Subsurface Oil-Shale Samples of the Upper Pennsylvanian Cline Shale, Midland Basin, West Texas: Core Sampling for Measured Vitrinite-Reflectance (R_o) Determination

Tucker F. Hentz, Reed S. Roush, and Caroline Breton

Introduction

This report summarizes activities carried out by the Bureau of Economic Geology (BEG) during fiscal year (FY) 2015 for the National Coal Resources Data System State Cooperative Program (NCRDS project). In a continuation of the sampling strategy for measured vitrinite-reflectance (Ro) determination initiated 6 years ago (Hentz and others, 2009) and conducted during the following five years (Hentz and others, 2010, 2011, 2012, 2014, 2015), this report provides a collection of oil-shale samples from the Upper Pennsylvanian Cline Shale of the Midland Basin in West Texas (Fig. 1).

In FY2009, 2010, 2011, 2013, and 2014 we provided samples of the Eagle Ford Shale from the San Marcos Arch and Maverick Basin areas, the deeper Pearsall Formation from the Maverick Basin of the eastern part of Texas, the Smithwick Shale from the Fort Worth Basin of north Texas, and Lower Permian Wolfcampian and lower Leonardian mudrocks and upper Leonardian Spraberry Formation from the Midland Basin, West Texas, respectively. As specified in our work plan for FY2010 through 2014 (Hentz, 2010), this year we provide samples of the productive Upper Pennsylvanian Cline Shale of the Midland Basin of West Texas.

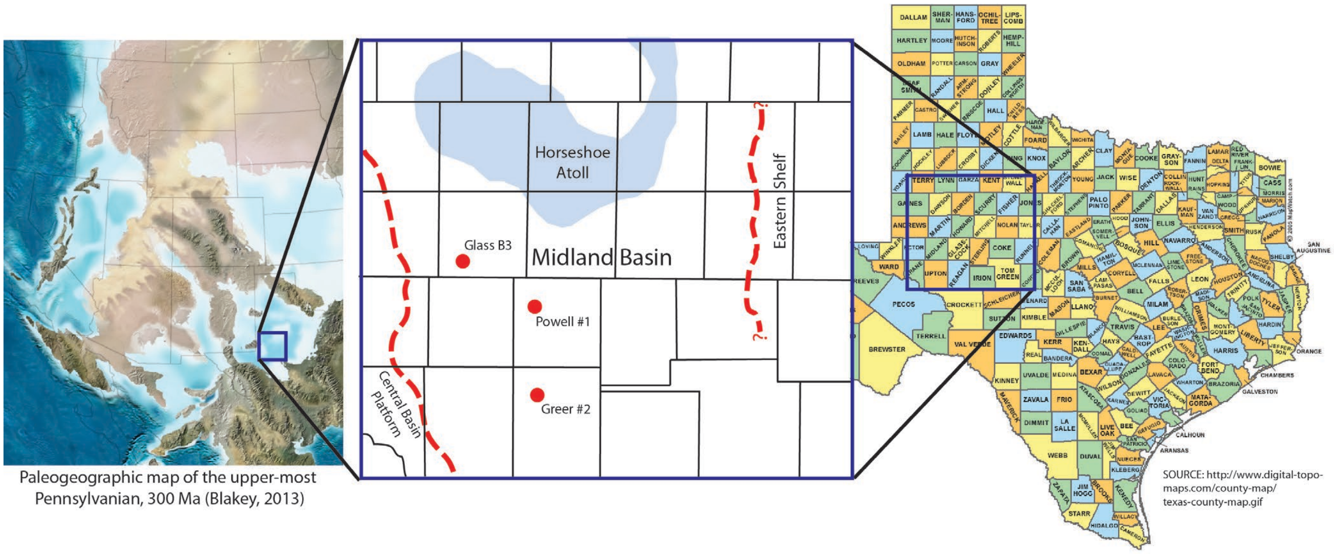

Figure 1. Map of the Midland Basin showing the location of three cored wells from which samples of the Upper Pennsylvanian Cline shale were extracted.

We provide analyses of oil-shale samples from whole cores of the Upper Pennsylvanian Cline Shale from three West Texas wells. These wells include the Clinton O. L. Greer #2 in Reagan County, Gulf G. W. Glass #B3 in Martin County, and Pan American E. L. Powell #1 in Glasscock County (Figs. 1–3, Table 1). Thirty-four samples of Cline Shale were delivered to Dr. James Hower (Center for Applied Energy Research, University of Kentucky) for measured vitrinite reflectance (Ro) analysis. The results provided by him are presented in both this report and the accompanying CD in which each of the well names, its unique API number, sample number and depth, precise geographic location, and sample's measured vitrinite reflectance and total organic carbon (TOC) values—using GIS applications—are provided (Table 1, CD). TOC values for the same samples from three wells was measured by Weatherford Laboratories of Houston and are also provided in Table 1.

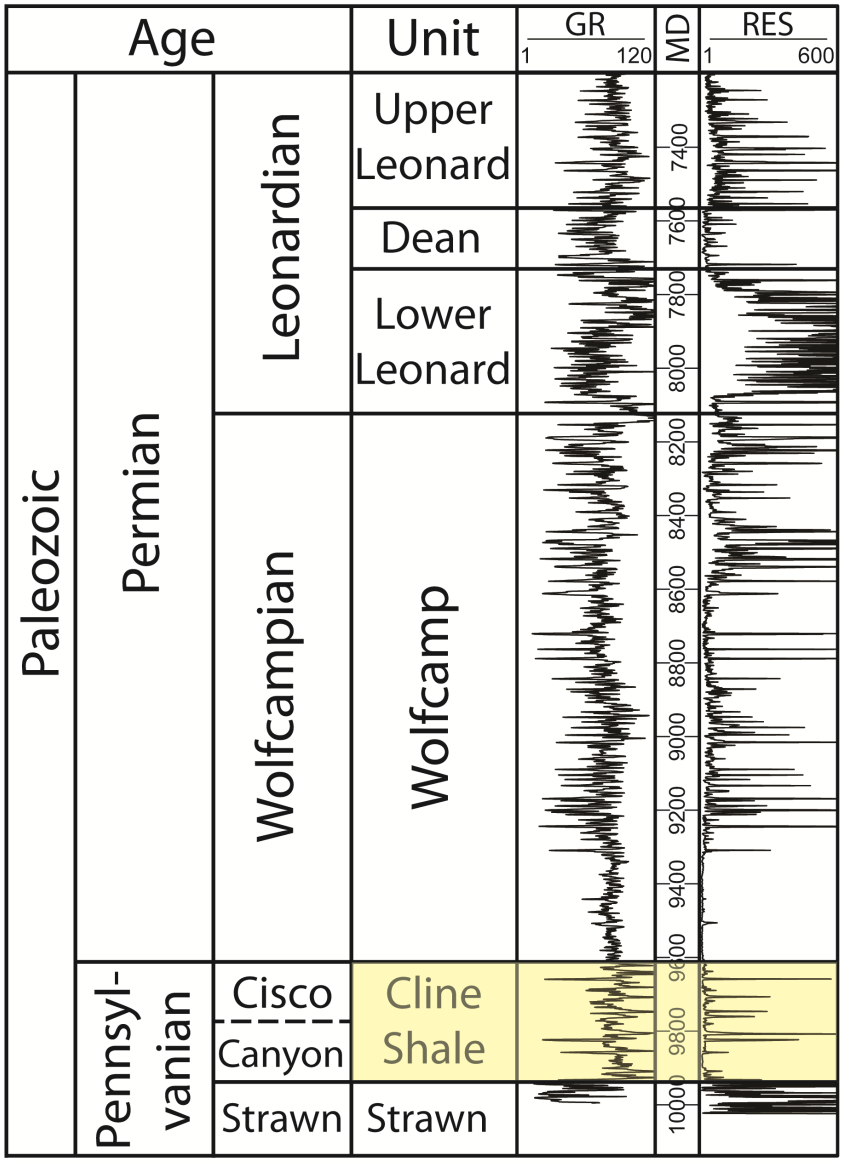

Figure 2. Generalized stratigraphy of the Cline Shale and adjacent productive Upper Pennsylvanian and Lower Permian strata of the Midland Basin, West Texas.

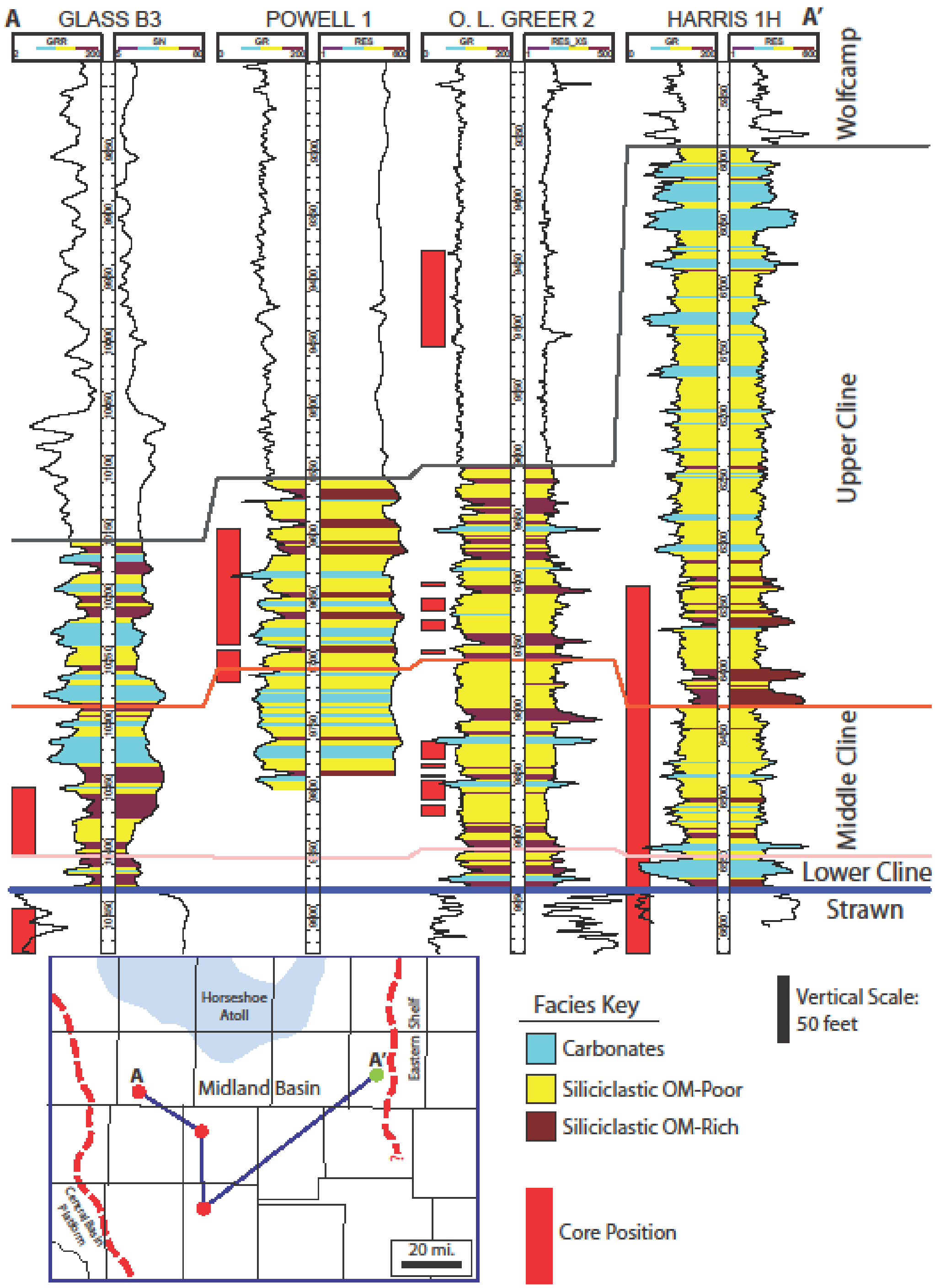

Figure 3. Well logs of the three cored wells from which samples of the Cline Shale were taken: Gulf G. W. Glass #B3, Pan American E. L. Powell #1, and O. L. Greer #2. OM = organic matter.

Geologic Setting and Petroleum Exploration

The Cline Shale is an organic-rich mudrock deposited during the Missourian and Virgilian Epochs of the Upper Pennsylvanian. The Cline Shale was deposited in the Midland Basin, an epicratonic foreland basin of the Marathon-Ouachita orogenic belt and the eastern sub-basin of the greater Permian Basin (Fig. 1) (Yang and Dorobek, 1995). Cline Shale deposition was constrained geographically by the Central Basin Platform to the west, the Horseshoe Atoll to the north, the Eastern Shelf to the east, and the Ozona Arch and Southern Shelf to the south. Productive Cline Shale facies are restricted to basinal mudrocks, although there was considerable siliciclastic and carbonate deposition on the slopes and shelves contemporaneous with Cline deposition (Brown et al., 1990).

The Cline Shale marks the beginning of the transition from the ramp carbonates deposited in the Strawn Group to rimmed platforms ubiquitous on the Eastern Shelf during the Wolfcampian Epoch (Fig. 1) (Mazzullo and Reid, 1988). Paleobathymetric relief from the Eastern Shelf to the Midland Basin increased from 600 ft to at least 2000 ft during Cline and Wolfcamp deposition (Brown et al., 1990). Basin deepening is attributed to an acceleration of subsidence that allowed for sufficient physiographic relief and the development of slope environments (Brown et al., 1973).

Exploration and production success has been varied in the Cline Shale. Apache Corporation reported a 30-day initial production average from 341 to 623 barrels of oil equivalent per day (BOEPD) from four wells in Glasscock County, and Laredo

Petroleum, Inc. reported a 30-day initial production average of 831 to 1,331 BOEPD from five wells also in Glasscock County (Jacobs, 2013). Pioneer Natural Resources has experienced positive results in Andrews County. Their fourth Cline well (Pioneer labels this interval as "Wolfcamp D"), the University 7-43 10H, had a peak initial production of 3,605 BOEPD (Pioneer Natural Resources Company, 2013). The Devon Harris 1H had a 30-day initial production rate of 169 BOEPD. Although multiple successful wells have been drilled in the Cline Shale, the Wolfcamp, on average, is cheaper to produce and has better rates of return (Jacobs, 2013). For this reason and poorly understood variable production rates, the Cline Shale has been treated as a secondary target in developing the Midland Basin unconventional resource plays.

Table 1. Measured vitrinite-reflectance results for oil-shale samples from cores of the Cline Shale in the Midland Basin, West Texas. TOC analyses by Weatherford Laboratories. "Lean" indicates no visible vitrinite.

Clinton O. L. Greer #2 (API # 42383105750000)

Sample depth (ft)	*TOC (%)*	R_o
9700.5	1.997	lean
9715.5	1.418	0.47
9719.8	3.337	lean
9732.5	3.063	0.49
9754.75	1.055	lean
9834.75	1.39	lean
9844.6	1.255	lean
9852	1.207	0.43
9862.75	1.097	lean
9866.25	1.06	lean
9869.25	0.979	lean
9885.75	1.292	lean

Gulf G. W. Glass #B3 (API # 42317000000000)

Sample depth (ft)	*TOC (%)*	*R_o*
10357.9	1.993	lean
10359.7	2.579	0.4
10366.8	2.681	lean
10369.9	1.553	0.44
10377.1	2.326	lean
10386	1.095	lean
10394.7	1.699	lean
10398.3	1.553	lean
10402.2	1.632	lean

Pan American E. L. Powell #1 (API # 42173100000000)

Sample depth (ft)	*TOC (%)*	*R_o*
9599.5	3.809	0.85
9605	3.166	0.41
9612.25	5.601	0.6
9625.75	0.938	0.63
9634.5	0.517	lean
9640	1.095	0.88
9650.5	1.2827	lean
9667.25	4.935	0.36
9674.25	3.595	0.81
9681.5	1.801	lean
9694	1.618	lean
9709.75	0.487	lean
9711.5	2.464	0.5

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