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Review Article

Controversial Issues of Hydrocarbon Field Formation and the Role of Geomagnetic Fields

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This review paper presents controversial issues on the formation of hydrocarbon deposits. We look into the geological contradictions of the abiogenic and biogenic theories of petroleum origin, indicating the connection between hydrocarbon deposits and disjunctive dislocations, as well as present disputes about the geological period over which hydrocarbon deposits have been formed. We further overviewed the radical chain mechanism of hydrocarbon generation from organic matter as proposed by Prof. Nesterov. It is noted that the petroleum generation process in reservoir conditions occurs almost instantly in the presence of discrete geomagnetic fields and does not require a long geological time. This is explained by spin magnetic effects (spin catalysis, magnetic isotope properties). We briefly highlight the effect of magnetic fields on chemical reactions involving organic compounds and the use of magnetic fields to enhance oil recovery. We also present the leading causes of discrete magnetic fields in the sedimentary cover: Earth's geomagnetic reversals, generation of ferromagnetic minerals in oil deposits, electromechanical effects of rock friction near faults, and intermixing of reservoir waters with different mineralization (spontaneous ion polarization). Based on the material reported, we conclude that the radical chain mechanism of petroleum generation processes explains some contradictions of the abiogenic and biogenic theories of petroleum origin. Elaborating this research area has excellent prospects for developing new criteria for hydrocarbon prospecting and devising innovative methods to enhance the oil recovery for shale oil production.

1. Introduction

Reliable knowledge of oil reservoir formation processes is essential to improve the efficiency of oil exploration. The formation of oil deposits consists of two stages: oil generation in the parent sediments and the subsequent migration of hydrocarbons into the trap [1]. The present review paper discusses in detail the problem of the oil generation mechanism and highlights the unconventional factor of the ambient environment, which affects the process of oil generation.

Understanding the process of oil generation in oil matrix rocks will contribute to developing new search criteria for oil deposits. In addition, the resources of hard-to-recover oil in clay-bituminous sediments (shale oil) are enormous. For example, the Green River Formation (the Piceance Basin) geological resources of shale oil are estimated at 1.525157 trillion barrels [2], and similar deposits exist all over the world [3].

The main problem of shale oil is its extraction from the reservoir. To solve this problem, it is required that the filtration characteristics of the reservoir be improved technologically [4]. It is known that because of oil generation in oil-bearing sediments, fracturing is formed (autofracturing of rock), and filtration characteristics of the reservoir are increased [5]. In this regard, understanding the natural mechanism of oil generation in oil-bearing sediments is essential to developing new effective methods to increase oil recovery.

In this review paper, we consider the central contradictions of the biogenic [6] and abiogenic [7] theories of oil origin and try to explain these contradictions from the position of an unconventional theory of oil generation, which was proposed in the 20th century by Ulmishek [8].

Here, we will not consider the mechanism of oil generation according to biogenic and abiogenic theories. We will focus our attention on the geological contradictions of the existing concepts. We will try to explain some contradictions from the perspective of the role of radical reactions in the processes of oil generation [8], which are activated by natural geomagnetic fields [9]. From the viewpoint of fundamental laws of chemistry, we will present a brief review of the properties of isotopes with magnetic moment [10], as well as the phenomena of spin catalysis, which were discovered by Buchachenko and Berdinsky [11].

In the present study, we use the term "discrete geomagnetic fields" implying the strength of the natural geomagnetic field which is a variable. This discretization manifests itself most intensely in the geomagnetic reversals (discretization is due to the high field strength values on different territories of the Earth: the strength of the geomagnetic poles is two times that of the geomagnetic equator). Besides, we also imply local intermittent geomagnetic fields arising from the rock frictions within faults and the intermixing of reservoir waters differing in mineralization.

2. Geological Contradictions of Biogenic and Abiogenic Theories

According to the biogenic theory, oil is formed from organic matter by catagenesis [12]. The critical environmental factors in this process are reservoir temperature and geological time [13]. However, the abiogenic theory advocates believe that formation temperatures are not sufficient to transform solid kerogens into liquid petroleum hydrocarbons [14]. The analysis of geological features of hydrocarbon deposits distribution according to abiogenic and biogenic theory is presented in Table 1.

The analysis of Table 1 leads to a conclusion that the authors of this table are not supporters of the biogenic theory of oil origin, as the geological features of interest do not take into account factors such as:

(i) Rotational polarization typical of oil and organic tissues

(ii) Porphyrin derivatives of chlorophyll and hemoglobin in oil

(iii) The presence in the oil of fossil spores and algae which have provided waxy, oily, and greasy secretions for oil formation

In the context of this study, we state that we adhere to the biogenic theory of petroleum formation but believe that the current theory requires improvement. In particular, in this review article, we will try to illustrate that the biogenic theory can explain points 7, 8, and 9 presented in Table 1.

3. General Conditions for the Transformation of Organic Matter According to Nesterov

This section highlights Prof. Nesterov's view on the generation of hydrocarbons from organic matter. When writing this section, we have used several scientific works by Nesterov [16].

Organic matter is the initial product from the formation of oil and gas deposits. In his work, Prof. Nesterov hypothesized a radical chain mechanism for hydrocarbon generation from organic matter. He gave an essential role in this process to the concentration of paramagnetic centers in organic matter. The principal scheme for the generation of gaseous and liquid hydrocarbons from solid organic matter with paramagnetic centers located at the ends of aliphatic chains of molecules is shown in Figure 1.

Temperature (T) and pressure (P) are the main parameters determining the ambient conditions of organic matter transformation during catagenesis. It is noted that an increase in temperature leads to the intensification of gassing processes. In contrast, an increase in pressure shifts them towards the formation of heavier hydrocarbons and reduces the process intensity through to a complete cessation.

The stressed state of reservoir system (ne) is constantly changing due to tectonic movements, ocean level changes, longitudinal wave fields, phase transitions of rock-forming minerals, and others. When the stress state changes, electromagnetic fields arise in the rocks of reservoir systems, which depends on the strength and speed of such a change. The stronger the electromagnetic field, the more likely the generation of hydrocarbons by the radical chain mechanism. This phenomenon can be conventionally called an "underground thunderstorm".

To confirm this hypothesis, special studies were conducted on kerogen samples from the black shales of the Bazhenov Formation of Western Siberia and various types of coals with enough paramagnetic centers of organic matter. In the case of electromagnetic field irradiation of organic matter, the molecules had no paramagnetic centers—no changes were observed. In paramagnetic centers in organic matter, an explosion occurred during irradiation.

In nature, in the presence of paramagnetic centers in organic matter, liquid and gaseous hydrocarbons form at certain temperatures and pressures under conditions of intense electromagnetic fields arising from changes in the stressed state of rocks.

At low concentrations of paramagnetic centers in organic matter, but not high temperatures and pressures, the formation of methane and ethane occurs. In contrast, heavier gaseous methane and liquid naphthenic hydrocarbons are formed at higher concentrations. Liquid alkanes and aromatic compounds then appear.

If these processes are regional, water-soluble and rock-sorbed gases and bitumoids are formed. Suppose the change

Table 1: Peculiarities of oil and gas formation (by Yu.I.Pikovsky, supplemented by the authors) [15].

	Oil and gas accumulation features	Does the phenomenon, without further assumptions, follow from the concept of oil and gas formation? Biogenic theory	Abiogenic theory
1	Bound to sedimentary basins	Yes	No
2	The presence in the rocks of oil and gas-bearing areas of dispersed oil similar in composition to the oil in the accumulations	Yes	Yes
3	Secondary accumulation of oil and gas in natural reservoirs	Yes	Yes
4	The possibility of significant hydrocarbon accumulation throughout the sedimentary basin, including the crystalline basement, irrespective of the lithological composition of the rocks and their organic matter content and type	No	Yes
5	Uneven oil and gas accumulation. A high density of giant and supergiant oil and gas deposits in relatively small separate areas	No	Yes
6	Abnormally high pressures in hydrocarbon accumulations	No	Yes
7	A relatively narrow range of geological time, close to modern times, over which all world's significant deposits have formed	No	Yes
8	Linking oil and gas deposits to recent crustal movements, the continuation of oil and gas accumulation at present	No	Yes
9	Oil and gas accumulations confined to major deep-lying activated faults	No	Yes
10	Recoverability of exploitable hydrocarbon reserves	No	Yes

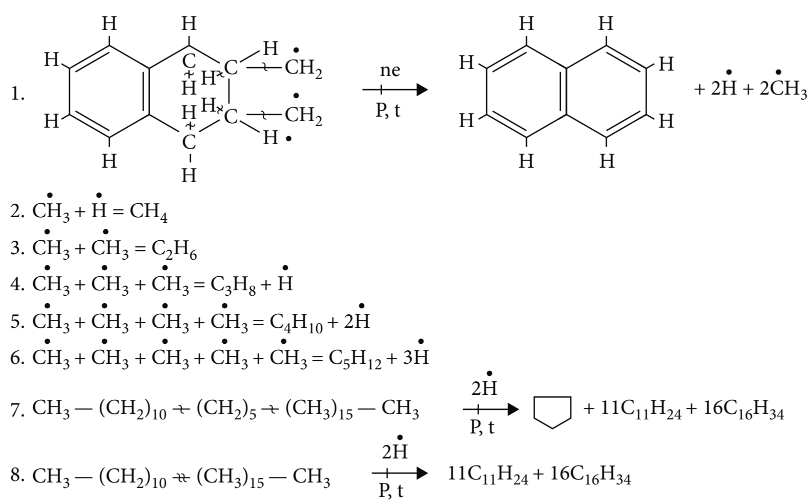

Figure 1: Schematic diagram of hydrocarbon generation from organic matter. P is the reservoir pressure, T is the reservoir temperature, and ne is the stress state of reservoir system.

in the stress state of rocks during the lower stages of catagenesis is local. In that case, deposits of predominantly methane gases or heavy oils and condensates are produced, depending on the intensity of the stress field.

High paramagnetic centers increasing temperature and pressure produce gas condensate and then methane aromatic and methane oil reservoirs. Favorable initial conditions for forming hydrocarbon reservoirs appear in the decompaction zones with minimal pressure in each trap. Such conditions most often occur in the vaulted parts of anticlines and the barrier traps in the most elevated zones.

Electromagnetic fields arise when the stress state of rocks changes. They interact with the paramagnetic centers of organic matter and form free radicals $CHCH_{3,2}$ and H. They have high energy and combine to form hydrocarbon gases within a fraction of a second or break carbon-carbon (-C-C-) bonds in aliphatic chains to form liquid hydrocarbons.

The process of oil deposit formation in oil-bearing sediments can be described by the equation [17]:

$$q = k\frac{\mathrm{cdt}}{p}\left(\frac{D}{1\times 10^{22}}\right)\frac{P}{T}, \tag{1}$$

where q is the amount of oil and gas produced in $1\,\mathrm{m}^3$ of rock (t/m); c is the organic matter content of the rock (weight fractions per unit); d is the specific gravity of the rocks containing the deposit (t/m); t is the paleotemperature when the deposit is formed (°C); p is the paleopressure when the deposit is formed (MPa); D is the concentration of

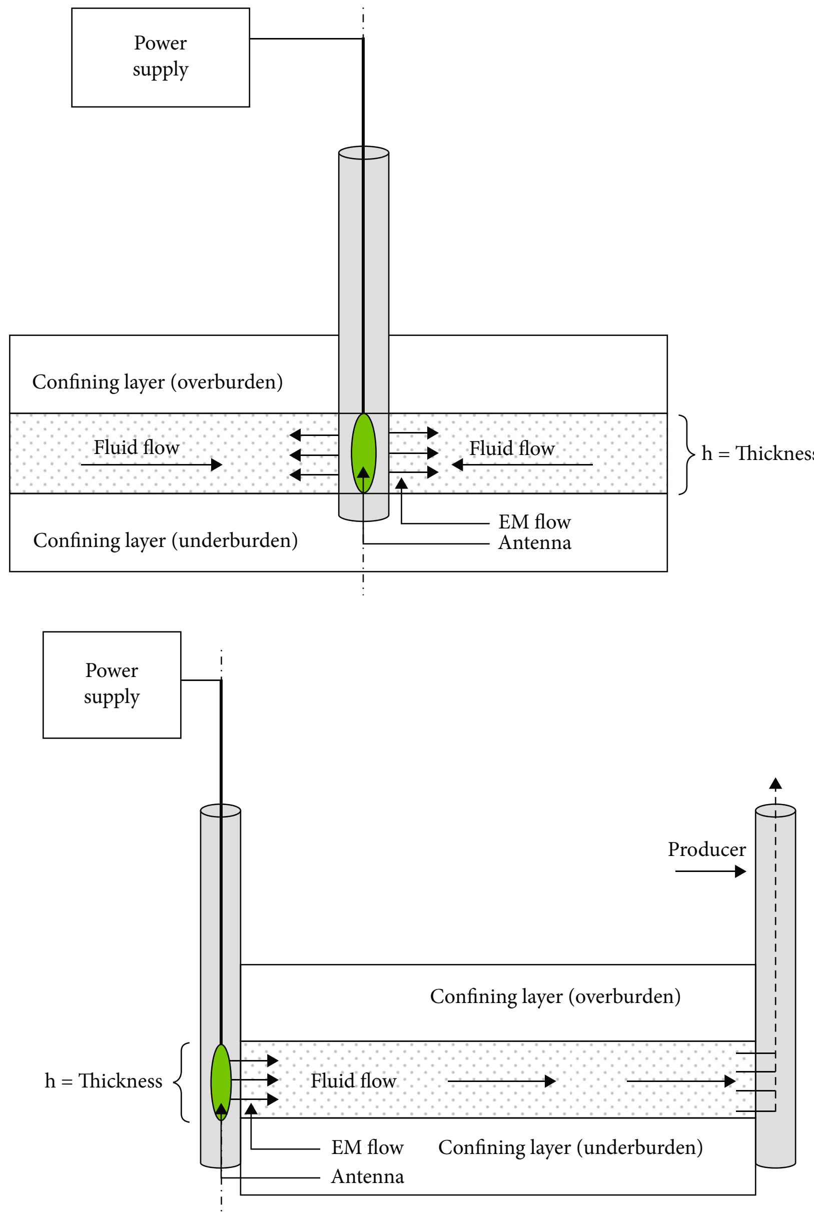

FIGURE 2: Diagram of the placement of a microwave device in a production well [31].

paramagnetic centers in organic matter (spin/g); 1×10^{22} is the limiting concentration of paramagnetic centers in organic matter (spin/g); P is the pressure at which oil-gas-forming processes are practically stopped (MPa); T is the temperature at which oil-gas-formation processes are practically stopped (°C); k is the coefficient of the electromagnetic field strength when the stressed state of rocks changes.

4. Effect of Magnetic Fields on Chemical Reactions of Organic Compounds

In continuation of Nesterov's idea [18, 19], this section highlights the influence of magnetic fields on chemical reactions in organic chemistry. Here, we present the current research results regarding spin magnetic effects in the petroleum industry.

Spin magnetic effects in chemical reactions are phenomena that are related to the spin behavior of electrons and nuclei in chemical reactions. They are characteristic for reactions involving free radicals, paramagnetic ions, molecules in the triplet state, and other particles containing unpaired electrons [20]. The spin magnetic effects in chemical reactions are the high spin selectivity of chemical reactions involving paramagnetic particles. Reactions in which the total electron spin of the reacting particles coincides with the spin of the products are allowed. The spin effect depends on the reactivity of radical pairs and on their electron spin. Magnetic interactions that change the spin states of radical pairs and their occupancy can be induced by an ambient magnetic field and then lead to a dependence of the reaction rate on the field strength. They can also be induced by the internal magnetic field created by the nuclei. Then they lead

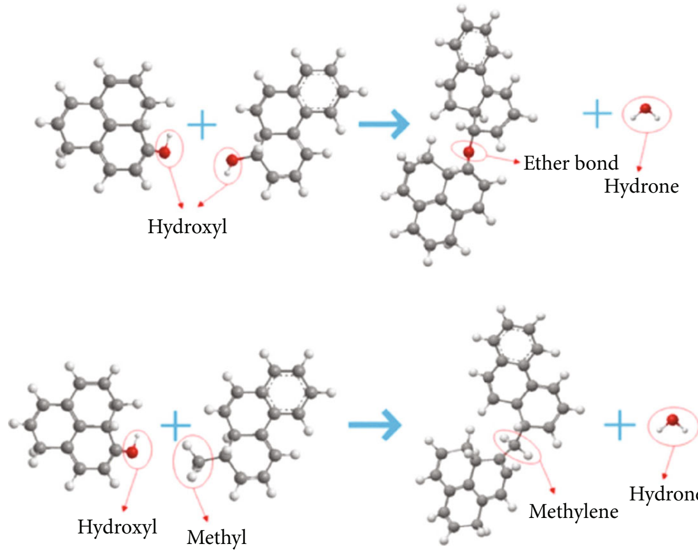

FIGURE 3: Scheme of complex catalytic reactions when organic matter is exposed to microwave radiation [33].

to a difference in the reaction rates of radicals with magnetic and nonmagnetic nuclei, i.e., to the magnetic isotope effect [21].

The external magnetic field affects the yield of reaction products and the rate of elementary interaction processes of paramagnetic particles (recombination of radicals, annihilation of triplet-excited molecules, quenching of triplet molecules by radicals, etc.). The magnetic isotope effect is accompanied by the separation of magnetic and nonmagnetic isotopes, for example ^{12}C and ^{13}C,^{16}O and ^{17}O, and ^{1}H and ^{2}H [15].

Spin magnetic effects are currently the most investigated in biochemical reactions involving organic compounds [22]; it is noted that the rate constant of chemical reactions increases in an ambient magnetic field [21]. Organic matter and oil include radicals with free electrons (this is evidenced by the presence of paramagnetic centers) [23, 24]. As well as the presence in the composition of oil and organic matter of stable isotopes with the magnetic moment, such as ^{2}H, ^{13}C, and others [25, 26]. Based on this, it can be concluded that spin magnetic effects are also present in oil generation processes. These effects may be observed in case discrete geomagnetic fields are present in the oil matrix rocks, which may be caused by various natural phenomena which are detailed in the next section of the paper.

Here, we further present additional research on the use of magnetic fields as enhanced oil recovery methods, to demonstrate that natural geomagnetic fields can impact the oil recovery process.

The prospects of the magnetic impact on oil reservoirs have been under study since the mid-20th century [27]. Most studies suggest using magnetic influence on an oil reservoir [28, 29] to increase temperature and reduce oil viscosity [30]. An approximate schema of using electromagnetic emitters for heavy oil production is shown in Figure 2.

In addition, a method for the integrated use of magnetic fields and various catalysts has been gaining popularity in

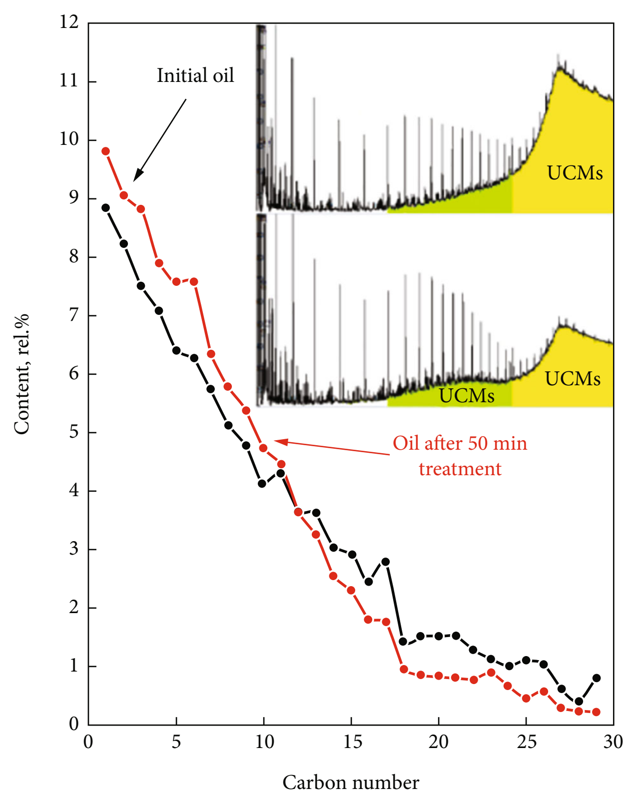

FIGURE 4: A composition of the saturated fraction according to GCMS data for the original oil and oil after 50 min exposure. The inset indicates chromatograms showing naphthene "humps" [40].

recent years, and a decrease in oil viscosity has been noted [32].

In terms of molecular changes in the composition of oil when exposed to microwave radiation, an increase in the degree of polycondensation of aromatic structures, reducing the length of alkane side chains, and increasing the degree of

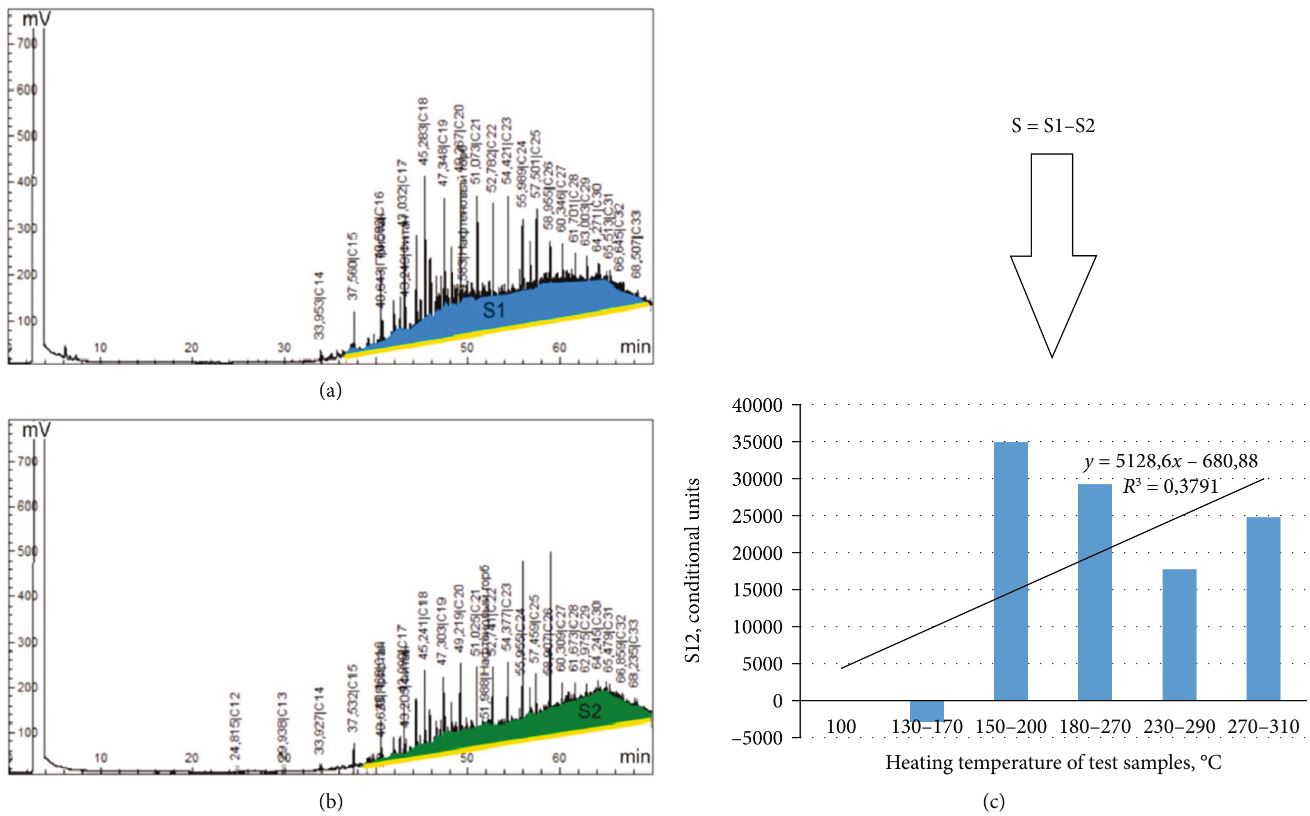

Figure 5: A decline in the complex mixed naphthenes after the source rock (shale) was heat-treated under the magnetic field: (a) bitumoid chromatogram after the thermal treatment without magnetic field; (b) bitumoid chromatogram after the thermal treatment under a magnetic field, and (c) a histogram of the difference in the naphthene "hump" (total naphthenes in bitumoid) for samples heat-treated under a magnetic field and with no magnetic field [41].

maturity of organic matter [33]. Figure 3 displays a scheme of catalytic reactions when the organic matter is exposed to microwave radiation.

Polycondensation of aromatic rings, the release of alkane side chains, and oxidation of oxygen-containing functional groups caused by microwave exposure are the causes of changes in the molecular structure parameters of organic matter [33]. Another work on the microwave exposure of bituminous coals notes that the amount of aliphatic hydrocarbons is decreased by the decomposition of methylene bridging bonds, and hydroxyl self-associated hydrogen bonds are broken by microwave radiation (phenol and carboxylic acid are converted into either groups) [34].

Moreover, quite a few experimental studies in the literature show a decrease in the viscosity of oil when exposed to electric or magnetic fields [35–38]. The method of electromagnetic influence on the oil-saturated reservoir shows an increase in the debits of producing wells [39]. Moreover, it is noted in the literature that in a permanent magnetic field, the rate of petroleum generation processes is increased when the activation energy of carbon-carbon (-C-C-) bond breaking is reduced or the reaction rate raised [9]. In the other work [16], it is shown that the exposure of oil to a 50 Hz low-frequency field changes the fractional composition of oil. In our recent studies [40–42], we reported the results of experimental studies on the variation in the chemical composition of oil when exposed to a 50 Hz electromagnetic field and a 50 mT constant magnetic field combined with a thermal treatment. Below, we outlined the most significant results from those studies that demonstrate the magnetic fields breakdown the -C-C- bonds in heavy components of oil and transform the same into lighter components (Figures 4 and 5). Besides, we were able to document some of spin magnetic effects that arise from the interaction between the magnetic field and oil (Figure 6).

It is seen in Figure 4 that the 50 Hz magnetic field initiates chemical reactions that render a complex mixture of naphthenic compounds into *n*-alkanes having a lighter composition (with a lower number of carbon atoms).

Figure 5 illustrates experimental results for shales heat-treated under a magnetic field and without. The results suggest that in 4 cases out of 5, the content of complex mixed naphthenic hydrocarbons in the matched samples heated up to the same temperatures was observed to decrease. And again, this evidences that the magnetic fields intensify the processes of cracking and -C-C- bond breaking.

Figure 6 displays isotopic effects that are observed in the compositional components of oil, and it can be inferred from the results that the magnetic impact on oil induces isotopic effects associated with the change in the isotopic composition of oil. This can explain the reason why the complex mixture of naphthenic hydrocarbons turned to

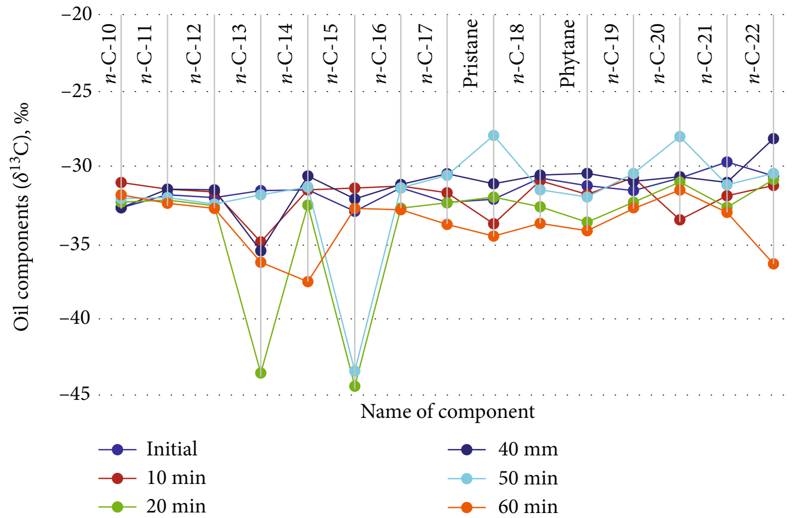

FIGURE 6: A change in the carbon isotopic composition (δ 13C) of oil when exposed to a 50 Hz electromagnetic field [42].

light n-alkanes because the experiment with the 50 Hz electromagnetic exposure was performed without any additional thermal treatment.

Magnetic and electromagnetic fields affect organic compounds. They can break carbon bonds and produce effects associated with the recombination of radicals in organic compounds. Although the effects of exposure of organic compounds to magnetic fields in the oil and gas field are understudied and there are quite raw studies so far that indicate a decrease in oil viscosity or cracking of organic matter, we can confidently conclude that the spin magnetic effects described [16] play an essential role in this process. In this regard, the next section of the present review highlights the presence of natural geomagnetic fields. We conclude that they also influence the natural processes of petroleum generation during the transformation of organic matter at the diagenetic, catagenetic, and metagenetic stages.

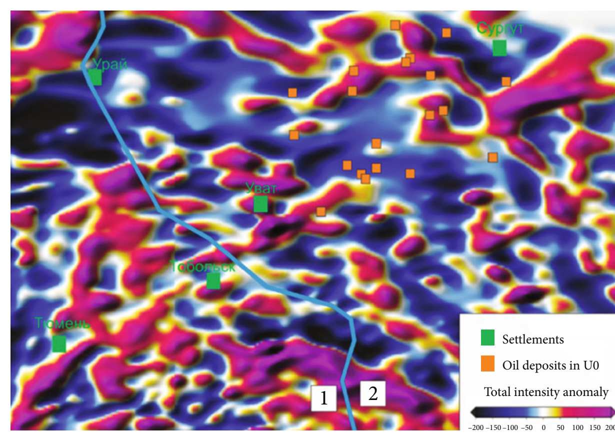

FIGURE 7: Magnetic anomalies and oil deposits in the Bazhenov suite: (1) no-prospect oil-bearing zone and (2) potentially productive oil-bearing zone [9].

5. Natural Geomagnetic Fields and their Possible Involvement in Petroleum Generation Processes

The previous section already showed that magnetic fields can influence radical reactions in organic compounds. Clearly, in the case of natural geomagnetic fields, they can also influence petroleum generation processes to a greater or lesser extent. This is due to spin magnetic effects that are common for all types of chemical reactions of organic compounds. In this section, we will try to show from whence discrete geomagnetic fields may arise in the sedimentary cover (where according to the biogenic theory of petroleum origin, the petroleum generation processes occur in oil-bearing sediments).

Firstly, we would like to note that Earth is a vast magnet. At the same time, the mechanism of this magnetism is still not completely clear, and there are only theories that explain it [43–45]. It is known that 183 geomagnetic reversals have been observed on Earth in the past 83 million years [46]. For understanding, it is necessary to note what a reversal is and why the magnetic field strength changes on a particular territory. The geomagnetic field reversal is a phenomenon occurring when the geomagnetic poles of our planet are reversed, moving over the whole territory of the planet over a particular time. It is known that the geomagnetic field strength at the geomagnetic poles is ~2 times higher than that at the geomagnetic equator [47]. This suggests that, depending on the position of the geomagnetic poles during reversal, the petroleum generation processes on different territories could be different. Recent studies show that the generation intensity was more substantial on those territories where the geomagnetic poles were concentrated and were the most extended during reversals. Figure 7 shows a relationship between the oil deposits of the Bazhenov suite and the magnetic anomalies.

We noted previously [9] that the oil-bearing potential of the Bazhenov suite could be associated with areas exhibiting

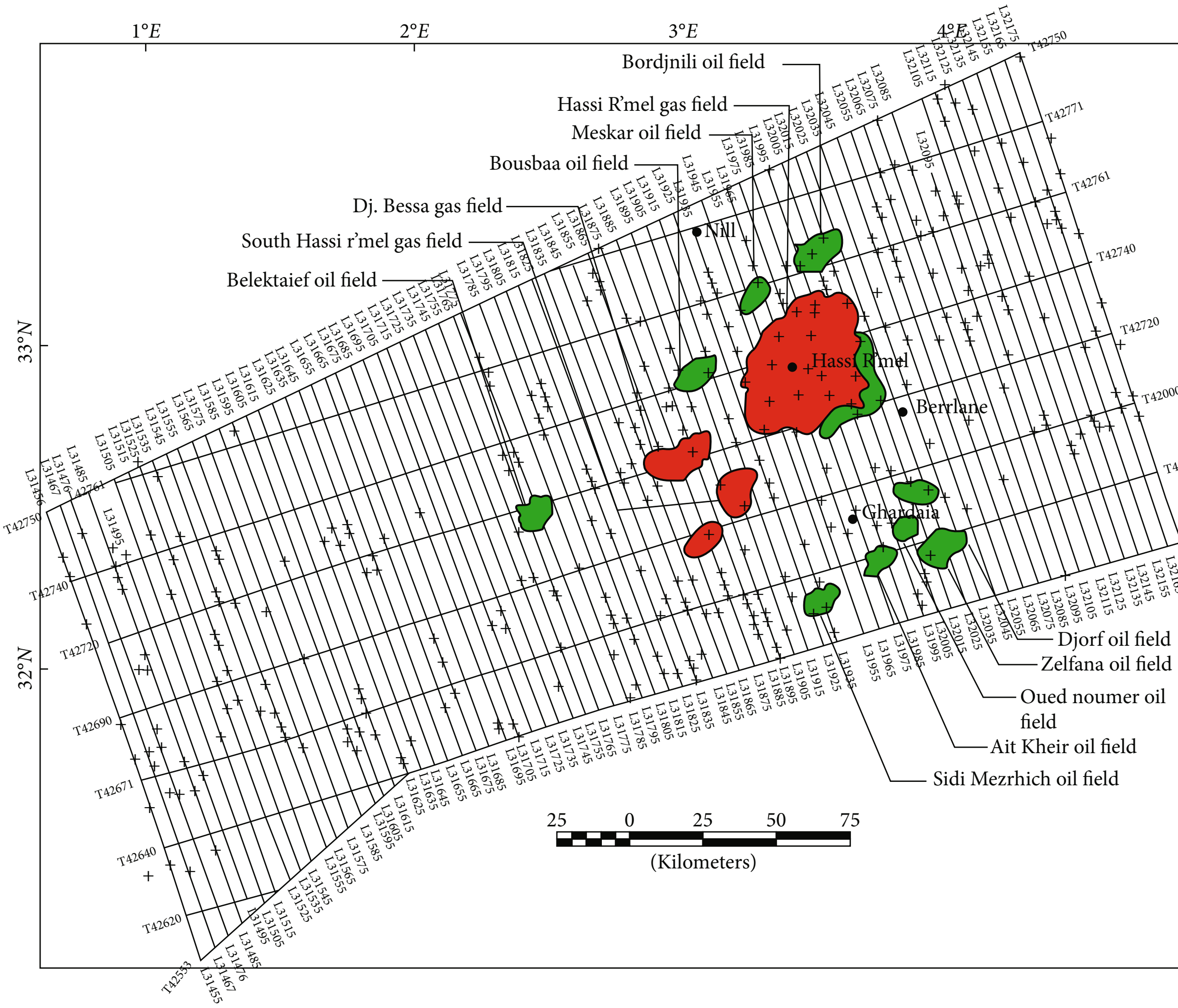

Figure 8: Black crosses represent the location of center-points of picked AS-SRM anomalies (the amplitude threshold for AS is 1.5 nT/km); red polygons represent the gas fields, and green polygons represent the oil fields [48].

TOC values > 4%, reservoir temperature values > 70 ∘ C, and magnetic anomalies on the EMAG2 maps ranging from -100 to 100 nT.

In addition, scientists note the relationship of magnetic anomalies (magnetic anomalies are formed due to geomagnetic pole reversals) with hydrocarbon fields [48]. Figure 8 shows a relationship between the oil-and-gas deposits and the magnetic anomalies. In this case, the magnetic anomalies are recorded by magnetic survey and their formation nature is associated with ferromagnetic minerals, like pyrrhotite and probably magnetite, being generated in oil source rocks and migrating [49].

Allek et al. [48] note that the degree of the established positional connection between the hydrocarbon deposits and the delineated sedimentary residual magnetic anomalies increases considerably with a certain class of anomalies, suggesting that the areas where they subsequently manifest themselves comprise more hydrocarbon deposits than one could expect it by chance. From a geological perspective, those authors associate is with the migration of magnetic minerals, but one cannot rule out the assumption that the magnetic anomalies stem from the geomagnetic reversals. The idea that magnetic anomalies arise from the generation of ferromagnetic minerals in oil deposits and migration thereof is also corroborated by the other studies [50, 51]. Overall, the idea of the secondary generation offer electromagnetic minerals in oil deposits is well consistent with Nesterov's idea because these magnetic minerals create a magnetic field around themselves and can accelerate the oil generation process and take part in the scheme suggested by Nesterov, as shown in Figure 1.

Secondly, we want to overview the electromechanical effects that can occur near faults due to rocks rubbing against each other. Electromechanical effects have been studied to a greater extent by scientists from the perspective of earthquake prediction [52–54]. However, in the context of this study, electromechanical effects near faults are essential because they can indicate the presence of spin magnetic effects near faults and explain the relationship between hydrocarbon deposits and faults. There is no absolute tectonic quiescence—it means that the microfriction of rocks in sites of tectonic faults occurs constantly. The literature

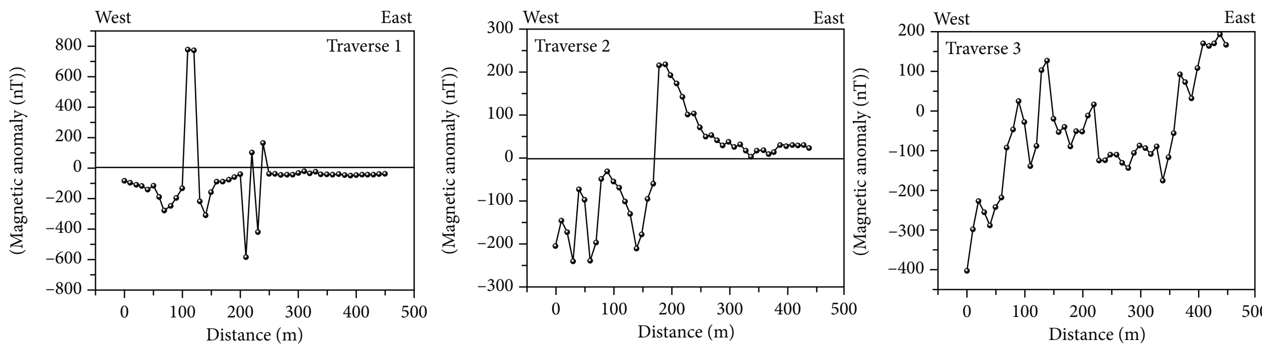

Figure 9: Source data on magnetic anomalies for the prediction of faults (ground magnetic data obtained along traverses 1, 2, and 3) [58].

has sufficient reports that confirm the occurrence of electromagnetic emission when rocks rub on each other [55–57]. Given high magnetic field strengths being present near the faults, it can be concluded that the petroleum generation processes were more intense due to the spin magnetic effects. Figure 9 depicts the source data on the delineation of faults using the magnetic field strength characteristics.

Adepelumi et al. [58] have managed to establish a connection between the magnetic anomalies and the faults. These authors note that the vertical fault model explains adequately the anomalies observable on the three traces. The vertical fault was predicted from the magnetic data inversion. This fault is responsible for the anomalies observed 12 m deep on traverse TR1, 25 m deep on traverse TR2, and 45 m deep along traverse TR3, with incidence angles of 75° for traverse TR1, 85° for traverse TR2, and 80° for traverse TR3 [58].

Thirdly, we want to demonstrate that the intermixing of reservoir waters differing in mineralization can result in an electric field due to the spontaneous ion polarization [59]. Spontaneous potentials arise when two aqueous solutions with different ions come into contact through a porous semipermeable membrane. In nature, ions migrate from high to low ion concentrations, resulting in an electric field. This method is commonly called the "potential spontaneous log" [60, 61]. It is important to note that Maxwell's two equations, Faraday's law, and Ampere-Maxwell's law, illustrate a convenient feature of the electromagnetic field. Faraday's law can be roughly formulated as "the changing magnetic field creates an electric field." Ampere's law roughly states that "the changing electric field creates a magnetic field" [61].

Given that migration and intermixing of reservoir waters differing in mineralization [62] occur in reservoir systems, it is logical to state that electric and magnetic fields arise consequently. The reservoir fluids move from the highest pressure areas to the lowest ones along the path of least resistance. Such pathways can be vertical disjunctive faults in the sedimentary cover [63–66]. Following this, the zones near faults may be the source of discrete geomagnetic fields, which in turn may influence the petroleum generation processes due to the spin magnetic effects during the transformation of organic matter.

6. Conclusions

The present review highlighted, in brief, the problem of oil genesis and presented the main criticisms of the abiogenic theory's advocates. We attempted to explain some of them and answer the concerns raised by the abiogenic theory's advocates who associate oil-and-gas fields with recent crustal movements and confinement of reservoirs to significant activated faults. In addition, we gave the abiogenic advocates a hint that the spin magnetic effects can also explain the narrow range of geological time over which they claim all worlds' significant reservoirs to have formed. The material reported herein contradicts the chemical kinetic modeling which is extensively employed by the biogenic theory's advocates [66, 67]. This contradiction is primarily attributed to the basin kinetic models that factor in only reservoir temperature and geological time, in which case the effect of discrete geomagnetic fields on the petroleum generation kinetics is disregarded.

The overview of spin magnetic effects and discrete geomagnetic fields agrees well with the petroleum generation concept introduced by Nesterov. In accordance with the concept, radical reactions initiated by temperature, pressure, and magnetic fields play the most important role in petroleum generation. A distinctive fundamental feature of Nesterov's theory is that it does not take a long geological time to generate the large quantities of hydrocarbons needed to form oil or gas deposits. The radical chain processes of petroleum generation under certain environmental conditions occur almost instantaneously—this phenomenon is conventionally called an "underground thunderstorm".

The elaboration of Nesterov's concept and the comprehensive study on spin magnetic effects in petroleum geology could significantly improve the efficiency of oil-and-gas exploration in the future and boost the development of innovative technologies for shale oil production.

We should also note the weaknesses of our study findings. First, the idea that the natural geomagnetic fields have an impact on oil generation and geochemical evolution began to evolve in 2021, and before that, no one had conceived the idea that the geomagnetic fields could influence those processes. That is why there are few experimental studies on this problem. Second, Buchachenko's works were written in the late 20th century, as was Nesterov's theory, whose ideas have not become widespread in the world of science. Despite the said shortcomings, we presented herein statistically significant results of the studies demonstrating how the magnetic and electromagnetic fields influence the cracking of heavy hydrocarbons. It should be noted that magnetic minerals are present in oil and sources rocks and, from Nesterov's standpoint, can quite reasonably participate in oil generation processes, as shown in Figure 1, because they create a magnetic field around themselves. Besides, these minerals can migrate together with oil, which explains the nature of magnetic anomalies over oil deposits. This means that magnetic survey data can be used not only to locate anticlines but can also provide some quantity of information on the assumed saturation of reservoirs at a qualitative level. We can recommend the use of magnetic survey coupled with surface geochemical survey for a more accurate prognosis of the saturation of inferred oil deposits.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure

This article was prepared as part of the Digital Core technology project at the West Siberian Interregional World-class Science and Education Center.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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