

# Sandy Lithofacies within the Icebox Formation (Ordovician), North Dakota and Montana

Richard D. LeFever<sup>1</sup> and Julie A. LeFever<sup>2</sup>

<sup>1</sup>University of North Dakota, <sup>2</sup>North Dakota Geological Survey



The Winnipeg Group (Ordovician) represents the initial mid-Ordovician transgression in the northern Great Plains. The Icebox Fm (Ordovician) is the middle of three formations within the Winnipeg Group, underlain by the sandstones and siltstones of the Black Island Fm, and grading up into argillaceous carbonates of Roughlock Fm. It is a regionally extensive shale, typically dark green to black, and reaches a maximum thickness of about 190 ft (58m) in the center of the basin.



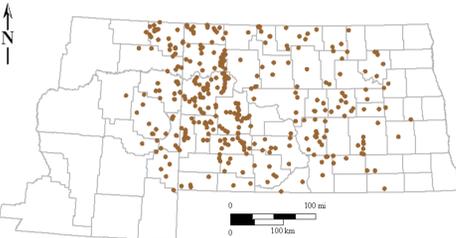
Stratigraphic nomenclature of the Winnipeg Group

The area of study included all of North Dakota, and Montana from the eastern boundary west to about longitude 106W. Wireline gamma-ray logs were digitized and examined for evidence of coarser intervals within the Icebox Fm. Of the more than 400 wells which were deep enough, only 365 had usable gamma-ray traces.

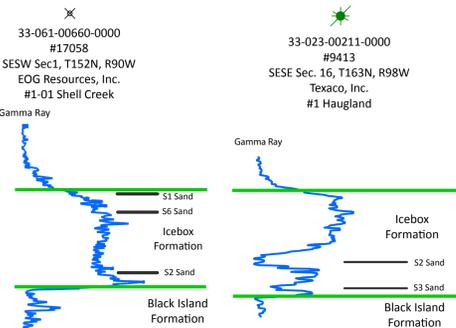
A total of 40 sandy lithofacies were identified in the study area; they were arbitrarily designated S1 - S40. Five have regional extent, and cover most of the study area. These major bodies have a maximum thickness of at least 20 ft (6 m), and one is 72 ft (22 m) at its thickest. Although typically 5-10 ft thick over much of North Dakota, the major bodies, with one exception, tend to thicken westward, and their greatest known thicknesses occur near their western limits.

Five additional sand bodies each extend across several 10s of miles, and have maximum thicknesses ranging from 10 ft (3 m) to 23 ft (7 m). These extensive sand bodies average somewhat thinner than the major bodies, but show no obvious thickness trends.

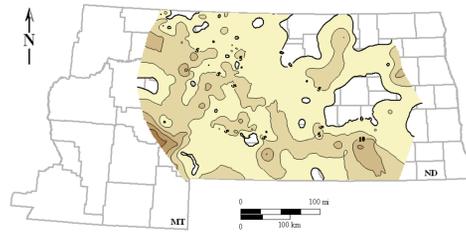
The remaining 30 identifiable bodies are of only local extent, and typically are evident in only a few wells.



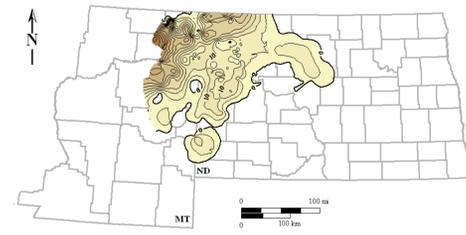
Locations of wells used in this study.



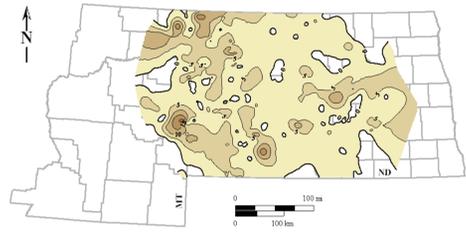
Example gamma-ray traces and sandy units



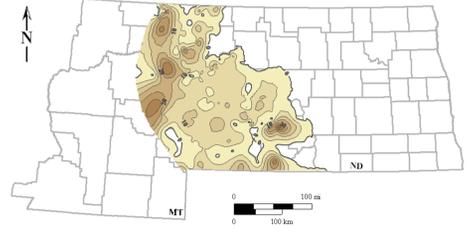
Distribution and thickness of sandy unit S1



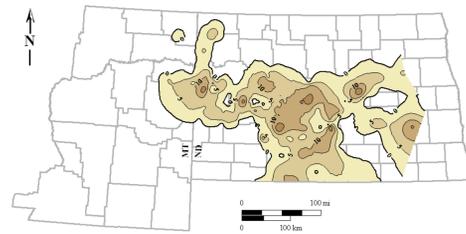
Distribution and thickness of sandy unit S2



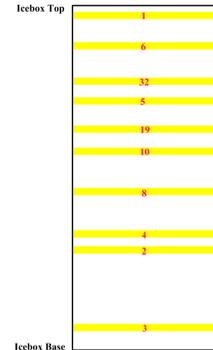
Distribution and thickness of sandy unit S3



Distribution and thickness of sandy unit S5

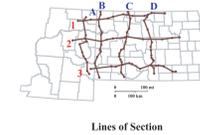


Distribution and thickness of sandy unit S6

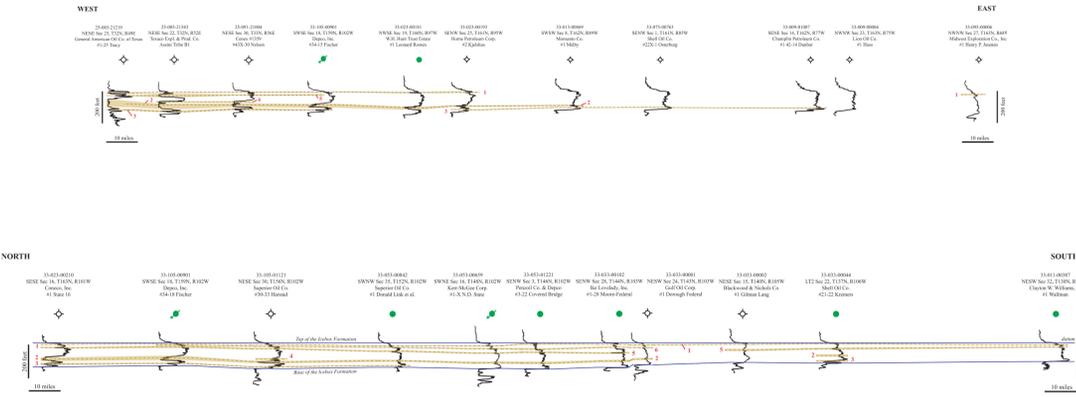


The Icebox Formation was deposited in a marine environment, seaward of the nearshore environments. Normal marine conditions are indicated by the invertebrates present; the high degree of bioturbation indicates that oxidizing conditions existed for at least the upper part of the substrate. The depth of water is uncertain, but the presence of several sandy lithosomes may indicate that depths were not great. The lack of coarse material may reflect distance from shore rather than water depth.

Approximate stratigraphic positions of the major and extensive sand bodies within the Icebox Fm.



Lines of Section

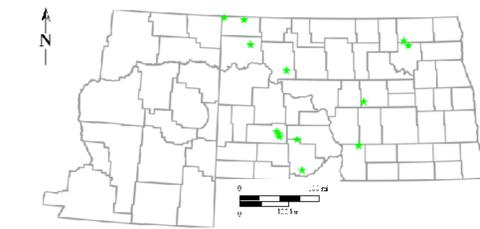


Cross-sections 1 (E-W) and B (N-S)

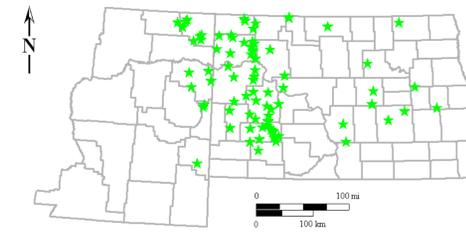
Only 13 cores have penetrated the sandy bodies in the Icebox Formation in North Dakota, largely in the lower part of the formation. Based on the existing cores, it appears that the sandy lithofacies probably represent intervals of bioturbated sandstone and siltstone within the shallier Icebox Formation.

Formation tests on the Winnipeg Group, including both drill stem tests and production tests, have been reported on 85 wells in North Dakota and eastern Montana. Of the 85 tests, 43 reported gas from the Winnipeg, and 9 reported oil. The Winnipeg Group has produced from 14 wells in seven fields in North Dakota. Not all of the wells are still active producers. All of the production is from the Black Island Formation, below the Icebox. Although there is minor oil production, the wells are primarily gas producers. There appears to have been no Winnipeg production in Montana.

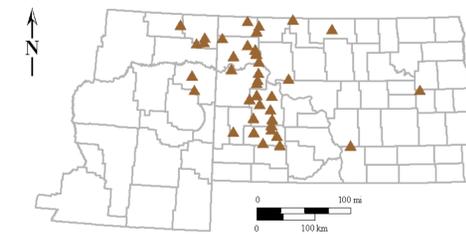
One core of the Icebox Formation in eastern Montana has been tested (Amerada Hess Federal #36-44, SESE Sec. 36, T32N R54E, Sheridan County). The core was taken in the lower Icebox and includes all of sand body S2 and a small part of sand S3. Reported permeabilities averaged about 21 md (.01 - 90 md), and porosity averaged 7.3% (2.5 - 12.1%). Oil saturation ranged from 0 to 28.7% (average 7.3%), and water saturation from 4.7% to 43.7% (average 20.4%).



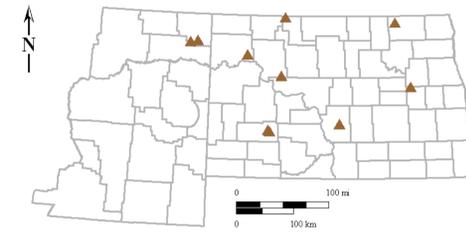
Locations of cores which penetrated sandy bodies within the Icebox Formation



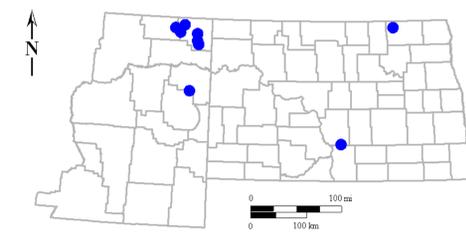
Locations of wells in which the Winnipeg Group was tested.



Locations of wells reporting gas in Winnipeg tests



Locations of wells reporting oil in Winnipeg tests



Locations of wells in which the Icebox Formation was tested

Production tests were run on the Icebox in two wells in Sheridan County, Montana. In both cases, the tested interval was in a thick section of one of the sandy units.

Most of the reported tests were done on the Black Island Formation, or on an interval which included the Black Island and some of the overlying Icebox, or some of the underlying Deadwood Formation. Nine tests were done on the Icebox Formation. Of the nine, four reported gas and three reported oil. Five of the nine, all in eastern Montana, appear to have tested the sand bodies in the Icebox; one test reported oil, one gas, and one both.

On balance, it seems likely that the Icebox Formation, particularly the sand bodies, has some oil and gas potential. The sand bodies have only been tested in five locations in eastern Montana. Large areas of sand body occurrence are entirely untested. The sand bodies are good candidates for reservoir rock, and interbedding with an extensive source rock may have allowed generated hydrocarbons to accumulate in the sand bodies. Any production from the Icebox will probably be predominantly gas.

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