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Research Article

REFINEMENT OF LITHOLOGICAL FACTORS DURING FORMATION OF HYDROGEN-SULFIDE WATER IN THE BUKHARA-KHIVA BASIN

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ABSTRACT
The formation of hydrogen sulfide occurs in the productive horizon of the gas-oil fields of the Bukhara-Khiva basin, due to high pressure and temperature, a thermochemical reaction takes place in the interaction of methane and sulfate salts
In the absence of one of the necessary conditions (sulfates or gas-oil deposits), high-concentration hydrogen sulfide waters are not formed. Hydrogen sulfide waters in the identified anticlinal structures are formed due to the presence of minor gas and oil deposits, which have no industrial value.

Keywords: *Hydrosulfuric Waters, Formation Water Unloading, Oil-Bearing Field, Sulphate-Containing Rocks, Artesian Basin*

INTRODUCTON
In health care practice, the role of mineral waters as an important therapeutic and prophylactic effect on the human body is steadily increasing. Identification of promising areas for hydrogen sulfide water on the territory of the republic is relevant. There is information on the availability of hydrogen sulfide water in the Fergana, Surkhandarya and Bukhara-Khiva oil and gas regions (Zhuraev *et al.,* 2014). Below, we consider in detail the degree of prospects for the distribution of hydrogen sulfide water in the Bukhara-Khiva artesian basin (Fig. 1).

The degree of knowledge of the problem. The problem of the origin of hydrogen sulfide in the underground hydro and lithosphere attracted the attention of many researchers. At the end of the last century, hydrogeological scientists A.M.Ovchinnikov, V.V. Ivanov, G.N.Plotnikova, A.I. Rivman studied and analyzed the conditions for the formation of hydrogen sulfide waters in the CIS countries (former USSR) (Zhuraev *et al.,* 2015). In Uzbekistan, DS Ibrahimov studied the hydrogeology of hydrogen sulfide deposits in the southern part of the Fergana artesian basin. L.S. Balashov studied the conditions for the formation of groundwater in the Surkhandarya artesian basin, A.I.Rivman - substantiated the main hydrochemical types of hydrogen sulfide waters of the Fergana and Afghan-Tajik intermountain depressions (Plotnikova, 1981). All researchers analyzed hydrogeochemical factors and identified the main hydrochemical types of hydrogen sulfide water.

Conditions for the formation of hydrogen sulfide. Distribution areas of hydrogen sulfide waters are usually confined to oil and gas bearing (or prospective for oil) basins of platform and folded areas, in the context of which evaporate deposits are developed. The greatest amount of hydrogen sulfide is observed in the waters of open and decaying oil fields, i.e. where there is a connection with surface waters (Zhuraev, 2016).

The ratio and stability of various sulfur-containing compounds in groundwater is determined by the combined effect of Eh and pH. Sulfur migrates in the aquatic environment in the form of sulfate sulfur; in an acidic reducing medium, a stable sulfur-containing component H2S, which with increasing pH changes to HS- (pH ~ 7) and S_2- (pH ~ 14) (Ivanov, 1977).

The formation of hydrogen sulfide in groundwater, their concentration and dispersion are determined by hydrodynamic and closely related hydro chemical conditions. Its distribution, as a rule, depends on the development of sulfate-reducing bacteria in them, but they have not been found in some hydrogeological closed structures with a high content of hydrogen sulfide. This gave grounds for microbiologists to assert that the process of sulfate reduction is carried out only in the presence of water exchange. In the course of

the life of sulfate-reducing bacteria, sulfates of various minerals (gypsum, barite, celestine, etc.) and organic compounds are used (Ivanov, 1977). The reaction goes according to the scheme:

$SO_4^2 + 2C_{org} + 2\,H_2O = H_2S + 2HCO_3$

Figure 1: Overview map.

In recent years, various experiments have been carried out on the reduction of sulfate compounds under conditions of high temperatures and pressures.

The experiments of S.M. Grigoriev (Ivanov, 1977) in an autoclave showed that at t 100 - 150 ° C and pressure up to 10 atm. the interaction of methane and sulfate salts is the formation of hydrogen sulfide by the reaction:

$$CaSO_4 + \mathrm{CH_4} \rightarrow CaCO_3 + H_2O + H_2S$$
$$Na_2\,SO_4 + CH_4 \rightarrow Na_2CO_3 + H_2O + H_2S$$

Sakai (Ivanov, 1977) proved the formation of hydrogen sulfide as a result of the chemical reduction of methane sulfate at a temperature of about 500 ° C.

Of great interest are the experimental works of Malinin and Khitarov (1969), who conducted research on the reduction of sulfur under hydrothermal conditions and showed that at a temperature of about 200 ° C there is a reduction of sulfate sulfur with hydrogen. Experimental data on natural conditions can be reasonably assumed that hydrogen sulfide superheated brines (170–200 ° C) opened in Ciscaucasia (well, Perekrestnaya, Galyugaevskaya, Malgobek, etc.) at depths of 4200 - 5250 meters in sulfate-containing and bituminous Jurassic deposits and chalk, have a thermochemical origin (Plotnikova, 1981).

Search criteria for the formation of hydrogen sulfide waters. The regular relationship of the distribution of hydrogen sulfide waters with sulfate-containing and petroleum-bearing sedimentary complexes

determines the main search criteria for hydrogen sulfide waters and the selection of promising areas. Among natural factors and conditions, the decisive importance in the process of forming hydrogen sulfide waters are: 1) the lithofacial composition of water-bearing rocks (primarily the presence of sulfate-containing sediments) and the oil and gas content of the sedimentary sequence; 2) geological and structural conditions; 3) hydrogeochemical environment; 4) hydrodynamic and geothermal conditions (Ivanov, 1977).

Below are considered and analyzed lithofacial factors associated with the formation of hydrogen sulfide water in the oil and gas fields of the Bukhara-Khiva artesian basin.

AIM OF THE RESEARCH

1. Study and synthesis of the actual material associated with the hydrogen sulfide waters of gas and oil-bearing fields of the Bukhara-Khiva artesian basin.
2. Analysis of water-bearing rocks of the Jurassic sediments in the gas-oil horizons of the Bukhara-Khiva artesian basin, in order to study sulfate-containing rocks
3. Mapping the main areas of distribution of hydrogen sulfide waters within the Bukhara-Khiva artesian basin.

MATERIALS AND METHODS

This term refers to the flat territory of South-Western and Western Uzbekistan, bounded from the north by the uplifts of the Central Kyzylkum, from the north-east by the spurs of the Turkestan and Zarafshan ranges, in the south-east by the south-western spurs of the Gissar Range. In the southwest, it ends at the border between Turkmenistan and Uzbekistan. The Bukhara-Khiva Oblast is the northeast side of the vast Amudarya oil and gas basin, for which the regional productivity of the Jurassic and Cretaceous sediments is indicative.

Geological structure. Paleozoic sediments. The nearest outcropping of Paleozoic rocks is located in the Zirabulak-Ziaetda mountains and in the South-Western Gissar, where the pre-Paleozoic formations were also revealed. Their total capacity exceeds 10 - 11 km. *Mesozoic group.* In Western Uzbekistan, Late Gotriass sediments are reliably recorded in the lower reaches of the Amudarya, where they are expressed in a series of dark gray mudstones and siltstones, overlaid with Lyas sediments. *Lower Jurassic sediments.* In the plains of Western Uzbekistan, the faunistic, characterized Lyassian deposits are distinguished in the Pitnyaksky area and, according to Yu. M. Kuzichkina, in the Kimirek Square. Undifferentiated Lower Middle Jurassic deposits are distinguished (Krylov and Maltsev, 1967) on Farab Square, and conventionally lower Jurassic - on Karabair Square (well 2), Aktepe, (well 1), Azlyartepe (well. 1). *Upper Jurassic.* In the plain areas of Western Uzbekistan, the faunistic characterized sediments of the lower Callovian were established in the areas of Northern Kamashi, Alat, Akkum, Kandym, Yangikazgan, Kimirek, Kulbesh, as well as others. In Karabaire, in the lower part (27.5 m), the section is composed of gray clay with thin sandstone layers and in the upper (52 m) light and dark gray sandstones, various-grained, quartz-glauconitic, calcareous, resistant layers of gravelites and dark gray clays. On rocks of the Lower Callovian, a thick stratum of carbonate rocks accords with it. The age of this stratum is determined by the organic remains found in its various parts along the section (Darganata, Urta-Bulak, Kimirek, etc.) and the similarity of the petrographic composition with similar formations of the south-western spurs of the Gissar the ridge. *Kimeridzh-titon.* Gypsum-anhydrite deposits of the Gourdak Formation are opened by wells in almost all exploration areas, with the exception of the extreme northern ones - Sultansandzhar, Meshekli, Gazli, etc. The most complete sections of the evaporite formation have been opened in the area of the Chardzhou steps, where their thickness often reaches 700-1000 m.

Tectonics. The Bukhara-Khiva region is an area of staged foundation diving. According to this concept, there is no direct connection between the folds of the mountain frame and the flat part of the territory. In this variant, the Bukhara-Khiva region is divided into the northern or Bukhara and southern or Chardzhoy stages. The boundary between the stages is the zone of the Bukhara graded rift, reliably established on all

structures of the fault zone. The northern (Bukhara) stage is separated from the structures located to the north of the basement, which reach the surface of the basement outcrops, by deep faults. The steps of Chardzhou from the south are also limited by the deep rupture of the Amu Darya. Since these faults and formed the basement steps, they were called parogradnye - grade-forming. However, these faults not only caused the occurrence of steps in the foundation, but at the same time turned out to be the boundary of the main fields of distribution of various sediments. Thus, the Amudarya Fault traces the northern boundary of the distribution of Permian-Triassic deposits of the Pitnjak type, Bukhara - the Lower Jurassic, and predzykilkumsky - Lower Cretaceous.

Gas and oil. In the 60-70s of the last century, geological exploration work was carried out on a regional scale to search for oil and gas in the Bukhara-Khiva basin. Within its limits, 44 fields have already been identified, with gas and gas condensate deposits in the Cretaceous (IX, X, XI, XVa, XII, and XIII productive horizons) and Jurassic sediments (XV, XVa, and XVI productive horizons).

Hydrogeological characteristics. During the exploration, hydrogen sulfide waters in some gas and oil-bearing fields were also identified.

The steps of Bukhara. The Karaktay oil and gas field hydrogen sulfide in the stratum waters of the XV, XVa and XVI horizons was found in the range from 39 (well 5) to 833 mg / l (well 39). In the Gazli oil and gas field, hydrogen sulfide in reservoir waters of horizon XIII is present in the range from 62 mg / l (well 114) to 90 mg / l (well 27). The Uchkyr gas field, hydrogen sulfide in the reservoir waters of the XV horizon is in the range from 120 mg / l (well 28) to 132 mg / l (well 18). At the Karim deposit, the amount of hydrogen sulfide in the stratal waters ranges from 97 mg / l (well 5) to 115 mg / l (well 3).

The Stage of Chardzhou. At the Kulbeshkak deposit, hydrogen sulfide in the stratum waters of the XVI horizon was found in amounts from 99 mg / l (well 21) to 154 mg / l (well 16). At the Dengizkul-Khauzak deposit, industrial accumulations of gas are confined to the XV horizon of Callovian-Oxford deposits of the upper Jurassic. In the formation water there is dissolved hydrogen sulfide in the range from 14 mg / l (well 9Dk) to 537 mg / l (Well 3Dk). The industrial gas content of the Urtabulak structure, the amount of dissolved hydrogen sulfide in the formation waters is present from 54 mg / l (well 7) to 400 mg / l (well 13). At the Kandym field, the content of dissolved hydrogen sulfide in reservoir waters of the XV horizon varies from 99mg / l (well 7) from 170 mg / l (well 17).

The obtained hydrochemical parameters (the content of hydrogen sulfide and microcomponents in the reservoir waters) based on the results of the tested intervals of oil and gas wells, shows the formation and distribution of hydrogen sulfide in various concentrations in the reservoir waters in almost all gas and oil fields of the Bukhara-Khiva basin.

RESULTS

Determination of lithofacial factor. The lithofaciesis factors associated with the formation of hydrogen sulfide waters were examined and analyzed in order to study sulphate-containing rocks and gas-oil complexes. Water-bearing rocks were analyzed for Jurassic deposits in the oil and gas fields of the Bukhara-Khiva basin (Figure 2).

Gas condensate deposits on the Dayakhatin fold are confined to the XV-1 and XV-2 horizons of the Callovian-Oxford layers of the upper Jurassic. Horizon XV-1 is represented by gray dense limestone with anhydrite interlayers. Horizon XV-2 is represented by weakly cemented gray and dark gray limestones. The terrigenous stratum consists of dark-gray and gray fine-grained, dense sandstones with silt layers and clay of the same color.

Parsankul-Akkum gas condensate field. Horizon XV-1 lies at the very top of the carbonate stratum. An impenetrable layer of dense limestone, this horizon is divided into two packs - A and B. Pack A occupies the upper part of the horizon and is composed of detrital rocks interbedded with anhydrite with limestone interlayers. Pack B occupies the lower part of horizon XV-1 and is represented by limestone. Above the Callovian-Oxford sediments lies the Kimmeridge-Tyton salt-anhydrite sequence, represented by

anhydrites containing single thin layers of plastered clay and sandstone, and rock salt. Thickness of 36 - 50 m.

Industrial gas content of the XV-1 and XV-2 horizons has been established at the Kandym field. Horizon XV-1 is represented by limestones with rare intercalations of oolitic and loose "lumpy" limestones, fine-grained sandstones and dense gray clays with anhydrite inclusions. Horizon XV-2 consists of gray, dense, cryptocrystalline detrital and, to a lesser extent, lumpy-clotted, sometimes fractured limestone.

At Dengizkul, industrial gas accumulations are confined to the 15th horizon. Although the deposit has a single gas-water contact, it consists of two floors. The bottom of them is formed by several unseparated impermeable layers of layers of granular reservoirs filled with gas. The upper one, on the contrary, is made up of a series of thin reservoirs separated from each other by poorly permeable carbonate rocks. Low-thickness reservoirs consist of pore limestone with anhydrite beds (carbonate-sulphate pack). The Kimeridi-Titon section is represented by a layer of anhydrite and rock salt, whose thickness ranges from 350 to 636 m.

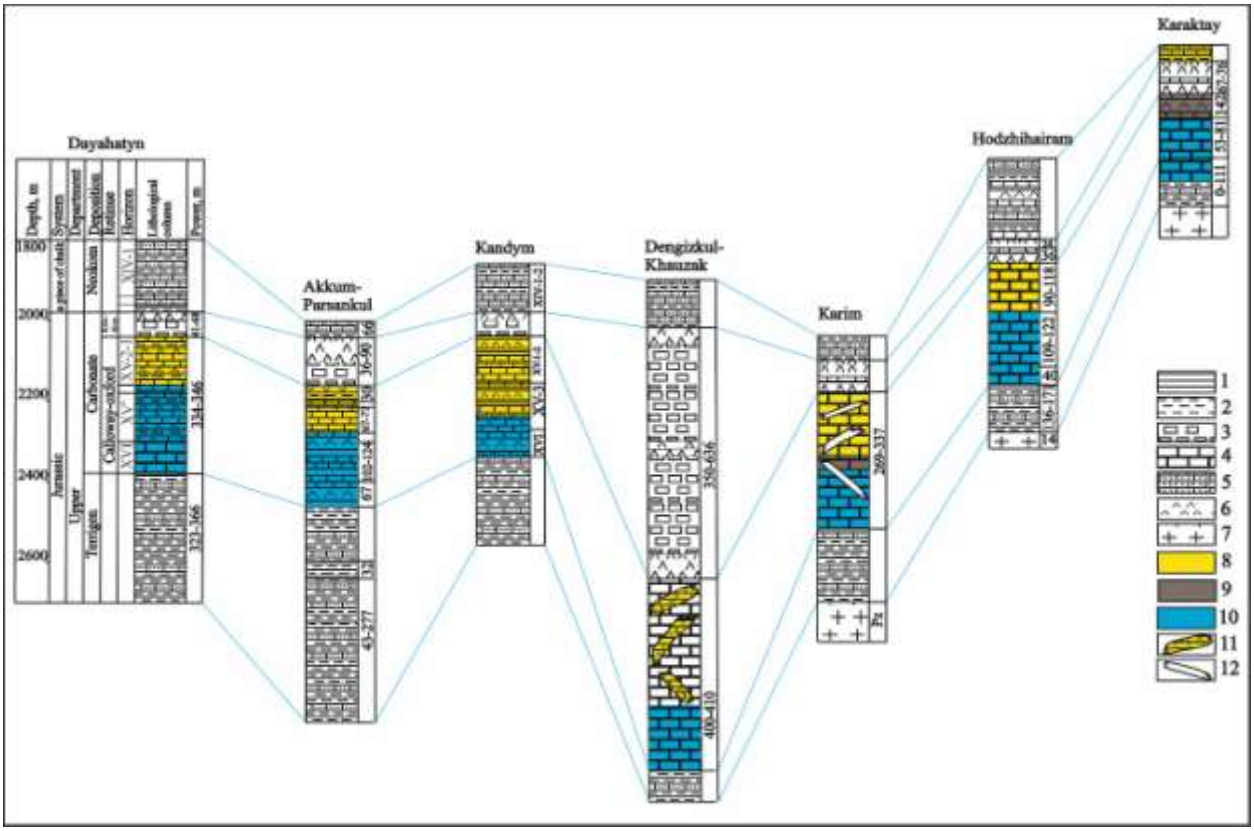

Figure 2. Comparison of the Jurassic deposits of the Bukhara-Khiva basin along the line A-A. 1- Clay; 2- Alevrolity; 3- The salt; 4- Limestone; 5- Sandstones; 6- Anhydrite; 7- Intrusive arrays; 8- Thickness saturated with gas; 9- Thickness saturated with oil; 10- Thickness saturated with water; 11- Carbonate Sulfate Pack; 12- Impermeable lenses and interlayers.

At the Karim field, industrial gas inflows are set in the XV + XVa horizons. The XV + XVa horizons form the upper half of the section in Callovian-Oxfordian sediments of the upper Jurassic and are

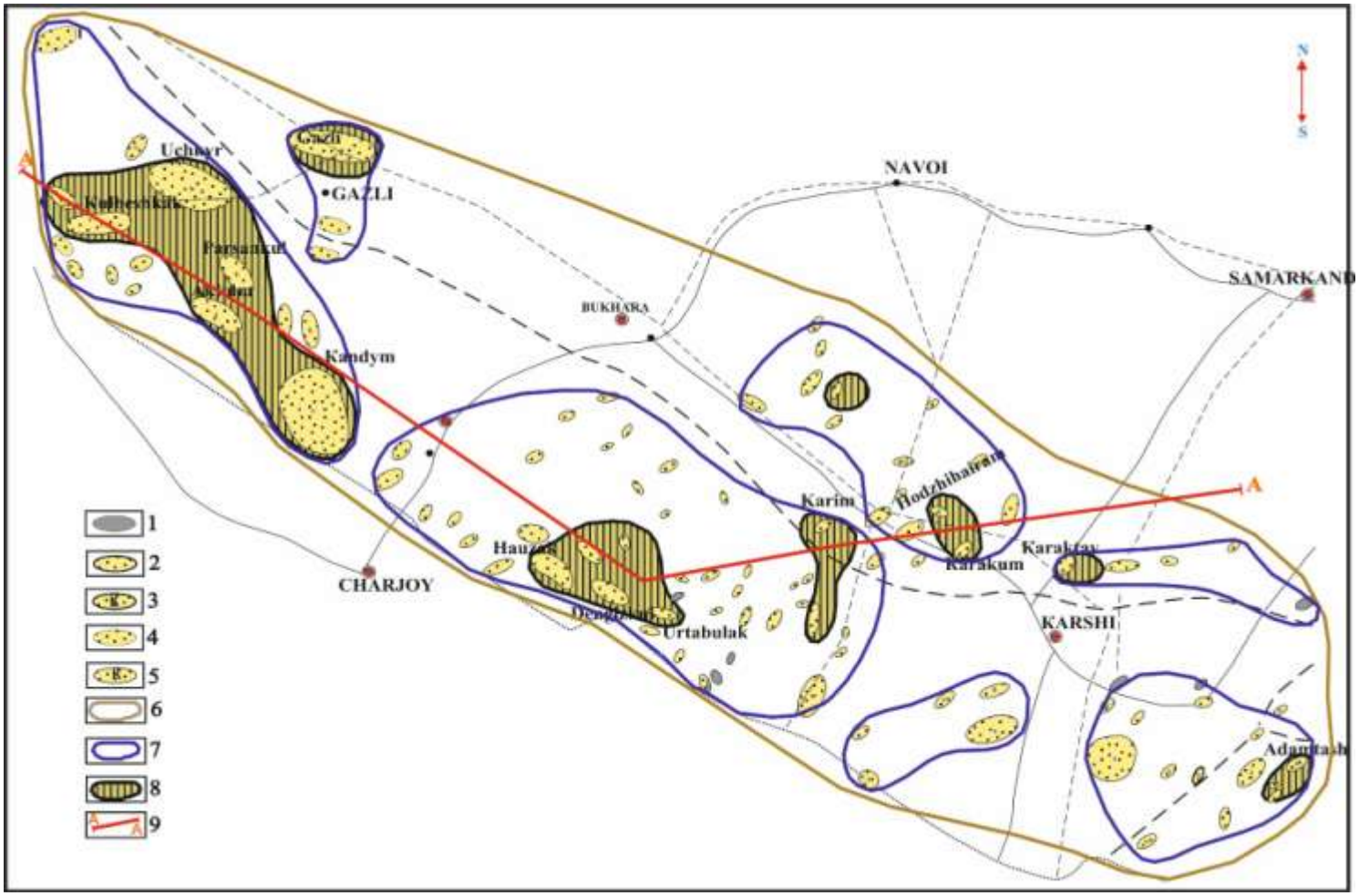

Figure 3: Map of the paragenetic relationship of hydrogen sulfide waters with evaporites and gas-oil-bearing complexes of the Bukhara-Khiva basin

Exploration deposits: 1-oil; 2-oil and gas; 3-oil and gas condensate; 4-gas; 5- gas condensate; 6- contour of evaporitic sediments; 7- contour developed and operating oil and gas field; 8- areas promising for hydrogen sulfide water; 9-line comparison of Jurassic sediments

represented by loose, chalk-like limestone in the lower part (XVa - horizon) and gray dense fissured in the upper (XV horizon). In permeable horizons there are lenses and interlayers of impermeable rocks. The total thickness of the horizons is 269 - 337 m. The Jurassic section ends with white, strong, fissured anhydrites.

The Upper Jurassic deposits of the Khodzhikhayram deposit are represented by two lithologically distinct packs of rocks: the lower one is composed of limestones, massive, thick clay. The top is represented by dense anhydrites with a capacity of up to 36m.

Industrial gas deposits of the Karaktai oil and gas field are confined to horizons XII and XIII, oil deposits - and XV, XVa and XVI horizons. In the carbonate stratum three packs are distinguished: the lower one - strong sandy limestone (XVI horizon), the middle one - chalk-like limestone and dense cryptocrystalline limestone (XVa horizon), the top one - strong cryptocrystalline limestone with interlayers of anhydrite (XV horizon). The Jurassic section ends with strong anhydrite kimeridzh-titon.

The analysis shows that in the compiled scheme for comparing the gas-oil horizons of the Jurassic deposits of the Bukhara-Khiva basin, almost all the rocks of the productive horizon consist of limestone with anhydrite beds. The Dengizkul-Khauzak Reef Reef Area is a permeable reservoir that consists of carbonate-sulfate packs (limestone and anhydrite). The host rocks of the productive horizon consist of limestone without anhydrite in the deposits of Karim and Khodzhikhayram, however, productive horizons are covered by a powerful anhydrite-salt stratum kimeridzh-Titonian stage in all deposits.

DISCUSSION

After summarizing the analyzes, it was revealed that sulfate-containing rocks spread in the form of anhydrite layers in the gas-oil stratum of carbonates, and also the gypsum-anhydrite stratum kimeridzh-titon covers over the productive horizon throughout the basin (Fig. 3).

Consequently, hydrogen sulfide is formed in the productive horizons at the Dayakhatin, Akkum-Parsankul, Kandym and Karaktay fields due to the presence of a carbonate stratum with anhydrite beds at t 80–100 ° C and pressure up to 10 atm. in the interaction of methane and sulfate salts. In a gas reservoir, hydrogen sulphide gas is formed in the carbonate-sulfate pack of the Dengizkul-Khauzak field. There are no layers of anhydrite in the productive horizons at the deposits of Karim and Hodzhikhayram. However, dissolved hydrosulfuric gases are found in reservoir groundwater, and industrial gas contains impurities of hydrogen sulfide of 0.31 - 0.35%. Then about the formation of hydrogen sulfide gas in the productive horizons of the fields Karim and Hodzhikhayram, we can assume the following: hydrogen sulfide gas is formed here due to the interaction of methane and sulfate salts upon contact of the carbonate and gypsum-anhydrite strata.

To compare the areas of distribution of hydrogen sulfide waters with gas-oil-bearing territories and halogen formations, a map of the main areas of distribution of hydrogen sulfide waters within the Bukhara-Khiva basin has been compiled. The map shows the territories of the established development of hydrosulfuric waters and their boundaries corresponding to the distribution of evaporite sediments of water-bearing rocks of Jurassic deposits, contoured by developed and existing oil and gas fields promising for hydrogen sulfide waters (Fig. 3).

Developed and existing gas-oil deposits, confined to the Jurassic deposits, are located in the western part of the basin (Kulbeshkak, Uchkyr, Parsankul, Akkum, Kandym, Gazli, Dayakhatyn, Khodzhikazgan, Khoji, Atamurad, Uchburgan, Garbi), the central part (Khauzak, Alat, Tegermen, Shady, Dengizkul, Mathonat, Zekr, Kruk, Pamuk, Pirnazar, Urtabulak, Kamashi, Beshkent, Girsan, North. Nishan, Aknazar and Kultak), northeastern part (Dzharkak, Karaulbazar, Shurtepe, Khodtak), Nizhan, Khortak, Nizhan, Zhaqrak, Nizhan Akjar, North Muborak and Kyzylrabot) and the eastern part (Karak Thai, Tashli, Sarycha, Shurtan, Buzakhur, Adamtash, Tandyrcha, Pachkamar and Gumbulak).

Hydrogen sulfide waters are promising in the following oil and gas fields: in the western part - Kulbeshkak, Uchkyr, Parsankul, Akkum, Kandym and Dayakhatyn; in the central part - Khauzak,

Dengizkul, Urtabulak, Karim and Pamuk; in the north-eastern part - Khojahairam, Karakum; in the eastern part - Karaktay, Adamtash and Gumbulak.
The contours of the distribution of sulfate-containing rocks of the Bukhara-Khiva basin along the Jurassic deposits are noted. Almost all productive horizons (XV and XVI) are limestone with anhydrite beds. As well as productive strata cover powerful gypsum-anhydrite deposits of kimeridzh-titon. Consequently, the distribution of sulfate-bearing strata covers the entire basin.

CONCLUSION

Hydrogen sulfide is formed in the production horizon of the gas-oil fields of the Bukhara-Khiva basin, due to high pressure and temperature, a thermochemical reaction occurs, i.e. in the interaction of methane and sulfate salts.
As can be seen from the map, the distribution of hydrogen sulfide water is closely related to the areas of joint development of halogen rocks and gas-oil complexes. Since the term paragenesis (paragenesis) refers to the coexistence of minerals or chemical elements that are genetically related, this map is a map of the paragenesis of hydrogen sulfide waters with evaporites and gas-oil-bearing complexes.
In the absence of one of the necessary conditions (sulfates or gas-oil deposits), high-concentration hydrogen sulfide waters are not formed. Hard hydrogen sulfide water in the identified anticline structures is formed due to the presence of minor gas and oil deposits, which have no industrial value.

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