

Phase Transformations in Gas Producing Wells of the Kovyktinskoye Gas Condensate Field and Chayandinskoye Oil and Gas Condensate Field (Eastern Siberia)

Y.A. Gerasimov¹, V.B. Krapivin^{1,2}, V.A. Istomin^{1*}, V.G. Kvon¹, D.V. Sergeeva³, A.A. Troynikova⁴,
S.I. Dolgaev¹

¹Gazprom VNIIGAZ, Razvilka, Leninsky municip., Moscow Region, Russian Federation

²Department of Chemistry, Lomonosov Moscow State University, Moscow, Russian Federation

³Skolkovo Institute of Science and Technology, Moscow, Russian Federation

⁴Gazprom Dobycha Irkutsk, Irkutsk, Russian Federation

Abstract. The main characteristics of the Kovyktinskoye gas condensate field (KGCF) and the Chayandinskoye oil and gas condensate field (ChOGCF) were analyzed: formation temperature and pressure, gas composition, total mineralization and ionic composition of formation water. For the KGCF, the formation gas water content in equilibrium with pure and mineralized water was calculated. Temperature profiles of a typical production well at different gas flow rates were determined and compared with the temperature profiles of the ChOGCF wells. A detailed analysis of phase equilibria in the “water + gas + mineral salts + methanol” systems in the wells was carried out. It was shown that for KGCCF wells in the absence of formation water flow, water vapor condensation in the well tubing does not begin immediately, but at some distance from the well bottom, and water vapor condenses into liquid water. Hydrate formation is possible in the top of the tubing closer to the wellhead. Whereas for the ChOGCF well, the water vapor contained in the gas condenses in the tubing into the hydrate phase, bypassing liquid water. When methanol or water-methanol solution (WMS) is injected to the well bottom, the phase transformation pattern changes. In the tubing of the Kovyktinskoye field wells, methanol initially completely evaporates into the gas phase, and WMS condensation begins higher up the wellbore, preventing the hydrate formation at the wellhead. In the case of the Chayandinskoye field, methanol injected into the well bottom partially evaporates into the gas phase with simultaneous condensation of water vapor. This process forms diluted WMS, which can intensify the hydrate formation process. In the case when the mineralized formation water flows into the well, the condensation of water vapor from the gas begins immediately at the bottom and the concentration of salts in the liquid phase decreases. For the KGCF, the salt concentration is nevertheless sufficient for self-inhibition of the wells, while for the ChOGCF, additional methanol injection is required. The features of the unstable hydrocarbon condensate formation and changes in its composition along the well tubing of were also analyzed.

Key words: Chayandinskoye oil and gas condensate field, Kovyktinskoye gas condensate field, production well, gas hydrates, mineralized formation water, methanol, water content of gas, phase equilibria

Recommended citation: Gerasimov Y.A., Krapivin V.B., Istomin V.A., Kvon V.G., Sergeeva D.V., Troynikova A.A., Dolgaev S.I. (2026). Phase Transformations in Gas Producing Wells of the Kovyktinskoye Gas Condensate Field and Chayandinskoye Oil and Gas Condensate Field (Eastern Siberia). *Georesursy = Georesources*, 28(1), pp. 32–42. <https://doi.org/10.18599/grs.2026.1.10>

*Corresponding author: Vladimir A. Istomin
e-mail: V_Istomin@vniigaz.gazprom.ru

© 2026 The Authors. Published by Georesursy LLC

This is an open access article under the Creative Commons Attribution

4.0 License (<https://creativecommons.org/licenses/by/4.0/>)

Introduction

Gas condensate fields of Eastern Siberia are characterized by a number of features that significantly affect the thermodynamic operating modes of gas producing wells and possible technological problems in well tubing. In this regard, it is important to analyze in detail the nature of phase transformations of produced fluids.

Thermodynamic features of the Chayandinskoye oil and gas condensate field (ChOGCF), such as abnormally low reservoir temperature, high mineralization of formation water, formation of hydrates in wells directly from the gas phase without condensation of liquid water, were previously considered in (Istomin et al., 2022a–d; Krapivin et al., 2023). These features provide the possibility of long-term operation of wells in the hydrate mode in the absence of formation water flow. In this case the hydrates form with low rate and predominantly in the colder central part of the gas flow not on the well walls. Nevertheless, hydrates can be deposited on the tubing walls in the form of loose sediments during a sufficiently long operation of the ChOGCF wells.

The Kovyktinskoye gas condensate field (KGCF) has significantly higher reservoir temperatures and higher water content of the gas. When gas moves up the wellbore, water initially condenses from the gas to the liquid phase. The hydrate formation mode can only be achieved near the wellhead when the gas flow cools to +20 °C and below. At the same time, the formation water has high mineralization and a similar ionic composition as at the Chayandinskoye field and can act as an inhibitor of hydrate formation.

In this paper, a comparative analysis of wells operating modes at the Chayandinskoye and Kovyktinskoye fields was carried out, taking into account the influence of formation water flow on hydrate formation. Phase equilibria in wellbores involving such components as water, methanol, mineral salts, natural gas and gas hydrate were considered. The distribution of phases along the wellbore is studied, taking into account the thermobaric profile of typical wells at the ChOGCF and KGCF.

Comparison of the main characteristics of the Chayandinskoye and Kovyktinskoye fields

Below presents the main characteristics of the Chayandinskoye and Kovyktinskoye fields.

1. Low reservoir temperatures (9–12 °C for the ChOGCF and 55–56 °C for the KGCF). Initial reservoir pressures: 12.5–13.5 MPa for the ChOGCF and 25–26 MPa for the KGCF. The fields have abnormally low reservoir pressure, with the anomaly coefficient varying between 0.67 and 0.81.

2. Low permeability of rocks in productive horizons is typical, especially for the Kovyktinskoye field.

The structure of Parfenov horizon reservoir rocks of the KGCF is analyzed in (Kvon et al., 2022). Low permeability of rocks makes it advisable to carry out hydraulic fracturing in wells. However, hydraulic fracturing can also lead to a number of negative consequences (for example, early appearance of formation water in well production).

3. Mineralized formation and residual waters of reservoirs have the calcium chloride type, the total mineralization of water is not lower than 340–350 g/l, and for individual horizons it can reach 400–420 g/l.

4. Low gas condensate factor: the C_{5+} content at the ChOGCF is about 15 g/m³, and for the KGCF it is on average 45 g/m³, and the dew point pressure for hydrocarbon condensation in the formations is close to the initial formation pressure. Therefore, already in the initial period of fields development, hydrocarbons can begin to condense in the formation bottomhole zone and then in the well tubing.

5. The ChOGCF is characterized by the presence of oil rims. Even in the purely gas condensate part of the field, the oil film presence in the productive reservoirs is possible. In some cases, this leads to oil shows in a number of gas condensate wells, which significantly affects the gas preparation process at low-temperature separation units. With regard to oil and gas condensate deposits, this phenomenon is analyzed in detail in (Shandrygin, Filonenko, 2022; Shandrygin, Filonenko, 2024).

The noted thermodynamic characteristics of considered fields lead to interesting features of phase transformations in gas production systems, starting from the bottomhole formation zone. Thus, thermodynamic calculations (Istomin et al., 2022a, b) show that the productive horizons of the Chayandinskoye field are in the hydrate formation zone if the total mineralization of residual water in the reservoir is below ~200 g/l. In this case, the deposits of this field would be classified as gas-gas hydrate type. But since the water mineralization values are about 350 g/l, there are no hydrates in the productive horizons. Therefore, the ChOGCF, as well as a number of other low-temperature fields in Yakutia with a reservoir temperature 9–15 °C, can be figuratively called “self-inhibiting hydrate fields”.

In the bottomhole formation zone (BFZ) at the Chayandinskoye OGCF, due to the Joule-Thomson effect, the gas temperature decrease. Therefore, with a certain depression on the formation, risks of hydrate formation in the BFZ arise. For the estimation the values of hydrate-free depressions, specialists from Gazprom VNIIGAZ LLC have revised the thermodynamics of the bottomhole formation zone. The high mineralization of the residual waters and the possibility of their dilution (due to the precipitation of condensation water) in the bottomhole zone with the ingress of filtered gas into the hydrate formation zone were taken into account.

The calculated values of hydrate-free depression vary from 1.0 to 1.4 MPa (Istomin et al., 2022a), depending on reservoir temperatures, pressures and water mineralization. It should be noted that the production wells of the main productive horizon of the Chayandinskoye OGCF, the Botuoba, as a rule, operate with a depression on the formation that does not exceed 0.3–0.5 MPa, i.e. obviously without hydrate formation in the BFZ. Whereas for other productive horizons of this field, working depressions on the formation above hydrate-free ones are not excluded. But it is important to note that the hydrate formation process in the BFZ with depressions up to 2.5–3.0 MPa occurs quite slowly due to the extremely low moisture content of the formation gas. Therefore it is possible to conduct gas-dynamic studies of the wells in a wide range of depressions practically without the risk of distorting the results.

At the same time, in the bottomhole zone of the Kovyktinskoye GCF, the hydrate regime is impossible in principle, even with the implementation of depressions on the formation at the level of 5–7 MPa. It is associated with a fairly high formation temperature and a low value of the Joule-Thompson coefficient at gas pressures above 20 MPa. The stationary (steady-state) mineralization of residual water in the BFZ reservoir also decreases significantly near the well bottom (in the absence of formation water flow).

Comparison of formation gas and formation water compositions of the Chayandinskoye and Kovyktinskoye fields

This section consists the analysis of formation gas composition and equilibrium water content. The average gas composition of the Chayandinskoye and Kovyktinskoye fields is presented in Table 1.

The main differences in the formation fluid composition of the Kovyktinskoye field from the Chayandinskoye field are an insignificant amount of

nitrogen and a significantly higher condensate content (approximately three times). Note that a comparative analysis of the gas condensates physicochemical properties from various fields in Eastern Siberia is presented in the article (Istomin et al., 2013; Istomin, Fedulov, 2013). The issue of the oil rim influence on the process of developing gas condensate deposits and producing natural gas at the ChOGCF also deserves consideration. This aspect is described in works (Bylkov, Raskulova, 2017; Fedulov et al., 2017; Burakova et al., 2013) and is beyond the scope of this work.

As for the ionic composition of residual and formation water of the Chayandinskoye field, it was not analyzed during the field operation period, since formation water in gas producing wells had not yet been detected. Therefore, only data obtained at the exploration stage of the field can be considered. The total mineralization for different productive horizons varies in the range of 350–420 g/l (Churikova et al., 2019). At the same time, the ratio of sodium/calcium cations in water varies widely: from a virtually pure solution of calcium chloride to saturation of water with sodium chloride up to equilibrium with halite precipitated in the formation. The presence of halite deposition zones in the formation is quite typical for the Chayandinskoye OGCF, which sharply reduces the permeability of reservoir rocks in these zones.

The Parfenov productive horizons of the Kovyktinskoye field are also characterized by high mineralization of residual formation water, at a level of 340 g/l. The main components are chlorides of sodium, potassium, calcium and magnesium. Lithium, ammonium, iron, as well as bromides, sulfates and hydrocarbonates are present in small quantities. At present, water flow are already occurring in a number of wells of KGCF (presumably, this is due to the specifics of hydraulic fracturing). Variations in the ionic composition of formation waters are currently being

Component	Content, mol. %	
	ChOGCF	KGCF
Methane	80.49	90.16
Ethane	4.81	4.82
Propane	1.47	1.10
i-Butane	0.16	0.24
n-Butane	0.32	0.36
i-Pentane	0.05	0.19
n-Pentane	0.04	0.15
ΣC ₆₊	0.074	1.06
Carbon dioxide	0.004	0.04
Nitrogen	11.94	1.60
Helium	0.64	0.28

Table 1. Compositions of natural gases of the Chayandinskoye and Kovyktinskoye fields

analyzed in detail. The appearance of formation water in well production leads to the risk of salt deposits in the process chain: from well tubing to surface equipment.

The model composition of the KGCF formation water adopted for calculations is presented in Table 2.

The equilibrium water content of reservoir gases is discussed below. This value is determined by the temperature, pressure and mineralization of the formation water which is in the contacts with gas. The results of calculating the water content of the KGCF gas in equilibrium with pure and mineralized water are shown in Figures 1 and 2. The calculations were performed using the equation of state Cubic plus Association (CPA).

Water content calculations of ChoGCF reservoir gases are presented in the work (Istomin et al., 2022a). It is 90–120 g/1000 m³ depending on the reservoir temperature.

Because of the presence of high mineralization residual water, the equilibrium water content of reservoir gases is lower by approximately 30% compared to its equilibrium water content above pure water. Moreover, calculations show that the coefficient characterizing the decrease in water content (amounting to ~0.7) depends mainly on the total water mineralization, and not on variations in the ionic composition. The ionic composition and total mineralization of the formation

water of the Kovyktinskoye field are quite close to the water of the Chayandinskoye field. But due to higher reservoir temperatures, the water content of the KGCF gas is 6–7 times higher and amounts to 700 g/1000 m³.

At the same time, in the case of the mineralized water flow into the well, the inhibiting effect of salts may be sufficient to ensure a hydrate-free regime for the Kovyktinskoye GCF wells. The assessment of the mineral salts influence on the hydrate formation conditions is described in (Troynikova et al., 2022).

Thermobaric characteristics of the Kovyktinskoye gas condensate field production wells

Modeling and analysis of well temperature and pressure operation modes at the Chayandinskoye OGCF are shown in (Istomin et al., 2022b, d). Here we present results of the temperature profiles calculations of a typical gas production well at the Kovyktinskoye field. At the KGCF, the geothermal gradient averages 1 °C/100 m. The dependence of rock temperature on depth is shown in Figure 3. The gas temperature at wellheads, depending on the flow rate, can vary in the range of 15–25 °C, and averages about 20 °C. Production wells have vertical, inclined and horizontal sections. The vertical part of a typical wellbore is about 1400 m, and the formation roof is at a depth of 3250 m.

Ion	Content	
	g/l	wt. %
Na ⁺	35.7	2.9
K ⁺	4.2	0.3
Ca ²⁺	74.1	6.0
Mg ²⁺	9.7	0.8
Cl ⁻	218.2	17.6
In total	341.9	27.6
Density (20 °C), g/l	1239.6	

Table 2. Model composition of formation water of the Parfenov horizons of the Kovyktinskoye GCF

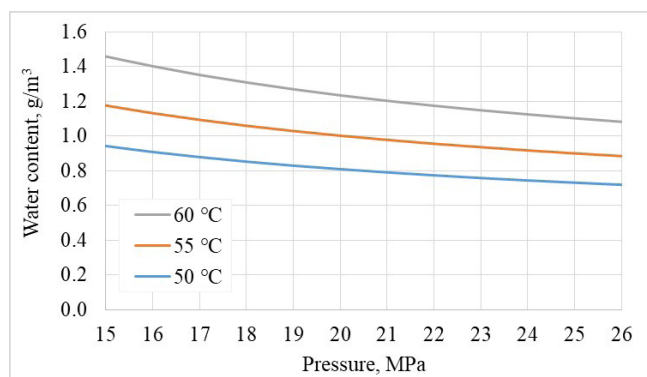


Fig. 1. Water content of gas from the KGCF depending on pressure for the equilibrium “natural gas – pure water”

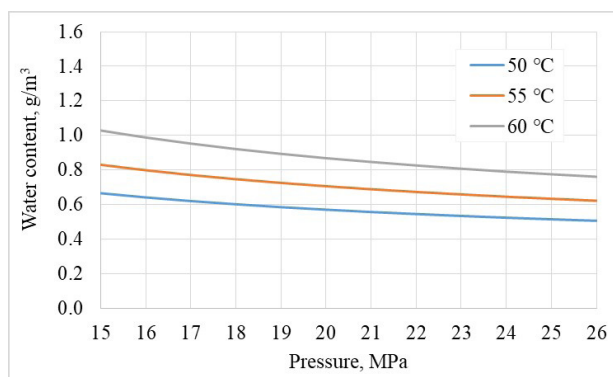


Fig. 2. Water content of gas from the KGCF depending on pressure for the equilibrium “natural gas – mineralized water (340 g/l)”

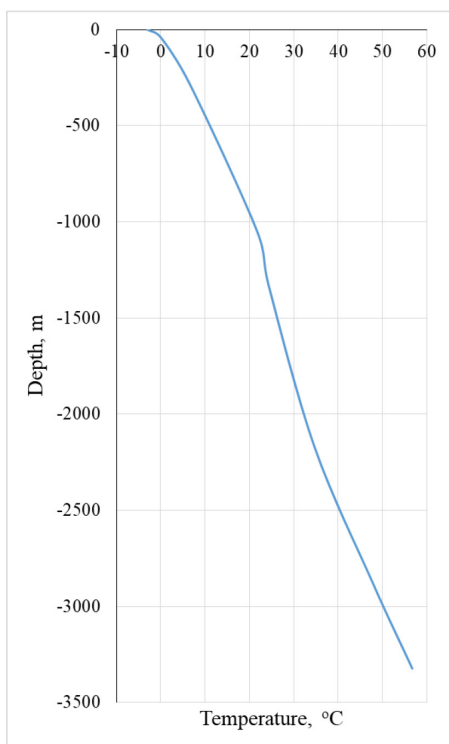


Fig. 3. Temperature-depth dependence of host rocks for the Kovyktinskoye gas condensate field

Figure 4 shows the simulated temperature profiles of a typical well with superimposed hydrate formation curves at equilibrium with pure water. The calculations were performed using the PIPESIM modeling program.

At the initial period, according to the development project, there is no formation water flow (however, at present, water shows occur at a number of wells of this field). In the absence of formation water flow in the lower section of the wellbore, water condensation from gas has not yet been observed (which is due to the high mineralization of formation water in the productive horizon). The water condensation in the tubing begins from a depth of ~2500 meters. Figure 4 also shows the inhibitor valve installation depth – 1200 m.

It follows from the temperature profiles that at the initial period of development, only the upper part of the wellbore and the wellhead can enter the hydrate formation zone. Whereas formation of gas hydrates in the lower part of the wellbore (below the inhibitor valve) and especially in the BFZ is excluded for thermodynamic reasons. At the flow rate increases, the wellhead temperature initially increases, and the well is completely in a hydrate-free mode. However, at very high flow rates (more than 1 000 000 m³/day), the temperature at the wellhead decreases again due to the strong choke effect. Therefore, the upper part of the wellbore again enters the hydrate mode.

Comparison of well operating modes at the Chayandinskoye and Kovyktinskoye fields

As noted above, due to the high mineralization of formation water, gas enters the well partially dried, i.e. has a lower water content than under the BFZ conditions at equilibrium with pure water. Therefore, in the absence of formation water flow into the well, the effects of water condensation from the gas in the form of liquid or hydrate will begin to show above the filter part of the well with a sufficient decrease in the formation fluid temperature. As previously established (Istomin et al., 2022b), at the Chayandinskoye OGCF, hydrates are formed from the gas phase in the wellbores, bypassing the condensation of liquid water.

Figure 5 demonstrates the calculated temperature profiles of a typical low-flow well with superimposed hydrate formation curves. Comparing the Figures 4 and 5, the following well operation features can be noted:

1) At the Kovyktinskoye field, with an increase in the flow rate, the degree of gas flow cooling during its movement up the wellbore decreases, i.e. the wellhead temperature increases. Whereas for the Chayandinskoye field, the opposite trend is typical. This is because of the different nature of heat exchange with the host rocks. At the Kovyktinskoye GCF, the formation gas has a high temperature and cools both due to the choke effect and due to heat transfer with the rocks. Whereas at the Chayandinskoye OGCF, due to the abnormally low reservoir temperature and abnormally low geothermal gradient, heat exchange between the fluid and the rocks is practically absent and the choke effect plays the key role. It is greater, than greater the pressure drop and, accordingly, the gas flow rate.

2) At both fields, the formation gas contacts with highly mineralized water and enters the well partially dried. In the case of the Kovyktinskoye field, the reservoir water content of the gas is high and liquid water begins to condense from the gas at a great depth. Hydrate formation from condensed water is possible only near the wellhead. At the Chayandinskoye field, due to the extremely low water content of the gas (associated with low reservoir temperatures), water begins to condense from the gas phase immediately in the form of a gas hydrate. Moreover, the calculated point of liquid water condensation (if the hydrate does not form) turns out to be above the hydrate point along the wellbore.

The considered features of the Chayandinskoye field lead to a very low hydrate formation rate in wellbores even at high flow rates, as described in (Istomin et al., 2022d). However, when liquid injected the well (the formation water or a hydrate formation inhibitor), the hydrate formation process is abruptly intensified.

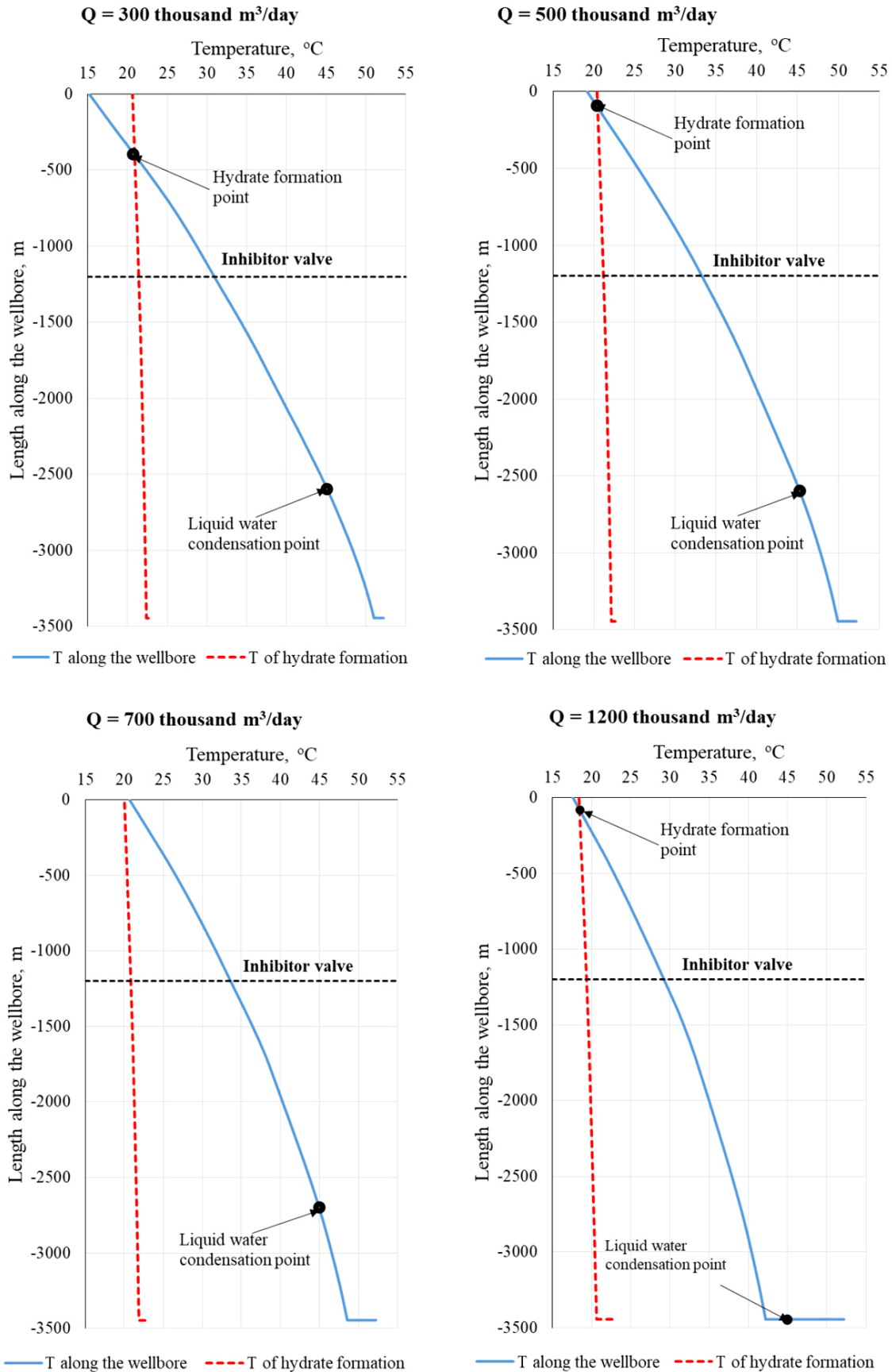


Fig. 4. Temperature profiles of a typical well of the Kovyktinskoye GCF for different flow rates. The hydrate formation area is located on the left side from the dotted line (hydrate formation curve)

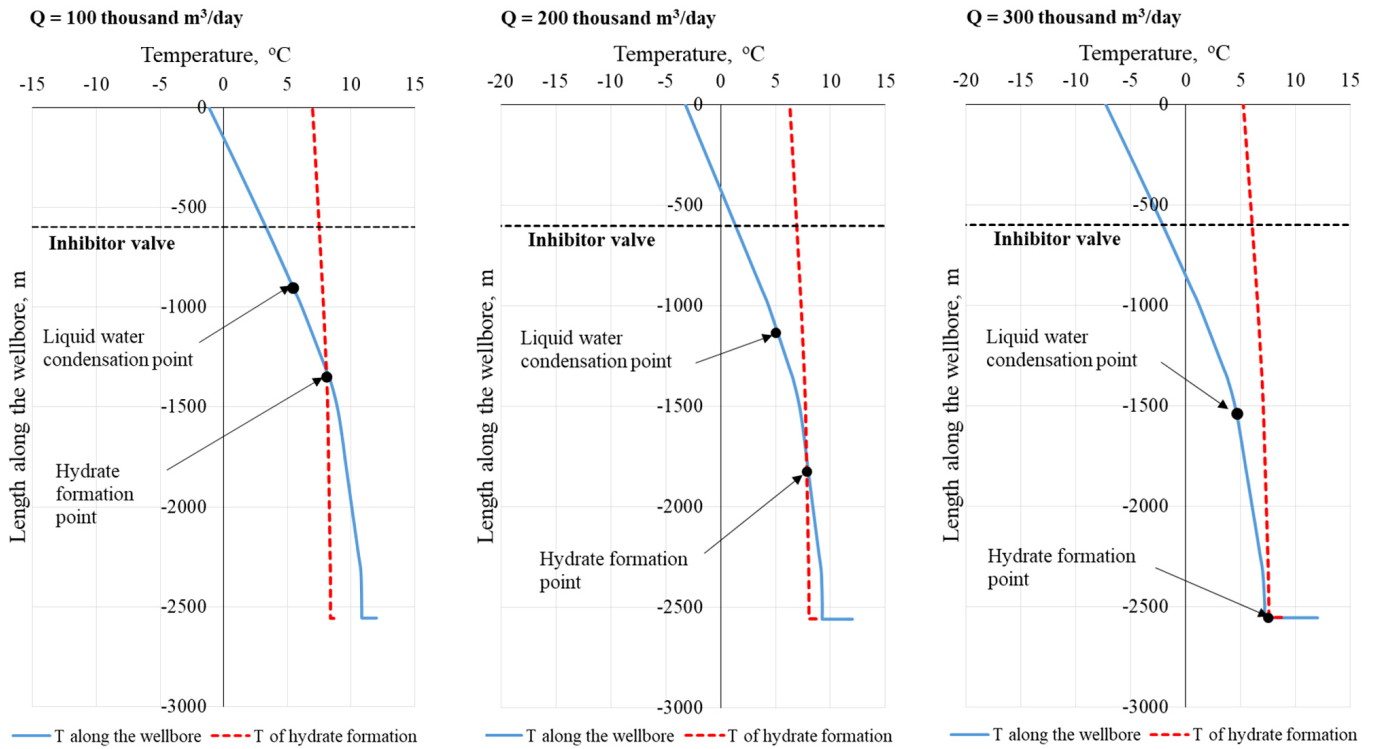


Fig. 5. Temperature profiles of the low-flow well of the Chayandinskoye OGCF for three operating modes. The hydrate formation area is located on the left side from the dotted line (hydrate formation curve)

Thus, if the amount of methanol supplied is insufficient to prevent hydrate formation, it will evaporate into the gas phase, causing partial condensation of water vapor, and the well will turn out in the hydrate formation mode. The flow of a small amount of mineralized formation water will also contribute to the formation of hydrates, since the antihydrate effect of salts will be insufficient, and the appearance of liquid water in the system will change the conditions of hydrate formation.

Next, a detailed analysis of phase equilibria occurring in typical wells of the ChOGCF and KGCF during injection of methanol, water-methanol solution (WMS) and in the presence of formation water flow will be conducted. Figure 6 shows the distribution of gas water content and the amount of water phase along the wellbore of the Chayandinskoye field for various operating modes. In the calculations, it was assumed that injection of WMS or formation water flow has virtually no effect on the well thermobaric profile.

The graphs in Figure 6 show that in the absence of liquid (WMS or formation water) entering the well, the water content of the gas remains constant to a depth of ~2000 m (Fig. 6b), i.e. no water condensation occurs from the gas. Then, starting from a depth of ~1900 m, water vapor condensation from the gas begins. As shown in Figure 5, water precipitates immediately in the form of gas hydrates (bypassing the liquid water stage).

Injection of methanol or its aqueous solution to the well bottom results to methanol evaporation into the gas

phase with simultaneous condensation of water from the gas. In this case, the concentration of methanol in the liquid phase decreases significantly. Thus, when 250 g/1000 m³ of concentrated methanol is pumped to the well bottom, its concentration in the liquid phase decreases to 16 wt. % (Fig. 7a, red curve). When 500 g/1000 m³ of methanol is injected, its concentration at the well bottom is already 29 wt. % (Fig. 7a, olive curve). Moreover, when the fluid moves to the wellhead, the concentration of methanol increases due to cooling of fluid and methanol condensation from the gas. Thus, in order to completely eliminate the hydrate formation process in the wellbore, it is necessary to achieve the working concentration of methanol at the point of three-phase equilibrium “natural gas-WMS-hydrate”, which can be located at different depths depending on the well operating mode, including at the bottomhole.

Next paragraph contains the analysis of formation water flow effect on phase transformations in the tubing. The flow of formation water with a mineralization of 350 g/l (28.2 wt. % salts) leads to immediate water condensation from the gas phase (Fig. 7b) due to fluid cooling at the well bottom as a result of the choke effect. In this case, the condensation water dilutes the formation water, and the concentration of salts in the solution decreases. Here, the “self-inhibition” mode can be realized, when hydrate formation at the wellhead is suppressed because of the high salts concentration.

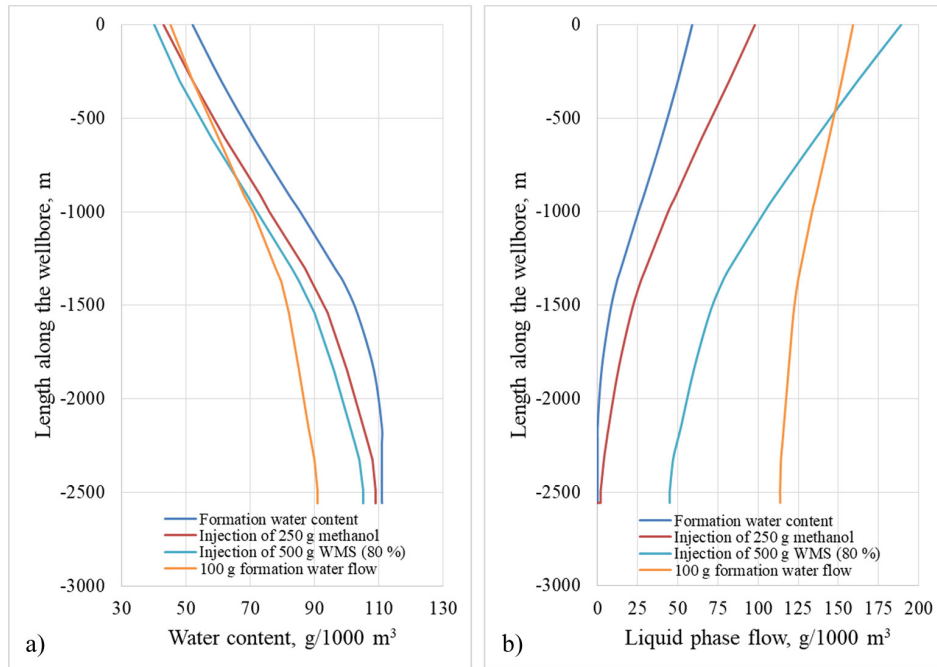


Fig. 6. Distribution of water content of gas (a) and water phase (b) along the wellbore of the Chayandinskoye field for a flow rate of 300 thousand m³/day

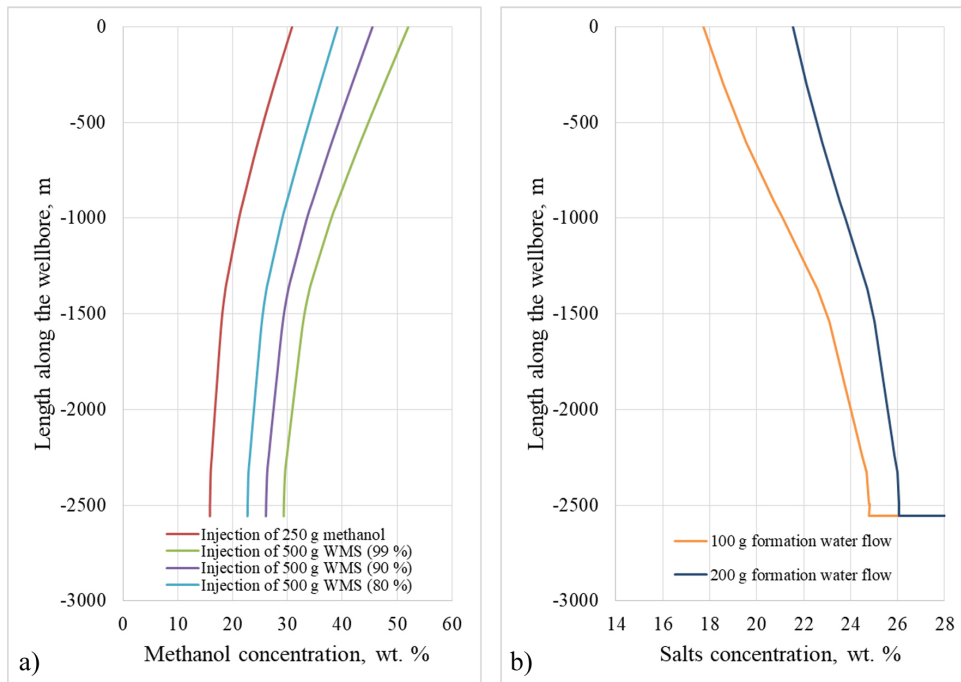


Fig. 7. Distribution of methanol (a) and salt (b) concentrations in the liquid phase along the wellbore of the Chayandinskoye field for a flow rate of 300 thousand m³/day

Calculations show that such effect is possible with formation water flow is more than 250 g/1000 m³ and a gas wellhead temperature is at least (-2)-(-3) °C (Istomin et al., 2022c).

Now let's discuss about phase transformations in the well of the Kovyktinskoye field under various conditions. The dependence of the water content in the gas and the total amount of liquid water phase on the depth along the wellbore is shown in Figure 8.

As can be seen from the graphs in Figure 8a, in the absence of formation water removal, liquid condensation begins at a depth of ~2400 m. Methanol is completely evaporates into the gas phase at injection rate of 500 and 1000 g/1000 m³. The point of liquid condensation is practically independent of the amount of injected methanol. In the case of formation water flow, liquid condensation begins immediately on the wellbore due to gas cooling.

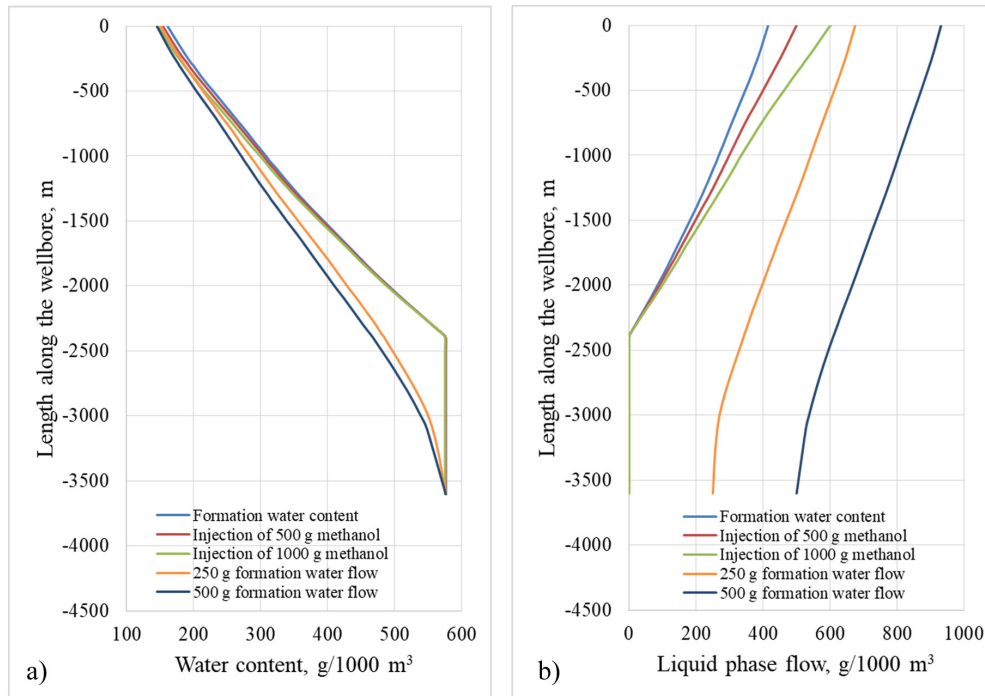


Fig. 8. Distribution of water content of gas (a) and water phase (b) along the wellbore of the Kovyktinskoye field for a flow rate of 300 thousand m³/day

Figure 9 shows the distribution of methanol and salt concentrations in the liquid phase along the wellbore. Due to the relatively high moisture content of the formation gas, even large quantities of injected methanol result to its low concentration in the liquid phase. Thus, injection of 500 g/1000 m³ of concentrated methanol provides its concentration at the condensation point only 5 wt. %, and for 1000 g/1000 m³ – 10 wt. % (Fig. 9a). At the wellhead, the concentration will be 16 and 29 wt. %, respectively. Whereas, due to the large formation water flow observed at the KGCF, the concentration of salts in the aqueous phase in the tubing will be quite high. At the well bottom, the mineralization is equal to the formation mineralization – 28 wt. % (350 g/l). At the wellhead it

and for 1000 g/1000 m³ – 10 wt. % (Fig. 9a). At the wellhead, the concentration will be 16 and 29 wt. %, respectively. Whereas, due to the large formation water flow observed at the KGCF, the concentration of salts in the aqueous phase in the tubing will be quite high. At the well bottom, the mineralization is equal to the formation mineralization – 28 wt. % (350 g/l). At the wellhead it

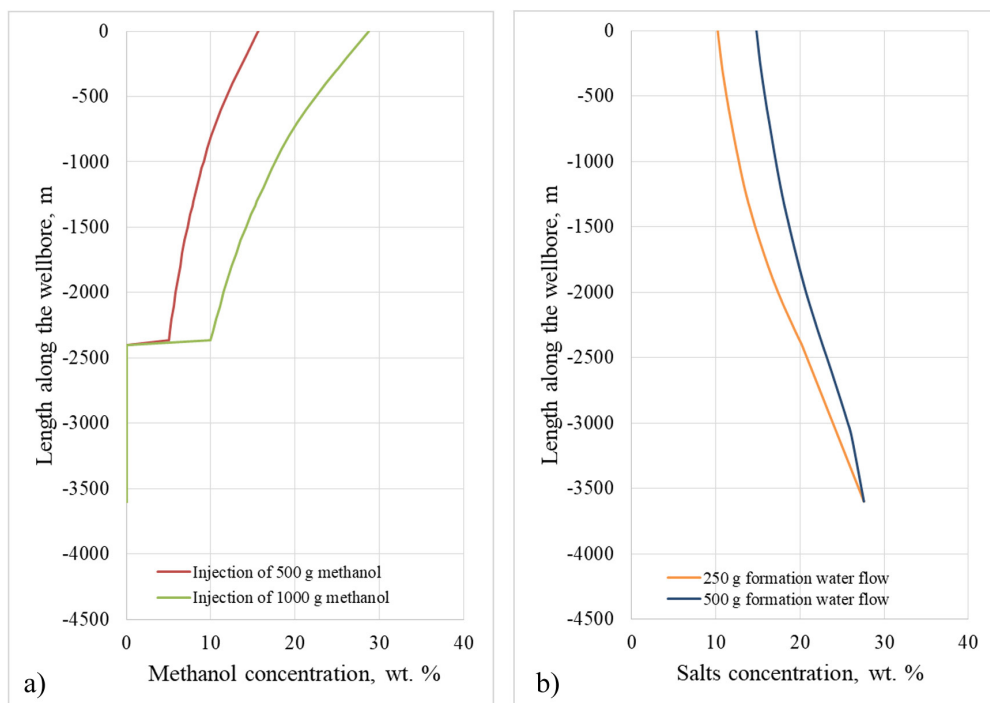


Fig. 9. Distribution of methanol (a) and salt (b) concentrations in the liquid phase along the wellbore of the Kovyktinskoye field for a flow rate of 300 thousand m³/day

will decrease to 10 and 15 wt. % for water flow of 250 and 500 g/1000 m³, respectively.

Finally, let's briefly discuss the features of unstable condensate formation in well tubing of Eastern Siberia gas condensate fields. These features were first analyzed in (Kokarev et al., 2018). This paper considers changes in the properties of the liquid hydrocarbon phase with changes in thermobaric conditions near the boundary of the two-phase region. The composition of the gas and liquid phases was calculated using the Patel-Tay, Peng-Robinson, and CPA equations of state. The properties of the liquid phase (density, viscosity, and surface tension) were calculated based on the obtained compositions. The main result is a strong change in the properties of the liquid hydrocarbon phase when the fluid moves in the tubing, since the system is near the boundary of the two-phase region on the phase diagram. Therefore, such changes in the physicochemical properties of the liquid hydrocarbon phase must be taken into account in hydrodynamic calculations of two- and three-phase flows in well tubing.

Conclusion

Thus, the thermobaric characteristics of the Kovyktinskoye gas condensate field were analyzed: the composition and mineralization of formation water, the water content of gas. A comparison with characteristics of the Chayandinskoye oil and gas condensate field was provided. Unlike the Chayandinskoye OGCF, the Kovyktinskoye field has a significantly higher formation temperature of 53–56 °C and a pressure of 25 MPa. The formation water has a similar ionic composition and mineralization. The water content of the formation gas, taking into account the influence of mineral salts, is ~700 g/1000 m³, which is approximately 7 times higher than at the Chayandinskoye field.

The thermobaric characteristics of the Kovyktinskoye GCF provide operating modes in which only a wellhead part of the tubing may turn out in the hydrate formation zone. On the contrary, in the wells of Chayandinskoye OGCF hydrates can form already at the bottomhole.

In the absence of formation water flow in the well of the Kovyktinskoye GCF, the liquid water condensation from the gas begins not at the bottomhole, but higher up the wellbore when the fluid cools. When methanol or concentrated WMS is injected into the bottomhole in an amount of up to 1000 g/1000 m³, it will completely evaporate into the gas phase. Condensation of the water-methanol solution begins only higher up the wellbore. In the case of formation water flow, the condensation of water from the gas will begin immediately at the bottomhole. At the same time, the concentration of salts in the liquid phase will decrease as it moves up

the tubing. It is predicted that at large formation water flow, the concentration of salts at the wellhead will be sufficient to prevent the hydrate formation process.

Whereas in the wells of the Chayandinskoye OGCF in the absence of water flow the condensation of water vapor from the gas occurs immediately in the form of gas hydrate. In addition, due to significantly lower reservoir temperatures, when methanol or WMS is injected into the well, only partial evaporation of methanol with simultaneous condensation of liquid water expected at the bottomhole. This can lead to the entering of well in the hydrate formation zone and intensification of the hydrate formation process if methanol concentration in the aqueous phase is insufficient. When mineralized formation water enters the well bottomhole, condensation of water vapor from the gas phase will begin immediately. Due to the low water content of the formation gas, mineralized formation water dilution with condensation water will be less significant than at the Kovyktinskoye field. At the same time, the inhibitory effect of salts is predicted to be insufficient to prevent hydrate formation in the wellbore. Thus, to prevent hydrate formation in the wells of the ChOGCF, it will be necessary to supply methanol to the well bottom even when formation water flow occurred. In this case, methanol mixing with formation water requires additional assessment of the halite precipitation risks.

References

- Burakova S.V., Izyumchenko D.V., Minakov I.I., Istomin V.A., Kumeyko E.L. (2013). Problems of developing thin oil rims of gas condensate deposits in Eastern Siberia (as example of the Botuobinskaya deposit of the Chayandinskoye oil and gas condensate field). *Vesti Gazovoy Nauki*, 16(5), pp. 124–133. (In Russ.)
- Bylkov V.A., Raskulova T.V. (2024). Comparative characteristics of physico-chemical properties of gas condensates from Kovyktinsky and Sredneviluyusky fields. *Vestnik AnGTU*, 18, pp. 55–59. (In Russ.)
- Churikova I.V., Pylev E.A., Semenov E.O., Churikov Y.M., Semanova E.V., Chudina A.A., Simonov A.V. (2019). Distribution and properties of saline vendian reservoirs belonging to chayanda oil-gas-condensate field. *Vesti Gazovoy Nauki*, 41(4), pp. 153–163. (In Russ.)
- Fedulov D.M., Istomin V.A., Nikolayev O.V., Moiseykin P.A. (2017). Changes in behavior of a volatile hydrocarbon condensate, when a gas-condensate field fluid moves in a “reservoir – well – tail pipeline” system. *Vesti Gazovoy Nauki*, 30(2), pp. 132–138. (In Russ.)
- Istomin V.A., Fedulov D.M. (2013). Thermodynamics of the bottom-hole zone taking into account the mineralization of residual water in collector and the possibility of hydrate formation. *Vesti Gazovoy Nauki* 15(4); 6–14.
- Istomin V.A., Fedulov D.M., Minakov I.I., Kvon V.G., Burakova S.V. (2013). Prevention of hydrate formation in the bottom-hole zone of the formation with high mineralization of residual water in the reservoir. *Vesti Gazovoy Nauki*, 15(4), pp. 15–21. (In Russ.)
- Istomin V.A., Fedulov D.M., Sergeeva D.V., Kvon V.G., Krapivin V.B., Troynikova A.A., Gerasimov Y.A. (2022a). Hydrate formation in gas production at Chayandinskoye oil, gas and condensate field. Part 1. Bottom hole formation zone. *Gazovaya promyshlennost*, (2), pp. 46–54. (In Russ.)
- Istomin V.A., Izyumchenko D.V., Krapivin V.B., Troynikova A.A., Gerasimov Y.A., Dolgaev S.I., Fedulov D.M., Kvon V.G. (2022d). Analysis of thermobaric operation modes of production wells at the Chayandinskoye oil and gas condensate field. *Nauka i tekhnika v gazovoy promyshlennosti*, 90(2). (In Russ.)

Istomin V.A., Izyumchenko D.V., Krapivin V.B., Troynikova A.A., Kvon V.G., Sergeeva D.V. (2022c). Features of methanol application for hydrate control in the wellbores of the chayandinskoye oil gas condensate field. *NefteGazoKhimiya*, (1–2), pp. 60–67. (In Russ.) <https://doi.org/10.24412/2310-8266-2022-1-2-60-67>

Istomin V.A., Krapivin V.B., Troynikova A.A., Kvon V.G., Sergeeva D.V., Gerasimov Y.A., Fedulov D.M., Dolgaev S.I. (2022b). Hydrate formation in gas production at Chayandinskoye oil, gas and condensate field. Part 2. Gas condensate wells. *Gazovaya promyshlennost*, 830(3), pp. 42–48. (In Russ.)

Kokarev P.N., Serdyukova V.A., Dikikh I.A. (2018). Structural features of parfenovsky horizon reservoir formations of the kovykta gas condensate field by well logging data and well testing results. *Nauki o Zemle i nedropolzovanie*, 41(3), pp. 78–92. (In Russ.) <http://doi.org/10.21285/2541-9455-2018-41-3-78-92>

Krapivin V.B., Istomin V.A., Kvon V.G., Sergeeva D.V., Gerasimov Y.A., Troynikova A.A. (2023). Analysis of the compatibility of mineralized formation water of eastern siberia gas condensate fields with methanol aqueous solutions. *NefteGazoKhimiya*, (1), pp. 33–39. (In Russ.) <https://doi.org/10.24412/2310-8266-2023-1-33-39>

Kvon V.G., Krapivin V.B., Glazova T.V., Istomin V.A., Dolgaev S.I., Troynikova A.A., Sergeeva D.V., Gerasimov Y.A. (2022). The features of hydrate formation and accumulation in wells of Chayandinskoye OGCF. *Studies of Petroleum Reservoir Systems: Challenges and Prospects: Proceedings of the IV International Scientific and Practical Conference (September 22–23, 2022)*. Moscow. (In Russ.)

Shandrygin A.N., Filonenko P.P. (2022). Saturation estimation of rock-bound oil at oilgascondensate deposits based on mathematical modeling of reservoir hydrocarbon system. *Studies of Petroleum Reservoir Systems: Challenges and Prospects: Proceedings of the IV International Scientific and Practical Conference (September 22–23, 2022)*. Moscow. (In Russ.)

Shandrygin A.N., Filonenko P.P. (2024). On the issue of assessing the relict oil saturation of pore space of gas caps of oil-gas condensate reservoirs. *Geology, Geophysics and Development of Oil and Gas Fields*, 395(11), pp. 55–61. (In Russ.)

Troynikova A.A., Istomin V.A., Semenov A.P., Sergeeva D.V., Kvon V.G., Muratova E.Zh. (2022). Outlooks for application of electrolytes as inhibitors of hydrating. *Vesti Gazovoy Nauki*, 52(3), pp. 90–100. (In Russ.)

About the Authors

Yuriy A. Gerasimov – Senior Researcher, Gazprom VNIIGAZ

15 Gazovikov Str., bldg. 1, Razvilka Village, Leninsky Urban District, 142717, Russian Federation
e-mail: Y_Gerasimov@vniigaz.gazprom.ru

Vladimir B. Krapivin – Cand. Sci. (Chemistry), Senior Researcher, Gazprom VNIIGAZ; Researcher, Department of Chemistry, Lomonosov Moscow State University
15 Gazovikov Str., bldg. 1, Razvilka Village, Leninsky Urban District, 142717, Russian Federation
e-mail: V_Krapivin@vniigaz.gazprom.ru

Vladimir A. Istomin – Dr. Sci. (Chemistry), Chief Researcher, Gazprom VNIIGAZ
15 Gazovikov Str., bldg. 1, Razvilka Village, Leninsky Urban District, 142717, Russian Federation
e-mail: V_Istomin@vniigaz.gazprom.ru

Valery G. Kvon – Cand. Sci. (Technical Sciences), Head of the Laboratory, Gazprom VNIIGAZ
15 Gazovikov Str., bldg. 1, Razvilka Village, Leninsky Urban District, 142717, Russian Federation
e-mail: V_Kvon@vniigaz.gazprom.ru

Daria V. Sergeeva – PhD, Researcher, Skolkovo Institute of Science and Technology
30 Bolshoy Boulevard, bld. 1, Moscow 121205, Russian Federation
e-mail: D.Sergeeva@skoltech.ru

Anna A. Troynikova – Cand. Sci. (Technical Sciences), Leading Engineer, Gazprom Dobycha Irkutsk
14 Nign'aya Naberezhnaya Str., Irkutsk, 664011, Russian Federation
e-mail: TroynikovaAAI@irkutsk-dobycha.gazprom.ru

Sergey I. Dolgaev – Cand. Sci. (Physics and Mathematics), Leading Researcher, Gazprom VNIIGAZ
15 Gazovikov Str., bldg. 1, Razvilka Village, Leninsky Urban District, 142717, Russian Federation
e-mail: S_Dolgaev@vniigaz.gazprom.ru

*Manuscript received 29 June 2025;
Accepted 18 August 2025; Published 30 March 2026*