Appraisal of the possibility and economic expediency of using salt-water zones contained in rock salt beds or the salt structures as a source of rare elements

I.I. Koreneva* V.A.Manoukian*, E.V.Dedikov**

*Moscow, Podzemgazprom Ltd.
**Moscow, JSC Gazprom

In the present work two problems were examined: (1) the value of concentrated brines as raw mineral, and (2) the way of environmental safety providing during drilling of production wells at gas condensate fields.

1. INTRODUCTION

In gas condensate fields (GCF) such as the Astrakhan GCF, the roof of the field is formed by a salt deposit. The complicated tectonics of the formations may cause the presence of jammed lenses of salt brine with abnormally high formation pressure. Evidently, the salt deposits were formed by crystallization from concentrated brines at specific conditions (pressure and temperature). During drilling of deep production wells a self-release of concentrated brine to the surface often occurs due to the high pressure in annular space between casing strings. This results in some problems in the course of drilling.

Besides, the release of concentrated brines onto the surface may induce contamination (salinization) of ground and soil. Water-bearing horizons may also suffer from salt contamination if the filtration process proceeds.

In accordance with the present legislation on environmental protection, the self-release of concentrated brines on the earth surface is prohibited. Therefore, the poured out underground brines are collected, at the best, or the well is stopped up hermetically to cut off self-release. Eventually, this results in the loss of money spent on well drilling and increases the number of "dead" non-operating wells.

The study of logs regarding well drilling operations at Astrakhan gas condensate fields showed that the major number of wells was stopped up due to brine release. Accordingly, the volume of concentrated brine self-release may reach hundreds of cubic meters.

2. BRINE CONTENT AND VALUE

Study of the chemical composition of brines taken from some wells revealed the presence of such elements as cesium, rubidium, boron, antimony, arsenic, bromine, iodine and silver. The level of mineralization of samples varies in a wide range from 246 to 338 g/l. The type of brines ranges from "soda" to "chloride-calcium" types with pH values ranging from weak acidic to strong alkaline (pH = 6.0---13.8).

The content of microelements was preliminary detected by spectral analysis and then by a more precise analytical method. The results of analyses should be appraised in two ways: (1) salt brines as a potential source of chemical materials, and (2) salt brines as a source of contamination in the case of releasing on the ground.

Table 1 presents the data on the chemical composition and lowest exploitable content of salts and elements in salt brines for wells in the Astrakhan GCF, and the price listed on the basis of 1995 world prices.

Soda waters from the well #1 (cordon area) have the concentrations of sodium carbonate and bicarbonate around 90-110 g/l. In the well #85 a high iodine content (up to 121 mg/l) was found that is 12 times higher than the lowest exploitable concentration. The bromine concentration in this well was found to be up to 133 mg/l that is 6 times more than the lowest exploitable concentration. Silver is also present at the rather high concentration of 1.34 mg/l as well as boron at a concentration of 417 mg/l which are, respectively, 134 and 8 times more than the lowest exploitable concentrations.

A high content of antimony and arsenic was detected in the wells #64 and #65 that exceeds the economic exploitation values by 2-16 times (well #64 - antimony concentration is 16 mg/l, well #65 - arsenic concentration is 12 mg/l). These elements are known to be highly toxic and their contents exceed Acceptable Ceiling Concentration (ACC) by more than 240-320 times.

The boron content (600 mg/l - the well #1 was found to exceed the minimum economically exploitable concentration by 15 times, whereas that of rubidium (50 mg/l is 17-23 times higher the minimum economically exploitable concentration. Besides, lithium and cesium were found as components of the brine.

Bromine and boron, which are highly dangerous in underground water, were detected at a concentration 6660 and 834 times higher, respectively, than permitted by ACC (GOST 8310-95). Besides, such hazardous elements as fluorine and iron were found in salt brine at concentration exceeding Acceptable Ceiling Concentration by 47 and 623-1860 times, respectively.

The following are the prices, taken from world price list (1995) [1] for 1 kg of a material in US dollars:

Sodium carbonate (soda) - $0.151; Silver $15,030.7; Iodine - $16.0; Antimony - $11,000.0; Lithium - $36.0; Rubidium - $13,000.0.

Accordingly, a component extracted from one thousand m^3 of salt brine will cost:

NaHC03 - $9,815.0; Silver - $20,14 1.0; Iodine $1,936.0; Bromine - $1,732.0; Antimony $176,000.0; Boron -$154.0; Lithium - $680.0; Rubidium - $884,000.0.

It was calculated that the yield of sodium carbonate from 1000 m^3 of salt brine should be 490 tons, at a cost of $73,990. Assuming the extraction coefficient equal to 0. 17, one can find that about 343 tons of sodium carbonate may be extracted from 1000 m^3 of salt brine at a total cost of $51,793.

It should be noted that the above-estimated earnings do not take into account the expenses for technology applied for separation of each substance from salt brine. Notwithstanding, it is evident, that the salt brine is a valuable source: for production of vitally important substances.

3. BRINE EXPLOITATION

The second important problem is utilization of salt brines. We have got a good experiences regarding the utilization of construction brines associated with creation of underground reservoirs in salt deposits by the dissolution method. This experience allowed to substantiate the technology, based on accumulation and holding of associated brines, in lake-deflation hollows and similar morphological structures of semidesert Astrakhan region.

Earlier, we have performed detailed hydrogeological and geophysical studies of the region and a set of computer calculations of models for accumulation in underground water of such hollows was carried out. It was proven that genuine salt brines are formed in underground aquifers if they are located at a depth of no more than 3 meters.

When the associated brines and salt brines from production wells are released into such hollows they do not form a mixture with "maternal" brine, but "float" on a surface of the latter without increasing the area of the latter.

We chose two perspective areas and appraised the suitability of the existent lake-deflation hollows for accumulation and temporary holding of concentrated salt brines released during drilling of exploration wells. Preliminary conclusions drawn on the basis of geophysical studies regarding possible use of lake-deflation hollows for accumulation and holding of highly saturated salt brines were supported by the results of prognostic modeling.

To model a process of genuine salt brine formation, the method was applied to perspective regions for well drilling (Devonian area, well #1) assuming the constant climatic conditions for the next 20 years.

The problem was solved with a personal computer IBM PC 486 using modernized and unified program TOPAZ – NS. Additional salt accumulation due to evaporation was also taken into account. The primary data for solution of the problem were mean falls value, evaporation from the lake area, characteristics of filtrating layers of Klivalyn-KItazar water-bearing horizon, local relief, and capacity of aeration zone. The modeling period was taken as long as 20 years.

As a result of the modeling studies, the schemes of evaporation regime leading to underground water mineralization were obtained as well as its differentiation in plan projection.

Good correlation between the morphological structures (hollows) and high degree of underground water mineralization (up to 120-150 mg/l). have been additionally confirmed by the results of modeling. Thus, in principle, the possibility of forming genuine brines in lake-deflation hollows of the Karasor and Aidyk type was reaffirmed.

It should be noted that for the last 8 years the release of associated brines with salt concentration of 270-300 g/l was carried out in hollows of Aidyk Lake and Karasor Lake. This did not impact the natural hydrochemical situation. of the underground waters since the genuine brines were pushed down by associated brine and the stability was maintained. These data have been obtained by hydrogeological regime control and geophysical studies of the associated brines in hollows of Karasor Lake and Aidyk Lake.

For the newly chosen hollows in the region of the well drilling, a complex of morphometric, hydrogeological and geophysical studies will be carried out to confirm the presence of genuine brines in underground waters and, consequently, to permit salt brine release into those hollows.

REFERENCES

1. World Price List for Raw Materials and Materials, All-Russian Institute MVES RF, 2nd Ed., Moscow, 1995

Table 1. Microcomponent contents in brines from wells at AGCF

№№ of wells	Labora -tory, date	Microelement contents, mg/l																	
		I	Br	As	Sb	Ag	F	Hg	Au	Mo	TiO_2	P_2O_5	SiO_2	V	B	Li	Rb	Cz	Rare earthe elements
1	VIMS*, 1995	14.4	26.3	< 5	< 3	0.0058	70	not found	< 0.0004	0.140	2.13	18.0	260.0	not found	600.0	0.3	6.1	1.2	0.049
64	VIMS, 1995	6.8	38.5	< 10	16	0.0181	0.5	not found	< 0.0004	0.040	2.40	12.0	922.0	not found	0.5	4.1	66.1	2.0	< 0.025
65	VIMS, 1995	4.0	18.1	12	10	0.0164	0.8	not found	< 0.0004	0.392	2.53	24.0	787.0	not found	0.5	8.4	49.1	1.3	0.085
85	VIMS, 1995	3.2	13.1	< 5	< 1	0.0171	0.2	< 8-10	< 0.0004	< 0.025	2.13	3.4	424.0	not found	< 0.5	4.7	51.1	2.8	0.68
85	S-KNII GAZ** 1998	121.4	464.0			1.34													
85	UralNIF Igaz***	13.9	1331.9												416.7				
112	VIMS 1995	8.8	28.4	9	< 1	0.0276	0.6	not found	< 0.0004	not found	4.00	52.0	271.0	not found	0.5	3.5	68.5	1.9	< 0.025
113	VIMS 1995	6.4	37.4	< 5	< 1	0.0111	0.3	6.4-10	0.00064	0.092	2.13	6.0	539.0	0.10	< 0.5	3.1	65.4	1.9	< 0.025
116	VIMS 1995	22.0	268.0	< 5	< 1	0.0018	1.5	< 8-10	0.00106	< 0.025	2.67	32.0	112.0	not found	< 0.5	18.9	1.8	0.7	1.323
206	VIMS 1995	9.8	231.2	< 5	13	0.0041	0.2			< 0.025	1.73	2.4	239.0	0.08	0.9	18.6	52.1	1.3	< 0.025
ACC on drinking water			0.2	0.05	0.05	0.05	1.5	0.0005	0.001	0.01	0.10		10.0	010	0.5	0.03			
The least industrial concentrations		10.0	200.0	5	5	0.01		100.0		0.10				0.10	40.0	10/0	3.0	0.5	0.5

* All Russian Inctitute for Metrology and Standards

** North Caucas R&D Gas Institute

*** Ural R&D Industrial Institute for Gas

Appendix 1.

Block-diagram of Sary-Sorsky salt dome