

The produced waters of oil deposits in Tomsk region: its use for iodine industrial production

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Abstract. In world practice, groundwater is the main raw material for iodine production. In the current geopolitical conditions, a significant part of the traditional areas of iodine production is located outside the Russian Federation. As iodine is biogenic by its origin, it associates with oil and petroleum water. Therefore, the produced waters of oil deposits of Western Siberia acquire the leading role as the raw-material base for iodine production.

1. Introduction

In world practice, groundwater is the main raw material for iodine production. In the current geopolitical conditions, a significant part of the traditional areas of iodine production is located outside the Russian Federation. As iodine is biogenic by its origin, it is largely bonded to oil and petroleum water. Therefore, the produced waters of oil deposits of Western Siberia are frequently used as the raw-material base for iodine production.

Iodine entry to waters begins with the burial and organic-rich deposit transformation [4]. Waters are highly saturated with iodine in the coastal areas of the seas having lots of organic matter.

Iodine accumulation in groundwater is also related to lithofacial characteristics of water-bearing rocks. Iodine concentrations in different types of rocks were determined by some researchers. Large variations in the iodine content were revealed in the upper horizons of both oceanic and continental crust. High concentrations of iodine in the deep sea (30 g/t) and continental (2.5 g/t) carbonate rocks result from accumulation in plankton and shallow water organisms. In continental clays its content is less (1.8 g/t) than in the deep ones (3.9 g/t). During diagenesis iodine is noted to be more stable than carbon. However, during katagenesis iodine is significantly more lost (from 75 to 95%), so the iodine content in rocks ranges from 12 to 25 mg/t.

2. Subjects and methods

In the current research the peculiarities of iodine distribution in the groundwater of Tomsk region (southeastern western Siberia) within transitional sedimentation and infiltration hydrogeological structures and its connection with oil and gas content and formation are considered [3,7]. Iodine in the groundwater of the studied basin is distributed all over the region and varies from 0.2 to 48 mg/l [2].

The waters of Cretaceous deposits have the highest concentrations of iodine. In the upper Aptian-Albian-Cenomanian aquifer the iodine content varies from 0.2 to 19.3 mg/l with an average of 8.6 mg/l. Its content increases with depth, and the highest concentration of iodine for the Cretaceous deposits is noted in the Neocomian aquifer. The content varies from 0.13 to 28.4 mg/l, the average values of which are 8.3 mg/l for the western part and 3.1 mg/l for the eastern one (Table1).



In the Upper Jurassic aquifer, the iodine content ranges from 0.2 to 30.3 mg/l. The calculated average contents of 310 sampling points are 4.6 mg/l in the western part and 3.1 mg/l - in the east. The highest iodine concentration (6-10 mg/l) is in the western and central parts of Tomsk region and is mainly confined to some areas of Nizhnevartovsk, Srednevasyugan, Parabel arched uplifts, Nurol and Ust-Tym depressions due to the presence of the Upper Jurassic oil and gas productive strata (Table 1).

Thus, the Srednevasyugan arched uplift has the highest concentrations in the Yuzhno-Myldzhinskoye gas deposit (18 mg/l) and Verhnesalatsky oil and gas deposit (7.6 mg/l).

The areas with the high iodine concentrations of the Nurol depression are locally confined to the Fedyushkinsky deposit (Fedyushkinsky - 11 mg/l) and to the areas in the south-eastern part of the sedimentary basin (6-10 mg/l). The groundwater in the eastern part is greatly depleted in iodine, where its concentration does not exceed 2 mg/l [2].

Table 1. The average values of geochemical indicators of oil and gas deposits groundwater in the Tomsk region (1 – western, 2 – eastern) [2].

Aquifer	Area	T, °C		M, g/l		I, mg/l		Br, mg/l		points
		Average	min / max	Average	min / max	Average	min / max	Average	min / max	
Apt-alb-senoman	1	56.0	31 / 83	15.3	3 / 26	8.6	2.3 / 19.3	43.3	2 / 90	59
	2	38.6	18 / 84	3.9	2 / 18	2.3	0.2 / 8.7	12.5	1 / 45	15
Neocomian	1	76.0	42 / 116	19.0	3 / 48	8.3	0.3 / 28.0	52.9	4 / 306	278
	2	72.5	45 / 100	11.1	2 / 43	3.1	0.1 / 9.2	25	1 / 98	64
Upper Jurassic	1	90.5	71 / 106	23.0	6 / 64	4.6	0.3 / 30.3	71.6	9 / 178	267
	2	80.9	53 / 121	24.6	5 / 49	3.1	0.2 / 8.8	57.2	12 / 160	43
Lower Middle Jurassic	1	92.6	79 / 126	29.2	8 / 67	4.7	0.5 / 25.3	69.1	9 / 167	113
	2	87.9	54 / 132	31.1	5 / 80	4.3	0.2 / 20	72.6	5 / 258	59
Pre-Jurassic	1	104.2	70 / 140	43.3	15 / 91	9.5	0.2 / 38.2	102.9	12 / 293	186
	2	89.0	55 / 110	50.8	11 / 84	3.2	0.2 / 9.5	116.1	20 / 284	46

In the lower Middle Jurassic aquifer, the iodine content is lower than in the waters of the Cretaceous and Upper Jurassic rocks. The concentration of iodine varies from 0.2 to 25.3 mg/l over the area (the average content is 4.7 mg/l). In the south-eastern part of the region under question its content does not exceed 1.4 mg/l. The high iodine content (13 mg/l) is found in the waters of Tyumen suite deposits in the Parbic area of Krylovskaya. Its elevated concentrations (4-8 mg/l or more) in the groundwater of the lower Middle Jurassic deposits, as well as in the above aquifers are found in the western, central, and north-eastern parts of the Tomsk region (Kaymysovsk, Pudinsky, Srednevasyugan, Pyl-Karaminsky arched uplifts, Nurol and Ust-Tym depressions). The maximum concentrations are detected within the Kalinovoe, Shirotная, and Nizhnetabagan Nurol depressions, they are 25, 11.3, and 12 mg/l respectively. The high concentrations of iodine are found in the Verhnesalatsky (11.4 mg/l) and Yuzhno-Myldzhinskoye (12.7 mg/l) of Srednevasyugan megaswell, Kolpashevo (20 mg/l), West Silginsky (9.6 mg/l) of Parabel megaswell (Table 1).

In the groundwater of the Paleozoic aquifer iodine is unevenly distributed all over the area and varies from 0.2 to 38 mg/l. Its average content is 9.5 mg/l (Table 1) in the western part of the region and 3.2 mg/l - in the east. Iodine accumulates mostly in the western, south-western parts of the Tomsk region, where iodine has the high (6-9 mg/l) (Nurol and Ust-Tym depressions, Srednevasyugan, Pudinsky and northern part of Parabel megaswell) and maximum (over 10 mg/l) concentrations (south-eastern part of Nurol sedimentary basin).

The maximum values of the iodine contents have local character and are more confined to the gas deposits than to the oil ones. For example, the iodine contents in the eastern part of the Nurol depression in Nizhnetabagan, Selveykinskaya, Tambaevskaya are 28.2, 37 and 38.1 mg/l respectively. The iodine contents of the Yuzhno-Myldzhinskoye, Verhnesalatsky of Srednevasyugan megaswell are 14.8 and 10.5 mg/l respectively. The iodine content of Pudinsky megaswells (Verhnekombarskaya) reached 36.4 mg/l, while in the waters of the eastern part of the Tomsk region it does not exceed 1.2 mg/l (Table 1).

3. Results and discussion

Thus, the iodine concentration values in the groundwater change unevenly over the region increasing with the depth. The most frequent values of iodine in the aquifer of low hydrogeological level range from 0 to 5; from 5 to 10 or 15 mg/l. In the Jurassic deposits the waters with the concentration of this element from 10 to 15 and from 15 to 20 mg/l are rare, and the iodine content of about 20-25 mg/l or more is very rare. This content range is defined only to the waters of the Neocomian deposits and the pre-Jurassic formations. The highest concentrations range from 25-30 mg/l to 35-40 mg/l in the pre-Jurassic aquifer [2].

For all the aquifers chloride and sodium formation waters and weak brines are favorable for the accumulation of iodine. The concentration of the element rises with increasing depth, temperature, salinity, and water saturation with hydrocarbons. The relationship between the iodine content, groundwater mineralization, and chemical composition differs for the different aquifers and areas. Thus, the dependence in the pre-Jurassic and Cretaceous aquifers is clearer and characteristic for the groundwater where the accumulation of iodine is more intense and reaches the maximum value.

In the groundwater of the Jurassic deposits, the dependence on mineralization is slight, and the iodine content usually does not exceed 10 mg/l, but in the pre-Jurassic aquifer it is 15 mg/l. Good relation is observed with the content of chloride ion. Strong positive correlations are marked with ammonium. In the waters of the Jurassic and pre-Jurassic deposits, there are good relations with the potassium, sodium, calcium, magnesium, rubidium.

The sources of water enrichment in iodine are different in the region under question. Currently, the iodine content in the interstitial waters of modern seas and oceans is considered to be much higher than its content in the incoming water [6]. Therefore, a large volume of iodine is buried due to sedimentation. As a result, according to A.V. Kudelsky the iodine content degree of the sedimentary basins groundwater is determined by the total thickness of the sedimentary formations. In the region the volume of the Cretaceous deposits exceeds several times the one of the Jurassic deposits. It affected the enrichment of water in iodine during diagenesis and early epigenesis. Large amounts of iodine came from the rocks (especially clay) with water to the sandy reservoirs [5].

4. Conclusion

The produced waters of the oil and gas deposits with the iodine concentration of more than 10 mg/l [1] are referred as industrial. Such waters are most widely distributed in the Cretaceous deposits and only in the western part of Tomsk region within Kaymysovsk uplift, Srednevasyugan megaswell, Nurol and Ust-Tym depressions. In the Jurassic deposits the industrial concentrations of iodine-rich waters are confined to certain areas of Srednevasyugan uplift, the eastern part of the Nurol depression and Kolpashevo of Parabel megaswell, and in the pre-Jurassic formations they are found only in Yuzhno-Myldzhinskoye and Verhnesalatsky of Srednevasyugan megaswell, and Nizhnetabagan, Selveykinskaya, and Tambaevskaya of Nurol depression. Moreover, the concentration of iodine in the groundwater of the pre-Jurassic formations is higher than in the Cretaceous deposits. This demonstrates the feasibility of further study of groundwater in oil deposits as the source of industrial production of a variety of components, such as iodine.

Tomsk region has all the conditions for the formation of one more resources producing industry along with the oil and gas one, it will solve the problem of import substitution of iodine.

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