

PAPER • OPEN ACCESS

## Ways of helium development in Eastern Siberia

To cite this article: A B Feodorov *et al* 2020 *J. Phys.: Conf. Ser.* **1515** 022052

View the [article online](#) for updates and enhancements.



**IOP | ebooks™**

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection—download the first chapter of every title for free.

## Ways of helium development in Eastern Siberia

A B Feodorov<sup>1,2</sup>, A V Egorov<sup>3</sup>, L I Sviridov<sup>1</sup>, E V Prokaten<sup>1</sup> and A V Bushkina<sup>1</sup>

<sup>1</sup> Siberian Federal University, 79 Svobodny Av., 660041 Krasnoyarsk, Russia

<sup>2</sup> ElseTech, 1 Robespierre Av., 660021 Krasnoyarsk, Russia

<sup>3</sup> Volga State University of Technology, 3 Lenin Square, 424000, Yoshkar-Ola, Russia

E-mail feodorov@mail

**Abstract.** The Baikal natural gas deposits are ten times higher than the Orenburg oil and gas condensate field in terms of helium content. The Orenburg field is the raw material base of the Orenburg helium plant, which is part of Gazprom Dobycha Orenburg. Helium is characterized by increased ability to leak out. It is no coincidence that two deposits of Eastern Siberia geographically gravitate towards the deep Baikal fault. Hydrocarbon deposits in the north of the Krasnoyarsk Territory characterized by an increased fracturing system may have interconnections with deep faults. The study of such geological conditions in the development process is promising for increasing the raw material base of helium mining. Helium production technology is based on low-temperature gas condensation. The application of membrane gas separation technology is promising. Separation blocks can be incorporated into the infrastructure of compressor stations. This approach to the deployment of helium production capacities will increase the efficiency of capital investments. Relatively small volumes of productive helium can be transported without reference to pipeline systems. The proximity to the Yenisei and the Northern Sea Route makes the issue of the development of gas condensate production relevant. Placing production wells near the intersection of several fracturing faults is also effective in terms of high inflows. Of particular interest are wells drilled near discontinuous faults. Under these conditions, one can rely on helium inflows through microcrack systems from deep horizons.

### 1. Introduction

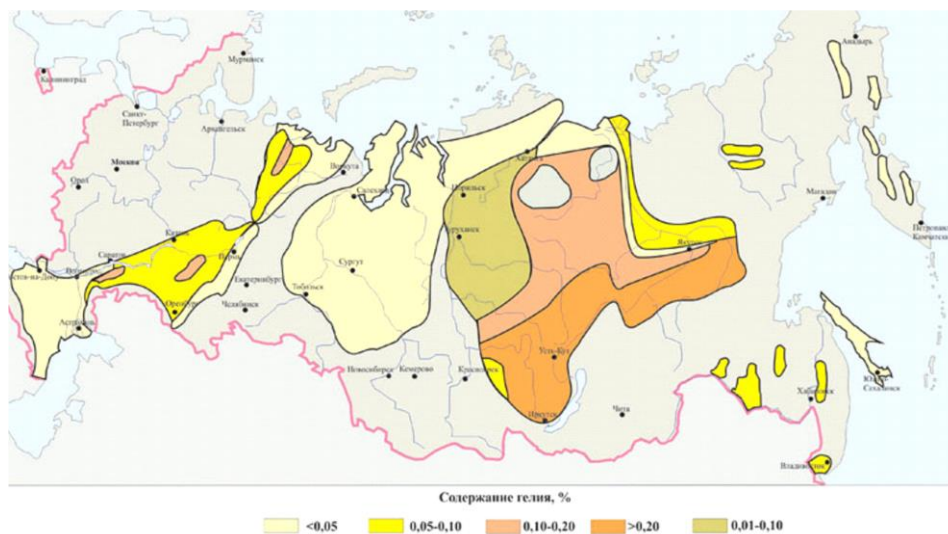
In Russia, so far only about 5 million cubic meters of helium are produced per year. This is a small amount for the global market. The main reserves of this substance in Russia are concentrated in the fields of Eastern Siberia and the Far East. These deposits are in the initial development phase. Meanwhile, the helium content in these deposits is high 0.01–0.2%. They are suitable for industrial production of helium. On the Siberian platform in the near future they will begin to actively develop the helium resource base. In Russia, new large centers for the production of helium in the future can be created on the basis of the Chayandinsky, Kovyktinsky and other deposits in Eastern Siberia and the Far East. Thus, there is reason to form a large-scale global production of helium. Through the river and sea transport network, it is possible to organize the supply of this substance to the world market. It is necessary to start producing helium in a timely manner. There are risks that it may be lost. Associated petroleum gas was a byproduct. It was just burned. On an industrial scale, helium is extracted with natural gases. Since helium is characterized by an increased ability to leak out, it is



necessary to organize in East Siberia a specialized system for the production, extraction, storage and supply of helium to the domestic and international markets.

Helium is a by-product of raw materials. In free form, it does not occur in the bowels. Distributed industrially in natural gases with concentrations mostly less than 0.5-1.0%. When disposing of gases, it is lost to the atmosphere. In the atmosphere it is only 0.0005%. Assessing the importance of helium production, it is necessary to take into account that helium is a by-product of the development of hydrocarbon deposits.

Currently, about a hundred gas, oil and gas condensate and oil fields have been discovered on the territory of the Siberian platform. Fields are localized in ancient strata (Riphean, Vendian, Lower Cambrian). They contain industrial concentrations of helium. Helium concentration in these deposits is high - 0.01–0.2%. Figure 1 shows a diagram of helium resources in natural gases in the oil and gas basins of Russia.



**Figure 1.** Scheme of helium content in natural gases of oil and gas basins of Russia [1].

With the development of gas fields in Eastern Siberia with industrial concentrations of helium, losses will increase. Losses arise due to the lack of helium storage infrastructure. The market cannot accept the amount of helium significantly exceeding modern needs. Therefore, the problem of rational and integrated development of gas helium raw materials should be solved in parallel with the development of natural gas fields. It is necessary to take into account the high commodity importance of helium in the domestic and world markets and the limited nature of its high-quality resources. The demand for helium extends to a wide range of innovative branches of technology. This is a consequence of the unique properties of helium.

The development of hydrocarbon deposits in Eastern Siberia today is focused on oil recovery [2]. This circumstance leads in some cases to the loss of natural gas and helium.

## 2. Technological features of the development and conservation of helium

The plans for the development of the region's pipeline structure include a gas processing plant where liquid commodity helium will be produced [3].

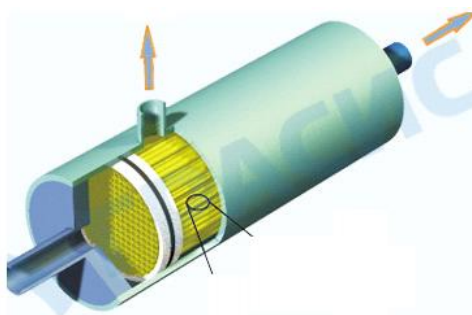
To reduce helium losses with natural gas combustion products during oil production at natural gas outlets for supplying turbines of booster compressor stations, it is advisable to install helium extraction membrane plants [4]. For these purposes, it is natural to use modular plants for the separation of helium from fuel gas. Today there are cryogenic, membrane and combined methods for the extraction of helium from natural gas.

The use of cryogenic technologies is associated with the use of low temperatures necessary for the liquefaction of methane to  $-196^{\circ}\text{C}$ . The achievement of such temperatures is ensured by the expansion of gas using a turboexpander. Otherwise, they create cold with the help of propane, freon or nitrogen refrigeration units. Energy costs are reduced by a combination of a turboexpander and a heat pump.

Cryogenic technologies for the extraction of helium are used for large-scale production with the release of all valuable components from natural gas (helium, ethane, propane, butane, pentanes, etc.) and the release of excess nitrogen to increase the calorific value of the gas to the required values. It is necessary to remove impurities of water, carbon dioxide, sulfur compounds and a number of other impurities from the gas. Gas treatment equipment occupies large areas, requires large maintenance costs and consumes a significant amount of energy resources (electricity, water vapor, fuel gas) [5, 6].

At the Cryogenmash enterprise, work was carried out to create a number of small-tonnage plants for the extraction of helium. Cost recovery was considered due to the production of liquefied natural gas for sale on local markets [7]. Cryogenic recovery of helium is accompanied by liquefaction of methane. High costs for helium excluded the industrial distribution of small-tonnage cryogenic plants of the company.

The basis of membrane gas separation technology is the membrane. With the help of the membrane, gas is separated (figure 2).



**Figure 2.** Grasys membrane module [8].

For membrane hydrocarbon gas separation technologies, hollow fiber or roll type membranes can be used. The thickness of the gas separation layer of the fiber is one hundred nanometers. Polymer membranes are highly selective in gas separation and provide high purity of gaseous products. The modern membrane module used for membrane separation of hydrocarbon gases with the release of helium consists of a replaceable membrane cartridge and housing.

The separation of gases using membrane technology occurs due to the difference in partial pressures on the outer and inner sides of the membrane. Gases that quickly penetrate through the polymer membrane (water vapor, He, H<sub>2</sub>, CO<sub>2</sub>, O<sub>2</sub>) pass through the membrane and exit the membrane cartridge through one of the outlet pipes. Gases that slowly penetrate through the membrane (for example, CO, CH<sub>4</sub>, higher hydrocarbons) exit the membrane module through a second outlet pipe. When removing helium using membranes, the driving force behind the separation is the pressure drop across the membrane. As a rule, sufficient gas pressure at the inlet is from ten megapascals.

Membrane plants have a number of technological advantages in comparison with cryogenic technologies. For gas separation using membrane technology, there is no need for deep gas purification from undesirable impurities. Gas purification from some impurities is not required. Moisture content is allowed up to dew point temperatures. There is no need to pre-extract carbon dioxide. Helium membrane extraction is carried out without restrictions on the content of carbon dioxide.

There are no moving parts in the membrane module. The compressors needed to pump permeate into the pipeline have little power and do not require a reserve. In the event of a compressor failure, the membrane units are simply turned off.

Scaling is easy. Installations of various capacities are formed by changing the number of membrane modules.

Modern membranes have a fairly high level of reliability due to good quality and process automation. Automation allows you to quickly prevent emergency situations. A quick start and stop is performed, since flow-type devices are used. Gas separation is carried out at low temperatures up to sixty degrees Celsius. There is no need for phase transformations. This is an important advantage of membrane technology. Significantly reduced costs compared to cryogenic technology.

Membrane separation technology is resistant to fluctuations in the helium content in the feedstock. Full automation allows you to control the installation remotely. There is no need for a permanent stay of people to monitor the progress of the process. Membrane cartridge cases, gas heaters, compressors have a long service life. The equipment can operate in continuous and periodic modes.

A disadvantage of membrane technology is the need to remove solids with a particle size of more than five microns. In the case of an expander, the limitation is an impurity with a particle size of more than fifty microns. A filter with finer filtration is required in front of the membrane.

In Russia, the Grasy research and production company, which does not have its own membrane production, specializes in this area. Cartridges are manufactured using UBE Industries hollow fiber membranes. Work has begun on the creation of membrane plants for the separation of helium in the enterprises of the Gazprom Group. In Russia there are a number of patents applicable to the conditions for the extraction of helium by the membrane method. The selection of gas components along the length of the main gas pipeline [9-12] is being developed.

Membrane technologies, as a rule, are used for small-tonnage production of helium concentrate.

For the extraction of helium, two types of membrane plants are used, which differ in the number of membrane steps along the gas. Plants with one membrane step are designed to concentrate helium in permeate to the level of the first percent depending on the initial concentration. Installations with two or more membrane steps are designed to produce permeate with a helium concentration of more than 80% [13-15].

The first type has an advantage over the second type. It is quite simple and at a lower cost solves the problem of returning permeate to the highway or other consumer. Helium can be concentrated by diffusion through the membrane in one step to a helium content of about ten times higher than in the source gas. Then a smaller by an order of magnitude volume of concentrated helium gas can be subjected to cryogenic fractionation in an existing facility. This will significantly reduce energy costs compared with cryogenic technology for the production of helium concentrate with a concentration of more than 80%.

### 3. Discussion

The significance of the development of the largest gas-helium deposits in Eastern Siberia stems from the understanding that helium is a passing product, and not the target product of their development. For the initial stages of development, before the creation of the appropriate infrastructure, it is necessary to provide for the reverse injection of helium-bearing gas into gas-producing strata. These measures will preserve helium reserves and support reservoir pressure in the oil part of the reservoir.

In the Krasnoyarsk Territory, the main in terms of helium reserves is the Sobinsky deposit prepared for industrial development. The field is characterized by a high helium content of 0.58% and reserves of 0.8 billion cubic meters. It is considered the least valuable in gas composition [1]. The nitrogen content in it is 25%, which sharply reduces the helium content in the residual concentrate after liquefaction to 4-5%.

The situation is radically changing with the focus on the application of membrane gas separation technologies. Blocks for separating helium from gas can be integrated in areas of compressor

equipment. It seems effective to organize the process at the stage of pumping natural gas into the oil reservoir to maintain reservoir pressure.

Relatively small volumes of commodity helium, in comparison with world production, can be brought to markets without fear of affecting the pricing environment. Commercial grade helium obtained using membrane technology can be liquefied for transportation. Energy costs in this case will not have a critical impact on the cost of production.

With the advent of the domestic helium tank, Russia's gas processing complex can build the infrastructure for the production and supply of liquid helium on its own elemental base. This should affect the overall cost and cost of the product - liquid helium [16]. JSC "PO Geliymash" - a leading Russian cryogenic enterprise and its experience in building of the first domestic helium container for helium transportation in Russia and abroad.

A tank container with a capacity of 40 m<sup>3</sup> for transporting liquid helium by road and sea is a key element of the logistics system for the supply of liquid helium worldwide.

Membrane blocks and cryogenic tanks create a convenient tuple for effective interaction with the helium market.

The Sobinskoye field is adjacent to the Paiginskoye field, which is similar in composition (He - 0.52%), but with smaller reserves. They are part of the westernmost in the region Yurubcheno-Tokhonsky block of deposits. These deposits are characterized by a significant oil component. The gel content of gases here reaches 0.18%, nitrogen 8.2% [1]. Helium production can be periodically connected to oil development. It is reasonable to link such inclusions in periods of increased helium prices in the world market.

## References

- [1] Yakutzeni V P 2009 Raw material base of helium in the world and prospects for the development of helium industry *Oil and gas geology. Theory and practice* p 24
- [2] Mnushkin I A, Erokhin E V and Syrkin A M 2017 Comparative analysis of modular settings technology of the helium extraction out of natural gas *Chemical technologies and products* p 5
- [3] Kontorovich A E, Kerzhubayev A G and Eder L V Raw 2017 *Materials base and prospects for the development of helium industry in Russia and the world* Retrieved from <http://www.vipstd.ru/gim/content/view/46/>
- [4] Mnushkin I B 2016 *Cluster for processing natural gas with helium extraction* Patent of the Russian Federation № 2574243 (Moscow: Rospatent)
- [5] Murin V I, Kislenko N N and Surkov Y V 2002 *Technology of processing of natural gas and condensate* (Moscow: Nedra-Biznestsentr)
- [6] Stolyпин V I, Shakhov A D and Syrkin A M 2006 Improvement of the adsorption process of drying and purification of natural gas at the Helium plant LLC Orenburggazprom *Khimicheskaya tekhnologiya* p 18
- [7] Kuz'menko I F, Peredel'skiy V A and Dovbish A L 2010 Natural gas liquefaction of on the basis of expander nitrogen cycles *Tekhnicheskije gazy* p 3943
- [8] Grasys membrane module Retrieved from <https://www.grasys.ru/>
- [9] Mkrtychan Y S and Ruban G N 2013 *The method of pipeline transportation of helium-containing natural gas to remote consumers* Patent of the Russian Federation 2502913 (Moscow: Rospatent)
- [10] Mkrtychan Y S, Kozlov S I, Fateyev V N and Mamayev A V 2011 *Method of pipeline transportation of helium and hydrocarbon products from deposits to consumers* Patent of the Russian Federation 2415334 (Moscow: Rospatent)
- [11] Mkrtychan Y S, Lyugay D V, Ruban G N and Kozlov S I, 2012 Patent of the Russian Federation № 2454599 *Method of pipeline transportation of helium from deposits to consumers* (Moscow: Rospatent)
- [12] Levin Y V, Okunev A Y and Borisyuk V P 2013 Patent of the Russian Federation 2489637 *The*

- method of transportation and distribution between consumers of helium-containing natural gas* (Moscow: Rospatent)
- [13] Afanas'yev I P, Vazhenin Y I and Minlikayev V Z 2012 *Purification unit for natural gas of high pressure from helium* Patent of the Russian Federation 145348 (Moscow: Rospatent)
- [14] Solomakhin V I 2014 *Membrane separation unit of a high-pressure gas mixture* Patent of the Russian Federation 145348 (Moscow: Rospatent)
- [15] Solomakhin V I, Laguntsov N I, Kurchatov I M and Davydov Y S 2015 *Device for extraction of helium from natural gas of increased pressure options* Patent of the Russian Federation 150520 (Moscow: Rospatent)
- [16] Udut V N 2012 *Technological breakthrough in the creation of a large-capacity container tank for multimodal transportation of liquid helium Geliymash technological breakthrough Industrial Gases* p 2