POTENTIAL SALINE RESERVOIR SINKS FOR STORAGE OF CO_2 GENERATED IN THE CAROLINAS

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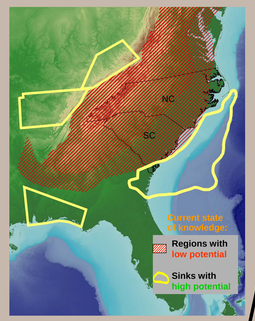
ABSTRACT

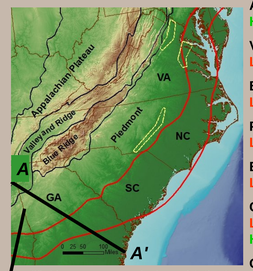
Saline reservoirs are one type of geologic CO_2 "sink." They require depths sufficient to maintain CO_2 at or near supercritical phase (>800 m), integrity of overlying seal, and capacity sufficient to prevent displacement of saline water into freshwater zones. Large areas of the southeastern U.S. either are unsuitable or have low potential for geologic storage of CO_2. Work completed for power companies in the Carolinas in cooperation with SECARB shows that much of the Carolinas is underlain by (1) fractured crystalline rocks that lack overlying seals or (2) sequences of sediment not thick enough to store CO_2 at sufficient density and that contain freshwater aquifers in most horizons. Few options are left for onshore geologic storage of CO_2 within North and South Carolina.

Alternatives include transporting CO_2 via pipeline from power plants to sinks underlying nearby states or to potential Atlantic margin subseafloor sinks. Potential onshore sinks outside of the Carolinas are in (1) Upper and Lower Cretaceous and Triassic units in the South Georgia Basin, (2) Upper Cretaceous units in southeastern Alabama and the Florida panhandle, (3) Mt. Simon Formation in Tennessee, and (4) Knox Formation in Kentucky and West Virginia. Cretaceous-age strata, 25-175 km offshore in the western Atlantic, show promise for subseafloor (>1 km depth below seafloor) CO_2 storage. Water column height (50-1000 m) overlying the seafloor enhances suitability of potential subseafloor sinks because of added pressure. The CO_2 storage potential for the subseafloor Atlantic margin could be significant along the entire U.S. eastern seaboard. Costs associated with transporting CO_2 from power plants in the Carolinas to potential geologic sinks are not trivial but are small compared with CO_2 capture costs.

REGIONAL SETTING

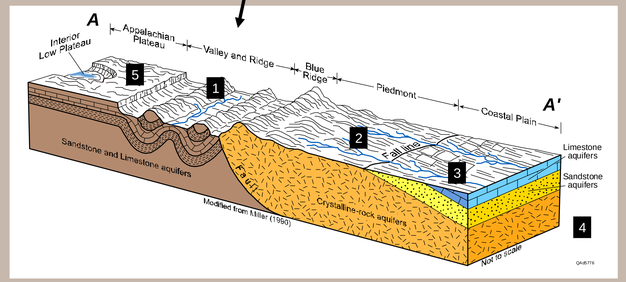
Problem: Limited CO_2 storage options in Carolinas and onshore southeastern U.S. Atlantic coast. CO_2 sources are not evenly distributed geographically. Many power plants lack suitable geologic sinks below them, and pipelines are expensive.





Modified from Fenneman and Johnson (1946), NOAA (2006), Scripps (2006), and Olsen et al. (1991).

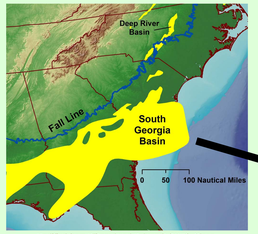
- Appalachian Plateau — HIGH POTENTIAL
- Valley and Ridge — LOW POTENTIAL
- Blue Ridge — LOW POTENTIAL
- Piedmont — LOW POTENTIAL
- Exposed Rift Basins — LOW POTENTIAL
- Coastal Plain — LOW POTENTIAL, HIGH POTENTIAL
- Offshore Subseafloor — HIGH POTENTIAL



Southeast U.S. by area: 1. LOW POTENTIAL Valley and Ridge, 2. LOW POTENTIAL Exposed Mesozoic Basins, 3. HIGH POTENTIAL Buried Mesozoic basins, 4. HIGH POTENTIAL Offshore subseafloor, 5. HIGH POTENTIAL Appalachian Plateau Paleozoic sediments.

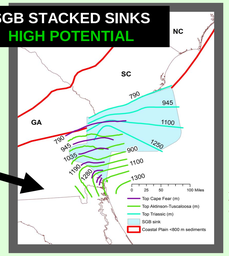
DETAILS OF SELECTED SINKS

SOUTH GEORGIA BASIN



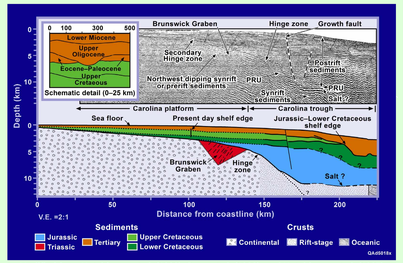
Modified from Klitgord and Behrendt (1979), Olsen et al. (1991), and Hutchinson et al. (1982)

SGB STACKED SINKS — HIGH POTENTIAL



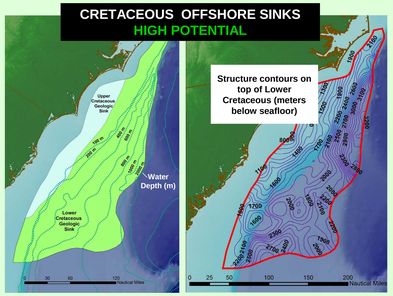
Formation contours modified from Hovorka et al. (2000), Temples (pers. comm. (2006), Gohn et al. (1980), and Renkin et al. (1989).

CRETACEOUS-AGE SUBSEAFLOOR SINKS



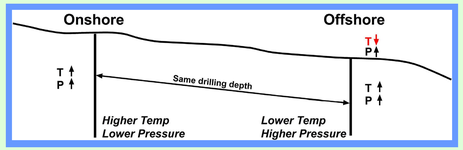
Modified from Hutchinson et al. (1982), Grow et al. (1988), and Hutchinson et al. (1997)

CRETACEOUS OFFSHORE SINKS — HIGH POTENTIAL



Data sources: Structure contour - Hutchinson et al. (1997), imagery: land - NOAA (2006), and ocean - Scripps (2006).

Both Onshore and Offshore Sites Favor Deep Geologic Storage



Environmental issues

- Below freshwater aquifers, not as much of a problem offshore
- Integrity of overlying seal; not much previous drilling offshore Atlantic, especially offshore from Carolinas
- Prevention of geohazards – proposed sinks are landward of known hydrate occurrences

Economic issues

- High-density CO_2, ideally supercritical-phase CO_2
- CO_2 total pipeline construction costs ~$4,000,000,000; CO_2 transport costs ~$4/metric ton
- Underground-injection-control permitting for onshore sites.

ACKNOWLEDGMENTS

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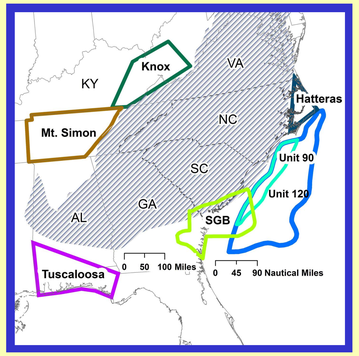
SUMMARY

POTENTIAL SINK	CAPACITY (Gt)
South Georgia Basin (SGB)	~15
Offshore Subseafloor	~193
Mt. Simon Formation	~3
Knox Dolomite	~32
Florida Tuscaloosa	~10

Capacity estimates from MIT (2006)

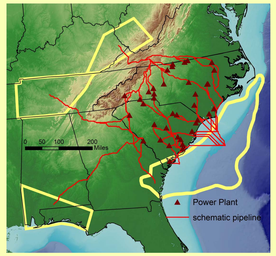


Locations of geologic units in which subsurface saline aquifers (i.e., potential geologic sinks) are found.

Sinks have been chosen on the basis of geologic suitability alone. We have not taken into account the environmental, economic, or socio/political issues that will need to be balanced with geologic suitability.

SINK OPTION	TOTAL CONSTRUCTION COST (BILLION $)	AVERAGE TRANSPORT COST ($/ton CO_2)
Scenario 1	3.8	3.56
Scenario 2	3.8	3.63
Scenario 3	4.0	3.84
Scenario 4	4.2	4.17
Scenario 5	4.3	4.21

Pipeline costs from MIT (2006)



Pipeline routes from MIT (2006)

Current State of Knowledge

- We have identified areas with low potential for CO_2 sequestration and saline reservoir sinks with high potential for CO_2 sequestration on the basis of regional-scale data from existing studies.
- Regional scale data means there is modest data density and limited borehole distribution.
- Areas with LOW POTENTIAL may contain small footprint, limited volume sinks. These include Appalachian Valley and Ridge, Blue Ridge, and Piedmont physiographic provinces of Appalachian Mountains and areas of Coastal Plain where sediment thickness is less than 800 m.
- We have good initial estimates of capacity within HIGH POTENTIAL areas. These include three stacked sinks in the South Georgia Basin; subseafloor Cretaceous units offshore from the Carolinas; Knox and Mt. Simon sinks in the Appalachian Plateau of Kentucky, West Virginia, and Tennessee; and Tuscaloosa Fm. in the Florida panhandle.
- There are up to five different pipeline scenarios for matching coal-fired power plants that generate greater than 100 megawatts with potential geologic sinks.

Next Steps

- HIGH POTENTIAL areas need to be more thoroughly characterized through drilling, seismic, etc. to define salinity, rock types, porosity, permeability, and other petrophysical properties (residual saturation, sweep efficiency, and seal quality).
- Need to fill in data gaps in both HIGH and LOW potential areas by acquiring subregional or site-specific data.
- More data needed for two potential sinks identified in this study: Hatteras - depth to base of freshwater; FL Tuscaloosa – probably additional deeper sinks.
- Need to assess environmental, economic, and socio-political issues for each potential saline reservoir sink.

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