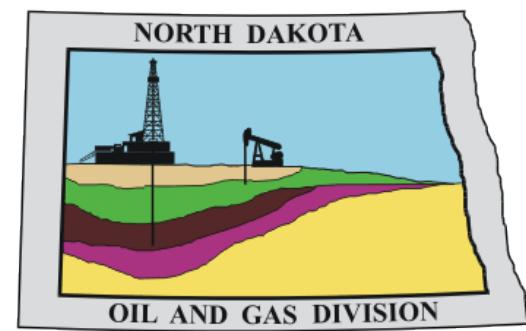


Dunham Salt Extent and Thickness

Williston Basin, North Dakota

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Summary

A total of 4,938 wells were examined to determine the lateral extent and thickness of the Dunham salt, of which 1,539 contained Dunham salt as identified in well logs. As mapped the Dunham salt covers ~3.2 million acres (~13.3 billion m²) of North Dakota's subsurface (fig. 1). Thicknesses vary dramatically (fig. 2) and range from 0 to 190 ft (0 to 57.9 m). Volumetrically, there is over 150 million acre feet (185 billion m³) of Dunham salt in North Dakota. Subsea depths range between -2991' SSTVD (5053' TVD) to -5057' SSTVD (7300' TVD). Isopach map, well data, associated shapefiles, subsea and TVD structure maps are included.

Methodology

Wells with digital and/or raster logs containing gamma ray (GR), bulk density (RHOB), deep resistivity (RESD) and/or sonic (DT) curves were examined and interpreted to determine the lateral extent and vertical thickness of the Dunham salt. Salt thickness from digital logs was calculated using cutoffs for RHOB (< 2.3 g/cm³) and/or RESD (> 200 ohms). All calculated salt thicknesses were manually checked to remove erroneous data. Salt thickness from raster logs was determined using a traditional top minus base isopach methodology using the manually picked top and base of the Dunham salt. Salt intervals were interpreted from RHOB (< 2.3 g/cm³) and/or DT (~65 µs/ft) curves in raster logs. Deep resistivity was not used to identify salt using raster logs due to poor image quality, often caused by overlap of multiple resistivity curves, making an individual curve difficult to consistently identify. Isopach and structure maps were subsequently created using these data.

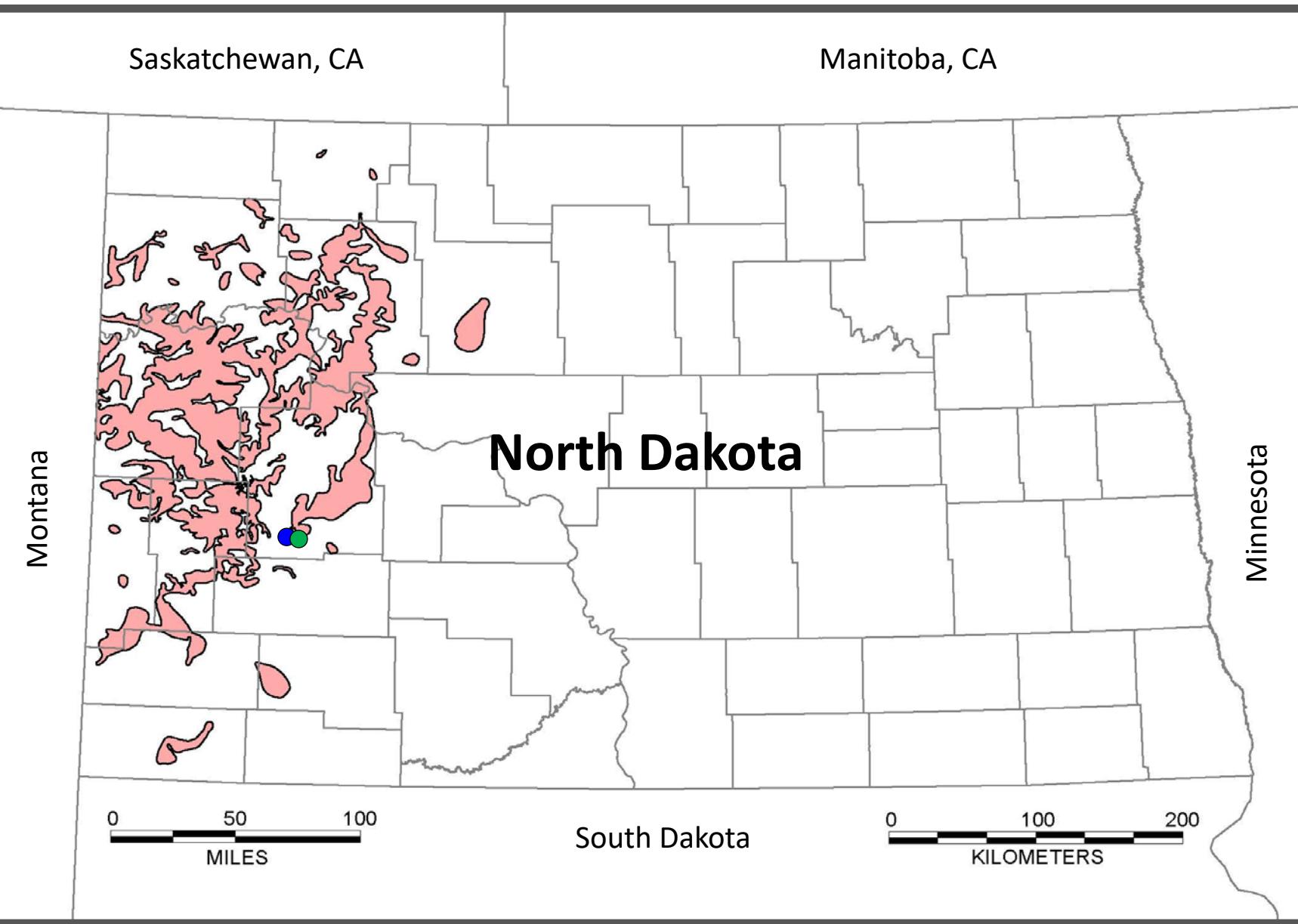


Figure 1. (ABOVE) Location map showing the lateral extent of the Dunham salt in pink. The blue and green dots represent the approximate location of the corresponding wells in Figure 2 (right).

Figure 2. (RIGHT) Two example well logs of the Dunham evaporite interval and surrounding strata from west-central North Dakota. Located less than 5 miles apart, these wells show vastly different sediment packages in the lower portion of the Piper Formation (green line). Dunham salt is identified in the **Miller** well (green dot). The salt lies within a larger interval that contains interbedded shales and anhydrite. The top of this interval is defined as the top of the uppermost anhydrite and is consistent regionally (blue line). The base is defined as the top of the underlying Spearfish Formation (black line). Log curves from the **Miller** well provide excellent examples of common log responses to salt. In the area interpreted as Dunham Salt: GR decreases, RESD increases by orders of magnitude, RHOB decreases below 2.3 g/cm³ and DT remains relatively static around 65 µs/ft. The **Kovash** well (blue dot) does not contain salt in the evaporite interval. Log curve responses in the Kovash well suggest interbedded shales and anhydrite.

