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ACEE ISSN 2574-0350 ANNALS OF CIVIL AND ENVIRONMENTAL ENGINEERING

Review Article

The Influence of Gravity on the Frequency of Processes in Various Geospheres of the Earth. Biogenic and Abiogenic Pathways of Formation of HC Accumulations

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Abstract

Based on the results obtained in the study of the interaction of geological and biosphere processes, we found out that there is a close relationship between them. It was also found that the gravity of the bodies of the solar system on the Earth plays a significant role in the above relationship. The effect of gravity was demonstrated on the movement of lithosphere plates, on the processes in the atmosphere and hydrosphere, on related climatic cycles, and the biosphere processes, including "living" organisms' evolution and their mass extinctions. The periodicity of these processes due to gravity is shown. It is expressed in the alternation of short-term orogenic periods of the beginning of the processes with long-term geosynclinal periods of their development and completion. Both periods constitute the repetitive orogenic cycles. The relationship of the cycles with the evolution of photosynthesis, as well as with related Organic Matter (OM) accumulation in sediments after mass extinction of organisms, including OM transformation leading to the formation of Hydrocarbon (HC) accumulations, is shown. Biogenic processes accounting for the accumulation and transformation of organic matter in sediments constitute the biogenic pathway of the formation of hydrocarbon accumulations. It is shown that the influence of gravity extends to the processes in the inner geospheres, including the movement of magma in the asthenosphere under the lithosphere shell, to the movement of hydrogen gas coming from the Earth's core, combining with volatile compounds of elements present in magma, as well as to the rifting process. It is shown that rifting processes lead to the formation of gaseous HC accumulations and constitute a pathway called abiogenic. The obtained results shed light on the peculiarities of the formation of HC accumulations by biogenic and abiogenic pathways, allowing prediction of their chemical characteristics. This is essential when searching for oil and gas and planning exploration works.

More Information

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Submitted: June 25, 2024
Approved: July 08, 2024
Published: July 09, 2024

How to cite this article: Ivlev AA. The Influence of Gravity on the Frequency of Processes in Various Geospheres of the Earth. Biogenic and Abiogenic Pathways of Formation of HC Accumulations. Ann Civil Environ Eng. 2024; 8(1): 052-056. Available from: https://dx.doi.org/10.29328/journal.acee.1001067

Keywords: Gravity; Lithosphere plates; Orogenic and geosynclinal periods; Orogenic cycles; Photosynthesis; Accumulation of shale enriched in OM; Rifting; Magma; Hydrogen degassing; Biogenic and abiogenic pathways of formation of hydrocarbon accumulations

The effect of gravity on the movement of lithosphere plates and biosphere processes. Their coupling

The problems considered in this paper continue to excite geologists in connection with the problem of the origin of oil. So far, its discussion has been going on with the same disputes and lack of agreement. Here we did not describe the state of the problem, at least in Russian science, since the arguments of the parties, participating in the discussion, are considered in detail in the work [1], which is to be published in the journal "Geology of Oil and Gas" in No. 4 in 2024.

The movement of the lithosphere plates covering the earth and making up its solid shell has been noticed for a long time [2]. It was found that this movement is continuous. As a part of the study of the global cycle of biosphere carbon [3], it was suggested that the observed constant movement of lithosphere plates is a result of the gravitational influence of the bodies of the solar system on the Earth rotating around the Sun. The movement of the plates along the underlying molten magma of the asthenosphere is uneven and consists of a short period called orogenic, during which the plates move with acceleration, and a subsequent long period, called geosynclinal, during which the movement of the plates slows down.

The orogenic and geosynclinal periods form alternating orogenic cycles. It is important to note that the orogenic period coincides with the tectonically active state of the Earth's crust, while the geosynclinal period coincides with the tectonically quiet state of the crust.

It was found that the lithosphere plates themselves are formed from the molten magma, which periodically breaks through the lithosphere shell. The newly formed lithosphere plates, pushing apart neighboring plates, cause their movement with acceleration [3,4]. In the lower part of the earth's crust, in the subduction zone, oceanic plates, colliding with larger continental plates, sink and dissolve in magma, while the continental plate in the collision zone rises, participating in mountain formation.

In addition to the above-mentioned result of the collisions, which occur during the orogenic period in the subduction zone, the released energy is sufficient to initiate a redox reaction of thermochemical sulfate reduction, in which gypsum, formed from seawater, initiates the oxidation of OM (organic matter), which has descended from the Earth's surface. The latter was formed as a result of photo- and heterotrophic synthesis reactions during orogenic cycles. Carbon dioxide (CO_2, carbon dioxide), formed during oxidation, rises to the surface, where it participates in the OM synthesis.

If plate collisions occur during the geosynclinal period, when the plates are moving with deceleration, the collision energy is not enough to initiate thermochemical sulfate reduction. The OM is not oxidized and CO_2 does not enter the surface at this time.

As a result of the described biosphere events, the concentration of CO_2 on the Earth's surface reaches maximal values during the orogenic period. Photosynthesis and related heterotrophic synthesis also occur at a maximal rate. A hot "greenhouse period" is reigning on the Earth. During the geosynclinal period, CO_2 does not flow from the subduction zone to the Earth's surface, but photosynthesis continues, which leads to a decrease in the concentration of CO_2 on the Earth and a decrease in temperature. At the end of the period, the CO_2 concentration decreases to minimal values, and the "ice period" and glaciations occur on the Earth.

In addition, due to the constant decrease in CO_2 concentration during the geosynclinal period and O_2 concentration increase thanks to photosynthesis, the climate and the qualitative composition of the biosphere on the Earth are changing causing the corresponding alterations in the composition of organic matter and its organic derivatives [4].

The main features of a biogenic pathway leading to a transformation of OM to oil hydrocarbon accumulations

Considering the connection of lithosphere plates' movement with the evolution of photosynthesis within the framework of the biosphere carbon cycle, it should be underlined that with the change of orogenic cycles, during the transition from the "ice" (geosynclinal) period of the previous cycle to the greenhouse (orogenic) period of the next cycle, due to a sharp change in climatic conditions and habitat conditions of "living" organisms, mass extinction occurs. This leads to the entry of a large amount of biogenic material into the sediment. A sediment rich in organic matter is formed. At a certain stage of its transformation, the condensed part (kerogen) and the mobile part (bitumen) are released from it. The latter is a source of labile hydrocarbons, which emigrate into traps, and fill them, forming accumulations (deposits) of oil. All recovered carbon, including oil, eventually falls into the subduction zone, where it turns into CO_2, closing the global cycle of biosphere carbon [3].

Thus completing the consideration of biogenic pathway OM transformation some important features of it should be noted.

1. The biogenic pathway begins with collisions of lithosphere plates in the subduction zone. Thanks to collisions in the orogenic period the thermochemical sulfate reduction is initiated to oxidize organic matter descending from the surface. The resultant CO_2 enters the surface and stimulates their photo- and heterotrophic synthesis OM.

2. The great amount of the biogenic material, produced in sulfate reduction, gets into the sediment forming so-called "black shales", which further transform converts into main oil-generating rocks [5-7].

3. The various dynamics of plate collisions in the subduction zone during the orogenic and geosynclinal periods lead to different dynamics of the evolution of photosynthesis in the course of repetitive orogenic cycles and cause changes in the rate of formation and composition of OM entering the sediment. Ultimately, this affects the chemical composition of HC accumulations bound to this matter.

Thus it can be concluded that gravity not only controls the movement of lithosphere plates, but also utilizes the above movement to influence biosphere events, including photosynthesis and its evolution, climate, and all the associated processes. The so-called biogenic pathway of oil formation is associated with the transformation of sedimentary OM. This means that gravity spreads through all the above-listed processes that make up the biogenic pathway of the formation of hydrocarbon accumulations.

The influence of gravity on the processes in the Earth's inner geospheres. The abiogenic pathway of formation of HC clusters

It is logical to assume that gravity controls not only the movement of lithosphere plates but the regular sequence of biosphere events as well. It also affects the processes occurring in the inner geospheres of the Earth. It is believed that the movement of lithosphere plates floating on the surface of the molten magma reflects the fluid rotation under the lithosphere shell. Many geologists [8-10] believe that internal fluid, rotating under the lithosphere shell, breaks through it from time to time. The unloading occurs, and as a result, the inner fluids enter the Earth's crust.

This sequence, in particular, coincides with the periodicity observed by geologists for a long time in the earth's crust when tectonically active short periods of violent volcanic activity are changed by long periods of monotonous calm. Prof. Umbgrove [11] aptly named it "the pulse" of the Earth. Later, the famous Russian geochemist V.I. Vernadsky [12] at the beginning of the last century drew attention to the fact that many geological processes have pulsation dynamics and used the poetic term "breath of the Earth" to describe it. This term turned out to be so expressive that it became entrenched and began to be used by many geologists, although the meaning they put into this term is not always the same. The pulsation dynamics of hydrogen degassing was noted in his book Larin [13,14]. The process of unloading fluid through the lithosphere shell is called rifting.

We believe that the above-mentioned acceleration of the movement of lithospheric plates is associated with this process, since at the moment of the shell rupture, magma, solidifying and turning into a new plate, pushing apart neighboring plates, causes their acceleration. Based on this statement, we conclude that the rifting process coincides with the orogenic period, and the interval between rifting processes corresponds to the geosynclinal period. Consequently, the influence of gravity discussed above affects not only the movement of lithospheric plates and biospheric processes but also the movement of fluids in internal geospheres. Indirectly, this is evidenced by the above-mentioned coincidence in time of the orogenic and geosynclinal periods with the tectonic states of the earth's crust. As for methane, which is the main product of the interaction of hydrogen with carbon, it is quite stable in conditions of deep magmatic flows. This is evidenced by data on drilling deep and ultra-deep wells, in particular, in Tyumen. This explains the deep emanations (outflows) of methane into the sedimentary cover [15]. It is also confirmed by the results of thermodynamic calculations indicating the possibility of the existence of methane in the Earth's mantle at temperatures up to 1300 ^{0}C - 1500 ^{0}C [16].

As noted, with the influence of gravity on biospheric processes (through the control of the movement of lithospheric plates) we link the biogenic pathway of the formation of liquid hydrocarbon accumulations (oil). It remains to consider what happens after the internal fluids enter the Earth's crust. The internal fluid is a mixture of molten magma mixed with a gaseous stream of hydrogen and volatile products of its interaction with other elements contained in the magma. One of these elements is carbon, which appeared in magma at the origin of the planet during the agglomeration of meteorites [17-19]. Under magmatic melt conditions, methane and its closest homologs are the most likely compounds to be formed from hydrogen and carbon.

During rifting, methane and its homologs are separated from the molten magma used to form a new lithospheric plate [3]. Due to the difference in fluid density, gaseous compounds separate from magma and fill voids, forming large accumulations of gas. Unlike hydrocarbon accumulations of oil, the path through which gaseous hydrocarbon accumulations are formed during rifting should be called abiogenic.

Since the realization of both pathways occurs during orogenic periods, their detection in the earth's crust can occur simultaneously. An example of simultaneous coexistence is the finding of anomalous geochemical associations of "black shales" with ores of rare metals U, Mo, V, Re, Se, Zn, Si, Hg, and several other rare elements [20].

Indeed, it has been shown [6] that the formation of "black shales" is associated with the biogenic pathway of their synthesis and occurs when orogenic cycles change, when a significant part of living organisms dies out, providing the formation of sediments enriched with organic matter. At the same time, it is shown that the association of rare metal minerals accompanying the deposits of "black shales" is of volcanic origin [21], which indicates that rare metals enter the Earth's crust during rifting together with the magma flow contained in the deep fluid.

Signs of both pathways can be found in the work of Kharakhinov [10] in the form of simultaneous detection of signs of basalt volcanism and biotic crises, which the author discovered when studying HC clusters.

The peculiarities of the formation of hydrocarbon accumulations along biogenic and abiogenic paths are manifested in the chemical composition of gases, formed along with oil, and gases, formed during rifting. We emphasize that during the formation of HC accumulations along the biogenic pathway, in which the biomass of organisms is used as a substrate for oil synthesis, the destruction of complex organic molecules can also be associated with the formation of gaseous hydrocarbons. This gas is called associated gas. Since carbon bonds in complex organic molecules can break in different places, gaseous hydrocarbons, and their isomers with several atoms, as a rule, not exceeding 6, are formed (Table 1). In contrast, the gas, which is formed by the interaction of hydrogen and carbon, like in abiogenic synthesis, forms a simpler mixture of hydrocarbons in chemical composition. It is dominated by methane (more than 90%) and a small number of the closest homologs with the number of carbon atoms, as a rule, no more than 4. Isomers are practically absent.

Data for the individual fields the data were supplemented from the Internet [24-26].

Table 1: Gas composition in the largest gas fields in Russia and the UIS. Numerical data are taken from reference books [22,23].

Field	Volume content, %					
	CH_4	C_2H_6	C_3H_8	ΣC_4H_{10+}	N_2	Gas reserves
Urengoyskoye	96.31	0.09	0.01	0.10	3.41	3.5
Yamburgskoe	95.20	0.04	0.02	0.10	4.64	2.0
Shtokmanovskoe	96.24	1.33	0.37	0.19	1.87	3.9
Medvezh'e	98.56	0.01	0.01	0.60	0.82	1.9
Gazlinskoe	94.60	2.06	0.27	0.30	2.77	2.2
Ust-Vilyuyskoe	90.0	4.50	0.9	1.4	3.0	0.5
Shatlykskoe, Turkmenistan	95.05	1.63	0.20	0.04	1.40	2.5
Karadagskoe, Azerbaijan	96.45	1.50	0.20	0.10	1.75	1.3
Bovanenkovskoe	90.83	4.76	1.63	2.22	0.56	4.6
Shebelinovskoe, Ukraine	92.95	3.85	1.05	0.31	1.50	0.7
Severo-Stavropolskoe	98.90	0.29	0.16	0.05	0.60	0.9

Considering from this point of view the composition of the known largest gas deposits of the CIS countries (Tables 1,2), two groups of gases can be clearly distinguished differing from the described features. If gas deposits formed along the abiogenic pathway during rifting (Table 1), it is possible to distinguish them quite confidently from deposits placed in Table 2, which formed along the biogenic pathway. Only a certain degree of caution should be taken into account due to the possible mixing of the gases of both origins.

As noted, the formation of structural traps and their filling occurs during orogenic periods of the cycles. Taking into account this fact and the lability of gases, and their possible mixing when they move within the oil and gas basin, it becomes evident the difficulties in distinguishing deposits of gases of different origins.

A few remarks concerning hydrocarbon deposits formed along the abiogenic pathway. The fact that needs to be explained where is the hydrogen that was used for methane, and its closest homologs synthesis. As can be seen from Table 1, in the examined gas deposits of abiogenic origin the hydrogen wasn't disclosed.

There are two possibilities to explain this paradox. The first is to assume that hydrogen reacted completely when interacting with carbon in the molten magma. This probability seems unlikely because a large excess of carbon or continuous removal of the reaction product is needed during the synthesis. Another explanation seems more likely, related to the high mobility and permeability of hydrogen due to its electroneutrality, high diffusion rate, and low molecular weight. There is a lot of information in the scientific and technical literature about studies of the high permeability of hydrogen through various materials. What is especially important is that gases, like CH_4, C_2H_6, N_2, and others that might present with hydrogen in deposit, have much less permeability [22,29].

Therefore, assuming that the lifetime of large hydrocarbon

Table 2: Composition of petroleum (associated) gases of some fields [27,28].

Fields	Volume content, %						
	CH_4	C_2H_6	C_3H_8	ΣC_4H_{10}	ΣC_5H_{12+}	ΣC_6H_{14+}	N_2
Samotlorskoe	68.0	4.4	9.6	7.8	1.05	3.5	1.7
Pravdinskoye, Khanty-Mansiysk. AO	58.40	11.65	14.53	9.20	3.62	0.57	0.66
Romashkinskoe, Tatarstan	49.41	20.38	16.23	6.39	1.64	0.43	11.23
Korobkovskoye, Lower Volga area	76.25	8.13	8.96	3.54	1.04	-	1.25
Yuzhno-Balykskoye Khanty-Mansiysk. AO	68.16	9.43	15.98	4.50	0.51	0.66	0. 64
Bavlinskoye, Tatarstan	35.0	20.7	19.9	9.8	5.8	-	8.4
Uzenskoye Kazakhstan	50.2	20.2	16.8	7.7	3.0	-	2.3

accumulations from the moment of rifting to the moment of studying the gas composition is quite long. Hence it is quite possible to assume that during this time hydrogen could dissipate.

The following considerations lead to the same conclusion. The lithosphere shell is not completely impenetrable. This is evidenced by the emanations (outflows) of hydrogen found in different parts of the world, which in most cases occur in combination with methane from deep and ultra-deep wells, as well as the study of the composition of volcanic gases.

This is supported by the only world's hydrogen well Bugu 1 near Burakebugu, Mali, with a yield of 98 % hydrogen, which has been in operation since 2011 [30]. Recently (2023) in France, in the province of Lorraine, French geologists Pironen and De Donoto from the National Center for Scientific Research discovered an outflow of hydrogen with a content of (20%) in a well [31]. The probable source of hydrogen is estimated at 46 million tons. Today it is the largest source of hydrogen in the world. The discovered facts indicate that the source of hydrogen is located somewhere in the bowels of the Earth. This confirms the mentioned hypothesis of Larin [12] about a constant flow of hydrogen from the core of the planet (hydrogen degassing). Another confirmation of the hypothesis is the fact that hydrogen is always found in combination with methane in the outflows. At the same time, the volume content of hydrogen will increase with the depth of the well. When drilling at 1000 m, the hydrogen content was 14%, and when drilling at 1250 m - 20% [32]. The prevalence of hydrogen outflows around the world is widely represented: Turkey and Iceland (12%), Japan (51%), Oman (82%), and the USA (96%).

Indirect evidence that hydrogen is part of a liquid-gas melt that breaks through the shell of the lithosphere is the appearance of multi-scale ring structures, the so-called concenters [10]. They appear in places where large oil and gas basins are formed. It can be imagined that due to the release of hydrogen during the formation of gas deposits, when hydrogen meets with oxygen, a "rattling mixture" is formed, during the explosion of which ring-shaped funnels are formed.

Conclusion

It is shown that gravity from the bodies of the solar system on the Earth orbiting the Sun affects the processes occurring in all geospheres of the Earth, including the movement of lithospheric plates, the biosphere, the evolution of photosynthesis, and the sequence of biospheric events, life and mass extinctions of organisms, and the alternation of climatic conditions. Gravity influences the conditions of accumulation and transformation of OM

It is shown that the oil - generating process as part of the biosphere carbon cycle is a regular repetitive process controlled by the movement and collisions of lithosphere plates in the subduction zone (and therefore also depends on gravity). The formation of HC accumulations constitutes a biogenic pathway for the transformation of hydrocarbons.

Under the influence of gravity, the processes take place in the inner geospheres of the Earth, which are synchronized with the movement of lithosphere plates and biosphere processes. They include the rotation of fluid flows under the lithosphere shell, consisting of a magma melt and a gaseous hydrogen stream and products of its interaction with elements present in magma as well as rifting. The abiogenic path of formation of hydrocarbon gas accumulations is associated with the breakthrough of internal fluids through the lithosphere shell (rifting) and coincides with the orogenic period of lithosphere plate movement.

Acknowledgement

The author expresses his sincere gratitude to Prof. V.I. Petersillie to Prof. N.M. Przhevalsky and to PhD. V.A. Arakelyan for their support, useful comments, and pieces of advice while discussing the work.

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