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STRATA MATTER FORMATION MODEL**Evgeniy P. Zaporozhets, Nikita A. Shostak, Dmitry G. Antoniadi, Sergey V. Dolgov**

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МОДЕЛЬ ОБРАЗОВАНИЯ ВЕЩЕСТВ В НЕДРАХ**Е.П. Запорожец, Н.А. Шостак, Д.Г. Антониади, С.В. Долгов**

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matter, water, gas, dissociation, crust, mantle, strata, neutrino, neutron, formation, Periodic system, planet, proton, synthesis, chemical element, electron.

Using the model developed in the paper, the process of genesis in depths of the planet of all chemical elements given in the Periodic Mendeleev's system is presented. Formation of nuclei and atoms occurs according to the elementary reactions of the interaction of electrons, neutrinos and protons entering the subsoil with high-energy cosmic streams and as a result of high-temperature dissociation of water descending into the depths of the planet under the action of gravity. Matter synthesis goes on the principle of a simple chemical element to the complex. It is mathematically expressed in terms of the relative time of formation of any chemical element of the Periodic System in hydrogen. This time indirectly indicates the prevalence of a chemical element in nature. Formation of chemical elements occurs with the release of a large amount of thermal energy, which heats the magma, moving it to the sides with a lower energy level. Getting into areas with a lower energy level, atoms of chemical elements interact with each other and form various molecular compounds according to chemical reactions. Moving magma affects the crust of the planet. As a result, cracks and faults are formed in thin places of the crust. Chemical elements and molecular compounds rise to the surface under the action of high pressure and temperature. Massive chemical elements and heavy substances are deposited in deeper layers of the earth's crust or carried to the surface with magma. Light matter such as hydrocarbons reaches the surface through cracks and fractures. Oil is formed from condensed hydrocarbons; gas is formed from uncondensed ones. When they enter geological confined spaces, they form new or fill the known formations and field being developed. If there are no closed cavities in the way of hydrocarbons, then hydrocarbons appear on the surface as emissions from faults and mud volcanoes.

The model reflects reverse processes such as dissociation of chemical elements into protons, electrons and neutrinos. During the dissociation, energy is absorbed; a local compression of the magma occurs.

Expansion of magma during the formation of chemical elements and its contraction during their dissociation cause low and high frequency pulsations of the planet, during which excess energy is discharged into space.

It is indicated that initially all chemicals, including water, were formed in the mantle from high-energy particles such as protons, electrons and neutrinos emitted by the sun and space. It means that our planet is the product of protons, electrons and neutrinos.

The main provisions of the developed model are confirmed by results of experimental studies of similar processes and results of geological and geophysical studies in the Black and Caspian Seas, on sea and ocean shelves as well as on the Kolskaya ultradeep well. This allowed to assert that the developed model has a fairly high degree of reliability.

Ключевые слова:

вещества, вода, газ, диссоциация, земная кора, мантия, недра, нейтрино, нейтрон, образование, Периодическая система, планета, протон, синтез, химический элемент, электрон.

С помощью разработанной модели представлен процесс генезиса в глубинах планеты всех химических элементов в Периодической системе Д.М. Менделеева. Образование ядер и атомов происходит согласно элементарным реакциям взаимодействия электронов, нейтрино и протонов, поступающих в недра с высокоэнергетическими космическими потоками, и в результате высокотемпературной диссоциации воды, опускающейся под действием гравитации в глубины планеты. Синтез веществ идет по принципу от простого химического элемента к сложному. Он математически выражен через относительное время образования любого химического элемента Периодической системы по водороду. Это время косвенно указывает на распространенность в природе того или иного химического элемента. Образование химических элементов происходит с выделением большого количества тепловой энергии, которая разогревает магму, перемещая ее в стороны с меньшим энергетическим уровнем. Попадая в области с меньшим энергетическим уровнем, атомы химических элементов вступают между собой во взаимодействие и, согласно химическим реакциям, образуют различные молекулярные соединения. Магма, перемещаясь, воздействует на кору планеты, и в тонких местах последней образуются трещины и разломы. Химические элементы и молекулярные соединения под действием высокого давления и температуры поднимаются к поверхности. Массивные химические элементы и тяжелые вещества осаждаются в более глубоких слоях земной коры или выносятся на поверхность с магмой. Легкие вещества типа углеводородов достигают поверхности через трещины и разломы. Из сконденсированных углеводородов образуется нефть, из несконденсированных – газ. При попадании в геологические замкнутые пространства они образуют новые или пополняют известные разрабатываемые залежи и месторождения. Если на пути углеводородов не встречаются замкнутые полости, то углеводороды проявляются на поверхности в виде выбросов из разломов и грязевых вулканов. В модели отражены обратные процессы – диссоциации химических элементов на протоны, электроны и нейтроны. В процессе диссоциации поглощается энергия и происходит локальное сжатие магмы.

Расширение магмы при образовании химических элементов и сжатие ее при их диссоциации вызывают низко- и высокочастотные пульсации планеты, во время которых излишняя энергия сбрасывается в пространство.

Указано, что изначально все химические вещества, в том числе и вода, образовались в мантии из высокоэнергетических частиц: протонов, электронов и нейтрино, излучаемых солнцем и космосом, т.е. наша планета является порождением последних.

Основные положения разработанной модели подтверждены результатами экспериментальных исследований подобных процессов и результатами геологических и геофизических исследований в Черном и Каспийском морях, на морских и океанических шельфах, а также на Кольской сверхглубокой скважине. Это позволило утверждать, что разработанная модель обладает достаточно большой степенью достоверности.

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Introduction

It is extremely important to know the origin of extracted matter which is widely used in human activities. Understanding of matter origin will help to say whether they belong to renewable or non-renewable material or energy sources. Such substances include hydrogen, carbon, their compounds such as oil, natural and associated petroleum gases, oxygen, silicon, metals and other chemical elements included in the Periodic Table. In order to solve this problem, a model of their formation in the strata of the planet has been developed. Theoretical ideas of D.I. Mendeleev about interactions of water with metals and their carbides in the earth's crust that form hydrocarbons as well as views of N.A. Kudryavtsev [1] on the genesis of oil and gas in the depths of the planet were used as a base idea in the model.

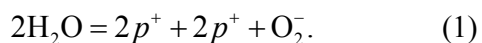
Strata matter formation model

Based on the model developed, various substances located deep in our planet are caused by two matter sources.

The first source is represented by streams of high-energy particles such as protons, electrons and neutrinos emitted by the sun and coming from space [2]; water is the second one. Protons and electrons reach the depths of the planet due to high speed, about 700-1,000 km/s depending on sun activity and cosmic radiation intensity. There are no obstacles for neutrinos.

Water is the second source. According to some ideas, water penetrates into the mantle under the influence of gravity from the surface of the planet through cracks and faults in its crust or flow and diffuses through the lithosphere. According to others [3] – that is the result of the chemical reaction of silicon dioxide with hydrogen at the temperature of 1400 °C and pressure of 20 thousand times greater than the surface of the planet.

Nevertheless, water is at the top of the mantle, where at high temperature (about 1,000-2,500 °C) and pressure (more than 20 GPa) under the influence of a magnetic field and radiation, water dissociates [4] into protons and oxygen ions:



Electrons, neutrinos and protons, which entered the mantle from space and water, interact with each other, forming neutrons, according to elementary reactions [2]:

– charge

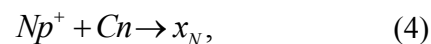
$$p^+ + e^- + \nu = n \quad (2)$$

– and material balance

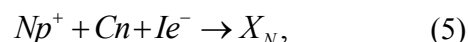
$$m_p + m_e + m_\nu = m_n, \quad (3)$$

where p^+ – proton; e^- – electron; ν – neutrino; n – neutron; rest masses: electron $m_e = 0.91 \cdot 10^{-27}$ g; proton $m_p = 1,836m_e$; neutrino $m_\nu \sim 3 m_e$; neutron $m_n = 1,840m_e$.

Protons and neutrons together form the atomic nuclei of chemical elements.



and their atoms together with electrons:



where N – the number of protons; C – neutron number; I – number of electrons; x_N and X_N – nucleus and its chemical element. The number of protons N in the nucleus of a chemical element is equal to the atomic number of the latter and determines its place in the Periodic Table of D.I. Mendeleev [2].

Protons and neutrons in nuclei and atoms of chemical elements are connected due to their collisions with high kinetic (thermal) and potential (pressure) energy. Stable nuclei from them and, accordingly, atoms are formed due to enormous magnetic forces acting at distances close to their geometric centers. Magnetic forces on the magnetic moments of the proton $\mu_p = 2.792763\mu_{\text{nucleus}}$, neutron $\mu_n = -1.91315\mu_{\text{nucleus}}$, electron $\mu_e \approx -1.0016\mu_B$, where $\mu_B = 9.274 \cdot 10^{-21}$ erg·G⁻¹ – Bohr magneton; $\mu_{\text{nucleus}} = 5.051 \cdot 10^{-24}$ erg·G⁻¹ – nuclear magneton.

The nuclei and atoms of chemical elements are formed on the principle of sequence from simple, having a small atomic mass, to a complex, with a larger atomic mass. For clarity Fig. 1 shows the models of the nuclei of atoms of chemical elements, reflecting the sequence of their formation from hydrogen to oxygen [5].

At a high magma temperature, a positively charged proton enters into a bond with a free electron, and hydrogen is formed by the first chemical element (Fig. 1*a*). Further, the isotopes of the hydrogen atom are formed (see Fig. 1*b*, 1*c*), nuclei of which contain one or two neutrons in addition to the proton. The atom in the nucleus of which a nucleon is formed due to the magnetic forces of the magnetic fields with opposite poles of the proton and neutron is called deuterium (see Fig. 1*b*). There is tritium nucleus model presented in Fig. 1. There is 0.015 % deuterium and 10^{-10} % tritium exists in nature. A small amount of deuterium and tritium in nature compared with the amount of hydrogen indicates the difference in the structures of the magnetic fields of the proton and neutron, which does not provide sufficient stability of the nucleus of deuterium and tritium.

The following combination of proton and neutron compounds (see Fig. 1*d*, 1*e*) leads to the formation of nuclei of helium atoms. If the neutron is between two protons (see Fig. 1*d*), then it will shield their electric fields and weaken the electrostatic forces of repulsion of protons. This is how the structure of the isotope of the helium atom is formed, which is presented in nature in the amount of 0.000138 %. Fig. 1*d* shows the second option of the formation of the nucleus of the helium atom. Two neutrons screen the electric fields of two protons. Here the repulsive forces are more weakened than in the previous version. Therefore, such a core is more stable.

The number of helium atoms whose nuclei consist of two protons and two neutrons is 99.999862 %. There are isotopes of helium atoms, the nuclei of which contain four or six neutrons. Such isotopes are very unstable, and their lifetime is in milliseconds [6-8].

A flat symmetric nucleus (see Fig. 1*e*) belongs to the carbon atom that enters organic compounds. It sets the shape of the scaled graphite structure. The carbon core with a different spatial arrangement (see Fig. 1*h*) is inherent in diamond. This structure has seven neutrons. One is located in the center of the spatial coordinate system, and three pairs of other neutrons are directed along the

coordinate axes. Along these axes, a proton is attached to each neutron. The nucleus of a carbon (diamond) is an ideal site of the crystal lattice. This shape of the core provides the strength of a diamond crystal. The mechanical properties of diamond are radically different from the mechanical properties of graphite. Experimental spectroscopy [9, 10] shows that 98.90 % of the carbon nuclei contain six protons and six neutrons and only 1.1 % of the nuclei of this element have seven neutrons.

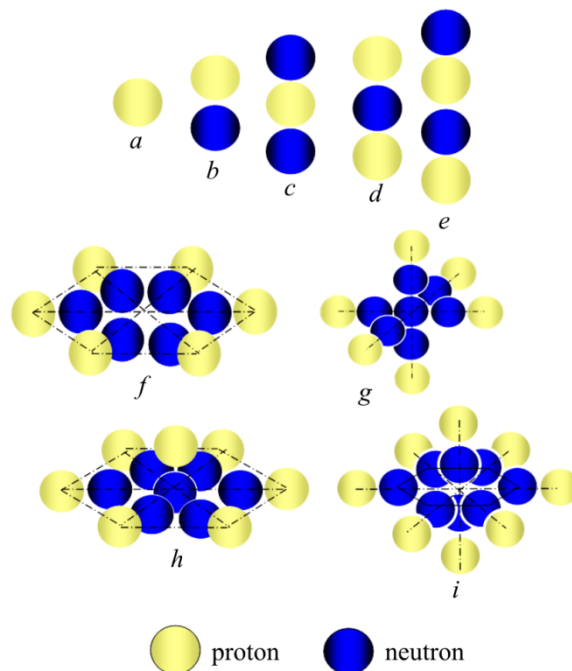


Fig. 1. Models and order of formation of atomic nuclei:
a – hydrogen; *b* – deuterium; *c* – tritium;
d – isotope helium; *e* – helium; *f* – carbon type graphite;
g – carbon diamond; *h* – nitrogen; *i* – oxygen

Seven neutrons and seven protons have the nucleus of the nitrogen atom (see Fig. 1*h*).

The nucleus of the oxygen atom (see Fig. 1*i*) has eight protons and eight neutrons. The experimenters ascribe magical stability to the nucleus of this atom. The symmetry of the arrangement of neutrons and protons in this nucleus confirms this. In nature there are 99.762 atoms of oxygen that have eight neutrons and eight protons, 0.038 % of oxygen isotopes contain nine neutrons and eight protons, 0.2 % – ten neutrons and eight protons.

As an example Fig. 2 shows the nuclei of atoms of sodium, magnesium, chlorine and potassium. The nuclei of these elements are more

complicated, and, naturally, the atomic masses of their chemical elements are larger than those of hydrogen, helium, or carbon.

The Fig. 1 and Fig. 2 show that the nuclei of a simple structure serve as the fundamental basis for the following nuclei of a more complex structure. In this regard, the atoms corresponding to the nuclei of chemical elements are formed in the same sequence: from simple to complex. This principle can be expressed in terms of the relative time $\bar{\tau}_{X_N}$ of formation of any chemical element of the Periodic System of hydrogen:

$$\bar{\tau}_{X_N} = \frac{\tau_{X_N}}{\tau_H} = \left(\frac{A_N}{A_H} \right)^e, \quad (6)$$

where τ_{X_N} and τ_H – time of chemical element and hydrogen atoms formation; A_N – atomic mass of a chemical element having a serial number N in the Periodic System; A_H – atomic mass of hydrogen; $e = 2.71828$.

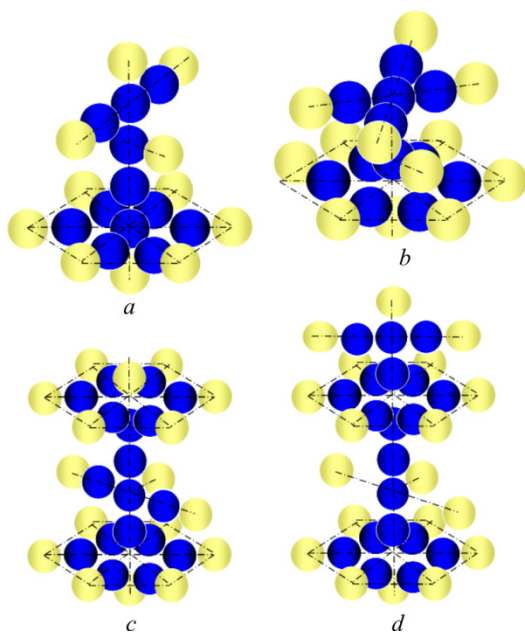


Fig. 2. Models of atomic nuclei: *a* – sodium; *b* – magnesium; *c* – chlorine; *d* – potassium

The ratio of atomic masses, in brackets, reflects the complexity of the structure of the formed chemical element compared to hydrogen. The greater its value, the more difficult the atomic compound of a chemical element in comparison with hydrogen is. The power dependence with e exponent indicates the universal character of the process of the

formation of the chemical element atom. This character is inherent in the processes occurring in almost all natural systems.

Consuming the time during which a hydrogen atom is formed as 1 according to equation (6), relative time of formation of the remaining atoms of the chemical elements of the Periodic Table can be roughly estimated. For example, its value for helium is 43.3; carbon – 858; nitrogen – 1,305; oxygen – 1,876; sodium – 5,030; magnesium – 5,647; aluminum – 7,778; silicon – 8,586; chlorine – 16,241; potassium – 21,133; calcium – 22,638; ... iridium – 1,609,356; platinum – 1,678,631; gold – 1,725,844; mercury – 1,822,769; lead – 1,974,494; ... one hundred and tenth element of Darmstadtia – 4,148,012. Values of the relative time of formation of the first and one hundred and tenth elements differ by $4 \cdot 10^6$ times. Taking the duration of the experiment to obtain the one hundred and tenth element of lead bombardment by nickel atoms during five days [11] as the time of its formation $\tau_{X_{110}} \approx 4.32 \cdot 10^5$ s, we can determine the time of formation of the hydrogen atom $\tau_H \approx 0.1$ s.

Relative time indirectly indicates the prevalence of a chemical element in nature. Hydrogen has the lowest relative time and is the most common. Hydrogen is the part of the water of the most common substance. Then, chemically inactive helium, practically unrelated to anything, very volatile, goes into the upper atmosphere and leaves the planet under the influence of solarwind. Lithium is a very active element and is the integral part of many chemicals. Carbon, nitrogen and oxygen are widespread in nature. Chemicals that have large values of the relative time of formation such as iridium, platinum and gold are found rarely. Rare earth elements are found extremely few. Elements such as iridium, platinum, gold and mercury will be in the same area, since their relative time is almost the same. A.N. Tolstoy was astute, describing the existence of the olivine belt in the mantle, where all these elements exist together, and gold is dissolved in mercury and is in the form of amalgam. Chemical elements with a small atomic mass are concentrated in the upper

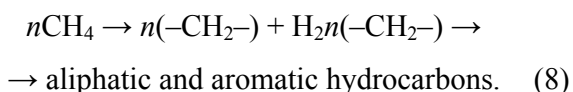
layers of the mantle, while heavy elements tend to gravitate to its depth.

Chemical elements are formed with the release of a large amount of thermal energy, which heats the mantle. According to the laws of thermodynamics local heating of the mantle substance (magma) leads to the displacement of the latter in the direction of a lower energy level. During such movements, hydrodynamic mixing of magma occurs, which naturally leads to some redistribution of elements in the mantle space. However, the general trend of their distribution persists.

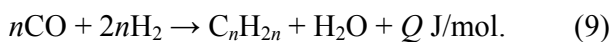
Getting into areas with a lower energy level, the atoms of chemical elements interact with each other and according to chemical reactions (redox, reductive, redox-reductive, ... synthesis), form various molecular compounds, for example H_2O ; CO ; CO_2 ; SiO_2 ; Fe_3O_4 ; oxides, hydroxides, salts etc. At the temperature of $\sim 1,000-1,500$ °C in presence of carbides, nitrides, borides and oxides of metals of group IV of the Periodic System, hydrocarbon radicals CH , CH_2 , CH_3 , methane CH_4 and other complex hydrocarbons are formed by reaction [4]



In presence of metals of the VIII group of the Periodic System (cobalt nickel, iron with additives of thorium oxide, magnesium, zirconium, titanium) complex hydrocarbons are obtained by the reaction



Paraffin hydrocarbons are obtained from carbon monoxide and hydrogen in the presence of group VIII metals:



Moving magma affects the crust of the planet, in which thin places cracks and faults are formed. Chemical elements and molecular compounds under the action of high pressure and temperature rise to the surface. Atoms of metals that do not react with other elements precipitate and accumulate on the solid surfaces of the lithosphere as they cool down. At the same time,

their concentration decreases with decreasing temperature and, accordingly, depth. Distribution of gold over the depth of the Kolskaya ultradeep well is an example [12] (Fig. 3). Massive chemical elements and heavy substances are deposited in the deeper layers of the earth's crust or are carried with the magma to the surface.

Hydrocarbons going up through the cracks and faults form new or replenish known developed deposits when get into geological closed spaces [13]. Oil is formed from condensed hydrocarbons; gas is formed from uncondensed ones. In the case of the diffusion of hydrocarbons into small closed pore spaces in the rock, shale gas or oil reservoirs are formed. If there are no closed cavities on the way of hydrocarbons, then hydrocarbons appear on the surface for example in the form of emissions from faults and mud volcanoes (Fig. 4-8) [14-24]. Ways of emission of hydrocarbons into the atmosphere are described in [25]. Huge reserves of hydrate deposits are confined to gas manifestations in faults on the oceanic and sea shelves (Fig. 9). Their global reserves are estimated at $3.114 \cdot 10^{15} \dots 7.634 \cdot 10^{18}$ m³ [26, 27]. For comparison, the amount of air in the atmosphere is $5 \cdot 10^{18}$ m³.

The formation of the new mass of substance from elementary particles (protons, electrons, neutrinos) should lead to the growth of the planet. In 1888, engineer I.O. Yarkovskiy suggested that some types of pervasive ether can be absorbed inside the Earth and transmute into new chemical elements, leading to the expansion of the planets and changes in gravity [28].

For a long time of geological epochs, the planet should have incredibly increased or exploded from the excess of internal energy. However, during the existence of modern human civilization, this has not happen. Therefore, it can also be concluded that inside the planet there are reverse processes such as dissociation of chemical elements and substances into elementary particles.

The process of dissociation takes place in deeper layers of the mantle, where its temperature exceeds the temperature at which nuclei and atoms of chemical elements are formed. In the process of dissociation, energy is absorbed, a local compression of magma occurs.

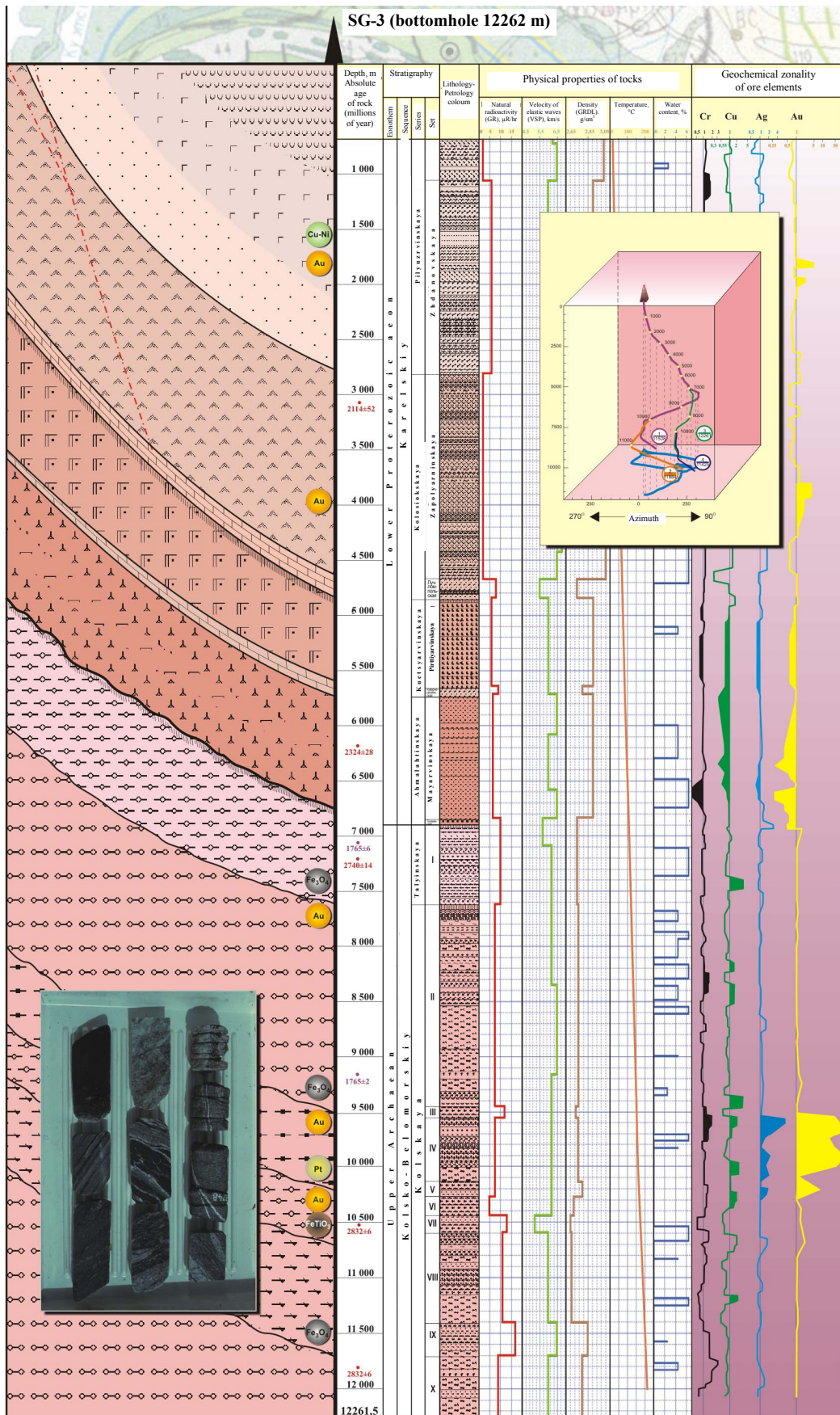


Fig. 3. Geological profile of the Kolskaya ultra-deep well

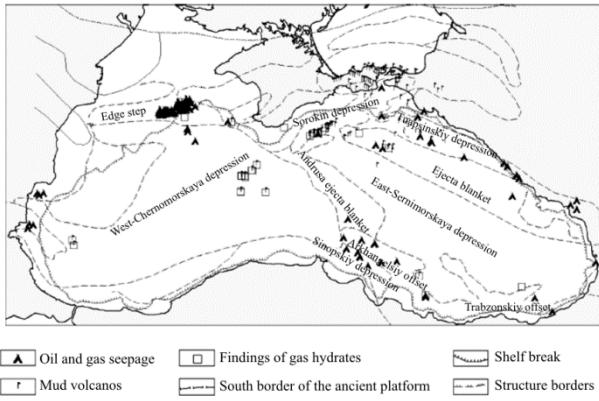


Fig. 4. Overview of the location of mud volcanoes, gas and oil outlets and accumulations of gas hydrates at the bottom of the Black Sea

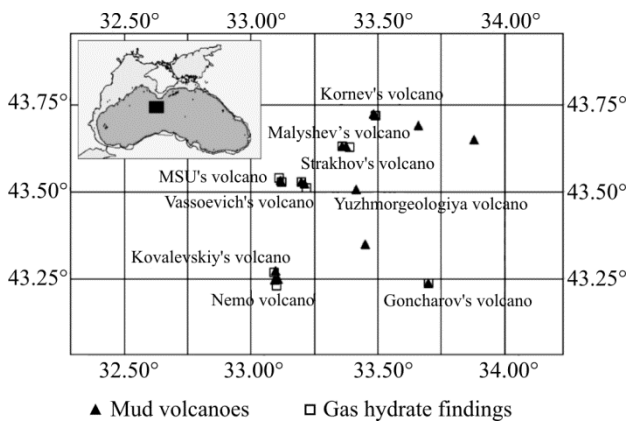


Fig. 5. Layout of mud volcanoes and gas hydrate findings in the West Black Sea depression

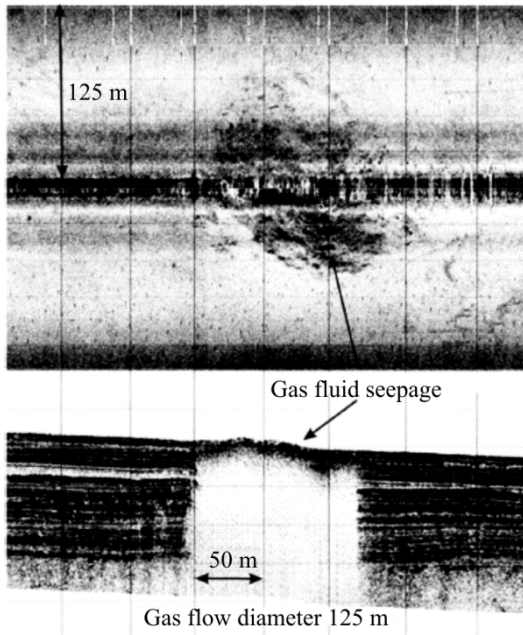


Fig. 6. Sonogram and profilogram of gas flow from a mud volcano

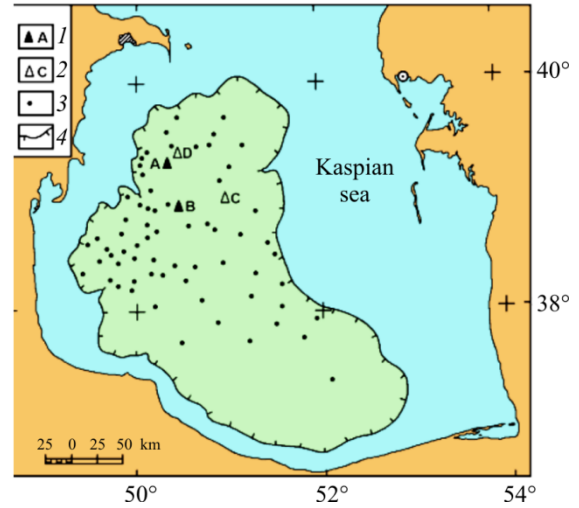


Fig. 7. South Caspian gas hydrate province of mud volcanoes: 1 – identified accumulations of gas hydrates on mud volcanoes (A – Buzdag, B – Elm); 2 – clay diapirs that do not contain gas hydrates (C – northern, D – nameless on the Abih shaft); 3 – underwater mud volcanoes; 4 – boundary of the gas hydrate province

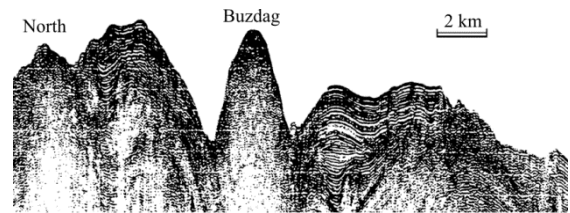


Fig. 8. Fragment of seismic profile passed through the investigated hydrate-bearing mud volcano in the Caspian Sea



Fig. 9. Continental and subaqueous manifestations of gases and hydrates: BSR – supposed gas hydrate deposits; by core – confirmed gas hydrate deposits; production – gas hydrate deposits under development; Mallik – gas field in the delta. Mackenzie, Canada; Messoyha – gas hydrate deposit located in the north-east of Western Siberia, 250 km west of the city of Norilsk; Nankai – gas hydrate field on the shelf of Japan in the region of the eastern Nankai trough

Magma expands during formation of chemical elements and compresses during their dissociation. That causes low- and high-frequency pulsations of the planet, during which excess energy is dumped into the space.

In conclusion, it can be said that initially all chemicals, including water, were formed in the mantle from high-energy particles such as protons, electrons and neutrinos emitted by the sun and space, i.e. our planet is a product of the latter.

Model verification

The verification of the developed model is based on the following known data.

1. Comparison of the main parameters and results of plasma-chemical effects on water with the processes occurring with it in the magma.

Experimental parameters and results of studies of plasma-chemical processes are taken from the work of Japanese [29] and Russian [5] scientists. Research in this direction was carried out by them jointly. The Russian group was headed by F.M. Kanarev, Japanese one – by Tadahiko Mizuno, working in Division of Quantum Energy Engineering Research group of Nuclear System Engineering, Laboratory of Nuclear Material System Faculty of Engineering, Hokkaido University, Kitaku, North 13, West-8 Sapporo 060-8628, Japan. The Russian group put and carried out experimental work, while Japanese one conducted a chemical analysis using spectroscopy (EDX).

The processes are comparable in terms of material. Aqueous solutions of electrolytes are used in the plasma-chemical process in the developed model. Basically, water located at the top of the mantle is an electrolyte, since it is in contact with a multicomponent substance of magma and act as an electrolyte.

In terms of energy during plasma-chemical process the aqueous electrolyte is affected by electrical, radioactive (there is a hard radiation when an electric discharge is presented) and thermal energy with a temperature of $\sim (1-3)10^3$ °C. Water in the mantle is affected by high-temperature magma, which has a similar energy level. It is radioactive; a magnetic field in the magma always excites an electric current.

Based on the stated above and similarity theory it can be argued that the processes occurring during the plasma chemical effect on water are similar to the processes occurring with water in magma. Therefore, we use experimental results of studies of the first processes to characterize the second ones.

As a result of studies of plasma-chemical processes by Japanese and Russian scientists:

– experimentally detected and confirmed neutron formation;

– on the surfaces of the cathodes, made of 99.9 % iron, precipitation appeared, which had chemical compositions presented in the table.

Chemical composition of precipitation on surfaces of cathodes, %

Electrolyte solution	Al	Si	Cl	K	Cr	Fe	Cu
KOH	–	0.94	–	4.50	1.90	92.00	0.45
NaOH	1.10	0.55	0.20	0.60	1.60	94.00	0.65

Thus, it was experimentally shown the possibility of the formation of neutrons from water in the mantle of new atomic elements.

2. Formation of a new mass of substance from elementary particles (protons, electrons, neutrinos) leads to the planet's growth. The circumference of the globe increases on average by 17.6 cm/g, which is confirmed by measurements of NASA experts [31].

3. An increase in thermal energy of about 1.4-1.8 times compared with the consumed electrical energy, indicating the occurrence of low-temperature nuclear (atomic) synthesis of chemical elements from water, was experimentally detected in the plasma-chemical process [5]. This confirms the theory stated in the model about the release of energy in the process of formation of chemical elements.

4. The effect of cold nuclear fusion was experimentally revealed in [32-38], as well as by Professor Yoshiaki Arata from Osaka University (Osaka University) and his Chinese counterpart Yue-Chang Zhang from Shanghai University (Shanghai Jiao Top University). Deuterium was pumped into a special cell of palladium and zirconium oxide under ultrahigh pressure. Nuclei of atoms were close to each other in the resulting

palladium-zirconium-deuterium “plasma”, that a cold fusion reaction begins with the release of helium and energy. The temperature rose from 20 to 70 °C and remained constant for 50 hours [32]. This experiment confirms the statement about the release of energy in the process of formation of chemical elements under high pressure.

5. The postulate of low and high frequency pulsations of the planet caused by the expansion of magma during the formation of chemical elements and its compression during their dissociation, during which excess energy is discharged into space, is confirmed by theoretical studies on the stability of matter [39, 40], which states that any body (substance) emits two types of radiation: high-frequency and low-frequency, depending on mass and density respectively.

6. The formation of hydrocarbons in depths (mantle and crust) of the planet with their release through faults and cracks to the surface is confirmed by results of extensive geological and geophysical studies in the Azov-Black sea and Caspian basins, as well as on the oceanic and sea shelves [14-24, 26, 27] (see Fig. 6-9).

7. The model’s statement according to which hydrocarbons located deeply in the planet form deep oil and gas deposits is confirmed by the discovery of a gas field at a depth of around 6,000 m in Jurassic sediments on the Krupskaya area of the Taman Peninsula. The license for geological exploration belongs to Gazprom Dobycha Krasnodar LLC. The gas from this field has the following abnormally high temperature and pressure parameters: pressure is more than 120 MPa at the mouth of an exploratory well, the temperature is more than 300 °C.

8. It has been confirmed that newly formed hydrocarbons feed oil and gas fields that have been developed for a long time. This phenomenon is expressed in periodic well production and gradual accumulation of hydrocarbons in the developed deposits of the Krasnodar Territory (Fig. 10).

Replacement of reserves of hydrocarbon is observed in the fields of Tatarstan [13]. For example, the Romashkinskoye oil field, which has been developed since 1948, according to initial estimates, recoverable reserves amounted to 710 million tonnes. However, today production

has exceeded 3 billion tonnes; the field continues to be developed. At the same time, it is observed that density and viscosity of oil decreases occasionally, while a drop in flow rates are suddenly replaced by growth. Similar behaviour is observed in oil fields of Western Siberia (Samotlor) and in the Terek-Sunzhenskiy region of the Chechen Republic.

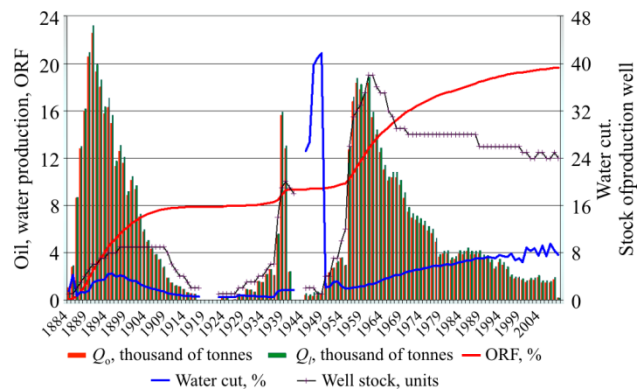


Fig. 10. Dynamics of oil production at the Ilinskaya Dolina field (Krasnodar region): Q_o – oil production; Q_1 – fluid production (oil + water); ORF – oil recovery factor

9. The statement that says that massive chemical elements and heavy substances are deposited in the deeper layers of the earth’s crust is confirmed by a decrease in the concentration of metals, including noble ones, with a decrease in its depth (see Fig. 3) [12].

Thus, the main provisions of the developed model are confirmed by the results of experimental and theoretical studies of such processes and results of geological and geophysical surveys. This suggests that the developed model is sufficiently reliable.

Conclusions

The model developed proves that all chemical elements represented in the Periodic system of D.I. Mendeleev were formed in the mantle of the planet. Material sources of this process are streams of high-energy elementary particles emitted by the sun and space as well as water coming from the surface and existing in the depths of the planet. Formation of nuclei and atoms of chemical elements in rocks occurs according to the elementary reactions of interaction of electrons, neutrinos and protons

that have arrived with the space stream, and as a result of high-temperature dissociation of water. Neutrons are formed from protons, electrons and neutrinos. Then nuclei and atoms of chemical elements are formed from neutrons, protons and electrons. It is shown that their formation proceeds from simple to complex, with the atomic nucleus of a simple element serving as the foundation for the formation of a nucleus of a more complex chemical element. This principle is mathematically expressed in terms of the relative time of formation of any chemical element of the Periodic System in hydrogen. The greater the atomic mass of chemical element the greater the relative time of its formation. Relative time indirectly indicates the prevalence of chemical elements in nature. Chemical elements occur with the release of a large amount of thermal energy, which heats the mantle. According to the laws of thermodynamics local heating of the mantle substance (magma) leads to the displacement of the latter in the direction of a lower energy level. Getting into areas with a lower energy level, the atoms of chemical elements interact with each other and, according to chemical reactions, form various molecular compounds. Moving magma affects the crust of the planet. Therefore, cracks and faults are formed in thin places of the latter. Chemical elements and molecular compounds under the action of high pressure and temperature rise to the surface. Massive chemical elements and heavy substances are deposited in the deeper layers of the earth's crust or are carried with the magma to the surface. Light matter such as hydrocarbons reach the surface through cracks and fractures. Oil is formed from condensed hydrocarbons; gas is formed from uncondensed

ones. When released into geological confined spaces (traps), they form new or replenish known developed deposits and hydrocarbon fields. If there are no geological traps on the way of hydrocarbons, then hydrocarbons appear on the surface as, for example, emissions from faults and mud volcanoes.

The model shows the reverse processes of dissociation of chemical elements into protons, electrons and electrons. Processes occur in the deeper layers of the mantle, where its temperature exceeds the temperature at which nuclei and atoms of chemical elements are formed. During the dissociation, energy is absorbed and magma compresses locally.

Expansion of magma during the formation of chemical elements and its compression during their dissociation cause low and high frequency pulsations of the planet, during which excess energy is dumped into outer space.

The model shows that, initially, all chemicals, including water, were formed in the mantle of high-energy particles: protons, electrons and neutrinos emitted by the sun and space, i.e. our planet is the product of the last.

Essential statements of the developed model are confirmed by the results of experimental studies of similar processes and results of geological and geophysical studies in the Black and Caspian seas, on the sea and ocean shelves, and in Kolskaya ultradeep well also. Therefore, it is possible to conclude that the developed model is sufficiently reliable.

Based on the model developed, it can be concluded that all chemical atoms and their molecular compounds are renewable material and energy sources.

References

1. Kudryavtsev N.A. *Genesis nefi i gaza* [Genesis of oil and gas]. Leningrad, Nedra, 1973, 216 p.
2. *Fizika. Bolshoj jenciklopedicheskiy slovar* [Big Encyclopedic Dictionary]. Ed. A.M. Prohorov. Moscow, Bolshaja rossijskaja jenciklopedija, 1999, 699 p.
3. Futera Z., Yong X., Pan Y., Tse J.S., English N.J. Formation and properties of water from quartz and hydrogen at high pressure and temperature. *Earth and Planetary Science Letters*, 2017, vol.461, pp.54-60.
4. *Kratkaya khimicheskaya entsiklopediya* [Brief chemical encyclopedia]. Moscow, Sovetskaja jenciklopedija, 1961, vol.I-V.
5. Kanarjov F.M. *Nachala fiziki mikromira* [Beginning of the physics of the microworld]. Krasnodar, Kubanskiy gosudarstvennyy agrarnyy universitet, 2002, 334 p.
6. Kanaryev F.M. *Modeli yader atomov* [Atomic nucleus models]. Krasnodar, Kubanskiy gosudarstvennyy agrarnyy universitet, 2002, 23 c.
7. Erden-Gruz T. *Osnovy stroeniya materii* [Basics of the structure of matter]. Moscow, Mir, 1976, 487 p.
8. Obrezha A.V. *Stroenie atomnykh yader* [Structure of atomic nuclei]. Krasnodar, 2001, 95 p.

9. Nikitin A.A., Rudzikas Z.B. Osnovy teorii spektrov atomov i ionov [Fundamentals of the theory of the spectra of atoms and ions]. Moscow, Nauka, 1983, 324 p.
10. Kustanovich I.M. Spekttralnyy analiz [Spectral analysis]. Moscow, Vysshaya shkola, 1967, 390 p.
11. Hofmann S. et al. Production and decay of $^{269}110$. *Zeitschrift für Physik A*, 1995, vol.350, no.4, pp.277-280. DOI: 10.1007/BF01291181
12. Kolskaya sverkhglubokaya. Nauchnye rezultaty i opyt issledovaniy [Kolskaya superdeep. Scientific results and research experience]. Moscow, Tekhnoneftegaz, 1998, 260 p.
13. Iktisanov V.A. Skorost sinteza nefiti pri razrabotke mestorozhdeniy [Rate of oil synthesis in the development of fields]. *Neftepromyslovoe delo*, 2017, 4, pp.49-54.
14. Ginzburg G.D., Gramberg I.S., Guliev I.S., Guseynov R.A., Dadashev A.A., Ivanov V.L., Krotov A.G., Muradov Ch.S., Solovev V.A., Telepnev E.V. Podvodnogryazevulkanicheskiy tip skopleniy gazovykh gidratov [Subsea-mud-volcanic type of gas hydrate accumulations]. *Doklady akademii nauk SSSR*, 1988, vol.300, no.2, pp.416-418.
15. Ginzburg G.D., Kremlev A.N., Grigorev M.N., Larkin G.V., Pavlenkin A.D., Saltykova N.A. Filtrogennye gazovye gidraty v Chernom more (21 reys NIS "Evpatoriya") [Filtrogenic gas hydrates in the Black Sea (21st flight of the NIS Evpatoria)]. *Geologiya i geofizika*, 1990, no.3, pp.10-20.
16. Solovev V.A. Prirodnye gazovye gidraty kak potentsialnoe poleznoe iskopaemoe [Natural gas hydrates as a potential mineral]. *Rossiyskiy khimicheskiy zhurnal*, 2003, vol.XLVII, no.3, pp.59-69.
17. Kruglyakova R.P., Kruglyakova M.V., Shvetsova N.T. Geologo-geokhimicheskaya kharakteristika estestvennykh proyavleniy uglevodorodov v Chernom more [Geological-geochemical characterization of hydrocarbon natural shows in the Black Sea]. *Geologiya i poleznye iskopaemye mirovogo okeana*, 2009, no.1, pp.37-51.
18. Dovgiy S.F., Shnyukov E.F., Starostenko I.I. et al. Geologo-geofizicheskie issledovaniya 57 reysa NIS "Professor Vodyanitskiy" v severo-vostochnoy chasti Chernogo morya [Geological and geophysical studies of 57 flights of the NIS "Professor Vodyanitskiy" in the northeastern part of the Black Sea]. *Geodinamika i neftegazonosnyye sistemy chernomorsko-kaspiyskogo regiona. Tezisy dokladov iv mezhdunarodnoy konferentsii*. Simferopol, 2002, pp.60-61.
19. Shnyukov E.F., Pasyukov A.A., Maslikov N.A. Chernoe more – zona aktivnoy glubinnoy degazatsii [Black Sea – zone of active deep degassing]. *Neft i gaz Chernogo, Azovskogo i Kaspiyskogo morey. Tezisy dokladov iv mezhdunarodnoy nauchno-tekhnicheskoy konferentsii*. Gelendzhik, 2004, pp.9-12.
20. Shnyukov E.F., Pasyukov A.A., Lyubitskiy A.A., Bogdanov Yu.A. novye proyavleniya gazovogo i gryazevogo vulkanizma v chernom more [New manifestations of gas and mud volcanism in the Black Sea]. *Geologiya i poleznye iskopaemye mirovogo okeana*. Kiev, NANU, 2007, no.2, pp.107-110.
21. Sokolov B.A. Novye idei v geologii nefiti i gaza: Izbrannyye trudy [New Ideas in the Geology of Oil and Gas: Selected Works]. Moscow, Izdatelstvo Moskovskogo gosudarstvennogo universiteta, 2001, 480 p.
22. Andreev V.M. Gryazeveye vulkany i nefteproyavleniya v Tuapsinskom progibe i na valu Shatskogo (Chernoe more) [Mud volcanoes and oil seepage in the Tuapse Trough and on the Shatskiy Shaft (Black Sea)]. *Doklady RAN*, 2005, vol.402, no.3, pp.305-362.
23. Andreev V.M., Tugolesov D.D., Khrenov S.N. Gryazeveye vulkany i nefteproyavleniya rossiyskogo sektora Chernogo morya [Mud volcanoes and oil shows of the Russian sector of the Black Sea]. *Geologiya i poleznye iskopaemye Mirovogo okeana*, 2006, no.3, pp.50-59.
24. Nechaeva O.L., Kruglyakova R.P. Geokhimiya organicheskogo veshchestva kaynozoykskikh otlozheniy vostochnoy chasti Chernogo morya [Geochemistry of the organic matter of the Cenozoic deposits of the eastern Black Sea]. *Geologiya nefiti i gaza*, 2008, no.1, pp.50-55.
25. Zaporozhets E.P., Shostak N.A., Antoniadi D.G. Model obrazovaniya uglevodorodov i ikh proyavleniya v prirode [Model of formation of hydrocarbons and their occurrence in nature]. *Povyshenie effektivnosti razrabotki neftyanykh i gazovykh mestorozhdeniy na pozdney stadii: sbornik tezisov dokladov mezhdunarodnoy nauchno-prakticheskoy konferentsii*. Kubanskiy gosudarstvennyy tekhnologicheskii universitet. Krasnodar, Yug, 2017, p.23.
26. Makogon Yu.F. Gazogidraty. Istoriya izucheniya i perspektivy osvoeniya [Gas hydrates. History of study and development prospects]. *Geologiya i poleznye iskopaemye Mirovogo okeana*, 2010, no.2, pp.5-21.
27. Zaporozhets E.P., Shostak N.A. Gidraty [Hydrates]. Krasnodar, Yug, 2014, 460 p.
28. Yarkovskiy I.O. Vsemirnoe tyagotenie kak sledstvie obrazovaniya vesomoy materii vnutri nebesnykh tel. Kineticheskaya gipoteza [World widespread as a result of the formation of weighty matter within celestial bodies. Kinetic hypothesis]. Moscow, Tipolitografiya tovarishchestva I.N. Kushnerev i Ko, 1889, 388 p.
29. Ohmori T., Mizuno T. Strong excess energy evolution, new element production, and electromagnetic wave and/or neutron emission in light water electrolysis with a tungsten cathode. *Infinite Energy*, 1998, vol.4, iss.20, pp.14-17.
30. Zaporozhets E.P., Gaponenko A.M., Zakharchenko E.I. Matematicheskoe modelirovanie [Math modeling]. Krasnodar, Yug, 2011, 126 p.
31. Knyazhin S.L. U. Keri – velikiy geolog planety [Carey – the great geologist of the planet]. *Uralskiy geologicheskii zhurnal*, 2001, no.4, pp.205-212.

32. Ivasyshin G.S. Kholodnyy yadernyy sintez i nauchnye otkrytiya v mikro- i nanotribologii. Delovaya slava Rossii. Mezhotraslevoy almanakh [Cold nuclear fusion and scientific discoveries in micro- and nanotribology. Business glory of Russia. Interindustry almanac]. Moscow, Slavitsa, 2009, iss.I, pp.106-109.

33. Rossi A. Fluid heater. Pat. US 9115913. 14.03.2012.

34. Kanarev F.M. Ustroystvo dlya polucheniya teplovooy energii vodoroda i kisloroda [Device for receiving thermal energy of hydrogen and oxygen]. Patent Russian Federation no.2157427 (2000).

35. Kanarev F.M., Podobedov V.V. Ustroystvo dlya polucheniya teplovooy energii i parogazovoy smesi [A device for generating thermal energy and steam-gas mixture]. Patent Russian Federation no.2157862 (2000).

36. Tsarev V.A. Nizkotemperaturnyy yadernyy sintez [Low-temperature nuclear fusion]. *Uspekhi fizicheskikh nauk*, 1990, vol.160, iss.11, pp.1-53.

37. Kuzmin R.N., Shvilkin B.N. Kholodnyy yadernyy sintez [Cold nuclear fusion]. Moscow, Znanie, 1989, 64 p. (Seriya "Fizika", no.10).

38. Gac K., Kolonowski M., Skladanowski Z. et al. Preprint Kaliski Inst. of Plasma Physics. Warsaw, 1989.

39. Titov N.S. Teoriya ustoychivosti materii [Matter stability theory]. *Gazovaya promyshlennost*, 1997, no.3, pp.32-33.

40. Titov N.S. O silakh vzaimodeystviyakh form materii [On the forces of interaction of forms of matter]. *Gazovaya promyshlennost*, 1990, no.3, pp.34-35.

Библиографический список

1. Кудрявцев Н.А. Генезис нефти и газа. – Л.: Недра, 1973. – 216 с.

2. Физика: Большой энциклопедический словарь / гл. ред. А.М. Прохоров. – 4-е изд. – М.: Большая российская энциклопедия, 1999. – С. 699.

3. Formation and properties of water from quartz and hydrogen at high pressure and temperature / Z. Futera, X. Yong, Y. Pan, J.S. Tse, N.J. English // *Earth and Planetary Science Letters*. – 2017. – Vol. 461. – P. 54–60.

4. Краткая химическая энциклопедия. – М.: Советская энциклопедия. – 1961. – Т. I–V.

5. Канарев Ф.М. Начала физики микромира. – Краснодар: Кубанск. гос. аграрн. ун-т, 2002. – 334 с.

6. Канарев Ф.М. Модели ядер атомов. – Краснодар: Кубанск. гос. аграрн. ун-т, 2002. – 23 с.

7. Эрден-Груз Т. Основы строения материи. – М.: Мир, 1976. – 487 с.

8. Обрежа А.В. Строение атомных ядер. – Краснодар, 2001. – 95 с.

9. Никитин А.А., Рудзикас З.Б. Основы теории спектров атомов и ионов. – М.: Наука, 1983. – 324 с.

10. Кустанович И.М. Спектральный анализ. – М.: Высшая школа, 1967. – 390 с.

11. Production and decay of $^{269}110$ / S. Hofmann [et al.] // *Zeitschrift für Physik A*. – 1995. – Vol. 350, № 4. – P. 277–280. DOI: 10.1007/BF01291181

12. Кольская сверхглубокая. Научные результаты и опыт исследований. – М.: Технонефтегаз, 1998. – 260 с.

13. Иктисанов В.А. Скорость синтеза нефти при разработке месторождений // *Нефтепромысловое дело*. – 2017. – № 4. – С. 49–54.

14. Подводногрязевулканический тип скоплений газовых гидратов / Г.Д. Гинзбург, И.С. Грамберг, И.С. Гулиев, Р.А. Гусейнов, А.А. Дадашев, В.Л. Иванов, А.Г. Кротов, Ч.С. Мурадов, В.А. Соловьев, Е.В. Телепнев // *Доклады академии наук СССР*. – 1988. – Т. 300, № 2. – С. 416–418.

15. Фильтрогенные газовые гидраты в Черном море (21-й рейс НИС «Евпатория») / Г.Д. Гинзбург,

А.Н. Кремлев, М.Н. Григорьев, Г.В. Ларкин, А.Д. Павленкин, Н.А. Салтыкова // *Геология и геофизика*. – 1990. – № 3. – С. 10–20.

16. Соловьев В.А. Природные газовые гидраты как потенциальное полезное ископаемое // *Российский химический журнал*. – 2003. – Т. XLVII, № 3. – С. 59–69.

17. Круглякова Р.П., Круглякова М.В., Швецова Н.Т. Геолого-геохимическая характеристика естественных проявлений углеводородов в Черном море // *Геология и полезные ископаемые Мирового океана*. – 2009. – № 1. – С. 37–51.

18. Геолого-геофизические исследования 57-го рейса НИС «Профессор Водяницкий» в северо-восточной части Черного моря / С.Ф. Довгий, Е.Ф. Шнюков, И.И. Старастенко [и др.] // *Геодинамика и нефтегазоносные системы Черноморско-Каспийского региона: тез. докл. IV Междунар. конф.* – Симферополь, 2002. – С. 60–61.

19. Шнюков Е.Ф., Пасынков А.А., Масликов Н.А. Черное море – зона активной глубинной дегазации // *Нефть и газ Черного, Азовского и Каспийского морей: тез. докл. междунар. науч.-техн. конф.* – Геленджик, 2004. – С. 9–12.

20. Новые проявления газового и грязевого вулканизма в Черном море / Е.Ф. Шнюков, А.А. Пасынков, А.А. Любичский, Ю.А. Богданов // *Геология и полезные ископаемые Мирового океана*. – 2007. – № 2. – С. 107–110.

21. Соколов Б.А. Новые идеи в геологии нефти и газа: избр. тр. – М.: Изд-во Моск. гос. ун-та, 2001. – 480 с.

22. Андреев В.М. Грязевые вулканы и нефтепроявления в Туапсинском прогибе и наvalu Шатского (Черное море) // *Доклады РАН*. – 2005. – Т. 402, № 3. – С. 305–362.

23. Андреев В.М., Туголесов Д.Д., Хренов С.Н. Грязевые вулканы и нефтепроявления российского сектора Черного моря // *Геология и полезные ископаемые Мирового океана*. – 2006. – № 3. – С. 50–59.

24. Нечаева О.Л., Круглякова Р.П. Геохимия органического вещества кайнозойских отложений восточной части Черного моря // Геология нефти и газа. – 2008. – № 1. – С. 50–55.

25. Запорожец Е.П., Шостак Н.А., Антониади Д.Г. Модель образования углеводородов и их проявления в природе // Повышение эффективности разработки нефтяных и газовых месторождений на поздней стадии: сб. тез. докл. междунар. науч.-практ. конф. на базе Кубанского технологического университета совместно Российской академией естественных наук, посвященной 100-летию ФГБОУ ВО «Кубанский государственный технологический университет» (3–6 октября 2017 г.) / ФГБОУ ВО «Кубанский государственный технологический университет». – Краснодар: Юг, 2017 – С. 23.

26. Макогон Ю.Ф. Газогидраты. История изучения и перспективы освоения // Геология и полезные ископаемые Мирового океана. – 2010. – № 2. – С. 5–21.

27. Запорожец Е.П., Шостак Н.А. Гидраты. – Краснодар: Юг, 2014. – 460 с.

28. Янковский И.О. Всемирное тяготение как следствие образования весомой материи внутри небесных тел. Кинетическая гипотеза. – М.: Типо-литография Товарищества И.Н. Кушнерев и Ко, 1889. – 388 с.

29. Ohmori T., Mizuno T. Strong excess energy evolution, new element production, and electromagnetic wave and/or neutron emission in light water electrolysis with a tungsten cathode // Infinite Energy. – 1998. – Vol. 4, iss. 20. – P. 14–17.

30. Запорожец Е.П., Гапоненко А.М., Захарченко Е.И. Математическое моделирование: учеб. пособие / Кубанск. гос. техн. ун-т – Краснодар: Юг, 2011. – 126 с.

31. Княжин С.Л. У. Кэри – великий геолог планеты // Уральский геологический журнал. – 2001. – № 4. – С. 205–212.

32. Ивасьшин Г.С. Холодный ядерный синтез и научные открытия в микро- и нанотрибологии // Деловая слава России. Межотраслевой альманах. – М.: Славица, 2009. – Вып. I. – С. 106–109.

33. Fluid heater: Pat. US 9115913 / Rossi. A. 14.03.2012.

34. Устройство для получения тепловой энергии водорода и кислорода: пат. Рос. Федерация № 2157427 / Канарев Ф.М. Оpubл. 10.10.2000, Бюл. № 28.

35. Устройство для получения тепловой энергии и парогазовой смеси: пат. Рос. Федерация № 2157862 / Канарев Ф.М., Подобедов В.В. Оpubл. 20.10.2000, Бюл. № 29.

36. Царев В.А. Низкотемпературный ядерный синтез // Успехи физических наук. – 1990. – Т. 160, вып. 11. – С. 1–53.

37. Кузьмин Р.Н., Швилкин Б.Н. Холодный ядерный синтез. – М.: Знание, 1989. – 64 с. – (Физика. № 10).

38. Preprint Kaliski inst. of plasma physics / K. Gas, M. Kolonowski, Z. Skladanowski [et al.]. – Warsaw, 1989.

39. Титов Н.С. Теория устойчивости материи // Газовая промышленность. – 1997. – № 3. – С. 32–33.

40. Титов Н.С. О силах взаимодействиях форм материи // Газовая промышленность. – 1990. – № 3. – С. 34–35.

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