INITIAL GIS ANALYSIS OF CO_2 SEQUESTRATION IN COAL BEDS IN OHIO

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ABSTRACT

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Concerns about anthropogenic increases in CO_2 and its potential influence on global warming have led to a number of proposals for the geologic sequestration of CO_2. Proposed methods include injecting the CO_2 into deep ummineable coal beds or using the CO_2 to enhance recovery of coal bed methane (CBM). This initial evaluation of geologic CO_2 sequestration in coal beds in Ohio is part of a U.S. DOE-funded project, the Midcontinent Interactive Digital Carbon Atlas and Relational dataBase (MIDCARB), which is looking at the feasibility and economics of geologic CO_2 sequestration in a five-state region.

Recently completed coal-resource projects in Ohio form the framework for the evaluation of coal beds for CO_2 sequestration. U.S. Geological Survey co-funded studies of the availability of the Middle Kittanning (No. 6) and the Upper Freeport (No. 7) coal beds in Ohio are the primary GIS datasets that will be used. Other existing GIS databases include the Ohio Geological Survey's 1:24,000-scale bedrock geology GIS and 1:24,000-scale abandoned underground mine GIS, and the U.S. Geological Survey's National Coal Resource Data System (NCRDS). Initial data products that will be generated for the assessment will include a structure contour map of the Mississippian/Pennsylvanian unconformity, a net coal thickness map, an overburden map of the Pennsylvanian and younger age sediments, and structure contour and isopach maps of the most significant coal beds in Ohio. Each of these products will be created in a GIS and used to assess the potential feasibility and economics of both coal bed methane and CO_2 sequestration.

DATA SOURCES

The Ohio Division of Geological Survey, the State of Ohio, and the U.S. Geological Survey have developed numerous digital data products over the past ten years. These data sources form the basic framework of the Ohio portion of the MIDCARB project. The digital data sources include:

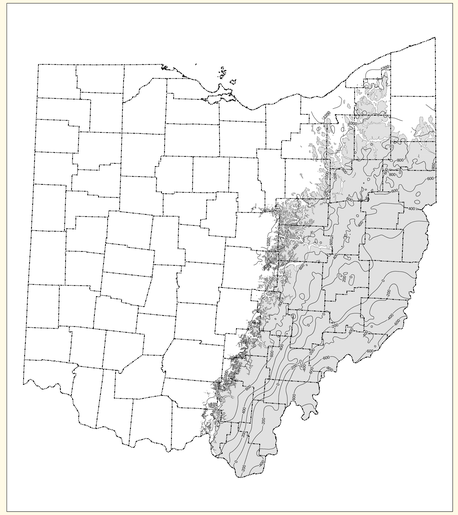
- 1:24,000-scale reconnaissance bedrock geology maps (Swinford, 1997)
- U.S. Geological Survey National Coal Resource Data System (NCRDS)
- U.S. Geological Survey funded Coal Availability projects for the Middle Kittanning and Upper Freeport coal beds in Ohio
- 1:24,000-scale Digital Line Graph (DLG) and Digital Elevation Model (DEM) data from the U.S. Geological Survey

The 1:24,000-scale bedrock-geology maps provide the polygon outlines of the coal-bearing Pennsylvanian system and the Upper Freeport coal bed. These polygons are used to clip other data themes, so they will be contained within area of the polygon.

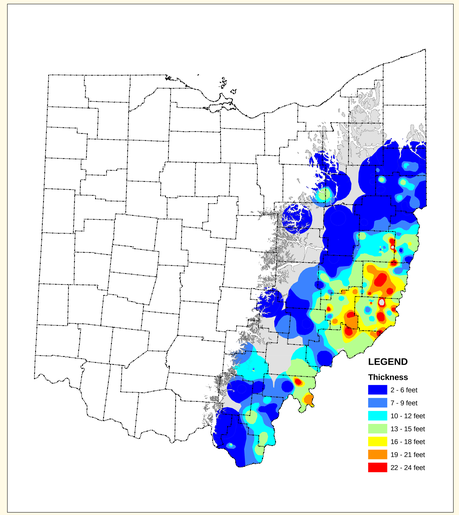
The NCRDS database contains information from continuous cores holes, oil-and-gas wells, other types of drill holes, and measured stratigraphic sections. The NCRDS point data were used to create structure contour maps of the base of the Pennsylvanian system, the Upper Freeport and Middle Kittanning coal beds, as well as isopach maps of Upper Freeport and Middle Kittanning coal beds. The isopach and structure contour maps form the basis from which calculations of the remaining coal resources for the Upper Freeport and Middle Kittanning coal beds were determined. These coal resource values were then used to calculate potential coalbed methane resources and CO_2 sequestration potential.

During the 1990's, the U.S. Geological Survey and the State of Ohio cooperated to convert all the 1:24,000-scale topographic quadrangles to DLG format. The conversion process, completed in 1997, included the surface hypsography (Center for Mapping, 1996; Ramirez, 1996). These data files, along with the Digital Elevation Models for the 7.5-minute quadrangles, provide political boundaries and surface topography for this project.

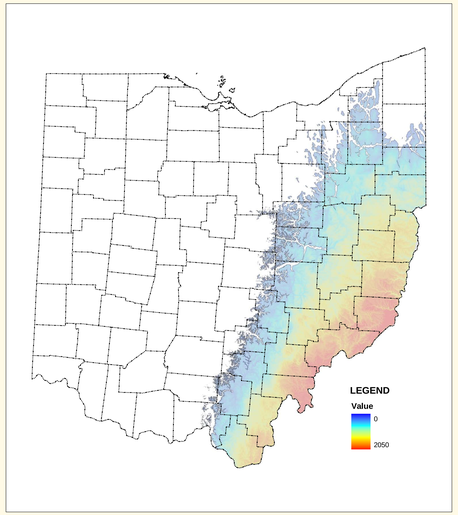
Structure Contour Map on the Base of the Pennsylvanian System



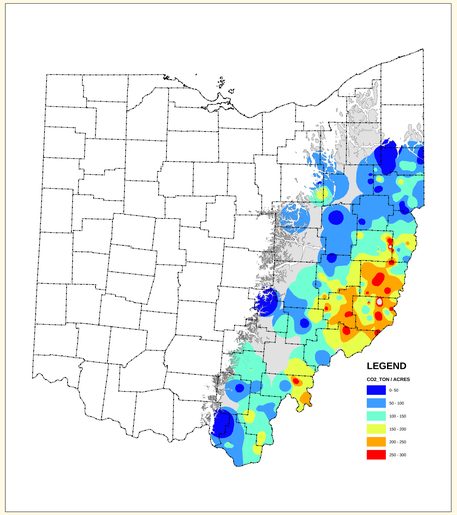
Net Coal Thickness Map



Maximum Overburden Thickness Map in the Coal-Bearing Region



CO_2 Sequestration Potential in Coal-Bearing Region



DISCUSSION AND RESULTS

CO_2 can be sequestered in coalbeds in a number of ways. For example, hydrodynamic, solubility, and mineral adsorption trapping mechanisms can sequester CO_2 (Lewis and Shinn, 2001). CO_2 can also be geologically sequestered either as a gas or in a supercritical state (Bachu, 2001). In order to understand the possible trapping mechanisms, a structure contour map of the Mississippian-Pennsylvanian boundary, a map of the surface hypsography, a net coal thickness map, and an overburden map of the Pennsylvanian-Permian sedimentary section were generated. These maps were used to make a first order approximation of the suitability of coal beds to sequester CO_2 and the potential amount that could possibly be sequestered.

The potential trapping mechanisms can be approximately evaluated using the isopach and overburden maps. The structure contour map is subtracted from the surface hypsography to produce the Pennsylvanian-Permian overburden map. The overburden map shows that the maximum thickness of Pennsylvanian-Permian sediment in Ohio is approximately 2050 feet. Assuming an average geothermal gradient in the crust, this is too thin to allow for storage of CO_2 as supercritical gas. Rapid facies changes within the Pennsylvanian-Permian of Ohio sediments are common. Rocks with a highly variable lithologic types usually indicate that laterally extensive aquitards does not exist. This would preclude large scale hydrodynamic trapping of CO_2 in the deeper coalbeds. However, solubility trapping maybe possible in the formation waters associated with the coalbeds, especially if the regional flow path travels deeper into the basin. Adsorption trapping can be done in areas where there is potential for enhanced recovery coalbed methane production. This is the most promising method for CO_2 sequestration within coalbeds in Ohio.

Using the following values and assumptions, coal resources, coalbed methane resources, and the potential amount of CO_2 can be calculated. The coal gas content is assigned a value of 57.83 ft³/ton from the 23 known values (Couchot and others 1980). Using the assumption that CO_2 is preferentially adsorbed onto coalbeds at a 2:1 ratio, the following calculations can be made:

Net Coal Resources – 105.9 Bt

Coalbed Methane Resources – 6.1 Tcf

CO_2 sequestered – 710.3 Mt

There is one important note. Coalbed methane is assumed to be producible when the coal is at a depth of greater than 500 feet. We cannot apply this assumption to the current net coal map. In order for us to apply this assumption, we would need to create isopach maps for all the coal beds, eliminate the coal that is under less than 500 feet of overburden for each coal bed, and then add all the coalbed isopach maps together. The method we used to create the current net coal thickness precludes us from eliminating coal that is less than 500 feet deep. Therefore, our estimates of coalbed methane and CO_2 sequestration potential will be too high. This calculation still gives an order of magnitude estimate of the coalbed methane and CO_2 sequestration potential.

REFERENCES

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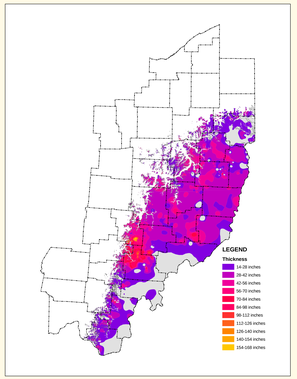
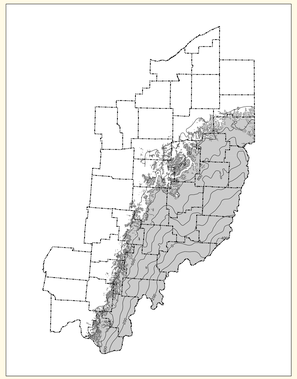
MIDCARB

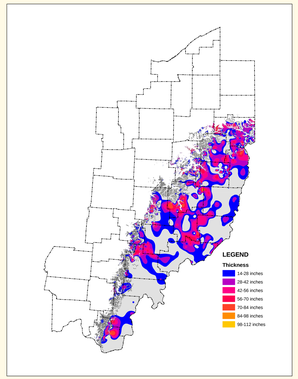
Middle Kittanning Isopach Map



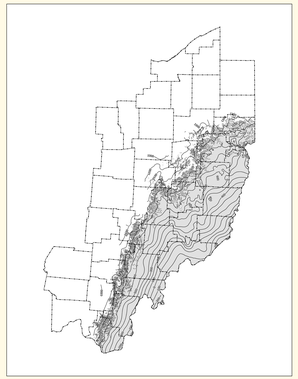
Middle Kittanning Structure Contour Map



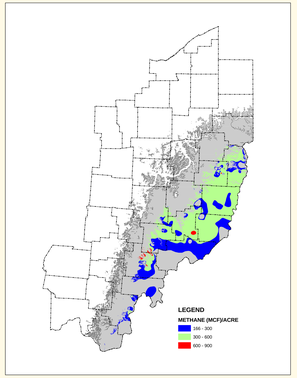
Upper Freeport Isopach Map



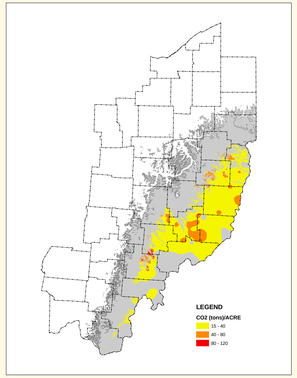
Upper Freeport Structure Contour Map



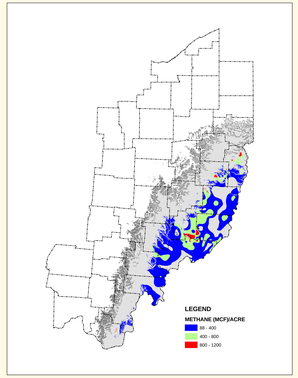
Middle Kittanning Coal Bed Methane Potential



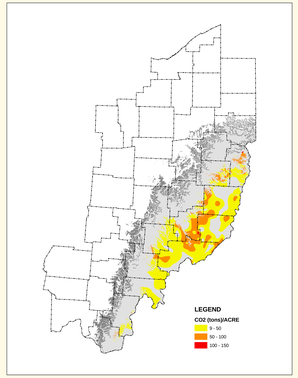
Middle Kittanning CO_2 Sequestration Potential



Upper Freeport Coal Bed Methane Potential



Upper Freeport CO_2 Sequestration Potential



DISCUSSION AND RESULTS

Better evaluations of coalbed methane resources and CO_2 sequestration potential can be obtained using data from the detailed coal resources studies. The recently completed studies of the available coal resources of the Middle Kittanning and Upper Freeport coal beds are examples of such investigations. Therefore, evaluations performed on a per bed basis will be more accurate than those calculations using the net coal resources. As part of the MIDCARB project, future work will be to calculate the coal bed methane resources and CO_2 sequestration potential of all the significant coalbeds in Ohio.

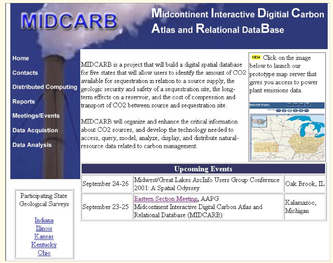
As was done for the net coal resources, the coal resources, coal bed methane resources, and the potential sequestered CO_2 were calculated. Similar assumptions are made for the calculations, using the gas content values of Couchot and others (1980) and the previously discussed assumptions. For the Middle Kittanning coal bed, the coal gas content is assigned an average value of 57.22 ft^3/ton from the five known published values, while for the Upper Freeport coalbed the coal gas content is assigned an average value of 88.16 ft^3/ton from the seven known published values. Coal bed methane is assumed only to be produced below 500 feet of overburden. Thus, using the assumption that CO_2 is preferentially adsorbed onto coalbeds at a 2:1 ratio, the following calculations can be made:

Middle Kittanning coalbed

- Coal Resources (below 500 ft overburden) – 8.27 Bt
- Coalbed Methane Resources – 473 Bcf
- CO_2 sequestration potential – 54.9 Mt

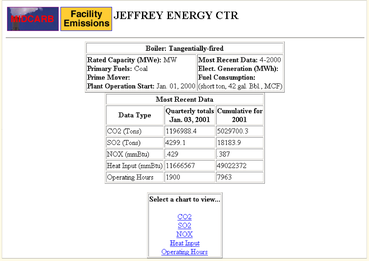
Upper Freeport coalbed

- Coal Resources (below 500 ft overburden) – 4.05 Bt
- Coalbed Methane Resources – 356 Bcf
- CO_2 sequestration potential – 41.4 Mt

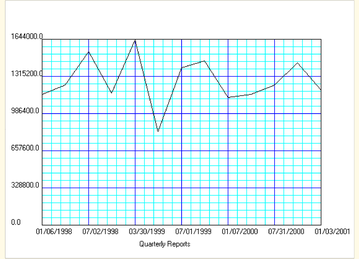


MIDCARB is a cooperative project between the five state geological surveys of Kansas, Illinois, Indiana, Kentucky, and Ohio. The MIDCARB project will be looking at the feasibility and economics of geologic CO_2 sequestration potential in the five state region. The project will use GIS technology to evaluate potential sinks of CO_2. Potential sinks include abandoned oil & gas fields, saline aquifers, and unmineable coalbeds. The CO_2 has the potential of being used in a beneficial way in enhanced oil recovery and enhanced coalbed methane recovery.

The MIDCARB project will be using web technologies to allow the display, query, and analysis of the different themes. The data themes will be managed by the different state survey, but accessed through a common portal. The MIDCARB web site address is: **WWW.MIDCARB.ORG**



Using the GIS web technology, one can query individual themes and display the results. For example, one of the CO_2 sources, the Jeffery Energy Center coal-fired power plant has been queried.



Addition applications can be developed and deployed. For example, a Java servlet application has developed for the MIDCARB project. It can graphically display the CO_2 emissions over time.