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# Commercial gas production from Messoyakha deposit in hydrate conditions

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ABSTRACT

It has been 47 years since the article, "The formation of hydrates in gas-bearing reservoirs", was published in the Gas Industry Journal № 5 (Makogon, 1965), and 43 years since the development of Messoyakha gas hydrate field began. The potential world resources of gas hydrates are conservatively estimated at $1.5 \times 10^{16}$ m$^3$ ($53 \times 10^{16}$ SCF). More than 230 gas hydrate deposits have been discovered around the world. There exist several production technologies which have been tested already. However, the development of Messoyakha field is the only successful example of a commercial gas hydrate field. This paper will summarize the progression of its development.



## 1. Introduction

The assumption that natural gas hydrates exist was made several times. Donald Katz, a professor at the University of Michigan, was the first who proposed this idea in 1943. His hypothesis was formulated from oil and gas field development data in the northern part of Canada. However, he failed to scientifically prove hydrate formation (Makogon, 1997). The second attempt was made by professor Strizhev (Strizhev and Khodanovich, 1946), Gubkin Russian State University of Oil and Gas. He also expressed skepticism about the feasibility of developing gas hydrate fields. As a result, no further research has been conducted in the world (Fig. 1).

Throughout the 1950s the USSR rapidly expanded its gas industry and encountered major problems associated with hydrates formation in the transportation systems. This resulted in the increasing study of hydrate formation and decomposition conditions with the first PhD thesis on hydrates awarded in 1962.

While drilling exploratory well at the Markha River in 1963 a gas blow out occurred which gradually stalled. Using data obtained during the drilling it was determined that gas at these pressures and temperatures could only exist in hydrate state (Makogon, 1965). Although many geologists rejected this idea published in the "Gas Industry" journal. With mixed reaction of the scientific community more research was required to prove the existence of gas hydrates.

Intricate research was performed (Makogon, 1965, 1966), to study the formation and decomposition conditions of hydrates in porous media including testing of real cores. The results obtained confirmed under specific pressures and temperatures hydrates can be formed in the porous media. The results of this work were presented in April, 1965 at the Conference of Young Professionals and Scientists in Gubkin Institute and won the first prize (Makogon, 1965). After international examination these results were registered in the State Register as a scientific discovery of the USSR, No. 75 (December 24, 1969).

The intensity of research of any problem depends on its relevance. Only 48 papers, of pure academic studies on hydrates, were published during the period, 1778–1934. Approximately 143 works were published during 1934–1965 and after the discovery of natural gas hydrates the number of papers published rocketed up to 12,000.

The Markha River field not Messoyakha should be considered the first discovery of a gas hydrate field. However, the Messoyakha field is the first commercial application of hydrate development and shows the potential of this vast resource.

Results of laboratory studies and initial data of the Messoyakha gas hydrate field development were presented at the XI International Gas Congress and the VIII International Petroleum Congress (Makogon and Chersky, 1970; Makogon et al., 1971). It attracted a great interest among international engineers and scientists in the petroleum industry. Several countries have started their own federal gas hydrate research programs. More than 150 wells have been drilled and thousands of kilometers of seismic and core sampling have been performed so far. Several production methods have been tested in Canada, USA and Japan (Kurihara et al., 2010). However, commercial development has been only been accomplished in the Messoyakha field.

## 2. Geology of Messoyakha gas hydrate deposit

The Messoyakha gas hydrate deposit was discovered in 1967. It is located in the Arctic, on the eastern border of West Siberia. After

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**Fig. 1.** The results of gas open flow at the Markha well, Yakutiya, 1963. ©Makogon.

the discovery, the deposit was drilled in a short period of time and production began in December, 1969. This field was drilled and developed without taking into account the presence of hydrates.

Messoyakha field is located in the Arctic with a sharp continental climate. Minimal winter temperature is −55 °C (−67 F); average winter temperature is −28 °C (−18.4 F). The average temperature in July is 10 °C (50 F). The average annual temperature is −18 °C (0 F). The depth of the permafrost within this area is 420–480 m (1378–1575 ft). Geothermal gradient (GTG), in the permafrost rocks, is 1 °C/100 m. GTG under the permafrost is 3.4 °C/100 m.

The temperature at the top of the formation is 8 °C, and at the base is about 12 °C. GTG in the productive part of the reservoir, prior to the beginning of production, was 4.75 °C/100 m. Cyclical phenomena of hydrate formation and decomposition in the field history contributed to the destruction of the cement between the rock particles in the reservoir. Currently, reservoir rock is characterized by low strength, and the maximum allowable drawdown pressure in the wells without downhole filters does not exceed 2.4 atm.

The areal extent of the structure is about 19.5 × 12 km. The structure stretches in the northwest–southeast direction. The gas water contact is at −805 m (2630 ft.). The structural map of reservoir top is shown in Fig. 4. The height of the structure is about 74 m (275.5 ft). The porosity varies from 16% to 38% with an average value of 25%. Irreducible water saturation varies from 29% to 50%, averaging at 40%. Permeability varies from several mD to 1.14 D with an average of 203 mD. Initial reservoir pressure is 78 atm. The initial gas in place estimated from the first project without taking into account the presence of hydrates is $24 \times 10^9$ $m^3$.

The initial composition of the free gas is $C_1$ − 98.6%, $C_2$ − 0.1%, $C_3$ − 0.1%, $CO_2$ − 0.5%, $N_2$ − 0.7%. It has not changed during the life of the field. The salinity of water does not exceed 1.5%, which confirms the presence of hydrates in the field.

Over geological time, the deposit has repeatedly changed its phase state, moving from a pure gas hydrate field with an oil rim to a free gas hydrate with an oil rim. At the time of field discovery, it had two layers: gas hydrate and free gas which were not separated by any lithological layer.