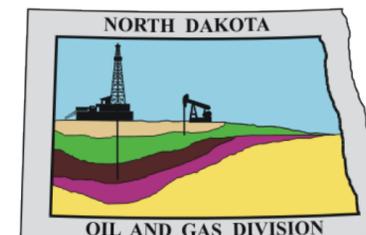




# Pine Salt Extent and Thickness

## Williston Basin, North Dakota

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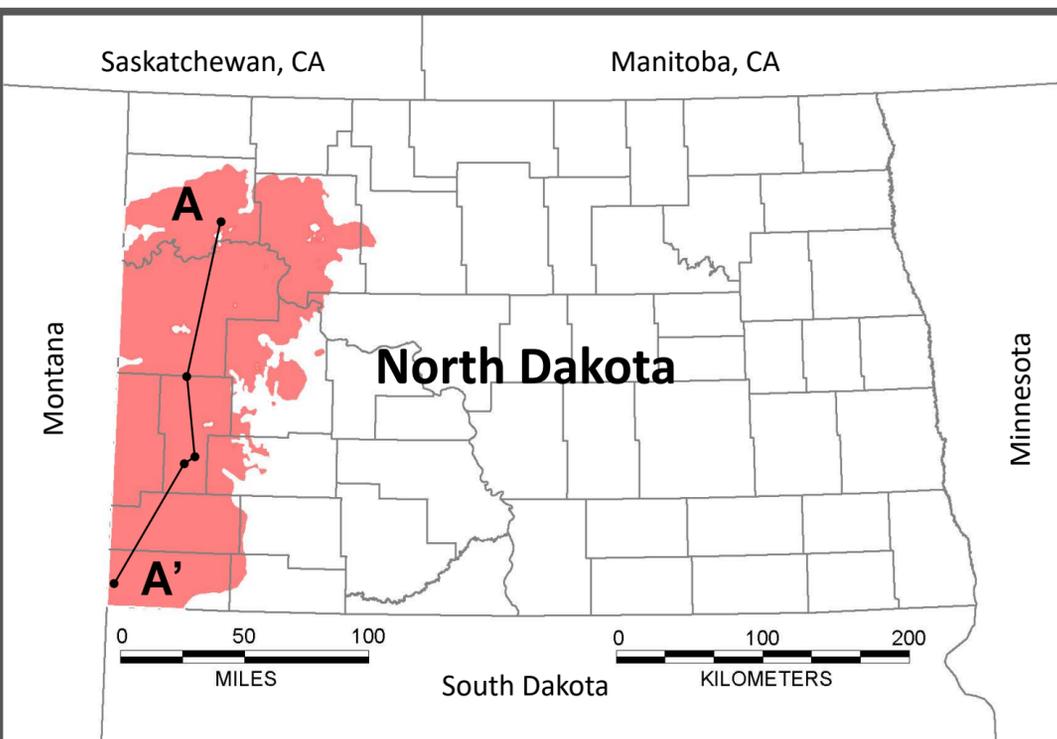


### Summary

A total of 3,122 wells were examined to determine the lateral extent and cumulative (net) thickness of the Pine salt (Pine Member, Spearfish Formation), of which 2,164 contained Pine salt as identified in well logs. As mapped the Pine salt covers ~7.6 million acres (~30.5 billion m<sup>2</sup>) of North Dakota's subsurface (fig. 1). Net thicknesses vary dramatically (fig. 2) and range from 0 to 164 ft (0 to 50 m). Volumetrically, there is over 353 million acre-feet (436 million m<sup>3</sup>) of Pine salt in North Dakota. Subsea depths range between -2180' SSTVD (5062' TVD) to -5389' SSTVD (7682' 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), and deep resistivity (RESD) curves were examined and interpreted to determine the lateral extent and net vertical thickness of the Pine salt. Net salt thickness from digital logs was calculated using a combined cutoff methodology with RHOB (< 2.3 g/cm<sup>3</sup>) and RESD (> 200 ohms). All calculated net salt thicknesses were manually checked to remove erroneous data. Net salt thickness from raster logs was determined using a traditional top minus base isopach methodology using the summation of manually picked tops and bases of individual salt beds within the larger Pine evaporite interval as net thickness. Salt intervals were interpreted from RHOB (< 2.3 g/cm<sup>3</sup>) curves in raster logs. Isopach and structure maps were subsequently created using these data.



**Figure 1. (LEFT)** Location map showing the lateral extent of the Pine salt in pink. The black circles represent the approximate location of the corresponding wells in the stratigraphic cross-section in Figure 2 (below).

**Figure 2. (BELOW)** Five example well logs of the Pine evaporite interval and surrounding strata from west-central North Dakota plotted in a stratigraphic cross-section utilizing the Spearfish Formation top as the datum. Spanning most of the basin, these wells show similar sediment packages in the Spearfish Formation with highly variable net salt thicknesses. The Pine salt lies within a larger interval, informally referred to here as the Pine evaporite interval, that contains interbedded shales and likely other evaporites such as anhydrite. The top of the Pine evaporite interval (*upper purple line*) is defined as the top of the uppermost salt and varies regionally. The base of this interval (*lower purple line*) is defined as the base of the lowermost salt and similarly varies regionally. The net thickness and location of salt within the stratigraphic section change considerably throughout the basin. A separate salt package is identified within and south of the Tracy Mountain Federal 12-2H well and has been previously labeled the G Salt or Unnamed Salt by LeFever and LeFever (2005) and Nordeng (2009). For the purpose of this project, this salt package is considered part of the Pine evaporite interval.

