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INVESTIGATION OF NATURAL GAS HYDRATE POTENTIAL OF THE SOUTH CASPIAN SEA

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Summary. Some unique characteristics of the Caspian Sea, especially the South Caspian Sea, such as low geothermal gradient, rapid sedimentation, a great number of mud volcanoes, suitable temperature and pressure conditions make it worth for exploration of gas hydrate potential. In this study, gas hydrate potential of the South Caspian Sea is determined within the targeted coordinates, 39°N - 50°E, 40°N - 50°E, 40°N - 52°E and 39°N - 52°E, which includes Absheron area and several mud volcanoes but excluding the parts shallower than 100 m water depth. The total area is subdivided into three categories, namely gas hydrate concentrated zone, gas hydrate bearing zone and around craters of mud volcanoes. The mean of accessible resource volume is estimated as 2.18×10^{12}, 1.53×10^{14}, 1.65×10^{10} Sm^3 of gas for these three zones, respectively. The mean of total accessible resource volume of targeted areas is estimated as 1.75×10^{14} Sm^3 of gas.

Introduction

The Caspian Sea is one of the oldest regions that petroleum industry is actually established. Recently, the region is under study as being gas hydrate province as well as being oil and gas province. Some unique properties of the region, like low geothermal gradient, rapid sedimentation, a great number of mud volcanoes, suitable temperature and pressure conditions, and actively generation of hydrocarbons make it attention grabbing (Buryakovsky et al., 2001).

Seismic, geological, and geophysical investigations are conducted and analyzed Under Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP). It was determined that the Caspian Sea has all essential conditions for formation of gas hydrates especially in the southern part.

A rough estimation of amount of methane is done in (Gerivani and Gerivani, 2015). According to their calculation in Gas Hydrate Stability Zone (GHSZ) in Absheron region, which is 100 km away from Baku, with thickness of 200 m extending for 10 km and only 5% of the sediments volume being composed of gas hydrates is assumed. Around 1 billion cubic meters of methane hydrate is estimated. Since 1 m^3 of solid hydrate can contain 160 Sm^3 of methane has around 160 standard billion cubic meter of hydrocarbon gas.

An estimation of mud volcanoes is done by Muradov (2002). In that study, resources of hydrocarbon gases in hydrates saturate sediments up to a depth of 100 m and are estimated at $0.2\cdot10^{15}$– $8\cdot10^{15}$ m^3. The amount of hydrocarbon gases concentrated in them is 10^{11}– 10^{12} Sm^3 (Huseynov and Guliyev, 2004).

In this study, natural gas hydrate potential in the South Caspian Sea is investigated. The targeted area is taken almost within the coordinates 39°N, 50°E - 40°N, 50°E and 39°N, 52°E - 40°N, 52°E, excluding the parts shallower than 100 m. The area is divided by three according to hydrate saturation in sediments.

Three gas compositions are adapted from Diaconescu and Knapp (2000). Pure and saline water environments are considered and compared regarding the gas compositions and related zones. Methane hydrate equilibrium pressure values are obtained by CSMHYD program (CSMHYD, 2017). Pressure-temperature and temperature-depth diagrams are obtained accordingly.

Mud volcanoes in the region experiences very high geothermal gradient values and intensive gas seepage. Different gas compositions and geothermal gradient values from mud volcanoes of the South Caspian Sea are available in (Ginsburg et al., 1992). CSMHYD is used again to obtain hydrate formation pressure values. Pressure-temperature and temperature-depth diagrams are obtained for three mud volcanoes, Buzdag, Elm, and unnamed one on the Abikha bank.

Calculations are done by volumetric method. Estimations are calculated by Monte Carlo method using @RISK (@RISK, 2018). Parameters are obtained from literature and other studies from different fields in the

world. Accessible resource volumes are obtained from all three zones within the field of interest. Total accessible resource volume is reached finally.

Methodology

Equation 1 is used for the estimation of gas in hydrate reservoirs:

$$OGIP = A \times h \times \emptyset \times S_h \times VR \times CO \quad (1)$$

Where:

OGIP: Original CH_4 in-place in gas hydrate reservoirs, Sm^3

A: Cross-sectional area of hydrate zone, m^2

h: Thickness of hydrate zone, m

∅: Porosity, fraction

S_h: Gas hydrate saturation in pore space, fraction

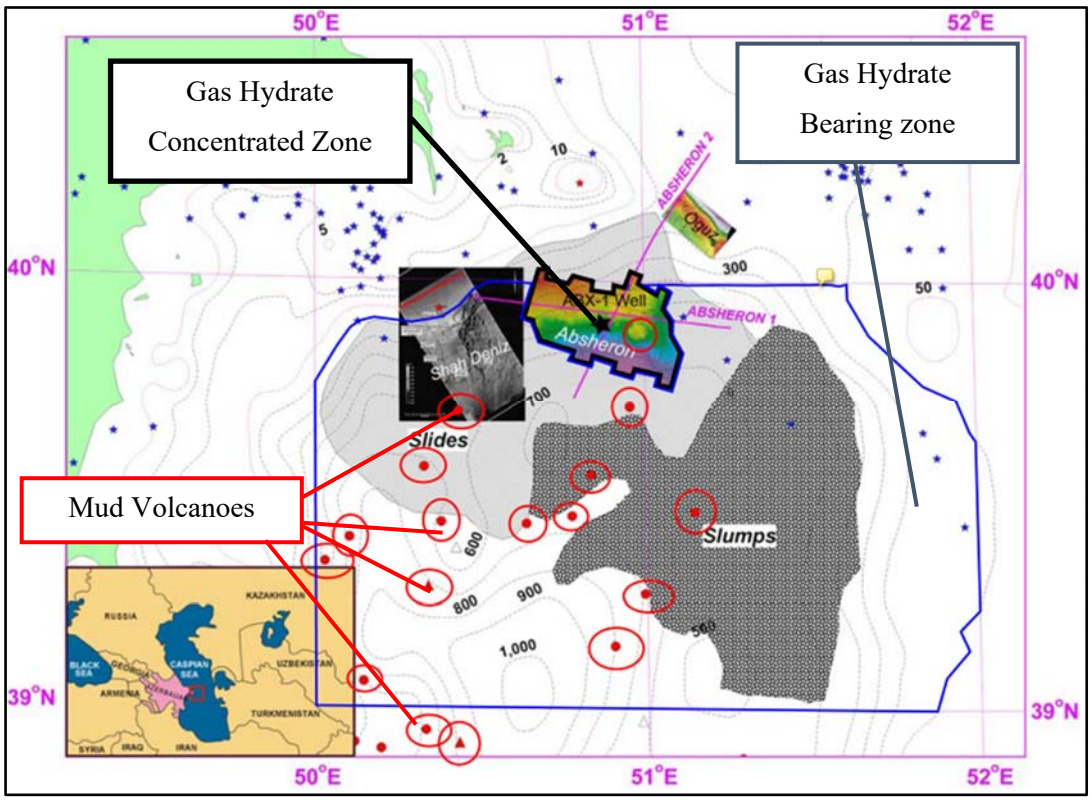
VR: Gas/hydrate volume ratio (volume of gas at STP in 1 m^3 of gas hydrate), Sm^3/m^3

CO: Cage occupancy, fraction

Since the field needs further explorations, some data are unavailable in the literature. Estimations from other fields and some assumptions are used for parameters for which are not presently known.

The targeted area of this study is determined within the coordinates 39°N, 50°E - 40°N, 50°E and 39°N, 52°E - 40°N, 52°E, excluding the parts shallower than 100 m in the South Caspian Sea (Figure 1). Elm and unnamed mud volcano on the Abikha bank is also added to calculations due to their high probable gas hydrate potential. Planimeter measurements are applied on the available maps to estimate different hydrate bearing areas. The study area makes totally 17576.93 km^2. While dividing the area into different sections, idea from Fujii et al. (2008) is used. It is divided into three zones according to hydrate saturation. Gas hydrate concentrated zone is highlighted in black color. Bearing zones are highlighted in blue. Mud volcanoes are highlighted in red circles (Figure).

Details of the determination of numerical values of parameters in Equation 1 can be found in (Mustafayeva, 2018). The resultant values of three zones are listed in Table 1.



Map showing gas hydrate concentrated and bearing zones and mud volcanoes. Black line: gas hydrate concentrated zone; blue line: gas hydrate bearing zone; red circles: mud volcanoes

Table 1

Input parameters of three zones used in Equation 1

ZONE		A (m^2)	h (m)	S_h (fraction)	∅ (fraction)	VR (%)	CO (fraction)
Hydrate Concentrated Zone	Minimum	5.70×10^{8}	200	0.45	0.1	166	0.96
	Mean	7.13×10^{8}	841	0.60	0.2	-	0.98
	Maximum	8.55×10^{8}	1400	0.90	0.4	172	0.99
Hydrate Bearing Zone	Minimum	1.36×10^{10}	190	0.21	0.1	166	0.96
	Mean	1.70×10^{10}	877.2	0.29	0.2	-	0.98
	Maximum	2.04×10^{10}	1420	0.35	0.4	172	0.99
Mud Volcaneos	Minimum	4.75×10^{7}	15	0.15	0.1	166	0.96
	Mean	5.94×10^{7}	20	0.35	0.2	-	0.98
	Maximum	7.12×10^{7}	30	0.50	0.4	172	0.99

Results

Estimations of gas volumes in different zones are done by @RISK program. @RISK is an add-in for Microsoft Excel, which performs risk analysis using Monte Carlo simulation. @RISK gives an opportunity to users see and analyze all possible outcomes. It presents a range of possible values in Microsoft Excel spreadsheet that allows making the best choice under uncertainty. So, after determining value range for parameters, probability density functions are used for 10,000 iterations by @Risk. The resulted outcomes give the probability of the minimum, mean, and maximum estimations. Table 2 lists the estimates obtained within this study.

Table 2

Estimated gas volumes within three different zones (Sm^3)

ZONE	Minimum	Mean	Maximum
Hydrate Concentrated Zone	5.47×10^{11}	2.18×10^{12}	6.53×10^{12}
Hydrate Bearing Zone	2.00×10^{13}	1.53×10^{14}	5.23×10^{14}
Mud Volcaneos	2.80×10^{9}	1.65×10^{10}	4.80×10^{10}
TOTAL	2.55×10^{13}	1.74×10^{14}	5.88×10^{14}

Conclusion

Accessible resource volumes are obtained from all three zones within the field of interest. Total accessible resource volume is reached finally. Although these estimations are done under lots of uncertainties, unique geologic and stratigraphic features make South Caspian Sea worth for researching for gas hydrates.

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