Clinker ("scoria") as Road Surfacing Material in Western North Dakota

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The reddish roads and red-mud-caked pickup trucks are part of the fabric of the western North Dakota landscape. However, anyone who has ever slipped and slid on a wet clinker road, generated a massive red cloud of dust on a dry clinker road, had their tires cut to pieces while driving on a newly surfaced clinker road, or bounced across washboard grooves on a well-worn clinker road may have a hard time seeing the romantic side of this road surfacing material. That some clinker can start out razor sharp and wear down relatively quickly to a powder illustrates the relative shortcoming of this rock as a road material (fig. 1).

Why then is this rock used on the roads? The short answer is that it is available in abundant supply while gravel often is not. The vast majority of sand and gravel deposits in North Dakota are glacial in origin. Unfortunately for southwestern North Dakota, glaciers did not advance into that portion of the state, at least not in the last two million years or so. Because of the general lack of sand and gravel deposits throughout much of western North Dakota, resourceful people used a reddish colored rock because it was the hardest rock in the area. Hares (1928) noted that clinker was being used as road metal and railroad track ballast in 1911 in southwestern North Dakota (his study area included present day Golden Valley, Billings, Slope and Bowman counties). Its use on roads certainly predates that year and it likely was the original road metal used when roads were first constructed in many of these areas. This rock is relatively hard because it has been baked or fused by the heat generated from the burning of an underlying coal bed.

Figure 1. A NDGS pickup truck struggles for traction on East River Road south of Medora in 1982. I had to back down the wet clinker road and put on tire chains.

Geologists in North Dakota call this rock clinker, but everyone else in western North Dakota knows it as scoria. Scoria is the geologic name for a highly vesicular volcanic rock. Although true scoria can resemble some of the clinker found in North Dakota, the name "scoria" implies the wrong geologic origin. The rocks in western North Dakota are not igneous, but sedimentary rocks that have undergone low grade metamorphism. Unfortunately, the name is so entrenched locally that our attempts over the years to change it have been futile.

Figure 2. A brief summer storm that contained intense lightning started a number of fires in central Billings County (Buck Hill, Mikes Creek, Ash Coulee, etc.) in July 1988.

Figure 3. A burning coal seam ignited by the Buck Hill fire emits smoke and is baking the overlying rock as evidenced by scattered clinker. The picture was taken in December 1988; five months after the seam began burning.

Years ago, during fieldwork on the major buttes of western North Dakota, John Hoganson and I discovered clinker pebbles in the Arikaree Formation indicating that coals had been burning prior to when these rocks were deposited some 25 million years ago. Probably as far back as 40 million years ago, when grasslands were first established, fires have swept across the plains of North Dakota igniting coal seams. Lewis and Clark witnessed burning coal while in North Dakota and noted it in their journals. In fact, they collected two pieces of clinker in North Dakota that were sent back from Fort Mandan to President Jefferson. They referred to these specimens as "Lava Stone" and "Pumice Stone." They are housed today in the Academy of Natural Sciences of Philadelphia (Hoganson and Murphy, 2003). For hundreds or perhaps thousands of years Plains Indians set prairie fires to burn off weeds and encourage the new growth of grasses to entice bison herds into the area. As a result of both natural and manmade fires, as well as spontaneous combustion, numerous coals have burned throughout western North Dakota leaving vast expanses of clinker. More recently this phenomenon was witnessed when the Buck Hill, Mikes Creek, and Ash Coulee fires of 1988, the Halloween "Gap" Fire of 1999, and the Deep Creek Fire of 2007 each ignited a number of lignite beds that burned for a number of years (figs. 2 and 3). The Gap Fire started an estimated 30 coal seam fires and at least $64,000 was spent suppressing some of those burning seams (Bruce Beechie, 2012, ND Public Service Commission, personal communication).

Figure 4. Thirty-five feet of clinker exposed along Deep Creek in Slope County, North Dakota.

Figure 5. Fossil leaf preserved in clinker.

While clinker may look very uniform and consistent when spread on a road or at first glance in outcrop, it typically is not (fig. 4). There are a number of variables that go into the creation of clinker including the original rock type, the intensity of the burn, and distance from the burning seam. Before it was baked, clinker consisted of alternating beds of claystone, mudstone, siltstone, sandstone, and lignite. The majority of clinker (60-80%) formed from fine-grained rocks (claystone, mudstone, and siltstone) because they are the most common rocks in the Fort Union Group and in a typical stratigraphic sequence they directly overlie the coal. At times the baking process fuses these lithologies into a nondescript red rock. At other times both large and small scale bedding features are left visually intact. This appears especially true when the original beds were siltstone or sandstone. The organics in clinker are typically baked away, but the molds of fossil leaves are sometimes well preserved (fig. 5).

An outcrop of a typical coal burn contains a thin white ash layer at the base which is often all that remains of the original coal bed (fig. 6). A ten-foot-thick lignite seam is typically reduced to a foot or two of ash. It is not uncommon to find multiple ash layers within a given clinker deposit where overlying coals were ignited by the burning of an underlying coal. It is often evident in outcrop that the base of the clinker has been subjected to the highest heat

Figure 6. This lignite seam had burned along the right side of the outcrop and all that remains is a thin white ash layer visible at the base of the clinker. A white volcanic ash layer (tonstein) is visible in the upper one third of the coal seam on the left. Unfortunately, the contact between the unburned coal and the adjacent clinker is obscured by an apron of slopewash. Photograph taken from a canoe in June 1982 when the Little Missouri River was in floodstage.

Figure 7. Examples of clinker from western North Dakota.

buttes in western North Dakota. In these cases, the clinker caprock has protected the underlying softer rock (claystone, mudstone, siltstone, sandstone, and lignite) from the elements even as these surrounding rocks eroded away. The hardened or fused rock is also very susceptible to fracturing and is typically riddled with cracks and void spaces as prairie rattlesnakes discovered thousands of years ago. In some areas of western North Dakota, an individual coal seam is largely responsible for all of the clinker found in a given area. When that is the case, that clinker is very useful to geologists as a stratigraphic marker. For example, the Harmon coal burned over large areas of south-central Slope and north-central Bowman counties and the resulting clinker caps hills and buttes throughout this area (fig. 8).

because it is typically highly fused – sometimes glassy, variously colored, and often vesicular (contains small voids) resembling true volcanic scoria (fig. 7). Although clinker occasionally comes in a variety of colors, the vast majority is reddish orange to reddish brown. As the plant manager of the Hebron Brick plant can attest to, if you place the green, blue, white, yellow, purple, brown, or gray clays of western North Dakota into a kiln and bake them, you invariably end up with a standard red brick. This explains why the vast majority of brick plants operating throughout North Dakota in the late 1800s and early 1900s produced red bricks that stand preserved today along the main streets of the state. The iron oxide content of the clay is primarily responsible for the red color of these bricks just as it is for the predominantly red color of the "naturally baked" clinker.

Because clinker is typically more resistant to erosion than the surrounding sedimentary rocks, it is often found as caprock of

Dozens of new clinker pits have sprung up across western North Dakota in recent years to fill the insatiable need for aggregate created by the Bakken oil play. Absorbency, a feature that makes clinker less than desirable on roads is very desirable on well pads because it can help to soak up and contain minor diesel and crude oil spills.

References

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Hoganson, J. W., and Murphy, E. C., 2003, Geology of the Lewis & Clark Trail in North Dakota: Missoula, Mountain Press, 247 p.

Figure 8. Harmon clinker capping hills and small buttes east of Deep Creek in Slope County.