Site Charcterization for Potential Geologic Carbon Capture and Storage in the Fort Worth Basin, Texas

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Abstract

Carbon Capture and Storage (CCS) is essential for reducing carbon dioxide (CO2) emissions from industrial activities. Within the last decade, carbon emissions have seen a large increase in Texas due to the growing demand for energy driven by population growth. While the sedimentary basins in Texas have large potential for CCS, detailed site screening, ranking, and characterization are necessary to identify the most favorable geologic units within each basin for secure, long-term storage of CO2. This project aims to determine the CCS potential of the Fort Worth Basin in North Central Texas. This study first utilizes a modified method of basin screening and ranking for CCS to assess the different geologic units and five areas of the Fort Worth Basin. The ranking considers regional and local geologic and economic factors. The geologic units include the Cambrian and Ordovician dominated by limestone, Mississippian dominated by shale, and Pennsylvanian and lowermost Permian characterized by interbedded shale, sandstone, and limestone. These five areas, including the northeastern, eastern, southern, western and Bend Arch regions, are divided based on the Paleozoic tectonic and subsidence history. Our results show that the Pennsylvanian and lowermost Permian units in the northeastern, eastern, and Bend Arch areas have the highest suitability, and the Cambrian and Ordovician unit throughout the basin have the lowest suitability. The CCS potential of the Pennsylvanian and lowermost Permian in the northeastern part of the basin and the Bend Arch area will be examined in depth to quantitatively estimate the CCS potential.

Study Area

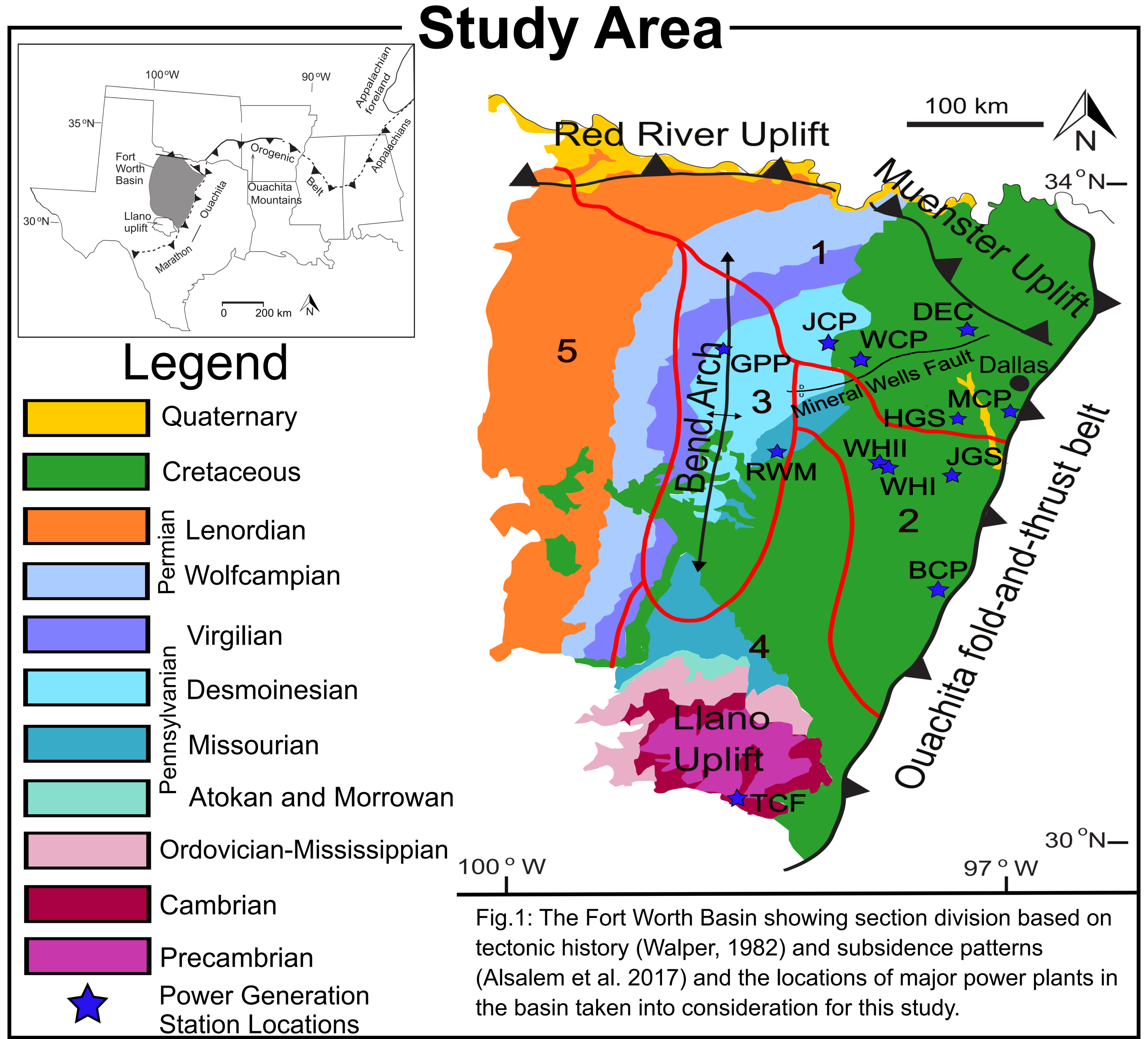

Fig.1: The Fort Worth Basin showing section division based on tectonic history (Walper, 1982) and subsidence patterns (Alsalem et al. 2017) and the locations of major power plants in the basin taken into consideration for this study.

Objective

Use site screening and ranking methods for various geological and economic factors to determine what sections and units of the Fort Worth Basin hold the highest potential for carbon capture and storage geared for use by major power generation stations.

Stratigraphy

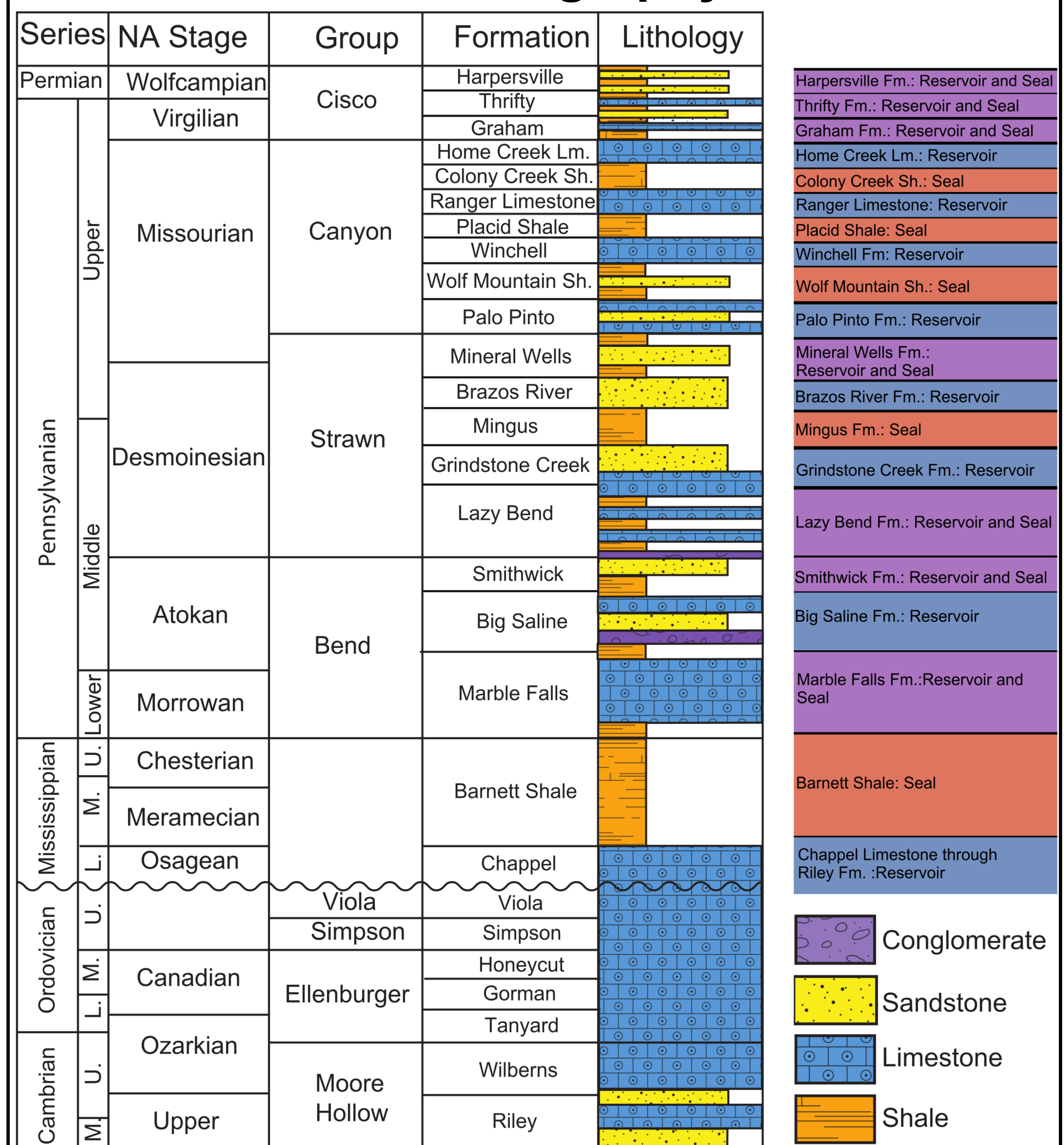

Fig. 2: Generalized stratigraphy of the Fort Worth Basin (Alsalem et al., 2017) showing lithology and whether each formation is considered to be a reservoir, seal, or both.

Methodology

Table 1: Site Assessment Criteria

i	Criterion	Classes (j) 1	2	3	4	5	Weight
1	Tectonic Setting	Convergent Oceanic Basin	Convergent Intramontane Basin	Divergent Continental Shelf	Divergent Foreland Basin	Divergent Cratonic Basin	0
2	Depth	Shallow (<1500 m)	Intermediate (1500-3500m)	Deep(>3500 m)			0.09
3	Geology	Extensively faulted	Moderately faulted and fractured	Limited faulting and fracturing, extensive shales			0
4	Reservoir Flow Systems	short range flow systems	Intermediate flow systems	Regional, long range flow systems			0.1
5	Geothermal	Warm (>35 deg C/km)	Moderate (20-35 deg C/km)	Cold (<20 deg C/km)			0.12
6	Hydrocarbon Potential	None	Small	Medium	Large	Giant	0.08
7	Maturity	Immature R_o < 0.6	Mature R_o 0.6-1.1	Overmature R_o > 1.1			0.1
8	Coal and CBM	None	Deep (>800m)	Shallow(200 -800m)			0.06
9	Lithology	Limestone with no saline water present	Shale or Sandstone	Alternating sandstone and shale	Limestone with saline water present		0.12
10	Onshore/ Offshore	Deep Offshore	Shallow Offshore	Onshore			0
11	Climate	Arctic	Sub-Arctic	Desert	Tropical	Temperate	0.1
12	Accessibility	Inaccessible	Difficult	Acceptable	Easy		0.05
13	Infrastructure	None	Minor	Moderate	Extensive		0.07
14	CO2 Sources	None	Few	Moderate	Major		0.11

Formulas for Section and Unit Suitability Calculation (Bachu, 2003)

$$(1)\quad P_i^k = \frac{F_{i,j} - F_{i,1}}{F_{i,n} - F_{i,1}} \rightarrow (2)\quad \sum_{1}^{15} w_i = 1 \rightarrow (3)\quad R^k = \sum_{1}^{15} w_i P_i^k$$

Results

Table 2: Unit Results Per Section

Criterion	Maximum J Values	Weight	Cambrian and Ordovician J Values: Section 1	Section 2	Section 3	Section 4	Section 5	Mississippian J Values: Section 1	Section 2	Section 3	Section 4	Section 5	Pennsylvanian and Lowermost Permian J Values: Section 1	Section 2	Section 3	Section 4	Section 5
Tectonic Setting	5	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Depth	3	0.09	2	2	1	1	2	2	2	2	1	1	2	2	2	2	2
Geology	3	0	1	1	3	1	3	1	1	3	1	3	1	1	3	1	3
Hydrogeology	3	0.1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Geothermal	3	0.12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Hydrocarbon Potential	5	0.08	1	1	1	1	1	4	4	4	2	2	4	4	5	2	2
Maturity	5	0.1	1	1	1	1	1	2	3	2	2	2	2	2	2	2	1
Coal and CBM	3	0.06	1	1	1	1	1	1	1	1	1	1	2	1	3	3	3
Lithology	4	0.12	4	4	4	4	4	2	2	2	2	2	3	3	3	3	3
OnShore/Offshore	5	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Climate	5	0.1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Acessibility	4	0.05	4	4	3	2	2	4	4	3	2	2	4	4	3	2	2
Infrastructure	4	0.07	4	4	4	2	3	4	4	4	2	3	4	4	4	2	3
CO2 Sources	4	0.11	4	3	2	2	1	4	3	2	2	1	4	3	2	2	1

Table 3: Suitability Values

	Section 1	Section 2	Section 3	Section 4	Section 5	Low: <.40
Cambrian and Ordovician	0.53	0.45	0.4	0.33	0.36	Moderate: .40 to .59
Mississippian	0.54	0.52	0.45	0.3	0.28	High: .60 to .79
Pennsylvanian and Lowermost Permian	0.63	0.56	0.59	0.47	0.4	Very High: .80 to 1.00

Conclusions:

1. The Pennsylvanian and lowermost Permian of the northeast section of the basin shows the highest suitability with a value of 0.63.

2. Suitability decreases with depth within the basin with the Cambrian and Ordovician showing the lowest suitability for all sections. This is due to changes in lithology, hydrocarbon potential and maturity.

Future Directions

- Use well log data from the northeast section of the basin to perform lithologic correlation of units which have potential to be used as reservoirs for CCS.
- Make storage capacity estimates for promising reservoirs.
- Refine storage capacity estimates using reservoir modeling software.

References

Alsalem et al., (2017) Late Paleozoic subsidence and burial history of the Fort Worth basin

Bachu S., (2003) Screening and ranking of sedimentary basins for sequestration of CO2 in geological media in response to climate change

Walper J.,(1982) Plate Tectonic Evolution of the Fort Worth Basin