ORIGINAL RESEARCH ARTICLE
DOI: https://doi.org/10.18599/grs.2019.1.92-98

Methods of minimization of uncertainties and geological risks based on Umid gas-condensate field

*E.H. Ahmadov, R.V. Veliyev**
State Oil Company of the Republic of Azerbaijan (SOCAR), Baku, Republic of Azerbaijan

Abstract. Geological mining data resulted from exploration-prospecting and testing operations at Umid gas condensate field as one of important projects of the State Oil Company of the Azerbaijan Republic (SOCAR) have been systemized and analyzed in the article. There conducted uncertainty analyses of the obtained geophysical and mining data and hydrocarbon reserves on horizons have been estimated. Impact of uncertainties to hydrocarbon reserves of the field have been studied through modern approaches and geological risks have been assessed by usage of new risk matrix. Also, strategy of actions has been proposed in order to mitigate geological risks.

Keywords: field, hydrocarbon reserves, uncertainty analysis, geological risk, horizon, exploration well, seismic exploration, development

Recommended citation: Ahmadov E.H., Veliyev R.V. (2019). Methods of mınımızatıon of uncertaıntıes and geologıcal rısks based on Umıd gas-condensate fıeld.*Georesursy = Georesources*, 21(1), pp. 92-98. DOI: https://doi.org/10.18599/grs.2019.1.92-98

Introduction

At this stage of development of oil and gas industry of the Republic of Azerbaijan stable preservation and increase of natural gas production is one of the main task. State Oil Company of the Republic of Azerbaijan (SOCAR) performs such an important commitment. For successful implementation of the commitment, a modern approach to making new investments and riskless management of projects is applied. For this purpose, attraction of explored fields for efficient development is studied by using modern approaches and research methods.

At present SOCAR studies the process of assessment of hydrocarbon reserves and selection of projects by using international system PMI. This process can be set forth by the following scheme (Fig. 1). Primarily, hydrocarbon reserves of fields are being assessed in accordance with international standards. Field development plans are designed and submitted to the selection board. Upon the evaluation of the risks and economic efficiency of the selected options a final development concept shall be built up. Subsequently, execution of completed full filed development plan is commenced.

One of such projects is an efficient involvement in development of Umid-Babek fields that may provide the impetus for the development of industry.

*Corresponding author: Rasim Veli oglu Veliyev
E-mail: rasim.valiyev@socar.az*

Initial stage of studies

Umid upheaval (the former name is Andreyev bank) is located in the central part of oil and gas area of Baku archipelago, 75 km to the south of Baku and within a distance of 44 km from Khara-Zira island (Fig. 2). Sea depth is 40-60 m in the upheaval. The Bulla-Deniz field is located in the north-west of the structure and Babek is in the south-east. Umid and Babek structures are separated by the mud volcano.

Umid upheaval was discovered in 1953 by reflection wave (RW) method as a result of seismic exploration carried out by Marine Geophysical Survey Agency. Drilling operations in Umid upheaval started in 1954 by drilling 4 structure wells; the bottom of 70 m deep wells did not go beyond the breccia of mud volcano (Abasov et al., 1997; Guliyev et al., 2010). This upheaval stretching from north-west to south-east was supposed to consist of two undulations. In 1962-1963 as a result of seismic exploration deep exploration drilling of the Umid structure was set up.

In 1977 for the purpose of studying Upper and Lower Pliocene sediments seismic exploration was carried out by common depth point (CDP) method. Geophysical well logging (GWL) carried out in 12 exploration wells drilled here in different years helped to define petrophysical characteristics, composition, and oil-gas saturation of sediments presented in the geological section of the block and to specify the geological structure to a certain extent. These data confirmed the assumption that the island was formed by the mud volcano activity.

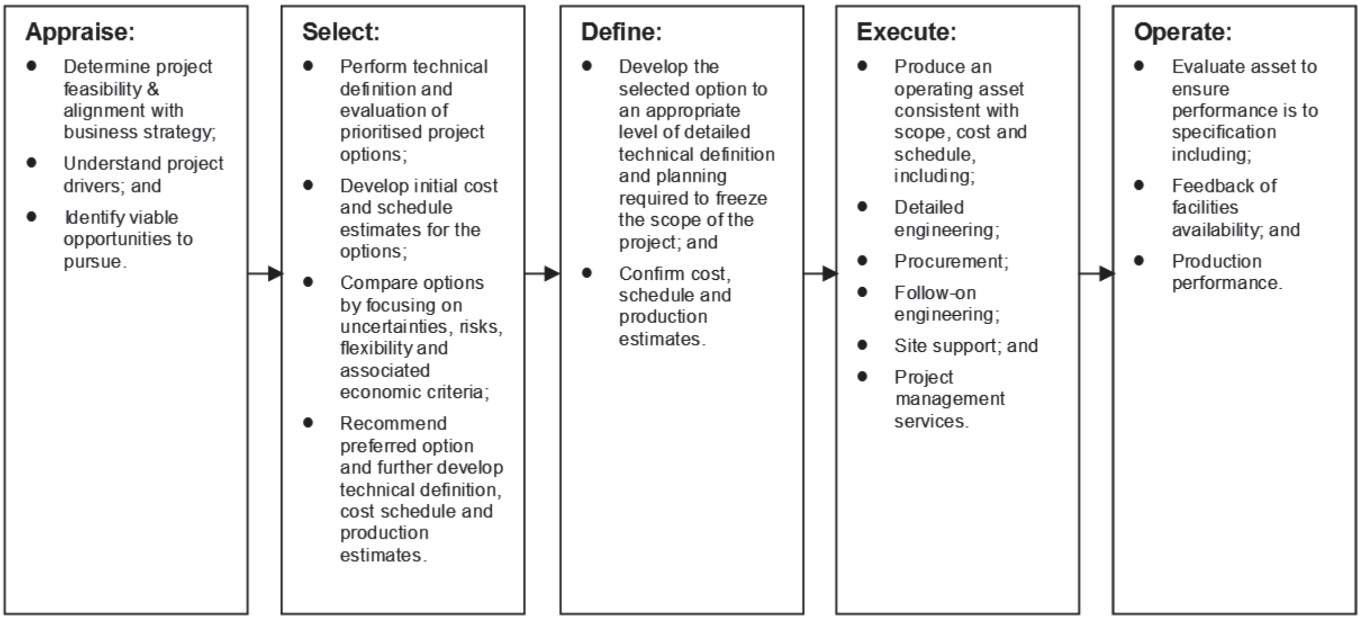

Fig. 1. Scheme of Capital Value Process

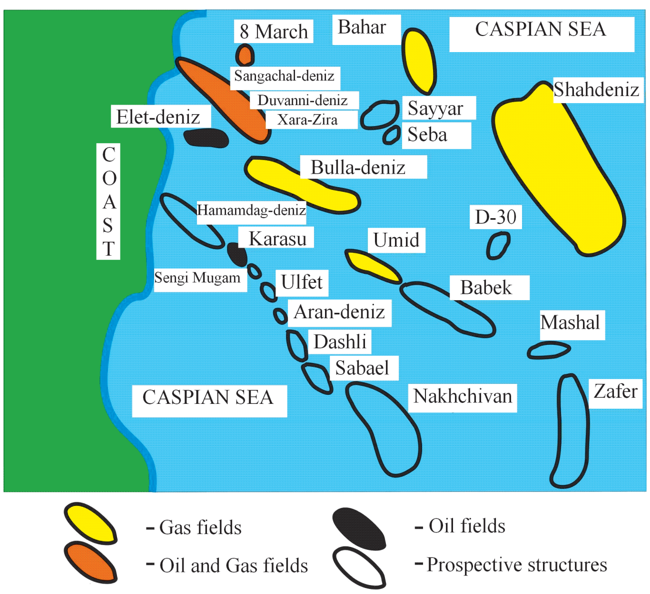

Fig. 2. Overview map

At the same year the first deep Well-1 was drilled up to a depth of 6,158 m at the structure. The well encountered productive series (PS) vault at a depth of 2,273 m. Zone V of the PS was encountered within the range of 5,922-6,060 m. By its lithological composition, Zone V was laid down by alternating medium- and fine-grained sand and sandstone sediments and intermediate clay bodies. Sand and sandstone strata have the estimated specific resistance of 10 ohm.m and are characterized by well-differentiated well potential (WP) curves.

In 1979 drilling of exploration Well-3 with the design depth of 6,500 m was started. The well was located at a distance of 1,100 m to the south-west from Well-1 toward the vault, located in the north-east limb of the upheaval. The well was abandoned for technical reasons due to the failure to prevent geological complications occurred at a depth of 2,649 m.

In 1980 drilling of exploration Well-5 with the design depth of 6,500 m was started in the north-east limb of the upheaval. During the drilling within the range of 3,836-5,150 m the loss of clay mortar with a density of 2.05-2.15 g/cm^3 and water effects were observed. The well was abandoned for technical reasons due to drill-pipe clogging.

In 1981 drilling of exploration Well-4 with the design depth of 6,750 m was started in the north-east periclinal of the upheaval. The well encountered Zone V of the productive series within the range of 6,163-6,300 m, and Zone VII – within the range of 6,618-6,715 m. By its lithological composition, Zone V was laid down by alternating greyish medium-grained sandstone strata and greyish calcareous clays; gas odor was observed in sandstones. Zone V has the estimated specific resistance of 8-12 ohm.m and well potential curves. In spite of the fact, that Zone VII in lithological terms is the same as Zone V, its estimated specific resistance reaches 30-35 ohm.m. No flow was produced from the stratum for long; water flow and low gas produced from the stratum of Zone V within the range of 6,234-6,179 m.

As a result of seismic exploration carried out (by CDP method) in 1981, the geological structure of the block was determined and information on the availability of a tectonic fault in the arch of the Umid structure was obtained.

In 1982 drilling of exploration Well-7 with the design depth of 6,500 m was started in the north-east limb of the upheaval. Due to the wellbore problems at a depth of 4,409 m, drilling operations were suspended and the well was abandoned for technical reasons.

Well-6 with the design depth of 6,500 m was drilled in the north-east limb of the upheaval. Drill-pipe clogging occurred at the bottom of the well at 6,619 m and the well was abandoned for technical reasons. Although Zone

V of the productive series and 54 m thick upper part of Zone VII showed favorable results in the well prognosis, it was impossible to conduct tests for technical reasons. Two more wells, Well-9 and Well-11, were opened in the block and abandoned on technical reasons at a depth of 4,449 and 4,445 m, respectively.

The results of the seismic explorations carried out by CDP method in 1987 provided the information on a single anticlinal fold combining Umid and Babek undulations. In 1989 subsequent seismic explorations were carried out to confirm the data obtained in 1987.

The 2D seismic profile net was carried out and covered the Umid and Babek upheavals in 1995-1999.

The Well-8 with the design depth of 6,500 m was drilled in the north-east limb of the Umid upheaval in 2009. The well encountered Zone V of the productive series within the range of 5,475-5,582 m, and Zone VII within the range of 5,923-6,006 m. The estimated specific resistivity (ESR) of Zones V and VII varies within the range of 10-12 and 30-32 ohm.m, respectively. WP curves are well-differentiated. When the bottom of the well was at 6,006 m, production casing was run into the well in order to perform testing in Zones V and VII; at the depth of 4,550 m gas effects occurred in the well and the clay mortar flow was laid down. The clogging of the production casing was recorded and the well development was suspended for three years.

Drilling of exploration Well-10 started on 01.07.2011 and was carried out up to a depth of 6,400 m. Zone V in the well was opened at 5,777-5,868 m and Zone VII – at 6,248-6,364 m. Production casing was run until 6,400 m. On 08.06.2013 a sieve was opened in the well within the range of 6,356-6,336 m. The well started operation on 19.09.2012 and is currently operating.

3D acquisition of seismic data was conducted on the study area in 2010-2012. The area covered by seismic surveys was 417.99 km². According to seismic and drilling data, the geological structure of the block was complicated with one high-amplitude longitudinal split toward the central vault axis of the upheaval and a few relatively low-amplitude cross splits around the vault.

Well-12 was drilled to 6,309 m (the upper part of Zone VII of the productive series), and production casing was run into the well and cemented. In 2014 testing operations were carried out in the stratum of Zone VII and the well started operation with high production of gas condensate (750,000 m^3 gas, 150 tons of condensate).

Currently, more than 750,000-800,000 m^3 of gas and 100-110 tons of condensate are produced in two wells of the field (Table 1).

Risk assessment methods

Irrespective of the volume of drilling operations carried out in the field, uncertainties of geological parameters also require attention. Such uncertainties are connected with the degree of quality of drilling operations carried out in the area. At the exploration area, the depth, high temperature and pressure of the Umid block caused complications during the drilling operations and therefore made it difficult to carry out complex research. As a result, geological and reservoir data have not been properly studied. Therefore, the evaluation of uncertainties and geological risks is an important issue for scheduling a full field development plan. The development plan must provide surveillance plan in order to minimize risks. At present, according to

Well No	Depth, (m) (project/actual)	Depth of layers, (m)			Note
		PS	Zone V	Zone VII	
1	6500 / 6158	2273	5922-6060		Log indicator is positive in front of V Zone Abandoned for technical reasons
3	6500 / 2649	1950			Abandoned for technical reasons
5	6500 / 5150	2325			Abandoned for technical reasons
4	6700 / 6750	2543	6153-6300	6600-6715	Produced water and gas from Zone V Log indicator is positive in front of Zone VII Abandoned for geological reasons
7	6500 / 4409	2275			Abandoned for technical reasons
6	6700 / 6619	2425	6046-6156	6565-?	Log indicator is positive in front of Zone V and VII Abandoned for technical reasons
2	6500 / 2936	2050			Abandoned for technical reasons
9	6500 / 4449	2277			Abandoned for technical reasons
11	6500 / 4445	2005			Abandoned for technical reasons
8	6500 / 6006	1960	5475-5582	5905-?	Fountain from Zone VII Abandoned for technical reasons
10	6500 / 6400	1995	5777-5868	6248-6364	Producing (Zone VII) (Log indicator is positive in front of Zone V)
12	6500 / 6309	1995	5765-5885	6236-?	Producing (Zone VII) (Log indicator is negative in front of Zone V)
14	6400 / 6341	2000			Completion stage (Zone VII) (Log indicator is negative in front of V Zone)

Table 1. Well data

international standards, it is required to estimate reserves by statistical techniques (Monte Carlo method). In this view, hydrocarbon reserves of Zones V and VII of the Umid field were estimated by this method, through M-Ball software. The basic important condition is substantiation of geological parameters in the estimate of reserves. The definition of variation interval and base quantities of these data must rest on full geologically grounded data (Abasov et al., 2000).

A gas-water contact (GWC) of Zone V of the Umid field is characterized by a large uncertainty. If we evaluate GWC of the Zone V, the 5,850 m isohyps (according to the log data of Well-10 obtained from the upper part of Zone VII), the 6,000 m isohyps (according to the log data of Well-6) and the 6,100 m isohyps (according to log and testing data of Well-4) can be accepted as GWC (Fig. 3).

Hydrocarbon filling factor of fields located at Sangachal-Duvanny-Khara-Zira island and Babek anticlinal line is taken as equal to 0.20 in Umid field according to its regional correlation. In other words, the 6,000 m isohyps is accepted. The areas of closing of such isohypses were used in the estimation. The minimum value of net thickness was accepted as equal to 2 m according to the data of Well-14 and Well-12, the medium value of 23 m according to the regional correlation and the data of wells of Umid field, and the maximum value of 35 m according to the log data of well-4 and well-6. The porosity and gas saturation were based on the data of the wells drilled in the field and in the same manner on the data of Bulla-Deniz field. It was deemed reasonable to accept them. Pressure, temperature and other geological parameters of reservoir were accepted similarly according to the data of Bulla-Deniz field (Table 2).

If we evaluate GWC of Zone VII of the field the 6,400 m isohyps (by the data of Well-10 operated from the upper part of Zone VII), the 6,700 m isohyps (according to the log data of Well-4), and the 6,870 m isohyps (according to the correlation of hydrocarbon filling factor) can be accepted as GWC (Fig. 4).

The minimum value of net thickness was accepted as equal to 33 m according to the data of Well-8, the medium value of 37.4 m according to the data of wells opened at Umid field, and the maximum value of 50 m according to the log and operating data of Well-10. The porosity and gas saturation were based on the data of the wells drilled in the field and in the same manner on the data of Bulla-Deniz field. It was deemed reasonable to accept them. Pressure, temperature and other geological parameters of reservoir were accepted similarly according to the data of Bulla-Deniz field (Table 3).

The results were presented in the below-stated Monte Carlo diagrams (Fig. 5). As it can be seen from the diagrams, the estimate values of hydrocarbon reserves vary in a wide range. This is attributable to the uncertainty of basic estimate data.

Research works, as well as the development of marine reserves confirmed under the existing development plan require several-fold more investments than onshore fields. In this view, uncertainties and risks that may arise at the exploration and development phases of the offshore fields must be estimated more precisely. Risks are deemed to be estimated upon the study and the

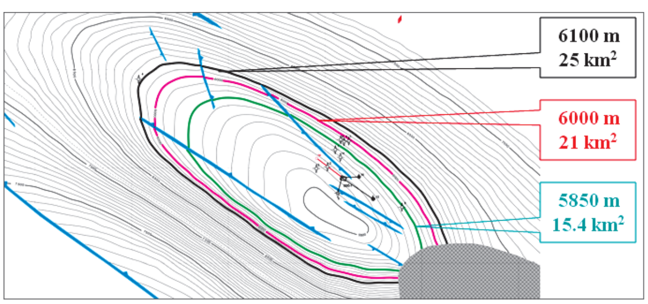

Fig. 3. Evaluation of GWC of Zone V

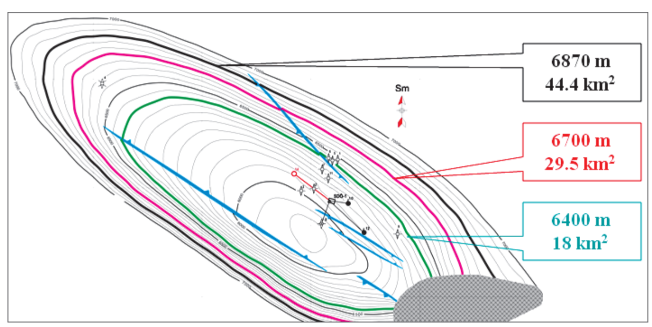

Fig. 4. Evaluation of GWC of VII Zone

Price	Area, (10^3 m^2)	Effective thickness, (m)	Gas saturation, (%)	Porosity, (%)	Reservoir pressure, (MPa)	Reservoir temperature, (°C)	Gas density, (kg/m^3)	Condensate density, (kg/m^3)	CGR, (g/m^3)
Minimum	15400	2,0	56	12	70	90	0,670	810	170
Base	21000	23,0	76	18	80	100	0,680	815	176
Maximum	25000	35,0	80	23	90	110	0,740	820	200

Table 2. Calculation parameters for evaluation of reserves of Zone V

Price	Area, (10^3 m^2)	Effective thickness, (m)	Gas saturation, (%)	Porosity, (%)	Reservoir pressure, (MPa)	Reservoir temperature, (°C)	Gas density, (kg/m^3)	Condensate density, (kg/m^3)	CGR, (g/m^3)
Minimum	18000	33,0	70	15	90	100	0,670	810	170
Base	29500	37,4	77	18	100	110	0,680	815	176
Maximum	44439	50,0	85	20	110	120	0,740	820	190

Table 3. Calculation parameters for evaluation of reserves of Zone VII

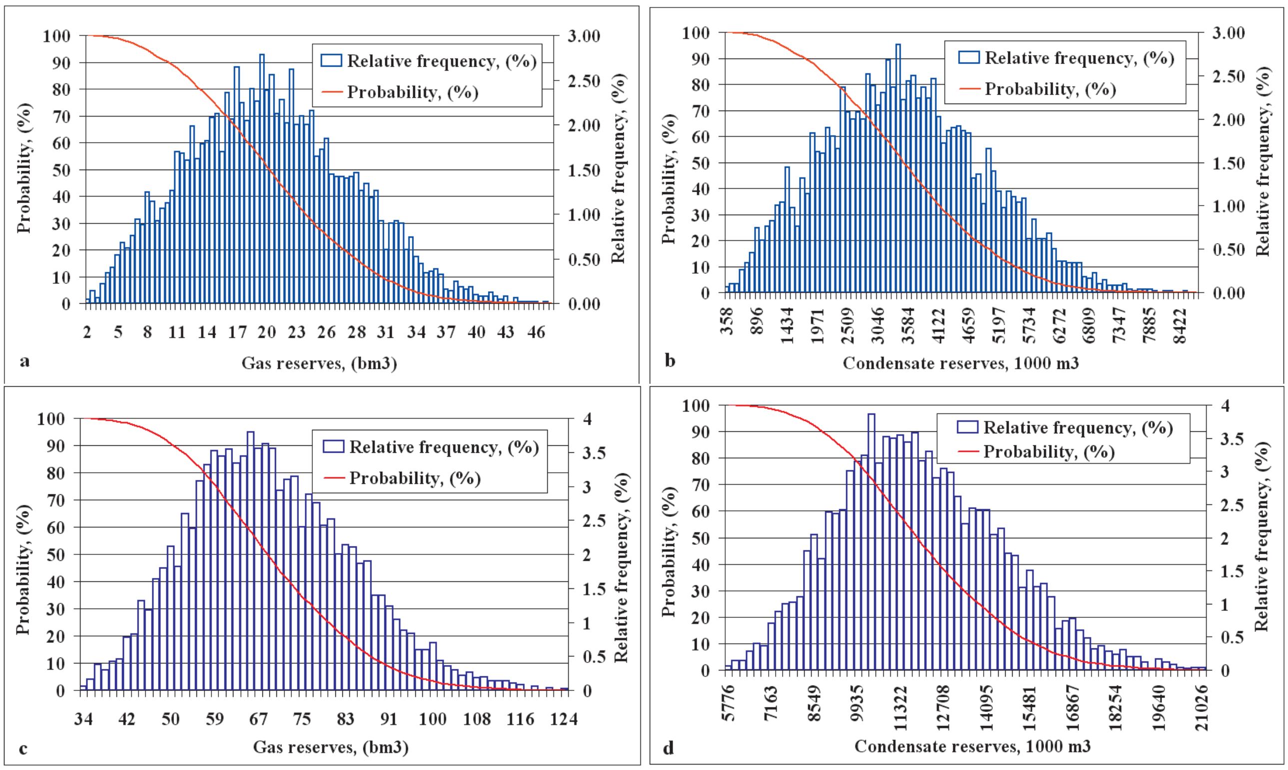

Fig. 5. Diagrams of gas (a) and condensate (b) reserves of Zone V, gas (c) and condensate (d) reserves of Zone VII

determination of possibility of such uncertainties.

The key objective of this research paper is to determine the ways of assessment and minimization of geological risks in the estimation of hydrocarbon reserves of the field in compliance with international standards PMI.

To assess geological risks, it is necessary to determine the reliability of reserves in the field. It requires that the impact of formation and fluid parameters on the hydrocarbon reserves should be identified.

For the purpose of studying uncertainties in estimations and the degree of their impact on the results, multivariant sensitivity analyses of statistical models were carried out according to minimum, maximum and mode values of geological parameters (Ahmadov, 2015). Sensitivity analysis means the impact of the value of the stated geological parameters on the results that is very important for the assessment of risks.

Thus, the sensitivity analysis was carried out on 21 variants; the first variant was estimated according to the basic values and the others according to the minimum and maximum values of each geological parameter. The results of sensitivity analyses are presented in Tornado diagrams (Fig. 6).

It seems from the diagrams, gas condensate reserves in Zone V are mainly influenced by net thickness and porosity, and in Zone VII by the area and net thickness. In other words, the variation of these geological parameters in a broad range may be stated as a reason for the minimization of geological reserves.

For more precise assessment of geological risks, a new risk matrix was developed (Fig. 7). Geological risks were assessed by the degree of parameter study for the area and its impact on reserves. The matrix rows indicate three levels of parameter study degree on the area and its columns show five levels of the degrees of impacts of such data on reserves.

Area, net thickness, gas saturation, and porosity for Zone V, and area and net thickness for Zone VII were determined as key uncertain and risky geological field parameters. Consequently, for calculation reserves, relatively precise values of these parameters must be determined on the area and section. For the solution of the problem subsequent performance of geological, geophysical field investigations particularly important at the present preliminary phase of field development was studied and reflected in the conclusions and recommendations.

Conclusions and Recommendations

It seems from the results of the research paper, the minimization of geological risks is very important for the design of full development of Umid field Zones V and VII. This afforded ground for the pursuance of geological, geophysical and field research and study of their significance. The results of the performed research paper were analyzed and the recommendations offered.

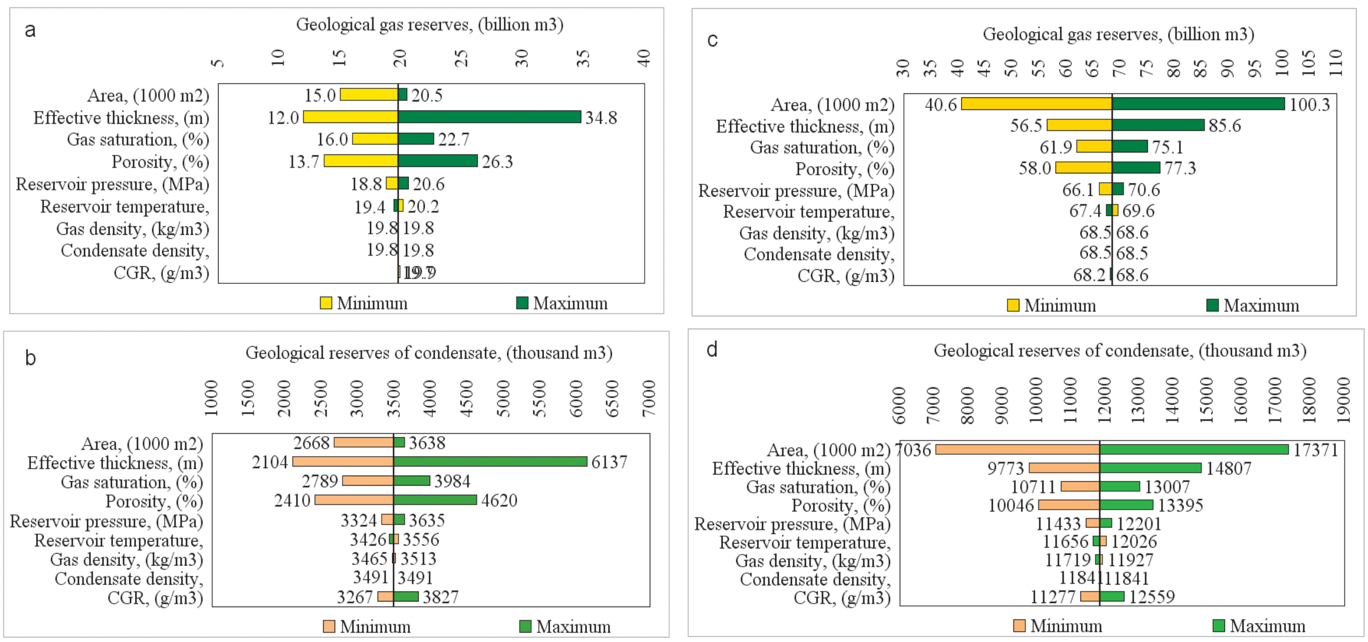

Fig. 6. Tornado diagrams for Zone V (a, b) and Zone VII (c, d)

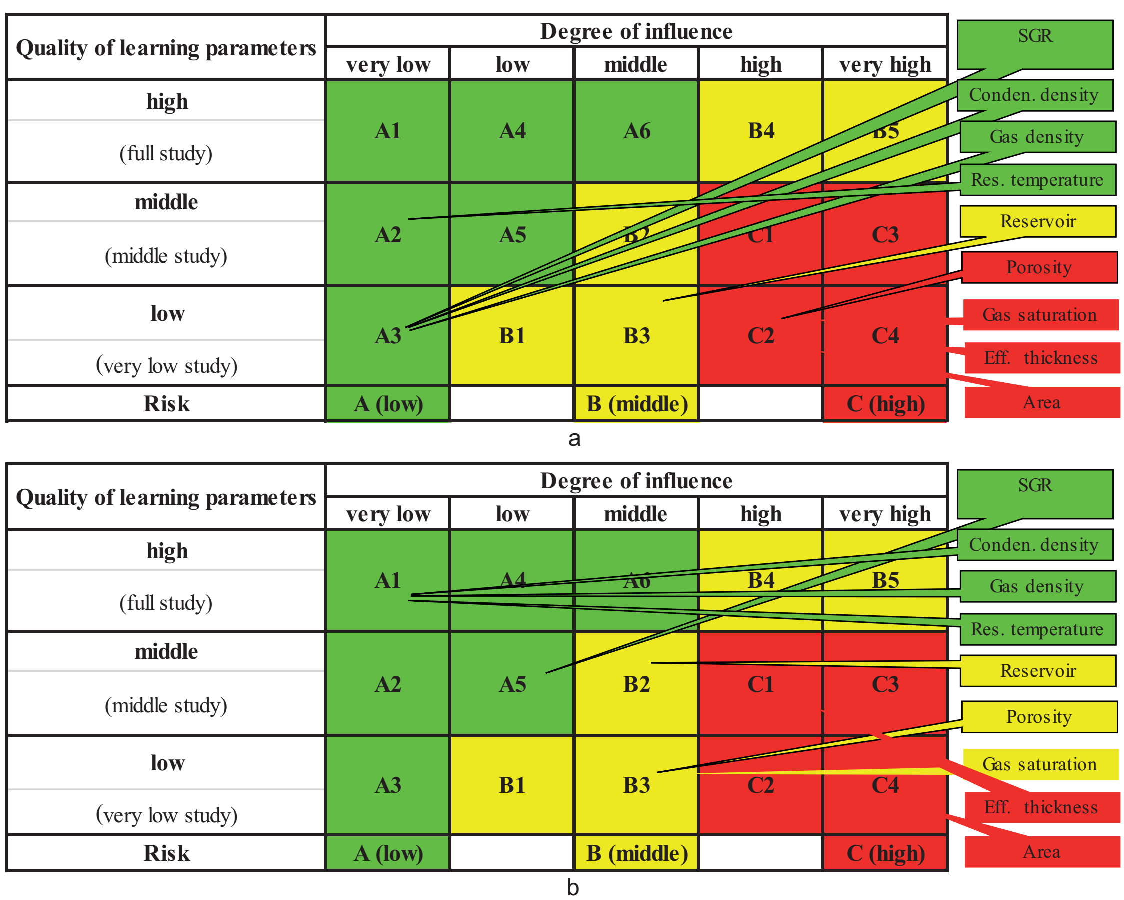

Fig. 7. Risk matrix for Zone V (a) and Zone VII (b)

1. For the study of gas-water contact it is necessary:

- To carry-out of an AVO (amplitude versus offset) analysis, vertical seismic profiling (VSP);

- To drill subsequent wells in the northern part of the field.

2. To specify gas saturation and porosity, modern well-logging survey has to be used in exploration wells to be drilled and core data must necessarily be obtained.

3. Formation pressures must be measured and well tests performed. It is planned to perform measurement of formation pressure in Well-13 that will be drilled next.

According to new geological data, geological and hydrodynamic models developed for Umid field have to be optimized, risks re-identified, the economic efficiency of development plan evaluated, hydrocarbon reserves of new research areas (Zone VIII) re-forecasted and full development plans of the field drawn up.

Acknowledgments

The authors are grateful to the reviewer for valuable critical comments and recommendations which have been very helpful in improving the work.

References

Abasov M., Azimov E., Aliyarov R., et al. (1997). Theory and Practice of Geological – Geophysical Studies and Development of Marine Oil and Gas Fields: on the example of South-Caspian depression. Baku, Azerneshr. 203 p.

Abasov M.T., Bagirov B.A., Salmanov A.M. (2000) Methods of allocation of deposits with passive oil reserves in the South Caspian basin and recommendation for passive reserves development. *AAPG's Inaugural Regional International Conference. Istanbul*. pp. 126-127.

Abasov M.T., Kondrushkin Y.M., Salmanov A.M. (2000). Problems of deep hydrocarbon reservoir exploitation in the South Caspian basin. *AAPG's Inaugural Regional International Conference. Istanbul*. pp. 227-228.

Ahmadov E.H. (2015). Appraisal of oil reserves by using geological-mathematical models. *VI International Conference of Young Scientists and Students "Multidisciplinary approach to solving problems of geology and geophysics". Baku*. pp. 119-120.

Guliyev I., Aliyeva E., Huseynov D., et al. (2010). Hydrocarbon potential of Ultra Deep Deposits in the South Caspian Basin. *Materials of AAPG European Region Annual Conference. Ukraine*. pp. 28-30.

About the Authors

Elvin Hajiqulu oglu Ahmadov – PhD, Senior Geologist, Development of Oil&Gas Reservoirs Department

State Oil Company of the Republic of Azerbaijan (SOCAR)

121, Heydar Aliyev Ave., AZ1029, Baku, Republic of Azerbaijan

Rasim Veli oglu Veliyev – Deputy to Head, Science and Technical Department

State Oil Company of the Republic of Azerbaijan (SOCAR)

121, Heydar Aliyev Ave., AZ1029, Baku, Republic of Azerbaijan

Manuscript received 14 November 2018;
Accepted 18 December 2018;
Published 30 March 2019