

Theory of Hydrocarbons

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The presence of hydrocarbons in the Earth's crust is a recognizable fact and an idea that they are the remains of life on the Earth's surface that have been buried a long time ago and now appear as oil and natural gas. However, pioneering work and ideas have even sprung up in another direction... Recently, there is a growing number of supporters who believe that deep in the Earth (deep hot biosphere), underground sources of chemical energy exist. Here, we will try to give a transparent reflection theory of deep natural gas. Keywords: hydrocarbons, the theory of the origin of oil and gas.

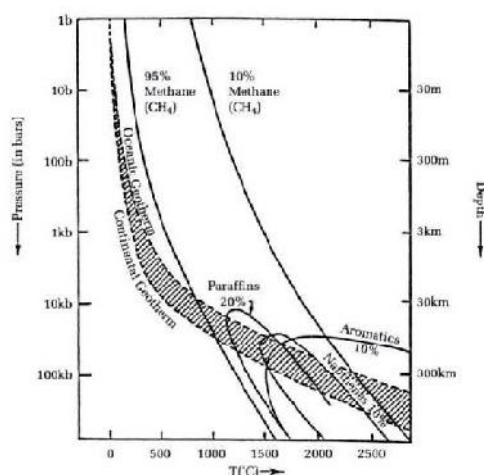


Figure 1. Stability of hydrocarbons at temperatures and pressures in the earth (from Chekaliuk, 1976).

Historical views of the theories of oil occurrence

An abiogenic hypothesis was first proposed by Georgius Agricola in the 16th century and various additional abiogenic hypotheses

were proposed in the 19th century, most notably by the Prussian geographer Alexander von Humboldt, the Russian chemist Dmitri Mendeleev and the French chemist Marcellin Berthelot. Abiogenic hypotheses were revived in the last half of the 20th century by Soviet scientists, who had little influence outside the Soviet Union because most of their research was published in Russian. The hypothesis was re-defined and made popular in the West by Thomas Gold who developed his theories from 1979 to 1998, and published his research in English.

Some of the evidence used to support abiogenic theories includes:

Proponents	Item
Gold	The presence of methane on other planets, meteors, moons and comets
Gold, Kenney	Proposed mechanisms of abiotically chemically synthesizing hydrocarbons within the mantle
Kudryavtsev, Gold	Hydrocarbon-rich areas tend to be hydrocarbon-rich at many different levels]
Kudryavtsev, Gold	Petroleum and methane deposits are found in large patterns related to deep-seated large-scale structural features of the crust rather than to the patchwork of sedimentary deposits
Gold	Interpretations of the chemical and isotopic composition of natural petroleum
Kudryavtsev, Gold	The presence of oil and methane within non-sedimentary rocks upon the Earth

Gold	The existence of methane hydrate deposits[2]
Gold	Perceived ambiguity in some assumptions and key evidence used in the conventional understanding of petroleum origin
Gold	Bituminous coal creation is based upon deep hydrocarbon seeps
Gold	Surface carbon budget and oxygen levels stable over geologic time scales
Kudryavtsev, Gold	The biogenic explanation does not explain some hydrocarbon deposit characteristics[2]
Szatmari	The distribution of metals in crude oils fits better with upper serpentinized mantle, primitive mantle and chondrite patterns than oceanic and continental crust, and show no correlation with sea water
Gold	The association of hydrocarbons with helium, a noble gas

A world-famous scientist Thomas Gold contends that there is a false thesis of the oil crisis. Namely, the Gold hydrocarbons that make up the oil reservoirs are constantly supplemented.

Thomas Gold, a prominent astronomer and professor emeritus at Cornell University in Ithaca, N.Y., considered for years that oil is actually a renewable energy source that is constantly created on earth under hot conditions and extremely high pressures.

Most scientists hold that oil, which can be reached by drilling, is a result of the decomposition of the prehistoric plants. But Gold believes that the oil was there from the moment of the Earth's formation, and that life there preceded life on the Earth's surface. The existence of [deephot biosphere] could prove to be one of the monumental discoveries of our time. Maybe, life is an inevitable consequence of physical laws and can arise spontaneously in millions of places.

At depth, it will, given sufficient time, perform this feat of alchemy, transforming the remains of surface life buried within sediments-or so we are told. Petroleum is therefore regarded as "fossil fuel." Yet the assemblage of widely accepted facts on

petroleum chemistries and their geographical and geological occurrences, considered as a whole, does not support a preference for this standard solution. Pushed aside or not even reported because it does not fit, that particular science is in deep trouble. This has happened quite often in several fields. In geology, for example, a person who thought that continents or parts of continents might have moved in the past was ridiculed before 1960, despite the existence of good evidence from magnetic rock measurements. After 1965 anyone who did not believe in such movement was again a subject of ridicule. In petroleum geology, the massive and persuasive evidence of a deep origin of the fluids is still treated with disdain and cannot be published in certain journals.

The Deep-Earth Gas Theory

New ideas in science are not right just because they are new. Nor are old ideas wrong just because they are old. A critical attitude is clearly required of every seeker of the truth. But one must be equally critical of both the old ideas as of the new. When the established ideas are accepted uncritically the conflicting new evidence is brushed aside.

Carbon and hydrogen can form a great variety of molecules that have different ratios of carbon to hydrogen and different molecular geometries, and all are called hydrocarbons. At the temperatures and pressures on or near the earth's surface, some hydrocarbons are solid (coal), some are liquid (crude oil), and some are in the vapour state (natural gas, which is predominantly methane).

Liquid and gaseous hydrocarbons are commonly called petroleum, which exhibits a great variation in the proportions of the various hydrocarbon molecules. Petroleum also has unifying features that suggest a similar mode of generation. Nowadays, most petroleum geologists outside the former Soviet Union would say that the question has been completely answered - deposits of biological debris, reworked by geological processes, account for all natural petroleum.

Elevated temperatures (but not elevated to volcanic levels) and elevated pressures prevailing at depth will, given sufficient time, perform this feat of alchemy, transforming the remains of surface life buried within sediments-or so we are told.

The Origin of Petroleum: Two Conflicting Theories

Even though the biogenic origin theory leads to many inconsistencies (which will be addressed in Chapters 4 and 5), it is, nevertheless, virtually impossible, in the Western world, to conduct any research in petroleum geology, that implies a questioning of this accepted position, now.

A young person- however brilliant-with no scientific standing, who attempted to do so would have no hope of passing the peer review, either for obtaining funds or for publishing adverse results.

Fortunately for me, by the time I began nosing around in the field of petroleum geology, I had established a favourable standing for myself in the fields of physics, including geophysics, and in astronomy. I had, by then, been elected to memberships in several prestigious learned societies, and this standing made it possible for me to air my heretical views on the origin and ubiquity of oil and natural gas. Beginning in 1977, I wrote a number of papers on the subject of "deep-earth gas," in which I explained my reasons for thinking that natural gas and other hydrocarbons had originated at great depth-perhaps 100 to 300 kilometres beneath the earth's surface.

This depth is nearly 100 to 300 kilometres deeper than the depth that the proponents of the biogenic view would place the origin of petroleum in, as a consequence of their central presumption that petroleum forms from the remains of surface life, buried within the sediments. I presented the deep-earth gas theory during the time of the so-called energy crisis, which, to my mind, had arisen not because there was a physical shortage of oil and gas but because a cartel of major oil producers had gained much strength when several senior petroleum geologists forecast that within fifteen years all the reservoirs of crude oil in the world would be exhausted.

It was in the interest of the oil producers to cut back on production and exact the most revenue possible from the remaining reserves. Now, twenty-five years later, the world is awash in oil and has more than it requires, even by conservative estimates and even projecting significantly increased rates of consumption. My proposal (and that of many

Russian colleagues) that petroleum is abiogenic and ubiquitous deep in the earth, though far from the mainstream opinion, did receive attention, particularly from petroleum entrepreneurs because of its practical importance well beyond the boundaries of pure science.

In 1982 I supplemented the deep-earth gas theory in my own mind with the concept that a "deep hot biosphere" was thriving on these deep resources. A full decade passed before I was able to publish this hypothesis. In taking this next step, however, I finally managed to put together all the pieces of evidence, including some that had initially been supportive of the biogenic theory of origin, in a way that I felt provided a satisfactory resolution of all the paradoxical information.

The origin of petroleum has been the subject of many intense and heated debates since the 1860s, when crude oil was first discovered to be present in large quantities in the pore spaces of many rocks. Was it present when the earth was first formed, or is it a fluid concentrated from huge amounts of vegetation and animal remains, that may have been buried in the sediments over hundreds of millions of years? Arguments have been advanced for each of these two viewpoints, and although they seem to conflict, each line of argument has its strong points.

The biogenic theory holds that biological debris buried in sediments decays into oil and natural gas in the long course of time, and that this petroleum then becomes concentrated in the pore spaces of sedimentary rocks in the uppermost layers of the crust. The search for oil was conducted with this theory of biological origin in mind, so the presence of biological material in the sediments was regarded as a key indicator of strata worth prospecting.

Where petroleum reservoirs were found in rocks possessing no materials that could have given rise to the oils, it was simply accepted that crude oil and natural gases often migrate through vast distances and that source rocks may, therefore, sometimes be indeterminable.

The biogenic theory of the origin of petroleum was widely adopted around the 1870s, when the earth was thought to have formed as a very hot body, perhaps a body of molten rock. If this had been correct, then no hydrocarbons supplied with the hot rocky material could have survived; they would all have been oxidized to CO₂ and H₂O. So long as this mode of origin of the earth was the dominant view, an

abiogenic origin of petroleum, formed from materials accumulated in the formation of the earth, was not a tenable viewpoint. At that time, the formation of petroleum from vegetation, after the surface had cooled sufficiently, seemed to be the only possible explanation. The subsequent discovery of molecules of clearly biological origin in all natural oils greatly strengthened the biogenic theory.

The present theory of the formation of the earth is that it formed by the assembly of cold solid pieces, condensed from a nebula surrounding the sun. Much of the material acquired in that way would have escaped excessive heating, and an abiogenic solution now seemed possible, but the biogenic theory was, by then, so firmly entrenched that the opposing evidence was brushed aside. Even when, in the 1940s, the presence of many hydrocarbons on other planetary bodies of the solar system was discovered (bodies that could not have acquired them from vegetation), it continued to be maintained that just our earth acquired hydrocarbons from a source that could be supplied only here: vegetation.

Now, whenever crude oil or natural gas is encountered in igneous rocks (rocks formed by the solidification of magma), the hydrocarbons are deemed to have migrated from a sedimentary "source" rock. In this view, igneous rocks underlying the deepest sedimentary rocks offer no prospect whatsoever for containing hydrocarbons, and so very few holes have been drilled into these "basement" rocks. Nearly all wells were drilled in sedimentary rocks, so nearly all oil was produced from sedimentary rocks.

Before long, this fact was then taken to show that sediments were essential for producing oil. Sedimentary strata were indeed essential for the production of much of the oil we now have, not because there is necessarily more oil in the sediments, but because that is where oil companies chose to drill. The belief in the biogenic origin of petroleum thus led to a self-fulfilling prophecy.

The theory of the biological origin of hydrocarbons was so favoured in the United States and in much of Europe that it effectively prevented work on the opposing viewpoint. This was not the case in the countries of the Former Soviet Union. Much work has continued there, on both sides of the debate, since the middle of the nineteenth century. In attempting to resolve this issue, the Soviet Union seems to have been more lenient toward scientific dissent than were the Western countries, probably because Mendeleyev,

the revered Russian chemist, had supported the abiogenic view. The arguments he presented are even stronger today, given the greatly expanded information pool we now have. The abiogenic theory holds that hydrocarbons were a component of the material that formed the earth, through accretion of solids, some 4.5 billion years ago.

Due to the increasing internal heat, liquids and gases were liberated, and because they were less dense than the rocks, buoyancy forces drove them upward. In favourable conditions, the upward journey from the regions of origin would be temporarily dammed in porous rocks at depths that our drills can reach, and from which we then derive commercial petroleum. In volcanic regions we have a different situation.

There, channels of liquid can extend to great depths without interruptions, as pressure differentials between the solid rock and the nearly equally dense magma will be small. If methane from deeper levels enters such a channel, it will ascend as a mass of bubbles, and each bubble will have contact with the fresh magma surface many times over in the ascent. Whatever loosely bound oxygen may be available there will be captured by the bubbles and at the high temperature will oxidize the methane to CO₂ and water. So, it is not surprising that the emission from volcanoes, at quiet times, produces mostly CO₂ and water, and only a small percentage of methane (reported in most volcanoes as 2-5 percent, but much higher in some; in the Azores the figure quoted is 17 percent).

But, in major eruptions of the same volcanoes, a large amount of flammable gas is often involved, and flames have been seen on many such occasions. The most clearly identifiable case was in the course of eruptions under the sea surface of one of the Krakatau volcanoes in the Sunda Straits; eruptions that did not break through the surface of the water but resulted in flames dancing on the surface over large areas.

In this case, there can be no confusion between flames and volcanic spray of red-hot ash, as has been suggested for many events where the presence of flames had been reported. The seemingly reliable reports of flames have also come from Central American volcanoes, from Santorini in the Mediterranean, North of Crete, and from the great African Rift. (The chance of seeing the flames in an eruption depends on the wind driving the dense smoke aside from the more vertical flame.) In a violent eruption, the small bubbles that come up at

quiet times will not be present; instead large plumes of gas will appear, racing upwards through the molten rock. The contact area between gas and rock will be much smaller, and the time of such contact much shorter, thus reducing the amount of oxidation that can take place. All in all, a variety of evidence indicates that hydrocarbons or hydrogen are major components of the volcanic gases. The CO₂ that is commonly seen in volcanoes at quiet times gives no proof that CO₂ is the primary carbon gas supplied to the surface of the earth.

Where the emission of gases into the atmosphere can be measured directly, methane is almost always the dominant carbon gas, except when the measuring zone approaches an area of active volcanism, where CO₂ often dominates. (I will return to this point in the discussion of mud volcanoes in Chapter 8.) Plumes of hydrocarbons that find their way to the earth's surface without encountering magma may or may not be oxidized en route. They will, in any case, be oxidized soon after the exposure to the oxygen-rich atmosphere. This means that the ultimate fate of primordial hydrocarbons is to be oxidized into carbon dioxide and water.

The abiogenic theory of petroleum formation depends on the verity of five underlying assumptions. Firstly, hydrocarbons, or compounds that could have been converted into hydrocarbons at the intense pressures of the earth's depths, must have been a common constituent of the primordial materials out of which the earth was formed.

Secondly, in the four and a half billion years since the earth accreted, the primordial hydrocarbons must not subsequently have become dissociated and fully oxidized to carbon dioxide and water by exposure to the significant amounts of oxygen bound in the rocks of the earth's crust. Thirdly, hydrocarbons must be chemically stable at the combination of high temperature and pressure that prevail deep within the earth.

Fourthly, hydrocarbon fluids must have found or created suitable pores in which to exist at depth, and through which to travel in their journey upward, driven by buoyancy forces due to their low density compared with that of the rocks. Finally, a source of hydrocarbons must still exist at great depth. Can these five assumptions all be valid?

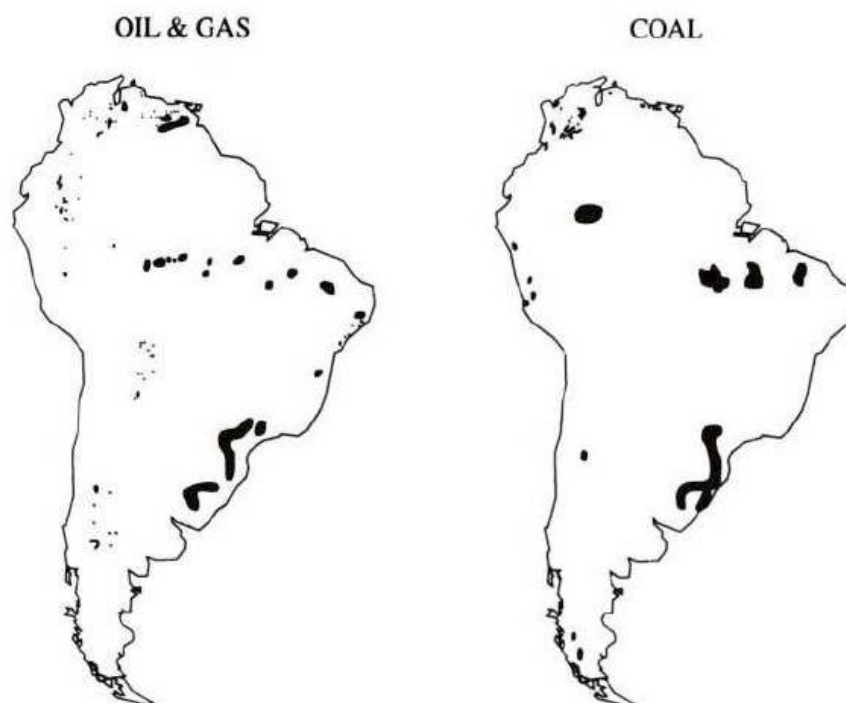


Figure 5.3 Overlap in the distribution of coal and oil in eastern Brazil. Many other such areas of overlap exist, which presents problems for the biogenic theories of coal and oil formation but is readily explained by the abiogenic theory.

SOURCE: oil map adapted from International Petroleum Encyclopedia, 1994, p. 85; coal map adapted from a commercial atlas by H. M. Goushu Company, San Jose, Calif.

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Teorija ugljikovodika

SAŽETAK

Prepoznatljivo je prisustvo ugljikovodika u Zemljinoj kori. Ideja da su ugljikovodici ostatci života na Zemljinoj površini koji su već davno sahranjeni i pojavljuju se kao nafta i prirodni gas. No, pionirski radovi i ideje nikle su i u drugom smjeru...U posljednje vrijeme raste broj pobornika da duboko u Zemljinoj (deep hot biosphere) kori postoje podzemni izvori hemijske energije. Ovdje ćemo pokušati dati pregledno razmišljanje teorija dubokog zemnog gasa.

Ključne riječi: ugljikovodici, teorije o porijeklu nafte i plina.