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Autor: Bitterli, Peter
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On the origin of petroleum

(A discussion stimulated by VASSOEVICH's ¹⁾ publications)

by P. BITTERLI, Den Haag

In a recent paper²⁾ VASSOEVICH reviews and discusses the various theories advanced over the years by the two opposing schools of thought which support, respectively, the abiogenic and the organic origin of oil.

The article begins with a description of what the Russians have contributed to the subject matter and, with occasional pauses to acknowledge Western efforts, goes on to enumerate «immutable facts» proving the organic (biogenic) origin of oil, interwoven with the author's own ideas. After an exercise in formal logic to account for all theoretical possibilities of genetical relationship – both biogenic and abiogenic – it ends with an impassioned claim for the ubiquity of hydrocarbons and a strong plea for continued efforts to discover the truth.

To many a «Western» reader this procedure may deviate somewhat from the accepted form of an ordinary scientific paper, but VASSOEVICH's article is nevertheless well worth reading: apart from its rather elaborate review of the various aspects of petroleum genesis and its «plugging» of Russian information and ideas, the text also demonstrates the mounting difficulties of keeping abreast of the world's flood of publications, and of the struggle against ignorance and want of judgment («... this fact is quite obvious, but it is being stubbornly ignored by N. A. KUDRYAVTSEV»).

While VASSOEVICH in this way rather violently attacks those of his own countrymen who support the hypothesis of an abiogenic (inorganic) origin of petroleum, he pays fair tribute to the scientists of the «Western world». Among the 51 references cited in his bibliography, there are a remarkable twenty from non-Russian authors! As a matter of fact, VASSOEVICH probably ranks, with V. A. SOKOLOV, W. W. WEBER, the late I. O. BROD, and, a few others, among the Russian authors on the subject most widely read outside their own country.

The organic hypothesis was originated – according to VASSOEVICH – by the scientific genius M. V. LOMONOSOV³⁾, who in his work «Layers of the Earth» (1763!) accounted for the formation of (liquid and dry) oil by distillation from coal through underground heat (and pressure). This *pyro-biogenetic* hypothesis found many early adherents in W. Europe, too, and still survives today.

¹⁾ German transliteration: WASSOJEWITSCH. Credit has to be given to K. KREJCI-GRAF, who introduced and discussed much of VASSOEVICH's work in the German literature.

²⁾ VASSOEVICH, N. B. (1962): *The origin of petroleum* (The development of the organic theory from M. V. LOMONOSOV to the present). Vestnik Mosc. Univ., Ser. IV: Geol., 1962, 3, p. 10-30. (Engl. transl.: Assoc. Techn. Serv., East Orange, N. J., U.S.A.)

³⁾ See also A. A. SAUKOW (1953): *Geochemie*, p. 17; VEB Verlag Technik, Berlin.

In 1876 D. I. MENDELEEV first advanced his abiogenic *carbide* theory according to which petroleum is created by the reaction of water with carbides of iron.

About ten years later V. D. SOKOLOV put forward the *cosmic origin* hypothesis, which in recent years has repeatedly been adduced to account for the organic matter found in meteorites.

In the 20th century many other hypotheses and variations, though chiefly «organic» in nature, were postulated, but discussions often reached a dead end because the divergent ideas of geologists, chemists, physicists, and biologists could not be reconciled.

K. ENGLER (1890) is credited with the theory on the animal origin of petroleum; later (with HÖFER), however, he assumed a mixed (*vegetable-animal*) source. H. POTONIÉ (1903–1908) coined the term *caustobioliths* and linked the formation of petroleum with *sapropelic* sediments (sapropelites)⁴), which are still today generally regarded as a – or perhaps the – most important type of source facies, if not the only one.

In a significant article by G. MIKHAILOVSKII (1906), the processes of petroleum formation had already been quite accurately visualized; his ideas were later modified and incorporated in the following general scheme, published by GUBKIN in 1937 (abbreviated):

- 1) mixed organic matter origin;
- 2) burial in argillaceous muds (not sand);
- 3) transformation by aerobic and anaerobic bacteria;
- 4) physico-chemical processes (pressure, temperature);
- 5) formation of primary, diffusely scattered petroleum;
- 6) accumulation in reservoirs (secondary);
- 7) formation of oil pools in structures.

VASSOEVICH continues to enlarge on various points of this scheme by discussing the work of a number of Russian and foreign scientists, such as ARKHANGELSKII, STRAKHOV, TRASK and KREJCI-GRAF, the latter being lauded because «... unlike a number of other foreign scientists, (he) has always followed Soviet literature...»

After naming 47 Russian and 31 foreign authors working in the field of petroleum genesis, VASSOEVICH describes his concept of:

- a) diffusely dispersed oil (*micropetroleum*)⁵) and
- b) crude oil proper (*macropetroleum*)⁵)

with the help of two diagrams, demonstrating his classification of «Bitumens» and «Bitumoids»⁵). These rather intricate diagrams, which show a somewhat entangled relationship between the various terms, contain the following noteworthy terms:

Bitumoids: Extracts by organic solvents (to replace or restrict the loosely applied term «bitumen»);

⁴) *Sapropel* = Faulschlamm: Recent to sub-Recent, highly organogenous mud of an anaerobic environment. Term probably first introduced by R. LAUTERBORN in 1900: *Die «sapropelische» Lebewelt*. – Zoolog. Anz., 24, p. 50–55; Leipzig, 1901. An extensive biological description is given by the same author in: *Die sapropelische Lebewelt*. – Verh. Naturhist.-mediz. Ver. Heidelberg, 13, (1914–1917) p. 395–481. «Sapropel» was also used by H. POTONIÉ (1904); Later, R. POTONIÉ and many others describe sapropelic rocks as possible source rock of petroleum (Sapropelite = sapropelic coal).

The German term *Sapropelit* is, however, generally used to denote an indurated, sapropelic rock.

⁵) The term «micropetroleum» was coined by VASSOEVICH to designate diffusely dispersed petroleum components present in latent form in source-bed organic matter, in contrast to «macropetroleum» which has migrated from the source-bed into the reservoir.

VASSOEVICH has already used these terms in earlier publications:

- a) «O proishozhdenii nefiti»: Geol. Sbornik 1, Leningrad 1955.
- b) «Probleme der Erdölgenese»: Z. angew. Geol., 4/11, Berlin 1958.
- c) «Mikronaphtha»: Trudy W.N.N.-I. Geol. rasw. Inst., 132, 1959.
- d) ditto (in German): Z. angew. Geol., 6/10, Berlin 1960.

Micropetroleum: The most readily migrating portion of autochthonous bitumoids;

Naphtbides: Crude oil and its natural derivatives.

Other terms coined include: Lipobitumoids, lithobitumoids, technobitumoids, syn-bitumoids, epibitumoids and naphthoids.

In order to support the theory of crude oil being of biogenic origin, VASSOEVICH enumerates the following «immutable facts»:

- 1) the wide distribution of organic matter in sediments, except for special lithofacies (e. g. red beds)! Using CLARKE values, the total mass of organic matter in the earth's sediments is stated to be about 3×10^{15} tons, which is 10,000 times the world's oil reserves (WEEKS 1958 and HUNT 1961 give comparable estimates, while WICKMAN 1956 calculated the total amount of organic matter, incl. coal and oil, to be 6×10^{15} tons),
- 2) the evidence from thousands of chemical analyses of rock samples (i. e. of their bitumoids) and oils, revealing significant similarities,
- 3) the observations made on the hydrocarbons contained in the organic matter (and oils) as regards their:
 - a) structural composition,
 - b) distillation curves,
 - c) infrared absorption spectra,
 - d) compounds as revealed by chromatographic method,
 - e) porphyrin content,
 - f) optical activity,
 - g) ratios of paraffinic, naphthenic and aromatic hydrocarbons,
 - h) fractional distribution,
 - i) odd/even relationship (of higher n-alkanes),
 - j) composition of aromatics,
 - k) composition of individual hydrocarbons.

These similarities prompt the conclusions that micropetroleum (derived from the organic matter) and crude oil are links in the same genetic chain, that oil was formed by concentration of the micropetroleum that had matured in depressions (catagenesis!) and migrated into reservoirs and that, therefore, oil is of an organic (biogenic) nature (origin).

The genetical relationship between micro- and macropetroleum of either biogenic or abiogenic origin is then discussed by assuming eight possible, «logical» alternatives, the necessity of which we fail to grasp.

Concluding, VASSOEVICH states that the achievements of science in the field of *petroleum genesis* leave no doubt that this problem is no longer «one of the most treasured secrets of nature», but – putting a damper on this – he adds that the problem as a whole is as inexhaustible as the atom or the electron (. . . and he may be right here, too!)

Viewed as a whole, VASSOEVICH's article does not contain revolutionary ideas nor does it contribute much new evidence on the genesis of oil; his (earlier) concept of «micropetroleum» and his classification of the «bitumoids» will mainly help by serving as the basis for more precise discussion of the various problems. The paper presents, in addition, a synopsis which is fairly up to date and which covers the viewpoints of both East and West.

The acceptance of the omnipresence (ubiquity) of organic matter, oil and «favourable» facies conditions in the earth's sediments (a hypothesis embraced by PRATT (1942), LEVORSON (1954), LANGE (1958), K. LANDES (1960) and others) has, of course, far-reaching consequences on directing the search for oil.

An opposite stand is taken up by KREJCI-GRAF (1959) and others, who adhere to the principle that the restricted, discontinuous occurrence of «isolated» oil indicates that the genesis of oil is not an ordinary case in the formation of sediments, but that oil is formed in sapropelic rocks only, i. e. in a very special deposit of a characteristic, restricted environment or facies.

We believe that both schools of thought, in their extreme interpretations, may turn out to be incorrect, but that they are by no means irreconcilable.

Our own study of bituminous rock sequences (BITTERLI, 1963) has shown that all kinds of gradations occur between different environments, sequences, rock types, etc. and that in particular a gradual transition from bituminous to non-bituminous rocks can often be observed.

Although certain geological periods and certain regions are privileged as regards oil and gas content, the occurrence of bituminous sequences and of potential source rocks appears to be rather widespread. But oil in commercial quantities can only be due to a more or less accidental concurrence of a number of favourable factors leading to the production, preservation and transformation of sufficiently large amounts of organic matter and – last but not least! – to the «economic» accumulation of hydrocarbons; migration, concentration and conservation of these are in turn much dependent on a fortuitous «co-operation» of geological history.

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