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The Heart of Everything That Is
2008 NSF He Sapa Bloketu Woecun
A Black Hills Summer Cultural and Science-Based Field Experience

Field trip Guidebook to Science and Cultural Sites in the Black Hills and Badlands, South Dakota

June 2-26, 2008

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## GENERAL OUTCROP SECTION OF THE BLACK HILLS AREA

<table>
<thead>
<tr>
<th>FORMATION</th>
<th>SECTION</th>
<th>THICKNESS IN FEET</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QUATERNARY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PLIOCENE</strong></td>
<td>OAHALLA GROUP</td>
<td>0-100</td>
<td>Sand, gravel, and boulders. Light colored sands and silts.</td>
</tr>
<tr>
<td><strong>MIocene</strong></td>
<td>ARKAROE GROUP</td>
<td>0-600</td>
<td>Light colored clays and silts. White and black beds of shale.</td>
</tr>
<tr>
<td><strong>OLIGOCENE</strong></td>
<td>WHITE RIVER GROUP</td>
<td>0-600</td>
<td>Light colored clays with sandstone and lenticular limestone beds.</td>
</tr>
<tr>
<td><strong>TERTIARY</strong></td>
<td>TONGUE RIVER MEMBER</td>
<td>0-425</td>
<td>Green marine shales and wavy sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>PALEOCENE</strong></td>
<td>CANNONBALL MEMBER</td>
<td>0-225</td>
<td>Green marine shales and wavy sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>LEWISIAN</strong></td>
<td>LUOLOW MEMBER</td>
<td>0-330</td>
<td>Green marine shales and wavy sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>CRETACEOUS</strong></td>
<td>NELL CREEK FORMATION (Lance Formation)</td>
<td>425</td>
<td>Green marine shales and wavy sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>UPPER</strong></td>
<td>FOX HILLS FORMATION</td>
<td>25-200</td>
<td>Gray to white sandstones.</td>
</tr>
<tr>
<td><strong>PIERRE SHALE</strong></td>
<td>Turner Sand Zone</td>
<td>1200-2000</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>MISBRARA FORMATION</strong></td>
<td></td>
<td>100-225</td>
<td>Light-gray shales with numerous large lenticular sandstones and sandy layers.</td>
</tr>
<tr>
<td><strong>CARLILE FORMATION</strong></td>
<td></td>
<td>400-700</td>
<td>Light-gray shales with numerous large lenticular sandstones and sandy layers.</td>
</tr>
<tr>
<td><strong>GREENHORN FORMATION</strong></td>
<td></td>
<td>(25-30)</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>BELL FOURCHE SHALE</strong></td>
<td></td>
<td>(600-360)</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>MOWRY SHALE</strong></td>
<td></td>
<td>300-500</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>NEWCASTLE SANDSTONE</strong></td>
<td></td>
<td>150-250</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>SKULL CREEK SHALE</strong></td>
<td></td>
<td>20-60</td>
<td>Light-gray shales with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>WINDMILL GROUP</strong></td>
<td>FALL RIVER (DAKOTA?) SHALE</td>
<td>170-270</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>PIERRE SHALE</strong></td>
<td></td>
<td>10-60</td>
<td>Massive to thick bedded sandstones.</td>
</tr>
<tr>
<td><strong>MORRISON FORMATION</strong></td>
<td></td>
<td>10-80</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>SUNDANCE FORMATION</strong></td>
<td></td>
<td>250-450</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>MADORA FORMATION</strong></td>
<td></td>
<td>0-45</td>
<td>Gray to white sandstones. Lower gray shale with thin beds! of limestone.</td>
</tr>
<tr>
<td><strong>JURASSIC</strong></td>
<td></td>
<td>0-225</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>UNKARA FORMATION</strong></td>
<td></td>
<td>0-225</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>SUNDANCE FORMATION</strong></td>
<td></td>
<td>0-225</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>GYPSUM SPRING</strong></td>
<td></td>
<td>0-45</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>TRIASSIC</strong></td>
<td></td>
<td>250-700</td>
<td>Gray to white sandstones. Lower gray shale with thin beds of limestone.</td>
</tr>
<tr>
<td><strong>SPEARFISH FORMATION</strong></td>
<td></td>
<td>30-80</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>PERMIAN</strong></td>
<td></td>
<td>30-150</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>MINNELUSA FORMATION</strong></td>
<td></td>
<td>350-950</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>MISSISSIPPIAN</strong></td>
<td></td>
<td>300-630</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>DEVONIAN</strong></td>
<td></td>
<td>30-80</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>ORDOVICIAN</strong></td>
<td></td>
<td>30-60</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>CAMBRIAN</strong></td>
<td></td>
<td>10-400</td>
<td>Massive gray, laminated sandstones.</td>
</tr>
<tr>
<td><strong>PRE-CAMBRIAN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** This section is best viewed in color for full detail. The colors represent different types of rock and sedimentary layers. The thickness values indicate the range of stratigraphic units found in the area. The description column details the characteristics of each formation, including color, texture, and any notable features such as fossils or mineral deposits. The section is part of the geologic map of the Black Hills, South Dakota, and is a valuable resource for understanding the area's geologic history and composition.
Introduction to the Field Guide

Welcome to the 2008 He Sapa Bloketu Woecon! This guidebook highlights scientific and cultural information about sites in the Black Hills and Badlands, South Dakota that we will be visiting. Each section of this guidebook contains information about geology, natural sciences, Lakota culture, and other interesting details for each site that we will visit. Concepts are presented at an introductory level, to be used as references by each participant. Detailed explanations of each site are given during lectures on day one of each camp, as well as during the field trips.

The cultural, natural, and geological history of the Black Hills has always been one of the most unique aspects of this beautiful region. Almost any location one would choose to visit has a rich history. This field guide is not intended to be the final word on the history of this region, but instead, it is meant to be an introduction to the richness and beauty of the Black Hills and surrounding area. It is hoped that each participant of these field camps will leave with a vigorous interest in some aspect of the local history. It will be up to each of you to look up, visit, and learn more and more about this area.

The field guide is not arranged in any particular order, nor is it designed in a travel log fashion. Each of the major Native American cultural sites is listed separately and discussed individually. Thus, when visiting these sites, the information in this guide will be useful without the need to sort through a complex list of stops, as a travel guide would have.

Geologic terms will be used in this guide but these are explained in the text. One of the common terms used will be “Formation”; this can be defined as “a grouping together of rocks of various type that characterize a particular property of the rocks, such as a common process of deposition, or deposition during the same time period”. “Deposition” is the term used to describe the accumulation of the small, individual particles that make up the rock body. Some of the rock units are called Formations and some are not. For example, on the General Outcrop Section (previous page), the Jurassic Period has the “Sundance Formation” and the “Unkpapa Sandstone”. The Sundance Formation is a grouping of different rocks, the Unkpapa Sandstone is an individual type of rock.

It is hoped the field guide will prove useful and informative. The greatest level of success for this guide will be in sparking an interest in culture or science in individuals.

Many of the cultural facts in this document were collected from the research of Victor Douville.

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Black Hills – He Sapa

The He Sapa are named for the appearance of the pine-covered slopes from a distance, which appear black in color. As people approached this land, the horizon was dark and black only turning to a green color as one encountered the outer slopes of the forested lands.

The He Sapa were part of the 1868 treaty between the great Sioux Nation and the newly-established American government. These lands were to remain the property of the Great Sioux Nation. The treaty was broken around 1876 after gold was ‘officially’ discovered in these mountains during a scouting expedition led by General George Armstrong Custer. Despite appeals to Washington by the Natives, the homelands of the Great Sioux Nation were soon flooded with prospectors hoping to strike it rich. However, the attitude of the Natives has never changed and is expressed in the Lakota language as: “He Sapa Kin waken yelo, oheniya kik suyapo.” This is translated as: “Always remember the Black Hills are sacred.”

The photo shows some of the members of the 1968 treaty council that was held at Fort Laramie, Wyoming Territory.

Most of what is now western South Dakota and parts of surrounding states were included in the land divisions established in the 1868 treaty. All of the land shown in orange color on this map, extending to the Missouri River, was Tribal land. The present location of the several Reservations are shown in gold color.
The He Sapa are actually mountains, but “hills” has always been a part of the common name. Geologically, the mountains are very old and contain some of the oldest rocks in this part of the country. Geology can be intimidating to someone not familiar with all of the terms that are used. The ‘General Outcrop Section of the Black Hills Area’, which is shown at the beginning of the field guide, shows the names of the various rock units, or ‘formations’, that have been named. The left-most column includes the geologic ‘time period’ that the formation has been assigned to. On this figure, the formations at the bottom are the oldest and the formations at the top are the youngest. The right-most column contains the general description of the formations, basically, this is the type of rock that the formation is made up of. The center column titled “section” shows a cartoon drawing, or symbol, for the rock type in that formation.

The Black Hills are oval in shape, sort of like a cereal bowl turned upside down. This means that the formations that are exposed occur in a ring-like pattern around the mountain belt, as shown in the graphic to the left. This ‘ring’ appearance has special meaning for Native American culture and is described in the next section on the Red Race Track. The oval shape also means that geologically, the age of the rocks progressively get older toward the center of the mountain belt. The highest point in the Black Hills is Hinhan Kaga Paha, the Ghost Butte, also called Harney Peak. It is located in the south-central part of the mountain chain and has an age of “Pre-Cambrian”, which can be seen at the very bottom of the ‘General Outcrop Section of the Black Hills Area’. The rock type is ‘igneous’ and is called ‘granite’. An igneous rock forms from a molten magma as it cools and solidifies. Granite in the Black Hills has very large crystals in it that are easily seen with the naked eye. This can be observed at several of the cultural locations.

As this field guide is used, it will be useful to refer to the ‘General Outcrop Section of the Black Hills Area’ to be able to place a particular rock formation within the general sequence of rocks that make up these mountains. This will also aid in understanding some of the geological and natural significance of each of the cultural sites that are discussed in the following pages.
Red Race Track – Ki Inyanka Ocanku

Ki Inyanka Ocanku, interpreted as “Race Track Valley”, holds critical significance in Lakota culture and history. This unique feature of the He Sapa, or Black Hills, was the site of the famed race between the 2-leggeds and the 4-leggeds. Viewing images at the beginning of this guide reveals that the Race Track Valley is oval shaped and surrounds the He Sapa. It was the perfect location for this great race. The race was to determine the order of things in the world. So many 2- and 4-legged creatures ran in the race, and the race was so long and difficult that the feet were bloodied, staining the ground red. More details of this race, and its cultural significance, will be discussed during the field trips.

Geologically, the Race Track consists of the Mesozoic Triassic Spearfish Formation and is made up of between 250 to 700 feet of bright red sandy shale, siltstone, fine-grained sandstone, and minor limestone, all interbedded with gypsum (a white mineral located throughout the formation). Deposition of this formation (which is the process of making a rock formation) began about 245 million years ago when a large sea existed here. Some of the sediments, which are called shale, were derived from settling of very small particles in seawater. Other sediments were deposited on the beach area or locations near the shoreline. Geologists refer to this environment as ‘marine to marginal marine’.

The current landform is a low and often wide valley that surrounds the Black Hills much like a ring. This ‘ring’ form that encircles the Black Hills appears as an erosional artifact from the

Cross section by Dr. Larry D. Stetler; digitized and rendered in 3-D with extrusions by James J. Sanovia
‘uplift’ of the land to form the mountain chain. Geologists refer to this event as the ‘Laramide Orogeny’ (mountain building event) which began about 65 million years ago. After millions of years of wind and water erosion, much of the softer sediment has been removed. The rock units that surrounded the red shale were harder and more resistant to erosion. These rocks now stand at higher elevations (ridges) than the soft red shale which has formed a valley. The final valley form between higher ridges of harder rock is a natural location for a road, or a race. The cross-section above shows these features and illustrates the low-level valley between two higher elevation ridges and hills.

From a geological/scientific point of view, the red color comes from iron oxide that is present throughout the formation. The iron that was originally present in the sediments was over time subjected to alternating hot and dry to cool and wet climates. During the wet periods, the iron became ‘oxidized’, meaning it combined with oxygen. The result of the oxidation was rust, just like a tin can that has been left outside in the rain and snow. Rust is usually red and has produced the red color of this formation.

Fossils in Triassic-age ‘red beds’ are rare because the rusting process has destroyed most of them, but there are some stromatolites, which are mounds of algae, and bivalves, such as clams and oysters. Some of the oldest dinosaur fossils are from the Triassic period, although none have been found locally.

I-90 between Rapid City and the Wyoming border is constructed on the Red Race Track and is situated between the higher Black Hills to the south and the Hogback Ridge to the north. The white gypsum beds are often viewed as thick white bands at the base of the Hogback Ridge and as low hills in the middle of the Race Track. The gypsum was formed by evaporation of the seawater and is much like evaporation of salt water from a glass that leaves a white powdery residue. Because gypsum was formed as seawater evaporated, it is easily dissolved when it
comes into contact with water. As it dissolves, large open spaces are formed and the overlying land often falls into these holes. These forms are called ‘sinkholes’ and are depressions into the land surface. One of the culturally significant sinkholes was used as a buffalo kill site by Native American tribes and is located along I-90 in Wyoming. The Vore Buffalo Jump site is included as a cultural site in this field guide.

Red Race Track (covered by snow)

This view of the Red Race Track, from Google Earth, is looking in the same direction as the above picture but is shown in winter time. Again it is easy to see the Race Track in the lower elevation valley running through the center of the picture.

This photograph is looking northwest from inside the Red Race Track. Again, note the higher elevation ridges on both sides of the Track. The Hogback Ridge is to the right. The “white dot” in the above image is the location this photo was taken.

Red Race Track (looking NW)
**Hogback Ridge Geology**

The Hogback Ridge forms the outer rim of the Red Race Track and also surrounds the Black Hills. Driving from Rapid City north to Spearfish, the Hogback is located on the north and east side of I-90. By visiting many of these cultural sites, a majority of the Hogback on the eastern side of the Black Hills can be seen and studied.

The Hogback Ridge includes rocks from the Jurassic and Cretaceous periods. In the cross-section above, these are designated J₃ and K₃. Individual formations included in these two groups are, from oldest to youngest, the Sundance, Unkpapa, and Morrison Formations (Jurassic) and the Lower Cretaceous Inyan Kara Group, which consists of the Lakota Formation and Fall River Sandstone. Descriptions for each of these rock units can be seen in the General Outcrop Section chart at the beginning of the field guide.

The Jurassic Sundance Formation consists of red and gray silty shale, thin lenses of limestone, and yellow sandy beds near the top and bottom of the formation. The environment that created this formation was fluctuating between near shore marine, shoreline, and lagoon. Fossils in the Sundance Formation include Pachyteuthis (also called Belemnite—a Greek word meaning shaped like a dart of javelin), which look like a bullet or a small squid, Pentacrinus (Sea Lily plant-like animal), and Amaltheus (also called Ammonites), which are circular shells.

The Unkpapa Sandstone overlies the Sundance Formation and consists of massive, white to bright red and yellow fine grained sandstone. The environment in which this sandstone was formed was shoreline dunes. At that time, a broad desert was present in the Black Hills and eastern Wyoming area. Deserts do not preserve fossils very well and as a result, there are no known fossils in the Unkpapa Sandstone.

The youngest formation of Jurassic age is the Morrison Formation, which overlies the Unkpapa Sandstone. The Morrison Formation consists of green to maroon shale with thin beds of sandstone. The environment of deposition for these sediments were floodplains and streams with a seasonally dry and warm climate. The Morrison Formation reveals that dinosaurs were starting to be prominent in the Black Hills area and has many fossils including Ostracodes (microscopic aquatic bivalve animal), Barosaurus (similar to Brontosaurus found on top of Skyline Drive), Allosaurus (Smaller version of Tyrannosaurus Rex), and Camarasaurus (also similar to Brontosaurus). The Morrison Formation is well known throughout the western United States as a rich zone of fossil dinosaurs.
The upper-most part of the Hogback Ridge consists of the Lower Cretaceous Inyan Kara Group (K\textsubscript{L} on the above cross-section). The Inyan Kara group is made up of the older Lakota Formation and the overlying younger Fall River (Dakota) Sandstone. The Lakota Formation is a massive gray to yellow cross-bedded conglomeratic quartz sandstone interbedded with shale and limestone. The Lakota Formation sediments were deposited in an environment consisting of streams, lakes, and tidal flats. Fossils are common in these units and include Cyadeoidea (fern looking leaves; its fossilized trunk looks like a pineapple), Gymnosperm wood, and Theropod dinosaur footprints (carnivorous relative to Tyrannosaurus rex).

The lower section of the Fall River Sandstone makes up the highest elevations on the Hogback Ridge. The sandstone unit consists of moderately well rounded, fine grained, massive to slabby, quartz sandstone. The lower section is more massive and thins toward the upper sections. Sediment making up the Fall River Sandstone was deposited in a ‘transgressive’ marine shoreline environment. A ‘transgressive’ shoreline is when the level of the ocean is rising and floods over the surface of the land, inundating it. Geologists call the ocean the “Cretaceous
Seaway” and it extended throughout most of the central part of what is now the United States. Fossils are rare in this rock.

**Bear Butte – Mato Paha**

Mato Paha is an important cultural site where Sweet Medicine, a Cheyenne man, received guidance and gifts about 4000 years ago during a trek to the top of the mountain. Today it is a site where people go for vision quests, sweat ceremonies, and couples visit to make plans about family.

Mato Paha is believed to be a bear in eternal sleep after receiving mortal wounds from combat with Uncegi Tanka, a dinosaur-like creature. The battle between the bear and Uncegi was long and hard-fought resulting in great rips and tears in the earth. The area of the battle is now the Mako Sica, or the Badlands. The bear, wounded and dying, limped away and laid down to final rest at this site.

Mato Paha is a unique geologic feature located about 5 miles northeast of Sturgis, SD. The makings of the mountain were formed during the Laramide Orogeny, a geologic event lasting from about 65 to 40 million years ago. During this time, the Rocky Mountains and the Black Hills were lifted up above the surrounding plains. Part of the uplift event included hot molten magma (melted rock) making its way upward toward the surface but not reaching it. The magma then cooled underground to form a rock called “porphyritic quartz monzonite”. The age of the rock has been dated at 51 million years old. Quartz monzonite is much harder than the surrounding sandstone and shale rocks that the magma flowed into. As a result of erosion, the softer rock has been removed, leaving the quartz monzonite elevated above the plains and creating this beautiful landform.

![This view of Mato Paha is looking to the north. The mountain rises about 1250 feet above the surrounding plains. Talus slopes can be seen to surround the mountain.](image_url)

A climb to the top of Mato Paha is quite strenuous and the trail is steep in several places. All along the way broken and fractured rock fragments are lying about the trail. Deposits of broken pieces of the quartz monzonite surround Mato Paha. These pieces of rock are often flat and
smooth and on a steep slope will slide easily from under your feet. Such deposits of broken rock are called ‘talus’. These represent the natural process by which mountains are broken down. Be very sure of your steps! Note also that the pieces of rock sound like glass or china plates as they clink against one another (carefully pick up 2 pieces and clang them together). It makes this ‘china’ sound because the primary mineral that forms this rock is quartz, or natural glass. These broken pieces also display other properties of glass, such as a ‘swirl’ patterns formed on the broken surfaces of rock (just like on a broken piece of glass) and the sharp edges make great cutting tools.

![Broken shards of the quartz monzonite surround Mato Paha and form talus slopes. These are very steep and slide easily.](image)

The mountain is located in the middle of a flat prairie and is several miles north of He Sapa. This makes Mato Paha a prominent landmark and adds to its natural beauty. The view from its peak is unparalleled and makes the tough journey worth the while.

![This view is from the top of Mato Paha southward into the He Sapa.](image)
Vore Buffalo Jump – Vore Mayaktewicayapi

Vore Mayaktewicayapi, the Vore Buffalo Jump (kill) site is about 35 miles west of Mato Paha on I-90. A drive to this site is in the middle of the Red Race Track. This feature is a large sinkhole formed in the center of the Red Race Track (Spearfish Formation) by the dissolution of gypsum. Recall that gypsum is formed by evaporation of water which means that if gypsum and water come together (by rain, snow, streams, etc.), the result will be gypsum minerals dissolving back into the water. When this happens, solid material (gypsum) is removed and replaced by a void spot, or a hollow. Overlying rock will usually fall into the void because there is nothing below to support it. In this case, the gypsum dissolved and the red shale collapsed, forming this sinkhole.

Sinkholes are common features in many locations in the Red Race Track. On the South Dakota – Wyoming border lies a series of small lakes, called Cox Lakes and Mirror Lakes. These circular lakes are formed in sinkholes that have been filled by groundwater forming a small oval-shaped lake. At Vore Mayaktewicayapi, the sinkhole remained dry allowing it to be utilized as a kill site for buffalo.

It is believed that as many as five different Native American tribes utilized the Vore site to obtain skins, meat, and other commodities that the buffalo supplied. The Cheyenne, Kiowa, Kiowa-Apache, and possibly the Lakota utilized this site for at least 400 years, from 1300 to 1700. Herders would slowly push buffalo toward the sinkhole and at the last second stampede them. As many as 100 animals may have died in any one ‘event’. With the introduction of horses to the plains in the 1700’s, the jump sites were abandoned in favor of hunting from horseback.

The Vore site is about 200 feet across the top and 45 feet deep. Originally it was about 25 feet deeper than it is today. Much of the bottom of the sinkhole consists of the bones of an estimated 20,000 buffalo. Dog bones have also been found in the bone layers but no human remains have been detected. If humans died during the kill, their remains were removed from the pit.
View into the sinkhole from the top. Gypsum (white rock) can be seen at the surface on the far side of the sink. It was the removal of the overlying gypsum, due to dissolution in water, that created the collapse structure. 22 cultural layers have been identified in the bottom, as well as the bones of about 20,000 buffalo.

The exposed bones in this picture are from the 4th layer, about 3 feet below the surface. About 18 more bone layers lie below this level. Note the buffalo skull—the top of the skull has been removed to allow access to the brain tissue (used to tan the buffalo hides). The site is excavated for a brief time each summer by the University of Wyoming.

Regional Jump Sites
Additional jump site locations are known from around the western plains. These include Shield Cave (MT), Natural Trap (WY), Salamander Cave (SD), Graveyard Cave (SD), Mammoth Site (SD), and Porcupine Cave (CO).

Possible Kill Site in NW South Dakota
It is thought that Native peoples utilized resources where they were available. In the very northwest part of what is now South Dakota, there are a series of small buttes that rise abruptly from the plains forming a steep cliff on the east side. These buttes are now named the “Cave Hills”.
Cave Hills buttes form a natural area for a kill site location. The gully in the foreground is part of the same systems where the pictures below were taken.

In this particular area, a natural ‘ramp’ exists from the west side where buffalo could have been herded to the top of the cliff, forcing them to jump to their death. If these cliffs were actually utilized as jump sites or not is not presently known. However, recent field work by Dr. Stetler has revealed the presence of bone beds and signs of human occupation at depths from 6 to greater than 12 feet below the present surface. These bone layers could be processing grounds for buffalo kills. It is apparent that the area also served as temporary camp sites for Native people. There are many ‘petroglyphs’ on the sandstone cliffs in this area, further attesting to Native peoples’ occupation.

Tradition also says that these buttes were the last camp sites for Sitting Bull and his followers during the summer months when they were allowed to leave the Reservations to hunt and camp for the summer.
Devils Tower – Mato Tipila

Mato Tipila, also called Devils Tower, is located about 60 miles west and north of Mato Paha. It is a massive igneous monolith rises 1267 feet above the Belle Fourche River. It was formed in much the same way as Mato Paha. The primary difference is that the molten rock, or ‘magma, at this site had a different chemical composition than was present at Mato Paha. This resulted in Mato Tipila being composed of a rock type called ‘phonolite porphyry’. Geologically, this rock has been dated at 50 million years old. It is an enormous, almost rectangular column rising nearly vertically upward from its base and is an impressive structure. The top of the pillar is about 400 feet across.

The most visible and interesting features of this mountain are the characteristic columns on the side of the monolith. Geologically, this pattern is referred to as “columnar jointing”. The columns form by a geologic process where the magma cools and solidifies into rock at different rates. When the magma migrated up toward the surface, it intruded into the surrounding rocks. The edges of the magma that came into contact with the existing rock cooled quickly because the existing rock was already cold. This essentially formed a solid rock ‘skin’ around a molten center. Rock does not allow heat to move through it very well (a process known as ‘conduction’) and so once the outer skin solidified into rock, it took a much greater amount of time for the center of the pillar to cool. Because there was a solid skin all around the outside, the interior cracked as it cooled, forming these great columns.

The process is the same as mud drying in a puddle. As the mud looses water to evaporation, the volume of the ‘mud’ lessens and the result is a shrinking of the leftover material in the puddle (which occupies less space after the water has been removed) and it cracks. The most common cracking pattern is a 5-sided shape. The columns on Mato Tipila are also 5-sided, although they are much larger than cracks one would see in a dried-up mud puddle.
The phonolite porphyry making up the mountain was much harder and much more resistant to erosion than the surrounding softer rocks. After the soft rock eroded away, the pillar was left standing high above the plains.

Traditional Native stories tell us that a long time ago, seven sisters were being chased by a giant bear. A voice told them to go to a certain large rock and as they stood on the rock, one of them prayed, “Rock, please carry us up high where we can be safe”. As she prayed, the rock grew higher and higher into the heavens. The bear tried to climb after them and made great scratches on the side of the growing rock with its claws. These claw marks remain to this day. The rock stopped growing when the seven sisters were out of danger. Later, giant eagles transported them back down to the ground. The seven sisters eventually became stars (the Wincincila Sakowin or Pleiades).

Mato Tipila is one of three landforms that are elevated high enough to be seen from great distance. The other two are Mato Paha and Hinhan Kaga Paha. These three peaks form the skull of a buffalo at the summer solstice and were used as guide marks during the Great Race. Today, Lakota people hold sacred ceremonies on or near each of these landforms.

- Talus slopes surround Mato Tipila. The talus pieces are several feet in diameter and up to several feet in length.
Buffalo Gap - Pte Tali Yapa

Pte Tali Yapa, or Buffalo Gap, is located on the eastern flank of the Black Hills about 30 miles south of Rapid City. Traveling south on State Highway 79, the Hogback Ridge will be located on the west (right) side of the road. The landform that is called Buffalo Gap is an erosional gap through the Hogback Ridge that was carved by Capa Wakpala (Beaver Creek). At the small town of Buffalo Gap, Highway 101, also known as the 7-11 Road, proceeds through the center of Pte Tali Yapa. This is also known as Martin Valley. Continuing west on Highway 101 through Buffalo Gap eventually will connect to Highway 385 just outside of Custer State Park.

The town of Buffalo Gap, located about one mile southeast from the entrance to this feature, is named for this unique and significant location. The Lakota named this area Pte Tali Yapa because the Pte Oyate (Buffalo Nation) used this natural gap as the main entrance into and out of the Black Hills. This site is also the traditional entrance to the He Sapa by the Lakota people as they migrated from the prairies to the mountains each spring. This event also signaled the beginning of each new year’s ceremonial cycle.

When approaching the Hogback Ridge from the east, the dirt road is located next to Capa Wakpala which flows eastward through the entire gap area. Upon entering the gap and heading west, Ki Inyanka Ocanku, the Red Race Track, will begin to become very evident. Bright red sandstone located at the western base of the Hogback signals the Triassic red bed deposits and stands out in contrast to the green grass surrounding it.

Entrance to Pte Tali Yapa and looking to the west. The red hues to the west of the Hogback Ridge are the red shales making up the Red Race Track.

Most of the land along this road is privately owned and used for cattle ranching. While on the 7-11 road and near the center of the gap, be on the look out for a cowboy lassoing a Tyrannosaurus Rex! Further to the west of the T. Rex, look for the Red Valley Road branching off to the north. At this location, turn around and look back to the southeast to the tall triangular-shaped mountain peak in the distance. This peak is called Unkpapa Peak. The name “Unkpapa” was given for the Hunkpapa people, one of the seven bands of the Lakota. This name is also given to the Unkpapa Sandstone, a formation that is sporadically present at this locality.
From a biological view, the land in this entire area is classified as “herbaceous” rangeland and is used for cattle ranching throughout most of this area. Herbaceous is a term that means the plants have little or no woody tissue and that they generally “persist”, or grow, over a single season. About three quarters of the way through the gap, buffalo fencing will become evident on the north side of the road. If luck is with you, buffalo may be observed grazing in the distance. These buffalo are a part of the Wind Cave National Park herd which was established in 1916, and represents one of the first efforts to protect these massive creatures from extinction.

**Harney Peak Granite** (Crazy Horse Memorial, Mt. Rushmore National Monument, Harney Peak)

The Central Black Hills contains many Native American cultural sites that range in age from ancient Native history to the present day. The more important of these include Crazy Horse Mountain (Tasunke Witko), Harney Peak (Hinhan Kaga Paha), and Mt. Rushmore (native spelling). These sites may have varying cultural significance but they all share one major commonality, the rock they are all formed from.

Geologically, these sites are all composed of Pre-Cambrian Proterozoic granite and pegmatite (the bottom rock type shown in the General Outcrop Section at the beginning of the Field Guide). These rocks were formed from a magma (molten rock) that cooled into solid rock at a depth of about 10 to 12 miles below the surface of the earth. At this depth, cooling took a great deal of time. This is an important factor in the development of individual crystals that make up the rock in that crystal size gets larger with cooling time, so the longer it takes to cool into solid rock, the larger the crystals can grow. The entire area of the magma, which is now solid rock, has been estimated to be larger than 100 square miles in size. This large magma pocket, and the rock that formed from it, is called a “batholith”.

This batholith began its trip to the surface from deep within the molten part of the earth (probably more than 100 miles below the surface) several billion years ago. When it stalled, or stopped migrating upward, and to begin to cool into solid rock, crystals started to form. Geologists use sophisticated instruments to measure the amounts of certain elements that are in the crystals to determine how long ago the crystal was formed. The Harney Peak Granite has been dated to have solidified into rock about 1.7 billion years ago. Large sections of the batholith cooled very slowly, giving the rock a coarse texture with large crystals that form what is called “pegmatite”. Most of the small mines that were located in the area around Harney Peak south to the Custer area are all in a pegmatite rock. Some areas of the granite cooled more quickly forming a fine-grained granite, although the individual crystals can still be seen with the eye. Crazy Horse Memorial, Mount Rushmore National Memorial, Harney Peak, and the Needles in Custer State Park are mostly made of this fine-grained granite. The primary minerals contained in these granites and pegmatites are quartz, muscovite, tourmaline, biotite, microcline perthite, and oligoclase.

A unique feature that granite exhibits is its ability to weather in spherical columns and spheroidal boulders, which we can see in the Needles/Cathedral Spires, and the more massive granites behind and around Mount Rushmore and Crazy Horse area. This process is called ‘spheroidal’
weathering and proceeds primarily through a chemical reaction called ‘hydrolysis’. Hydrolysis works by water, from rain and snow, reacting with the minerals in granite, such as feldspar and biotite, to form clay minerals. This process actually transforms one mineral species into another. This process acts on edges of the granite and so rock that is fractured will have more edges. As the process continues, two things happen: the sharp edges become rounded, and many clay minerals ‘expand’, or get larger, because they are holding additional water. The end result is that the granite becomes stressed and fractured and breaks into smaller pieces. This weathering process gives the granite a spheroidal, rounded appearance.

*Harney Peak Granite: This granite body forms the central core of the Black Hills.*

*Granite spires with highly ‘rounded’ tops.*  
*‘Grus’ sand formed by weathering.*  

Granite can also be affected by climate in that in regions of high precipitation, the rock can actually become rotten. In geologic terms, this rock type is called ‘saprolite’ and results from chemical alterations, such as hydrolysis, hydration, oxidation, carbonation, ion exchange, and solution, change to the minerals in the rock due to a wet climate. Saprolite looks just like the original rock type except that it has lost all of the strength of the original rock. Saprolitic granite decomposes to a soft, earthy rock that most people can crumble with their bare hands. Crushed
saprolite is called ‘grus’ and is basically made from angular coarse-grained fragments of the pre-existing granite. Grus is really granitic sand and is located in many sections of granite around the Black Hills, particularly directly behind Mount Rushmore monument on the Peter Norbeck Scenic Byway (Hwy 244).

Tasunke Witko National Mountain (Crazy Horse Memorial)
This mountain carving is a memorial to the Lakota medicine man Crazy Horse (?). It was commissioned by the Lakota Chief Henry Standing Bear in 1948. The purpose of the Memorial is to honor the culture, tradition, and living heritage of the North American Indian.

An abbreviated story of Crazy Horse is as follows:
He was believed be have been born sometime around the year 1840 while the Lakota were camped along Rapid Creek (Mni Luzahan Wakpala). When he was born, a wild horse ran through the camp. He was first known as Curly and then His Looking Horse. His father gave him his name, Crazy Horse, after he performed an act of bravery against an enemy tribe. As he reached adulthood, many changes were coming to these lands and he saw first-hand the results of the 1868 treaty, in which it was stated by the then President of the United States: "As long as rivers run and grass grows and trees bear leaves, He Sapa -- the Black Hills -- will forever be the sacred lands of the Lakota Indians.". He witnessed the failure of the US Government to deliver on the promises of the treaty, to provide food, clothing, shelter, and basic human needs to the Lakota people. He witnessed the extreme depravity of his people as disease ravaged through the Native population. He saw the beginnings of the disease of alcoholism and its degrading treatment to the Native peoples. At this point, he began to fight back in the only way he knew—in battle. He surrendered to the US Army at Fort Robinson, NE and while a flag of truce waved, he was stabbed in the back by a soldier. He died on September 6, 1877.

Crazy Horse model with the carving in the rear.

View of the completed face on top of the arm.
The Memorial carving is not meant to be an exact representation, or even a similarity, to what Crazy Horse looked like. Instead, it is to honor his spirit and the people themselves. The carving will, when completed, show Crazy Horse sitting on top of a horse with his arm pointing across the horizon. This pose is to honor his view of his land, and his people. When asked the derisive question by a white man, "Where are your lands now?" he replied, "My lands are where my dead lie buried."

_Tunkasila Sakpe Paha (Mount Rushmore National Memorial)_
The original Lakota name for this mountain was Igmu Tanka Paha, or Cougar Mountain, named for the many wild cougars that lived in the forests around its peaks. In about 1870, a Lakota medicine man changed the name to Tunkasila Sakpe Paha, or six-grandfathers mountain, because of the six prominent outcrops of the mountain summit. It was named “Mt. Rushmore” in 1900.

Today, the faces of four US Presidents have been carved on the mountain.

The story of Tunkasila Sakpe Paha revolves about an Ogalala Lakota boy, Black Elk. When he was nine years old he became sick and suddenly collapsed. He was taken to the slopes of Cougar Mountain where six very old elders, or grandfathers, helped the boy. The six grandfathers gave him gifts. The first gave him the power to heal, the second gave him cleansing power, the third bestowed the gift of awakening and peace, the fourth provided growth power, the fifth gave him the power of transcending vision, and the sixth turned back his own old age and become the boy Black Elk and became a powerful medicine man.

_Wind Cave – Wasun Niye_

Wind Cave began at the bottom of a sea about 350 million years ago. Minerals in the seawater precipitated solid crystals as seawater temperature and mineral content varied. Also, as the sea evaporated, gypsum was deposited as well. A large portion of the rock is composed of the shells of sea creatures, such as the brachiopod shown below. Through a long period of time lasting millions of years, the level of the sea expanded and shrank due to evaporation and each fluctuation produced another layer of crystals. By about 320 million years ago, the sea was gone and the deposits were present as limestone. This limestone comprises the Pahasapa, or Madison
Limestone Formation. Water soaking through fractures in the limestone carried weak acid solutions with it and the acid began to dissolve the rock, particularly the calcium carbonate parts, or those parts that were mostly pure limestone. This slow work of flowing water through small fractures, cracks, and openings, has created the second and fourth longest cave systems existing in the world today, Jewel and Wind Cave’s, respectively. The sea moved into and out of this region many times for ten’s of millions of years, each time adding more to the rich history of the cave systems.

During the Laramide Orogeny, or mountain building period that occurred about 60 million years ago, the Black Hills were uplifted up into a small mountain chain. As this occurred, the once flat rock layers were tilted. In the region of Wind Cave, the formations tilt to about 10 degrees. This allowed the groundwater to now flow down-gradient, just like a surface stream flows from higher elevation to a lower elevation. It is known that the velocity of flowing water has a very large impact on the power it has to dissolve rock. With the new tilt to the land caused by the Black Hills uplift, water became much more aggressive at dissolving the limestone as it flowed between the fractures in the rock. As time went on, these small fractures became wider until, as now, a person can easily walk upright along them. Water began to drain downward through the fracture systems as it flowed down hill. About 40 million years ago, the water level dropped below the fracture system that was being dissolved into cave passageways. Today, the water level is about 500 feet below the surface of the ground and most of the cave system is above this level.

The first documented cave exploration occurred in 1881 as two brothers found a small opening in a canyon that had tremendous wind blowing from it. The wind moved into or out of the opening depending on the outside temperature and pressure. Today, geologists study the air flowing in or out of the cave as a way to determine its total volume, or spaces that are open under
the ground. In the Wind-Jewel Cave systems, the volume of the air moving is greater than both of the known cave volumes combined. This suggests that in this area, the largest cave system in the world most likely lies undiscovered. The Wind Cave National Park was created in 1903 in an effort to protect this natural beauty in the southern Black Hills.

The Native American history predates any exploration and knowledge of this cave by the white settlers and explorers. Native culture has many stories about a hole in the ground through which the wind blew. Many tipi rings have been discovered in this immediate area, further supporting the fact that this cave was known to the Native people. It is likely that its location was known for centuries before it was explored in 1881. It is this cave that birthed the Pte Oyate, the Buffalo People. In this story, the embryo that emerged from the cave was Tokahe, the first man, and was transformed into a human being. This natural history is recorded in the stars as the “Red Circle”.

Badlands National Park – Mako Sica

Mako Sica, or ‘land bad’, is an appropriate description of these hot, arid lands located about 40 miles east of Rapid City. The geologic formations that make up these pinnacles and dry, barren slopes are Cretaceous in age (refer to the General Outcrop Section of the Black Hills at the beginning of the field guide). These rocks were deposited in shallow seas about 150 to 65 million years ago when this part of the world was near the equator. Most of the rock types are shale, or rocks formed from mud that was deposited on the bottom of the shallow seas. Sandstone also occurs mainly as interbedded lenses in the shale units.

This area contains the world’s richest Oligocene epoch fossil beds, dating to 37-28 million years ago. Evolutionary stories of mammals, such as the horse and rhinoceros, arise from the 244,000 acres of sharply eroded buttes, pinnacles, and spires. Bison, bighorn sheep, endangered black-footed ferrets, and swift fox roam one of the largest, protected mixed-grass prairies in the United States.

The geologic story of the Badlands can be read by looking at the variations in horizontal layers (or bands) of this region. Each band tells about what was occurring at the time the band was formed. The layers of the Badlands are composed of sedimentary rocks, which formed initially as tiny grains of sand, silt, and clay that were cemented together into solid rock. The two main geologic processes that formed the Badlands into what we see today were deposition of sediment and their erosion by wind and water.

The creation of the Badlands began with a vast inland sea that covered what is now the Great Plains during the Cretaceous Period (69-75 million years ago). Sediments deposited on this sea bed formed a black mud that later hardened into shale, or compressed mud. This is known as the Pierre Shale, the oldest (bottom-most) layer of the Badlands. The ancient sea environment can be confirmed by the presence of sea animal fossils in this layer such as ammonites, sea reptiles, and clams.
In the Late Cretaceous Period, about 60 million years ago, the Laramide Orogeny began that resulted in the uplift of the Rocky Mountains and the Black Hills. Rocks that were formerly deep within the earth were uplifted to the surface as the result of crashing tectonic plates far to the west of this area. As the land uplifted, the inland sea drained away, exposing the black mud layer of the former sea floor to the open air. The top layers of this weathered into a yellow fossil soil (called a paleosol), forming what is now known as the ‘Yellow Mounds’ of the Badlands.

The next band to form was the grayish Chadron Formation, which is composed of soft mudstone. It can be recognized as low grey mounds with rounded ridges, gentle slopes, and very little vegetation. There are many islands of Chadron mudstone on the plain in front of the Badlands Wall and their color banding matches that of the Wall perfectly.

The Chadron mudstone layer was formed by river flood plain deposits dating from 34-37 million years ago. The Badlands area received deposits of rivers draining from the Black Hills to the west. Each time the rivers flooded, a new layer of deposits formed. There are alligator fossils in the Chadron mudstone layer, which says that this area had a lush, subtropical environment during that time. There are also many mammal fossils, including that of the titanothere, a large rhinoceros-like animal.

The tannish-brown Brule Formation was deposited above the Chadron rocks, also during the Oligocene Epoch (30-34 million years ago). The climate at that time was becoming cooler and dryer, changing the subtropical forests to open savannah or grassland. Fossils of sheep-like herd animals called oreodonts tell how the climate was changing during the period that this band was formed. Ancient rivers flowing down to this area from the Black Hills deposited sandstone in channels along the course of these rivers. The red layers within this formation are another type of fossil soil (paleosol). The Brule Formation is characterized by steep inclines, with slender spires rising above sharp ridges and intricately creased slopes.

Rounded ‘Yellow Mounds’ of the Chadron Formations are common views in the Badlands. A bright ‘red’ layer is an old soil layer, or paleosol.

Sharp, seep spires formed in the Brule Formation are the hallmark of Badlands topography.
During the late Oligocene Epoch, a thick layer of volcanic ash was deposited, the result of volcanic activity in the Yellowstone area, about 500 miles west of this site. This ‘ash’ is called the Rockyford Ash, and it forms the boundary between the Brule Formation and the next higher layer, called the Sharps Formation.

The light-colored Sharps Formation began forming about 20-28 million years ago. Deposits from wind and water covered this area as the climate continued to cool and dry out. There is also ash in this layer, as regional volcanic eruptions marked the end of the Laramide Orogeny (mountain building event). The Brule and Sharps Formations form the rugged peaks and canyons of the Badlands.

As each new layer formed, older layers were buried beneath them. At the end of the depositional phase, the area was a flat floodplain until about 500,000 years ago when erosion began to outpace deposition. Water and wind began to cut through the soft sediments and volcanic ash of this area and ancient fossil soils which had been buried for millions of years were exposed once again. Colored layers, representing these old soils horizons, can be traced from mound to mound across ravines by observing the color and characteristics of each layer.

Erosion continues to shape the Badlands to this day. On average, it has been estimated that the Badlands are eroding at a rate of one inch per year. Erosion is so fast in this area that a single thunderstorm can change the land overnight. It is estimated that in another 500,000 years, the Badlands will have completely eroded away.

**Native Americans in the Badlands**
There is a long history of Native people in the Badlands area, dating back for at least 11,000 years. Archaeological records and oral traditions tell of Native people camped in secluded Badlands valleys where fresh water and game were available year round. Today, there is evidence of these camps from campfire charcoal eroding out of the stream banks. Arrowheads and other tools that were used to prepare bison, rabbits, and other game animals have also been collected.

From the top of the Badlands Wall, Natives could scan the area for enemies and wandering herds of bison. If hunting was good, they might have remained into the winter before retracing their way to their villages along the Missouri River. The Seven Council Fires (Oceti Sakowin), or the Great Sioux Nation (Tetuwan Oyate) met in this area at least 150 years ago.

In the late 1800s non-Natives began moving into South Dakota. The U.S. government stripped American Indians of much of their territory and forced them to live on reservations. The Dakota Conflict of 1862 was the event used by the U.S. Government to cancel all treaties close the reservation system. Starvation, the constant presence of soldiers, and a loss of their traditional lifestyle had a devastating effect on Native Americans.

In 1890, thousands of Native Americans became followers of the Northern Paiute prophet Wovoka. Wovoka had a vision during the solar eclipse on January 1, 1889. His vision called for Native people to dance the Ghost Dance, a traditional round dance to be performed in a series of
five-day gatherings. Wovoka said that if Natives lived righteously and performed the Ghost Dance, the land and game of North America would be restored to the Native people.

Wovoka’s prophecy spread quickly among the Lakota, and one of the last known Ghost Dances was conducted on Stronghold Table in the South Unit, Badlands. Although Wovoka’s message was non-violent, the Ghost Dance frightened the non-Natives in the area, particularly the soldiers. As the winter of 1890 deepened, the ghost dancers returned to Pine Ridge Agency.

In late December, 1890, a band of Minneconjou and Hunkpapa Sioux headed south from the Cheyenne River and crossed a pass in the Badlands Wall. They were seeking refuge with Red Cloud on the Pine Ridge Reservation. Soldiers from units of the US Army, frightened by the Ghost Dance, pursued them.

The band, led by Chief Big Foot, was intercepted by the soldiers near Wounded Knee Creek and ordered to camp there. The next morning gunfire erupted, resulting in the destruction of nearly two hundred Lakota. This was the last major conflict between American Indians and the U.S. military and marked the end of the Plains Indian Wars. Conflict was renewed in the 1970’s with the American Indian Movement and also occurred in and around Wounded Knee, South Dakota.