Clinton Core Analysis: Reviving an Old Oil Field Play as CCUS & EOR Gain Momentum

Mindy B. Thomas
Ohio Department of Natural Resources, Division of Geological Survey, Columbus, Ohio

Introduction and Goals of the Study

The Gore Consolidated Oil Field (GCOF) located in southeastern Ohio is a legacy hydrocarbon field, discovered in 1907, whose primary producing reservoir interval is the Silurian-aged Grimsby Formation, or the more commonly known Clinton Sandstone. The Clinton interval in Ohio has become of interest recently as a potentially viable candidate for carbon capture, utilization, and storage (CCUS) & enhanced oil recovery (EOR), meaning a complete, in-depth geology work-up on the interval will be necessary for successful implementation of this technology. A fair amount of work has been done on the Clinton interval recently although not specifically in the GCOF. One prior study includes a detailed economic analysis by Fukai (2019) on the conversion of the GCOF into a full-scale CCUS/EOR project; however, what is lacking from this, and all the existing studies is a detailed, updated analysis of the Clinton interval within the GCOF utilizing all core and well-logs available within the field. This study aims to complete a highly detailed geologic characterization of the Clinton interval within the GCOF using all aforementioned pieces of data, along with new data items collected such as CT scan imagery and XRF data provided by the National Energy Technology Laboratory (NETL).

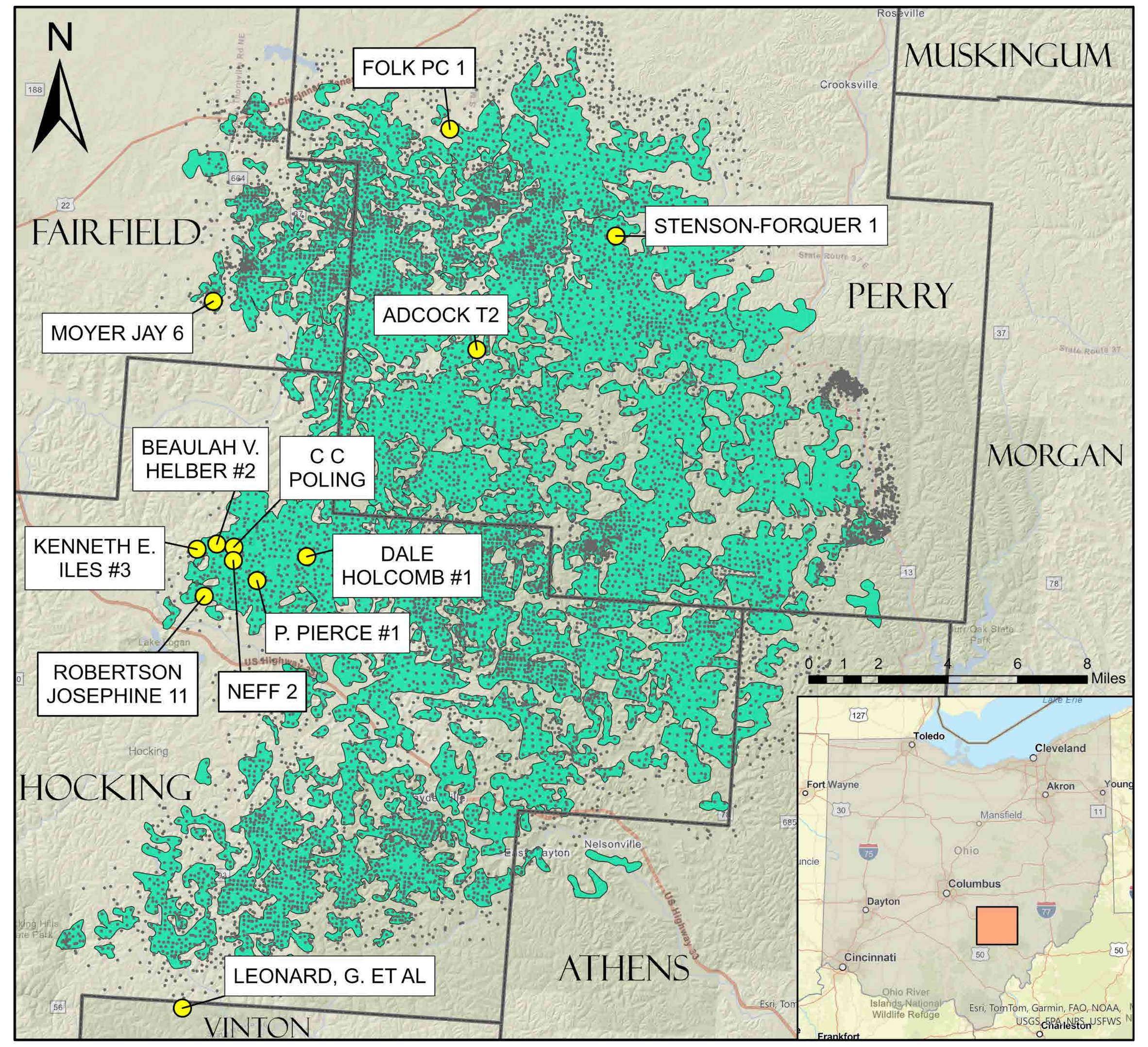


Figure 1: Map showing the GCOF in Ohio and cores examined in this study. The green polygons represent the many smaller oil fields that comprise the larger Gore Consolidated Oilfield. The 12 cores examined in this study are highlighted and labeled by well name and are represented by the yellow circles. Small inset map shows the location of the study area in southeastern Ohio; primarily Perry, Hocking, Athens, and Fairfield Counties.

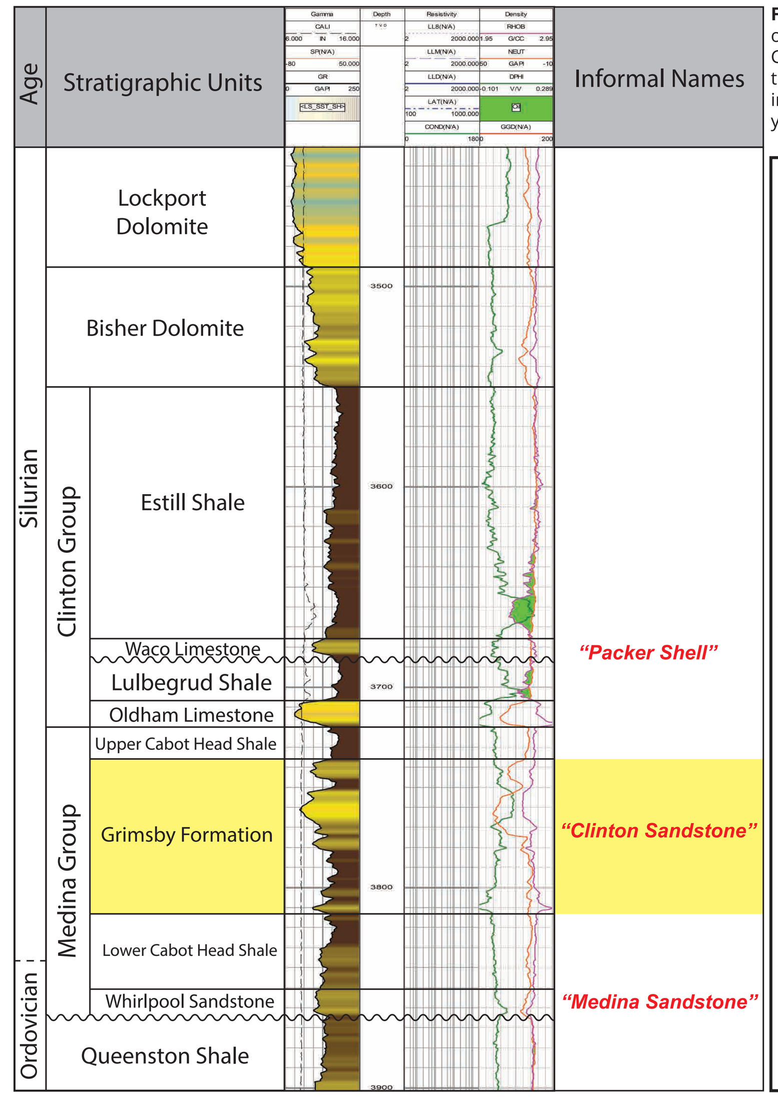


Figure 2, left: Generalized stratigraphic column of Silurian strata from eastern Ohio. The Grimsby Formation, more commonly referred to as Clinton Sandstone is the interval of interest in this study; it is highlighted by the yellow box on the figure.

Methods

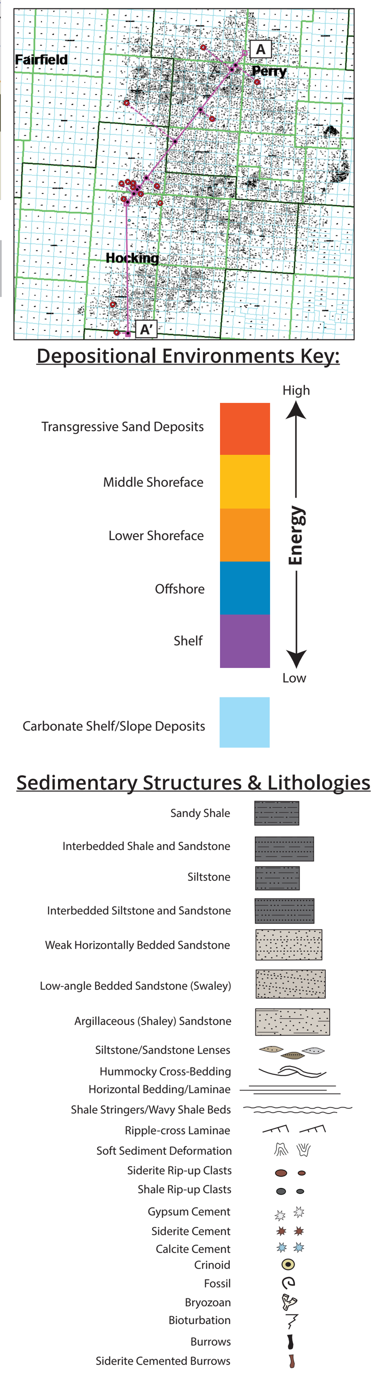
The Horace R. Collins Laboratory and Core Repository at the Ohio Geological Survey houses Clinton cores from the GCOF. Of the 14 cores that were available within the study area, 12 of them were of suitable condition for analysis. The cores were described at a 1" resolution, and key features were identified, including grain size, sorting, rounding, color, bedding, erosional surfaces, fossils, trace fossils, minerals, possible cementation type, and any other sedimentary structures.

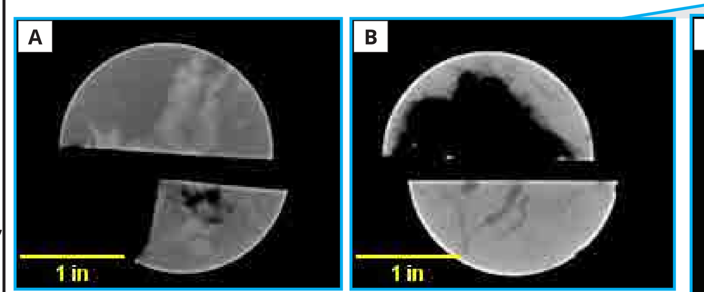
After core descriptions were completed, the cores were brought to the NETL in Morgantown, West Virginia, where they were then scanned for XRF data and with a medical CT scanner at a 10^{-3}m resolution. NETL then provided data back in the form of Excel spreadsheets and Strater plots of XRF data, along with CT data in the form of TIF stacks to analyze for each core.

The XRF data was used to calculate a spectral gamma curve (SGR) for each core in order to properly curve match it with the wellbore gamma ray well log so that each core could be depth shifted to the appropriate spot along the wellbore. The CT images have been analyzed using ImageJ software to identify internal trace fossils, cementation, and sedimentary structures as shown in Figures 5 and 6.

Figure 3, left: The cross-section to the left from A (north) to A' (south) is drawn across the Gore Consolidated Oil Field and shows both the geophysical well logs and the core descriptions for each cored well used in this study. The Clinton interval cored in each well is represented on the geophysical log by the black rectangle with corresponding footages. The cored wells are projected into the cross-section line A-A' shown below on the indicator map (fig. 4).

Figure 4, below: Indicator map showing the cored wells and their projection order into the cross-section line. Below the map, a color-coded key indicates interpreted depositional environments along each length of described core. Finally, a key is provided that explains the symbols used in the core descriptions that represent the varying sedimentary structures and lithologies observed.





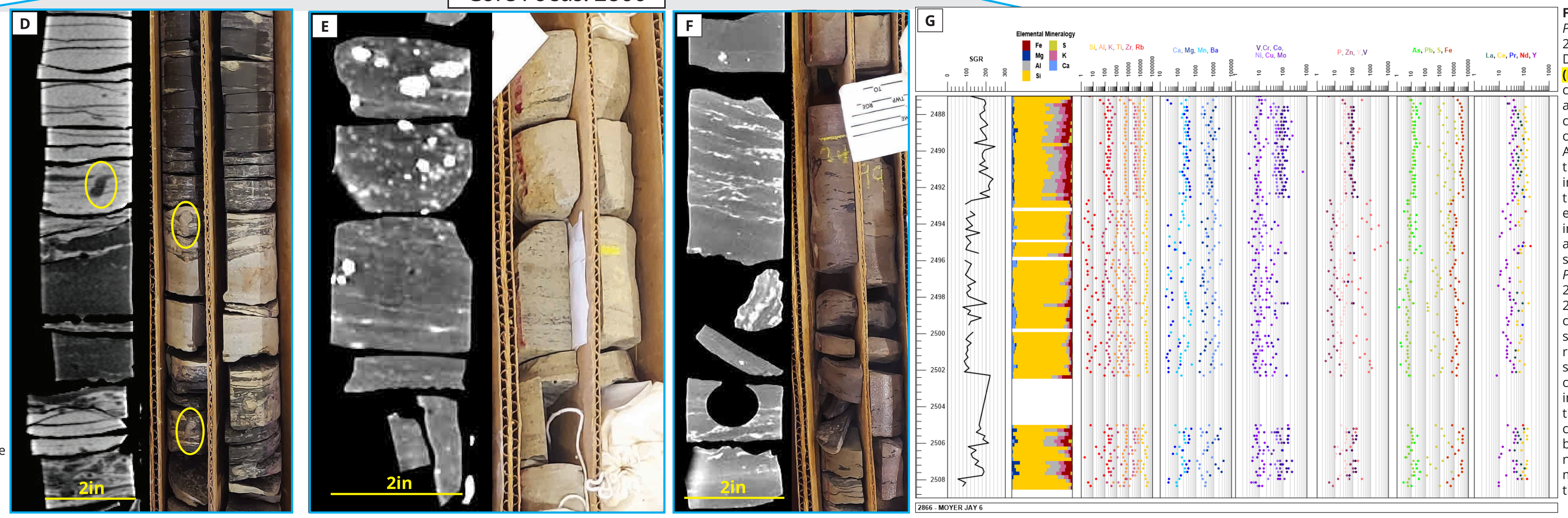
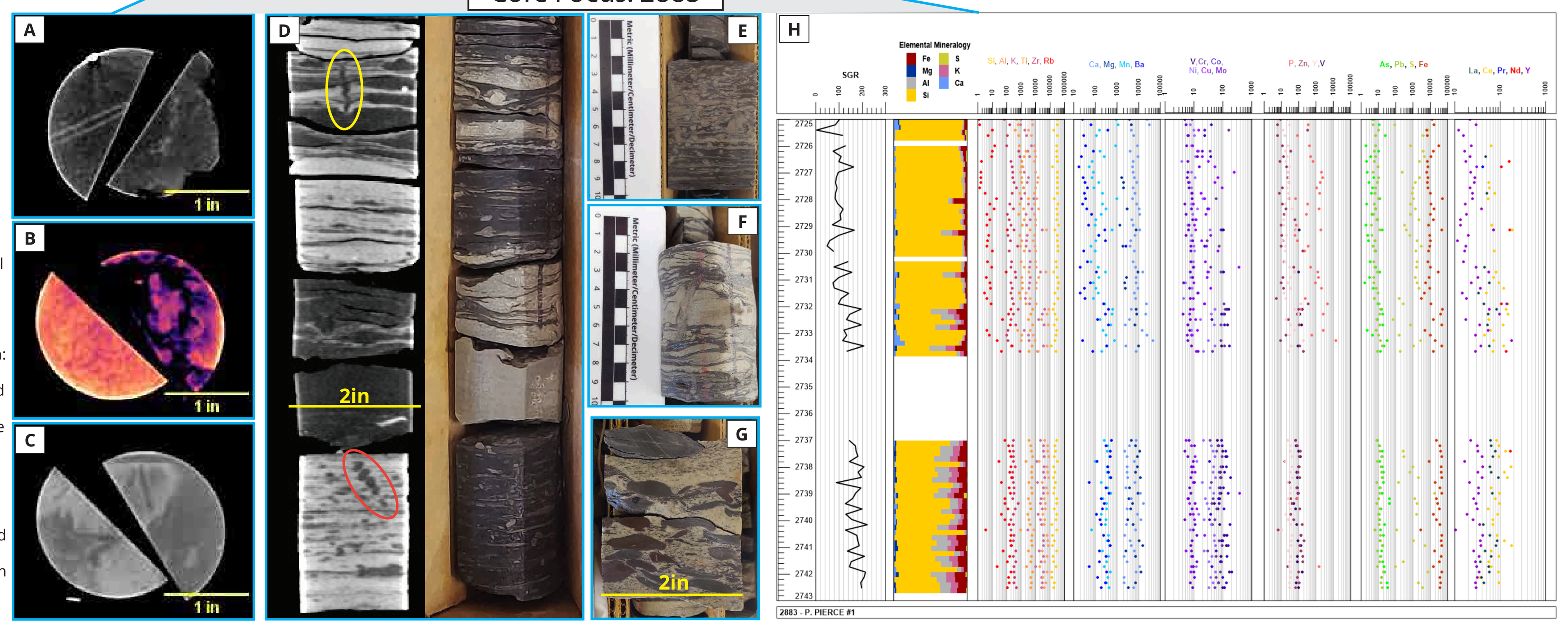


Figure 5: **(A)** Depth: 2488' *Nereites* trackway. **(B)** Depth: 2488' *Planolites* traces. **(C)** Depth: 2506' *Helminthopsis* burrows. **(D)** Depth: 2507' *Teichichnus* burrows seen on the outside of the core but also captured internally through CT scans. Core also shows multiple adjacent burrowed beds in what is interpreted to be the burrowed, sandy mudstone, offshore environment. **(E)** Depth: 2495.5' Low angled bedding and variation in cementation which is not visible upon looking at physical core. **(F)** Depth: 2499' Low angled bedding and thin wavy shale beds. **(G)** Strater plot, created by NETL, shows the changes in elemental abundances throughout the core length. U, K, & Th values measured were used to calculate a spectral gamma ray log, SGR, in order to properly depth shift the core along the borehole by matching the geophysical GR well log. Elemental changes along the core show the increase in clay minerals near the top/bottom, matching the lithology changes observed in the core description above.

Figure 6, right: **(A)** Depth: 2726' *Palaeophycus* burrow. **(B)** Depth: 2737' *Helminthopsis* burrows. **(C)** Depth: 2737.5' *Planolites* burrows. **(D)** Compressed *Skolithos* burrow circled in yellow at top end of core at depth of 2738'. Bottom end of core shows a *Gyrolithes* burrow, circled in red at a depth of 2738.5'. Additional burrows can be seen on the outside of the core, which is interpreted to be the offshore transitional depositional environment. **(E)** Depth: 2739' Small interval of core showing the abundant burrows present in some sections. Burrows appear to be *Planolites* and *Chondrites*. **(F)** Depth: 2740' *Teichichnus* burrow. **(G)** Depth: 2734.5' Matrix-supported conglomerate made of pebble-sized siderite rip-up clasts; interpreted to represent high energy transgressive sand deposits. **(H)** Strater plot, created by NETL, showing changes in elemental abundances throughout the core length. Higher clay elements are observed at the base of the core vs. quartz-rich sand near the top half of the core, matching the lithologies observed in the core description above.



Future Work

- Ichnofacies interpretations.
- Identifying key stratigraphic surfaces in cores, such as flooding surfaces and sequence boundaries, in order to identify sequence stratigraphic systems tracts.
- Expand systems tracts interpretations into nearby geophysical well logs.
- Correlate Clinton Sandstone around the GCOF; identify sand body geometries to better understand nature of distribution and complexity.
- Infer reasonable depositional model for the GCOF based on core work and available geophysical well logs.
- Calculate original oil in place & volume of recovered hydrocarbons in order to better estimate how much CO_2 could realistically be stored in reservoir today.

References

Fukai, I., Mishra, S., Scharenberg, M., Jimenez, M., Glier, J. and Peterson, R., 2019, Techno-economic assessment of carbon capture, utilization and storage for coal-fired power generation, and CO2-enhanced oil recovery in the USA—an Ohio case study: Greenhouse Gases Science and Technology, v. 9, no. 6, p. 1202–1220.