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Estimate of global oil resource and the forecast for global oil production in the 21st century

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Abstract

A probabilistic estimate of the global conventional recoverable oil resource was performed based on the concept of the Earth's sedimentary cover as a holistic system. A forecast for global oil production was made for the period till the end of the 21st century. It has been shown that the global oil production will most likely peak at 4.2–4.7 billion tons a year in 2020–2030. For that period, the top oil-producing regions in the world will be the Persian Gulf, West and East Siberia. The upstream sector at that time will turn its focus to the Arctic shelf. Annual oil production could be maintained at a level of 4.2–4.5 billion tons till the late 2040s.

Keywords: oil; world resources; world reserves; production; long-term forecast

Introduction

During the 20th century and the first years of the new century our world came face to face with a paradoxical situation. Global demand for oil and petroleum products has remained very strong yet cyclic (a rise followed by a fall, with a general trend sustained), especially in the past few decades of the 20th century: a synchronous dramatic upturn in crude oil prices was followed by a slump in oil production, which in turn triggered a fall in crude oil prices. What is going on? As to oil production, the usual answer to this question is: "Our planet is running out of oil resources and reserves. The world is already facing a global energy catastrophe!" But then, if that is true, why do oil prices keep falling? Or perhaps an assertion that the Earth's oil resources are finite is nothing but myth?

Amid such conflicting views, the "new" saviors of the world, their voices sounding pretty naive, argue for the abiotic (inorganic in geological slang) theory of the origin of oil on the planet. They used to say: "Geologists, they are always to blame for believing that oil in sedimentary rocks is generated from organic matter. If one assumes that crude oils are being produced by abiogenic synthesis, oil will never run out. And there will be no problem at all". Of course, it is not true. The Earth's resources and reserves of oil, as well as other fossil minerals, irrespective of the mechanism of their generation and the matter they are sourced from, are finite. Mankind should think about it and prepare for it.

Simple though, this answer may be, at least currently, unsatisfactory. We merely allow that answer to sidetrack us from seeking to find the correct solution. This paper does not aim at exposing all key economic and political factors, driving the processes in both upstream and downstream sectors, and in oil markets as well. My task is quite modest, hence simpler one, namely to demonstrate that the state of world's resources and reserves would allow oil production to be maintained at current levels or even grow for some time.

1. Background

It seems likely that the first attempts at estimating initial oil and gas resources in the Earth's sedimentary cover world were made right after World War II. After the war ended, the world had been preparing for peace. The post-war world, like wartime economy, needed oil and gas. The first estimates of the initial global recoverable oil resource were made by Duce (1946), Levorsen (1950), Pogue (1946), Pratt (1952), Weeks (1948, 1950), and Hubbert (1956).

For the purpose of this paper we suggest the term "initial global recoverable oil resource" abbreviated to IGROR, which

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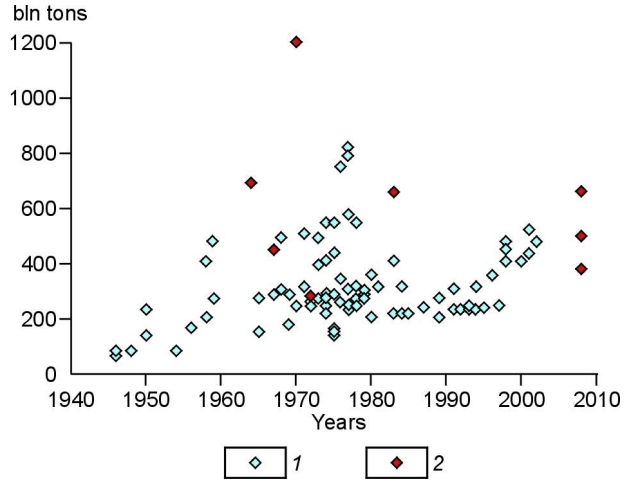

Fig. 1. Comparison of the global recoverable oil reserve estimates. *1*. Estimates from foreign sources. *2*. Estimates from Russian sources.

will be widely used below. History of IGROR estimates made over the last 60 years is given in Fig. 1 and Table 1.

According to first estimates the initial global recoverable oil resources did not exceed 140 billion tons. In the late 1940s, Levorsen (1950) raised his estimate of IGROR to about 200 billion tons. In the mid 1950s, Weeks (1958) increased this value to 400–460 billion tons.

In the 1960s, most experts were more conservative in their IGROR estimates, which ranged from 250 to 280 billion tons, far less than the ones made by Weeks.

In the Soviet Union, the IGROR estimates have been first published in the 1960s. According to the first estimate made by Kalinko (1964) and subsequently updated by the author, IGROR were reported as 695 billion tons. Later, similar figures were published by Vassoevich (1967), Khain (1970, 1971), and others.

In the 1970s, all experts engaged at this issue fell into two groups. In the first group (Moody, 1970, 1978; Warman, 1972; Hubbert, 1973; Moody and Esser, 1975; Moody and Geiger, 1975, and others) estimates hovered around 270 billion tons (in the range from 200 to 340 billion tons) at a slow pace of growth. The second group, following Levorsen, gave a more optimistic IGROR estimates, ranging from 400 to 540 billion tons (Grossling, 1976; Odell, 1973; Parent, 1977; Seidy, 1977; Starikovich, 1977; Weeks, 1958), the highest being 700–800 billion tons (Grossling, 1976; Seidy, 1977; Starikovich, 1977). In the Soviet Union, this issue was explored in great detail in a number of comprehensive studies by Modelevskii, Vysotskii and others (Oil and Gas Resources..., 1974, 1977).

Table 1
First estimations of initial global recoverable oil resources

Author	Year	Estimation, bln tons
J.T. Duce	1946	less than 140
J.T. Pogue	1946	
L.G. Weeks	1948	
A.I. Levorsen	1950	200
L.G. Weeks	1958	400–450
M.K. Kalinko	1964	695
P.R. Odell	1973	400–540
B.F. Grossling	1976	
R. Seidy	1977	
J.D. Parent	1977	
M.S. Modelevskii	1972–1977	280
A.E. Kontorovich	1983, 1988	660

In the mid-1980s, we got a period of pessimism. IGROR were estimated as low as 270 billion tons (Parent and Linden, 1974; Parent, 1977; Halbouty and Moody, 1979; Halbouty, 1981; Masters et al., 1983, 1984; Bookout, 1989). In the same period, the working group including Demin, Modelevskii, Bakulina, and myself (Kontorovich et al., 1983, 1988), introduced a new original approach using computer simulation, which yielded a more optimistic IGROR estimate, 660 billion tons.

The tendency to split estimates into two groups that had begun in the 1970s continued into the 1990s. Campbell (1997) came up with the most pessimistic estimate ranging from 240 to 250 billion tons. In the mid-1990s, however, the initial global recoverable resources were assessed as high as 400–520 billion tons of oil.

In recent decades, the problem of oil resource evaluation has received much more attention, and the estimates themselves were no longer considered interesting but simple theoretical gains that barely mattered to the applied research. These estimates have become critically important for understanding the future of the mankind and will eventually help elaborating the global energy policy.

The U.S. Geological Survey (USGS) made an effort to obtain the first probabilistic IGROR estimates. Of all assessments in the late 20th–early 21st centuries, those obtained by Masters, Root, Attanasi, and Turner (Masters et al., 1983, 1984, 1991, 1994, 1997) and Ahlbrandt, Klett, Charpentier and others (Ahlbrandt et al., 1998, 2005) are the most solid and detailed ones. All these assessments are presented in Table 2.

The first estimate (Table 1) implies, with a probability of 0.95, that the initial global oil resources exceed 250 billion tons. Ahlbrandt and co-authors gave somewhat more optimistic results: their lower limit estimate equals 325 billion tons. The most likely values of the above estimates are 303 and 420 billion tons, respectively. The above estimates given by two groups of researchers allow the assumption with probability 0.95 that the IGROR values are less than 375 and 546 billion tons, respectively.

Shell and BP estimated IGROR at 460–530 billion tons, while the USGS probabilistic estimates are close to those derived by BP and Shell only in their least probable upper limit.

Given the current numbers of 165 and 154 billion tons for proven reserves and cumulative production values, respectively, it might appear that all the global oil resources have already been discovered, according to estimates, both lower and modal, by Masters and colleagues (1994), which is not