

Southwestern North Dakota Kaolinite Study

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The vast majority of oil wells that are being drilled in the Williston Basin employ hydraulic fracturing as a completion technique. These wells use, on average, three to five million pounds of proppant, be it natural sand or spherical ceramic beads, to keep these fractures open. Because of the tremendous amount of product utilized in North Dakota, the North Dakota Geological Survey undertook 1) a study to find local sand deposits that would meet the criteria and could be used as natural proppant and 2) a study to find local clay resources that could be utilized in the manufacture of ceramic proppant.

In the sand study, we collected 125 sand samples from throughout North Dakota (Anderson, 2011a). Of these, ten were submitted for extensive testing and characterization. Tests included grain-size distribution, sphericity and roundness, turbidity, mineralogy, acid solubility, and crush resistance. Based on the test results, some of North Dakota's sand resources approach current industry standards and specifications for use as natural sand proppant. However, they are of lesser overall quality when compared to other domestic sand sources currently being utilized. It would likely take significant processing and refinement to bring these marginal deposits up to applicable standards and specifications. Advances in refinement or changes in proppant specifications may render North Dakota's sand deposits viable in the future, especially for use in shallower formations. In the meantime, the sand deposits that we characterized in detail may find other industrial applications. The results of this study were recently published by Anderson (2011b).

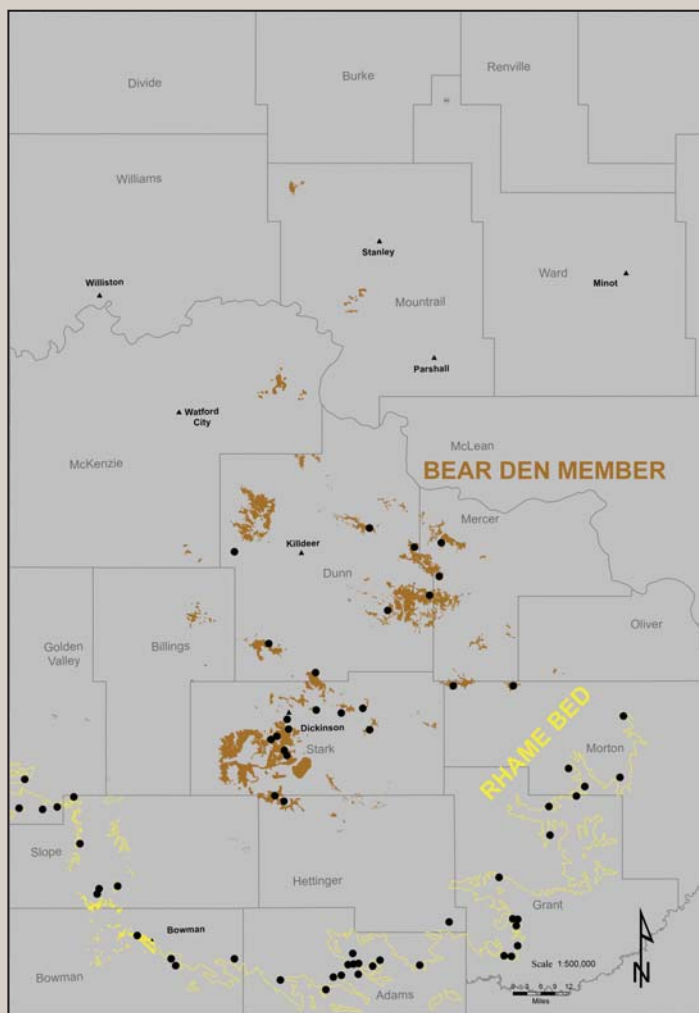


Figure 1. The extent of the Bear Den Member of the Golden Valley Formation (brown) and the Rhame Bed at the top of the Slope Formation (yellow) in western North Dakota. The clay sample locations are marked by black dots.



Figure 2. Outcrop of the Bear Den Member in Dunn County. A portion of a Bear Den outcrop is often colored gold or orange due to the presence of iron.

In the clay study, we focused on kaolinite deposits because high-aluminum kaolinite is typically one of the main ingredients in ceramic proppant. There are two stratigraphic units exposed at the surface in North Dakota that are kaolinitic and both are restricted to the western half of the state. These are the kaolinite-rich Bear Den Member of the Golden Valley Formation (Murphy, 2009) and the kaolinite-rich Rhame Bed of the Slope Formation (fig. 1). These stratigraphic units are dazzling white, gold, purple, and/or gray in color, range from claystone, mudstone, siltstone, sandstone, and



Figure 3. An outcrop of the upper part of the Rhame Bed in Adams County. The Rhame Bed is predominantly grayish white to dazzling white on outcrop, but may contain subtle shades of gray, pink or green.

occasionally lignite, and are 10-40 feet (3-12 m) thick. Paleocene in age, they are thought to have formed as a result of intensive leaching during a prolonged period of weathering. The intensive weathering that led to the creation of the kaolinite clays in the Bear Den Member occurred at the end of the Paleocene Epoch and the beginning of the Eocene Epoch some 56 million years ago (fig. 2). The weathering phenomenon that created the Rhame Bed occurred approximately 61 million years ago during mid-Paleocene time (fig. 3).

The North Dakota Geological Survey has a long history of clay studies that go as far back as 1892. The Bear Den Member was the focus of many of these early studies, called the “white fire clays” by Leonard (1906) and the “white clays” or “white high grade clays” by Clapp and Babcock (1906). The Hebron Brick Company began manufacturing bricks using claystone from the Bear Den Member in 1904. The Dickinson Fire and Pressed Brick Company began mining the Bear Den Member along the Heart River south of Dickinson in the early 1900s. That facility closed in the late 1930s. In the 1960s, the Dickinson Clay Products Company produced ceramic sewer pipe and tiles from Bear Den Member claystones but the plant was short-lived owing to competition from plastic sewer pipe. Claystone from this stratigraphic horizon as well as the Rhame Bed have also been used to make pottery (Murphy, 1995).

So far, 61 individual sites have been sampled and 231 clay samples have been collected. Where outcrop exposures are limited,

only one or two samples were collected. In areas of good rock exposure, up to a dozen samples were taken along a vertical profile to determine the range in kaolinite and aluminum oxide percentages at a given location. Five claystone samples collected last spring from the Bear Den Member ranged from 26 to 38 % Al_2O_3 . The remaining samples will be submitted for clay analysis over the winter months. The sampling program will be completed next spring and a final report should be published by late summer.

References

- Anderson, F.J., 2011a, Potential use of North Dakota sand and clay for natural and manufactured proppants: *GeoNews* v. 38, no.1, p. 7-10.
- Anderson, F.J., 2011b, Investigation of sand resources in ND – sedimentological characterization of surficial sand deposits for potential use as proppant: North Dakota Geological Survey Report of Investigation No.110, 77 p.
- Clapp, C.H. and Babcock E.J., 1906, Economic geology of North Dakota clays, *in* the Fourth Biennial Report of the North Dakota Geological Survey, p. 95-190.
- Leonard, A.G., 1906, The stratigraphy of North Dakota clays, *in* the Fourth Biennial Report of the North Dakota Geological Survey, p. 63-94.
- Murphy, E.C., 1995, North Dakota clays, a historical review of clay utilization in North Dakota: North Dakota Geological Survey Miscellaneous Series no. 79, 18 p.
- Murphy, E.C., 2009, The Golden Valley Formation, *GeoNews*, v. 36, no. 2, p. 1-4.