Geologic Framework of an Anthropogenic Carbon Capture and Sequestration System at the Kemper County Energy Center, East-Central Mississippi

Conn Wethington, Mercy Achang, Sam Martin, Jack Pashin, and Stone Urban

Oklahoma State University, 105 Noble Research Center, Stillwater, Oklahoma, USA
conn.wethington@okstate.edu

The Paluxy Formation and Tuscaloosa Group in the eastern Gulf of Mexico Basin constitute a widespread succession of sandstone and shale that presents a multi-gigatonne storage opportunity for anthropogenic CO_2. Geologic characterization of these strata at the Kemper County Energy Facility in east-central Mississippi as part of the U.S. Department of Energy's CarbonSAFE program focuses on delineating the stratigraphic framework with an emphasis on reservoir and seal analysis. Core studies in conjunction with petrophysical well-log analyses from three exploration wells have yielded a high resolution stratigraphic characterization of the targeted CO_2 storage reservoirs, baffles, and seals. The porosity of Cretaceous sandstone averages 30 percent, and permeability is locally as high as 16,000 mD. Sealing strata, baffles, and barriers to flow include mudstone units in the Washita-Fredericksburg interval and the Tuscaloosa Group.

SEM coupled with EDS analysis is widely used to characterize shale as a petroleum source rock and reservoir rock, but little work has been published evaluating mudstones as confining layers in CO_2 storage complexes. SEM and EDS are being used to characterize microfabric, mineralogy, and pore systems within mudrocks at the Kemper County Energy Facility. Characterization has two-fold importance: (1) to characterize free and adsorbed storage potential and (2) to characterize potential migration of CO_2 molecules into mudstone baffling layers and seals by capillary processes and diffusion, which can ultimately result in leakage from the primary injection targets.

Mudstone in the Tuscaloosa Group supports free storage in interparticle pores as well as adsorption on organic matter and smectitic clay surfaces. Mudstone in the Paluxy Formation and Washita-Fredericksburg interval lacks significant organic matter, and so most adsorption is on clay. High water saturation in the Cretaceous mudstone units helps keep capillary entry pressure high, and mudrock permeability is on the order of 1 nD. Entry of supercritical CO_2 into the mudrock units greatly reduces water saturation, and drying ultimately raises permeability by an order of magnitude. These low permeability values indicate that the mudrock units are effective baffles, barriers, and seals and that slow permeation of the mudrock pore systems makes significant migration of injected CO_2 out of the storage complex unlikely.