Underground storage facilities for helium concentrate in porous medium

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Abstract. The gas of many fields in Eastern Siberia (Chayandinskoye, Kovyktinskoye, Sobinskoye, Chikanskoye, etc.) has a complex component composition with a high helium content. In order to realize the advantage of a unique raw material base, it is necessary to put into practice solutions for the industrial implementation of technologies for the extraction of helium, storage and transportation. One of the directions for the solution of these problems is the creation of temporary underground storage of helium concentrate in a porous medium next to gas chemical plants. This will ensure supply flexibility and reduce helium losses. The global demand for helium is continuously increasing from year to year and in the long term, a favorable situation will emerge on the global helium market for Russia, a positive effect from which can be achieved, provided the benefits of the raw material base are realized. A positive effect means not only the monetary effect, but also takes into account the formation of prerequisites for the development of new spheres of influence: access to new trading platforms and sales markets, the development of high-tech industries, basic and applied sciences, etc. In order to realize the advantage of the raw material base, Russia needs in a fairly short period of time to put into practice the decisions on the industrial introduction of gas separation technologies and underground helium storage.

1. Introduction
In accordance with the Eastern gas program of PJSC Gazprom and the energy strategy of Russia in the East, new large gas production centers and a unified gas transportation system are being formed. This centers in the long term will allow organizing a new channel for exporting Russian gas to the countries of the Asia-Pacific region. Currently, several regional gas production centers have been formed in accordance with the location of large fields:

- Yakut on the basis of the Chayandinskoe field with the prospect of developing the neighboring fields - Sobolokh-Nedzhelinskoe, Verkhnevilyuchanskoe, Tas-Yuryakhskoe and Srednetyungskoe;
- Irkutsk based on the Kovyktinskoe field with the development of the Chikansky field and fields in the north of the Irkutsk Region;
- Krasnoyarsk based on the Sobinsko-Paiginsky and Yurubcheno-Tokhomsky fields with the prospect of developing the Omorinsky, Kuyumbinsky, Agaleevsky and other fields. (These fields do not belong to Gazprom).
2. Reserves of Russian helium

The gas of most of these fields has a complex component composition, but their main distinguishing feature is the high helium content [1].

![Figure 1. Large fields in eastern Russia](image)

The total reserves of Russian helium in the main prospective helium fields are estimated at 14.5 billion m³. Of these, helium reserves in the A + B + C₁ categories amounted to about 7.6 billion m³, and in the C₂ category - 6.9 billion m³ [2]. The largest helium fields of Russia in categories A + B + C₁ include [3]:

- **Kovyktinskoe field** - volume of explored reserves of helium 3.9 billion m³ (Irkutsk region, helium content - 0.26 - 0.28%)
- **Chayadinskoe field** - 1.85 billion m³ (Republic of Sakha, helium content - 0.43 - 0.65%)
- **Sobinskoe field** - 0.8 billion m³ (Evenki Autonomous Area, helium content - 0.50 - 0.70%)
- **Srednebobuinskoye field** - 0.6 billion m³ (Republic of Sakha, helium content - 0.2-0.67%)
- **Tas-Yuryakhskoye field** - 0.4 billion m³ (Republic of Sakha, helium content - 0.38%)

Russian reserves system is based solely on the analysis of geological attributes. Explored reserves are represented by categories A, B, and C₁; preliminary estimated reserves are represented by category C₂; potential resources are represented by category C₃; and forecasted resources are represented by categories D₁ and D₂. Natural gas reserves in categories A, B and C₁ are considered to be fully extractable [4].

Characteristics of the most promising helium-containing fields are presented below.
### Table 1. Information about Chayandinskoe field

| Field name                  | Chayandinskoe                  |
|-----------------------------|--------------------------------|
| Country                     | Russia                         |
| Region                      | Yakutia (Sakha Republic)       |
| Company owner (license)     | PJSC Gazprom, 2008             |
| Field content               | Gas, oil, gas condensate       |
| Rank                        | Large (unique)                 |
| Discovery date              | 1989 г.                        |
| Beginning of field development | 2015 г.                      |
| The field’s annual design output | 25 billion m$^3$ of gas, 1.9 million tons of oil and 0.4 million tons of gas condensate |
| Depth of the field          | 1450-1850 м                   |
| Reserves                    | $B_1$-$B_2$, 1.4 trillion m$^3$ of gas and about 76.7 million tons of oil and gas condensate |
| Helium content              | 0.43-0.65%                     |

### Table 2. Information about Kovyktinskoe field

| Field name                  | Kovyktinskoe                  |
|-----------------------------|--------------------------------|
| Country                     | Russia                         |
| Region                      | Irkutsk region                 |
| Company owner (license)     | JSC RUSIA Petroleum, 1992      |
|                              | PJSC Gazprom, 2011             |
| Field content               | Gas, gas condensate            |
| Rank                        | Large (unique)                 |
| Discovery date              | 1987 г.                        |
| Beginning of field development | 2001 г.                      |
| The field’s annual design output | 25 billion m$^3$ of gas       |
| Depth of the field          | 2838-3388 м                   |
| Reserves                    | $C_1$-$C_2$, 2.7 trillion m$^3$ of gas and 90.6 million tons of gas condensate |
| Helium content              | 0.26-0.28%                     |

In accordance with the classification, these fields are rich and very rich helium-containing gases

### Table 3. Classification of natural gas depending on the helium content

| Group name   | Helium concentration, % |
|--------------|-------------------------|
| Poor         | 0.02-0.05               |
| Rich         | 0.05-0.30               |
| Very rich    | 0.30-1.0                |
| Uniquely rich| >1.0                    |
These fields are key elements in the formation of the resource base for the Power of Siberia gas pipeline and are included in the contract for the supply of natural gas to China.

Figure 2. Gas pipeline Power of Siberia

In October 2015, the beginning of the construction of the Amur GPP for processing and extraction of valuable components from natural gas before delivery to China. The stage-by-stage commissioning of its production trains will be synchronized with the development of Gazprom’s production capacities in Yakutia and the Irkutsk Region [5].

Table 4. Characteristics of the Amur GPP

| Characteristics       | Value                                      |
|-----------------------|--------------------------------------------|
| Design processing capacity | 42 billion m$^3$ of natural gas per year. |
| **Helium production**  |                                            |
| Ethane production     | 60 million m$^3$ per year.                 |
| Propane production    | about 2.5 million tons per year.           |
| Butane production     | about 1 million tons per year.             |
| Plant’s area          | 800 hectare                                |

The supplier of the main technological equipment for cryogenic gas separation with the production of helium and other components for petrochemistry is the **German company Linde AG**. The design capacity for the production of helium will be about 60 million m$^3$/year or 10 thousand tons/year, the degree of extraction - **99.2%**.

Based on the assumptions of specialists of Gazprom VNIIGAZ LLC, the maximum annual production of helium concentrate will be in 2025. This year the maximum is 80 million m$^3$/year, the average value is 70 million m$^3$/year, and a minimum of 59.6 million m$^3$/year [5]. Thus, when dealing with helium, it is necessary to be guided by the principle of rational distribution and accumulation of the extracted helium reserves of Eastern Siberia and the Far East. The demand for helium in the domestic market is quite low, and the sale of large volumes of helium on the world market can cause
problems with the frequency and volume of purchases of Russian helium. Therefore, helium accumulation is required.

One of the ways to resolve this problem is the creation of underground storage facilities for helium concentrate (UHCSF) in a porous medium in close proximity to gas chemical plants. This will ensure supply flexibility and reduce helium losses [6].

Currently, the technical and technological aspects of the creation of UHCSF are not well researched.

### 3. Promising objects of helium underground storage

Analyzing domestic and foreign experience in underground storage of helium and helium concentrate in porous media, it was found that smaller fields, which were always more than large ones, were well suited for storing helium concentrate. And therefore it is possible to choose an object closer to the GPP, freeing up space for helium concentrate, either by developing the field, or by transferring the required volume of gas to the deposit of a large field [7].

When selecting objects for storage of helium concentrate, it is necessary to implement the requirements for the construction of underground gas storage facilities in porous media, but there are also specific requirements [1]. The geological and technical group of requirements imposed on helium storage facilities is primarily determined by the fact that helium is a gas with high penetrating power. A favorable factor in the creation of helium concentrate storage facilities is the existence of an overlying reservoir containing natural gas. When creating a storage facility in the lower deposit, even if helium leaks from the storage facility, it will be entrapped into the overlying gas reservoir and can be produced. Also, quite high requirements are placed on the tightness of wells in the storage and, therefore, it is necessary to strive to reduce the number of wells in the field [8]. Thus, on the basis of the literature analysis, the criteria for the initial selection of prospective deposits were formulated:

1. most suitable for long-term storage of gas field with a high initial content of helium. This is a criterion for the tightness of helium caprocks;
2. existence of an overlying reservoir containing natural gas.
3. fields of small sizes are suitable as a storage facility.
4. a little number of wells
5. objects for storage of helium concentrate should be located in the immediate vicinity of the gas processing plant.

Several promising fields were selected according to these criteria:

| Field                        | Productive formation                                      | Storage volume of helium concentrate billion m³ |
|------------------------------|-----------------------------------------------------------|-----------------------------------------------|
| Tas-Yuryahskoe (unallocated fund Yakutnedra) | Talakh sandstones horizon                              | 7                                             |
| Hoto-Murbayskoe (Gazpromneft-Angara LLC) | Sandstones Venda                                        | 4                                             |
| Chayandinskoe (PJSC Gazprom)  | Sandstones of the Khamakinsky Vendian of the Southern II or Samanchakitsky blocks | 9                                             |
| Adnikanskoe (unallocated fund)  | Sandstones, aleuroliths with interlayers of mudstone of the Kindal Formation (Cenomanalb) | 2                                             |
4. Conclusion

Considering the fact of a significant volume of exports through the city of Blagoveshchensk, it is necessary to consider the option of developing UHCSF in the area of this city.

The question of creating UHCSF in the Khabarovsk region is most actual. This UHCSF will be able to regulate the irregularity of helium consumption and ensure the reliability of export helium supply to China, the APR countries and the USA.

References

[1] Han S A, Igoshin A I, Kazaryan V A, Scriabin A S and Sohranskiy V B 2015 Underground storage of helium (Izhevsk: Institute for Computer Research)
[2] Scriabin A S 2016 The experience of underground storage of helium International research journal 10 (52) 2 155-159
[3] U.S. Geological Survey 2016 Mineral commodity summaries, available at: http://minerals.usgs.gov/minerals/pubs/mcs/2016/mcs2016.pdf
[4] Gluyas J G, Macpherson C G, Abraham-James T H, Bluett J J, Barry P H and Ballentine C J 2016 New High-Grade Helium Discoveries in Tanzania Goldschmidt Conference Abstracts, available at: http://goldschmidt.info/2016/uploads/abstracts/finalPDFs/A-Z.pdf
[5] Milovanov S V, Kislenko N N and Troyinkov A D 2016 Development and implementation of innovative technologies for the extraction of helium from natural gas Scientific journal of the Russian Gas Society 2 10-17
[6] Bondarev V L 2015 Storage prospects helium enriched natural gas in Eastern Siberia and the Far East News of Gas Science: Problems development and operation of gas gas condensate and oil and gas condensate deposits Gazprom VNIIGAZ 3 (23) 63–67
[7] Semenova K M, Churikova I V and Lopatin A Y 2018 Geological and gas-dynamical provisions for underground storing of helium in the terrigenous Vendian sediments at the north-east of Nepa-Botuoba antecline Scientific and technical collection NEWS OF GAS SCIENCE 3 (35) 68
[8] Starokon I V 2017 The influence of the processes of transient vortices formation and the resulting alternating loads on the stress state in the offshore oil and gas structures Construction of oil and gas wells on land and at sea 11 49-53