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U.S. Geological Survey Geologic Carbon Dioxide Storage Resource Assessment of the United States

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Abstract

The U.S. Geological Survey (USGS) is conducting geology-based carbon dioxide storage resource evaluations of approximately 40 major sedimentary basins in the United States in order to fulfill some of the requirements of the Energy Independence and Security Act of 2007. Individual storage assessment units (SAUs) within each basin are defined on the basis of geologic and hydrologic characteristics. Summary geologic descriptions of the evaluated basins and SAUs will be published, along with the results of the national assessment and related research.

Keywords: Carbon dioxide; geologic storage assessment; United States

1. Introduction

Based on recent projections by the U.S. Energy Information Administration (EIA) [1], electrical power demand in the United States will increase about 22% above current demand by the year 2035. Fossil fuel combustion, which will be used to generate most of the needed electricity, is a major source of carbon dioxide (CO_2) emissions to the atmosphere, and is expected to provide the dominant portion of total energy in both industrialized and developing countries for years to come. Overall reduction of CO_2 emissions will likely involve some combination of techniques, but for the immediate future, sequestration of CO_2 in geological reservoirs seems especially promising, and existing knowledge derived from the oil and gas production industries has already helped to solve some of the technological obstacles.

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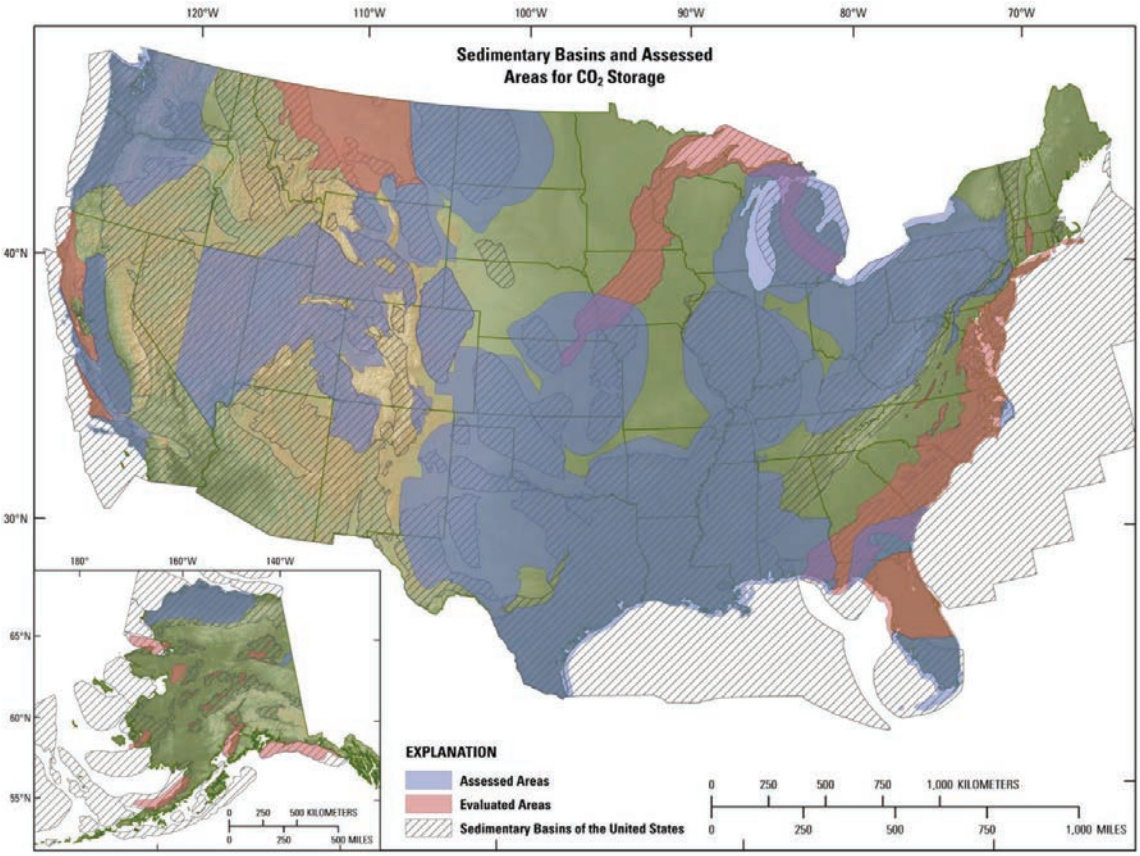

Fig. 1. Map of the United States showing sedimentary basins and areas (shown in blue) that were assessed for CO_2 storage potential. The areas in red were evaluated for CO_2 storage potential but were not assessed because of geologic conditions that did not meet the minimum requirements for CO_2 storage as outlined in Brennan et al. [4]. Diagonal lines show the sedimentary basins from Coleman and Cahan [5]. The green and tan background indicates topography–green indicates relatively flat terrain and tan indicates mountains. Offshore areas outside of State waters were not evaluated.

The U.S. Geological Survey (USGS) has a long history of assessing national and global ground- and surface-water resources and geologic energy and mineral resources. In 2007, the Energy Independence and Security Act (Public Law 110–140) [2] authorized the USGS to conduct a national assessment of geologic storage resources for CO_2 in consultation with the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and State geological surveys. In 2008 to 2009, the USGS developed a methodology to estimate storage resource potential that can be applied uniformly to geologic formations across the United States. The methodology was initially published as a USGS Open-File Report by Burruss et al. [3] and after receiving comments from the public and a panel of experts, a revised methodology report by Brennan et al. [4] was published in June 2010, and is the methodology currently used by the USGS to assess the capacity of the Nation's geologic resources for CO_2 storage. From 2010 to 2012, the USGS conducted geology-based, CO_2 storage resource evaluations of approximately 40 major sedimentary basins in the Nation, see Fig. 1. Individual storage assessment units (SAUs) for each basin are defined on the basis of geologic and hydrologic characteristics outlined in the assessment methodology of Brennan et al. [4]. Although geologic storage of CO_2 may be possible in some areas not assessed by the USGS, the SAUs identified in this assessment are the most promising

areas for future utilization for geologic CO_2 sequestration. In addition to the overview studies made by this project, detailed geologic evaluations of potential CO_2 storage sites will have to be made prior to the start of any injection project.

2. Methodology

The methodology of Brennan et al. [4], which is currently being used by the USGS for the national CO_2 geologic storage assessment, is probabilistic, non-economic, and is intended to be used at regional to subbasinal scales. SAUs are defined based on two depth categories—914 to 3,962 m (3,000 to 13,000 ft) below the surface, and deeper than 3,962 m (13,000 ft). The 914 m (3,000 ft) minimum depth limit of the storage reservoir ensures that the CO_2 would be in a supercritical state, which would minimize the storage volume. The 3,962 m (13,000 ft) depth is accessible with average injection pressures. The areas where reservoir formations have potential storage at depths below 3,962 m (13,000 ft) are assessed as separate SAUs. In addition, SAUs are restricted to formation intervals that contain saline waters (total dissolved solids greater than 10,000 parts per million) in order to prevent contamination of potential underground sources of drinking water. Carbon dioxide sequestration capacity is estimated for both buoyant and residual storage traps within the basins. For buoyant traps, CO_2 is held within porous formations by top and lateral seals; for residual traps, CO_2 is held within porous formations by capillary forces as individual droplets within pores. Results of the assessment are estimates of the technically accessible storage resources based on current (2012) geological and engineering technology related to CO_2 injection into geologic formations; therefore the assessment is not of total in-place resources. Probabilistic methods outlined by Brennan et al. [4] are used to incorporate uncertainty and natural variability in the volumetric parameters (such as area, thickness and porosity) that are used in the assessment. Assessment results will be statistically aggregated at basin, regional, and national scales using the aggregation methodology described by Blondes et al. [6, 7].

The International Energy Agency (IEA) recently (April and November, 2011) hosted workshops on geologic carbon sequestration assessment methodologies that were attended by representatives from geological surveys in North America, Europe, and Australia, as well as IEA and UNESCO (United Nations Educational, Scientific, and Cultural Organization) staff members. At these meetings, it was decided that the USGS assessment methodology [4] should serve as the starting point for conducting geologic CO_2 sequestration assessments for any location or jurisdiction. The USGS methodology [**4**] was chosen because of its ability to estimate storage resource potential at the basin scale. Other finer-scale (project-specific) methodologies may be applied after an initial regional assessment using the USGS methodology. The IEA is expected to publish a summary of the workshops in late 2012 or early 2013. Brennan et al. [8] (this volume) also summarize the workshop findings.

3. Associated Research

A secondary objective of the USGS geologic CO_2 sequestration project is to conduct relevant research that will be needed to refine the current and future CO_2 storage assessments. This research includes: (a) geochemical characterization of CO_2 interactions with organic-rich seals and other reservoir rocks and fluids with emphasis on CO_2 retention; (b) characterization of reservoir pressure, compartmentalization, and injectivity; (c) potential methods for assessing enhanced oil recovery and associated CO_2 storage potential; (d) research related to the storage of CO_2 in unconventional reservoirs (coal, shale, and mafic rocks); (e) aggregation methods to report resource numbers on basin, regional, and national scales; (f) the economics of geologic CO_2 sequestration and enhanced oil and gas recovery; and (g) assessing the potential for induced seismicity related to CO_2 injection and subsurface storage. These research areas are expected to lay the groundwork for future USGS investigations and assessments of CO_2 storage resources.

4. Results

As of September, 2012, preliminary geologic models have been developed to estimate CO_2 storage capacity in 36 basins in the United States. Several other basins were evaluated but not assessed because of geologic conditions that did not meet the minimum requirements for CO_2 storage as outlined by Brennan et al. [4], see Fig. 1. More than 200 SAUs have been identified within these basins. Each SAU has well-defined reservoirs and an overlying, regionally extensive sealing unit of low permeability. Assessment inputs and SAU boundaries are assembled with data obtained from proprietary commercial databases, published literature, and in cooperation with State geological surveys, universities, and the DOE Regional Carbon Sequestration Partnerships. Summary geologic descriptions of the evaluated basins and SAUs, along with supporting geographic information system (GIS) files are being prepared (for example, see Covault et al. [**9**]). The results of the national assessment, as well as assessment data input forms and resource tables are expected to be released in 2013 as USGS publications that will be available from the USGS geologic carbon sequestration project website [10].

Significant research accomplishments by the USGS geologic CO_2 sequestration project science teams include multiple publications that are related to the research topics listed in Section 3 above. In addition, several workshops were held that cover topics that include reservoir seal character, CO_2 and enhanced oil recovery, storage of CO_2 in unconventional reservoirs, and CO_2 storage efficiencies in subsurface formations. For a complete list of USGS geologic CO_2 sequestration publications and workshop summaries please refer to the USGS geologic carbon sequestration project website [10].

5. Conclusions

In accordance with the Energy Independence and Security Act of 2007 [2], the USGS has developed a scientific methodology for the quantitative assessment of geologic CO_2 sequestration [4]. A national-scale assessment is underway that will provide a comprehensive accounting of the Nation's geologic CO_2 storage potential. The assessment is scheduled to be completed in 2013. Supporting research that will help to refine the current and future CO_2 geologic storage assessments is also underway. A detailed description of the USGS geologic CO_2 sequestration project, along with reports and associated GIS files, are available at the USGS geologic carbon sequestration project website [10].

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