TOPIC OF THE ISSUE

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NATURAL HYDROGEN. PRELIMINARY SEARCH GUIDE.

The article, for the first time in Russian practice, examines the most promising geological environments where deposits are most likely to be found. natural hydrogen include igneous mafic and ultramafic rocks that provide a wide range of environments with hydrogen-rich gas as free gas, dissolved gas, and trapped fluid inclusions in ophiolites, rift zones, faults, and atmospheric degassing in volcanic gases, geysers, hot springs, and surface gas seeps. Coal beds (absorbed) and/ or carbonates (absorbed) have a high potential for

hydrogen accumulations, deep faults in the basement, which can provide migration and, in favorable places, concentration of diffuse sources of H2.

Fields of development of fairy circles (circuments), which in themselves cannot be concentrators of natural hydrogen deposits, but indicate that in this In the area, degassing of natural hydrogen occurs and the task of exploration work is to find potential traps for the formation of deposits on the flanks of hydrogen circumferential fields.

Taking into account the logistical features of promising territories in Russia, it is necessary to concentrate on the flanks of the hydrogen fields of the Voronezh and Lipetsk regions, clearly realizing that the hydrogen circles themselves are unpromising for the search for deposits.

Key words: hydrogen, innovative energy, energy, circulation, hydrogen degassing, geological exploration, fluids, global energy, green technologies.

April 4, 2022

The most promising geological signs of possible discovery of natural hydrogen deposits

Surface H_2 leakage, observed directly (measured) or indirectly (hydrogen rings, fairy circles, circumments) is an expression of either the absence of an effective seal or a leaky seal.

and, therefore, are not promising for finding deposits of natural hydrogen.

However, the most important parameter that can be obtained from H_2 percolation circuments is its value, which is a good guide to the size of the underlying H_2 resource and its sustainability. However, point sampling from the surface is not recommended. Instead, a continuous monitoring program for at least 24 hours at several closely spaced locations is strongly recommended.

located at monitoring points.

Taking into account a comprehensive review of all the data accumulated in the world, it is possible to outline the most promising geological settings where natural hydrogen deposits are most likely to be found.

These areas include:

1. Igneous rocks produce a wide range of hydrogen-rich gas environments in the form of free gas, dissolved gas, and trapped fluid inclusions in ophiolites, rift zones, faults, and atmospheric degassing in volcanic gases, geysers, hot springs, and surface gas vents.

2. Kimberlite pipes are rarely associated with hydrogen-rich gas, but it is in them that record-breaking natural hydrogen flows have been discovered to date – the Udachnaya pipe in Yakutia, where the flow rate was 100,000 m3 per day.

3. Ore bodies are often the site of accumulation of both igneous and sedimentary rocks.

4. Coal seams (absorbed) and/or carbonates (absorbed) have a high potential for hydrogen storage.

5. Inside gas-fluid inclusions, the older the rock, the higher the H_2 content, because time is the main factor controlling the degree of radiation.

lysis of water involving radioactive decay of 235, 238U, 232Th and 40K.

6. Evaporite sulfates can store large amounts of H_2 (up to 20-30% by volume), and high-potassium halite (e.g., K-potassium deposits) also provides a radiogenic-hydrolytic source of H_2 via an intermediate calcium metal (Ca) compound, which together with salt is a good screen for hydrogen accumulation.

7. Oil and gas fields do not typically contain large amounts of H_2, however, for fields with elevated H_2 content, H_2 production can be cost-effective, especially when produced

liquefied gas.

High reactivity of H_2 affects the structure and chemical composition of the rock, which

which it crosses, for example, the mechanical strength of carbonates decreases (Levshunova, 1991), potentially accelerates the development of faults, under stress conditions with the creation of additional migration paths. The H_2 content in wells usually increases with depth. However, a number of potential targets can already be identified, each with its own specific characteristics for the generation, migration and retention of H_2 ***(Fig. 1).***

It follows from the figure that only three types of screens for the concentration of natural hydrogen are currently possible: sills of basic rocks (already established in Mali, where the only natural hydrogen deposit to date was found under a screen of dolerites), salt stocks, and shales. To search for natural hydrogen deposits,

The following factors are most important before delivery:

I. the presence of iron-rich ultramafic and mafic rocks, especially the Archean basement, the rocks of which can be

potential sources of both radiolytic and hydrolytic H_2.

II. deep faults in the basement, which can provide migration and, in favorable places, concentration of diffuse sources of H_2.

III. There is reservoir potential at depth at the basement-sedimentary interface ***(Fig.*** 1). For example, natural gas from the Mt Kitty 1 well (Amadeus Basin) contains 11 mol% H_2 in a fractured igneous basement immediately overlain by sedimentary rocks.

IV. Fields of development of fairy circles (circumferences), which in themselves cannot be concentrators of natural hydrogen deposits, but indicate that degassing of natural hydrogen is occurring in this area and the task of exploration work is to find potential traps for the formation of deposits on the flanks of hydrogen circumference fields

Australia's 'hydrogen search fever'.

Currently, the "Hydrogen Rush" of searching for natural hydrogen has engulfed all of Australia. Each state has developed and adopted a program for searching for natural hydrogen. The state of South Australia is leading the way. According to data

Fig. 1

Source-migration-accumulation systematization for H2 exploration in conventional and unconventional settings. H2 content in oil fields (1 and 2) is likely supplemented by H2 from abiogenic sources (3).

H2a = advective migration and H2d = diffusive migration of H2.

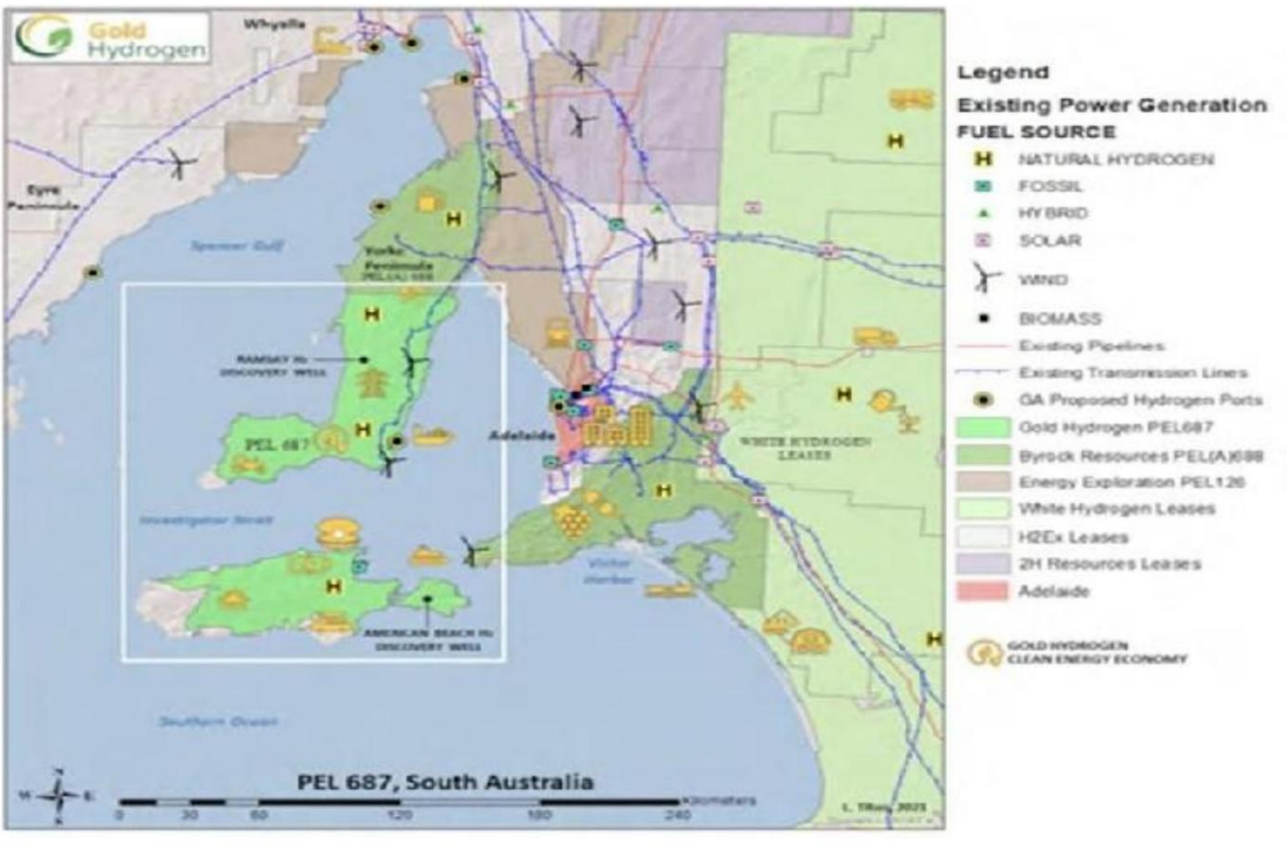

Fig. 2. *Gold Hydrogen exploration license with an area of 9,500 sq. km.* April 6, 2022

According to Australian energy consultancy EnergyQuest, over the past 12 months, six different companies have either been awarded or applied for 18 oil exploration licences in South Australia. Together, the permits cover about **570,000 square kilometres (km2), or 32 per cent of the total**

state, the consulting firm found, calling the sudden influx a "boom."

The boom began after the Ministry of Energy and Mines published an explanatory document on

licensing of hydrogen activities. *The Petroleum and Geothermal Energy (Energy Resources)* Bill 2021 proposes to extend the current scope of the provisions *of the Petroleum and Geothermal Energy Act 2000* (the Act) to include the production of hydrogen from means not already permitted under the current Act, such as water electrolysis. The proposed amendments are intended to provide all hydrogen production sectors with the same good regulatory practice and single-window government treatment that is currently afforded to the oil and gas industry under the current Act. It is proposed that this will be achieved by introducing specific hydrogen energy licences into the Act. As a result, it is proposed that existing provisions of the Act, such as those on environmental approval (through environmental objective statements), consultation, approval of activities, compliance and reporting, should apply

were applied to hydrogen projects licensed in accordance with the Law.1

On 1 February 2021, *the Petroleum and Geothermal Energy Regulations 2013* were amended to declare hydrogen, hydrogen compounds and hydrogen by-products as regulated substances under the *Petroleum and Geothermal Energy Act 2000.* Companies can now apply for natural hydrogen exploration through the PEL and the transfer of hydrogen or hydrogen compounds is now

permitted under the trunk pipeline licensing provisions of the PGE Act. The current review of the *Petroleum and Geothermal Energy Act of 2000* suggests

make it a "one-stop shop" for hydrogen under a new name - the Law on

energy resources.

1. *https:// www.petroleum.sa.gov.au/ geology-and-prospectivity/ hydrogen*

Information on current hydrogen exploration projects can be found in the Statewide Petroleum Exploration Licenses section of the Projects of Public Interest web page.

Fig . ***2*** shows the diagram of the obtained lines.
license to search for natural hydrogen.

It is particularly interesting that one of the companies that received what I consider to be the best natural hydrogen exploration area is called Gold Hydrogen Pty Ltd. Professor John Gluyas

was the first to use the term "golden water" "genus" to describe this type of natural hydrogen, to distinguish it from "grey hydrogen" which produced from fossil fuels, "blue hydrogen" which captures or buries waste CO2, or "green hydrogen" hydrogen,

obtained by electrolysis of water. The company that first uses this apt term gains a competitive advantage.

Gold Hydrogen Pty Ltd was granted exploration licence 687 (memorandum in appendix 3) for a term of 5 years to 2026 inclusive and was obliged to spend $20 million in the first 4 years to carry out geophysical work and to carry out exploration drilling worth $10 million in the last year 2026. The company was granted the right to explore approximately 9,500 km2 near Adelaide, in particular in the southern part of Yorke Peninsula and Kangaroo Island (a diagram of the licence area is shown below in ***Fig. 2).***

Gold Hydrogen's goal is to become the first company in Australia to produce, use and sell natural hydrogen, which the company describes as an "inexhaustible source of green energy".

Russian promising areas for searching for natural hydrogen deposits.

Taking into account the logistical features of promising territories, it is necessary to concentrate on the flanks of the hydrogen fields of the Voronezh and Lipetsk regions, clearly realizing that the hydrogen circles themselves are unpromising for searching for deposits. It can be stated with a high degree of certainty that the hydrogen fields themselves, developed on all continents, are the second most important (after the mid-ocean ridges) places of hydrogen degassing on the Earth.

Further on in ***figures 5, 6 and 7*** are Google maps of all areas on a larger scale. Considering the large areas to be searched, it is necessary to start the search with aerogeophysical work.

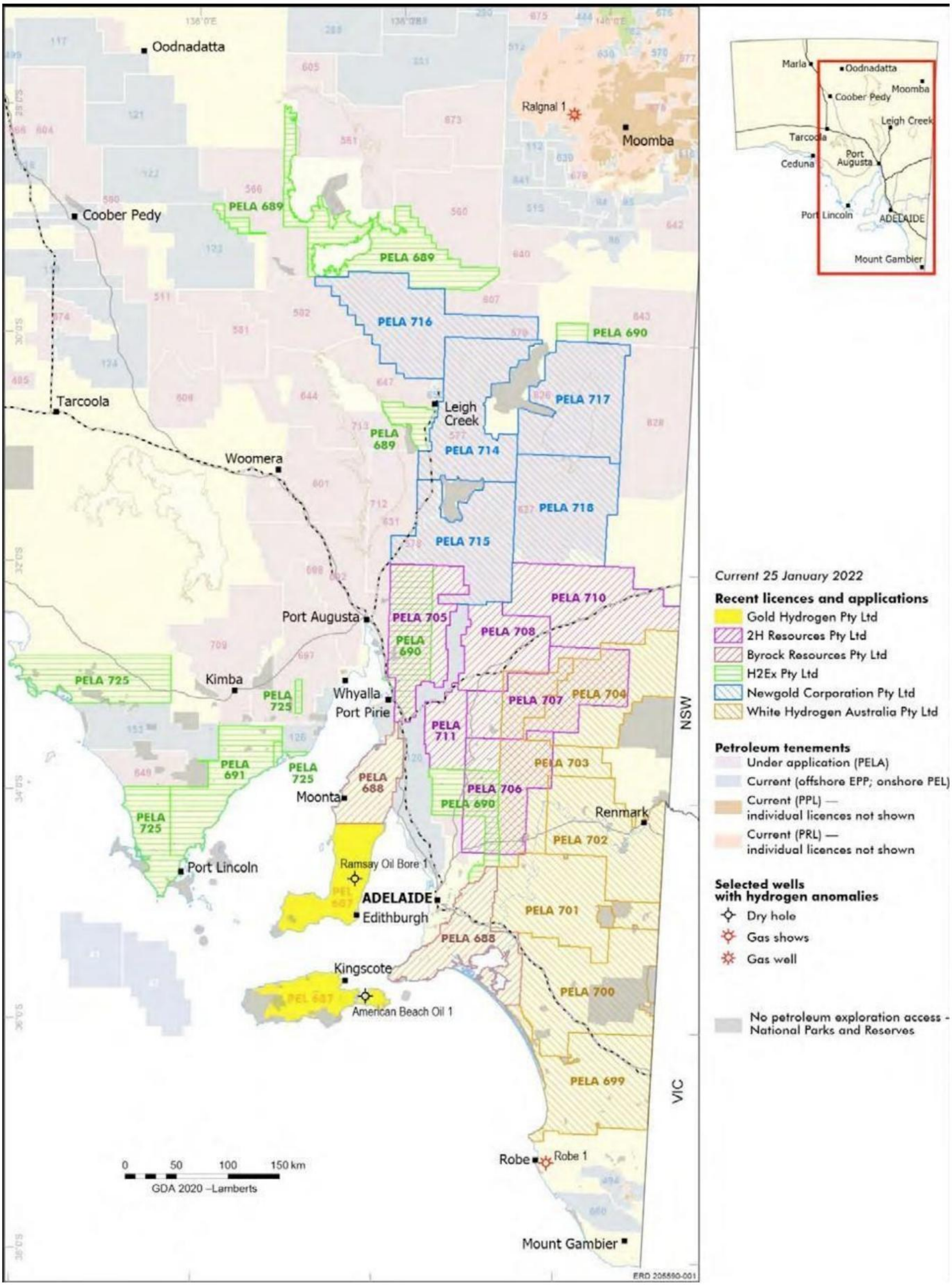

Fig. 3.

18 licences in South Australia to search for natural hydrogen

Fig. 4.

Three priority areas for searching for natural hydrogen deposits: Oktyabrskoye and Dobrinka in the Lipetsk region and Oktyabrskoye in the Voronezh region.

Fig. 5.

Oktyabrskoye hydrogen field in Lipetsk region.

Aerogeophysical methods search for hydrogen exploration.

1 Aeromagnetic methods

Main tasks to be solved:

• structural-tectonic mapping with defining hierarchy, relationships and kinematics of the main faults;

• identification of mineralized zones, skarn zones;

• mapping of intrusive bodies of various composition, both coming to the surface and buried;

• identification and mapping of metasomatism zones.

Here and below, the tasks that best correspond to the search for possible locations of natural hydrogen deposits are highlighted in italics with underlining.

2 Aerogamma spectrometry

Main tasks to be solved:

• definition of geological elements structures of the studied territory;

• search for deposits of radioactive raw materials;

• study of the nature and intensity of manifestation of superimposed processes (metasomatosis) and search for hydrothermal deposits;

• remote environmental monitoring ring, including an assessment of radiation contamination territories (Cesium-137);

• study of oil and gas prospects territories.

3 Aerogravimetry

Main tasks to be solved:

• structural-tectonic mapping buried foundation;

• identification of structures that are promising for hydrocarbon localization;

• mapping of the most contrasting formations of the sedimentary cover, primarily salt-bearing strata, as well as intrusive formations;

• mapping of faults, in including possible thrust dislocations and zones cracks;

4 Pulse electrical exploration

Main tasks to be solved:

• detailed searches for sulphide copper-nickel deposits and polymetallic lead-zinc ores;

• study of the internal structure of ore-controlling tectonic zones and tracing of ore-localizing faults laterally and in depth;

• identification of details of zones of superimposed changes;

Fig. 6.

Hydrogen field Dobrinka in Lipetsk region

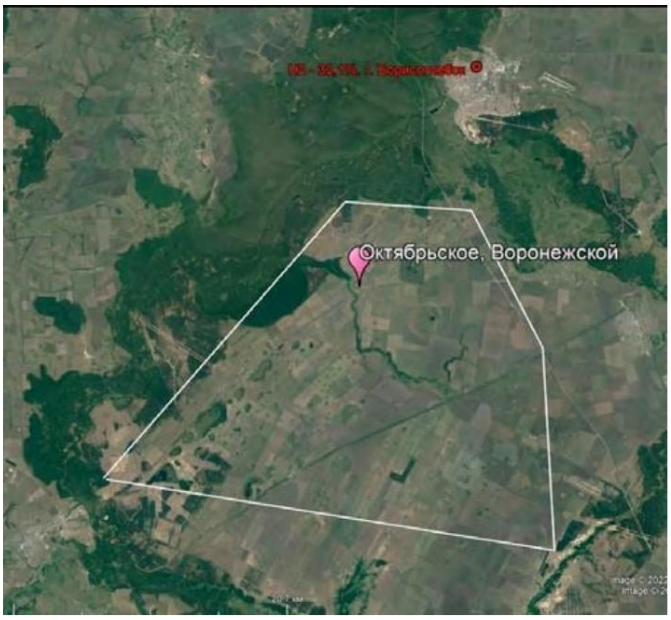

Fig. 7.

The Oktyabrskoye hydrogen field in the Voronezh region with an indication of the well in Borisoglebsk, where H2 degassing of 32.1% was discovered on the northern flank of the hydrogen field.

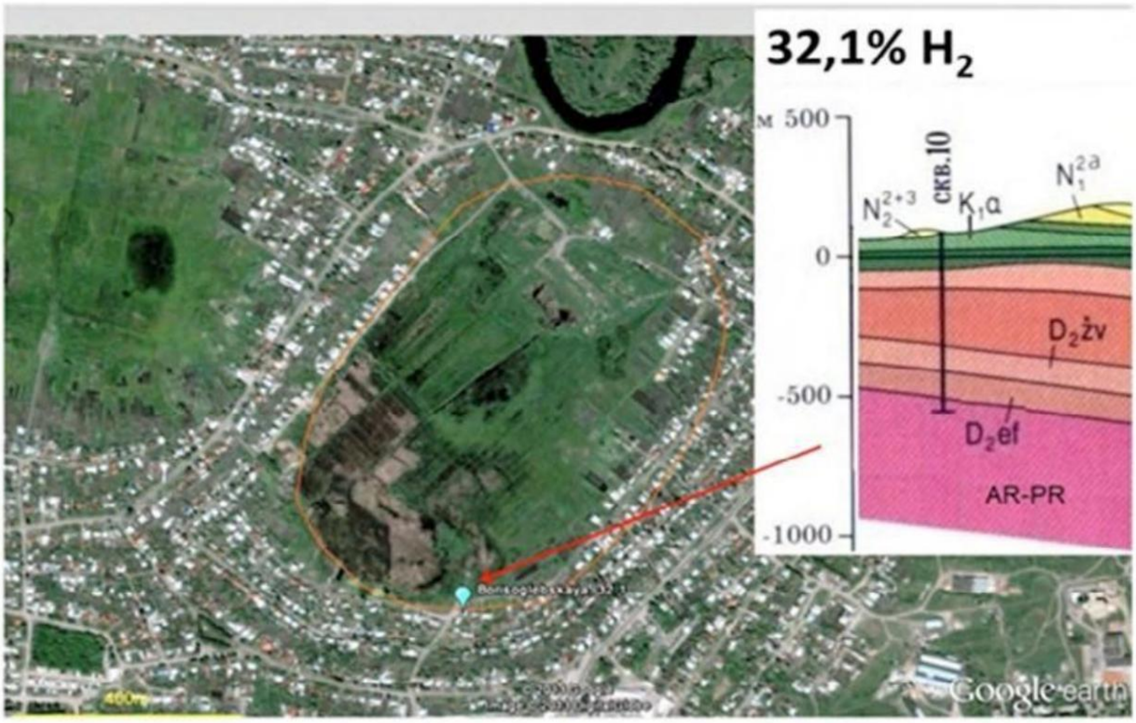

Fig. 8.

An anomalous well in Borisoglebsk on the northern flank of the Oktyabrskoye hydrogen field, where an H2 influx of 32.1% was obtained

• study of the geological structure of the upper part of the section by means of detailed probing;

• mapping of paleovalleys and karsts;

• assessment of spatial boundaries of distribution underground water drainage;

• analysis of the cryogenic state of soils, mapping of permafrost zones;

• creation of physical maps with geoelectrical with Russian incisions.

Taking into account the above, the primary aerogeophysical works for localizing the areas most promising for natural hydrogen deposits are **Aerogravimetry** and **Aero-magnetic methods.**

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Abstract: In the article, for the first time in Russian practice, the most promising geological settings are considered, where natural hydrogen deposits are most likely to be found, including igneous basic and ultrabasic rocks, which create a wide range of environments with hydrogen -rich gas in the form of free gas, dissolved gas and captured by fluid inclusions in ophiolites, rift zones, faults and atmospheric degassing in volcanic gases, geysers, hot springs and surface gas outlets. Coal seams (absorbed) and/or carbonates (absorbed) have a high potential for hydrogen storage, deep basement faults that can provide migration and, at favorable locations, concentrations of diffuse H2 sources.

The fields of development of fairy circles (circumferences), which in themselves cannot be concentrators of natural hydrogen deposits, but indicate that degassing of natural hydrogen occurs in this area and the task of prospecting is to find places of potential traps for the formation of deposits on the flanks of hydrogen circumferential fields.

Taking into account the logistical features of promising territories in Russia, it is necessary to concentrate on the flanks of the hydrogen fields of the Voronezh and Lipetsk regions, clearly realizing that the hydrogen circles themselves have no prospects for finding deposits.

Keywords: hydrogen, innovative energy, power engineering, circulations, hydrogen degassing, geological exploration, fluids, world energy, green technologies

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