ПЕРВОЕ ВЫСШЕЕ ТЕХНИЧЕСКОЕ УЧЕБНОЕ ЗАВЕДЕНИЕ РОССИИ

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
федеральное государственное бюджетное образовательное учреждение высшего образования
САНКТ-ПЕТЕРБУРГСКИЙ ГОРНЫЙ УНИВЕРСИТЕТ

УТВЕРЖДАЮ

____

Руководитель программы аспирантуры
профессор А.С. Егоров

МЕТОДИЧЕСКИЕ РЕКОМЕНДАЦИИ ДЛЯ ПРОВЕДЕНИЯ ПРАКТИЧЕСКИХ ЗАНЯТИЙ ПО ДИСЦИПЛИНЕ ИНОСТРАННЫЙ ЯЗЫК

Подготовка научных и научно-педагогических кадров в аспирантуре

Область науки:	1. Естественные науки
Группа научных специальностей:	1.6. Науки о Земле и окружающей среде
Научная специальность:	1.6.9. Геофизика
Отрасли науки:	Геолого-минералогические, технические
Форма освоения программы аспирантуры:	Очная
Срок освоения программы аспирантуры:	3 года
Составители:	к.филол.н., доц. Е.А. Варламова, к.филол.н., доц. В.А. Спиридонова

Санкт-Петербург

ВВЕДЕНИЕ

Данные материалы предназначены для всех направлений подготовки кадров высшей квалификации и соответствуют программе по английскому языку для неязыковых вузов. Целью методических указаний является совершенствование умений просмотрового и изучающего чтения текстов по направлениям подготовки, их перевода на русский язык; формирование навыков подготовки тематических презентаций и докладов; формирование умения перевода профессиональных терминов и терминологических групп.

В методические указания включены тексты об основных тенденциях и разработках в горной отрасли.

Тексты сопровождаются рядом заданий и упражнений, целью которых является отработка и закрепление лексического материала, контроль перевода и понимания оригинальных технических текстов на английском языке и развитие навыков чтения.

Методические указания способствуют формированию универсальных компетенций в части владения иностранным языком и профессиональных компетенций.

Предложенные методические указания можно использовать как для самостоятельной подготовки, так и для работы в аудитории.

Text 1

THE BIRTH OF SCIENTIFIC ENGLISH

Task 1. Read the words, underline the stressed syllable and find the Russian equivalents:

to dominate, global, audience, intellectual, Renaissance, expansion, magnetism, theory, enthusiasm, cartography, revolution, planet, encyclopaedia, mathematician, demonstration, lecture, linguistic, microscope, discipline, journal, committee, astronomy, humanist, monograph, inadequacy

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Research paper, prominence, be regarded as, revival, scholar, emergent, treatise, secrecy, hypothetical entity, to cling, notion, preliminary idea, property, commercial exploitation, sealed

Task 3. Read and translate the text:

World science is dominated today by a small number of languages, including Japanese, German and French, but it is English which is probably the most popular global language of science. This is not just because of the importance of English-speaking countries such as the USA in scientific research; the scientists of many non-English-speaking countries find that they need to write their research papers in English to reach a wide international audience. Given the prominence of scientific English today, it may seem surprising that no one really knew how to write science in English before the 17th century. Before that, Latin was regarded as the lingua franca for European intellectuals.

The European Renaissance (14th-16th century) is sometimes called the 'revival of learning', a time of renewed interest in the 'lost knowledge' of classical times. At the same time, however, scholars also began to test and extend this knowledge. The emergent nation states of Europe developed competitive interests in world exploration and the development of trade. Such expansion, which was to take the English language west to America and east to India, was supported by scientific developments such as the discovery of magnetism (and hence the invention of the compass), improvements in cartography and - perhaps the most important scientific revolution of them all - the new theories of astronomy and the movement of the Earth in relation to the planets and stars, developed by Copernicus (1473-1543).

England was one of the first countries where scientists adopted and publicised Copernican ideas with enthusiasm. Some of these scholars, including two with interests in language -John Wall's and John Wilkins - helped found the Royal Society in 1660 in order to promote empirical scientific research.

Across Europe similar academies and societies arose, creating new national traditions of science. In the initial stages of the scientific revolution, most publications in the national languages were popular works, encyclopaedias, educational textbooks and translations.

Original science was not done in English until the second half of the 17th century. For example, Newton published his mathematical treatise, known as the Principia, in Latin, but published his later work on the properties of light - Opticks - in English.

There were several reasons why original science continued to be written in Latin. The first was simply a matter of audience. Latin was suitable for an international audience of scholars, whereas English reached a socially wider, but more local, audience. Hence, popular science was written in English.

A second reason for writing in Latin may, perversely, have been a concern for secrecy. Open publication had dangers in putting into the public domain preliminary ideas which had not yet been fully exploited by their 'author'. This growing concern about intellectual properly rights was a feature of the period - it reflected both the humanist notion of the individual, rational scientist who invents and discovers through private intellectual labour, and the growing connection between original science and commercial exploitation. There was something of a social distinction between 'scholars and gentlemen' who understood Latin, and men of trade who lacked a classical education. And in the mid-17th century it was common practice for mathematicians to keep their discoveries and proofs secret, by writing them in cipher, in obscure languages, or in private messages deposited in a sealed box with the Royal Society. Some scientists might have felt more comfortable with Latin precisely because its audience, though in national, was socially restricted. Doctors clung the most keenly to Latin as an 'insider language'.

A third reason why the writing of original science in English was delayed may have been to do with the linguistic inadequacy of English in the early modern period. English was not well equipped to deal with the scientific argument. First, it lacked the necessary technical vocabulary. Second, it lacked the grammatical resources required to represent the world in an objective and impersonal way, and to discuss the relations, such as cause and effect, that might hold between complex and hypothetical entities.

Fortunately, several members of the Royal Society possessed an interest in language and became engaged in various linguistic projects. Although a proposal in 1664 to establish a committee for improving the English language came to little, the society's members did a great deal to foster the publication of science in English and to encourage the development of a suitable writing style. Many members of the Royal Society also published monographs in English. One of the first was by Robert Hooke, the society's first curator of experiments, who described his experiments with microscopes in Micrographia (1665). This work is largely narrative in style, based on a transcript of oral demonstrations and lectures.

In 1665 a new scientific journal, Philosophical Transactions, was inaugurated. Perhaps the first international English-language scientific journal, it encouraged a new genre of scientific writing, that of short, focused accounts of particular experiments.

The 17th century was thus a formative period in the establishment of scientific English. In the following century, much of this momentum was lost as German established itself as the leading European language of science. It is estimated that by the end of the 18th century 401 German scientific journals had been established as opposed to 96 in France and 50 in England. However, in the 19th century, scientific English again enjoyed substantial lexical growth as the industrial revolution created the need for new technical vocabulary, and new, specialised, professional societies were instituted to promote and publish in the new disciplines.

*** lingua franca: a language which is used for communication between groups of people who speak different languages

Task 4. Formulate the key ideas of each paragraph.

Task 5. Give answers to the following questions:

1. What are historical facts of introducing English into the scientific society?
2. What was the first international scientific journal like?
3. What steps were undertaken to improve English for scientific needs?

Text 2

FUTURE TRENDS IN ENGINEERING

Task 1. Read the words, underline the stressed syllable, find the Russian equivalents:

technology, transport, sector, urbanization, standard, emission, result, climate, defect, to formulate, status, electronics, economy.

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Future trend, challenging task, emerging state, shortage, integrated, long-span, steam engine, nonetheless, impact, sustainable, to encompass, reciprocal growth, term, to facilitate.

Task 3. Read and translate the text.

The prediction of future trends in engineering and technology is a challenging task. However, engineers should nonetheless attempt to articulate a future vision of technological trends – particularly in the energy, transport and communications sectors which are so critical to society.

The key trends that will influence engineering to 2070 are global urbanisation and the fourth industrial revolution. Urbanisation trends will result in a doubling in size of the urban population from 3.5 billion persons today to seven billion persons by 2070, according to the UN World Urbanisation Prospects Report 2011. The demand for higher living standards, particularly in the emerging states, will result in a doubling of energy use in the coming decades, a 50 per cent increase in transportation needs and tight water supply, with 75 per cent of the global population experiencing water shortages.

The environmental impact of increased carbon-dioxide emissions and pollution in urban areas will also create climate-change pressures. Engineers will have to play a key leadership role in terms of formulating technical solutions for cities that are sustainable in social and environmental terms.

The second key trend is the fourth industrial revolution, which encompasses a range of intelligent and integrated technologies in the energy and transportation sectors, where energy use can be optimised across different sectors. In the industrial sector, the concept of 'virtual production' will be key for modelling production in advance for 'zero defect' outcomes.

In considering future trends that will influence engineering, it is important to remember that these revolutionary changes have all happened before. The first industrial revolution emerged with the invention of the steam engine in the late-18th century, which led to the economic development of the North Atlantic region.

The second industrial revolution encompassed developments in the electrical, chemical and motor-vehicle engineering sectors at the end of the 19th century. These new technologies facilitated the exponential growth of cities such as New York, with steel production enabling long-span bridge and skyscraper construction to facilitate urban connectivity.

Mass transportation and the reciprocal growth of outer suburban areas was facilitated by mass production of motor vehicles and petro-chemical developments, while electrical power systems revolutionised energy supply to domestic and industrial settings. The leadership provided by Henry T. Ford in mass production, and the Carnegie family, the owners of the steel plants in Pittsburgh was key to implementing the new technologies which revolutionised urban development, production and transportation.

The 1950s saw the emergence of the third industrial revolution, with developments in the electronic and aerospace sectors. These were accompanied by a new shift from mass labour production to specialised labour, when over 50 per cent of American workers became 'white collar' semi-professional workers. Again, the political leadership of civic councils in the 'sunbelt states' of the US was key to implementing these new technologies of the third industrial revolution.

Since the 1960s, the technological advantages enjoyed by the North Atlantic region have eroded with the rise of the Asian economies, which have penetrated into the electronics, transportation and heavy-industry sectors. However, the decline in the economic status of the western states may also be explained by a decline in the status of the engineering and technology sectors relative to new service areas such as the media and financial-services sectors.

The future enhancement of science and technology in western societies will be key to reversing this economic power shift, particularly given the opportunities that will arise from mass urbanisation and the new fourth industrial revolution in the coming decades.

Task 4. Give answers to the following questions:

1. What was the historical background for the current and future changes in engineering?
2. What are the main trends in the development of engineering connected with?
3. What modern trends in engineering are observed in your country?

Text 3

INNOVATIONS IN OIL DRILLING

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

civilization, kerosene, automobile, barrel, market, innovation, method, operator, geophone, location.

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Leaps and bounds, oil well, to spur, rotary drill, bit, dramatic advancement, wharf, to retrieve, hydraulic fracturing, to inject, proppant, gravity, squiggly

Task 3. Read and translate the text.

Oil drilling has been around for more than a century. But because of the numerous developments in the technology, it has grown leaps and bounds in that time. And this growth of oil production has also been essential to changing the face of civilization.

In 1859, Edwin Drake dug what is considered the first oil well in Titusville, Penn. During that period, oil was used primarily to make kerosene for lighting purposes. But the development of the automobile industry soon ignited a new market for oil and spurred increased production -- from 150 million barrels produced worldwide in 1900 to more than one billion barrels in 1925.

One of the earliest innovations to improve oil drilling was the rotary drill, first used in the 1880s. This used a rotating drill bit to dig into the ground (as opposed to Drake's method of cable-tool drilling that lifted and dropped a drill bit into the well).

But the rotary drill was only the beginning in a long line of dramatic advancements that would develop in the 20th century. Some of the most notable that we'll discuss helped improve the efficiency of oil production while making it easier to find oil.

Oil drillers noticed quickly that wells near the shore often produced the most oil. It was obvious that there was a profitable future in finding ways to extract oil from beneath the sea floor. As early as the 1880s, drillers erected rigs on wharfs. But it wasn't until 1947 that an oil company built the first true oil well away from land.

Since then, and after a long political dispute in the United States about who has the rights to lease offshore areas for drilling purposes, the offshore oil drilling industry took off. One of the technologies that spurred the development of offshore drilling was remotely operated vehicles, or ROVs, which the military was already using to retrieve lost equipment underwater. Because diving in deep water is dangerous, the oil industry adapted ROVS for drilling in the 1970s.

Controlled from the rig above the water's surface, an ROV is a robotic device that allows operators to see underwater. Some types allow the operator to make an ROV's robotic arms perform different functions, such as subsea tie-ins and deepwater installations, as deep as 10,000 feet (3,048 meters).

Developed in the 1940s, the process of hydraulic fracturing has become increasingly important in oil drilling. It comes in handy with "tight" reservoirs -- where the rocks containing the oil don't have large pores. This means that the oil flow from the rocks is weak, and drilling a simple well into the rock won't get much of the oil out.

To help stimulate the well and drive out the trapped oil, drillers employ hydraulic fracturing. In this process, they inject water combined with chemicals into the well with enough pressure to create fractures in the rock formations -- fractures that can extend hundreds of feet long. To keep the fractures from closing again, drillers send down a proppant, which is a mixture of fluids, sand and pellets. These fractures allow oil to flow more freely from the rock.

According to the American Petroleum Institute, in the United States alone, hydraulic fracturing has helped pump an extra 7 billion barrels of oil from the ground.

At first, looking for a good place to dig for oil simply depended upon finding where it had bubbled to the surface. But because oil reservoirs can be buried deep in the earth, it's not always obvious from the surface. And because it's costly to set up a rig and dig a deep well, companies don't like to waste their time and money on an unproductive spot. Eventually, geologists were brought in to find out where oil would likely be by studying surface rock formations, magnetic fields and even slight variations in gravity.

One of the most important innovations in oil exploration was 3-D seismic imaging. This relies on the idea that sound bounces off and travels through different materials in slightly different ways. In this process, an energy source such as a vibrator truck sends sound waves deep into the earth. Special devices called geophones are positioned on the surface, which receive the sounds that bounce back up and send the information to recorder trucks.

Engineers and geophysicists study the recorded sound waves (in the form of squiggly lines) to interpret what kinds of layers of rock formation lie in that location. This way, they can construct 3-D images of what lies under the surface (4-D imaging also accounts for the passage of time). Although this advanced technology helps reduce the number of holes drilled and makes for more productive wells, it isn't foolproof: Engineers are lucky if they can accurately predict the location of oil reservoirs half of the time.

Task 4. Formulate the key ideas of each paragraph.

Task 5. Make a summary of the text (200-250 words). List the innovative technologies in oil drilling and describe them briefly.

Text 4

MINING THE UK

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

phenomenal, colossal, material, mineral, concentrate, lithium, flotation, tunnel, battery

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Depleted resources, open pit, commitment, to flourish, tungsten, closure, brine, purity, to kick off, to amend, mercury, polyhalite, fertilizer, tin, to plummet, fluorspar, galena, silica, remediation, scoop truck, pocket extraction.

Task 3. Read and translate the text.

During the Industrial Revolution, the UK's mining industry grew at a phenomenal rate as coal and iron fuelled growth. Today, depleted resources and the shift from coal have seriously reduced the size of activities. But while colossal open pits may now be a thing of the past, smaller scale operations in the UK are blazing a trail by finding more innovative ways of working.

There are around 2,000 mines and quarries in the UK which produce a vast range of materials. From the Highlands to Devon, its minerals industry supports tens of thousands of jobs and contributes billions of pounds to the economy.

Technological advances, changes in metal and mineral demand and a commitment to the landscapes in which they lie has allowed new mines to flourish and for many new projects to pop up.

Tin and tungsten from Devon

Hemerdon in Devon has the fourth biggest reserve of tungsten in the world. However, it has been left untapped for more than sixty years, following its closure in 1944. Several attempts to reopen the mine failed either because they couldn't meet safety standards or were quashed by mineral prices. But in 2011, Australian-based mining company Wolf Minerals was granted planning permission and began work to get the Drakelands mine up and running again. Extraction of tungsten and tin kicked off in 2015, taking advantage of the pit's total resource of 145.2 million tonnes (Mt).

Tungsten has become increasingly sought after in recent years, as it is used in a wide variety of applications, including in missiles, television tubes and as drill bits. Drakelands has an impressive capacity of greater than 3,000tpa tungsten concentrate, which is processed onsite. Each year it expects to produce 5,000t of processed tungsten and 1,000t of tin.

Lithium in Cornwall

As the desire for technologies has grown around the world, so too has the need for the metals and minerals to build them. Lithium is a prime example, with demand surging due to the success of the lithium-ion battery. As such, new sources of the mineral must be found, leading to a revaluation of Cornwall's historic resource.

Cornish Lithium is looking to extract the mineral from brines located below hot springs in the south-west of the UK. New technologies allow for an incredibly efficient extraction process, capable of yielding a purity of up to 99.9%. Currently only at the exploration stage, the company has secured the funding for the first exploration holes, which will be drilled this year with hopes to begin production within the next five years.

Gold from Scotland

In 2016, Scotsgold held the first ever auction for gold mined and processed in Scotland. Nestled in the Highlands, its Cononish mine has an ore reserve of 555,000t. Following initial exploration works and reserve estimates, Scotsgold must now raise £2.65m to begin full-scale operations.

Scotsgold is currently amending its plans to ensure it uses the most efficient and environmentally friendly techniques when advancing to commercial-scale operations next year. The company is also in the process of redesigning its tailings. Gold processing will take place on-site using gravity and flotation, as opposed to cyanide or mercury techniques which can be harmful in the event of a leak, to ensure damage to the landscape is kept to a minimum whilst growing Scotland's mining sector.

Polyhalite in Yorkshire

There have been numerous problems to overcome for Israel Chemicals (ICL) at its Boulby mine. Located on the north-east coast of the Yorkshire Moors, the mine is currently the only one in the world producing polyhalite, which when processed creates polysulphates that are used as fertiliser. Originally a potash mine, as reserves dwindled the company switched its sights to the more difficult mineral to extract.

Previously, polyhalite has been overlooked due to the challenges related to extraction. At ICL's mine, workers were going through a hundred cutting heads a shift due to the material's strength but following a redesign by the site engineers, this has been dramatically reduced and production has increased. The mine has now recorded its millionth tonne of polyhalite and ICL plans to increase production to three million tonnes per annum (Mtpa) of polyhalite by 2025.

Tin in Cornwall

Tin has been mined in Cornwall since 2,300 BC, with large-scale operations beginning in the 1600s. At its peak, there were 400 tin mines in Cornwall, but in 1985 the Great Tin Crash brought this to an end as prices plummeted. Despite this, the South Crofty tin mine survived until 1998, when it eventually shutdown and was left to flood.

However, Strongbow Exploration bought South Crofty mine in 2016 and the company plans to make the site operational again by 2020. Predominantly, it is the price of tin, which currently lies around £15,200/ t, which has rekindled this interest. South Crofty has an official mine life of eight years, producing 1,000t a day from the lower levels of the existing mine, but already Strongbow believes the resource could continue well beyond this.

Fluorspar and lead in Derbyshire

Fluorspar is now the main material produced in the Peak District. Mining of the mineral, which is predominantly used in chemicals such as hydrofluoric acid and fluorocarbons, began in the 1920s and has continued ever since, being able to take advantage of the rich seams that run though the area. In 2012, British Fluorspar reopened the Cavendish Mill mines, which now produce 65,000t per annum of fluorspar.

Mineralisation of the site's vertical veins is made up of fluorite, baryte and galena together with calcite and silica. British Fluorspar also excavates and processes the galena, or iron sulphide, making it the only iron producer left in Derbyshire.

Unlike historic mines throughout the Peak District, British Fluorspar is committed to the remediation of lands following use, resulting in 220 acres of land being restored. The company's current activities utilise remote controlled scoop trucks and trackless mining in underground drift mines to help minimise the impact on the surrounding areas.

In 2014, West Cumbria Mining set about screening an area near Whitehaven where it hopes to establish a new coal mine. Rich seams of coking coal run below this area and out under the sea. West Cumbria Mining hopes this coal could help minimise the 45Mtpa of coking coal currently imported by the UK and Europe.

The mine will sit on the former Marchon Industrial site, where it will take advantage of the existing Sandwith Anhydrite mine drift tunnels to gain access to the high-value coking coal that lies offshore. The Sandwith Anhydrite mine tunnels have now been fully investigated and planning can begin regarding their remediation, as they are currently damaged and unworkable from 30 years of neglect.

The mine, to be known as Woodhouse Colliery, is hoped to produce 3.2Mtpa. It will use run-out and pocket extraction, taking advantage of technological advances to mitigate many of the safety concerns surrounding the extraction. West Cumbria Mining hopes to begin production in 2019.

Task 4. Give brief characteristics of the UK mining areas mentioned in the text (minerals being extracted, technologies being applied)

Task 5. Find more information about mineral deposits on the territory of the UK.

Text 5

FUTURISTIC TECHNOLOGIES IN CONSTRUCTION

Task1. Read the words, underline the stressed syllable, give the Russian equivalents:

volcanic, architect, autonomous, capsule, bacteria, polymer, aquarium, artillery, machine, component, capillary.

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Human dwellings, unreinforced concrete, dome, girder, swarm, nanobot, self-charging, susceptible, to start from scratch, sodium silicate, durability, armored.

Task 3. Read and translate the text.

In the beginning, there was mud. The earliest human dwellings were constructed of nothing more than mud-and-straw bricks baked in the sun. The ancient Romans were the first to experiment with concrete, mixing lime and volcanic rock to build majestic structures like the Pantheon in Rome, still the largest unreinforced concrete dome in the world.

Over the centuries, engineers and architects have devised ever-new ways to build taller, stronger and more beautiful creations using game-changing materials like steel girders, earthquake-proof foundations and glass curtain walls.

But what does the future hold for construction technology? Will there come a day when noisy construction crews are replaced by swarms of autonomous nanobots? Will the cracks in concrete foundations one day miraculously heal themselves, or gas stations be replaced by electric cars running on self-charging roads?

Concrete is the single most widely used construction material in the world. In fact, it is the second-most consumed substance on Earth, after water. Think of all the concrete homes, office buildings, churches and bridges built each year. Concrete is cheap and widely adaptable, but it's also susceptible to cracking and deterioration under stresses like extreme heat and cold.

In the past, the only way to fix cracked concrete was to patch it, reinforce it, or knock it down and start from scratch. But not anymore. In 2010, a graduate student and chemical engineering professor at the University of Rhode Island created a new type of "smart" concrete that "heals" its own cracks. The concrete mix is embedded with tiny capsules of sodium silicate. When a crack forms, the capsules rupture and release a gel-like healing agent that hardens to fill the void.

This is not the only method of self-healing concrete. Other researchers have used bacteria or embedded glass capillaries or polymer microcapsules to achieve similar results. However, the Rhode Island researchers believe their method is the most cost-effective.

Prolonging the life of concrete could have huge environmental benefits. Worldwide concrete production currently accounts for 5 percent of global carbon dioxide emissions. Smart concrete would not only make our structures safer, but also cut back on greenhouse gasses.

For decades, chemical engineers have dreamed of a material that combines the strength and durability of metal with the crystal-clear purity of glass. Such a "clear metal" could be used to construct towering glass-walled skyscrapers that require less internal support. Secure military buildings could install thin transparent metal windows impervious to the highest-caliber artillery fire. And think of the monstrous aquarium you could build with this stuff!

Back in the 1980s, scientists began experimenting with a novel type of ceramic made from a powdery mix of aluminum, oxygen and nitrogen. A ceramic is any hard, usually crystalline material that's made by a process of heating and cooling. In this case, the aluminum powder is placed under immense pressure, heated for days at 2,000 degrees C (3,632 degrees F) and finally polished to produce a perfectly clear, glass-like material with the strength of aluminum. Known as **transparent aluminum**, or ALON, the space-age material is already being used by the military for making armored windows and optical lenses.

3-D printing has finally gone mainstream. Makerbot is selling nifty (and just about affordable) desktop machines that can print out fully rendered 3-D plastic toys, jewelry, machine parts and artificial limbs. But what if you want to print something bigger than a shoebox? Could you actually build a 3-D printer large enough to print out a plastic house?

The answer is "yes." A Dutch architecture firm has launched an ambitious public art project to build a 3-D printed house. But first, they had to build one of the world's largest 3-D printers, called the Kamermaker or "room maker." Using the same plastic source material as small-scale 3-D printers, the Kamermaker can print out large LEGO-like plastic components that will be assembled into individual rooms of the house. The rooms will then lock together — again, think LEGO — with the printed exteriors of the home designed to look like a traditional Dutch canal house.

Meanwhile, a Chinese construction company is building houses using a giant 3-D printer that sprays layers of cement and construction waste to assemble the homes. The company says the houses will cost less than $5,000 each, and it can produce up to 10 of them in a day.

Task 4. Give answers to the following questions:

1. Which technologies in constructions are mentioned in the text?
2. What prospects of construction are observed?
3. Which of the described technologies are being widely used in your country?

Text 6

ABUNDANCE, OCCURRENCE AND RESERVES OF RARE-EARTH ELEMENTS

Task 1. Read the words, underline the stressed syllable, find the Russian equivalents:

concentration, percent, product, element, province, ton, equivalent, reserve, manufacture, magnet

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Abundant, economically viable, economic recovery, to smuggle, scrap metal

Task 3. Read the names of elements properly. Use dictionaries if needed. Give the Russian equivalents.

Zirconium, uranium, cerium, thulium, lanthanum, europium, gadolinium, lutetium, bastnaesite, monazite, loparite, nickel.

Task 3. Read and translate the text.

The rare earths are fairly abundant, but their availability is somewhat limited, primarily because their concentration levels in many ores are quite low (less than 5 percent by weight). An economically viable source should contain more than 5 percent rare earths, unless they are mined with another product—e.g., zirconium, uranium, or iron—which allows economic recovery of ore bodies with concentrations of as little as 0.5 percent by weight.

Of the 83 naturally occurring elements, the 16 naturally occurring rare-earth elements fall into the 50th percentile of the elemental abundances. Cerium, which is the most abundant, ranks 28th, and thulium, the least abundant, ranks 63rd.

Lanthanum and the light lanthanoids (cerium through europium) are more abundant than the heavy lanthanides (gadolinium through lutetium). Thus, the individual light lanthanide elements are generally less expensive than the heavy lanthanide elements.

Rare-earth ore deposits are found all over the world. The major ores are in China, the United States, Australia, and Russia, while other viable ore bodies are found in Canada, India, South Africa, and southeast Asia. The major minerals contained in these ore bodies are bastnaesite (fluorocarbonate), monazite (phosphate), loparite and laterite clays.

Chinese deposits accounted for about 95 percent of the rare earths mined in the world in 2009–10. About 94 percent of the rare earths mined in China are from bastnasite deposits. The major deposit is located at Bayan Obo, Inner Mongolia (83 percent), while smaller deposits are mined in Shandong (8 percent) and Sichuan (3 percent) provinces.

In 2010 the demand for rare-earth materials was 124,000 metric tons of rare-earth oxide (REO) equivalent. Officially, 130,000 metric tons of REO equivalent was mined, but a black market in rare earths was said to produce an additional 10–15 percent of that amount. Most black-market rare-earth materials are smuggled out of China.

As of 2010, known world reserves of rare-earth minerals amounted to some 88 million metric tons of contained REO. China has the largest fraction (31 percent), followed by countries formerly of the Soviet Union (Kola Peninsula, Tuva republic, and eastern Siberia in Russia, Kazakhstan, and Kyrgyzstan; 22 percent overall), the United States (15 percent), Australia (6 percent), and the remaining countries (26 percent). With reserves this large, the world would not run out of rare earths for 700 years if demand for the minerals remained at 2010 levels.

Considering both the limited reserves and high value of the rare-earth metals, recycling these elements from consumer products that reach the end of their useful life is expected to become more important. At present, only scrap metal, magnet materials, and compounds used in the manufacture of phosphors and catalysts are recycled. However, products that contain relatively large amounts of rare earths could be recycled immediately using existing techniques. These include rechargeable nickel–metal hydride batteries that contain a few grams to a few kilograms of $LaNi_5$-based alloys as a hydrogen absorber as well as large $SmCo_5$- and $Nd_2Fe_{14}B$-based permanent magnets.

Considering the complexity of many modern electronic devices, recycling of rare earths must be done simultaneously with recycling of other valuable resources and potentially dangerous substances. These include precious metals (such as silver, gold, and palladium), nonferrous metals (such as aluminum, cobalt, nickel, copper, gallium, and zinc), carcinogens (such as cadmium), poisons (such as mercury, lead, and beryllium), plastics, glass, and ceramics. Numerous scientific and engineering issues, therefore, must be resolved, first, in order to create consumer products that are easily recyclable at the end of their life and, secondly, to make recycling of rare earths both meaningful and economical, thus making the best use of the rare earths—an extremely valuable but limited resource provided by nature.

Task 4. Match the words in both columns to form collocations.

1) nuclear
2) water
3) ventilating
4) oil
5) multiple
6) soil
7) urban
8) storage
9) liquid
10) communication
11) continental

a) state
b) area
c) use
d) tunnel
e) shelf
f) plant
j) agencies
h) well
i) waste
j) table
k) system

Task 5. Find additional information on rare-earth elements mined in your country. Compare with those mentioned in the text.

Text 7

BENEFITS AND PITFALLS OF AUTOMATED MINING

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

control, center, ventilation, megawatt, corporation, sensor, ounce, productivity, combination, infrastructure, project, strategy

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

To haul, to procure, diminished, shared value, stakeholder, to oversee, to gain, joint-venture, host mine, commodity, to impose.

Task 3. Read and translate the text.

Mining companies across the world are rapidly adopting the latest automation technology to modernize their operations. In four of Rio Tinto's iron-ore mines in Australia, for example, the company uses 73 driverless trucks to haul iron ore 24 hours a day. Employees oversee the vehicles' operation from 750 miles away at Rio Tinto's centralized control center in Perth.

Nearly 8,500 miles to the west, Swedish mine operator Boliden has partnered with cell phone company Ericsson to build an autonomous gold mine. The 5G network Ericsson installed at the site allows the mine's ventilation system to save 18 megawatts of energy per year, an efficiency gain of 54 percent.

In the United States, Barrick Gold Corporation has partnered with Cisco Systems to integrate wifi sensors in its mines near Elko, Nevada, to track the output of every miner. Barrick is using this and other automated technologies to achieve its goal of lowering production cost to US $700 per ounce of gold.

And in Africa, Randgold Resources and AngloGold Ashanti use robotic loaders 800 meters below the surface in the companies' joint-venture Kibali Mine to drive output and improve worker safety.

Autonomous technologies have certain benefits that simply cannot be overlooked. Companies that implement automation technologies will quickly realize a significant increase in productivity and a decrease in expenditures. Some companies have seen productivity rise by 15-20 percent as they adopted new technologies.

The industry also will benefit from considerable increases in safety. By using automated equipment that can be maneuvered into unsafe areas and difficult locations, mining companies can send fewer miners underground while extracting a higher output with lower risk to their employees. For example, since implementing autonomous technologies in several of its African mines, Randgold Resources has seen a 29 percent quarter-on-quarter injury rate improvement.

This rapidly shifting landscape is expected to provide substantial value to the mining sector and its stakeholders. One report suggests that the combination of increased productivity and safety with decreased expenses may cause the mining automation market to grow by almost 50 percent in the next six years, reaching US $3.29 billion by 2023

But these benefits are not without their costs. Automated mining technologies require governments and the mining industry to consider how efficiency gains will change local mining communities. A study issued by the International Institute for Sustainable Development (IISD) forecasts that efficiency gains from automation will reduce the amount that mines contribute to government revenue in low- and middle-income host countries by up to $284 million per country.

Increased automation likely will result in significant GDP decreases in the nations that host mines, as mining companies rely less on fuel and other resources that they typically procure locally. Job loss is also a significant concern. New technologies will create opportunities to retrain workers and employ those with specialized skillsets while reducing the overall number of mine employees, particularly in lower- and middle-income host countries. Decreased employment in these communities will lead to decreased revenue derived from local spending and personal income taxes.

These forecasts have led local governments and business leaders to begin to rethink how automated technologies and mines fit into local economies. The owners of the Wintergreen Dogsled Lodge in Ely, Minnesota, for example, have suggested that mining communities, which are often located in rural areas, should invest in recreation and tourism to adjust to changes brought by automation.

To account for the diminished benefits from local procurement and employment, local governments may attempt to maximize the value derived from other industries and opportunities that are linked to the mining sector. Shared value can be created, for example, through increased downstream processing of extracted commodities, or through shared use of railway and other infrastructure developed for mining projects. Governments may also seek to impose higher taxes on profits or higher royalties on production. As increased productivity and decreased costs generate higher profits, governments may rely on additional tax and royalty income to replace the lost revenue and local spending that will result from decreased employment in mining communities.

The use of automation technology is quickly accelerating and changing the landscape of the mining industry. The short-term benefits are straightforward: Increased use of automation technology has considerable potential to increase productivity and safety at mines while decreasing expenses, resulting in higher profits throughout the industry. But this rapidly changing reality will also significantly affect the long-term relationship between the mining sector and the communities that host and regulate mines worldwide.

Turning a blind eye to the complexities that automated mining technologies present is not an advisable strategy for mining companies. The industry must consider these long-term realities and relationships to ensure continued innovation and growth for the benefit of both mining companies and their host communities.

Task 4. Make a table to compare advantages and disadvantages of automated mining using information from the text.

Task 5. Make a plan of the text. Retell the text according to the plan.

Text 8

MODERN TRENDS FOR RENEWABLE ENERGY PRODUCTION AND CONSUMPTION

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

geothermal, percent, biomass, industrialization, to accumulate, atmosphere, turbine, panel

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

To deplete, to account for, primary fuel, volatile, incentive

Task 3. Read and translate the text.

"Renewable energy" is energy produced from a source that is not permanently depleted. Sunlight, wind, flowing water, geothermal heat, and plants are examples of renewable energy resources. They can be produced today without damaging their ability to be produced in the future.

Over the past decade the use of renewable energy is becoming more important to people, industry, and governments. Why? Renewable energy resources are not depleted, they are becoming less expensive, and they have a softer environmental impact.

In 2009, renewable energy accounted for about eight percent of United States energy production/consumption. Of that amount solar, geothermal, wind, hydropower, and biomass each accounted for at least 1% of the total. The quantity of energy produced from renewable sources has increased steadily over time. Most significant is the rapid growth in biofuels and wind during the past decade.

Two important sources of renewable energy in the United States have always been wood and water power. Animal power might also be considered an important early source of renewable energy. These accounted for almost all of the energy produced in the United States until coal mining began in the mid-1700s and drilling for oil and gas began in the mid-1800s.

Once the production of fossil fuels became commercialized, wood and water were gradually replaced as primary fuels. It became less expensive and more convenient to supply the energy needs of a home or a factory from fossil fuels than from wood or water. Fossil fuels became the new primary fuels. Today - over 100 years later - they are still in that dominant position.

Fossil fuels allowed the industrialization of the United States, but their use was mainly clustered around mines and wells until efficient transportation methods were developed. In areas away from coal, oil, and gas deposits, water, wood and sometimes wind continued to power the nation. Since about 1970 renewable energy sources have provided only about 5% to 7% of the power consumption in the United States. However, in the past ten years renewable energy has received greater attention.

The prices of oil, natural gas and coal have been rising steadily, and the fossil fuel prices can be volatile and unpredictable. Although renewable energy has historically been more expensive, the cost differential decreases as prices for fossil fuels rise.

When coal mining began in the mid-1700s, the coal seams close to the surface were the first to be exploited. Over time the easiest to mine and highest quality coals were quickly mined out. What remains today is usually more challenging to mine or has a lower quality. Exploration for oil and gas quickly found the largest, shallowest deposits. Today the exploration targets are often smaller, deeper and located in difficult environments such as the deep ocean or the Arctic.

Fossil fuels such as oil, natural gas and coal are rich deposits of carbon buried deep in the Earth. They accumulated there slowly over hundreds of millions of years. When fossil fuels are burned, their carbon is returned to the atmosphere in the form of carbon dioxide - a greenhouse gas that contributes to global warming and climate change. In about two hundred years, humans have produced and burned a significant portion of Earth's fossil fuel resource, sending it into the atmosphere nearly a million times faster than it was removed to form fossil fuels.

Today, governments worldwide accept the fact that burning fossil fuels is rapidly modifying Earth's atmosphere, leading to climate change that has many undesirable impacts. In an effort to slow the release of carbon dioxide into the environment, governments are offering grants, tax incentives, and other programs designed to support renewable energy development.

While fossil fuel prices are rising, the cost of manufacturing solar panels, geothermal systems, wind turbines and other renewable energy equipment is falling on a cost-per-BTU basis. While the cost of renewable energy still remains high, the price trend is in a favorable direction. This is when government support can make a big difference. As more renewable energy projects are completed, their ability to integrate smoothly with buildings, vehicles and primary energy sources is improving. Mass production brings down prices, and a growing adoption rate increases availability of reliable equipment, parts and service expertise.

Renewable energy currently accounts for about 8.20% of the United States energy consumption. Most of that comes from biomass and hydroelectric sources. Since 1995 the amount of energy produced by renewable sources has increased by 15.9%. If the United States hopes to have 25% of its energy produced from renewable sources by 2025, an enormous push will be needed.

The most rapidly growing renewable energy source since 1995 has been wind power. The implementation of wind power has exploded with an increase of over 2000%. Although this is spectacular growth, wind contributes less than 3/4% of the nation's energy supply. Solar has grown over 55% since 1995, and the rapid fall in the per-kilowatt price of solar panels should support future growth. Geothermal has grown nearly 27%. New technologies and higher fossil fuel prices now make geothermal space-heating projects cost competitive with fossil fuel units.

The future of renewable energy is very bright. The cost per BTU has been falling. Methods of integrating them smoothly into buildings, vehicles and primary energy sources are improving. Climate change fears are motivating governments to support renewable energy projects with grants, tax relief and other incentives.

Task 4. Complete the following sentences with the information from the text.

1. Renewable energy is a type of energy produced.............
2. Two major sources of the renewable energy in the Unites States have always been..........
3. Although renewable energy has historically been more expensive.......
4. When fossil fuels are burned......
5. In an effort to slow the release of carbon dioxide into the environment......................
6. While fossil fuel prices are rising, the cost of.............

Task 5. Find information on renewable energy technologies used in your country. What are tendencies in manufacturing and applying these technologies?

TEXT 9

THE FUTURE OF MINING

Part 1

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

to transform, sensor, monitor, status, automatism, to analyze, to optimize, aspect, method.

Task 2. Read the words and combinations, translate and memorize them. Use a dictionary if needed.

Profitability, brute, circumstance, onerous nature, blockchain, haul distance, trackability, compliance.

Task 3. Read and translate the text.

The clever implementation of digital technologies like the Industrial Internet of Things (IIoT) and automation could transform mining, making it safer, more productive, efficient, sustainable, and profitable, and therefore better able to take on the challenges it faces. When we consider that over the last 15 years, the average cost of producing copper has risen by more than 300%, while the grade has dropped by 30%, these new efficiencies offer a cost-effective way to increase profitability.

"IIoT technology enables mining organisations to collect vast quantities of data about their operations remotely and in real time through internet-connected sensors."

One of the biggest areas of promise is in IIoT's ability to transform expensive and inefficient manual and mechanical processes into digital ones. IIoT technology enables mining organisations to collect vast quantities of data about their operations remotely and in real time through internet-connected sensors. This data can then be acted upon and used to improve efficiency on site, ensure a safe environment for miners and monitor the operational status of machinery.

Take transport and haulage. Sensors are currently used to collect data on how long trucks are kept waiting at different points within a mine, such as the time to be loaded. This data can then be analysed and used to improve the efficiency of haulage operations, for example reducing or increasing the number of trucks required hour to hour to ensure production is optimised around fuel usage, minimal maintenance time and haul distance.

The mining industry is a combination of brute force and some of the most advanced scientific and mathematical processes used in any industry. The application of technology will continue to remove people from the brute force aspect of the business, whilst advancing the ability to find, extract and process mined materials, quicker, cheaper and at a better rate per tonne.

Given the onerous nature of the work, the future will see mine employees focused on the business aspects of mining, such as managing a company's strategic relationships, and not in the field. Machines will not only be able to operate autonomously to a pre-determined plan, but will process data themselves and make decisions when circumstances change and sensors detect different conditions.

"Not only will the mines themselves be intelligent and all assets connected, but the value chain from mine all the way to the ultimate user of the materials will be connected, so that production can be planned and flexed to meet demand and adapt to resulting changes in commodity price. Artificial intelligence will make decisions on production and routes to market, informed by learning from connected global trends and the real-time capabilities of the companies' mining properties."

– Chris Mason, director of sales for EMEA, Rajant Corporation

The recent modest recovery in mining productivity has been threatened again as demand improves and prices recover, and as a result, the industry is under pressure to focus on methods to improve efficiency. Naturally this falls on the supply chain, and we believe, blockchain and smart contracts will be a key building block to achieve this.

Blockchain's role in sustainable and transparent supply chains could be a game changer, thanks to its ability to promote trackability, transparency and security through open peer to peer and incorruptible data sharing. This will offer a new tool to monitor and confirm compliance with sustainability and environmental ethical standards. Further to this, smart contracts, with their self-executing automatism and ease of replication can create significant efficiencies for global procurement teams and help ensure regulatory compliance.

"Ultimately, with more pressure on margins and inflationary costs, as well as corporate social responsibility, this technology will be key for the future development of the mining industry's supply chain. It's not a question of if, but when."

– Rebecca Campbell, mining partner, White & Case LLP

Task 4. Read the following statements. Decide if they are true (T) or false (F) according to the text.

1. The IIoT is a new educational platform.
2. The efficiency of haulage operations can be improved by sensors.
3. The field work will be replaced by business aspects.
4. The mining machines will be able to make decisions in different conditions.
5. Blockchain technology will never be used in mining.

Task 5. Write a summary of the text. (150-200 words)

Text 10

THE FUTURE OF MINING

Part 2

Task 1. Read the words, underline the stressed syllable, give the Russian equivalents:

cobalt, ion, registration, decade, exponential, era, battery, passenger, geologist, intervention, prevalent.

Task 2. Read the words, translate and memorize them. Use a dictionary if needed.

To witness, albeit, stripping ratio, compute stack, compatible, fraud risks, asset custody, plethora, collateralization, savvy business

Task 3. Read and translate the text.

While base and precious metals mining are mature markets, we are witnessing the start of a new era for lithium and cobalt production as demand for these two materials undergoes exponential growth from lithium-ion batteries. The compound annual growth rate for electric vehicles (EVs) uptake over the next decade is expected to be around 27%, but already growth rates are much higher than this, albeit off a low base. China's EV sales are rising by around 80% year-on-year and in Q2 in Europe, battery EV registrations were up 45.5% compared with Q2 2017. Imagine what sales growth rates will be when battery-only EVs are cheaper than internal combustion engine vehicles.

"Following the demand shock in 2015, when China put its weight behind EVs, that saw a rapid run up in lithium and cobalt prices, we are now seeing the supply response that has led to price falls this year, but with the end use market for lithium-ion batteries already growing rapidly, but still at the early stages of the innovation 'S'-curve, lithium and cobalt producers are going to work hard to bring enough supply on in a timely manner. Battery cell requirements for EVs, passenger and commercial, are forecast to grow from around 70GWh in 2017, to 1,600GWh in 2030. For any supply chain to keep up with such a rate of growth for an extended period of time will be exhausting, but it will require the lithium and cobalt markets to grow from small markets to significant markets in double quick time."

– William Adams, head of research, Metal Bulletin

The mine remains a uniquely hazardous and inconvenient workplace. Mines often have to pay higher wages for remote workers, in addition to high transport and accommodation costs. Another challenge is the impact of high workforce turnover caused by the 'fly-in fly-out' lifestyle. IIoT and automation offers a way around all the risks and expense inherent in employing people in these locations, while bringing the precision and bandwidth of technology to the heart of remote mining operations, all whilst improving productivity.

"These drones not only scan the mines from perspectives that are dangerous and near-inaccessible to humans, they also instantaneously communicate any information they pick up."

For example, Freeport-McMoRan is already using drones to create steeper pit slope angles in its mines, reducing the stripping ratio and amount of waste rock hauled before ore can be extracted. These drones not only scan the mines from perspectives that are dangerous and near-inaccessible to humans, they also instantaneously communicate any information they pick up. This makes for a more rapid and detailed analysis of the mine slopes without having to deploy highly skilled geologists or geotechnical engineers into an inherently hazardous environment or affecting production by closing haul roads.

"With machines becoming progressively more capable of acting with little manual intervention, a future where adaptable and autonomous machines carry out the on-site, operational tasks of mining while human employees monitor them remotely looks probable and highly profitable."

– Joe Carr, director of mining innovation, Inmarsat

Critical infrastructure industries such as mining are struggling to attract and retain the right technological capabilities. Ultimately, the main barrier for graduates entering these industries is proprietary outdated technologies, which demands time-consuming and expensive training and limits future job prospects. As a result, the job market stagnates and older generations are the only people with the knowledge of how specific systems work.

However, the operational technology and automation space is moving to the same compute stack –and if we can streamline software languages, these various parties will soon begin to speak the same language. This will reduce costs and streamline effectively so that there are enough people within an organisation and the wider industry sharing the same knowledge and skillsets. The alternative future is one where we see an ever-increasing skills gap.

"Looking ahead, companies will need to agree on technical standards that are open, based on common languages. This means process control systems in one organisation are compatible with those from another. This will not only make it easier and cheaper for existing staff to replace and repair control systems, it will also be easier for new talent to be attracted to and retained within the mining sector."

– Ed Harrington, director, The Open Group's Open Process Automation Forum

Traditionally, gold investments have taken the form of share investments into gold exchange-traded funds or acquisition of physical gold bars, which then need to be stored. The introduction of blockchain technology and its inherent attributes brings about many advantages to the transfer of gold.

The public ledger and full public access to all traceability and authentication documentation can minimise fraud risks that are present in what would otherwise be just a physical supply chain of asset custody.

"Gold-backed tokens will lower the barrier to entry and enable more retail investors to enter the market and hold tokens in divisible form. There is a plethora of use cases and appetite from both individuals and institutions – portfolio diversification, wealth preservation, payments, collateralisation for lending, and more."

– Kai C Chng, CEO and founder, Digix

Now that intrinsically safe devices are more prevalent, we'll see more technology actually down in the mines and the savvy businesses will be those that start to take advantage of this early. This will include improving on processes such as digital audit checks, where safety and quality control remains paramount. But we're likely to see an increase in areas like in-location video conferencing and digital product tracking.

Task 4. Give answers to the following questions:

1. Which branches of mining are mentioned in the text?
2. What are perspectives for efficient mining according to professional's opinions?

Task 5. Write a summary of the text (200-250 words).

БИБЛИОГРАФИЧЕСКИЙ СПИСОК

Электронные ресурсы:

1. https://www.onlinecollege.org/geology-going-digital/, свободный._Загл. с экрана.-Яз. англ.

2. http://www.bbc.co.uk/learningenglish/english/course/lower-intermediate/unit-17/session-3, свободный._Загл. с экрана.-Яз. англ.

3. https://www.machines4u.com.au/mag/around-world-remote-control-mining/, свободный._Загл. с экрана.-Яз. англ.

4. http://www.engineersjournal.ie/2016/06/14/future-trends-in-engineering-global-urbanisation-the-fourth-industrial-revolution/, свободный._Загл. с экрана.-Яз. англ.

5. https://science.howstuffworks.com/environmental/energy/5-innovations-oil-drilling.htm, свободный._Загл. с экрана.-Яз. англ.

6. https://www.mining-technology.com/features/mining-the-uk/, свободный._Загл. с экрана.-Яз. англ.

7. https://www.ielts-mentor.com/reading-sample/academic-reading/723-ielts-academic-reading-sample-73-the-birth-of-scientific-english, свободный._Загл. с экрана.-Яз. англ.

8. https://science.howstuffworks.com/engineering/structural/10-futuristic-construction-technologies.htm, свободный._Загл. с экрана.-Яз. англ.

9. https://www.britannica.com/technology/tunnel/Future-trends-in-underground-construction, свободный._Загл. с экрана.-Яз. англ.
10. https://www.pri.org/stories/2014-10-06/how-did-english-become-language-science, свободный._Загл. с экрана.-Яз. англ. http://www.mining.com/web/benefits-pitfalls-mining-automation/, свободный._Загл. с экрана.-Яз. англ.

11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3341706, свободный._Загл. с экрана.-Яз. англ.

12. https://ucrtoday.ucr.edu/41025, свободный._Загл. с экрана.-Яз. англ.

13. https://www.pcmag.com/article2/0,2817,2372163,00.asp#, свободный._Загл. с экрана.-Яз. англ.

14. https://www.sciencenewsforstudents.org/article/scientists-find-easier-way-trap-carbon-dioxide-rock, свободный._Загл. с экрана.-Яз. англ.

15. https://www.mining-technology.com/mining-safety/future-of-mining-industry-predictions, свободный._Загл. с экрана.-Яз. англ.