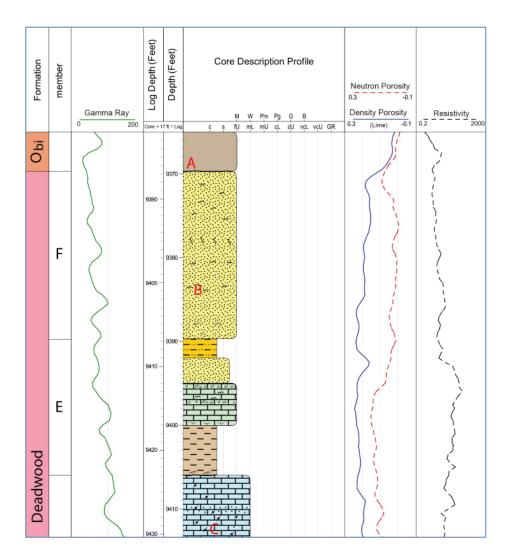
Deadwood Formation (Cambrian/Ordovician) of North Dakota

A Preliminary Core Atlas

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GEOLOGIC INVESTIGATION NO. 257 NORTH DAKOTA GEOLOGICAL SURVEY Edward C. Murphy, State Geologist Lynn D. Helms, Director Dept. of Mineral Resources 2021



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INTRODUCTION

The North Dakota Geological Survey (NDGS) is currently conducting studies of the Cambro-Ordovician Deadwood Formation (Deadwood) because of the increased interest in CO2 storage in underground saline aquifers. This document presents the preliminary results of these studies to release a baseline of information that will be further developed to eventually establish a detailed stratigraphic framework for the Deadwood, and other formations (Inyan Kara and Broom Creek) that are potential candidates for CO2 sequestration. The Deadwood Formation consists of marginal and shallow marine sedimentary units; dominantly thick, porous, and permeable sandstone and limestone that are present at great depths and thus are ideal for CO2 storage.

The Deadwood Formation represents two 3rd-order depositional sequences deposited in an overall 2nd-order transgressive-regressive cycle in the Late Cambrian and Early Ordovician Periods (Figs. 1 and 2). In general, the lower sequence (member A) represents the initial sea-level rise during the Cambrian (Fig. 2A) and consists of fluvial-deltaic and eolian deposits that give way to more marginal marine (Fig. 2B) (member B) and nearshore progradational deposits (members C-F) that shallow upwards as represented by 4 parasequences of the highstand normal regression of the upper sequence (Fig. 2C; Sarnoski, 2015).

This document presents detailed lithologic descriptions from two Deadwood Formation rock cores from the state of North Dakota (NDIC #6624 and NDIC #37672; Fig. 3) that will be expanded as further studies are conducted on additional core. Core was viewed and described at the Wilson M. Laird Core and Sample Library in 2014, November 2020, and August—October 2021. Core profiles including: 1) well information; 2) log responses for gamma-ray, resistivity, neutron porosity, and density porosity (Fig. 2); 3) detailed lithology graphic with generalized description; 4) sequence stratigraphic interpretation; and 5) core photographs, are presented. The logs are best viewed using a computer for optimal viewing and printing on 11x17 paper is recommended for readable graphics.

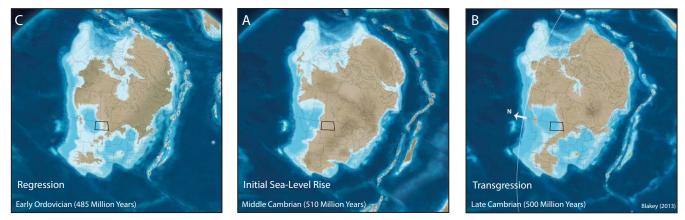


Figure 1. Cambro-Ordovician paleogeographic maps of North America showing transgression and regression of seaway during Deadwood deposition in North Dakota.

REFERENCES

Blakey, R., 2013, North America paleogeography: http://cpgeosystems.com/nam.html.

Sarnoski, A. H., 2015, The stratigraphy and depositional history of the Deadwood Formation, with a focus on Paleozoic subsidence of the Williston Basin: University of North Dakota Theses and Dissertations, https://commons.und.edu/theses/1957.

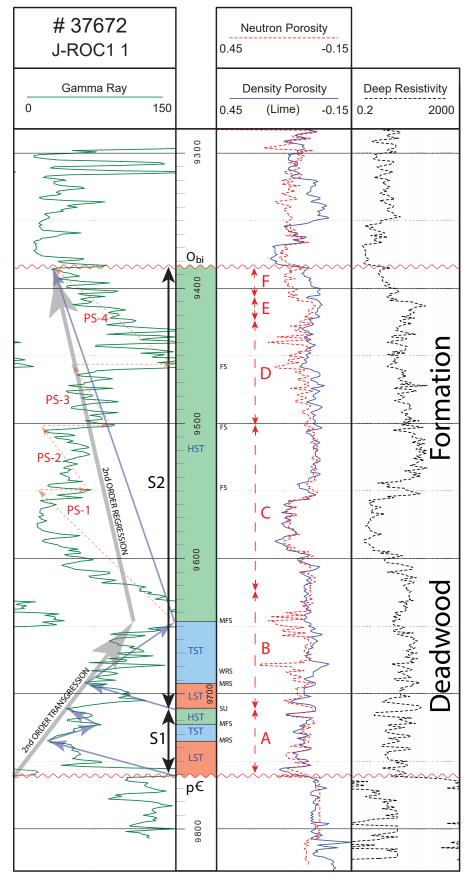


Figure 2. Geophysical logs for the J-ROC1 1 well showing sequence stratigraphic relations and members of the Deadwood Formation.

Legend

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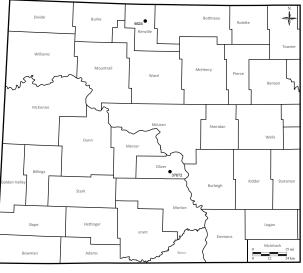
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| Sandstone | | Erosion surface |
|------------------|-------------|----------------------------|
| Siltstone | | Herring-bone cross bedding |
| Shale | (*) | Karst |
| Conglomerate | 000 | Lag |
| Limestone | ~~ | Mud crack |
| Dolostone | \sim | Planolites |
| Schist | ~ | Ripple cross-lamination |
| Anhydrite nodule | / | Rip-up clast |
| Burrow | \bigcirc | Thalassinoides |
| Chondrites | \sim | Unconformity |
| Crinoid | ~~~ | Wavy bedding |
| Cross bedding | \sim | Wavy lamination |
| | | |

- Obi Ordovician Black Island Formation
- p-C Precambrian
- FS Flooding surface
- HST Highstand systems tract
- LST Lowstand systems tract
- MFS Maximum flooding surface
- MRS Maximum regressive surface
- PS Parasequence
- TST Transgressive systems tract S Sequence
- SU Subaerial unconformity
- WRS Wave ravinement surface



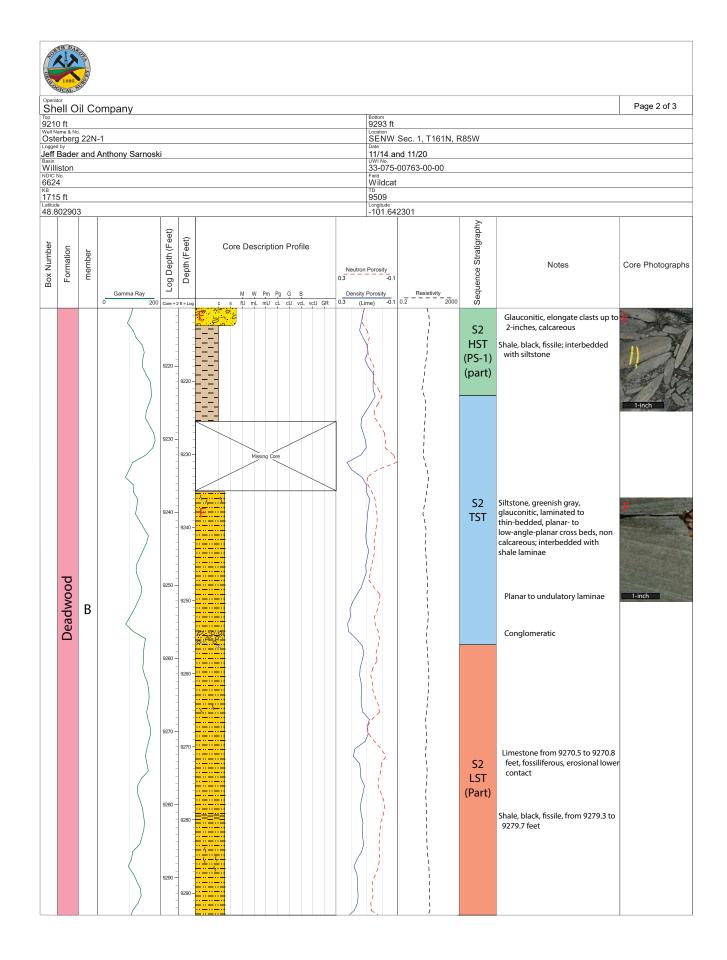
Map Area North Dakota

Explanation Well Location with NDIC number

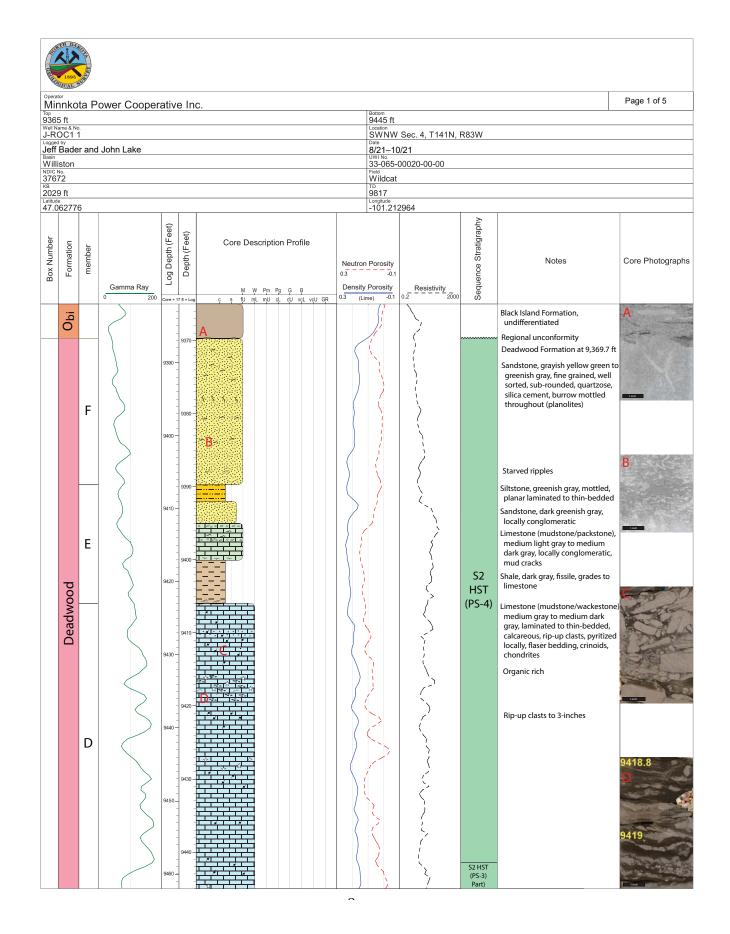
6624

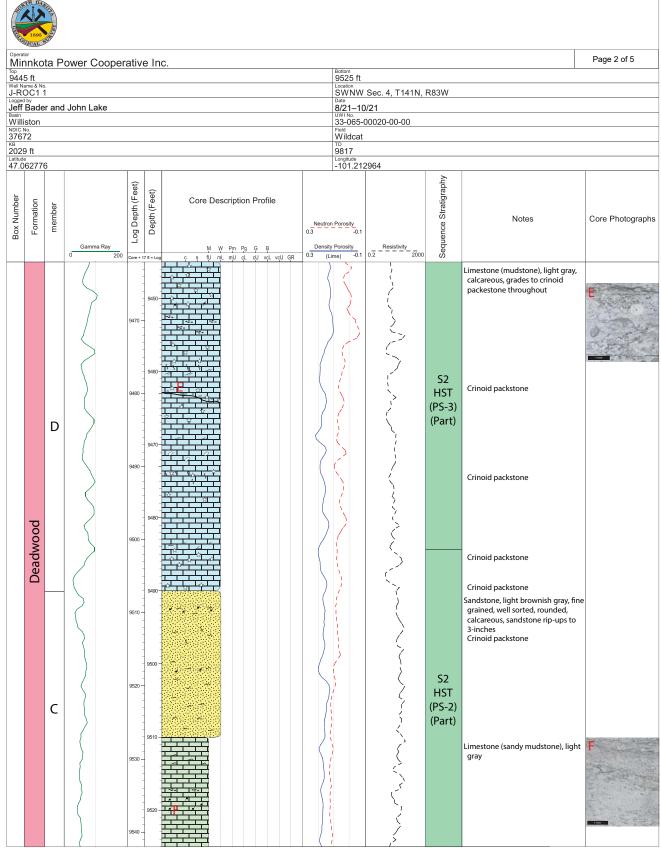
Figure 3. Index map showing well locations.

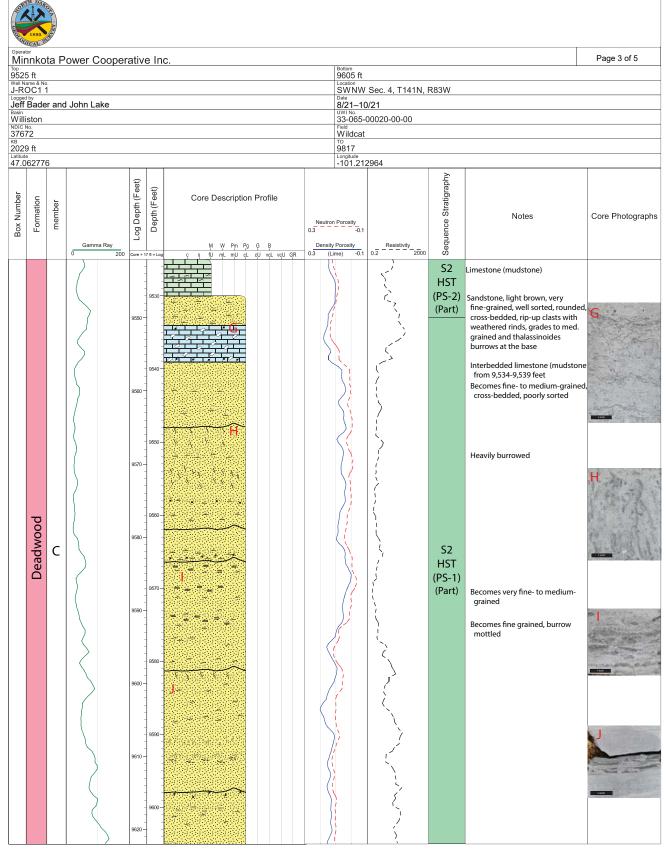
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|------------------|--------------------|--------|------------------|---|---|-------------------------------|----------------------------|--------|---------------------|-------------------------------|---|----------------|
| р 12 ell N | 7.5 ft ame & No | | | | | | Bottom 9210 Location | ft | | | | |
|)ste | erberg | 22N | | | | | SEN | WS | ec. 1, T161N, R | 85W | | |
| eff isin | Bader | and | Anthony Sarnoski | | | | 11/14 | and | 11/20 0763-00-00 | | | |
| 624 | iston No. 4 | | | | | | Field Wildo | | 1763-00-00 | | | |
| 71 | 5 ft | | | | | | 10 10 10 10 | at | | | | |
| titud | 02903 | 3 | | | | I | Longitud | 6423 | 301 | | | |
| BOX NUMBER | Formation | member | Gamma Ray | Log Depth (Feet) | Depth (Feet) | M W Pm Pg G B | Density Porosity | -0.1 | Resistivity | Sequence Stratigraphy | Notes | Core Photograp |
| | | | 0 200 | Core + 2 9130 - | ? ft = Log | c s fU mL mU cL cU vcL vcU GR | 0.3 (Lime) | -0.1 0 | .2 2000 | ŭ | Top of Deadwood Formation at | Δ |
| | Deadwood | с | | 91400 - - - - - - - - - - - - - - - - - - - | 9130 - 9130 - - 9140 - - 9140 - - 9140 - - 9150 - - - - - - - - - - - - - - - - - - - | В | | | | S2 HST (PS-1) (Part) | 9,127.5 feet. Sandstone, light to medium grayish green, to gray, to grayish yellow, fine- to medium-grained, well sorted, well rounded, massive to wavy bedded, heavily bioturbated. Bedding disrupted throughout; where present, planar laminated. Conglomeratic and anhydritic locally Medium- to coarse-grained Heavily bioturbated from 9,170 to 9,180 feet | I-inch |
| | | В | | 9180 - - - - - - - - - - - - - - - - - - - | 9180 | | | | | | Siltstone, planar laminated, heavily bioturbated Sandstone interbeds Sandstone interbeds Sandstone, light olive gray, very fine- to fine-grained, well sorted, planar- to low-angle cross bedding, glauconitic, shaley interlaminations | 1-inch |

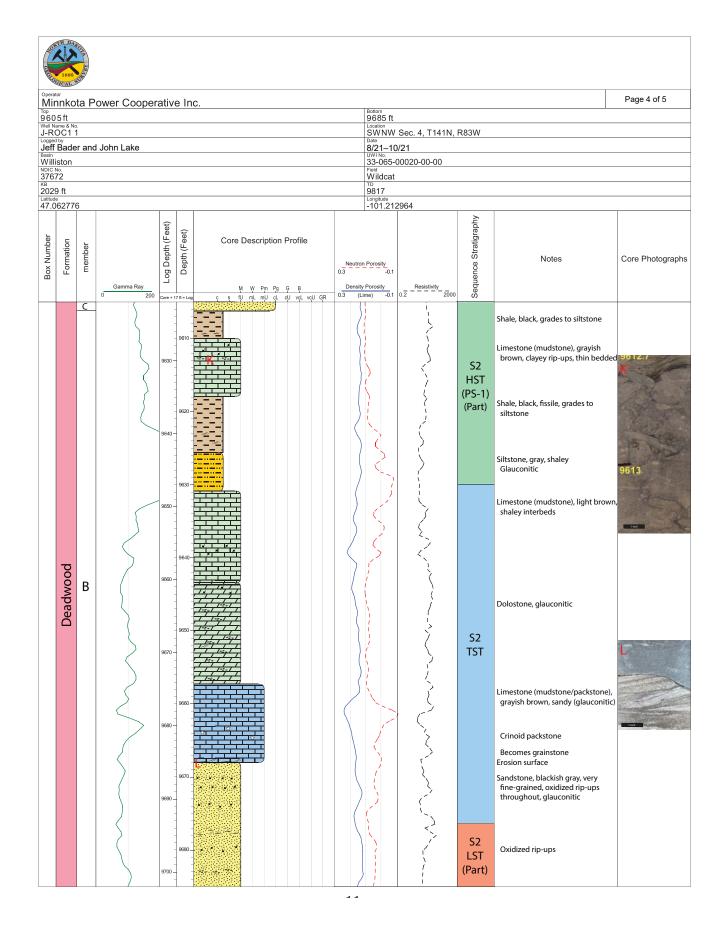


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| ^{Opera} | ell O | oil Co | ompany | | | | | | | | | | | Page 3 of 3 |
| Top 929 | 3 ft | | | | | | | | Bottom 9310.2 | ft | | | | |
| | lame & No erberg | | -1 | | | | | | Location SENW Date | / Se | ec. 1, T161N, F | R85W | | |
| Jeff | Bade | r and | Anthony Sarnosk | ci 👘 | | | | | 11/14 a | | | | | |
| Wil | iston | | | | | | | | 33-075 | 5-00 | 763-00-00 | | | |
| 662 кв | 4 | | | | | | | | Wildca | it | | | | |
| 171 Latitud | ie | | | | | | | | 9509 Longitude -101.6 | | | | | |
| 48.8 | 30290: | 3 | | | | | | | -101.6 | 423 | 01 | ~ | | |
| Box Number | Formation | member | Gamma Ray | Log Depth (Feet) | Depth (Feet) | W Pm | Pg G | B | Neutron Porosity 0.3 -0. | | | Sequence Stratigraphy | Notes | Core Photographs |
| | p€ Deadwood | B | | Core + : - - 9300 - - - - - - - - - - - - - - - - - - - | 2 ft = Log 9300- 9300- 9310- | <u>nL mU (</u> | | cL vcU GR | 0.3 (Lime) -0. | 1 0.2 | | on sz LST (part) S1 HST S1 TST S1 LST | Siltstone Subaerial Unconformity Sandstone, reddish brown, very-fine- to coarse-grained, poorly sorted, subangular to subround, massive to thin-bedded, oxidized Siltstone Conglomerate, light to medium brown, very fine- to coarse-grained, poorly sorted, subangular to subround, quartzose Regional Unconformity/Basement Gneiss | l-inch |









| Top 9688 Well N J-RC Jeff Basin Will NDIC 1 376 KB 2029 | nnko 5 ft OC1 ' ^{d by} Bade iston ^{No.} 72 | er and | ower Cooper | ativ | e In | <u>C.</u> | Loc SV Dat 8// UW 33 Fiel VW TD 7D | <u>000</u> 21–10 | Sec. 4, T141N, 0/21 00020-00-00 | R83W | | Page 5 of 5 |
|---|---|--------|--------------------|--|--------------|--------------------------|---|---------------------|---|-------------------------------------|---|------------------|
| Box Number | Formation | member | Gamma Ray 0 200 | Log Depth (Feet) | Depth (Feet) | Core Description Profile | Neutron Poi 0.3 Density Por | rosity0.1 | 2964 | Sequence Stratigraphy | Notes | Core Photographs |
| | Deadwood | В | | 9720 - 9770 - 97 | 9700 | | | | | S1 HST S1 HST S1 LST | Sandstone, grayish green, very fine-grained Subaerial Unconformity Limestone (mudstone), brownish gray, calcareous, planar laminatec calcite cement filling voids Karst | |
| | θ | | | 9750 - - - - - - - - - - - - - - - - - - - | 9740- | | | | | LST | Glauconitic to base Regional Unconformity/Basement Gneiss | 0, 9748 |