CO_2 Sequestration Risk Minimization Through Systematic Identification and Assessment of Faults: A Williston Basin Case Study

Charles D. Gorecki,[1]* James A. Sorensen,[1] David W. Fischer,[2]
Terry P. Bailey,[1] Wesley D. Peck,[1] Edward N. Steadman,[1] John A. Harju[1]

[1]Energy & Environmental Research Center (EERC)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018

[2]Fischer Oil and Gas
Grand Forks, ND 58201

Abstract

The Williston Basin in North Dakota has long been considered a relatively tectonically inactive area with few major fault systems in the Phanerozoic systems. The lack of tectonic activity and associated faulting makes the Williston Basin an attractive target for carbon dioxide (CO_2) sequestration activities because of the very low risk of leakage through faults and catastrophic release as a result of earthquakes. The Antelope, Nesson Anticline Boundary, Cedar Creek, and Heart River Faults have long been recognized as significant fault systems in the Williston Basin, but historically little attention has been given to any potential faulting outside these areas. Characterization of the Williston Basin conducted over the last 50 years as part of extensive hydrocarbon exploration activities has demonstrated that faulting does exist outside of the major fault systems, and its source is not always tectonic in nature but, rather, salt dissolution and subsequent cavern collapse. Large salt deposits are common throughout the Williston Basin in the Phanerozoic strata, with the thickest salt package over 600 ft[(1)]. These massive salt layers can act as excellent barriers, preventing the migration of sequestered CO_2 from escaping into overlying formations. In several areas, however, these salt layers have been dissolved by formation fluids, collapsed, and created faults and subsequent structures that could potentially create leakage pathways for formation fluids. One such area where this may have occurred is near the town of South Heart, North Dakota, which is currently being evaluated by the Plains CO_2 Reduction (PCOR) Partnership as a potential location for large-scale CO_2 sequestration and CO_2 enhanced oil recovery projects. A stepwise approach combining the use of aerial photographs, geophysical data, core samples, and detailed formation isopach mapping was used to identify and characterize the extent of faulting in the South Heart area. Results indicate some of the Permian Opeche Salt has been dissolved and the overlying formations have collapsed, causing faulting that can be seen on the surface but does not extend below the Opeche Formation. Faulting caused by the dissolution of the salts could have significant consequences for CO_2 sequestration or enhanced oil recovery operations undertaken in the South Heart area. There are at least six potential injection target formations below the Opeche Formation, each capped by a seal other than the Opeche, which would not be affected by the faulting. However, at least two potential target formations would be affected by the faulting and should be carefully considered before attempting a large-scale CO_2 sequestration project.

Keywords: CO_2 Sequestration, Faulting, Characterization

(1) LeFever, J.A., and R.D. LeFever, 2005, Salts in the Williston Basin, North Dakota: Report of Investigation no. 103, North Dakota Geological Survey.