general, heavy oils tend to be sour, whereas light oils tend to be sweet. At a refinery, low sulfur crude has 0 to 0.6% sulfur. Intermediate sulfur crude has 0.6 to 1.7% sulfur, and high sulfur crude has above 1.7% sulfur. Most of the sulfur in crude oil occurs bonded to the carbon atoms. A very small amount can occur as elemental sulfur in solution and as H_2S gas.

The color of crude oil ranges from colorless through greenish-yellow, reddish, and brown to black. In general, the darker the crude oil, the lower the °API. The smell varies from gasoline (sweet crude) to foul (sour crude) to fruity (aromatic crude). Crude oil has a calorific heat value of 18,300 to 19,500 Btu/lb.

Answer the questions:

1.Where does word petroleum come from? 2. What are crude oil and natural gas composeв of? 3. Why are crude oil and natural gas called hydrocarbons? 4. Which hydrocarbon molecules do occur as a liquid or a gas? 5. Why is sulfur undesirable

impurity? 6. What does the colour of oil depend on? 7. What are the main properties of oil?

Crude oil. Hydrocarbon Molecules.

Four types of hydrocarbon molecules, called the hydrocarbon series, occur in each crude oil. The paraffin or alkane molecule is a straight chain of carbon atoms with saturated (single) bonds between the carbon atoms (Fig. 1—1).

The relative percentage of each hydrocarbon series molecule varies from oil to oil, controlling the chemical and physical properties of that oil. The hydrocarbons series includes **paraffins**, **naphthenes**, **aromatics**, and **asphaltics**. Hydrocarbons that have only single **bonds** between carbon atoms are called saturated. If they contain one or more double bonds, they are unsaturated.

The formula for paraffins is C_nH_{2n+2}. They are five carbon atoms and longer in length. If the paraffin molecule is longer than 18 carbons in length, it is a wax and forms a **waxy crude oil.**

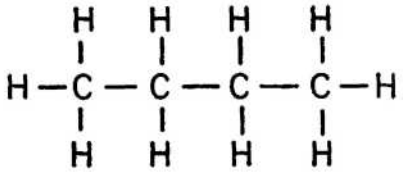


Fig. 1–1 *Paraffin molecule*

The naphthene or **cycloparaffin** molecule is a closed circle with saturated bonds between the carbon atoms (Fig. 1-2). The general formula for naphthenes is C_nH_{2n}. These molecules are five carbon atoms and longer in length. Oils with high naphthene content tend to have a large asphalt content that reduces the value of the oil.

The aromatic or **benzene** molecule is a closed ring with some unsaturated (double) bonds between carbon atoms (Fig- 1-3). Their general formula is C_nH_{2n-6}. Aromatic molecules are six carbon atoms and longer in length.

Paraffin – парафин

Naphthenes – нафтены, нафтеновые углеводороды

Aromatics - ароматический углеводород

Asphaltics - битумы

Bond – связь

Waxy crude oil – парафинистая нефть

Cycloparaffins - циклопарафины

Benzene - бензол

Yield – давать; выдавать; производить

Pungent – резкий, едкий

Lubricating oil - смазочное масло

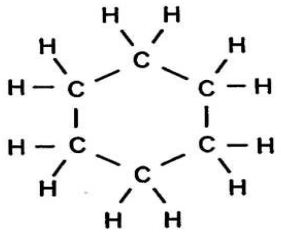


Fig. 1–2 Naphthene molecule

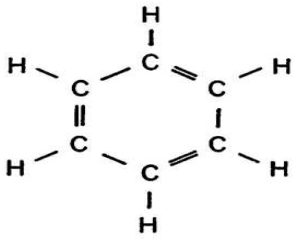


Fig. 1–3 Aromatic molecule

At the refinery, an aromatic-rich crude oil **yields** the highest-octane gasoline and makes a valuable feedstock for the petrochemical industry. The refiner often pays a premium for aromatic crude oil. Fresh from the well, normal crude oil has a **pungent** odor of gasoline. An aromatic-rich crude oil, however, has a fruity odor.

The asphaltic molecule has 40 to more than 60 carbon atoms. Asphalt is brown to black in color and is solid to semisolid under surface conditions. It has a high boiling point. Table 1-2 shows the hydrocarbon series content of crude oil. There are two types of crude oils at the refinery. An asphalt-based crude oil contains little or no paraffin wax. It is usually black. When refined, it yields a large percentage of high-grade gasoline and asphalt. Paraffin-based crude oil *c*ontains little or no asphalt. It is usually greenish. When refined, it yields a large percentage of paraffin wax, high-quality **lubricating oil**, and kerosene. A mixed-base crude oil is a combination of both types.

Table 1–2

Average and range of hydrocarbon series molecules in crude oil

	weight percent	*percent range*
paraffins	30	15 to 60
naphthenes	49	30 to 60
aromatics	15	3 to 30
asphaltics	6	remainder

(modified from Levorsen, 1967 and Bruce and Schmidt, 1994)

Answer the questions:

1.What are types of hydrocarbon molecules? 2. What crude does yield the highest-octane gasoline? 3. What odour can oil have? 4. How many types are there at the refinery? 5. What are they?

API, Benchmark crude oil

Crude oils are compared and described by density. The most commonly used density scale is °*API.* API stands for the American Petroleum Institute, based in Washington, D.C. It standardizes petroleum industry equipment and procedures. The formula for computing °API is:

°API = [(141.5 specific gravity at 60°F) - 131.5].

Fresh water, for example, has an °API of 10. The °API of crude oils varies from 5 to 55. Average weight crude oils are 25 to 35. Light oils are 35 to 45. Light oils are very fluid, often **transparent**, rich in gasoline, and are the most valuable. Heavy oils are below 25. They are very viscous, dark- colored, contain considerable asphalt, and are less valuable.

A **benchmark** crude oil is a standard against which other crude oils are compared, and prices are set. In the United States, West Texas Intermediate (WTI) is 38 to 40 °API and 0.3% S, whereas West Texas Sour, a secondary benchmark, is 33 °API and 1.6% S. Brent, the benchmark crude oil for the North Sea is very similar to WTI and is 38 °API and 0.3% S. Dubai is the benchmark crude oil for the Middle East. It is 31 °API and 2% S.

Transparent – прозрачный

Benchmark – стандарт, эталон

Answer the questions:

1.What is the main characteristic used to describe oil? 2. What is API used for? 3. What are degrees of API of different types of oil? 4. What is benchmark crude oil?

Pour point

All crude oils contain some paraffin molecules. If the paraffin molecules are 18 carbon atoms or longer in length, they are waxes. Waxes are solid at surface temperature. A crude oil that containing a significant amount of wax is called a waxy crude oil. In the subsurface reservoir where it is very hot, waxy crude oil occurs as a liquid. As it is being brought up the well, it cools, and the waxes can **solidify**. This can clog the tubing in the well and flow- lines on the surface. The well then has to be shut in for a workover to clean out the wax.

The amount of wax in crude oil is indicated by the

Solidify – затвердеть

Reflect – свидетельствовать

pour point of the oil. A sample of the oil is heated in the laboratory. It is then poured from a container as it is being cooled. The lowest temperature at which the oil will still pour before it solidifies is called the pour point. Crude oil pour points vary between +125° to -75°F (+52° to -60°C). Higher pour points **maxe** higher oil wax content. Cloud point is related to pour point. It is the temperature at which the oil first appears cloudy as wax forms when the temperature is lowered. It is 2° to 5°F (1° to 3°C) above the pour point. Very waxy crude oils are yellow in color. Slightly waxy crude oils can have a greenish color. Low or no wax oils are black.

In the North Sea, Ekofisk oil has a pour point of + 10°F (-12°C). Brent oil has a pour point of +27°F (-3°C) whereas oil from the Statfjord field is +40°F (+4.5°C) and has a higher wax content. Crude oils from the Altamont area in the Uinta basin of Utah have very high pour points between +65° and +125°F (+18° to +52°C) and range from heavy (19 °API) to light (54 °API) oil.

Answer the questions:

1. What are characteristics of waxy crude oil? 2. Does it have any disadvantages? 3. How can the amount of wax be indicated? 4. What is cloud point?

Refining

During the refining process, various components of crude oil are separated by their boiling points. In general, the longer the hydrocarbon molecule, the higher its boiling temperature. At the refinery, crude oil is first heated in a **furnace** until most is vaporized. The hot vapor is then sprayed into a distilling column. Gasses rise in the distilling column and any remaining liquid falls. In the distilling column **bubble trays** are filled with liquid (Fig. 1—4). The rising vapors bubble up through the trays and are cooled. The cooling vapors condense into liquid on the trays where they are then removed by **sidedraws**. Each liquid removed by cooling is called a cut (Fig. 1—5). Heavy cuts come out at high temperatures, whereas light cuts come out at low temperatures. In order of cooling temperatures, the cuts are heavy gas oil, light gas oil,

Furnace – печь

Bubble tray – колпачковая тарелка

Sidedraw – боковой погон

Cracking stock – исходное крекинг-сырьё

Caustic – едкий

Split – расщеплять

kerosene, naphtha, and straight run gasoline. Gasoline is the refining product in most demand. A process called cracking is used to make gasoline from the other cuts. Gasoline is composed of short molecules with 5 to 10 carbon atoms. The longer, less valuable, molecules of other cuts are used as **cracking stock**. Cracking stock is put into cracking towers at the refinery where high temperatures and pressures and **caustic** chemicals **split** the longer molecules to form gasoline.

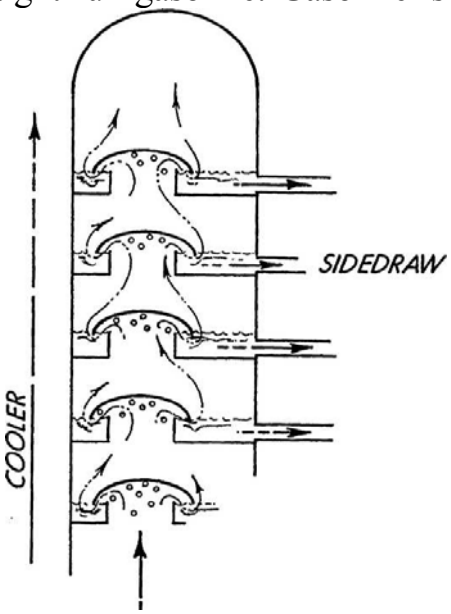


Fig. 1-4 Bubble trays in a column

Refineries also produce pure chemicals, called feedstocks, from crude oil. In general, the longer the hydrocarbon molecule, the higher its boiling temperature. These feedstocks are sold to the petrochemical industries, where the molecules are reformed, and a large variety of products are made. Plastics, synthetic fibers, fertilizers, Teflon, polystyrene, drugs, dyes, explosives, antifreeze, and synthetic rubber are examples.

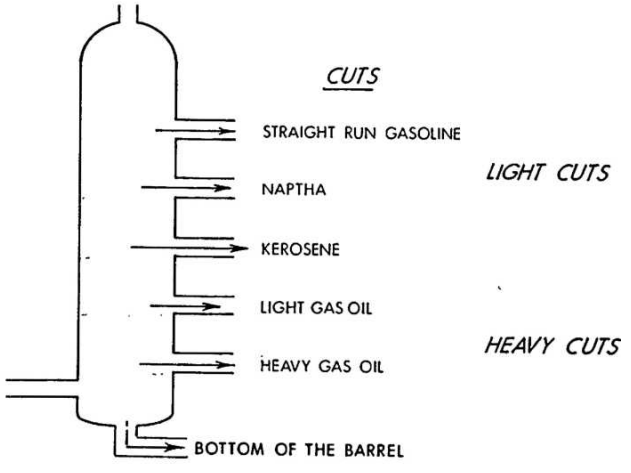


Fig. 1–5 *Distilling column cuts*

The average percent yield of crude oil in a refinery is

shown in Table 1-4.

Table 1-4

Percent yield of crude oil

gasoline	46%
fuel oil	27%
jet fuel	10%
coke	5%
liquefied gasses	4%
petrochemical feedstocks	3%
asphalt	3%
lubricants	1%
kerosene	1%

(American Petroleum Institute)

Answer the questions:

1.What does the boiling temperature depend on? 2. Describe the process of separating oil into cuts. 3. What cuts are there? 4. What do you know about them? 5. What are common feedstocks? 6. How can they be used?

Exercise № 1. Match English words with their Russian equivalents.

side branch	нежелательная примесь
to harm	двойная связь
undesirable impurity	парафинистая нефть
sweet crude	насыщенная связь
acid rain	едкий запах
pungent odor	смазочные масла
heavy oils	причинять вред
double bond	малосернистая нефть
benchmark crude	тяжёлая нефть
lubricating oils	эталонная нефть
waxy crude oil	кислотный дождь
saturated bonds	боковое ответвление

Exercise № 2. Make up word combinations and translate them.

hydrocarbon	oils
carbon	chain
straight	circles
sulfur	feedstock
sour	molecule
light	dioxide
physical	crudes

closed	atom
valuable	bond

Exercise № 3. Match words in English with their Russian equivalents.

to solidify	испаряться
to clog the tubing	колпачковые тарелки
pour point	затвердевать
calorific heat value	смазочные материалы
to vaporize	температура застывания
bubble trays	бензин первой перегонки
heavy cut	калорийность
straight run gasoline	продукты переработки нефти
lubricants	забивать НКТ
refining products	тяжелые фракции

Exercise № 4. Make up word combinations and translate them.

fruity	chemicals
boiling	process
density	cut
secondary	odour
cloud	stock
greenish	column
refining	point
hot	scale
distilling	benchmark
light	point
cracking	vapor
caustic	colour

Exercise № 5. Match the word with the definition.

Branch	chain	sweet oil	wax	lubricating oil
benchmark		pour point		cut

1. The fraction of the total flow rate produced from a well that is due to a particular fluid.
2. A standard against which the performance of processes are measured.
3. The lowest temperature (in °F or °C) at which it still behaves as a fluid.
4. Oil containing small amounts of hydrogen sulfide and carbon dioxide.
5. Any of various viscous or solid materials of natural origin: characteristically lustrous, insoluble in water, and having a low softening temperature.
6. A part of a molecule consisting of a number of atoms (typically carbon) bonded together in a linear sequence.

7. A substance, such as oil or grease, used for minimizing friction, esp. in an engine or component.

8. A lateral extension or subdivision extending from the main part of.

Exercise № 6. Complete the definitions given.

1. A group of atoms bonded together, representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction.

2. Substance that is present in small quantities in another substance and makes it dirty or of an unacceptable quality.

3. An attribute, quality, or characteristic of something.

4. Containing the relative amount of water, oil and gas in the pores of a rock, usually as a percentage of volume.

5. Industrial installation where a substance is separated and cleaned.

6. The temperature at which a liquid boils and turns to vapor.

7. Make or become hard or solid.

8. The temperature at which a solution of a surfactant or glycol starts to form micelles (molecular agglomerates), thus becoming cloudy.

9. Cause the fission of (an atom).

10. The process of splitting a large heavy hydrocarbon molecule into smaller, lighter components. The process involves very high temperature and pressure and can involve a chemical catalyst to improve the process efficiency.

Exercise № 7. Complete the sentences using the words given.

surface temperature the longer paraffin molecules mixture sulfur content slightly waxy crude oils colorless combination undesirable impurity crude oil the higher a fruity odor heavy oils molecules pungent odor cooling temperatures in color light oils the benchmark crude oil size a calorific heat value double bonds

1. Petroleum includes only … .

2. The difference between crude oil and natural gas is the … of the hydrocarbon molecules.

3. Waxes are solid at … .

4. Natural gas is composed of a … of the four short hydrocarbon … .

5. Sulfur is an … in fossil fuels

6. If they contain one or more …, they are unsaturated.

7. A mixed-base crude oil is a … of both types.

8. Crude oils are classified as sweet and sour on the basis of their … .

9. In order of… , the cuts are heavy gas oil, light gas oil, kerosene, naphtha, and straight run gasoline.

10. … are very viscous, dark- colored, contain considerable asphalt, and are less valuable.

11. Fresh from the well, normal crude oil has a … of gasoline.

12. The color of crude oil ranges from … through greenish-yellow, reddish, and brown to black.

13. All crude oils contain some … .

14. Crude oil has … of 18,300 to 19,500 Btu/lb.

15. An aromatic-rich crude oil, however, has … .

16. Asphalt is brown to black … .

17. … are very fluid, often transparent, rich in gasoline, and are the most valuable.

18. In general, … the hydrocarbon molecule, … its boiling temperature.

19. … can have a greenish color.

20. Dubai is … for the Middle East.

Exercise № 8. Put the verbs in brackets in correct form.

1. Petroleum (to include) both crude oil and natural gas.

2. The well then (to have) (to shut) in for a workover (to clean out) the wax.

3. Crude oil and natural gas (to call) hydrocarbons.

4. Four types of hydrocarbon molecules, (to call) the hydrocarbon series, (to occur) in each crude oil.

5. If they (to contain) one or more double bonds, they (to be) unsaturated.

6. Aromatic molecules (to be) six carbon atoms and longer in length.

7. Various components of crude oil (to separate) by their boiling points.

8. There (to be) two types of crude oils at the refinery.

9. When (to refine), it (to yield) a large percentage of paraffin wax.

10. Crude oils (to compare) and (to describe) by density.

11. Refineries also (to produce) pure chemicals, (to call) feedstocks, from crude oil.

12. Fresh water, for example, (to have) an °API of 10.

13. A sample of the oil (to heat) in the laboratory.

14. Gasses (to rise) in the distilling column and any remaining liquid (to fall).

15. Each liquid (to remove) by cooling (to call) a cut.

16. A process (to call) cracking (to use) (to make) gasoline from the other cuts.

17. These feedstocks (to sell) to the petrochemical industries, where the molecules (to reform), and a large variety of products (to make).

18. The lowest temperature at which the oil still (to pour) before it (to solidify) (to call) the pour point.

19. A benchmark crude oil (to be) a standard against which other crude oils (to compare), and prices (to set).

20. The refiner often (to pay) a premium for aromatic crude oil.

Exercise № 9. Translate the sentences into English.

1. Крекинг - современный метод переработки нефти – был изобретен в январе 1861 г.

2. Развитие промышленности потребовало огромное количество смазочных средств, нового более дешевого и более эффективного, чем уголь, топливо.

3. Нефть представляет собой смесь углеводородов, содержащую кислородные, сернистые и азотистые соединения.

4. Содержание в нефти большого количества парафинистых соединений делает ее высоковязкой и мало подвижной.

5. Важнейшим физическим свойством любой жидкости, в том числе и нефти, является вязкость.

6. Легкие нефти наиболее ценные; они, как правило, содержат больше бензиновых и масляных фракций.

7. Плотность - один из основных показателей товарного качества нефти.

8. Вязкость любой жидкости с повышением температуры уменьшается, поэтому при перекачке вязких нефтей и мазутов, особенно в зимнее время, их подогревают.

9. Пермская нефть содержит ароматические углеводороды.

10. Составными началами нефти, помимо небольшой подмеси кислородных, сернистых и других соединений, являются углеводороды.

11. Основным способом для отделения друг от друга, как промышленных продуктов (всевозможных смесей), так и самостоятельных в химическом смысле углеводородов, содержащихся в нефти и ее продуктах, является перегонка.

12. Представляя собой жидкость, более легкую, чем вода, нефть разных мест различна по многим свойствам: цвету, плотности, летучести, температуры кипения.

13. Углеводороды, содержащиеся в нефти, подразделяют на три основные группы: метановые, нафтеновые и ароматические.

14. Из нефти изготовляют другие продукты, например, топливо для реактивных двигателей, пластмассу, керосин, синтетическое волокно и шины.

15. Углеводороды - это класс органических соединений, состоящих из молекул углерода и водорода разной длины и разного строения.

16. Независимо от длины цепи углеводорода, все цепи имеют высокие точки кипения, поэтому их всех можно разделить при помощи процесса дистилляции (перегонки нефти).

17. За счет нагревания цепи начинают размыкаться при их температурах испарения.

18. Вначале, сырую нефть нагревают до определенной температуры, в результате чего она начинает испаряться, а затем конденсируют пар, т.е. превращают пар в жидкость.

19. Затем пар попадает на дно длинной колонны (ректификационная колонна) с тарелками.

20. Вещества с самой низкой точкой кипения начинают конденсироваться на самой высокой точке колонны; а вещества с более высокими точками кипения конденсируются на нижнем уровне колонны.

21. Нефть поступает в ректификационные колонны на атмосферную перегонку (перегонку при атмосферном давлении), где разделяется на несколько фракций: легкую и тяжёлую бензиновые фракции, керосиновую фракцию, дизельную фракцию и остаток атмосферной перегонки — мазут.

22. Плотность нефти, как и других углеводородов, сильно зависит от температуры и давления.

23. Введение сортности необходимо в связи с разностью состава нефти (содержания серы, различного содержания групп алканов, наличия примесей) в зависимости от месторождения.

24. Стандартом для цен служит нефть сортов WTI и Light Sweet (для западного полушария и вообще ориентиром для других сортов нефти), а также Brent (для рынков Европы и стран ОПЕК).

25. Чтобы упростить экспорт были придуманы некие стандартные сорта нефти, связанные либо с основным месторождением, либо с группой месторождений. Для России это тяжёлая Urals и лёгкая нефть Siberian Light. В Великобритании — Brent, в Норвегии — Statfjord, в Ираке — Kirkuk, в США — Light Sweet и WTI. Часто бывает, что страна производит два сорта нефти — лёгкую и тяжёлую. Например в Иране это Iran Light и Iran Heavy.

Exercise № 10. Render the text.

Нефть – это горючая жидкость, представляющая собой сложную смесь из углеводородов. Различные типы нефти существенно различаются по химическим и физическим свойствам: в природе она представлена и в виде черного битумного асфальта, и в форме светлых летучих разновидностей. Вопреки устоявшемуся выражению «черное золото», нефть отличается многообразием цветов – она может быть черной, коричневой, вишневой, зеленой, янтарной, желтой. Ее запах тоже бывает совершенно разным – от приятного и даже душистого до отвратительно сернистого. В состав сырой нефти входит около 1000 компонентов. Среди них преобладают алканы, циклоалканы и разнообразные ароматические углеводороды. Другие органические соединения, присутствующие в нефти, содержат азот, кислород, серу или незначительное количество металлов – железа, никеля, меди и ванадия.

Сырую нефть из скважины практически не используют в чистом виде. Место, где ее преобразуют в необходимые человеку продукты, – нефтеперерабатывающий завод (НПЗ). Именно сюда сырье доставляется по трубопроводам, железной дороге или морскими танкерами, чтобы после переработки получить бензин, авиационный керосин, мазут, дизельное топливо, смазочные масла, парафин и сырье для нефтехимических производств.

Сначала из нее удаляют механические примеси и растворенные газы, очищают от лишней соли и воды на электрообессоливающих установках. На этой же стадии определяют и свойства сырья.

Нефть делят на фракции в зависимости от температуры кипения и плотности. В лаборатории проводят «тренировочную» перегонку, чтобы узнать, какое количество бензина, керосина, смазочных масел, парафина и мазута можно получить из поступившей на завод нефти. (Нефти сильно различаются по химическому составу, поэтому из одних можно получить больше смазочных масел и парафинов, из других – больше бензина.) И только после этого приступают к промышленной перегонке.

Этот интересный процесс происходит в ректификационной колонне – специальном аппарате для разделения нефти на фракции.

Нефть, нагретую в змеевике до 320-390oC, подают в колонну в виде смеси горячей жидкости и пара. Там пары тяжелых, а потом легких фракций последовательно конденсируются и оседают на специальных тарелках – их может быть от 30 до 60. В результате получают прямогонный бензин (температура кипения 30-160oC), нафту, которую еще называют лигроином (105-160oC), керосин (160 - 230oC), газойль (230-400oC) и мазут, остающийся после отделения остальных фракций.

Do you know that?

The first clear evidence of distillation comes from Greek alchemists working in Alexandria in the first century AD. Distilled water has been known since at least ca. 200 AD, when Alexander of Aphrodisias described the process. Arabs learned the process from the Egyptians and used it extensively in their chemical experiments.

Clear evidence of the distillation of alcohol comes from the School of Salerno in the 12th century. Fractional distillation was developed by Tadeo Alderotti in the 13th century.

In 1500, German alchemist Hieronymus Braunschweig published Liber de arte destillandi (The Book of the Art of Distillation) the first book solely dedicated to the subject of distillation, followed in 1512 by a much expanded version. In 1651, John French published The Art of Distillation the first major English compendium of prac-

tice, though it has been claimed that much of it derives from Braunschweig's work. This includes diagrams with people in them showing the industrial rather than bench scale of the operation.

As alchemy evolved into the science of chemistry, vessels called retorts became used for distillations. Both alembics and retorts are forms of glassware with long necks pointing to the side at a downward angle which acted as air-cooled condensers to condense the distillate and let it drip downward for collection. Later, copper alembics were invented. Riveted joints were often kept tight by using various mixtures, for instance a dough made of rye flour. These alembics often featured a cooling system around the beak, using cold water for instance, which made the condensation of alcohol more efficient. These were called pot stills. Today, the retorts and pot stills have been largely supplanted by more efficient distillation methods in most industrial processes. However, the pot still is still widely used for the elaboration of some fine alcohols such as cognac, Scotch whisky, tequila and some vodkas. Pot stills made of various materials (wood, clay, stainless steel) are also used by bootleggers in various countries. Small pot stills are also sold for the domestic production of flower water or essential oils.

Early forms of distillation were batch processes using one vaporization and one condensation. Purity was improved by further distillation of the condensate. Greater volumes were processed by simply repeating the distillation. Chemists were reported to carry out as many as 500 to 600 distillations in order to obtain a pure compound.

In the early 19th century the basics of modern techniques including pre-heating and reflux were developed, particularly by the French, then in 1830 a British Patent was issued to Aeneas Coffey for a whiskey distillation column, which worked continuously and may be regarded as the archetype of modern petrochemical units. In 1877, Ernest Solvay was granted a U.S. Patent for a tray column for ammonia distillation and the same and subsequent years saw developments of this theme for oil and spirits.

With the emergence of chemical engineering as a discipline at the end of the 19th century, scientific rather than empirical methods could be applied. The developing petroleum industry in the early 20th century provided the impetus for the development of accurate design methods such as the McCabe-Thiele method and the Fenske equation. The availability of powerful computers has also allowed direct computer simulation of distillation columns.

Unit 3: Nature of gas.

Mind the definitions.

Associated natural gas	попутный природный газ	Natural gas can be found in oil deposits, as associated natural gas.
British thermal unit	Британская тепловая единица	The term "Btu" is used to describe the heat value (energy content) of fuels.
Carbon di-oxide	углекислота, углекислый газ	Carbon dioxide is a greenhouse gas.
Contain	содержать в себе, включать, иметь в своём составе	It sometimes contains significant amounts of ethane, propane, butane, and pentane.
Depleted oil field	истощённая залежь нефти	Can new reserves be discovered fast enough to replace depleted oil fields?
Dissolved	растворенный	This gas can exist separate from the crude oil in the underground formation, or dissolved in the crude oil.
Drip gaso-line	бензин, получаемый из конденсатной ловушки промы-слового трубопро-вода	Drip gas has industrial uses as a cleaner and solvent.
Dry gas	сухой природный газ (свободный от жидких УВ)	Dry gas typically has a gas-to-oil ratio ex-ceeding 100,000 scf/STB.
Expand	расширяться; уве-личиваться в объё-ме	The gas cap expands with the depletion of the reservoir, pushing down on the liquid sec-tions applying extra pressure.
Gas/oil ra-tio	газонефтяной фак-тор	Gas-Oil Ratios (GOR's) may vary substan-tially among petroleum accumulations in a basin due to a variety of factors.
Heat	нагревать	Heat reduces surface tension and viscosity of the oil.
Inert	инертный (обла-дающий низкой хи-мической активно-стью) газ;	The inert gases are obtained by fractional dis-tillation of air.
Liquefied petroleum gas	сжиженный нефтя-ной газ	LPG is synthesised by refining petroleum or "wet" natural gas.

Methane	метан	Like other hydrocarbons, methane is a very weak acid.
Natural gas liquids	газоконденсат, газовый бензин	Natural gas liquids can be classified according to their vapor pressures.
Percentage	процентное отношение; процентное содержание	The relative percentage of different types of hydrocarbon molecules varies from oil to oil, determining the properties of each oil.
Retrograde gas	Ретроградный газ	The Arun field is one of the world's giant retrograde gas reservoirs.
Pipeline	трубопровод	There is some argument as to when the first crude oil pipeline was built.
Pressure	Давление	The natural pressure in many reservoirs, however, eventually dissipates.
Solution	Раствор	The gas comes out of solution to form a gas cap at the top.
Vapor	Пар, испаряться	The condensate continues to be heated by the rising hot vapors.
Volatile	летучий; легкоиспаряющийся	A mixture of 96% ethanol and 4% water boils at 78.2 °C, being more volatile than pure ethanol.
Wet gas	жирный газ, газ с большим содержанием паров бензина	Wet gas is a particularly important concept in the field of flow measurement.

Composition

Natural gas is composed of hydrocarbon molecules that range from one to four carbon atoms in length. The gas with one carbon atom in the molecule is methane (CH_4), two is **ethane** (C_2H_4), three is **propane** (C_3H_8), and four is **butane** (C_4H_{10}). All are paraffin-type hydrocarbon molecules. A typical natural gas composition is shown in Table 1—5.

Ethane – этан

Propane – пропан

Butane – бутан

Pure – чистый, беспримесный

Distill – очищать

Table 1–5

Typical natural gas hydrocarbon composition [4]

methane	70 to 98%
ethane	1 to 10%
propane	trace to 5%
butane	trace to 2%

These percentages vary from field to field, but methane gas is by far the most common hydrocarbon. Many natural gas fields contain almost **pure** methane. The gas from pipelines that is burned in homes and industry is methane gas. Propane and butane burn giving off more heat than methane. They are often **distilled** from natural gas and sold separately. Liquefied petroleum gas *(*LPG) is made from propane gas.

The nonhydrocarbon, gaseous impurities that don't burn in natural gas are called inerts. A common inert is water vapor (steam). Another inert is carbon dioxide (CO_2), a colorless, odorless gas. Because it doesn't burn, the more carbon dioxide natural gas contains, the less valuable the gas is. In some gas reservoirs, carbon dioxide is greater than 99% of the gas. Large fields of almost pure carbon dioxide probably formed by the chemical reaction of **volcanic** heat on limestone rock. Carbon dioxide can be used for inert gas injection, an enhanced oil recovery process, in depleted oil fields. Nitrogen (N), another inert, is also a colorless, odorless gas that can be used for inert gas injection. **Helium** is a light gas used in electronic manufacturing and filling dirigibles. Gas from the Hugoton gas field in western Texas, Oklahoma, and Kansas contains 0.5 to 2% helium. It is thought to have been formed by the radioactive **decay** of K^{40} in granite. Amarillo, Texas, near the **giant** gas field, is called the "helium capital of the world."

Hydrogen sulfide (H2S) is a gas that can occur mixed with natural gas or by itself. It is not an inert and is a very **poisonous** gas that is **lethal** in very low concentrations. The gas has the **foul** odor of rotten eggs and can be smelled in extremely small amounts. It is associated with the salt domes of the Gulf of Mexico and **ancient** limestone reefs of Mexico, West Texas, and Lou-

Volcanic – вулканический

Helium – гелий

Decay – разлагаться

Giant – огромный

Hydrogen sulfide – сероводород

Poisonous – ядовитый

Lethal – смертельный; летальный

Foul – вонючий, омерзительный, отталкивающий

Ancient – древний

Overthrust belt – надвиговая зона

isiana. Hydrogen sulfide is common in Alberta, the **overthrust belt** of Wyoming, offshore Southern California, Utah, and the Middle East. Hydrogen sulfide gas is very corrosive. When it occurs mixed with natural gas, it causes corrosion of the metal tubing, fittings, and valves in the well. Hydrogen sulfide must be removed before the natural gas can be delivered to a pipeline. Sweet natural gas has no detectable hydrogen sulfide, whereas sour natural gas has detectable amounts of hydrogen sulfide.

Answer the questions:

1.What gases do you know? 2. What is the most common gas and why? 3. What are inerts? 4. Give examples. 5. How can inerts be used? 6. What do you know about hydrogen sulfide?

Occurrence

Because of high pressure in the subsurface reservoir, a considerable volume of natural gas occurs dissolved in crude oil. The formation, dissolved or solution gas/oil ratio is the cubic feet of natural gas dissolved in one barrel of oil in that reservoir under subsurface conditions. The volume **measurements** are reported under surface conditions. In general, as the pressure of the reservoir increases with depth, the amount of natural gas that can be dissolved in crude oil increases.

Measurement – снятие мерок, измерение

Relieve – ослаблять, уменьшать

Solution gas – природный газ, растворённый в нефти коллектора

Bubble – пузыриться; подниматься пузырьками

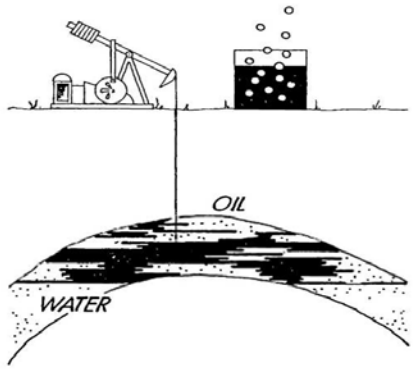


Fig. 1–6 Solution gas

When crude oil is lifted up a well to the surface (Fig. 1—6), the pressure is **relieved**, and the natural gas, called **solution gas**, **bubbles** out of the oil. The producing gas-oil ratio of a well is the number of cubic feet of

gas the well produces per barrel of oil.

Nonassociated natural gas is gas that is not in contact with oil in the subsurface. A nonassociated gas well produces almost pure methane. Associated natural gas occurs in contact with crude oil in the subsurface. It occurs both as gas in the free gas cap above the oil and gas dissolved in the crude oil. Associated gas contains other hydrocarbons besides methane.

Answer the questions:

1.Why and when does gas occur dissolved in crude oil? 2. What is nonassociated natural gas? 3. When does associated natural gas occur?

Condensate

In some subsurface gas reservoirs, at high temperatures, shorter-chain liquid hydrocarbons, primarily those with five to seven carbon atoms in length, occur as a gas. When this gas is produced, the temperature decreases, and the liquid hydrocarbons **condense** out of the gas. This liquid, called condensate*,* is almost pure gasoline, is clear to yellowish to bluish in color and has 45 °API to 62 °API. Condensate is commonly called **casinghead gasoline**, drip gasoline, white gas, or natural gasoline. Condensate can be added to crude oil in the field to decrease the °API and increase the volume of the oil. Condensate removed from natural gas in the field is classified as crude oil by **regulatory agencies**.

Refiners pay almost as much for condensate as crude oil. It doesn't have a high octane and must be mixed with high-octane gasoline made by cracking in the refinery. Because of the low octane, the posted price for condensate is usually slightly less than that for crude oil. Natural gas that contains condensate is called wet gas, whereas natural gas lacking the condensate is called dry gas. The condensate along with butane, propane, and ethane that can be removed from natural gas is called natural gas liquids *(*NGL*)*.

Condense – конденсировать

Casinghead gasoline – газовый бензин (получаемый в промысловом сепараторе или абсорбционной установке из нефтяного газа)

Regulatory agencies – органы государственного регулирования

Answer the questions:

1.What hydrocarbons do occur as a gas? 2. When do the liquid hydrocarbons condense out of the gas? 3. What is condensate? 4. What are the main characteristics of condensate? 5. Why do refiners pay almost as much for condensate as crude oil? 6. What does the gas name (dry or wet) depend on?

Measurement

The English **unit** of volume measurement for natural gas is a cubic foot (cf). Because gas expands and **contracts** with pressure and temperature changes, the measurement is made under or is **converted** to standard conditions defined by law. It is usually 60°F and 14.65 psi (15°C and 101.325 kPa) and is called standard cubic feet (scf). The abbreviation for 1000 cubic feet is Mcf, a million cubic feet is MMcf, a billion cubic feet is Bcf and a trillion cubic feet is Tcf Condensate content is measured in barrels per million cubic feet of gas (BCPMM).

The unit used to measure heat **content** of fuel in the English system is the British thermal unit (Btu). One Btu is about the amount of heat given off by burning one wooden **match**. Pipeline natural gas ranges from 900 to 1200 Btus per cubic foot and is commonly 1000 Btu. The heat content varies with the hydrocarbon composition and the amount of inerts in the natural gas. Natural gas is sold to a pipeline by volume in thousands of cubic feet, by the amount of heat when burned in Btus or by a combination of both. If the pipeline contract has a Btu adjustment clause, the gas is bought at a certain price per Mcf, and the price is then **adjusted** for the Btu content of the gas.

In the metric system, the volume of gas is measured in cubic meters (m^3). A cubic meter is equal to 35.315 cf. Heat is measured in kilojoules. A kilojoule is equal to about 1 Btu.

The Btus in one average barrel of crude oil are equivalent to the Btus in 6040 cubic feet of average natural gas and is called barrel of oil equivalent (BOE). Different companies often have a slightly different BOE numbers depending on the oil and gas composition of their production.

Unit – единица

Contract – уплотняться, сжиматься

Convert – преобразовывать; превращать

Content – доля, процент, содержание (чего-л. в чём-л.)

Match – спичка

Adjust – регулировать, корректировать

Answer the questions:

1.What is the traditional unit of measurement for gas? 2. Under which conditions

is measurement made? 3. What does the heat content depend on? 4. Why do different companies have different BOE numbers?

Hydrocarbon reservoir

Chemists **classify** reservoir hydrocarbons into 1) black oil, 2) volatile oil, 3) retrograde gas, 4) wet gas, and 5) dry gas. Laboratory analysis of a **sample** is used to determine type.

Both black and volatile oils are liquid in the subsurface reservoir. Black oil or **low-shrinkage oil** has a relatively high percentage of long, heavy, nonvolatile molecules. It is usually black but can have a greenish or brownish color. Black oil has an initial producing gas-oil ratio of 2000 scf/bbl or less. The °API is below 45.

Volatile oil or **high-shrinkage oil** has relatively more intermediate size molecules and less longer size molecules than black oil. The color is brown, orange, or green. Volatile oil has an initial producing gas-oil ratio between 2000 and 3300 scf/bbl. The °API is 40 or above.

Retrograde gas is a gas in the reservoir under original pressure but liquid condensate forms in the subsurface reservoir as the pressure decreases with production. The initial gas-oil ratio is 3300 scf/bbl or higher.

Wet gas occurs entirely as a gas in the reservoir, even during production, but produces a liquid condensate on the surface. It often has an initial producing gas-oil ratio of 50,000 scf/bbl or higher.

Dry gas is pure methane. It does not produce condensate either in the reservoir or on the surface.

Classify – классифицировать

Sample – образец, экземпляр

Low-shrinkage oil – нефть с низкой усадкой

High-shrinkage oil – нефть с высокой усадкой

Answer the questions:

1.What is the classification of reservoir hydrocarbons? 2. How can type be determined? 3. What are main characteristics of these types?

Exercise № 1. Match English words with their Russian equivalents.

LPG	химическая реакция
inert	истощённая залежь нефти
chemical reaction	вызывать коррозию
depleted oil field	встречаться растворенным

gas injection	сжиженный нефтяной газ
to cause corrosion	газонефтяной фактор
occur dissolved	инертный газ
gas/oil ratio	соприкасаться
to be in contact with	конденсат попутного газа
casinghead gasoline	закачка газа

Exercise № 2. Make up word combinations and translate them.

gas	gasoline
pure	amount
water	composition
radioactive	gas
hydrogen	methane
detectable	decay
surface	hydrocarbons
solution	conditions
liquid	vapor
drip	sulfide

Exercise № 3. Match English words with their Russian equivalents.

regulatory agencies	сжиженный природный газ
wet gas	британская тепловая единица
LNG	оговорка об урегулировании
unit of volume measurement	ретроградный газ
BTU	органы государственного регулирования
adjustment clause	немного меньше
retrograde gas	бензин без примеси
slightly less	жирный газ
pure gasoline	попутный газ
associated gas	единица измерения объема

Exercise № 4. Make up word combinations and translate them.

white	barrel
posted	oil
dry	condensate
temperature	gasoline
heat	type
wooden	gas
average	match
to determine	price
liquid	content

high-shrinkage changes

Exercise № 5. Match the words and definitions.

hydrocarbon LPG pure injection decay fittings condensate gas LNG volatile oil retrograde gas crude oil solution gas distill vapor

1. Components of natural gas that are liquid at surface in field facilities or in gas-processing plants.
2. A naturally occurring organic compound comprising hydrogen and carbon.
3. Free of any contamination.
4. A gaseous substance that is below its critical temperature, and can therefore be liquefied by pressure alone.
5. Rot or decompose through the action of bacteria.
6. Part on or attached to a piece of furniture or equipment.
7. Hydrocarbon liquid dissolved in saturated natural gas that comes out of solution when the pressure drops below the dewpoint.
8. Pumping of gas or other substance into the well.
9. Oil in its natural state before it has been processed or refined.
10. Purify (a liquid) by vaporizing it, then condensing it by cooling the vapor, and collecting the resulting liquid.
11. Dissolved gas in wellbore or reservoir fluids.
12. A natural oil typically obtained by distillation and having the characteristic odour of the plant or other source from which it is extracted.
13. Is called so since it is gas initially, then some liquid forms in reservoir and latter some part of this liquid transfer to gas phase again.
14. It is mainly composed of propane and butane, which has been liquefied at low temperatures and moderate pressures.

Exercise № 6. Complete the definitions given.

1. A long pipe, typically underground, for conveying oil, gas, etc., over long distances.
2. The chemical element of atomic number 2, an inert gas that is the lightest member of the noble gas series.
3. Causing or capable of causing death or illness if taken into the body.
4. A ridge of jagged rock, coral, or sand just above or below the surface of the sea.
5. Contain bubbles of air or gas rising to the surface.
6. Gas that comes from crude oil wells.
7. Any gas with a small amount of liquid present.
8. Gas that has had condensable hydrocarbons removed.
9. A traditional unit of energy equal to about 1055 joules.

10. The ratio of the volume of gas that comes out of solution, to the volume of oil at standard conditions.

11. A subsurface body of rock having sufficient porosity and permeability to store and transmit fluids.

12. A production facility composed of a group of chemical engineering unit processes and unit operations converting raw material into products of value.

13. The nature of something's ingredients or constituents; the way in which a whole or mixture is made up.

14. A gas which does not undergo chemical reactions under a set of given conditions.

Exercise № 7. Fill the gaps using the words given:

gas cap poisonous lacking inert crude oil into causes corrosion lethal dissolved varies more heat kilojoules sample condensate with either classify volume measurement or condense out

1. Propane and butane burn giving off … than methane.
2. A common … is water vapor.
3. It is not an inert and is a very … gas that is … in very low concentrations.
4. When it occurs mixed with natural gas, it … of the metal tubing, fittings, and valves in the well.
5. It occurs both as gas in the free … above the oil and gas … in the crude oil.
6. When this gas is produced, the temperature decreases, and the liquid hydrocarbons … of the gas.
7. Condensate removed from natural gas in the field is classified as … by regulatory agencies.
8. Natural gas … the condensate is called dry gas.
9. The English unit of … for natural gas is a cubic foot.
10. Heat is measured in … .
11. Laboratory analysis of a … is used to determine type.
12. It does not produce condensate … in the reservoir … on the surface.
13. Chemists … reservoir hydrocarbons … different types.
14. The heat content … … the hydrocarbon composition and the amount of inerts in the natural gas.
15. Refiners pay almost as much for … as crude oil.

Exercise № 8. Insert modal verbs can, may, must.

1. These sources … eventually more than triple the potential reserves of hydrocarbon fuels.
2. Even if only water flowed out of the surrounding rock into the well, the sides of the well … cave in and the well … be lost.

3. It is usually black but … have a greenish or brownish color.

4. Three geological conditions … have been met.

5. Some oil … simply be collected from seepage or tar ponds.

6. These wells were shallow by modern standards, often less than 50 meters, but … give quite large production.

7. In areas where oil is found in shallow reservoirs, seeps of crude oil or gas … naturally develop.

8. There … be a source rock in the subsurface of that area that generated the gas or oil at some time in the geological past.

9. Second, there … be a separate, subsurface reservoir rock to hold the gas or oil.

10. The rising gas and oil … intersect a layer of reservoir rock.

11. Oil companies realized that by mapping how the sedimentary rock layers crop out on the surface of the ground, the rock layers … be projected into the subsurface, and traps … be located.

12. The rig is mounted on a barge, floating platform, or ship that … be moved.

13. Two common sedimentary rocks that … be seals are shale and salt.

14. The ease in which the fluid … flow through the rock is called permeability.

15. Because of migration, the gas and oil … end up a considerable distance.

16. Third, there … be a trap on the reservoir rock to concentrate the gas or oil into commercial quantities.

17. The fluid … flow from pore to pore to pore up the angle of the rock layer toward the surface.

18. As the gas and oil migrates up along the reservoir rock, it … encounter a trap.

19. If gas and oil flowed up onto the floor of the drilling rig, it … catch fire.

20. Condensate … be added to crude oil in the field in a process called spiking to decrease the °API and increase the volume of the oil.

21. Cement … be poured down the well to seal the depleted reservoir and to protect any subsurface fresh water reservoirs.

22. Production from wells … be increased by acid and frac jobs.

23. The well … be drilled either almost straight down as a straight hole or out at an angle as a deviated well.

24. To complete the trap, a caprock … overlie the reservoir rock.

25. There … be thousands of feet of drillpipe with a bit on the end, called the drillstring, suspended in the well.

26. A subsurface deposit of gas or oil … be drilled without any indication of the gas or oil.

27. Depending on the test results, the well … be plugged and abandoned as a dry hole or completed as a producer.

28. Production from the well … be interrupted for repairs or remedial work during a workover.

29. Enhanced oil recovery … be attempted to produce some of the remaining oil.

30. The refiner … remove the sulfur as the crude oil is being processed.

31. As it is being brought up the well, it cools, and the waxes … solidify.
32. This … clog the tubing in the well and flow- lines on the surface.
33. Slightly waxy crude oils … have a greenish color.
34. It doesn't have a high octane and … be mixed with high-octane gasoline made by cracking in the refinery.

Exercise № 9. Translate sentences into English.

1. Уменьшение объема нефти при ее дегазировании в промысловой практике называется "усадкой" нефти.
2. Природный газ в пластовых условиях (условиях залегания в земных недрах) находится в газообразном состоянии — в виде отдельных скоплений (газовые залежи) или в виде газовой шапки нефтегазовых месторождений, либо в растворённом состоянии в нефти или воде.
3. Для облегчения транспортировки и хранения природного газа его сжижают, охлаждая при повышенном давлении.
4. Считается, что природный газ образуется в осадочной оболочке при бóльших температурах и давлениях, чем нефть.
5. В недрах газ находится в микроскопических пустотах (порах).
6. Сероводород вызывает сильную коррозию газового оборудования.
7. Природный газ широко применяется в качестве горючего в жилых, частных и многоквартирных домах для отопления, подогрева воды и приготовления пищи, как топливо для машин.
8. СПГ представляет собой бесцветную жидкость без запаха, плотность которой в два раза меньше плотности воды.
9. Газы, добываемые из чисто газовых месторождений, представляют собой сухой газ без тяжелых углеводородов.
10. Природные и попутные газы, состоящие в основном из метана, представляют собой не только высококалорийное топливо, но ценное сырье для химической промышленности.
11. На выходе из скважины давление падает, и попутный газ отделяется от нефти.
12. Газовый конденсат – природная смесь легкокипящих нефтяных углеводородов, находящихся в недрах в газообразном состоянии, а при охлаждении и снижении давления до атмосферного (в условиях дневной поверхности) распадающаяся на жидкую (конденсат) и газовую составляющие.
13. Сухой природный газ свободен от жидких углеводородов (алканов) и содержит более легкие метан и этан.
14. Влажный газ (с высоким содержанием алканов), жирный газ, газ с большим содержанием паров бензина.
15. Ещё одно использование британской тепловой единицы — котировки цен на топливо (как правило, на англо-американских рынках.

16. Газ, состоящий преимущественно из метана и этана и содержащий мало пропана и бутана, называют сухим или бедным.

17. Газ, в котором кроме метана и этана имеются пропан, бутан, пентан и др., называют жирным или богатым.

18. Сероводоро́д (серни́стый водоро́д, сульфид водорода) — бесцветный газ с запахом тухлых яиц и сладковатым вкусом. Химическая формула — H2S. Плохо растворим в воде, хорошо — в этаноле. Ядовит.

19. В отдельных газовых месторождениях наблюдается повышенное содержание углекислого газа, сероводорода и азота.

20. Как источник энергии природный газ является одним из главных на Земле, уступая лишь нефти.

Exercise № 10. Render the text.

Приро́дный газ — смесь газов, образовавшаяся в недрах земли при анаэробном разложении органических веществ.

Природный газ относится к полезным ископаемым. Часто является попутным газом при добыче нефти. Природный газ в пластовых условиях (условиях залегания в земных недрах) находится в газовом состоянии в виде отдельных скоплений (газовые залежи) или в виде газовой шапки нефтегазовых месторождений — это свободный газ, либо в растворенном состоянии в нефти или воде (в пластовых условиях), а в стандартных условиях (0,101325 МПа и 20 °C) — только в газовом состоянии.

Основную часть природного газа составляет метан — до 98 %. также могут входить более тяжёлые углеводороды: этан, пропан, бутан, водород, сероводород, диоксид углерода, азот, гелий.

Природный газ не имеет цвета и запаха. Чтобы можно было определить утечку по запаху, в газ добавляют небольшое количество меркаптанов, имеющих сильный неприятный запах.

Огромные залежи природного газа сосредоточены в осадочной оболочке земной коры. Согласно теории биогенного происхождения нефти они образуются в результате разложения останков живых организмов. Считается, что природный газ образуется при больших температурах и давлениях чем нефть. С этим согласуется тот факт, что месторождения газа часто расположены глубже, чем месторождения нефти.

Природный газ находится в земле на глубине от 1000 метров до нескольких километров. Сверхглубокой скважиной недалеко от города Новый Уренгой получен приток газа с глубины более 6000 метров. В недрах газ находится в микроскопических пустотах, называемых порами. Поры соединены между собой микроскопическими каналами — трещинами, по этим каналам газ поступает из пор с высоким давлением в поры с более низким давлением до тех пор, пока не окажется в скважине. Движение газа в пласте подчиняется определённым законам. Газ добывают из недр земли с помощью скважин. Скважины стараются

разместить равномерно по всей территории месторождения. Это делается для равномерного падения пластового давления в залежи. Иначе возможны перетоки газа между областями месторождения, а так же преждевременное обводнение залежи.

Газ выходит из недр вследствие того, что в пласте находится под давлением, многократно превышающем атмосферное. Таким образом, движущей силой является разность давлений в пласте и системе сбора.

Газ, поступающий из скважин, необходимо подготовить к транспортировке конечному пользователю — химический завод, котельная, городские газовые сети. Необходимость подготовки газа вызвана присутствием в нём примесей, вызывающих затруднения при транспортировке либо применении. Так, пары воды, содержащейся в газе, при определенных условиях могут образовывать гидраты или, конденсируясь, скапливаться в различных местах (изгиб трубопровода, например), мешая продвижению газа; сероводород вызывает сильную коррозию газового оборудования (трубы, ёмкости теплообменников и т. д.).

Если газ содержит в большом количестве гелий либо сероводород, то газ обрабатывают на газоперерабатывающем заводе, где выделяют гелий и серу. Эта схема реализована, например, на Астраханском месторождении.

В настоящее время основным видом транспорта является трубопроводный. Газ под давлением 75 атмосфер движется по трубам диаметром до 1,4 метра. По мере продвижения газа по трубопроводу он теряет энергию, преодолевая силы трения как между газом и стенкой трубы, так и между слоями газа. Поэтому через определенные промежутки необходимо сооружать компрессорные станции (КС), на которых газ дожимается до 75 атм. Сооружение и обслуживание трубопровода весьма дорогостояще, но, тем не менее — это наиболее дешёвый способ транспортировки газа и нефти.

Природный газ широко используется в химической промышленности как исходное сырьё. Также используется в качестве горючего, для отопления жилых домов, топливо для машин, электростанций и др.

Do you know that?

Before there was an understanding of what natural gas was, it posed somewhat of a mystery to man. The first known observations of natural gas seeps were made in Iran prior to 2000 BCE. Early writers described the natural petroleum seeps in the Middle East, especially in the Baku region of what is now Azerbaijan, and Iran. The gas seeps, probably first ignited by lightning, provided the fuel for the “eternal fires” of the fire-worshiping religion of the ancient Persians. Plutarch's writings of about 100 to 125 CE describe such "eternal fires" in the area of present day Iraq. One of the most famous of these types of flames was found in ancient Greece, on Mount Parnassus approximately 1,000 BCE. A goat herdsman came across what looked like a 'burning spring', a flame rising from a fissure in the rock. The Greeks,

believing it to be of divine origin, built a temple on the flame. This temple housed a priestess who was known as the Oracle of Delphi, giving out prophecies she claimed were inspired by the flame.

These types of springs became prominent in the religions of India, Greece, and Persia. Unable to explain where these fires came from, they were often regarded as divine, or supernatural. It wasn't until about 500 BCE that the Chinese discovered the potential to use these fires to their advantage. There is evidence that the Chinese used natural gas in certain regions as early as the fourth century BCE. Pockets of flammable gas were first discovered trapped under the Earth in areas used by the Chinese to extract brine. The Chinese quickly discovered the flammable nature of these pockets, and came to use them as convenient ways to both heat the brine they were extracting and to prepare food. Methane lamps could also be made, simply by filling a leather bladder with gas from a well, sliting a small hole in the bag and lighting escaping gas. Documents from the period maintain that a lamp prepared in this way would remain useful for an entire day.

In about the second century CE, the Chinese began systematically searching for natural gas rather than simply finding it in the process of searching for other resources. Perhaps at about this time as well, they began routing gas from deposits to other areas, sometimes as much as a day’s travel away. To do this, they tapped deposits of gas and routed it through pipes made of bamboo, sometimes crossing under and over roads to reach their destinations. As this became more common, the Chinese discovered that certain deposits of gas were unsafe to use because they were not mixed with air. These unsafe pockets of gas were put through a very complicated refining process utilizing the world’s first carburetor. After being mixed with air in this ingenious way, the gas could be used quite safely.

In America it was known to the natives who observed it issuing from the ground in various spots, chiefly along the western side of the Appalacian Highlands. It was used for illuminating purposes in Fredonia, N.Y., as early as 1821.

Unit 4: The Earth crust – where we find it.

Mind the definitions

Aggregate	агрегат (скопление, срастание минералов, составляющих горную породу)	A rock is an aggregate of minerals and/or mineraloids and does not have a specific chemical composition.
Basement rock	подстилающая порода	The term basement rock is used to define the rocks below a sedimentary platform or cover.
Brine	солёная вода; минерализованная вода	Brine is commonly produced during well completion operations, particularly after the hydraulic fracturing of a well.
Calcite	кальцит, карбонат кальция, известковый шпат	Limestone is a sedimentary rock composed almost entirely of the mineral calcite.
Clastic sediments	обломочные отложения	Clastic sediments are composed of fragments, or clasts, of pre-existing rock.
Clean sand	чистый песок	A “clean” sand consists of about 90 percent quartz.
Connate water	реликтовая вода; связанная вода	Connate water can be dense and saline compared with seawater.
Crystalline sediments	кристаллические осадочные породы	Chemical or crystalline sediments form from mineral solutions.
Dirty sand	заиленный песок	A “dirty” sand has more than 10 percent other material and/or silt mixed in.
Explore	вести разведку	The company explored for oil.
Fine-grained	мелкозернистый	Basalt is a dark-colored, fine-grained, igneous rock composed mainly of plagioclase and pyroxene minerals.
Ground water	мелкозернистый	Typically, groundwater is thought of as liquid water flowing through shallow aquifers.
Igneous	вулканического происхождения	In general, rocks are of three types, namely igneous, sedimentary, and metamorphic.
Interpret	объяснять, толковать	The evidence is difficult to interpret.
Intrusion	внедрение, интрузия	They are also formed when rock is heated up by the intrusion of hot molten rock called magma from the Earth's interior.
Insulator	диэлектрик;	It is not easy to choose the best insulator

	изолятор; непроводник	among the variety of those that are available at the market these days.
Lithology	литология	Lithology focuses on macroscopic hand-sample or outcrop-scale description of rocks.
Loose sediments	рыхлые отложения	The process of turning loose sediment into hard is called lithification.
Metamor-phic	метаморфический, метаморфный	Metamorphic rocks arise from the transfor-mation of existing rock types, in a process called metamorphism, which means "change in form".
Mineral	минерал	Minerals range in composition from pure elements and simple salts to very complex silicates with thousands of known forms.
Overlie	перекрывать (залегать выше)	Soft clays overlie the basalt.
Plutonic	вулканические породы	A pluton in geology is a body of intrusive igneous rock (called a plutonic rock) that crystallized from magma slowly cooling be-low the surface of the Earth.
Rock	порода	The scientific study of rocks is called pe-trology, and petrology is an essential com-ponent of geology.
Seashell	морская ракушка	Seashells have been admired, studied and used by humans for many different purposes throughout history and pre-history.
Stratifica-tion	напластование, наслоение	The upper units of stratification are younger and the lower are older.
Underlay	подстилать	The green fields are underlaid with lime-stone.
Volcanic	вулканический	Volcanic rocks are among the most common rock types on Earth's surface, particularly in the oceans.
Water table	уровень грунтовых вод	In permeable or porous materials, such as sands and well fractured bedrock, the water table forms a relatively horizontal plane.

Rocks and Minerals

The earth is composed of rocks, which are aggregates of small grains or crystals called minerals (Fig. 2-1). Minerals are naturally occurring, relatively pure chemical compounds. Examples of minerals are quartz (SiC_2) and calcite ($CaCO_3$). Rocks can be composed of numerous grains or several different minerals. The rock **granite**, for example, is composed of the minerals quartz, **feldspar**, **hornblende**, and **biotite**. Rocks can also be composed of numerous grains of the same mineral. The rock limestone consists only of calcite mineral grains.

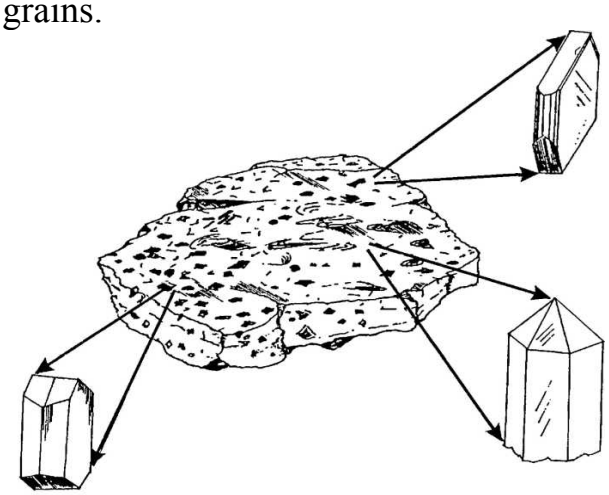


Fig. 2–1 Mineral grains in a rock

Granite – гранит

Feldspar – полевой шпат

Hornblende – роговая обманка, роговик

Biotite – биотит (чёрная слюда)

Molten – расплавленный

Beach – морской берег, взморье; отмель

Dune –дюна

Rocks have been formed throughout the billions of years of earth's history. The same chemical and physical process that form rocks today formed rocks throughout geological time. The **molten** lava flowing out a volcano in Hawaii or Italy today is forming lava rock similar to lava rock formed millions and billions of years ago. Ancient sandstone rock composed of sand grains was formed the same way sand is deposited today: along **beaches**, in river channels, and on desert **dunes**. There is nothing unusual about ancient rocks. They formed the same way rocks are forming today.

Answer the questions:
1.What can rocks be composed of? 2. How are rocks formed?

Type of rocks

Three types of rocks make up the earth's crust: igne-

Crystallize – вы-

ous, sedimentary, and metamorphic. Igneous rocks have **crystallized** from a hot, molten liquid. Sedimentary rocks are composed of sediments that were deposited on the surface of the ground or bottom of the ocean or salts that **precipitated** out of water. Metamorphic rocks have been recrystallized from other rocks under high temperatures and pressures.

звать процесс кристалли
зации, кристаллизовать

Answer the questions:
1.What are types of rocks? 2. How are they formed?

Igneous rocks

Igneous rocks are formed when a molten **melt** is cooled. Two types of igneous rocks are plutonic and volcanic, depending on where they formed.

Plutonic igneous rocks crystallized and solidified while still below the surface of the earth. Because the rocks that **surround** the cooling plutonic rocks are good insulators, plutonic rocks often take thousands of years to solidify. When a cooling melt is given a long time to crystallize, large mineral crystals are formed. Plutonic igneous rocks are easy to **identify** because the mineral crystals are all large enough to be seen by the naked eye. Plutonic rocks formed as hot liquids that were injected into and **displaced preexisting** rocks in the subsurface. Because of this, plutonic rock bodies are called intrusions.

Volcanic igneous rocks crystallize on the surface of the earth as lava. As the lava flows out of a volcano, it immediately comes in contact with air or water and rapidly solidifies. The rapid crystallization forms very small crystals that are difficult to **distinguish** with the naked eye.

Melt – таять, расплавлять

Surround – окружать; обступать

Identify – опознавать, распознавать;

Displace – вытеснять, заменять, замещать

Preexisting – существующие ранее

Distinguish – находить отличия; различать, распознавать

Answer the questions:
1.What are types of igneous rocks? 2. How are plutonic igneous rocks formed? 3. How are volcanic igneous rocks formed?

Sedimentary rocks

Sedimentary rocks are composed of sediments of which there are three types. Clastic sediments are whole

Particle – частица; крупица

particles that were formed by the breakdown of rocks and were transported and deposited as whole particles. **Boulders**, sand grains, and mud particles are examples. Organic sediments are formed biologically such as seashells. Crystalline sediments are formed by the precipitation of salt out of water. As sediments are buried in the subsurface, they become solid, sedimentary rocks. Sedimentary rocks are the rocks that are drilled to find gas and oil. They are the source and reservoir rocks for gas and oil.

Loose sediments (unconsolidated sediments) become relatively hard sedimentary rocks (**consolidated sediments**) in the subsurface by the processes of **cementation** and **compaction**. No matter how some sediments such as sand grains are packed together, there will be pore spaces between the grains (Fig. 2-2). Once the grains have been buried in the subsurface, the pore spaces are **filled** with water that can be very salty. Under the higher temperatures and pressures of the subsurface, salts often precipitate out of the subsurface waters to **coat** the grains. These coatings grow together to **bridge** the loose grains. This process, called cementation, **bonds** the loose grains into a solid sedimentary rock. Two common cements are the minerals calcite ($CaCO_3$) and quartz ($Si0_2$). Also, as the sediments are buried deeper, the increasing weight of overlying rocks **exerts** more pressure on the grains. This compacts the sediments that also solidify the rock.

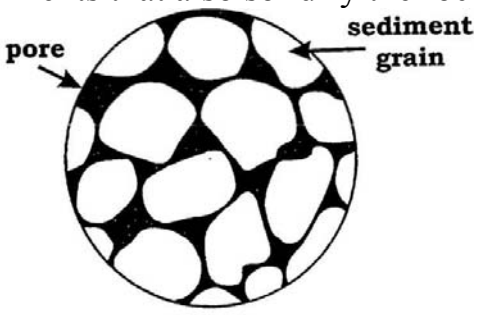


Fig. 2–2 Pores between sediment grains

Sedimentary rocks often consist of three parts when **examined** under a microscope (Fig. 2-3). First, there are sediment grains. These are composed of minerals such as quartz or feldspar or seashells. Second, there are natural cements coating and bonding the grains together.

Boulder – осадочный валун, диаметром не более 256 мм

consolidated sediments – уплотненные осадочные породы

Cementation – цементирование. скрепление, объединение

Compaction – уплотнение

Fill – наполнить

Coat – покрывать слоем чего-либо

Bridge – соединять

Bond – связывать, соединять, скреплять

Exert – оказывать

Examine – исследовать; изучать

Drinking water – питьевая вода

Seawater – морская вода

Brackish water – солоноватая вода

Fresh – свежий

Percolate – проса-

Third, there are pore spaces. The pores are filled with fluids (water, gas, or oil) in the subsurface.

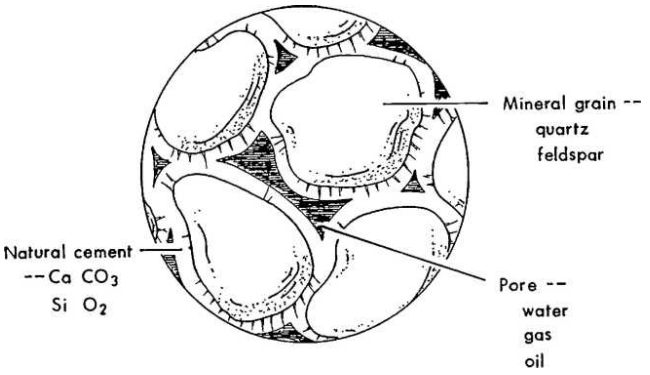


Fig. 2-3 Clastic sedimentary rock under a microscope

There is an enormous amount of water below the surface of the ground, called ground water, in the pores of the sedimentary rocks (Fig. 2-4). Ground water is described by salt content in parts per thousand *(ppt)*. Fresh water contains so little salt (0-1 ppt) that it can be used for **drinking water**.

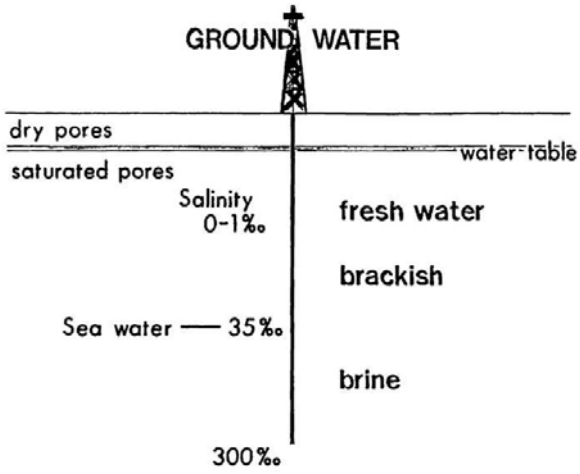


Fig. 2-4 Ground water

Brines are subsurface waters that contain more salt than **seawater** (35-300 ppt).

Brackish waters are mixtures of fresh waters and brines (1-35 ppt). Below the surface is a boundary called the water table between the dry pores above and pores that are filled with water below. The water table can be on the surface or very deep depending on how much rain falls in that area. Just below the water table, the ground water is usually **fresh** because of rain water that **percolates** down from the surface. Deep waters, however, are

чиваться, проникать сквозь

Meteoric water – подземные воды, образовавшиеся при просачивании атмосферных осадков

Cobble –крупная галька (размером 64-256 мм)

Pebble –гравий

Granule – гранула; мелкая частица (2-4 мм)

Silt – мелкозем, частицы почвы 0,05-0,002 мм в диаметре)

Sorting – сортировка, классификация

Determine – определять, устанавливать

Reduce – понижать, сокращать, уменьшать

Hold – сохранять, удерживать

Layering – наслаивание

Bedding – напластование; наслоение, слоистость;

usually brines. When a well is drilled, completed, and producing, near-surface fresh waters must be protected. **Meteoric water** is fresh, subsurface water. Connate water is saline, subsurface water that has been out of contact with the atmosphere for a long time. Connate water is often water that was originally trapped in the sediments when they were deposited.

залегание

Cause – вызывать

Environment – окружение

Ripple marks – рябь

Mud crack – трещина усыхания

Flow mark – знак течения

The sizes of the clastic grains that make up an ancient sedimentary rock are important. The rock is often classified according to the grain size. Sandstones are composed of sand-sized grains whereas shales are composed of fine-grained (clay-sized) particles. Also, the size of the grains controls the size of the pore spaces and the quality of the oil or gas reservoir. Larger grains have larger pores between them. It is easier for fluids, such as gas and oil, to flow through larger pores. Clastic grains in sedimentary rocks are classified by their diameters in millimeters (Fig.2-5). They are called boulder, **cobble**, **pebble**, **granule**, sand, **silt**, and clay-sized particles. The finest grains (i.e., sand, silt, and clay-sized) are the most common.

Sorting is the range of particle sizes in the rock (Fig. 2-6). A well-sorted rock is composed of particles of approximately the same size (Fig. 2-6a). A poorly-sorted, rock is composed of particles with a wide range of sizes (Fig. 2—6b). Sorting is the most important factor in **determining** the amount of original pore space in a clastic sedimentary rock. Finer-sized particles in a poorly sorted rock occupy the spaces between the larger-sized particles and **reduce** the volume of the pores. Poorly sorted rocks can **hold** less fluids and are lower-quality reservoir rocks than well-sorted rocks. Well-sorted sandstones are called clean sands. Because sand grains are light in color, clean sandstones are usually light in color. Poorly sorted sandstones with significant amounts of silt- and clay-sized grains are called dirty sands. Because silt- and clay-sized particles are usually dark in color, dirty sandstones are dark colored.

Sedimentary rocks are identified by their **layering**, called stratification or **bedding**. As the sediments are deposited, there are frequent variations in the amount and composition of sediment supply and the level of the ocean that **cause** the layering. Sediment layers are origi-

nally deposited horizontal in water. Geologists can interpret how sedimentary rocks were deposited. Lithology (rock composition) is an important clue as to how a sedimentary rock was formed. Sand grains, mud particles, and shell beds each form different sedimentary rocks. Each is originally deposited in a very different **environment**. Sedimentary structures such as **ripple marks**, **mud cracks**, and **flow marks** help to visualize the environment in which the rock was deposited. Another aid to interpretation is fossils, preserved remains of plants and animals.

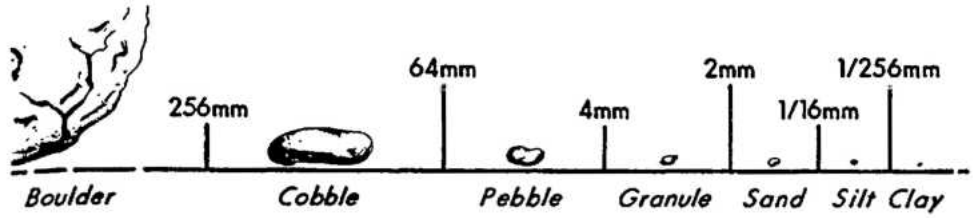


Fig. 2–5 *Grain sizes in millimeters (1mm = 1/25 in.)*

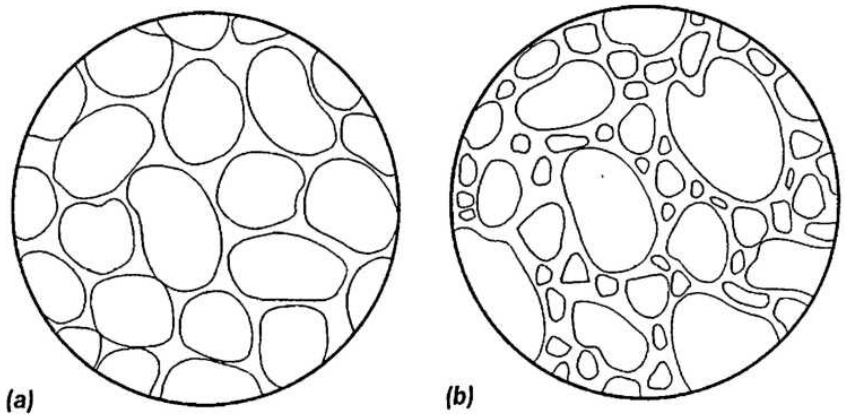


Fig. 2–6 *Particle sorting (a) well sorted (b) poorly sorted*

Answer the questions:

1.What are three types of sedimentary rock? 2. How can loose sediments become hard? 3. What are three parts Sedimentary rocks often consist of? 4. What types of water are there? 5. What is rock classified according to? 6. What is the difference between well- and poorly-sorted rocks? 7. How sediments are deposited?

Metamorphic rocks

Metamorphic rocks are any rocks that have been **altered** by high heat and pressure. **Marble** ($CaCO_3$), a metamorphic rock, is metamorphosed limestone ($CaCO_3$), and quartzite (SiO_2) is metamorphosed quartz sandstone (SiO_2). Since temperatures and pressures become greater with depth, a rock often becomes metamorphosed when buried deep in the earth.

Alter – изменять, видоизменять
Marble – мрамор

Structure of the Earth's Crust

The earth is **estimated** to be about 4.5 billion years old. Even the sedimentary rocks that generated and hold the gas and oil are millions to hundreds of millions of years old. During that vast expanse of geological time, sea level has not been constant. Sea level has been rising and falling. During the rise and fall of sea level, sediments were deposited in layers. Sands were deposited along the ancient beaches. Mud was deposited in the shallow seas offshore. Seashells were deposited in shell beds. These ancient sediments form the sedimentary rocks that are drilled to find gas and oil. The rise and fall of sea level has occurred in numerous **cycles** (Fig. 2-7). The largest cycles occurred every few hundreds of millions of years. There are shorter cycles on the large cycles and even shorter cycles on them. At least five **orders** of sea level cycles have occurred, with the shortest occurring every few tens of thousands of years. The shorter cycles are thought to be caused by the **freezing** and melting of **glaciers**.

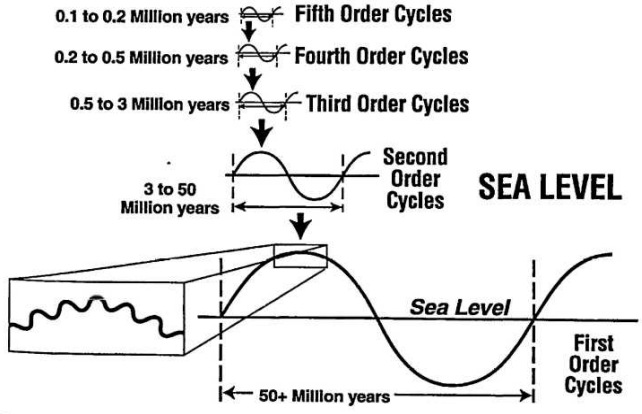


Fig. 2–7 Sea level cycles (Hyne, 1995)

In a typical section of the earth's crust such as Tulsa, Oklahoma, about 5000 ft (1500 m) of well-layered

Estimate – оценивать
Cycle – цикл; (хронологический) период
Order – порядок; последовательность
Freeze – замерзать, обледеневать
Glacier – ледник
Unproductive – непродуктивный
Shield – щит
Ore – руда
Iron – железо
Copper – медь
Lead – свинец
Zinc – цинк
Gold – золото
Silver – серебро
Mine – разрабатывать рудник; добывать
Kitchen – зона образования УВ
Interconnected – связанный, взаимосвязанный; соединённый
Flank – бок; край, сторона
Barren – пустой, не содержащий полезно-

sedimentary rocks are underlain by very old metamorphic or igneous rocks (Fig. 2-8).

There are about one hundred layers of sedimentary rocks. Sands form the rock sandstone. Mud forms the rock shale. Sea shells form the rock limestone. The **unproductive** rocks, usually igneous and metamorphic rocks underlying the sedimentary rocks, are called basement rocks. When drilling encounters basement rock, the drilling is usually stopped.

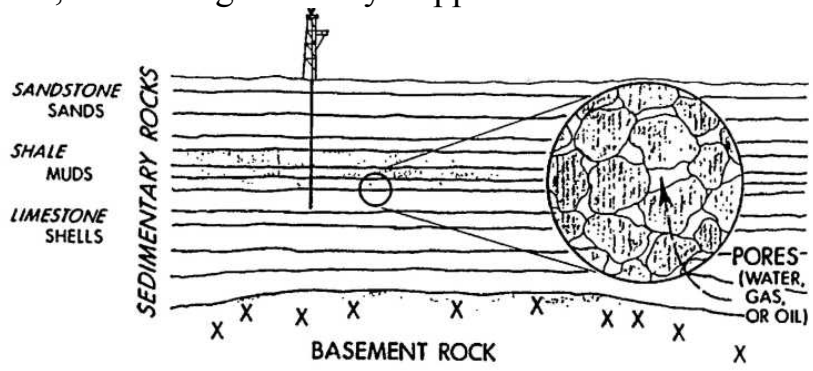


Fig. 2–8 *Cross section of earth's crust*

In some areas of the earth, there are no sedimentary rocks, and the basement is on the surface. These areas are called **shields**, and there is no gas or oil. Every continent of the world has at least one shield area (Fig. 2—9). A shield, such as the Canadian shield in eastern Canada, tends to be a large, low-lying area. **Ore** minerals such as **iron**, **copper**, **lead**, **zinc**, **gold**, and **silver** are **mined** from the basement rock in shield areas. The southwest portion of Saudi Arabia is a shield. All the Saudi Arabian oil fields are located in sedimentary rocks to the northeast of the Arabian Shield.

Fig. 2–9 *Map of world showing location of shields and areas where very old (Precambrian age) rocks occur on the surface in black*

го ископаемого; безрезультатный (о скважине) ; нефтенепродуктивный

In other areas called basins, the sedimentary rocks are very thick. The Caspian basin (Caspian Sea) has about 85,000 ft (26,000 m) of sedimentary rock cover. However, 20,000 to 40,000 ft (6,000 to 12,000 m) of sedimentary rocks is typical of many basins. Basins such as the Gulf of Mexico, the Anadarko basin of southwestern Oklahoma, and the Denver- Julesburg basin of Colorado are large areas that are often more than 100 miles (160 km) across.

It is in the sedimentary rock basins that the most gas and oil is found and produced. Because of the thick sedimentary rock, most basins have source rocks that have been buried deep enough in the geological past to generate gas and oil (Fig. 2—10). The deep part of the basin where the gas and oil forms is called the **kitchen** or oven. After the gas and oil is generated, it flows upward in the overlying rocks. If it intersects a layer of reservoir rock, the gas and oil then migrates through the **interconnected** pores of the reservoir rock layer up the **flanks** of the basin where it can be trapped and concentrated. The trap, such as an anticline, is a relatively small feature compared to the basin. Numerous traps can occur along the flanks of the basin.

There are about 600 sedimentary rock basins in the world. Of the basins that have been explored and drilled, about 40% are very productive. About 90% of the world's oil occurs in only 30 of those basins. The other 60% of the explored basins are **barren**. The unproductive basins either have no source rocks, the source rocks have never been buried deep enough to generate gas and oil, or the basin has was overheated, and the oil was destroyed.

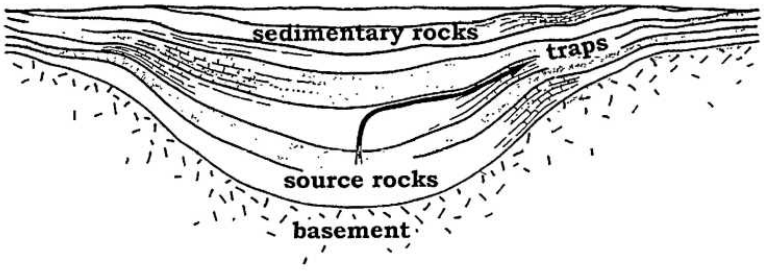


Fig. 2–10 *Cross section of sedimentary rock basin*

Answer the questions:

1.What are metamorphic rocks? 2. How are sedimentary rocks deposited? 3. How often did cycles occur? 4. What is shield? 5. What can you tell about basins?

Exercise № 1. **Match English words and their Russian equivalents.**

geological time	разлом породы
lava rock	быстрая кристаллизация
the same way	геологический период
rapid crystallization	рыхлые породы
preexisting rocks	возрастающий вес
whole particles	покрывать зерна
breakdown of rocks	вулканическая порода
loose sediments	породы, существующие ранее
to coat the grains	цельные частички
increasing weight	таким же образом

Exercise № 2. Make up word combinations and translate them.

molten	sediments
earth’s	crust
metamorphic	sediments
mineral	rocks
physical	hard
plutonic	process
clastic	lava
organic	sediments
crystalline s	rocks
relatively	grains

Exercise № 3. Match English words and their Russian equivalents.

exerts more pressure	подземные воды
water table	мелко-зернистые частички
dry pores	оказывать больше давления
meteoric water	непродуктивная порода
fine-grained particles	чистый песчаник
clean sandstone	уровень грунтовых вод
interconnected pores	подниматься и опускаться
ripple marks	взаимосвязанные поры
rise and fall	пустые поры
unproductive rock	рябь

Exercise № 4. Make up word combinations and translate them.

salt	trapped
drinking	rock
connate	color
originally	basins
well-sorted	water
light in	water
dirty	rocks
mud	environment
basement	cracks
different	content
barren	water
ground	sands

Exercise № 5. Match words and definitions.

igneous rock	mineral	precipitate	intrusion	cementation	kitchen
bridge	brackish waters	bedding	percolate	sorting	shields

1. Rock that is formed through the cooling and solidification of magma or lava.
2. Forms and spatial position of rocks in the earth's crust.
3. A naturally occurring solid chemical substance formed through biogeochemical processes, having characteristic chemical composition, highly ordered atomic structure, and specific physical properties. An area of the subsurface where source rock has reached appropriate conditions of pressure and temperature to generate hydrocarbons.
4. The range of sedimentary grain sizes that occurs in sediment or sedimentary rock.
5. Water that has more salinity than fresh water, but not as much as seawater.
6. Part of the continental crust in which these usually Precambrian basement rocks crop out extensively at the surface.
7. Cause (drops of moisture or particles of dust) to be deposited from the atmosphere or from a vapor or suspension.
8. Liquid rock that forms under Earth's surface.
9. The binding together of particles or other things by cement.
10. To connect pore spaces or fluid paths in a rock formation.
11. (Of a liquid or gas) filter gradually through a porous surface or substance.

Exercise № 6. Complete the definitions given.

1. A material or structure formed from a loosely compacted mass of fragments or particles.
2. Form or cause to form crystals again.
3. A rock formed from magma erupted from a volcano.

4. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water.

5. Water trapped in the pores of a rock during formation of the rock.

6. A description of its physical characteristics visible at outcrop, in hand or core samples or with low magnification microscopy, such as colour, texture, grain size, or composition.

7. Rocks that result when magma cools and crystallizes slowly within the Earth's crust (example granite).

8. Change (something) to a liquid condition by heating it.

9. A solution of salt (usually sodium chloride) in water.

10. A process that returns to its beginning and repeats itself in the same sequence.

11. A large-scale structural formation of rock strata.

12. Be situated under (something).

Exercise № 7. Fill the gaps using the words given.

examples precipitation minerals drinking water fossils grains metamorphic rocks aggregates igneous rocks to coat plutonic rocks the unproductive basins water table volcanic shields loose sediments brackish waters ground water connate water the oven clean sands the grain size cementation stratification a poorly-sorted basins

1. … have been recrystallized from other rocks under high temperatures and pressures.

2. Boulders, sand grains, and mud particles are … .

3. Because the rocks that surround the cooling plutonic rocks are good insulators, … often take thousands of years to solidify.

4. The earth is composed of rocks, which are … of small grains or crystals called minerals.

5. Rocks can be composed of numerous … or several different … .

6. Crystalline sediments are formed by the … of salt out of water.

7. Fresh water contains so little salt (0-1 ppt) that it can be used for … .

8. … have crystallized from a hot, molten liquid.

9. … become relatively hard sedimentary rocks in the subsurface by the processes of cementation and compaction.

10. The … can be on the surface or very deep depending on how much rain falls in that area.

11. … igneous rocks crystallize on the surface of the earth as lava.

12. Salts often precipitate out of the subsurface waters … the grains.

13. This process, called …, bonds the loose grains into a solid sedimentary rock.

14. There is an enormous amount of water below the surface of the ground, called …, in the pores of the sedimentary rocks.

15. The rock is often classified according to … .

16. … either have no source rocks, the source rocks have never been buried deep enough to generate gas and oil, or the basin has was overheated, and the oil was destroyed.

17. … is often water that was originally trapped in the sediments when they were deposited.

18. Well-sorted sandstones are called … .

19. In some areas of the earth, called …, there are no sedimentary rocks, and the basement is on the surface.

20. Another aid to interpretation is …, preserved remains of plants and animals.

21. … are mixtures of fresh waters and brines.

22. In other areas called …, the sedimentary rocks are very thick.

23. Sedimentary rocks are identified by their layering, called … .

24. The deep part of the basin where the gas and oil forms is called … .

25. … rock is composed of particles with a wide range of sizes.

Exercise № 8. Insert the verbs from brackets into correct form in Conditional sentences.

1. If the cooling (to be) so rapid as to prevent the formation of even small crystals after extrusion, the resulting rock may be mostly glass.

2. If the cooling of the lava happened slowly, the rocks (to be) coarse-grained.

3. The minute structures, however, disappear, often completely, if the thermal alteration (to be) very profound; thus small grains of quartz in a shale are lost or blend with the surrounding particles of clay, and the fine ground-mass of lavas is entirely reconstructed.

4. Paleo picks can also be used to determine if the sedimentary rock layers in a well (to be) higher or lower in elevation than those in a well that has already been drilled

5. If the anticlines are relatively young, they (not to erode) and appear as topographic ridges on the surface.

6. If an area of the earth's crust is compressed, the rocks (to fold) into anticlines and synclines.

7. If folds (to be) present in the rocks of the earth's crust, that area probably has been compressed some time in the past.

8. If the ancient reef is covered with a shale or salt caprock, it (to form) a gas and oil trap.

9. If the contour line elevations (to increase) in a direction, the slope is rising.

10. If the contours (to be spaced) relatively close together, the elevation is changing rapidly, and the slope is steep.

11. If the source rock is buried deeper, where temperatures are above 300°F (150°C), thermogenic gas (to generate) from organic matter left in the source rock.

12. Oil can be generated at lower temperatures if the source rock (to expose) to those temperatures for a longer time.

13. If there is no trap on the migration route, the gas and oil (to flow) out onto the surface as a gas or oil seep.

14. If there (to be) a trap along migration route, the gas and oil will accumulate in the trap.

15. If the trap (to form) after the migration, no gas and oil will occur in the trap

16. If the trap has been filled with oil and gas down to the spill point and more migrates into the trap, some of the oil (to spill) out the side of the trap.

17. If a large mass of magnetite-bearing rock (to occur) near the surface, it is detected by a larger magnetic force than the normal, regional value

18. If the seismic velocities through the rocks (to know), the structure-contour and isotime maps can be converted into structural and isopach maps.

19. If the reflections from two intersecting seismic records (not to correlate), it is called a mis-tie**.**

20. If no well is available, a stratigraphic test well (to drill) on the seismic line.

Exercise № 9. Translate sentences into English.

1. Магматические горные породы — это породы, образовавшиеся непосредственно из магмы (расплавленной массы преимущественно силикатного состава, образованной в глубинных зонах Земли), в результате её поступления в верхние горизонты Земли, охлаждения и застывания.

2. Магматические горные породы (интрузивные и эффузивные) классифицируются в зависимости от размера кристаллов, текстуры, химического состава или происхождения.

3. Горные породы вулканического происхождения, которые образовались на глубине, называются плутоничными или интрузивными.

4. Те породы, которые образовались в результате излияния на поверхность, называются эффузивными (излившимися) или вулканическими.

5. Благодаря быстрому остыванию, кристаллы в них мелкие, практически не различимы невооружённым глазом (базальт, риолит и др).

6. Интрузивные породы образуются за счёт полной раскристаллизации магматического расплава. Образуются глубоко в недрах Земли (от 5 до 40 км) в течение большого времени, при относительно постоянных температуре и давлении.

7. Грунто́вые воды образуют водоносный горизонт на первом от поверхности водоупорном слое. В связи с неглубоким залеганием от поверхности уровень грунтовых вод испытывает значительные колебания по сезонам года: он то повышается после выпадения осадков или таяния снега, то понижается в засушливое время. В суровые зимы грунтовые воды могут промерзать. Эти воды в большей мере подвержены загрязнению.

8. Солоноватая вода — вода, содержащая больше солей, чем пресная вода, но не больше чем морская вода.

9. Технически солоноватая вода содержит от 0,5 до 30 граммов соли на литр.

10. Пре́сная вода́ — противоположность морской воды, охватывает ту часть доступной воды Земли, в которой соли содержатся в минимальных количествах.

11. Вода, солёность которой не превышает 0,1 %, даже в форме пара или льда называется пресной.

12. Ледяные массивы в полярных регионах и ледники содержат в себе наибольшую часть пресной воды земли. Помимо этого, пресная вода существует в реках, ручьях, пресных озёрах, а также в облаках.

13. По разным подсчётам доля пресной воды в общем количестве воды на Земле составляет 2,5-3 %.

14. Около 85-90 % запасов пресной воды содержится в виде льда.

15. Литоло́гия (от лито- камень… и …логия- слово) — наука об осадочных породах и современных геологических осадках, их вещественном составе, строении, закономерностях и условиях образования и изменении.

16. Более строго литологию можно определить как отрасль объективного знания о составе, отношениях и связях между геологическими телами и слагающими их породами, образованными при процессах, происходящих в гидросфере, атмосфере и биосфере.

17. Классификация обломочных пород основана на величине обломков. Выделяют следующие виды обломочных пород:1. крупнообломочные породы или псефиты - размер обломков более 1 мм. Это валуны, галька, гравий и другие.2. среднеобломочные породы или псаммиты - размер зерен от 0,1 до 1,0 мм. Это пески и песчаники.

18. Песчаники представляют собой сцементированные пески.

19. Минералом принято называть природное химическое соединение, являющееся составной частью земной коры.

20. Каждый минерал обладает своей химической формулой, однако состав минерала довольно изменчив.

21. Минерал представляет собой решетку, в которой атомы одних элементов занимают строго определенное положение относительно других. Любому кристаллу и минералу свойственна своя кристаллическая решетка.

22. Каждый минерал имеет определенные физические свойства, такие как твердость, блеск, удельный вес, цвет и т. д. Минералы образуются везде: в недрах земли, в болотах, в пустынях, в озерах. Большинство минералов образуется из магмы.

23. Горные породы — это составляющая земной поверхности. Образовались горные породы около 4600 миллионов лет назад из природных кристаллических веществ — минералов.

24. Породы обладают разнообразными цветами и строением, но все они делятся на три типа: осадочные, магматические и метаморфические. Причем земные породы медленно выветриваются и постоянно превращаются друг в друга.

25. Канадский щит — выступ докембрийского складчатого фундамента, занимающий северную половину Северо-Американской (Канадской) платформы,

включая Гренландию. Состоит из ограниченных разломами плит, образованных метаморфированными и гранитизированными складчастыми участками архейской и протерозойской эпохи, с которыми связаны расположения здесь руд железа, золота, меди, никеля, кобальта, урана, свинца, цинка и др.

Exercise № 10. Render the text.

Го́рные поро́ды — природная совокупность минералов более или менее постоянного минералогического состава, образующая самостоятельное тело в земной коре. Планеты и другие твёрдые космические объекты состоят из горных пород.

По происхождению горные породы делятся на три группы: магматические (эффузивные и интрузивные), осадочные и метаморфические. Магматические и метаморфические горные породы слагают около 90 % объёма земной коры, однако, на современной поверхности материков области их распространения сравнительно невелики. Остальные 10 % приходятся на долю осадочных пород, занимающие 75 % площади земной поверхности.

Магматические горные породы по своему происхождению делятся на эффузивные и интрузивные. Эффузивные (вулканические) горные породы образуются при изливании магмы на поверхность земли. Интрузивные горные породы, напротив, возникают при изливании магмы в толще земной коры.

Разделение пород на магматические, метаморфические и осадочные не всегда очевидно. В осадочных горных породах, в процессе диагенеза, уже при очень низких (в геологическом смысле) температурах, начинаются минеральные превращения, однако породы считаются метаморфическими при появлении в них новообразованного гранита. При умеренных давлениях начало метаморфизма соответствует температуре 300 °C.

При высоких степенях метаморфизма стирается грань между метаморфическими и магматическими горными породами. Начинается плавление пород, смешение новообразованных расплавов с явно внешними. Часто наблюдаются постепенные переходы от явно метаморфических, полосчатых пород, к типичным гранитам.

По глубине формирования породы делятся на три группы: породы кристаллизующиеся на глубине — интрузивные горные породы, например, гранит. Они образуются при медленном остывании магмы и обычно хорошо раскристаллизованны; гипабисальные горные породы образуются при застывании магмы на небольших глубинах, и часто имеют неравномернозернистые структуры (доле-

рит). Эффузивные горные породы формируются на земной поверхности или на дне океана (базальт, риолит, андезит).

Важнейшей характеристикой магматической породы является состав. Существует несколько классификаций магматических горных пород по составу (номенклатура горных пород). Наибольшее значение имеет классификация по содержанию в породах кремнезёма SiO_2, и щелочей($Na_2O + K_2O$).

Образование магматических пород непрерывно происходит и сейчас, в зонах активного вулканизма и горообразования.

Метаморфические горные породы образуются в толще земной коры в результате изменения (метаморфизма) осадочных или магматических горных пород. Факторами, вызывающими эти изменения, могут быть: близость застывающего магматического тела и связанное с этим прогревание метаморфизуемой породы; воздействие отходящих от этого тела активных химических соединений, в первую очередь различных водных растворов (контактовый метаморфизм), или погружение породы в толщу земной коры, где на неё действуют факторы регионального метаморфизма —высокие температуры и давления.

Типичными метаморфическими Г. п. являются гнейсы, разные по составу кристаллические сланцы, контактовые роговики, скарны, амфиболиты, мигматиты и др. Различие в происхождении и, как следствие этого, в минеральном составе Г. п. резко сказывается на их химическом составе и физических свойствах.

Осадочные горные породы образуются на земной поверхности и вблизи неё в условиях относительно низких температур и давлений в результате преобразования морских и континентальных осадков. Осадочные горные породы (ОГП) — горные породы, существующие в термодинамических условиях, характерных для поверхностной части земной коры, и образующиеся в результате переотложения продуктов выветривания и разрушения различных горных пород, химического и механического выпадения осадка из воды, жизнедеятельности организмов или всех трёх процессов одновременно.

Более трёх четвертей площади материков покрыто ОГП, поэтому с ними наиболее часто приходится иметь дело при геологических работах. Кроме того, с ОГП генетически или пространственно связана подавляющая часть месторождений полезных ископаемых. В ОГП хорошо сохранились остатки вымерших организмов, по которым можно проследить историю развития различных уголков Земли. Исходным материалом при формировании ОГП являются минеральные вещества, образовавшиеся за счёт разрушения существовавших ранее минералов и горных пород магматического, метаморфического или осадочного происхождения и перенесённые в виде твёрдых частиц или растворенного вещества.

Изучением осадочных горных пород занимается наука Литология.

Do you know that?

Minerals are commonly named based on the following:

Named for the chemical composition or some other physical property (e.g. halotrichite, batisite, rhodonite).

Named for reasons that have been lost to antiquity (e.g., ice, quartz) or from long usage (e.g., cinnabar).

Named for the locality in which the mineral was first found (e.g., Ilmenite, andesine).

Named by applying a prefix to an existing mineral (e.g., meta-, para-, clino-, ortho-, ferro-, see Ferri-clinoferroholmquistite).

Named after a prominent scientist or other person, living or dead (e.g., roeblingite, perovskite).

Named for mythical creatures or deities (e.g. chabazite, neptunite, tapiolite).

Minerals Named after women:

Here is an incomplete listing of minerals (81) which were named after women (e.g. ankinovichite, aurivilliusite, bario-olgite, brassite, chantalite, dellaite, larisaite, malinkoite, olgite, petrovskaite, sophiite, , tatyanaite, yakhontovite).

Minerals Named for the Same Person

Having a mineral named after a person is a great honor. The following short list are those people who have more than one completely unrelated mineral named after them.

Marie Curie-Sklodowska (1867-1934), Polish-born French researcher of radioactive minerals. Discovered the element radium. See Curite (co-named with her husband, Pierre) and Sklodowskite.

Vyacheslav Gavrilovich Melkov (1911-1991), Russian mineralogist. See Melkovite and Vyacheslavite.

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