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(54) Title: METHOD OF CARBON DIOXIDE DISPOSAL IN WATER-BEARING STRATA

(57) Abstract: The present invention relates to protection of the environment from man-made emissions of greenhouse gases polluting the atmosphere, specifically - to methods for the underground disposal of carbon dioxide (C02) by injecting it into water-bearing strata. In addition, the invention makes it possible to synthesize hydrocarbons using carbon dioxide. The carbon dioxide disposal method includes: selecting at least one underground water¬ bearing stratum with an outlet, a catchment area in the form of a river, a sea or a lake, and a general active filtration regime; identifying at least one local lithological trap in the selected stratum; preparing the water-bearing stratum and the local trap for industrial utilization; determining the chemical composition of the stratal water and rock (core) samples; pumping carbon dioxide into the water-bearing stratum through at least one injection well located on the stratum's catchment area side that allows a downward flow of the injected carbon dioxide in the stratum; initiating or forming the hydrocarbon synthesis process and generation of hydrogen and oxygen from carbon dioxide and water in the stratum, adjusting the intensity of this process by varying the carbon dioxide injection into the stratum, and monitoring the process by analysing the fluid composition in the local trap. The technical result of the invention is an increase in the efficiency of the carbon dioxide disposal process in underground water-bearing strata through using this gas to form man-made hydrocarbon, hydrogen and oxygen deposits, which more effectively prevents back leakage of carbon dioxide from the stratum into the atmosphere.

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Method of Carbon Dioxide Disposal in Water-Bearing Strata

TECHNICAL FIELD

The present invention relates to protection of the environment from man-made emissions of greenhouse gases polluting the atmosphere, specifically – to the methods of underground disposal of carbon dioxide (CO_2) by injecting it into water-bearing strata. In addition, the invention makes it possible to synthesize hydrocarbons using carbon dioxide.

BRIEF SUMMARY AND PRIOR ART

Currently the world faces the challenge of disposing of carbon dioxide released into the atmosphere in large quantities by industrial plants, leading to warming of the planet's climate. Therefore, extensive research of carbon dioxide disposal and dumping on an industrial scale is being carried out in the Western Europe, USA, China, India, and other countries.

A method of carbon dioxide disposal by injection into underground oil-bearing strata in the form of carbonized water (carbon dioxide dissolved in water) during oil field development is known [Zheltov Yu. P. Oil Field Development. Moscow: Nedra, 1999. p. 249-253.]. This method has become most widespread at oil fields in the USA because of the presence of carbon dioxide deposits in the country as well as the close proximity of significant number of refineries to the producing oil fields.

According to this method, a system of production and injection wells is drilled at the oil field. Carbonized water is pumped into the injection wells. This is done by adding carbon dioxide (which is highly soluble in water) to the water being pumped into the stratum on site. This carbonized water performs the following functions:

- Maintains formation pressure at the oil field during its development for the purpose of oil recovery; the water forces oil towards production well bottoms;

- Water-dissolved carbon dioxide dissolves well in the oil and in the residual water present in the stratum before the beginning of oil field development. This decreases oil viscosity and density and increases oil volume and gas content. The volume of residual water also increases as well as its gas content, while its viscosity decreases. These factors lead to the aqueous phase forcing oil from pore space more efficiently. In addition, a decrease of interfacial tension at the oil-water surface is achieved.

As a result, the current and final oil recovery factor increases by 10% and more [Zheltov Yu.P. Oil Field Development. Moscow: Nedra, 1999. p. 249-253; Cinar Y., Riaz A., Tchelepi H.A. Experimental study of CO2 injection into saline formations // SPE Journal. 2009. Vol. 14, № 4, p. 588-594.]

This method has the following drawbacks:

- The majority of oil fields are developed by flooding, i.e. by pumping water from available sources (river, sea, infrabed water, water from a water-bearing horizon) into the stratum. This is largely done to minimize costs in the initial years of development. Therefore, the fact that carbon dioxide injection has not yet become common practice is explained by increased costs of such production technology.

- The method-analogue considered requires the carbon dioxide source to be located close to the producing oil field. Otherwise the additional oil recovery achieved by carbonized water injection does not warrant the associated costs.

- As shown below, this carbon dioxide disposal method does not take the findings of the latest research in hydrocarbon genesis into account.

The methods of carbon dioxide disposal by injection into depleted gas deposits or underground sub-salt water-bearing strata are known [Galis H., Cawley S., Bishop S., Todman S., Gas F. CO2 injection into depleted gas reservoirs // J. Petrol. Techn. 2010. № 7, p.76-79; Cinar Y., Riaz A., Tchelepi H.A. Experimental study of CO2 injection into saline formations // SPE Journal. 2009. Vol. 14, № 4, p. 588-594].

These methods of carbon dioxide underground disposal are quite realistic.

- They are all based on well-known methods of geology and geophysics for the study and research of the target objects of carbon dioxide injection. These are the methods used to identify the most suitable objects.

- The existing methods are based on equipment and technology used in the oil and gas industry. This includes injection well drilling techniques and technologies, pumps and compressors, and field equipment (separators, heat exchangers etc.) that make it possible to prepare depleted gas deposits or water-bearing strata for injection and pumping carbon dioxide into them.

- Substantiation of the appropriate design documents involves the use of state-of-the-art 3D computer modelling methods as well as laboratory experiments and research aimed to improve the calculation algorithms.

- There are examples of the practical implementation of carbon dioxide injection into depleted gas deposits [Galis H., Cawley S., Bishop S., Todman S., Gas F. CO2 injection into depleted gas reservoirs // J. Petrol. Techn. 2010. № 7, p.76-79]. But most importantly, traditional underground gas storage created in depleted gas deposits and water-bearing strata show the feasibility of carbon dioxide disposal in such natural objects.

- Methods for monitoring the carbon dioxide injection process as well as its storage in the stratum have been and are being developed.

At the same time, these methods-analogues are not universal and have the following drawbacks:

- Depleted gas deposits are usually located far away from industrial sources of carbon dioxide emissions into the atmosphere.

- Implementation of the carbon dioxide underground disposal methods in question does not provide for recovery of the capital and operating costs. Since it is difficult to assess the benefits for the planet's climate and take them into account, these methods do not appear attractive for investors. Therefore, unnatural as they may be, penalties for carbon dioxide emissions into the atmosphere remain the only incentive for implementation of such methods.

The closest equivalent to the proposed invention is the method of carbon dioxide disposal in water-bearing strata. However, the following should be noted.

- In general, water-bearing strata (as compared to depleted gas deposits) are more readily available to be used for carbon dioxide disposal. However, there are currently no strict criteria governing the selection of strata for disposal purposes. For example, storage of large volumes of carbon dioxide in stagnant water-bearing strata is difficult, since its dissolution is mostly determined by slow diffusion processes. At the same time, carbon dioxide injection into underground water-bearing strata with active but uncontrolled filtration without taking the structural features of the stratum position into account may lead to quick release of carbon dioxide back into the atmosphere. Carbon dioxide disposal in water bearing strata is even more costly than use of depleted gas deposits, since it requires drilling new wells and creating a field infrastructure.

DESCRIPTION OF DRAWINGS

Fig. 1 – Experimental plant diagram.

Legend: 1 – reaction column with a heating element, 2 – mixer, 3 – accumulating separator, 4 – gas chromatograph, 5 – carbon dioxide cylinder, 6 – pressure reducer, 7 – adjustable valve, 8 – pressure gauge, 9 – recirculating pump, 10 – flow meter, 11 – pH meter.

Fig. 2 – Chromatograms of gases synthesized by the reaction at low (a) and high (b) hydrogen output level.

Legend: a – hydrogen; b – methane; c – isopentane. At high output, the hydrogen peak surpasses the methane peak.

Fig. 3 – Carbon dioxide disposal diagram.

Legend: 12 – day surface, 13 – sandstone, 14 – water body, 15 – direction of natural filtration water flow, 16 – stratum roof, 17 – stratum floor, 18 – synthetic hydrocarbon deposit, 19 – producing hydrocarbon deposit, 20 – hydrocarbon inflow, 21 – injection well, 22 – production well.

Fig. 4 – Arrangement of injection wells near the producing field outline.

Legend: 23 – producing oil field, 24 – outer oil-water outline.

DETAILED DESCRIPTION

Experimental Evidence

The invention is based on the results of laboratory experiments simulating the process of carbon dioxide reduction to petroleum series hydrocarbons under pressure and temperature conditions existing in the upper layers of the Earth crust. A simplified diagram of the laboratory unit used for the experiments is shown in Fig. 1. The unit consisted of a reaction column (1) filled with an iron-bearing material. Water with the specified dissolved carbon dioxide concentration was supplied to the reaction column inlet from a mixer (2). Upon exiting the reactor the water was delivered to an accumulating separator (3) where gaseous reaction products were separated from it for subsequent analysis by a gas analyser (4). A 20 litre tank capable of withstanding pressure up to 15 atmospheres served as the mixer. A carbon dioxide cylinder (5) was used to prepare the solution. Carbon dioxide concentration in the water was adjusted by the water pressure and the time for the water in the mixer to saturate with carbon dioxide. Artesian well water was used. The carbon dioxide pressure supplied to the mixer varied from 0.5 to 15 atmospheres. This made it possible to control the velocity of the solution flowing through the reactor. The reactor was made of a plastic pipe section 1 m long with an inner diameter of 19 mm filled with an iron-bearing material (iron turnings, powdered iron oxide and dioxide etc.). An electric spiral was placed outside the pipe for heating purposes during some of the experiments. Chromoplast-001 gas chromatograph designed for measuring hydrogen, methane, ethane, isobutene, isopentane and pentane content in the air was used as the gas analyser. The analyser had two chromatographic columns of different length, which allowed measuring the concentration of hydrogen and above-mentioned gases with the accuracy of ~0.001%.

During laboratory trials of the device, it was discovered that dissolution of carbon dioxide in water (both common well water and distilled water) resulted in generation of hydrogen and hydrocarbon gases even in the iron-cased mixing chamber itself.

Fig. 2a shows the spectrum of gases generated in the mixer filled with distilled water under an excess pressure of 1 atmosphere in the chamber. The chromatograph readings in conventional units are shown on the Y axis, the time of analysis in the chromatograph – on the X axis. Hydrogen and methane peaks are clearly visible in the spectrum. Hydrogen content amounted to 0.016%, which exceeds the chromatograph's detection limit.

High-molecular methane homologs were detected in gases obtained by passing an aqueous solution of carbon dioxide through the reactor filled with sandstone or crushed marble with an admixture of iron acting as a catalyst. In this case ethane, isobutene and pentane were also observed. Methane measurement became difficult when hydrogen output exceeded 10% (Fig. 2b).

The experiments proved the fundamental possibility of hydrogen and oxygen generation as well as synthesis of hydrocarbons (primarily methane and its high-molecular homologs) in the natural conditions of the sedimentary cover of the Earth's crust. These experiments have expanded the area of the practical application of poly-condensation synthesis reactions which are currently widely used to obtain synthetic hydrocarbons [Storch G., Golambik N., Anderson R. Hydrocarbon synthesis from carbon dioxide and hydrogen. Moscow: Foreign Literature 1954. 516 p.] and hydrogen [Ione K.G. On the role of hydrogen in the man-made evolution of the earth (Is the earth a catalytic reactor?). Novosibirsk: CEOSIT Scientific and Engineering Centre Publishing House. 2003. 68 p.] on an industrial scale.

Phenomena that can only be explained by inflow of abyssal hydrocarbons into the deposits have been observed during development of the Romashkinskoye oil field [Muslimov R.Kh., Glumov N.F., Plotnikova I.N. et. al. Oil and gas fields – self-developing and continuously renewing objects // Oil and Gas Geology. Special edition. 2004. p.43-49.] and the Shebelinskoye gas condensate field [Zakirov S.N., Indrupskiy I.M., Zakirov E.S. et. al. New principles and technologies of oil and gas field development. Part 2. Moscow-Izhevsk, Institute of Computer Technologies. 2009. p.319-329.]. The source of such abyssal hydrocarbons remains an open question. The results of the experiments have provided a rationale for such source by proving the possibility of generation of a continuous abyssal hydrocarbon inflow through the reaction described herein.

Therefore, the results of the experiments also corroborate the alternative oil and gas formation model described in [Barenbaum A.A. Oil and gas deposit formation mechanism // Reports of the Academy of Sciences. 2004. Volume 399. No. 6. p. 802-805]. According to the findings of this work, oil and gas are by-products of a global geochemical carbon cycle on the planet.

This invention allows solving two urgent global problems. The first one is reliable underground disposal of excessive man-made carbon dioxide. The second one is the artificial generation of hydrocarbons as well as hydrogen and oxygen to replenish the depleting hydrocarbon reserves at oil and gas fields and create new fields.

The technical result of the invention is an increase in the efficiency of the carbon dioxide disposal process in underground water-bearing strata through creation of man-made hydrocarbon, hydrogen and oxygen deposits from this gas, which more effectively prevents back leakage of carbon dioxide from the stratum into the atmosphere.

These problems are solved and the technical result is achieved by performing the following actions as a part of the proposed carbon dioxide disposal method: selecting at least one underground water-bearing stratum with an outlet, a catchment area in the form of a river, a sea or a lake, and a general active filtration regime; identifying at least one local lithological trap in the selected stratum; preparing the water-bearing stratum and the local trap for industrial utilization; determining the chemical composition of the stratal water and rock (core) samples; pumping carbon dioxide into the water-bearing stratum through at least one injection well located on the stratum's catchment area side that allows a downward flow of the injected carbon dioxide in the stratum; initiating or forming the hydrocarbon synthesis process and generation of hydrogen and oxygen from carbon dioxide and water in the stratum, adjusting the intensity of this process by varying the carbon dioxide injection into the stratum, and monitoring the process by analysing the fluid composition in the local trap.

It is preferable that: the carbon dioxide is injected in the form of a gas plug and/or gas dissolved in water; the underground water stratum is selected in a natural hydrocarbon deposit area, and injection wells are located in the front part (on the natural filtration water flow side) of the deposit at the distance of 1-2 km from the outer water-oil or gas-oil contact (Fig. 3); the selected water-bearing stratum consists of highly porous sedimentary rocks containing iron group metals (Fe, Ni, Co, Mo), SiO_2 and Al_2O_3 oxides, and clays and zeolites with high catalytic reactivity in poly-condensation synthesis of hydrocarbons from carbon oxides and hydrogen [Barenbaum A.A. Oil and gas deposit formation mechanism // Reports of the Academy of Sciences. 2004. Volume 399. No. 6. p. 802-805]; hydrocarbon synthesis and hydrogen and oxygen generation in the stratum is controlled by adjusting the carbon dioxide injection pressure, flow rate and temperature; carbon dioxide is pumped into the water-bearing stratum through at least one injection well in a manner which ensures its uniform distribution throughout the stratum thickness; a natural filtration water flow is activated and a local artificial hydrocarbon deposit is created in the local stagnant filtration area of the water-bearing stratum by injecting carbon dioxide through at least one injection well and extracting water from at least one production well; extraction of oil from the producing deposit serves this purpose (Fig. 3, 4); previously drilled exploratory and pressure observation wells are used as injection and production wells; the hydrocarbon synthesis process and hydrogen and oxygen generation in the water-bearing stratum is monitored through at least one observation well hydraulically connected with the local trap as well as through at least one production well located within the local trap and/or the producing hydrocarbon deposit; the hydrocarbon synthesis process is monitored from the moment of carbon dioxide injection into the water-bearing stratum, including analysis for ^{14}C isotope content; the synthesized hydrocarbons consist primarily of methane and its high-molecular homologs.

The method is implemented as follows (see Fig. 3).

At least one regionally consistent underground water-bearing stratum (13) – a water-bearing basin with an outlet and a known catchment basin (14) in the form of a river, a sea or a lake, i.e. with a determined direction of the natural filtration water flow (15), is selected close to a natural hydrocarbon deposit with a day surface (12) or regardless of the presence of a deposit, but near a source of man-made carbon dioxide to be disposed. For example, all necessary preliminary seismic, geophysical and hydrogeological surveys are carried out for this purpose. The above water-bearing stratum or section thereof is selected or formed in such a way as to obtain a structural dip (plunge) and a general active filtration regime. At least one local stagnant filtration area characterized by structural features such as a dome structure serving as a barrier for hydrocarbon migration in the form of a geological trap (18) is selected in the water-bearing stratum in question (13) with a roof (16) and a floor (17).

The selected water-bearing stratum and the local trap are prepared for industrial utilization. This stage may include, in particular: collection of the necessary information on the state of the exploration targets, creation of 3D geological and hydrodynamic models, adaptation of the 3D hydrodynamic model to the actual data, performance of optimizing prediction calculations (taking into account the chemical reactions occurring in the stratum), selection of the best carbon dioxide injection and intrastratal hydrogen, oxygen and methane homolog generation option, and determination of the best injection and production well operating parameters as well as their pattern. The optimum values and parameters are determined based on the process and cost optimization objective.

The full chemical composition of water in the stratum (13) as well as rock (core) samples is determined to identify the possibilities for use of the ingredients in the implementation of the proposed method. In particular, the content of iron and other chemical elements that can serve as catalysts for the hydrocarbon synthesis and hydrogen and oxygen generation reaction initiated in the stratum is determined. If necessary, additional amounts of the catalyst or an additional catalyst can be injected into the water-bearing stratum.

Carbon dioxide is pumped into the selected water-bearing stratum (13) through at least one injection well (21) located on the water-bearing stratum's catchment area side (14) that allows a downward flow (15) of the injected carbon dioxide in this stratum. Previously drilled exploratory or pressure observation wells and/or newly drilled wells are used as injection wells (at least one).

Unlike traditional gas-based formation stimulation methods, the implementation of the proposed method imposes the following constraints.

Bottom hole pressures in injection wells should be sufficient to prevent the injected carbon dioxide solution or plug from escaping to the ground surface altogether or limit the amount escaping to a minimum. The model can be determined by computer calculations aimed at preventing the injected agent from floating up to the surface. The closer the designed injection well location is to the catchment area, the more likely it is that the injected carbon dioxide will float up to the day surface. However, placing the well further away from the catchment area requires drilling a deeper well.

Wells and standard equipment utilized at oil fields to implement gas injection methods and handle carbon dioxide as a working agent can be used to organize the process of carbon dioxide injection in the form of solution or plug.

The number of injection wells and the distance between them is predetermined by the number of lithological traps and producing deposits as well as their horizontal location. Injection wells should create a filtration flow of the injected working agent of such width as to ensure the maximum coverage of traps and deposits with the hydrocarbon, hydrogen and oxygen synthesis process. The specific characteristics of the carbon dioxide disposal process are determined through 3D computer calculations based on the stratum parameters, number and location of traps, and required carbon dioxide disposal volumes. 3D modelling of the stratum and process modelling is used for this purpose.

Carbon dioxide injection into the water-bearing stratum creates the necessary conditions for hydrocarbon synthesis and hydrogen and oxygen generation. Laboratory experiments have shown that the hydrocarbon synthesis reaction accompanied by hydrogen and oxygen generation occurs under pressures of up to 15 atmospheres. It is well known that the rate of such reactions increases with pressure. Therefore, favourable conditions for hydrocarbon, hydrogen and oxygen synthesis created by filtration of the carbon dioxide solution at great depths with inherent high pressures should be expected when the proposed method is implemented in practice.

Carbon dioxide is injected in a manner ensuring its optimum distribution throughout the water-bearing stratum thickness in accordance with the most preferable 3D hydrodynamic modelling results.

At least one production well is drilled and put into service to intensify the natural filtration water flow towards the structural trap (18). Initial extraction of stratal water from this well(s) is later followed by extraction of hydrocarbons synthesized in the stratum and the generated hydrogen and oxygen.

The most suitable procedure and method for the operation of production wells is determined based on traditional well survey under steady-state filtration regimes.

Production wells and standard field equipment utilized at oil fields to implement gas injection methods can be used to organize the water and synthesized hydrocarbon, hydrogen and oxygen extraction process.

Operation of flooded production wells (22) from which stratal water and oil is extracted serves to intensify the natural filtration water flow. The water extracted at the producing field is pumped back into the stratum through at least one injection well (21). Synthesized hydrocarbons, hydrogen and oxygen induced by carbon dioxide injection accumulate in local stagnant filtration areas – geological traps (18) – due to gravity. Some oxygen is consumed by oxidation processes in the stratum.

The hydrocarbon deposit (18) which is formed can be combined, for example, with a naturally produced hydrocarbon deposit (19). The inflow of synthesized hydrocarbons into the so-called artificial and natural deposits is shown in Fig. 3, item (20).

The hydrocarbon synthesis in the stratum is controlled by adjusting the composition and properties of the injected water – the carbon dioxide content and its injection mode as well as the type and amount of catalyst added to the water. The amount of synthesized hydrocarbons, hydrogen and oxygen is determined through chromatography. Gas samples are periodically taken from the separator for this purpose. The degree of utilization of the carbon dioxide injected into the water-bearing stratum is monitored by measuring the amount of synthesized hydrocarbons, hydrogen and oxygen accumulated in the local stagnant area of the stratum (18) where the well is drilled, including analysis of hydrocarbons for ^{14}C isotope content – for example, by means of fluid scintillation spectrometry that allows identifying natural and man-made hydrocarbons. If the amount of synthesized hydrocarbons, hydrogen and oxygen extracted from the production wells drops, polymer (for example, polyacrylamide) solution plugs are pumped into injection wells. As a result, the input profile is equalized, which makes it possible to involve additional parts of the water-bearing stratum in the target product synthesis process. This approach is widely used in oil production when working with flooded strata.

DESCRIPTION OF EMBODIMENT

The implementation and validity of the proposed method is primarily defined by the results of laboratory experiments. When analysing those results, it should be kept in mind that an aqueous solution of carbon dioxide injected into the reaction column did not react completely due to relatively small length (1 meter) of the column. Because of this, the product at the unit outlet contained a large amount of gaseous carbon dioxide that did not participate in the synthesis, leading to a considerable decrease in the percentage of synthesized hydrocarbon and hydrogen according to the chromatograph readings.

Under the proposed method, carbon dioxide injected into a water-bearing stratum is filtered over several kilometres, which drastically increases the degree of its conversion to hydrocarbons, hydrogen and oxygen. This scale factor forms the basis of some well-known technologies of industrial hydrocarbon production by poly-condensation synthesis [Storch G., Golambik N., Anderson R. Hydrocarbon synthesis from carbon dioxide and hydrogen. Moscow: Foreign Literature 1954. 516 p.]. This explains the estimated distance (1-2 km) between the injection wells and the field outline in Fig. 4. However, this distance should be adjusted (increased or decreased) based on multi-variant 3D geologic-hydrodynamic modelling for each specific case of industrial underground disposal of carbon dioxide.

As an example directly related to the practical implementation of the proposed invention, we would refer to experimental field research results [Šmigaň P., Greksak M., Kozankova J. et al. Methanogenic bacteria as a key factor involved in changes of town gas stored in an underground reservoir // FEMS Microbiology Ecology. 1990. V.73. P.221-224.]. The authors of this work provided data on chemical composition of so-called town gas pumped into and extracted from the Lobodice underground gas holder created in a water-bearing stratum in the Czech Republic. The gas injected into the holder contained 20% of CH_4, 20% of CO_2+CO, and 55% of H_2. However, when the gas was extracted half a year later, its composition was different: CH_4 – 40%, CO_2+CO – 12%, and H_2 – 37%.

The methane content in the extracted gas increased twofold as compared with the injected gas over half a year, with an almost equal decrease of the total carbon dioxide and monoxide content. The hydrogen content also dropped, which is most likely an indication of leakage of this mobile and very light gas from the trap in the water-bearing stratum of the Lobodice gas holder. The authors of the cited research refer to vital activities of methane-producing bacteria as a possible reason for the changes in the injected gas composition.

However, the results of laboratory experiments carried out by them provide an alternative and more convincing explanation of the facts observed.

The hydrogen leakage noted above is quite often observed in nature as a part of the so-called Earth degassing process [Earth degassing: geotectonics, geodynamics, geofluids, oil and gas, hydrocarbons and life. Materials of the Russian national conference with international participation marking the 100th anniversary of Academician P. N. Kropotkin's birth. November 18-22, 2010, Moscow]. According to actual data, hydrogen accounts for the largest share of the degassing products. However, this does not affect the planet's ecology since hydrogen rises to the stratosphere and escapes into space as the Earth's hydrogen trail. As for hydrocarbons, they mostly remain in the natural water flow and form or replenish oil and gas deposits [Barenbaum A.A. Oil and gas deposit formation mechanism // Reports of the Academy of Sciences. 2004. Volume 399. No. 6. p. 802-805].

Therefore, it can be said that the synthesis of methane from carbon dioxide dissolved in the water occurs in the water-bearing stratum of Lobodice gas holder, although one cannot rule out the possibility that the activity of microorganisms is an additional factor contributing to a more complete utilization of carbon dioxide in the underground water-bearing strata.

The authors of this invention believe that an even greater potential to increase the efficiency of the proposed method lies in the use of catalysts – both the natural ones present in the water-bearing stratum rocks and catalysts injected into the stratum with the aqueous solution of carbon dioxide. It is known that some metals and their oxides (for example, iron group metals) as well as many minerals can serve as such catalysts, drastically enhancing hydrocarbon and hydrogen synthesis reactions.

When implementing the proposed method on a specific geological object, it is recommended to start with laboratory experiments. The cycle of laboratory experiments performed on each actual object should be followed by appropriate pilot work that will allow substantiating the engineering and technological solutions necessary to implement the concept of this method on the object being tested as a whole with the required accuracy.

Therefore, the proposed method of carbon dioxide disposal in water-bearing strata supplements the known carbon dioxide underground disposal method by making it possible to turn a clearly unprofitable process into an economically viable enterprise through the opportunity which has been identified for obtaining hydrogen, oxygen and hydrocarbons synthesized in the stratum.

CLAIMS:

1. A method of carbon dioxide disposal by injection into water-bearing strata, according to which:

- an underground water-bearing stratum is selected, preferably with an outlet, a catchment area in the form of a river, a sea or a lake, and having a general active filtration regime;

- at least one local trap is identified in the selected stratum;

- the selected water-bearing stratum and the local trap are prepared for industrial utilization, including determination of the chemical composition of water and rock (core) samples taken from the stratum;

- carbon dioxide is pumped into the selected stratum through at least one injection well located on the stratum's catchment area side that allows a downward flow of the injected carbon dioxide in the stratum.

2. The method according to claim 1, wherein conditions for hydrocarbon synthesis and hydrogen and oxygen generation are additionally created in the water-bearing stratum, the intensity of this process is controlled by adjusting the properties of the water and varying the carbon dioxide injection into the stratum, and hydrocarbon and hydrogen synthesis as well as their subsequent extraction is monitored in the local stagnant area of the stratum and in the producing field wells.

3. The method according to claim 1, wherein carbon dioxide is injected in the form of gas plugs or gas dissolved in water.

4. The method according to claim 1, wherein the underground water-bearing stratum is selected in a natural hydrocarbon deposit area and at least one injection well is located in the front part of the hydrocarbon deposit, preferably on the natural filtration water flow side, at the specified distance, preferably 1-2 km, in accordance with the results of 3D hydrodynamic modelling from the outer water-oil or gas-oil contact.

5. The method according to claim 1, wherein previously drilled exploratory and/or pressure observation wells is used as injection wells.

6. The method according to claim 1, wherein highly porous sedimentary rocks containing, in particular, iron group metals (Fe, Ni, Co, Mo), SiO_2 and Al_2O_3 oxides, and clays and zeolites with high catalytic reactivity in poly-condensation synthesis of hydrocarbons from carbon oxides are selected as the water-bearing stratum.

7. The method according to claim 2, wherein the rate of hydrocarbon synthesis and hydrogen and oxygen generation reaction in the water-bearing stratum is controlled by adjusting the carbon dioxide injection pressure, flow rate and temperature.

8. The method according to claim 1, wherein carbon dioxide is injected into the water-bearing stratum in a manner which ensures its optimum distribution throughout the stratum thickness.

9. The method according to claim 2, wherein the hydrocarbon synthesis and hydrogen and oxygen generation processes in the water-bearing stratum is monitored through at least one observation well located within the producing deposit or in its vicinity and hydraulically connected with the local trap.

10. The method according to claim 2, wherein the hydrocarbon synthesis process and hydrogen and oxygen generation in the water-bearing stratum are monitored from the moment of carbon dioxide injection, including analysis for ^{14}C isotope content in the products extracted from production wells.

11. The method according to claim 1, wherein an artificial hydrocarbon, hydrogen and oxygen deposit is created in the local stagnant filtration area of the water-bearing stratum in addition to carbon dioxide disposal.

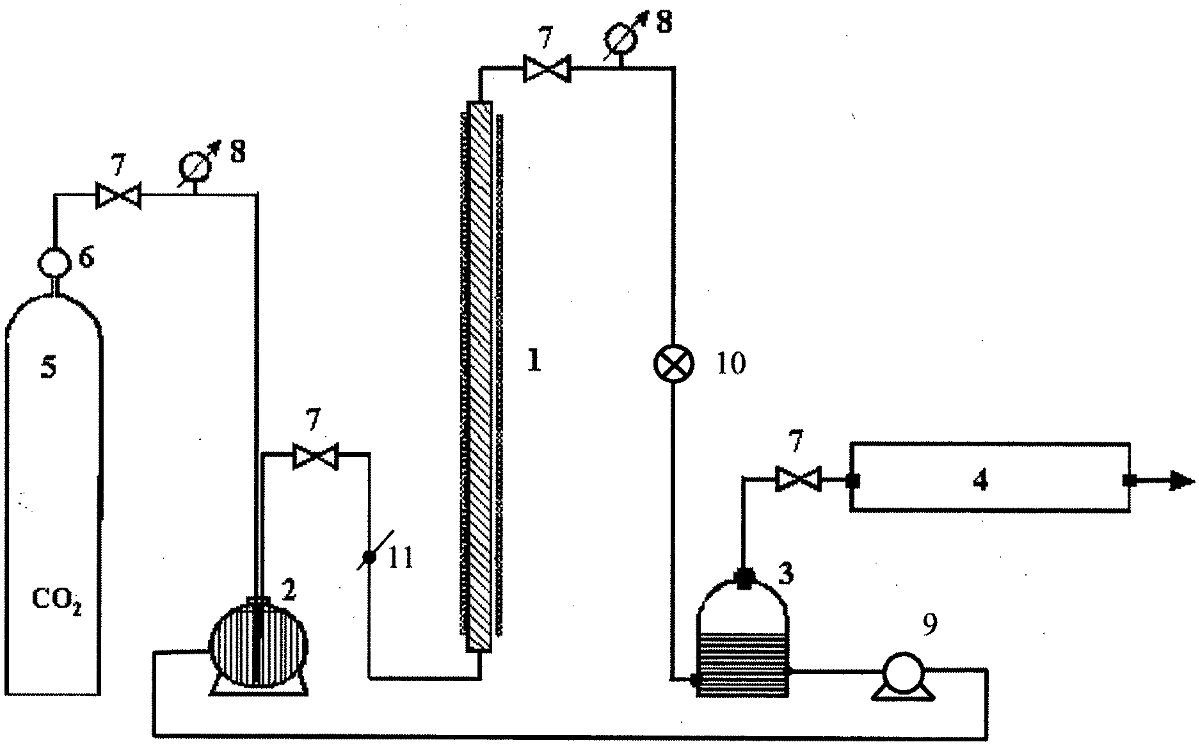

Fig. 1


Time (sec)
a
b
c
1020000
1030000
1040000
0
100
200
300
400
500
600
700
800
900
1000
Time (sec)
a
b
-1027000
-1028000
-1029000
-1030000
-1031000
100
200
300

b

a

Fig. 2

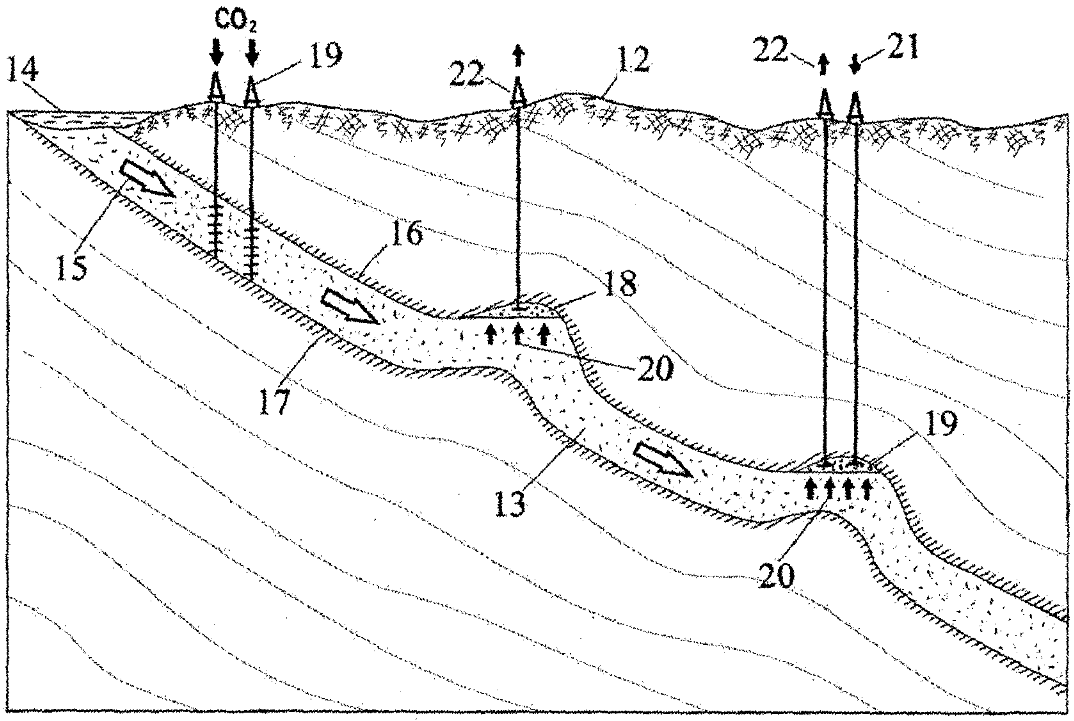

Fig. 3

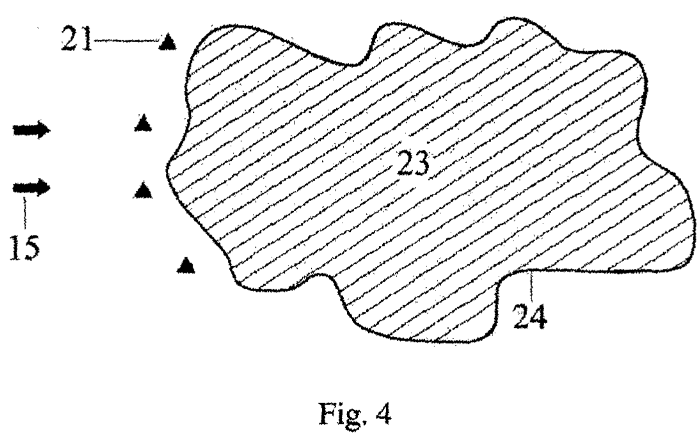

Fig. 4