Problems of Climate Warming and Sustainable Development from the Perspective of the Biosphere Concept of Oil and Gas Formation

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Abstract: We consider the consequences of the scientific revolution in oil and gas geology, which are directly related to the problems of climate warming and sustainable development. The biospheric concept of oil and gas formation is discussed, which solves the problems of the balance of carbon and water cycles in the Earth's biosphere, taking into account human activities. According to new ideas, oil and gas are the renewable resources of our planet, replenished during the exploitation of deposits. It has been established that the replenishment of hydrocarbons in deposits is taking place with the participation of a previously unknown 40-year carbon cycle in the biosphere: the transport of CO_2 from the atmosphere by meteoroid waters below the Earth's surface. In crustal rock, water-soluble carbon dioxide is involved in mechanochemical hydrocarbon synthesis reactions. The conclusion is obtained that with a scientifically based approach to the production and consumption of oil and gas there is an opportunity to exploit their deposits as replenished sources of hydrocarbons. This fact, on the one hand, makes it possible to classify oil and gas as "green" energy sources, and on the other hand, significantly reduce the impact of their consumption on the climate.

1 INTRODUCTION

At present, the world is facing two urgent challenges: ensuring the sustainable development of the world economy and warming the climate, with serious geopolitical and economic consequences for many countries. The increase in carbon dioxide (CO_2) and other greenhouse gases in the atmosphere, while the current consumption of fossil fuels (oil, gas and coal) is increasing, marks a change in climate. Their use as fuels results in large quantities of CO_2 entering the atmosphere. Therefore, the developed countries see the solution to the climate problem in the abandonment of fossil fuels and their replacement with renewable «green» energy sources, which are considered to be the energy of the Sun, wind and water. There are also plans to move the world economy towards the use of «clean» hydrogen that does not emit CO_2 into the atmosphere. Clean hydrogen is to be obtained from renewable energy sources. However, a complete phase-out of hydrocarbons in the transition to hydrogen energy is now evident and is unlikely to be necessary in the future.

There are two different approaches to countering anthropogenic warming. One is based on accounting for the amount of greenhouse gas emissions from human activities and attempts to reduce them in any way, while the other is based on addressing the fundamental problem of the origin of oil and gas, which is directly related to observed climate change.

The first approach is commercial, governed by the international climate agreements currently in place, signed by 192 countries. The approach is to trade greenhouse gas emissions between highly developed and developing economies. This approach is based on the view of the UN Intergovernmental Panel that warming of the climate is caused by anthropogenic emissions of carbon dioxide (CO_2) and methane (CH_4). However, it has been established that the main greenhouse gas is water vapor, the greenhouse effect of which far exceeds the influence of CO_2, CH_4, etc. on the climate (Table 1). However, this factor is not taken into account or taken into account by UN experts.

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The second is a scientific approach that identifies the true cause of climate change. This, in our view, is due to man's predatory interference with the global geochemical cycle of biosphere matter occurring on our planet. The scientific approach is based on the biosphere teaching of V.I. Vernadsky (Vernadsky, 2001), as well as the work of domestic scientists, including three scientific discoveries made by them over the past 40 years.

Table 1: Main greenhouse gases of the Earth's atmosphere and their contribution to the greenhouse effect (Wikipedia, 2022).

Compound	Formula	Contribution (%)
Water vapor and clouds	H_2O	36–72%
Carbon dioxide	CO_2	9–26%
Methane	CH_4	4–9%
Ozone	O_3	3–7%

These discoveries show the failure of a commercial approach to solving climate and sustainability problems as a "new energy strategy" that can solve both problems by moving away from the production of "dirty" oil and gas and replacing them as energy sources with "clean" hydrogen.

2 MATERIALS AND METHODS

The scientific approach implements three fundamental discoveries of Russian scientists, which together transfer oil and gas from the category of "dirty" fossil fuels to the category of renewable "green" energy sources. Let's look at these discoveries one by one.

2.1 First Discovery

This discovery is officially registered in the USSR as the scientific «Discovery №342» from 21.04.1982 (Trofimuk et al., 1982a, 1982b) under the name: «Phenomenon of transformation of organic matter of sediment rocks under the action of tectonic and seismic processes of the Earth's crust». This phenomenon consists in the formation of hydrocarbons as a result of mechanochemical transformation of organic matter of sediments under the action of tectonic and seismic fields (Trofimuk et al., 1981; Trofimuk et al., 1982a, 1982b). Later, the authors of the discovery N.V. Chersky and V.P. Tsarev proved in experiments that gas-oil hydrocarbons are formed from both organic and inorganic (Chersky et al., 1984) and fully oxidized carbon containing substance (Chersky et al., 1986). In this way, it has been established that hydrocarbons arise under natural conditions not only from heat but also from the mechanical energy of the host rocks. The discovery substantiated the possibility of the formation of a wide range of oil and gas hydrocarbons from a carbon substance with the participation of tectonic and seismic processes at formation temperatures of less than 60–70°C.

The new phenomenon was independently studied by V.I. Molchanov (Molchanov, 1967; Molchanov et al., 1969; Molchanov, 1981; Molchanov et al., 1992). Under his leadership, since the 1970s, the Institute of Geology and Geophysics of the USSR Academy of Sciences has been conducting studies of carbon-containing minerals and rocks during ultrafine grinding in water-saturated media. The result was an understanding of the mechanochemical mechanism of hydrogen generation and synthesis of hydrocarbons in sedimentary rocks under moderate thermobaric conditions.

This mechanism, called «geosynthesis», has been experimentally studied by S.N. Zakirov with employees at the Institute of Oil and Gas Research Institute Russian Academy of Sciences (OGRI RAS) since the beginning of the 2000s (Zakirov et al., 2013a; Zakirov et al., 2013b;Barenbaum et al., 2015; Zakirov et al., 2016; Barenbaum et al., 2020). The synthesis of hydrocarbons was studied according to the CO_2+H_2O reaction, thermodynamically impossible under standard conditions. Simulations of the CO_2+H_2O reaction showed that on the activated surface of the matrix of rocks it flows at low temperatures (25°C) and just above atmospheric pressure, accompanied by physical-chemical decay of water to form a large amount of hydrogen. It is obtained that from the chemical point of view the reaction of CO_2+H_2O belongs to the same class of polycondensation reactions of synthesis of hydrocarbons from carbon oxides and hydrogen (Barenbaum et al., 2020; Rudenko, 1969) as well as known reactions of Fisher-Tropsch (CO+H_2), Engelhardt-Kelbel (CO +H_2O) and others.

2.2 Second Discovery

In the 1990s, a group of geologists from Russia discovered that in a number of fields where oil and gas production was temporarily suspended, after 2-3 years there was an increase in hydrocarbon inflows in the deposits. These inflows were detected for the first time in the late stages of the exploitation of old deposits that were 50 years old or older (Sokolov et al., 1993; Smirnova, 1999; Ashirov et al., 2000;

Muslimov et al., 2004). An attempt was first made to establish a link between tributaries and the lack of accuracy in the estimation of recoverable reserves or in the feeding of nearby low-yielding deposits. However, in the 2000s, the widespread occurrence of this phenomenon became evident, leading geologists to conclude that hydrocarbons were continuously spilling into their mined deposits. First employees of Moscow State University B.A. Sokolov and A.N. Gusev understood and correctly explained the essence of the phenomenon (Sokolov et al., 1993). In 1993 they declared that: «oil and gas are apparently renewable natural resources, and therefore their development should take place on the basis of calculations of the balance of the amount of hydrocarbon generation and acceptable for the rational use of their extraction during the exploitation of deposits».

Ten years later, A.A. Barenbaum constructed the theory of this phenomenon, proposing the biosphere concept of oil and gas formation (Barenbaum, 2004, 2007a, 2007b, 2000, 2010, 2013, 2014, 2015a, 2015b, 2017, 2018, 2019). With the findings (Trofimuk et al., 1982a, 1982b) and (Sokolov et al., 1993) in mind, it has generalized the well-known traditional hypotheses of hydrocarbon genesis by complementing them with representations of participation in the formation of oil and gas hydrocarbons in the global water and carbon cycles across the Earth's surface. From these positions the key problems of carbon and water balance in the biosphere were solved and it was shown that oil and gas formation is a modern natural phenomenon closely connected with geochemical cycling of the biosphere and human economic activity, as her important representative. In this way, the biosphere concept allowed to give a new paradigm of hydrocarbon formation (Sokolov et al., 1993) the necessary theoretical justification, as well as to substantiate the possibility of exploitation of oil and gas facilities as replenished, i.e. «green» energy sources.

This phenomenon was never supposed to be organic or mineral hypotheses. Therefore, the creation of the concept of the biosphere carbon and water cycle on Earth was the beginning of new revolutionary discoveries in oil and gas geology. As a result, both hypotheses, which have been at odds with geology for more than 100 years, are now giving way to notions of oil and gas as indestructible minerals of our planet.

2.3 Third Discovery

According to the concept of the Earth's carbon and water cycle, underground oil and gas accumulations are natural geological traps of mobile carbon that circulate through the Earth's surface. At the same time it has three main cycle: two of them are geological (with times of ~10^6 years and ~10^9 years), and climatic or «biosphere» with a period of rotation ~ 40 years (Barenbaum, 2004, 2010). The last cycle is responsible for the carbon cycle (mainly in the form of water-soluble CO_2 in atmospheric air or organic matter). All these three cycles are closely interconnected and occur in such a way that above the Earth's surface, which acts as a geochemical barrier, the mobile carbon of the biosphere circulates mainly in the oxidized form (CO_2), and under the Earth's surface - in the earth's crust, conditions are created for its transformation into hydrocarbons (Zakirov et al., 2013; Barenbaum et al., 2015; Zakirov et al., 2016). In this mechanism, organic matter, aqueous CO_2 and carbonaceous minerals can be a carbon donor for hydrocarbons, and water can be a hydrogen donor. Because of their low water solubility, hydrocarbons form their own petroleum and gas accumulations in the geological trapping structures of the upper crust.

Geologists had not previously taken into account the contribution of the 40-year biosphere cycle to the formation of hydrocarbon resources. The dispute among adherents of traditional hypotheses of oil and gas formation concerned the predominance of a geological cycle of hydrocarbon formation (~10^6 and ~10^9 years). Climatologists, who considered the formation of hydrocarbons in the interior to be a very slow process that could be neglected, also did not consider this cycle. In reality, however, it is this cycle that plays a major role in the replenishment of oil and gas fields, as well as influencing regional and global changes in the planet's weather and climate.

These new concepts are reflected in the theoretical model (Barenbaum, 2000, 2010) which has made it possible to study the carbon and water cycling regimes of our planet at different periods of its geological history: pre-Cambrian, plywood and the modern era. The model showed, inter alia, that the biosphere's geochemical system is currently in a stable dynamic equilibrium that provides a biosphere cycle. In this state, any imbalance caused by external factors or human economic activity eliminates the biosphere by redistributing mobile carbon between its main reservoirs, which in the biosphere cycle are: atmosphere, oceans, Living organisms, soils, hydrocarbon deposits and underground hydrosphere.

Another important conclusion is (Barenbaum, 2010) that water, oxygen and carbon dioxide (CO_2) form a common geochemical cycling system on our planet. Its unifying beginning, as V.I. Vernadsky (Vernadsky, 2001) claimed, is the biosphere. By entering the cycles of water, carbon and oxygen as a constituent element, living organisms bring the velocity of the biosphere's material cycle into line with that of the geological cycle of the groundwater.

3 RESULTS AND DISCUSSION

Under the biosphere concept, the formation of hydrocarbons in the subsurface is caused both by sub-surface processes and by CO_2 circulation over the surface. Both processes are highly participatory and to some extent influenced by the individual.

Evidence shows that, with the current practice of exploiting hydrocarbon deposits, the regional and global geochemical equilibrium in the biosphere is disturbed by fracturing the formation by means of hydraulic fracturing methods that destroy geological traps. On the basis of the Le Chateller principle, the biosphere seeks to restore this balance by all possible means. Climate warming is therefore a reaction of the biosphere to imbalance, such as the replenishment of exploited deposits with hydrocarbons, an increase in the intensity of degassing of the subsoil, an increase in the atmospheric content of CO_2 and CH_4, etc. Thus, these effects are anthropogenic, but they are primarily caused by processes not on the surface, but in the interior of the Earth. The main cause is the activation of the carbon and water cycle across the Earth's surface within the 40-year cycle of the biosphere.

Hence, the formation of hydrocarbon deposits is determined not only by the conditions of their genesis and accumulation in the interior, but also by the geochemical carbon cycle in various forms over the Earth's surface. Therefore, human activities play an important role, affecting to some extent the regional processes of formation of oil and gas deposits in the subsoil (Barenbaum, 2007a, 2007b).

The recovery of oil and gas from deposits at a moderate rate (without serious disruption of groundwater circulation) should not significantly affect the oil and gas potential of the region, which will affect the rate of replenishment of its deposits. But this may be the case if extracted oil and gas are used within the same hydro-geological basin where they were extracted. The transportation of hydrocarbon raw materials to tens of thousands of kilometers from their production sites contributes to the regrouping of the world's oil and gas resources. The industrialized countries, which consume oil and gas intensively, contribute to their accumulation. In contrast, hydrocarbon-exporting countries deplete their resources.

Another predicted consequence is the displacement of large hydrocarbon accumulations in the oceans. Due to the absence of hydrocarbon storage conditions on the continental fringes, carbon is transported by groundwater run-off waters to the shelf and continental slope (Barenbaum, 2007a, 2007b). As a result, it is here that the main hydrocarbon reserves of our planet, which includes not only oil and gas, but also gas hydrates.

The last important conclusion is the emerging capacity to exploit oil and gas as a renewable source of hydrocarbon raw materials. In the case of careful subsoil use, at the rate of extraction of hydrocarbons from deposits not exceeding the rate of their natural replenishment, it becomes possible to replenish the resources of oil and gas fields. In this case, the industrial development may involve small deposits, which are currently considered uneconomical for economic reasons. The efficiency of using the hydrocarbon potential of the Earth's subsurface can also be improved by intensifying the hydrocarbon submergence in the deposits in specific fields by means of special drilling of wells and optimization of their operation modes.

4 CONCLUSIONS

Carbon dioxide, as an important component of carbon on the planet, is involved in many natural and technogenic processes and technologies. Carbon dioxide has long been used widely and with considerable effect in oil recovery (ERP) technologies. It is often seen as a negative gas due to the problem of global warming on Earth. Therefore, as a way out of this situation, many countries have begun to research and implement various technologies for the disposal of CO_2 in the Earth's interior. At the same time, the oil industry attracts the technology of carbon dioxide injection into depleted oil and gas fields to intensify additional oil extraction from depleted and developed reservoirs.

Recently, the issue of solving the «balance problem» of carbon in the biosphere, connected with its less order-of-magnitude flow into the crust of the Earth than from the subsoil, has become significantly more acute. It is becoming increasingly urgent to refine models of carbon circulation in the environment to obtain more objective estimates, as many models are based on highly inaccurate and

incomplete patterns describing the carbon fluxes between its main reservoir on the planet. It is reasonable to conclude that the biosphere cycle is not limited to the carbon cycle above the surface, but covers the entire biosphere, including its underground part.

As a result of discoveries of Russian scientists and creation of biosphere concept, a set of measures allowing to develop oil and gas deposits as renewable sources of hydrocarbons has been proposed, or in other words, as a "green" energy sources. These measures should include:

- strict control of mining technologies by fracturing techniques to maximize the conservation of natural oil and gas traps;
- extraction from the subsoil of hydrocarbons in a quantity not exceeding the amount of their entry into the deposits;
- well-designed logistics, in which hydrocarbons are consumed in the territorial vicinity of hydrological (oil and gas) basins of their production. Efforts should be made to ensure that as much CO_2 as possible is returned to the subsoil.

The experience of transporting hydrocarbon fuels over long distances from their production sites already leads to large accumulations of hydrocarbons on the ocean shelf, where they are deposited in the form of gas hydrates, creating new problems.

New ideas about oil and gas as indestructible energy carriers obviously require serious analysis and revision of the whole system of management that has been established in the world today. It should be borne in mind, however, that oil and gas can only be resumed to a sufficient extent in deposits with a sound scientific mining system.

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