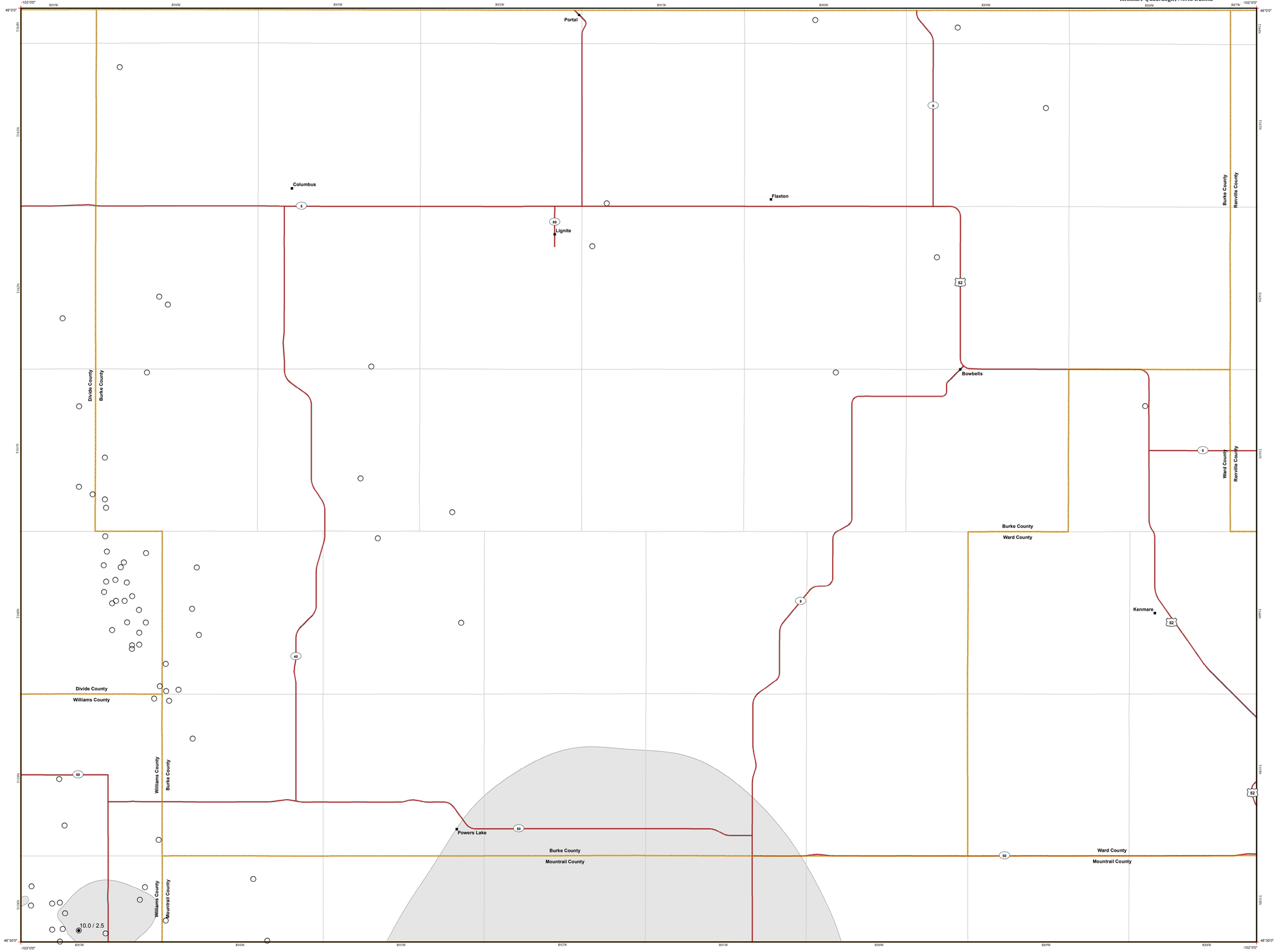
North Dakota Geological Survey
Geological Investigation No 215 - Sheet 1 of 6

K_2O Grades of the White Lake Member of the Prairie Formation

Kenmare 100K Sheet, North Dakota

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources



Ned W. Kruger

2019

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The White Lake Member was identified on the geophysical logs of 4 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average (K_2O) concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the White Lake Member represented by this sheet is approximately 10,700 acre feet.

Legend

Thickness (ft)

- 0
- 1-3

Symbols

- Well Control
- 10.0/2.5 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

Scale 1:100,000

0 1 2 3 4 Miles

0 1 2 3 4 Kilometers

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"W

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa

North Dakota Geological Survey
Geological Investigation No 215 - Sheet 2 of 6

K_2O Grades of the Mountrail Member of the Prairie Formation

Kenmare 100K Sheet, North Dakota

Kenmare Quadrangle, North Dakota

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

Ned W. Kruger

2019

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The Mountrail Member was identified on the geophysical logs of 21 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average (K_2O) concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the Mountrail Member represented by this sheet is approximately 987,000 acre feet.

Legend

Thickness (ft)

- 0
- 1-3
- 4-6
- 7-9

Symbols

- Well Control
- 10.2/4.5 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

- White Lake Mbr.
- Mountrail Mbr.
- Patience Lake Mbr.
- Belle Plaine Mbr.
- White Bear Mbr.
- Esterhazy Mbr.

Scale 1:100,000

0 1 2 3 4 Miles

0 1 2 3 4 Kilometers

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"W

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

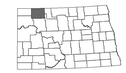
Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa

North Dakota Geological Survey
Geological Investigation No 215 - Sheet 3 of 6

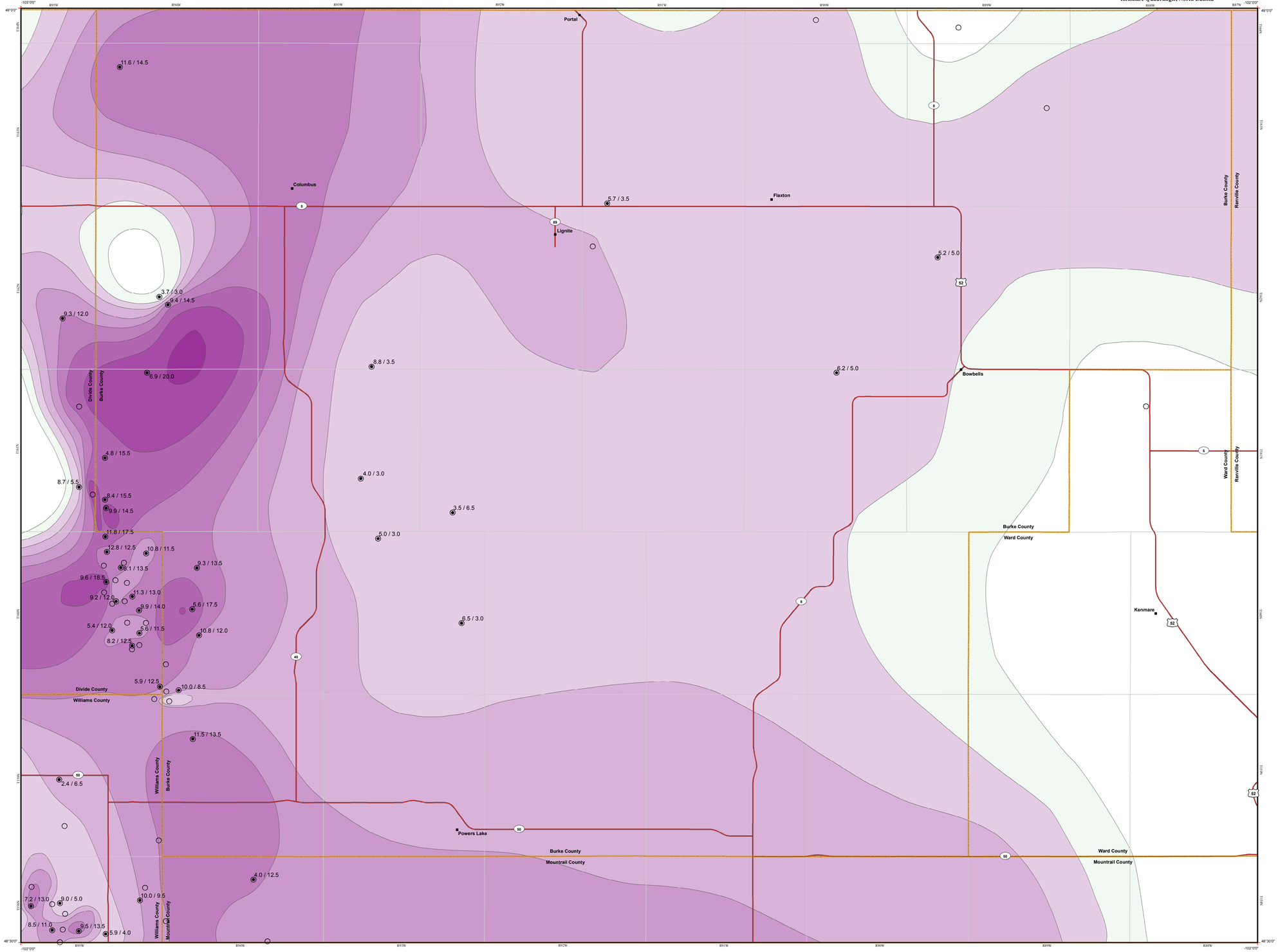
K_2O Grades of the Patience Lake Member of the Prairie Formation

Kenmare 100K Sheet, North Dakota



Kenmare Quadrangle, North Dakota

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources



Ned W. Kruger

2019

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The Patience Lake Member was identified on the geophysical logs of 72 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average (K_2O) concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

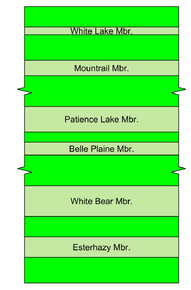
When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the Patience Lake Member represented by this sheet is approximately 6,161,000 acre feet.

Legend

Thickness (ft)

- 0
- 1-3
- 4-6
- 7-9
- 10-12
- 13-15
- 16-18
- 19-21
- 21-24



Symbols

- Well Control
- 3.5/6.5 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

Scale 1:100,000

Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"W

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa

North Dakota Geological Survey
Geological Investigation No 215 - Sheet 4 of 6

K_2O Grades of the Belle Plaine Member of the Prairie Formation

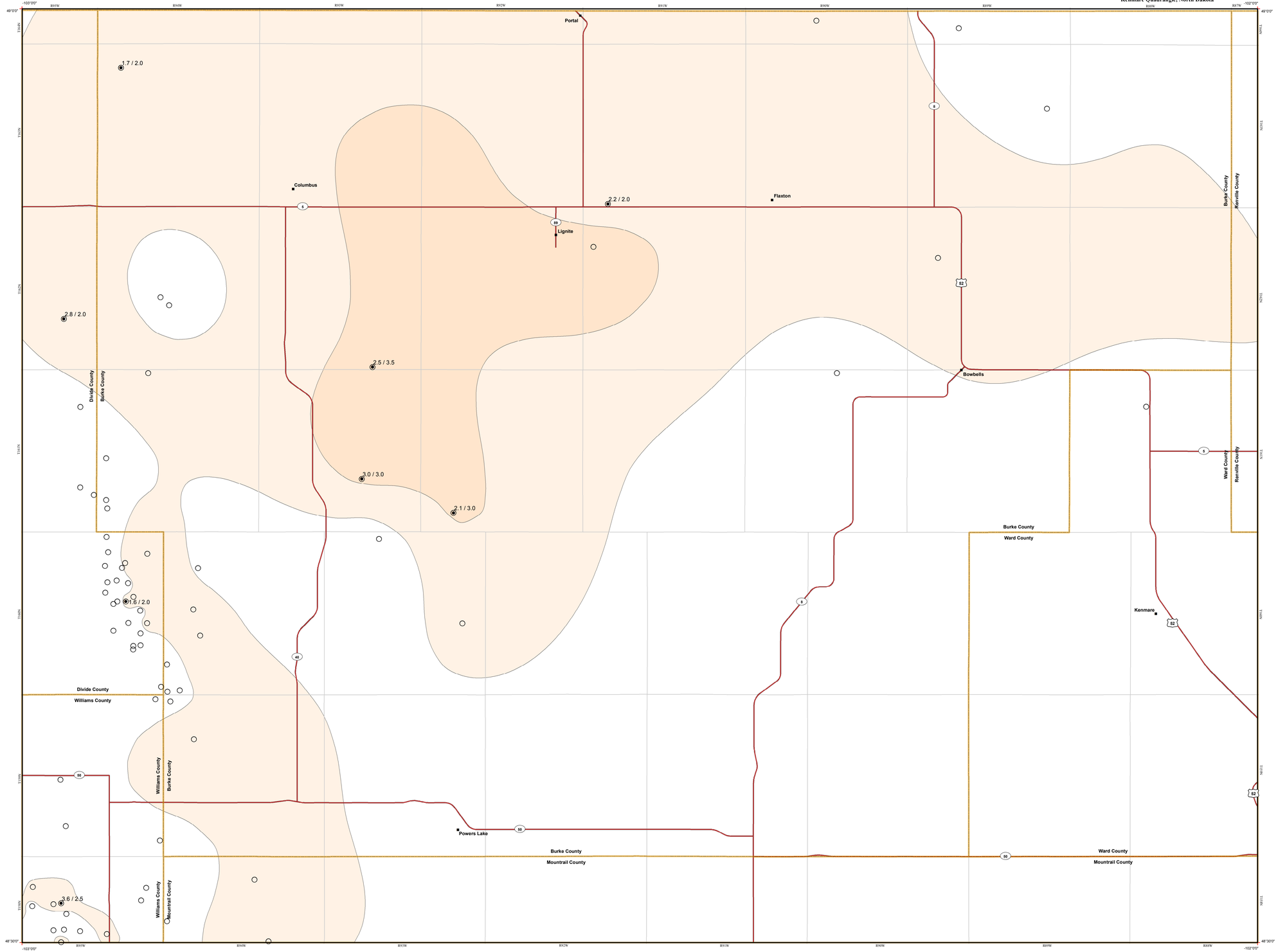
Kenmare 100K Sheet, North Dakota

Kenmare Quadrangle, North Dakota

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

Ned W. Kruger

2019



Legend

Thickness (ft)

- 0
- 1-3
- 4-6

Symbols

- Well Control
- 2.5/3.5 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

N
W
E
S

Scale 1:100,000

0 1 2 3 4
Miles

0 1 2 3 4
Kilometers

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"W

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The Belle Plaine Member was identified on the geophysical logs of 26 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average (K_2O) concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the Belle Plaine Member represented by this sheet is approximately 489,000 acre feet.

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

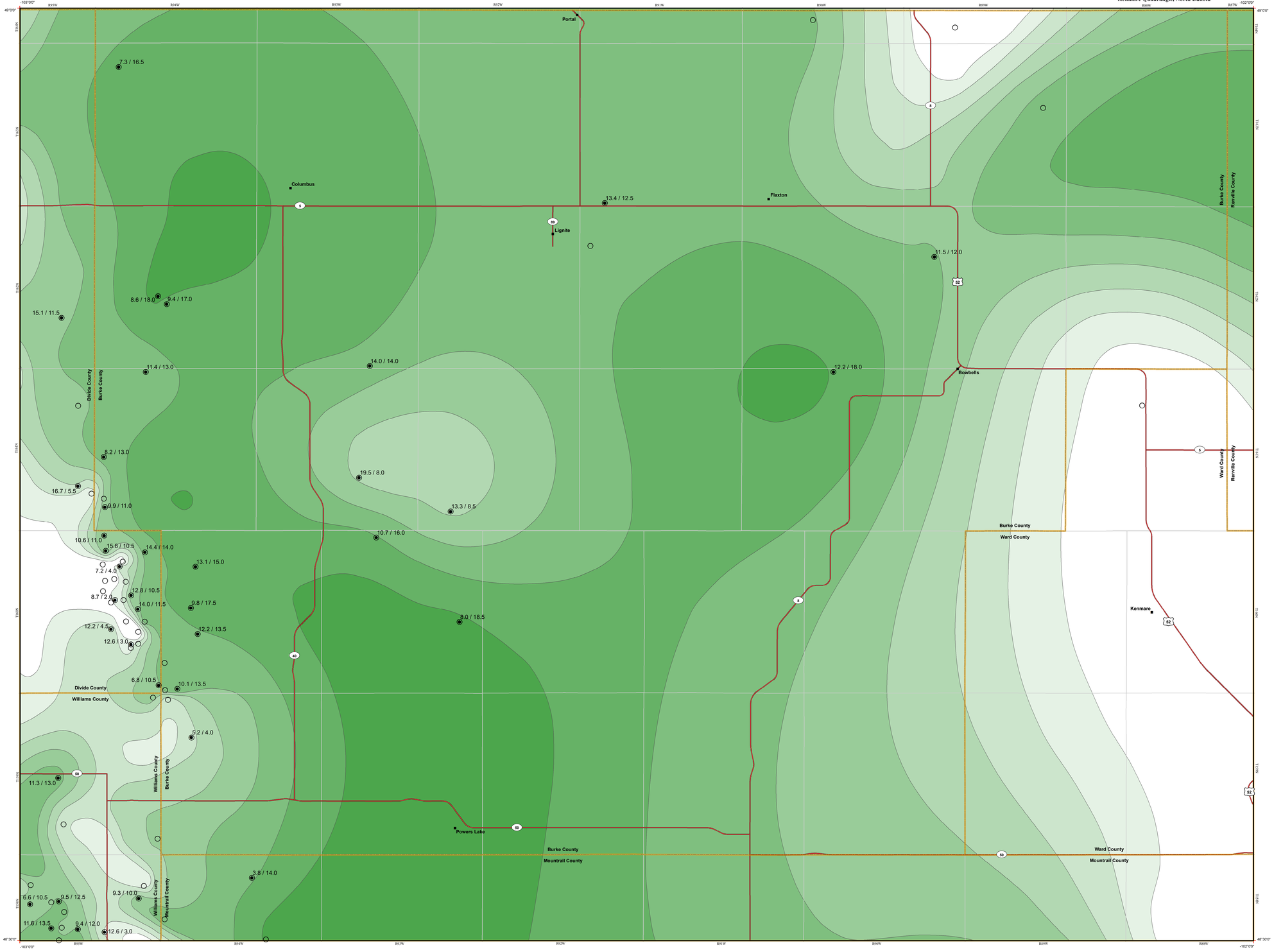
Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa

North Dakota Geological Survey
Geological Investigation No 215 - Sheet 5 of 6

K_2O Grades of the White Bear Member of the Prairie Formation

Kenmare 100K Sheet, North Dakota



Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

Ned W. Kruger

2019

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The White Bear Member was identified on the geophysical logs of 64 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average K_2O concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

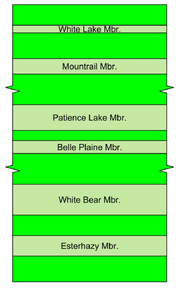
When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the White Bear Member represented by this sheet is approximately 11,800,000 acre feet.

Legend

Thickness (ft)

- 0
- 1-3
- 4-6
- 7-9
- 10-12
- 13-15
- 16-18
- 19-21



Symbols

- Well Control
- 10.7/16.0 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

Scale 1:100,000

Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"W

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

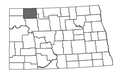
Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa

North Dakota Geological Survey
Geological Investigation No 215 - Sheet 6 of 6

K_2O Grades of the Esterhazy Member of the Prairie Formation

Kenmare 100K Sheet, North Dakota



Kenmare Quadrangle, North Dakota

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

Ned W. Kruger

2019

This series of maps of the Kenmare 100K Sheet was based on public data from 74 wells gathered by the North Dakota Industrial Commission – Department of Mineral Resources, Oil & Gas Division. The Esterhazy Member was identified on the geophysical logs of 30 wells. Isopach contours were generated via PETRA (ver. 3.9.13) geological software. The contour lines were computer-generated based on well-control data only, with minimal adjustments made by the author. Areas with a geological anomaly may not be accurately portrayed. The potash member thickness for each well, and the isopach contours generated from them, were modified from Kruger (2014).

All calculations were based on gamma-ray log measurements recorded in API units taken at six-inch increments throughout the potash-containing portion of the log. Corrections for borehole size and drilling mud weight as well as removal of the baseline gamma-ray signal were made (Crain, 2014) (Crain & Anderson, 1966). The corrected gamma-ray measurements were converted into apparent potassium oxide (K_2O) concentrations. Average (K_2O) concentrations and potash member thicknesses were obtained using the grade-thickness method described in Nelson (2007), where bed thickness is equal to the distance between the elevations at which the gamma-ray response declines to one-half its maximum value.

When a potash member displayed multiple gamma-ray log peaks separated by troughs representing salt or insolubles such as clay or anhydrite, thin potash intervals at the upper or lower boundaries of the member were not included in thickness or average-potash-grade calculations if the corrected gamma-ray measurements were less than 100 API or separated by more than four feet from main body of the potash member. This occurred most frequently in deposits of the White Bear Member, which may appear as one or two potash-rich beds underlying a thin potash-containing zone separated by an interbed of halite.

The volume of potash from the Esterhazy Member represented by this sheet is approximately 3,488,000 acre feet.

Legend

Thickness (ft)

- 0
- 1-3
- 4-6
- 7-9

White Lake Mbr.
Mountrail Mbr.
Patience Lake Mbr.
Belle Plaine Mbr.
White Bear Mbr.
Esterhazy Mbr.

Symbols

- Well Control
- 3.2/5.5 Avg K_2O % / Thickness (feet)

Other Features

- City
- Federal Highway
- State Highway

N W E S

Scale 1:100,000

0 1 2 3 4 Miles

0 1 2 3 4 Kilometers

Mercator Projection
Standard Parallel 48°30'0"N

North American 1983 Datum
Central Meridian 102°30'0"E

References:

Crain, E. R., 2014, Crain's petrophysical handbook; URL<http://spec2000.net/17-specpotash.htm>, accessed 14 January 2014.

Crain, E.R., and Anderson, W.B., 1966, Quantitative log evaluation of the Prairie Evaporite formation in Saskatchewan: Journal of Canadian Petroleum Technology, vol. 5, p. 145-152.

Kruger, N.W., 2014, The Potash Members of the Prairie Formation in North Dakota: North Dakota Geological Survey, Report of Investigation no. 113, 39 p.

Nelson, P.H., 2007, Evaluation of potash grade with gamma-ray logs: U.S. Geological Survey, Open File Report 2007-1292, 14 p.

Cartographic Compilation: Navin Thapa