Plains CO_2 Reduction (PCOR) Partnership

BLACK ISLAND FORMATION OUTLINE

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EXECUTIVE SUMMARY

The Williston Basin is a relatively large, intracratonic basin with a thick sedimentary cover in excess of 16,000 ft. It is considered by many to be tectonically stable, with only a subtle structural character. The stratigraphy of the area is well studied, especially in those intervals that produce oil.

The basin has significant potential as a geological sink for sequestering carbon dioxide (CO_2). This topical report focuses on the general geological characteristics of the Black Island Formation that are relevant to potential sequestration in petroleum reservoirs and deep saline formations.

This report includes general information and maps on formation stratigraphy, lithology, depositional environment, and hydrodynamic characteristics. The Black Island Formation in the Williston Basin is considered to be a potential sink for long-term sequestration of CO_2.

ACKNOWLEDGMENTS

The Plains CO_2 Reduction (PCOR) Partnership is a diverse group of public and private sector stakeholders working toward a better understanding of the technical and economic feasibility of capturing and storing (sequestering) CO_2 emissions from stationary sources in the central interior of North America. It is one of seven regional partnerships funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory Regional Carbon Sequestration Partnership Initiative, which represents more than 350 organizations in 41 states, three Indian nations, and four Canadian provinces. DOE is focused on understanding the opportunities and issues associated with CO_2 sequestration.

The PCOR Partnership represents public agencies, utilities, oil and gas companies, engineering firms, associations and nonprofit organizations, and universities (see PCOR Partnership list below). The Energy & Environmental Research Center (EERC) would like to thank the following partners who have provided funding, data, guidance, and/or experience to support the PCOR Partnership:

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- North Dakota Industrial Commission Oil and Gas Research Council
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INTRODUCTION

Formation outlines have been prepared as a supplement to the "Overview of Williston Basin Geology as It Relates to CO_2 Sequestration" (Fischer et al., 2004). Although the stratigraphic discussion presented in the overview is in a convenient format for discussing the general characteristics of the basin, it does not provide insight into the specific characteristics of every formation. A formation outline summarizes the current knowledge of the basic geology for each formation. If not specifically noted, the formation boundaries and names reflect terminology that is recognized in the North Dakota portion of the Williston Basin. The intended purpose of the formation outline is to provide a convenient basis and source of reference from which to build a knowledge base for more detailed future characterization. The development of sequestration volume estimates and rankings are beyond the scope of the formation outline.

FORMATION NAME

Black Island Formation

Williston Basin stratigraphic nomenclature follows that recognized by the North Dakota Geological Survey as summarized in the North Dakota Stratigraphic Column (Bluemle et al., 1986) and the Williston Basin stratigraphic nomenclature chart (Bluemle et al., 1981) (Figure 1).

FORMATION AGE (LeRud, 1982)

Middle Ordovician Period (Figure 1)
Blackriverian Epoch
Winnipeg Group

GEOLOGICAL SEQUENCE

Tippecanoe

HYDROSTRATIGRAPHY (Figure 1)

AQ1 Aquifer (Downey et al., 1987)

GEOGRAPHIC DISTRIBUTION (Modified from LeRud, 1982)

Williston Basin; southern Manitoba, eastern Montana, North Dakota, southern Saskatchewan, western South Dakota

THICKNESS

The Black Island Formation reaches a thickness in excess of 260 ft in north-central North Dakota (Figure 2).

CONTACTS

The upper contact is conformable with the Icebox Formation. The lower contact is unconformable with the Deadwood.

LITHOLOGY

Clastic; sandstone, siltstone, and shale

SUBDIVISIONS

Informally divided into a lower and upper member (Figure 3) (Thompson, 1984). In 1995, Ellingson and LeFever proposed to name the lower member, the Hawkeye Valley Member, and the upper member, the Garland Member.

LITHOFACIES (Ellingson and LeFever, 1995)

The lower member (Hawkeye Valley Member) comprises two lithofacies, a basal red-bed lithofacies containing quartz arenites and "clayshales" and an upper green quartz wacke.

The upper member (Garland Member) is further subdivided into two lithofacies, a quartz arenite and green quartz wacke.

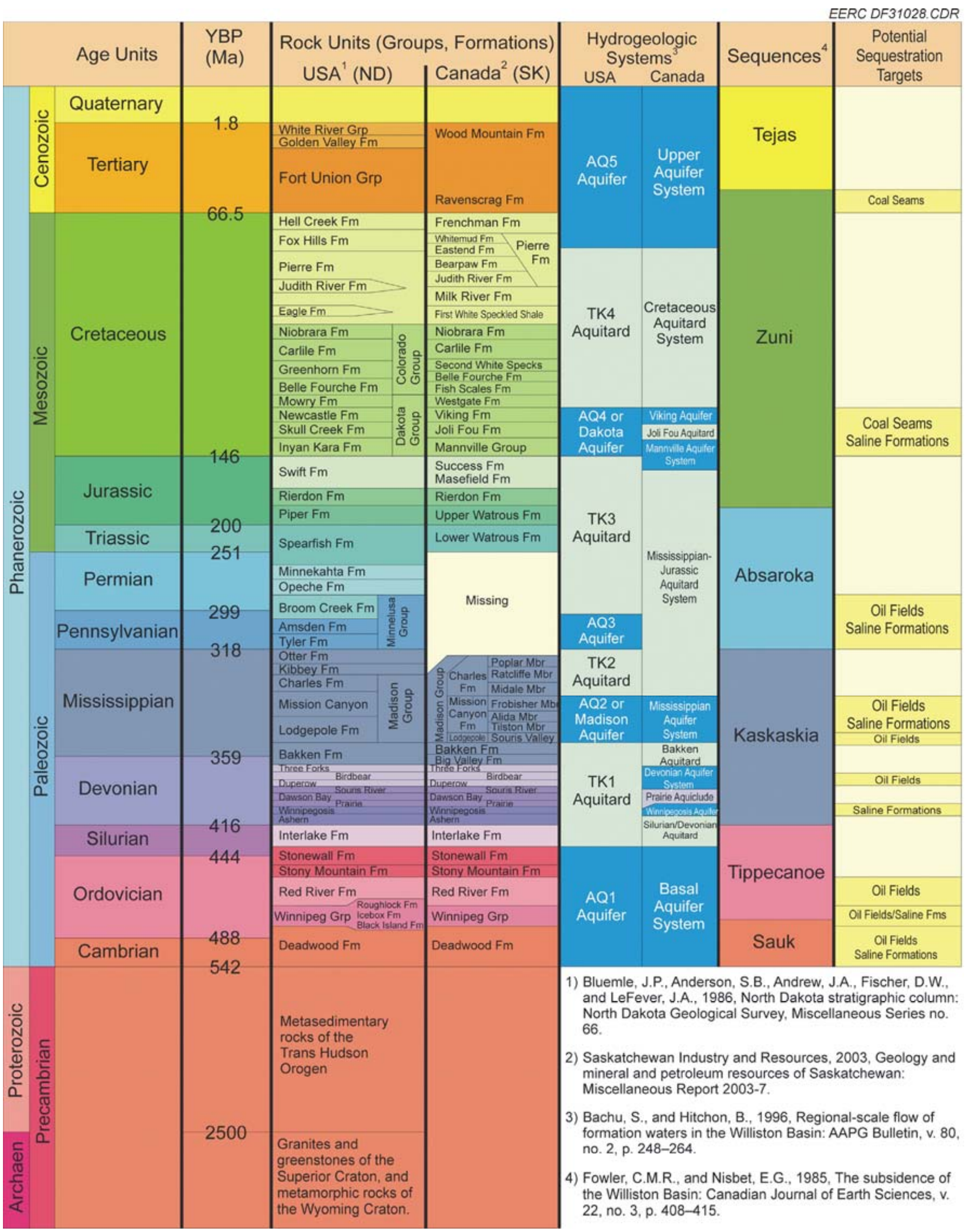

Figure 1. Williston Basin stratigraphic and hydrogeologic column.

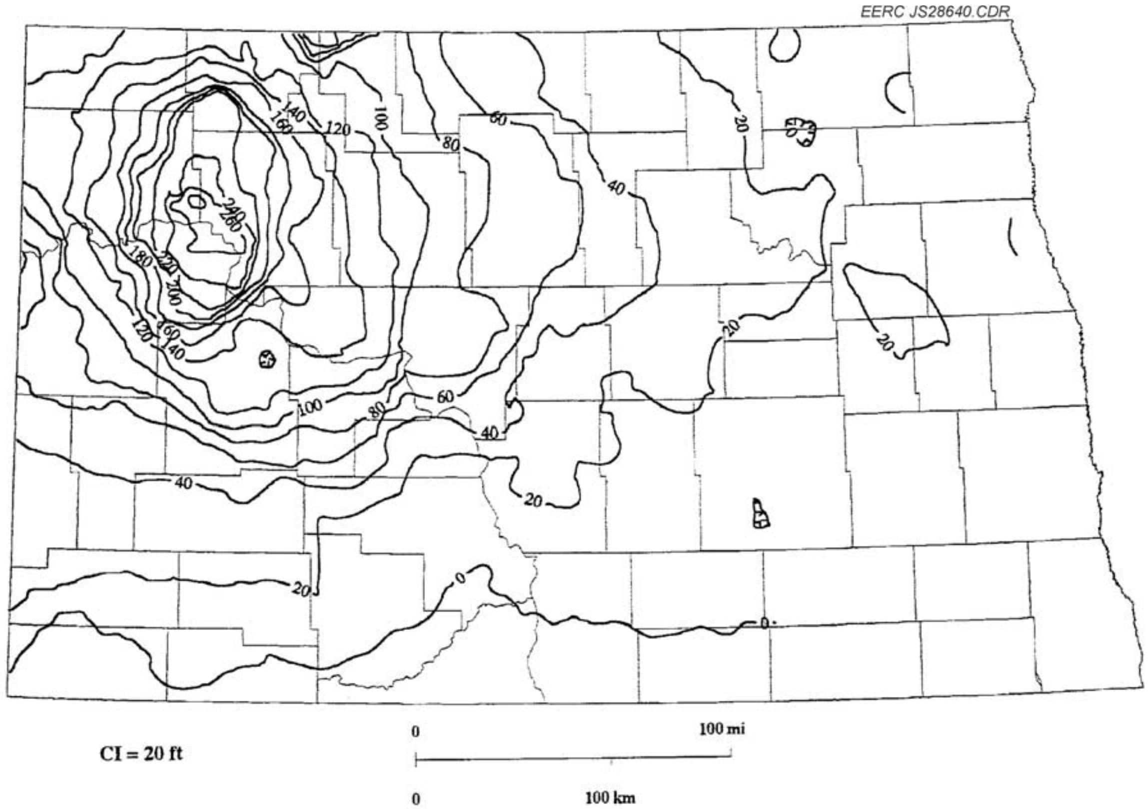

Figure 2. Black Island isopach (Ellingson and LeFever, 1995).

DEPOSITIONAL ENVIRONMENT

Marine to shallow marine

DEPOSITIONAL MODEL

Black Island sediments record the initial transgressive phase of the Tippecanoe Sequence. Tippecanoe sedimentation begins with the Williston Basin connected to the ocean through a southwest trending seaway (Foster, 1972). Sedimentation is recorded by the formations of the Winnipeg Group.

RESERVOIR CHARACTERISTICS (Vinopal and Edington, 1988)

From Vinopal and Edington, 1988.

- Porosity can be in excess of 10%.
- Permeabilities on occasion can approach 100 mD.

HYDRODYNAMIC CHARACTERISTICS (AQ4) (Downey, 1986)

From Downey, J.S., 1986, Geohydrology of bedrock aquifers in the Northern Great Plains in parts of Montan, North Dakota, South Dakota, and Wyoming, U.S. Geological Survey Professional Paper P 1402-E, p. E1–E87.

If hydrodynamic flow exists, it should be from outcrop positions in the Black Hills, northeast into the basin (Figures 4–6).

HYDROCARBON PRODUCTION

In North Dakota, the Winnipeg Group is productive on the Nesson Anticline and at Richardton and Taylor Fields on the

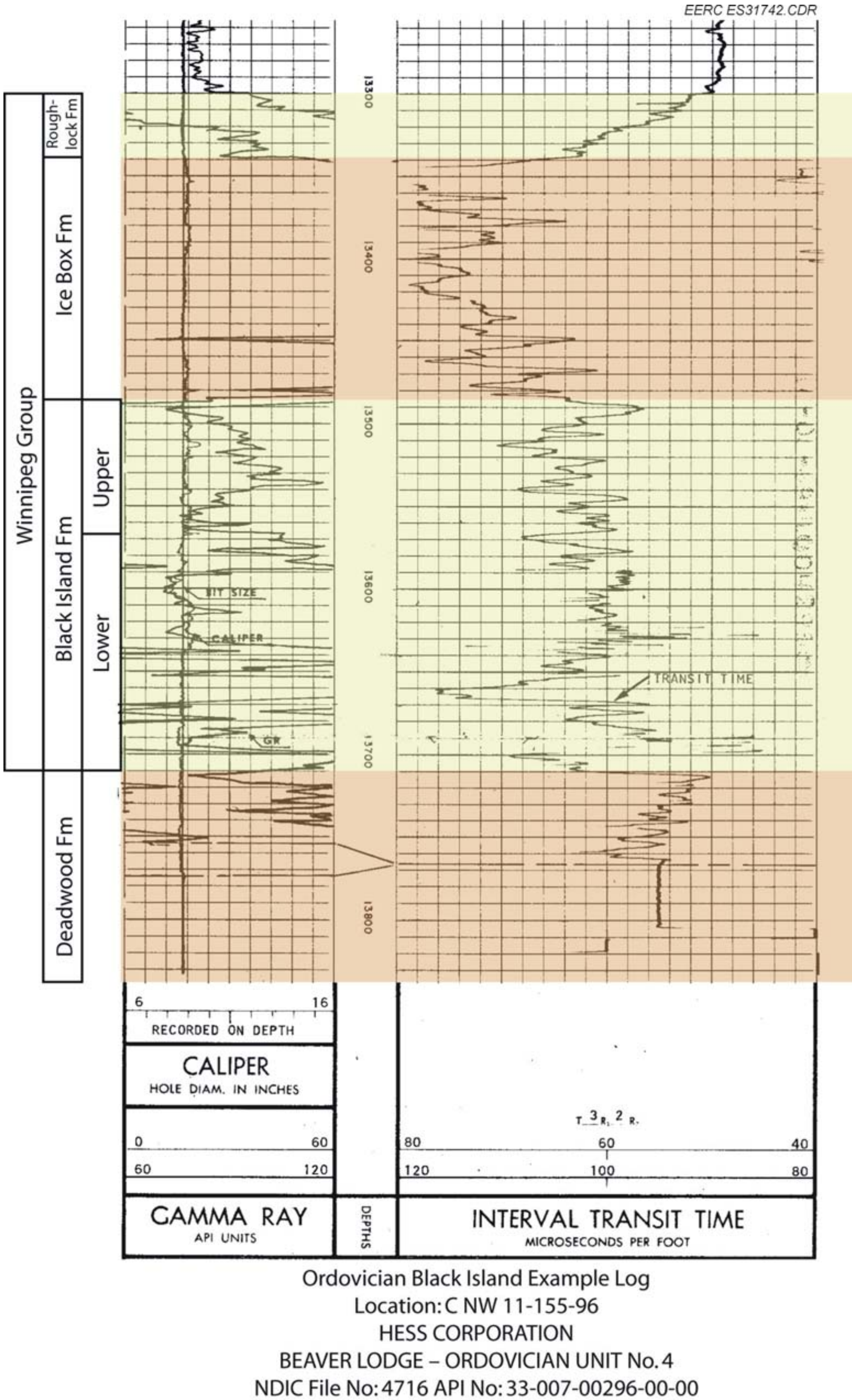

Figure 3. Ordovician Black Island example log.

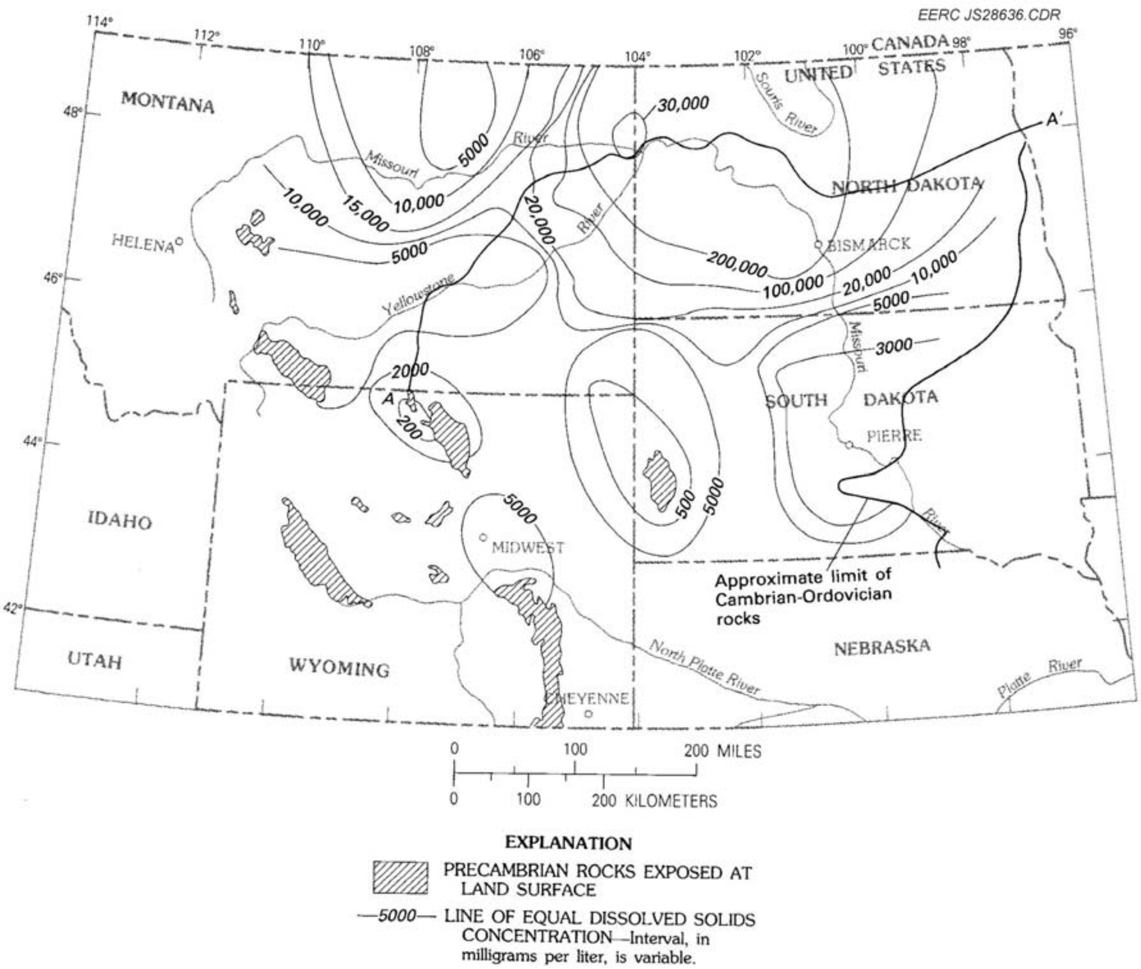

Figure 4. Concentration of dissolved solids in water from the Cambrian–Ordovician Aquifer.

Heart River Anticline in eastern Stark County.

SINK POTENTIAL

The Icebox Formation exhibits both conventional and unconventional sink potential. Where 'clean' quartz arenites are porous and permeable, conventional waste storage could be high.

A series of nearby vertical traps can be demonstrated for the Icebox Formation. Locally, individual clay lithofacies add a component of trapping. Such clay lithofacies can be identified from well logs.

Regionally, the Icebox Formation of the Winnipeg Group (commonly referred to as the Winnipeg Shale) acts as a trap. The Icebox, primarily a shale, is present throughout most of North Dakota.

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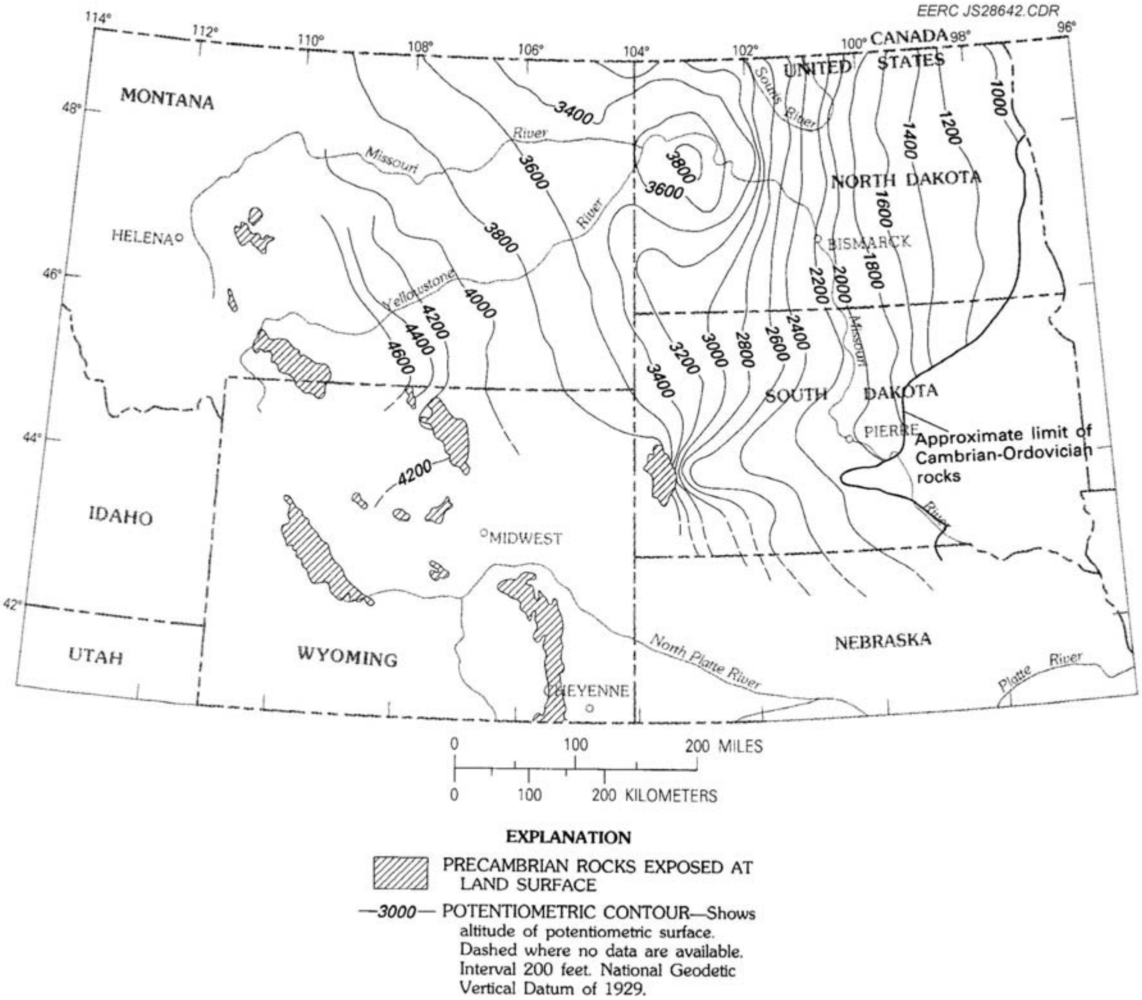

Figure 5. Simulated potentiometric surface of the Cambrian–Ordovician Aquifer.

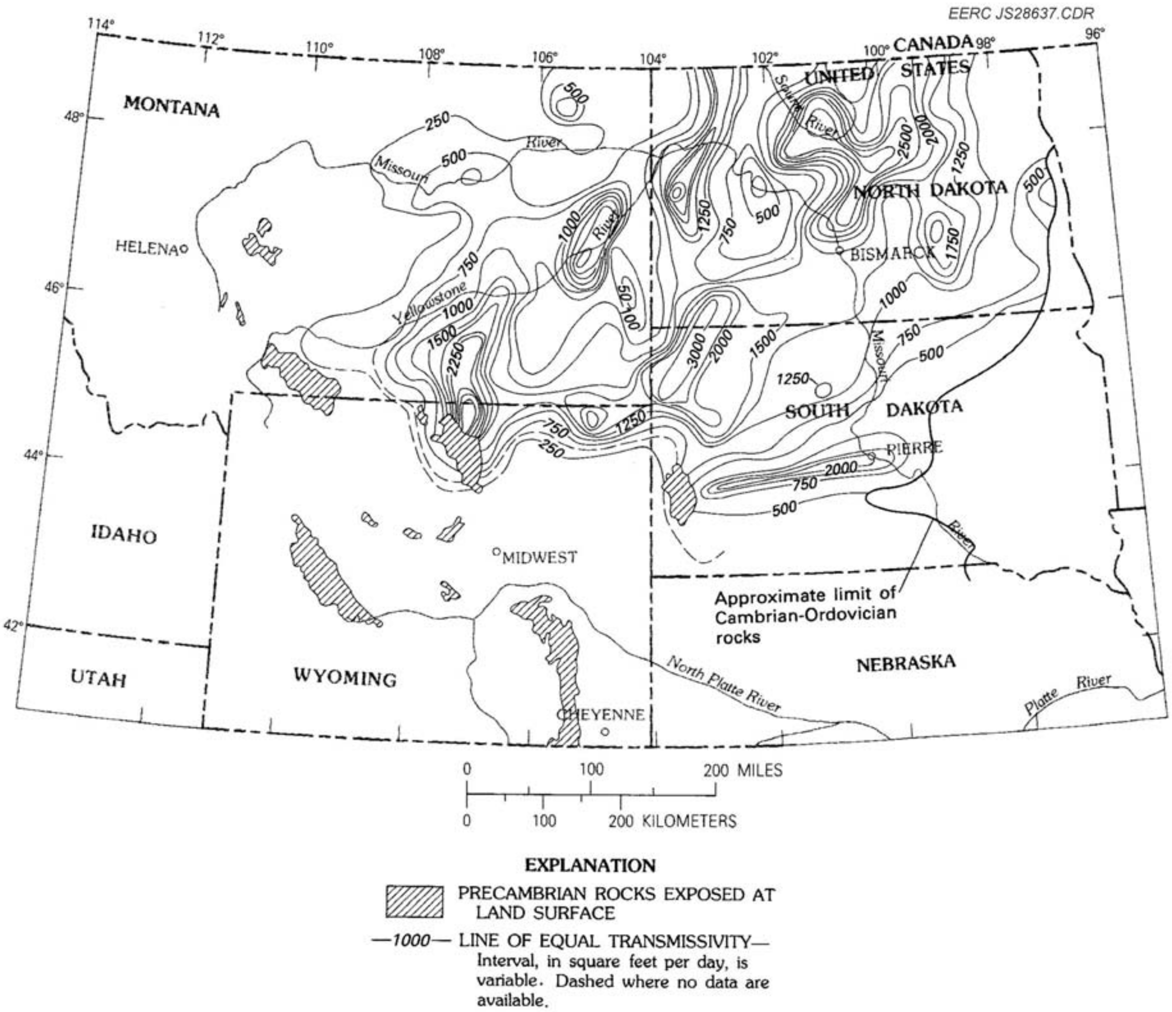

Figure 6. Water temperatures in the Cambrian–Ordovician Aquifer.

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