The Golden Valley Formation

By Ed Murphy

Introduction

As early as 1906, geologists from the North Dakota Geological Survey were tracing a brightly colored claystone throughout western North Dakota. They referred to this unit by various names; *white clay horizon, white fire clays, white sandy fire clays,* and *white Tertiary clays* (Leonard, 1906; Babcock and Clapp, 1906). They noted that both the Dickinson Pressed and Fire Brick Company as well as the Hebron Pressed and Fire Brick Company were mining this claystone to produce bricks. Forty years later, Wilson Laird and Bill Benson applied the name Golden Valley Formation to rocks in western North Dakota which included this brightly colored unit (Benson and Laird, 1947). The name was derived from outcrops near the town of Golden Valley in western Mercer County (fig. 1). Subsequently, Benson (1949, 1952) informally divided the Golden Valley Formation into two members, the lower member was the brightly colored claystone. In 1977, Leo Hickey formalized these members naming the brightly colored claystone the Bear Den Member and the overlying unit the Camels Butte Member. Although Laird and Benson had initially assigned an Eocene age to the Golden Valley Formation, Hickey determined that only the Camels Butte Member is Eocene and the Bear Den Member is latest Paleocene in age, meaning the rocks in the Golden Valley Formation were deposited roughly 50 to 57 million years ago (see stratigraphic column on page 28).

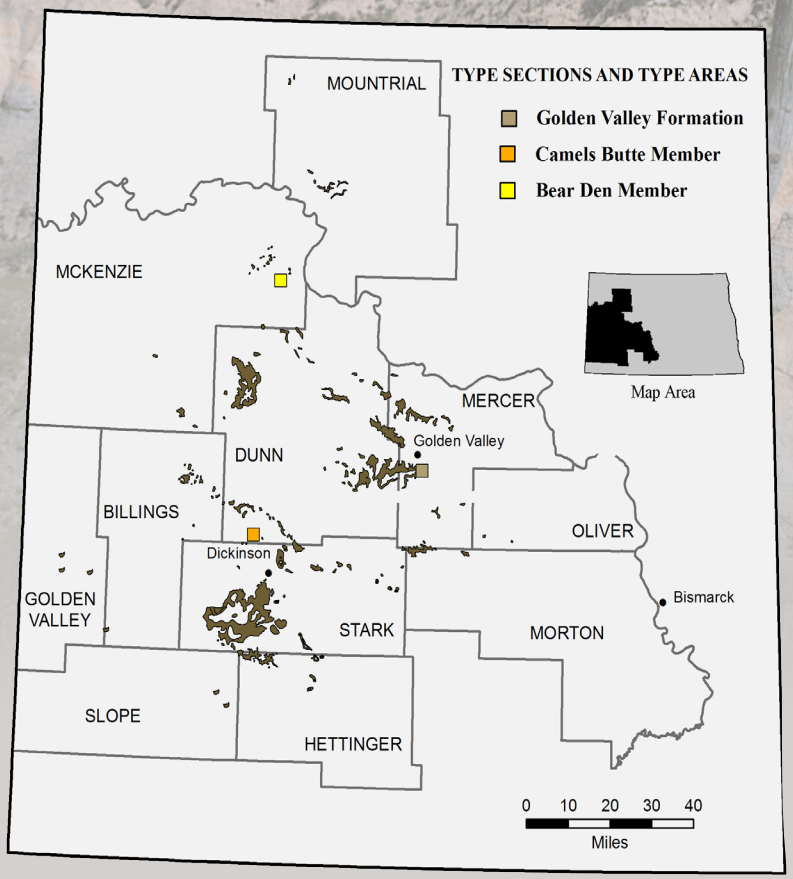

Figure 1. Surface exposures and type sections of the Golden Valley Formation in western North Dakota.

Bear Den Member

The Bear Den Member (Paleocene) consists of 20 to 50 feet of bright white to orangish/purplish gray, kaolinitic sandstone, siltstone, mudstone, and claystone. The latter two lithologies are dominant. At many localities the Bear Den Member can be subdivided into three distinctly colored zones. From bottom to top; gray, white to orangish white, and purplish gray (figs. 2 and 3). The Bear Den Member rests conformably on the Sentinel Butte Formation and is unconformably overlain by the Camels Butte Member of the Golden Valley Formation.

Figure 2. An outcrop of the Bear Den Member of the Golden Valley Formation in western North Dakota. As is typical of many outcrops, only a few feet of the overlying Camels Butte Member is exposed, most of it is covered with grass in the hill in the background.

Figure 3. Iron staining displayed in polygonal patterns on the outcrop face of the middle zone of the Bear Den Member.

The Bear Den Member is unique in comparison to the surrounding units because of its bright color and kaolinite content. Kaolinite is desirable in brick and porcelain manufacturing because it does not swell or contract very much. The clays in this unit average 66% kaolinite compared to only 10 to 20% for the overlying and underlying rocks. The Bear Den Member appears to be an ancient soil horizon or paleosol that developed on pre-existing Sentinel Butte rocks. In other words, this member is a bleached white zone that formed after a period of prolonged or intense weathering at the end of the Paleocene.

Alamo Bluff Lignite and Taylor Bed

A thin lignite (less than two feet thick) is present at the top of the Bear Den Member in much of western North Dakota. Benson (1952) named the bed for an exposure south of Golden Valley that was adjacent to the ruins of an old adobe house he facetiously called "the Alamo". When I visited that locality in the late 1990s, the building was gone. Some of the local residents thought a vivid imagination was the only explanation as to why anyone would have compared it to "the Alamo."

At many localities, the top of the Bear Den Member is capped by a 1-to 3-foot-thick silicious layer called the Taylor Bed. The bed was named for occurrences near the town of Taylor in Stark County (Hickey, 1977). Several geologists have suggested this silicious layer is a hardened soil crust or silcrete. The Taylor Bed is generally grayish brown, iron stained, and contains numerous fossil plant stem molds (fig. 4). It has a dull earthy appearance in fresh outcrop, but a polished surface where it has been exposed to the wind. The Taylor Bed is highly resistant to erosion and, as a result, pieces of it can be found lying as float on older strata throughout western North Dakota. In addition, because of its resistance to erosion, the Taylor Bed also caps many low, flat-topped hills and buttes in Morton, Mercer, Stark, and Dunn counties. Although early pioneers found chunks of it useful in stone foundations, modern contractors have found it to be an impediment to excavation (fig. 5). The Taylor Bed is also workable stone and has been found as Paleo-Indian tools and projectile points.

Figure 4. Molds of stems (similar to *Equisetum* or horsetails) are generally prevalent in pieces of the Taylor Bed. Ingenious farmers and ranchers in western North Dakota have used pieces of the Taylor Bed to weigh down or stabilize fence posts. They simply thread the fence wire through the hollow stem molds in the rock.

Camels Butte Member

The Camels Butte Member (Eocene) of the Golden Valley Formation has a maximum thickness of 350 feet and consists of alternating beds of yellowish brown to brown sandstone, siltstone, mudstone, claystone, and thin lignite.

Figure 5. An old stone foundation made from rocks of the Taylor Bed. Outcrops of the Golden Valley Formation are visible in the background.

Figure 6. Turtle Valley within the Little Badlands of Stark County is one of the few places in North Dakota where rocks of the Camels Butte Member are well exposed. Channel sandstones and mudstones in the Camels Butte are overlain by 30 feet of conglomerates and claystone of the White River Group (Eocene\Oligocene) in this photograph.

The Camels Butte Member is early Eocene in age as determined from sparse vertebrate fossils and the presence of an Eocene index fossil, the floating fern *Salvinia preauriculata*. Camels Butte lithologies are identical to those in the Sentinel Butte Formation, although beds of the latter generally are shades of gray and contain much thicker lignites. Due to these lithologic similarities, it can be difficult to differentiate between Sentinel Butte and Camels Butte rocks in areas where the Bear Den Member is not exposed at the surface. The middle and upper portions of the Camels Butte Member are dominated by channel sandstones, some of which contain intraformational conglomerates. The thick, massive sandstones that cap several major buttes in southwestern North Dakota (e.g., Square Butte, Bullion Butte, and Sentinel Butte) have been mapped as the Camels Butte Member (Murphy et.al., 1993). Aside from these well exposed cap rocks, Camels Butte strata are often limited to exposures of less than 50 feet at the tops of small hills and buttes (figs. 6 and 7). A major unconformity separates the Camels Butte Member from the overlying White River Group.

The Paleocene-Eocene Thermal Maximum

The Paleocene-Eocene Boundary is generally very well exposed in western North Dakota (fig. 8). As a result, several scientific groups studying this interval of geologic time have come to North Dakota to observe, record, and sample rocks across this boundary. The concern over recent and projected climate change has scientists investigating the geologic record for evidence of extreme climate change in the past. Geologists have been studying the rocks to determine what mechanisms drove climate change and what mechanisms may have played a role in buffering or reversing it. The Paleocene-Eocene Boundary has been recognized as the most rapid and significant global warming event in the last 65 million years. Scientists believe that atmospheric temperatures warmed by 5-9^{O} C during this event which was closely associated with the release of thousands of gigatons of carbon into the oceans and atmosphere (Wing and others, 2005; Bowen and others, 2006). During this time, the oceans acidified, rapid changes occurred in terrestrial and marine biota, and up to half of the benthic (or bottom dwelling) foraminifera became extinct. Scientists have suggested a variety of theories to explain the Paleocene-Eocene

Figure 7. Exposures of the Camels Butte Member are characteristically limited at it's type section at Camels Butte in Dunn County.

Figure 8. The Paleocene-Eocene Boundary occurs approximately two-thirds of the way up the slope of this small butte (Farmer's Butte) in eastern Stark County. The brightly colored unit at the mid point of the butte is the orange zone of the Bear Den Member.

Thermal Maximum including increased volcanic activity, a comet impacting the Earth, burning of large quantities of the Earth's peat deposits, cycles in the Earth's orbit, and the release of significant quantities of methane from gas hydrates (Clechenko and others, 2007).

Industrial Uses

More than thirty brick plants operated in North Dakota between the 1870s and 1920s (Murphy, 1995). Today, only the Hebron Brick Company is still in operation. It is no coincidence that Hebron Brick utilizes the Bear Den Member in its brick manufacturing in contrast to the vastly inferior clays that were used by most of the other plants. Two exceptions were the Dickinson Pressed and Fire Brick Company, which began operation prior to 1906 and ceased operation in the late 1930s, and the Dickinson Clay Products Company, which produced ceramic sewer pipe and tile in the 1960s. Both of these Dickinson plants mined Bear Den Member kaolinites from outcrops overlooking the Heart River in the southwestern part of that community (fig. 9a).

For more than a decade, sandstone in the Camels Butte Member has been mined for decorative stone in a pit south of Dickinson (fig. 9b). The iron-stained, cross-bedded, micaceous sandstone has been placed in planters and alongside buildings and sidewalks throughout the area. The Camels Butte sandstone caprock from Square Butte was also utilized locally for construction purposes. Individuals have picked polished stones of the Bear Den Member from fields and placed them in flower gardens as decorative stone. Aside from the lignite industry, the Golden Valley Formation has been one of the more utilized rock units exposed at the surface in western North Dakota.

REFERENCES

Babcock, E.J. and Clapp, C.H., 1906, Economic geology of North Dakota clays: North Dakota Geological Survey, Fourth Biennial Report, p. 95-190.

Benson, W.E., 1949, Golden Valley Formation of North Dakota: abstract, Geological Society of America Bulletin, v 60, p. 1873-1874.

Benson, W.E., 1952, Geology of the Knife River area, North Dakota: U.S. Geological Survey Open-File Report, 276 p.

Benson, W.E. and Laird, W.M., 1947, Eocene of North Dakota: abstract, Geological Society of America Bulletin, v 58, p. 1166-1167.

Bowen G. J., Bralower T. J., Delaney M. L., Dickens G. R., Kelly D. C., Koch P. L., Kump L. R., Meng J., Sloan L. C., Thomas E., Wing S. L. and Zachos J. C., 2006, Eocene hyperthermal event offers insight into greenhouse warming: Eos, Transactions of the American Geophysical Union, v. 87, p. 165-169.

Clechenko, E.R., Kelly, D.C., Harrington, G.J., and Stiles, C.A., 2007, Terrestrial records of a regional weathering profile at the Paleocene-Eocene boundary in the Williston Basin of North Dakota: Geological Society of America Bulletin, v. 119, no. 3/4, p.428-442.

Leonard, A.G., 1906, Stratigraphy of North Dakota clays: North Dakota Geological Survey, Fourth Biennial Report, p. 63-94.

Wing, S.L., Harrington, G.J., Smith, F.A., Bloch, J.I., Boyer, D.M., and Freeman, K.H., 2005, Transient floral change and rapid global warming at the Paleocene-Eocene Boundary: Science, v.310, p. 993-996.

Figure 9. (a) An abandoned clay pit in the Bear Den Member of the Golden Valley Formation near the Dickinson golf course. This pit was utilized by either or both the Dickinson Pressed and Fire Brick Company and the Dickinson Clay Products Company. (b) This iron-stained, micaceous sandstone from the Camels Butte Member of the Golden Valley Formation is mined in the Dickinson area for decorative stone.