EDITORIAL

Geologic Research and Assessments for Carbon Sequestration by the U.S. Geological Survey

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ABSTRACT

The US Geological Survey (USGS) was given permission by the US Energy Independence and Security Act of 2007 to conduct a national assessment of geologic storage resources for anthropogenic Carbon Dioxide (CO_2) and to assess the national technically recoverable hydrocarbon resources as a result of CO_2 injection and storage through CO_2 -Enhanced Oil Recovery (CO_2 -EOR). The USGS is also conducting research in a number of other areas related to carbon sequestration, such as the economics of CO_2 storage and CO_2 -enhanced oil recovery, as well as induced seismicity related to CO_2 geologic storage. These other areas include the study of natural CO_2 and helium reservoirs as analogues for anthropogenic CO_2 storage.

Key Words: *Energy Independence and Security Act (EISA), U.S. Geological Survey (USGS), Carbon Sequestration - Geologic Research and Evaluations (CS-GRA), CO_2 -Enhanced Oil Recovery (CO_2 -EOR).*

INTRODUCTION

The U.S. Geological Survey (USGS) has a long history of evaluating groundwater, surface water, geologically based energy, and mineral resources on a national and international scale. The USGS was given permission to perform a nationwide study of geologic storage resources for anthropogenic carbon dioxide by the U.S. Energy Independence and Security Act (EISA) in 2007. (CO_2) [1]. The USGS conducted a nationwide storage evaluation for CO_2 between 2008 and 2013 and created an assessment methodology [2,3]. According to the assessment's findings, the United States has the geological capability to store 3,000 gigatons of CO_2 [4-6]. Additionally, the USGS was tasked by the EISA to assess the national technically recoverable hydrocarbon resources as a result of CO_2 storage and injection (CO_2-EOR). The USGS was instructed to work with the Bureau of Land Management (BLM) and State geological surveys to analyse the availability of recoverable natural helium (He) and associated CO_2 found in natural gas reservoirs in the United States under the Helium Stewardship Act of 2013 (HSA) [7]. In order to create the necessary datasets for evaluating natural He and CO_2 resources, the USGS intends to collaborate with these organisations.

The USGS Carbon Sequestration - Geologic Research and Evaluations (CS-GRA) project will conduct research to develop the framework required to enhance future assessments of the Nation's geologic CO_2 storage capacity as mandated by EISA. The USGS will build on previous studies to examine natural CO_2 reservoirs in order to comprehend the effects of long-term anthropogenic CO_2 storage, study the economics of CO_2 storage, assess the storage potential of CO_2 in unconventional reservoirs (primarily coal), and assess the potential for induced seismicity related to geologic storage of CO_2. In the domain of geologic carbon sequestration, the USGS will continue its engagement with State, Federal, and international entities. The USGS study will support these organisations' continued work.

OBJECTIVES

During the next four years, the USGS will address the following six research and assessment topics. An outreach activity is also planned. The objectives of each topic are discussed below.

Methodology development and evaluation of linked CO_2 storage potential and national CO_2-enhanced oil recovery

The USGS intends to create a methodology for assessment and carry out a nationwide evaluation of recoverable hydrocarbons related to CO_2 injection. A thorough database of reservoir technical and geologic information has been created, and it may be used to screen reservoirs to determine if miscible or immiscible CO_2-EOR techniques are applicable.

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The goal of the CO_2-EOR research effort is to create a probabilistic assessment methodology based on geology and reservoir engineering that can be used to calculate the potential volumes of technically recoverable oil in the United States' onshore and state waters oil fields using CO_2-EOR and associated CO_2 sequestration.

USGS intends to use the assessment approach to carry out a nationwide assessment of recoverable oil after it has received a rigorous scientific review by specialists from industry using CO_2, academia, and government.

Geological studies of CO_2 storage capacity of selected basins' reservoirs and seals

In order to more clearly identify the distribution of the geologic storage resources for CO_2, this research project aims to reevaluate a number of national regions and storage assessment units (SAUs) that were established during the 2013 national storage assessment [4,5,6]. The distinctive geopressure and geothermal gradients in a number of sedimentary basins in the middle of the United States are being studied. In the subsurface, pressure and temperature change with depth depending on the location of the basin, the tectonic history, and the depositional history. Regional models must be developed to assist understand the geologic controls on over- and under-pressure development in basins since reservoir pressure directly affects CO_2 storage potential. To better understand the characteristics of ground water and the subsurface geochemical conditions in some SAUs, which are crucial in the evaluation of CO_2 storage project viability and probable environmental effects.

About 25% of the SAUs identified by the USGS in the 2013 storage assessment study [4,5,6] are carbonate reservoirs, which are distributed across the country in different sizes and lithologic compositions. These carbonate reservoirs are frequently regarded as excellent options for CO_2 storage because of their location, depth below the surface, high porosity and permeability, salinity, and seal integrity. However, because to variations in depositional environments, sedimentation, diagenetic processes, and subsequent rock modifications, differences in carbonate reservoirs can be large, and the characteristics of these rocks can vary greatly, even within a single formation. It is necessary to gain a deeper comprehension of these carbonate reservoirs and how they might be used to store CO_2.

Natural resources for CO_2 and Helium (He) as well as analogues for storing anthropogenic CO_2

To address the EISA and HSA legislation, the primary objectives of this activity are: to evaluate the geologic risks of long-term geologic storage of anthropogenic CO_2, and to work with BLM and State geological surveys to assess the He and CO_2 resources of the nation [1,7]. To evaluate the potential geologic risks associated with CO_2 storage, the project plans to study natural gas reservoirs that contain high amounts (greater than 10 percent) of CO_2. Samples of gas and produced water from wells producing gas from high- CO_2 reservoirs will help to define the origin, migration history, and ultimate fate of natural CO_2 and associated He. The geochemical impacts of atmospheric CO_2 on reservoir fluids and the rate of CO_2 dissolution into the reservoir formation waters will be the main topics of these field and laboratory research. By using geochemical and isotopic investigations of the gas and reservoir rocks, this research seeks to identify the source of CO_2 that is present in natural gas reservoirs. The amount and rate of CO_2-enhanced diagenesis (mineralization, recrystallization, dissolution, and bleaching) that has taken place in the reservoir rocks will be assessed using field and rock core investigations. Using the findings of field and laboratory research, potential analogues for anthropogenic CO_2 storage reservoirs will be created. The second objective is to work with BLM and State geological surveys to evaluate the distribution of discovered natural He and CO_2 resources in the United States. The BLM, State surveys, and USGS have geochemical databases that, if merged, would become the most comprehensive publicly available database to provide natural gas composition and isotopic information. This comprehensive gas geochemistry database would be maintained by USGS as part of the Energy Resources Program Energy Geochemistry Database Laboratory Information Management System, and could be used to evaluate the distribution of discovered natural He and CO_2 resources in the United States.

Economics of CO_2 storage and enhanced oil recovery

The USGS intends to use economic models of representative storage projects that combine geologic and engineering data to examine the economic implications of the USGS national assessment results for CO_2 storage resources [4,5,6]. Costs for a variety of tasks, such as site assessment, CO_2 injection, storage management, and other economic factors that can affect a particular CO_2 storage project's profitability, will also be calculated. Collecting the data necessary to use economic models to calculate the costs and economic repercussions of risks related to CO_2 storage will be one of the activities. In addition, information will be gathered to use published and created type curves to forecast the performance of injection and production wells for an economic analysis of CO_2-EOR and related carbon storage. The CO_2-EOR economic model will be used to evaluate the potential for additional economically extractable oil for assessed fields.

Storage of CO_2 in unconventional geologic reservoirs

With regard to the use of coal beds and shale as possible reservoirs for the long-term storage of CO_2, this project aims to gather pertinent data summarising the current state of knowledge. National maps displaying the location and other pertinent information (such as thickness) for potentially CO_2 storage-ready deep (>300 m) coal beds and organic-rich shale will be among the initial offerings. Coal beds deeper than 900 m may be available for super-critical CO_2 injection, while coal beds between 300 and 900 m may be viable for increased gas production utilising injected CO_2. The USGS intends to create a preliminary approach to assess the CO_2 storage capability in coal beds, as mandated by the EISA [1]. Any research initiatives to quantify the potential effects of CO_2 injection into organic-rich intervals will be coordinated with relevant State and Federal agencies as well as international organizations. The USGS will also compile research and demonstration-project reports related to CO_2 storage in basaltic rocks

Outreach

The USGS CS-GRA project outreach task's goals are to collaborate with other research groups at the USGS and outside organisations to address issues related to geologic carbon sequestration and to effectively communicate the results of our research with USGS and other organisations. It is necessary to create channels of communication to share information with Congressional, State, and worldwide groups working in the field of geologic carbon

sequestration, as well as State and Federal authorities, the general public, and the greater scientific community.

SUMMARY

The USGS CSGRA project is to assess the national technically recoverable hydrocarbon resources as a result of CO_2 injection and storage through CO_2-EOR after the national assessment of geologic storage resources for anthropogenic CO_2. The project is also examining a number of other carbon sequestration-related topics, such as the analysis of natural CO_2 and helium reservoirs as analogues for anthropogenic CO_2 storage, the economics of CO_2 storage and CO_2-EOR, and induced seismicity related to CO_2 geologic storage.

The results of this research will be covered in a number of reports. The USGS's study on carbon storage will contribute to the development of the knowledge base required to enhance future evaluations of the nation's geologic storage capacity for CO_2 produced by humans. The USGS's continuing research efforts will be complemented by new and ongoing exchanges and collaborations with industry, international organisations, state and federal agencies, and businesses that are engaged in or conducting research on geologic carbon sequestration.

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