Investigations of the Niobrara Formation in Eastern North Dakota as Potential Cement Rock

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With the recent passage of the Bipartisan Infrastructure Bill in Congress, a rush on construction materials such as Portland cement is anticipated as cement consumption rebounds in the next several years (Miller, 2021; PCA, 2021a). Portland cement is made from a mixture of calcium, silicon, aluminum, iron, and minor oxide constituents, typically found in limestone and shale which is heated to melting and ground into fine powder with the addition of gypsum as a binder. Cement is the binding ingredient of concrete, making around 11% of the mix, which effectively "glues" the aggregate together into a cohesive, strong material. North Dakota imports all of its cement from outside sources, and those shipments increased in 2021 (Hatfield, 2021) (fig. 1).

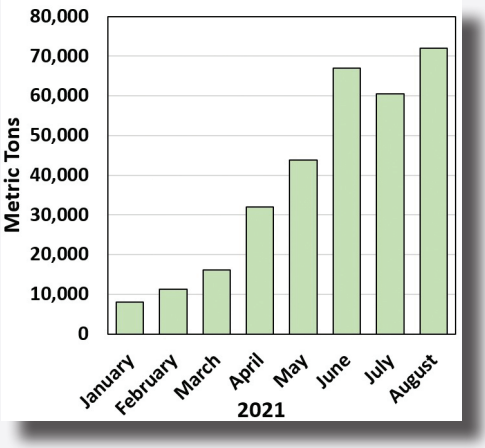

Figure 1. Portland cement shipments into North Dakota as reported by the U.S. Geological Survey.

Common source materials for Portland cement are limestones (calcium carbonate) or marls (combined with shale, clay, silica sand, and iron ore). Recently, Portland cement manufacturers have come up with a new carbon footprint reducing formulation which allows for a higher ground limestone content ranging from 5% to 15% limestone instead of the traditional 5% (PCA, 2021b). This translates to increased demand for carbonate source materials that can potentially supply these new requirements such as the chalky and calcareous shale members of the Niobrara Formation in northeastern North Dakota (fig. 2).

The Niobrara Formation is found to outcrop at some locations in northeastern North Dakota and generally subcrops beneath a thin veil of glacial cover in Pembina, Walsh, and Grand Forks counties making it an attractive exploration target (fig. 3).

The Niobrara Formation in northeastern North Dakota is calcareous (>50% calcium carbonate) and was utilized as a natural cement with historical production for over 17 years in the late 1800's and early 1900's near the town of Concrete (Leonard, 1912). North Dakota Geological Survey (NDGS) geologist Clarence (Kelly) Carlson investigated the shallow subcrop of the Niobrara Formation and reported on its possibilities for use as cement rock (Carlson, 1964) at several different localities in northeastern North Dakota (fig. 2).

Figure 2. The Niobrara Formation subcrops in the shallow subsurface across a north-south trend in eastern North Dakota and outcrops in minor localities in northeastern North Dakota (modified from Bluemle, 1983). In northeastern North Dakota the formation is found at shallower depths than in the south making it a more favorable exploration target.

The NDGS took a detailed look at the Shawnee-McCanna Prospect in 2005 as industry interest in this area was increasing at the time. A series of geologic maps, cross-sections, and core summaries were completed (fig. 3) providing a more detailed look at

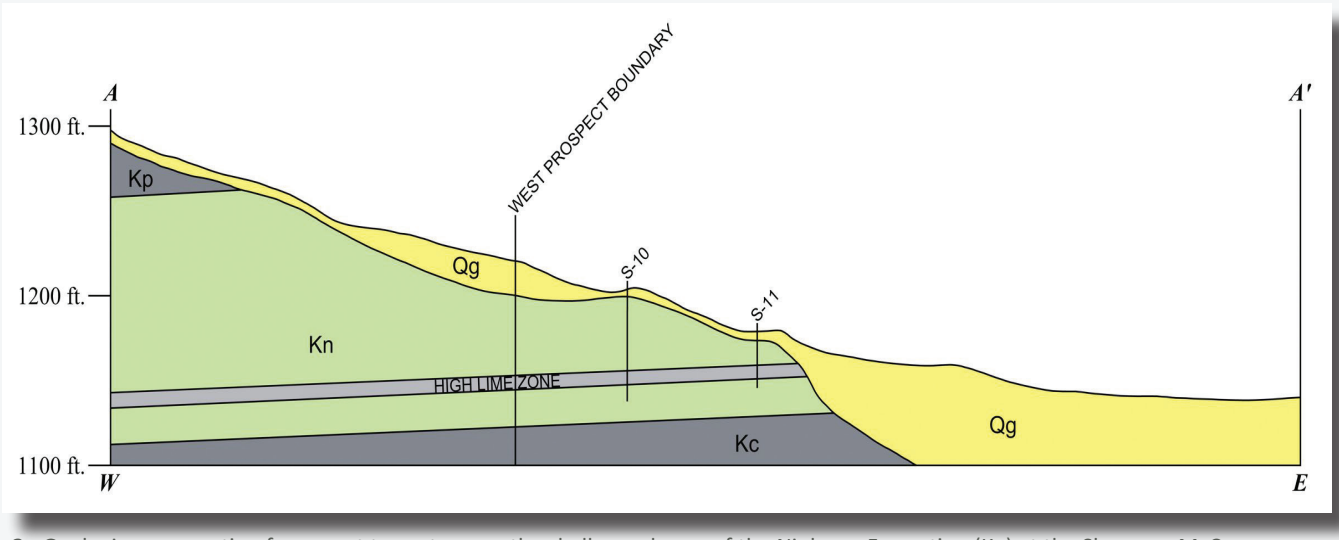

Figure 3. Geologic cross-section from west to east across the shallow subcrop of the Niobrara Formation (Kn) at the Shawnee-McCanna prospect in northeastern North Dakota. Based on detailed analytical testing of the rocks in this unit, a high-lime zone with increased levels of calcium carbonate is present in the lower portion of the unit.

the cement rock possibilities of western Grand Forks County. The resulting report features descriptions of Niobrara core samples coupled with detailed calcium carbonate analytical testing data (Anderson, 2005), important data for the evaluation of this resource potential.

The NDGS maintains the cores (fig. 4) and samples from these projects at the Wilson M. Laird Core and Sample library on the campus of the University of North Dakota. The core is available for study and additional testing upon request.

Additional studies of cement rock (limestone) possibilities were also completed on several of the Buttes in Hettinger and Stark counties in southwestern North Dakota (Hansen, 1953) and on the Red River Formation, a limestone which subcrops (fig. 5) beneath glacial sediments in the Red River Valley north of Grand Forks at depths of 200 feet (Anderson and Haraldson, 1969).

With a projected surge in demand in North Dakota as well as the U.S., and renewed interest in the possibilities of using the calcareous portions of the Niobrara Formation and other units as potential cement rock resources (fig. 6), perhaps the cement rock industry will see a revival of activity in northeastern North Dakota in the coming years.

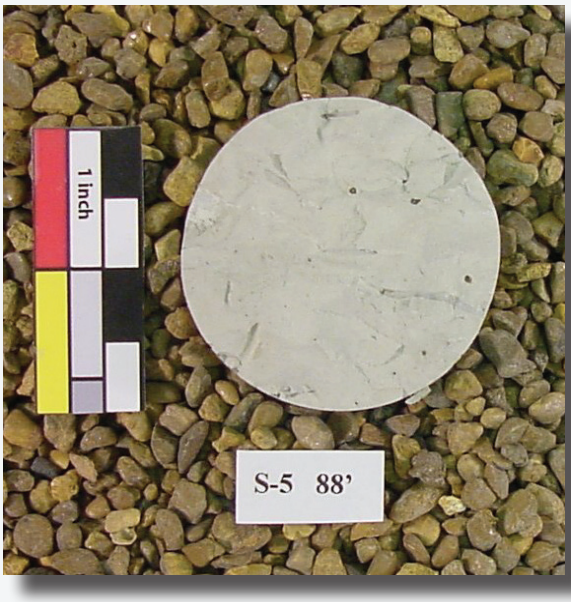

Figure 4. Core face of the calcareous shale of the Niobrara Formation from drillhole S-5 from the Shawnee-McCanna prospect in western Grand Forks County. Calcium carbonate content at this interval was 69.34%.

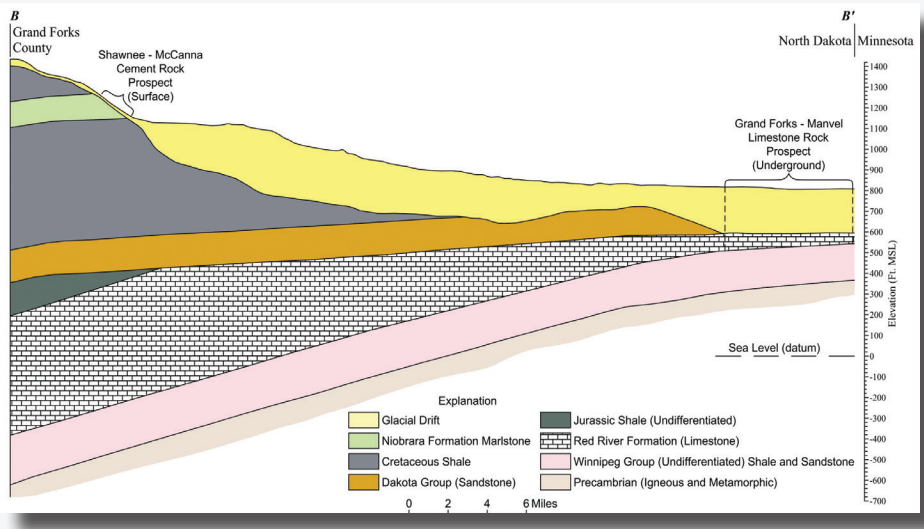

Figure 5. Simplified geologic cross section from west to east across Grand Forks County illustrating the relationship between surface cement rock (Shawnee-McCanna) and shallow underground limestone rock (Grand Forks-Manvel) prospects (modified from Anderson and Haraldson, 1969).

Figure 6. An outcrop of the Niobrara Formation in the Tongue River Valley near the old cement plant in Cavalier County. NDGS emeritus paleontologist John Hoganson can be seen studying the outcrop in 1994.

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