NORTH DAKOTA GEOLOGICAL SURVEY

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Bulletin 25

The Geology of the South Unit Theodore Roosevelt National Memorial Park

Grand Forks, North Dakota, 1950

Reprinted from

NORTH DAKOTA HISTORY

Volume 17, No. 4, October, 1950

1-72382

THE GEOLOGY OF THE SOUTH UNIT THEODORE ROOSEVELT NATIONAL MEMORIAL PARK

NEAR MEDORA, NORTH DAKOTA

By WILSON M. LAIRD, *State Geologist*

ABSTRACT

This report endeavors to give the visitor to the South unit of Roosevelt Park a general knowledge of the geologic features encountered in the Park area. In addition to a general description of the geology of the area, a road log is given pointing out features of geologic interest along the main road through the Park.

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- Present
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- Pliocene
- Miocene
- Oligocene
- Eocene
- Paleocene

Mesozoic Era:
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- Jurassic
- Triassic

Paleozoic Era:
- Permian
- Pennsylvanian
- Mississippian
- Devonian
- Silurian
- Ordovician
- Cambrian

Cryptozoic Era:
- Proterozoic
- Archeozoic

Figure 1

Location of the Park

The Theodore Roosevelt National Memorial Park was created by an act of the Congress of the United States on April 25, 1947, and was formally dedicated on June 4, 1949. As extended by acts of Congress, it consists of 58,341.26 acres of federally-owned land in three separate units, one near Medora, another near Watford City and the third, the Elkhorn ranch site about midway between the two others along the Little Missouri River. The south part of the Park and the only part considered in this report is located in Billings County, North Dakota, and is found roughly within the boundaries of Townships 140 and 141 north and Ranges 100, 101 and 102 West, the south boundary of the Park consisting mainly of U. S. Highway No. 10. The south entrance of the Park is about one and one-half miles east of the town of Medora, the county seat of Billings County.

Reason for this Report

This report is being presented so that the public may become better acquainted with some of the more interesting geological and scenic features of the Park. This report should not be considered a technical paper for it is not intended as such.

Acknowledgements

The writer owes many thanks to numerous individuals for the assistance given in the preparation of this report. The local officials of the National Park Service namely, Mr. Allyn Hanks, Mr. Ray Mattison and Mr. William Briggle were most helpful in furnishing transportation and giving suggestions in the course of the work. Three of my students, Mr. Calvin Truax, Mr. John Fyten and Mr. Erwin Strecker did the spade work in the geology of this area as a project for their summer field course. Mr. Nicholas Kohanowski and Mr. Stanley Fisher of the North Dakota Geological Survey helped with the supervision of the student work and many thanks are due them for many suggestions and assistance in the progress of the work. Mr. Saul Aranow kindly read the manuscript and made valuable suggestions. Mr. Russell Reid of the State Historical Society was most helpful in the suggesting of the problem and in the printing of this report.

Geology

Stratigraphy of the Bed Rock

The bed rock of this area belong to a division of geologic time known as the Cenozoic era (See Fig. 1). To be specific the rocks were laid down in the Paleocene period of this era. The Paleocene, oldest of the periods of the Cenozoic, began approximately 60,000,000 years ago which is relatively recent from a geologic standpoint.

The beds of the Paleocene exposed in the Park are called the Tongue River formation of the Fort Union group of formations. It is named from the area around the Tongue River in Wyoming where it is typically exposed. The formation consists of shales, clays, sandstones, silts, sands and lignite. In general, the shales and clays are gray to brown and the sandstones tend to be light yellowish-orange to buff and tan. The lignite is dark brown to black. The interbedded strata showing many different colors on the hillsides in the Park add much to its scenic beauty. Frequently, the lignites have burned out, baking and fusing the overlying clays, shales and sands into a red to brownish red color. This baked and fused material is locally called "scoria" but should be more correctly called "clinker."

The entire thickness of the Tongue River formation is not exposed in the Park area and only the near-basal part of the formation is seen here. The exposed part of the formation totals about 620 feet. This does not mean that this entire thickness is exposed in one spot but this is the entire thickness when all the beds are correctly placed in respect to each other. The formation dips very gently to the southeast about one to two degrees.

Fossils other than plant fossils are not particularly abundant in the Park. Many plant fossils are found particularly in the shale and clays. Sometimes these fossils are excellently preserved in the "clinker" beds even though the beds have been baked by the burning lignite.

The Tongue River formation was laid down entirely on land and contains no beds deposited in a marine environment. Visualize for yourself a large plain stretching eastward from the Rocky Mountains which at the beginning of the Paleocene period were very high and being rapidly eroded. This plain extended for unknown distances from northern Canada to the southern part of Texas encompassing about the same area as the present day Great Plains. Large rivers were coursed eastward across this plain on their way to the sea. Some of these rivers drained into the Gulf of Mexico while others drained to Hudson's Bay. Remember, however, that the climate in those times was not as it now is and probably was somewhat warmer and moister. Remember also that there is geologic evidence, too detailed to be gone into here, that the eastward extension of this plain in which is now the Dakotas was probably near sea level in elevation.

With all the foregoing pictures in mind, you are now prepared to visualize the deposition of the materials which are known as the Tongue River formation. Near the mountains in Wyoming and

Montana, the rivers were running swiftly and were carrying great quantities of coarse material such as gravel. At the point where the rivers flowed from the mountains out on the plain, they lost much of their carrying power due to decreased velocity and thus the coarser gravels and sands were deposited near the mountains. The finer materials such as the clays, silts and finer sands were carried farther eastward to the Dakotas where they were laid down on this large alluvial plain. This deposition in the Dakotas was not everywhere regular and blanket-like but as the rivers turned from side to side, they deposited at one spot at this time and somewhere else a few years later. This irregular mode of deposition made the strata somewhat lenticular.

Spaced here and there on this great plain were swamps probably similar in some respects to the present day swamps in Louisiana and Florida. In these swamps, there were great numbers of trees of the *Conifer* family growing. Some of these trees were *Sequoia* and were related to the redwoods which grow in California today. As these trees died and fell into the swamp, they began to decay due to bacterial action. However, this decaying action was not complete and before the trees could be completely decomposed, the bacteria action was arrested. The cause of the halt of the bacterial action was the fact that the bacteria had committed suicide by filling the stagnant swamp water with their body poisons to such an extent that they died. The partially decomposed trees or vegetation were later solidified by the weight of younger sediments deposited on them and thus the extensive lignite coal beds with which North Dakota is so well endowed were formed.

Physiographic History of the Little Missouri River

The foregoing paragraphs have in a cursory fashion set the scene for the later history of the Park, namely the formation of the present scenic features. After the deposition of the Tongue River formation, a long time elapsed during which there was little deposition of sedimentary materials in this area. Probably erosion of the upper surface of the Tongue River formation was taking place as well as its compaction and solidification. There is evidence to show that to the eastward, the formations of the Eocene period, the period following the Paleocene in Cenozoic time (See Fig. 1), were laid down but in the Park area they have all been eroded if they ever were deposited.

As Cenozoic time advanced, erosion of this region continued and an erosion surface called a peneplain was fairly well developed by the end of Eocene time. On this surface, there were streams meandered around depositing material here and there in their channels. Some of these stream deposits and lake deposits were laid down in the Oligocene period, the period of the Cenozoic which followed the Eocene. Only isolated remnants of these deposits exist today in North Dakota capping some of the higher buttes such as Black Butte, (the highest point in the State,) Sentinal Butte, Flattop Butte and Killdeer Mountains.

After the deposition of the Oligocene sediments, the erosion continued probably at an accelerated pace due to renewed uplift in the west and the area was worn down again to another near-level surface. On this surface, a number of streams were running; today, only remnants of their former courses remain. The Little Missouri was probably one of these streams although it is not flowing in exactly the same course and was not bordered by the same extensive badlands as today.

Then, as now, the Little Missouri headed far southward in Wyoming not far from Devils Tower and flowed more or less straight northward until it joined the Yellowstone River which was then flowing northward up the valley that is now known today as the Little Muddy Valley, east of Williston (See Fig. 2). Near the present site of Crosby, the Yellowstone then joined the Big Missouri which at that time was flowing northeastward to Hudson's Bay. The Little Missouri then was probably a much larger stream than it is now and was flowing in a broad shallow valley which now stands at an elevation some 200 feet above its present level in the present south Roosevelt Park area. This old level can be seen as remnants today, for example Johnson Plateau on the southwest boundary of the Park and Big Plateau northwest of the Peaceful Valley Park Headquarters. Gravel deposits on this old level can be observed at the site of the Medora airport in the SE¼ Sec. 23, T. 140 N., R. 102 W. (See Fig. 4)

At the end of Pliocene time and at the beginning of the Pleistocene period of the Cenozoic era, the Little Missouri began to

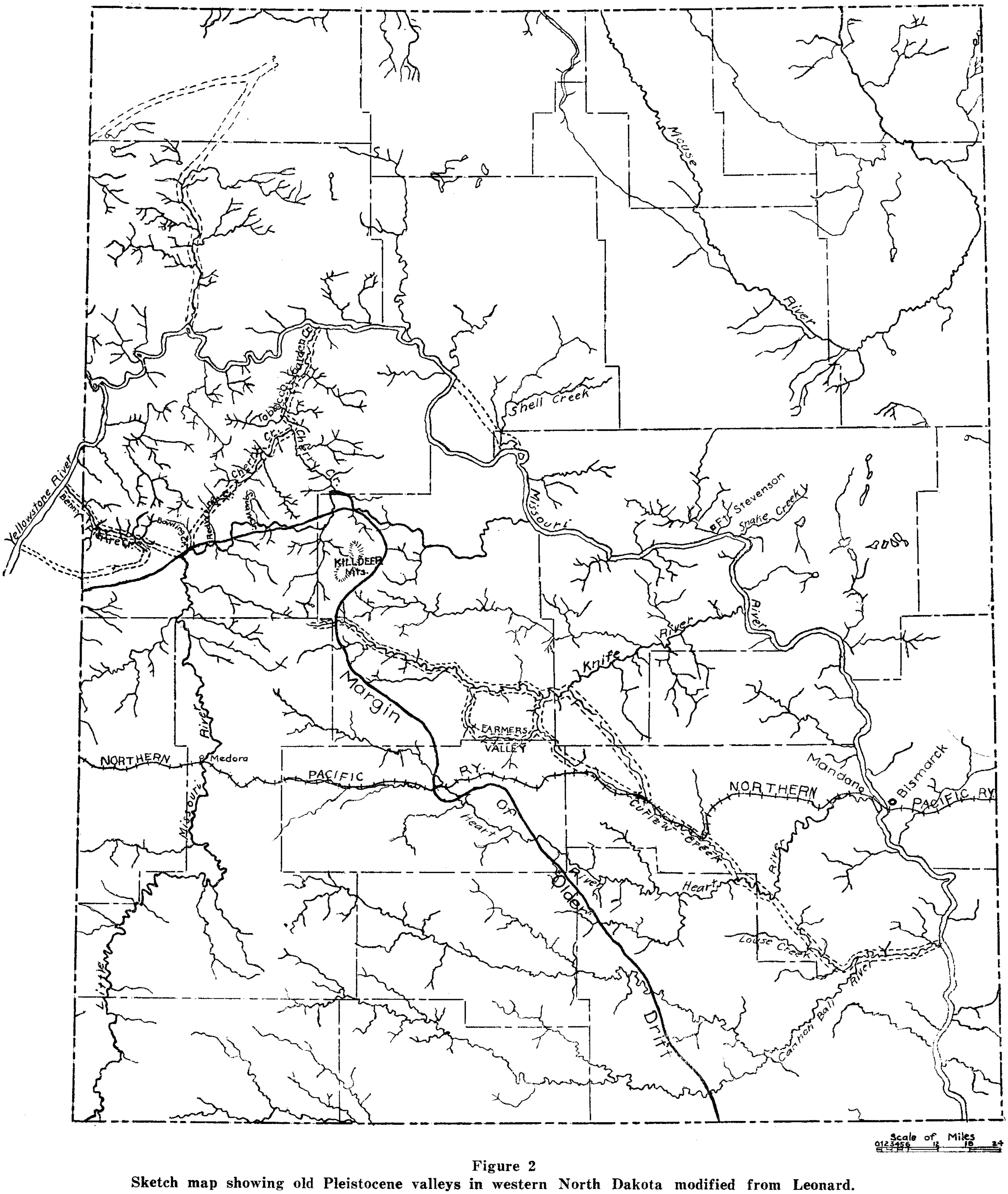


Figure 2

Sketch map showing old Pleistocene valleys in western North Dakota modified from Leonard.

experience a series of changes. In the first place, the headwaters of the Belle Fourche River in South Dakota which were located near the headwaters of the Little Missouri in Wyoming and South Dakota had been eating headward rapidly and actually captured the headwaters of the Little Missouri. This left the Little Missouri without some of the water with which it had normally been carrying its load of sediment. It then probably began to deposit some of this sediment along its course and the gravels that have been noted above may be part of such sediments.

The next thing that happened to the river was that its outlet was blocked by the advancing ice sheet which formed in Canada and which was moving slowly but relentlessly southward. This caused the waters of the Missouri, the Yellowstone and the Little Missouri as well as numerous lesser tributaries to be diverted southward and southeastward across western North Dakota in a series of channels most of which are now dry. After the ice melted, it is questionable if these rivers ever entirely returned to their original courses, but stayed in their new-found channels. The Little Missouri was one of these and its course from the great bend in the Little Missouri to the present day Big Missouri was formed at this time (See Fig. 2).

The elevation of the new mouth of the Little Missouri was considerably lower than it had been when it joined the old Yellowstone just east of present day Williston. Therefore, it began to downcut rapidly with the result that its tributaries also began to cut gullys on a grand scale and the formation of the badlands began. This badland formation progressed rapidly upstream and has to date reached about the present Bowman-Slope county line in North Dakota.

From the great bend of the Little Missouri southward, the badlands are within the old valley formed when the stream was flowing northward to the Yellowstone. In the Medora area, there is then, a valley within a valley, as the badlands are largely confined to the dissection of the old valley surface. As a result, only here and there are remnants of the old valley seen.

The work of running water is the most effective agent in the formation of the badlands but several other factors have aided and abetted this agent. These are: the nature of the formations and the effect of the burning lignite.

The complete story of the history of the Little Missouri River is incompletely known and will not be fully known until the terraces along the valley have been completely studied along the entire course of the river. However, in the south Park area, there appear to be at least four terrace levels including the uppermost level which represents the old valley stage mentioned previously (See Fig. 3).

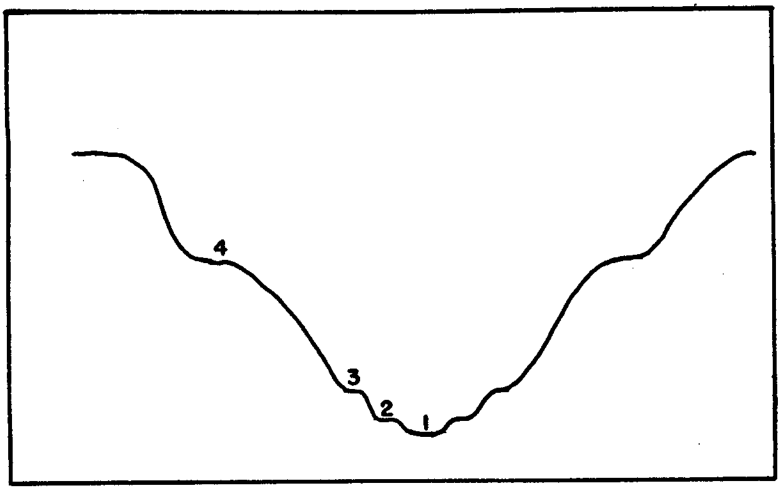


Figure 3
Diagram showing various terrace levels along the Little Missouri River in the South Roosevelt Park area.

All of these terraces are composed largely of alluvial or lake deposits particularly in the lower stretches of the terraces nearest the present day streams. Farther up each of the tributary streams, the terraces appear to be cut on bed rock as they have little or no alluvium covering their surfaces.

At this point some explanation might be given as to the way in which terraces are formed along streams. In general, there are two types, those that are formed along streams by the planation of the valley bottom by the streams themselves and those which are cut from previously deposited alluvium or lake deposits along the streams. Both types may be closely related and can be found in the same area. Both types are relatively flat-topped but the

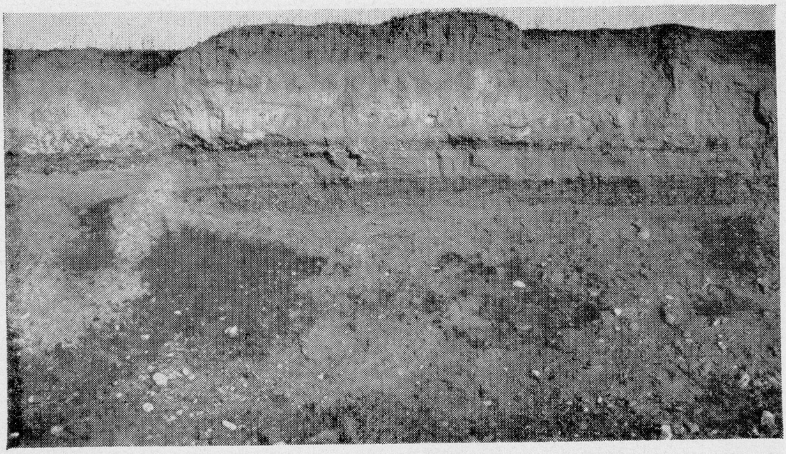


Figure 4
Gravels and silts deposited on the No. 4 terrace level near Medora airport.

Figure 5
View to the southeast from Big Plateau showing the No. 4 terrace level (upper) and the No. 3 terrace level (lower).

Figure 6
View just south of Park Headquarters near picnic area showing No. 2 terrace level in foreground and No. 1 (present stream) level in background.

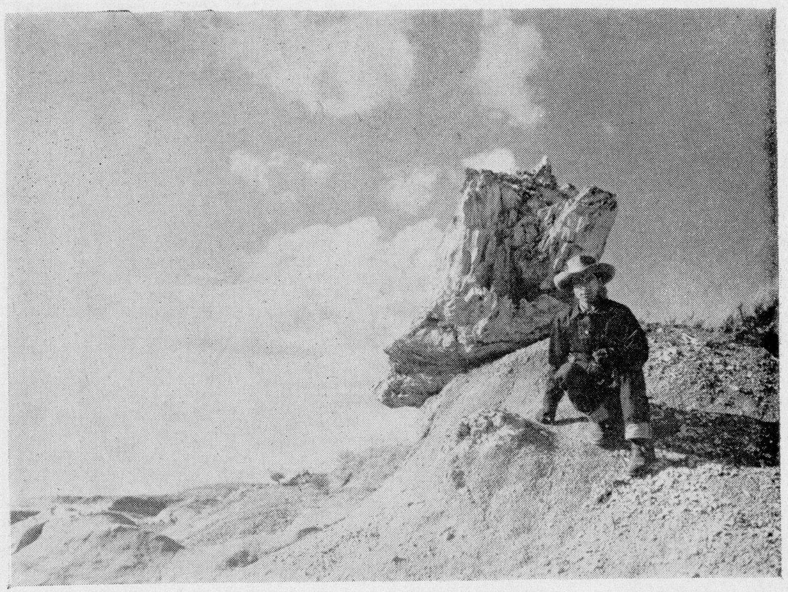


Figure 7
Stump zone in Petrified Forest area of South Roosevelt Park.

Figure 8
Petrified Sequoia stump in the Petrified Forest in the northwestern part of South Roosevelt Park.

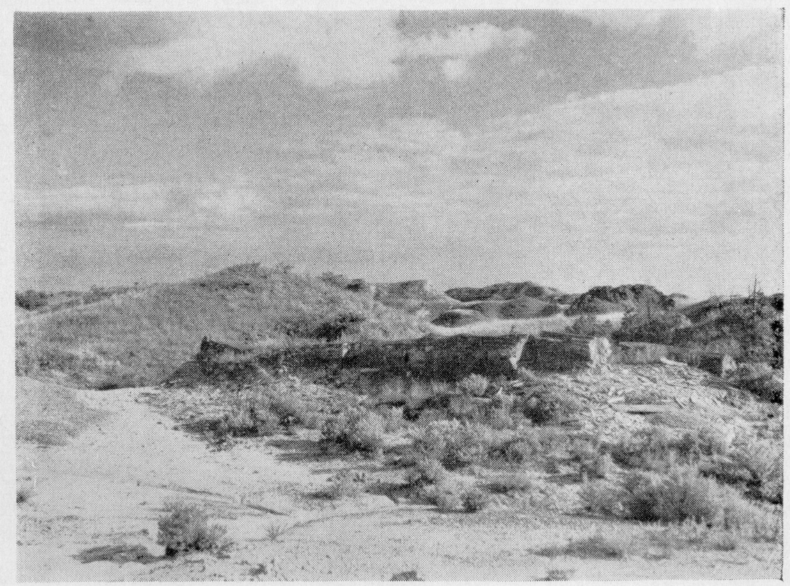


Figure 9
Petrified log located in north-central part of South Roosevelt Park.

terraces cut from previously deposited alluvium are apt to be more flat-topped than the true planation terraces.

In the formation of the first type, the stream swings back and forth along its course cutting first one side of the valley and then the other. In this way, providing that it does not down cut vertically very much, a relatively flat surface will be developed in the valley bottom along the stream. This surface will slope gradually up the tributary streams as these streams are also cutting in much the same fashion. The extensive development of such a surface demands that the stream be flowing at that level for a considerable period of time so that the work described above can be undisturbed.

In the second type of terrace formed from alluvium previously deposited, certain conditions of the stream's history are involved. First, the stream cut a deep valley and then this valley was filled by alluvium due to a change in the regimen of the stream. At some later date, it began to downcut vertically again leaving portions of the alluvium along the valley sides uneroded. These are called terraces.

The cause of renewed stream downcutting may be that the stream has gained more water, it may have lost part of its load it was formerly carrying or there may have been an increase in the gradient of the stream due to regional uplift.

Just below the upper old valley (No. 4 level), is the terrace level which will be called in this report No. 3 level. It is about 125 to 150 feet below the No. 4 level (See Fig. 5). This level is apparently an important one in the Park as much of the badland area appears to be related to this level after the development of the No. 4 level. This like all the levels, slopes steeply upstream on each of the tributaries away from the present Little Missouri. On its surface are some gravels and silts. One difficulty in delimiting this level is that it tends in many places to merge with the level below namely the No. 2 level. In other places, the scarp between the two is quite sharp.

In order to explain this and the lower terraces, it is necessary to take into account their relative positions and the fact that the surfaces of the terraces are more often than not covered with alluvial material. One hypothesis that can be offered is that after the cutting of the upper old valley level, there was a time when the river was very active and cut a deep valley down to at least and probably deeper than its present level. Then came a period of ponding possibly associated with the advance of the ice sheet and the stream was forced to drop its load in this deep valley. Subsequent to this filling, the stream began again to down cut and level No. 3 was formed. As was noted previously, this appears to have been a fairly extensive level and probably represents a greater time lapse than the levels following.

Away from the main stream the No. 3 level developed more as a planation surface while in the main valley the cutting was done primarily on previously deposited alluvium or lake sediments. After the development of No. 3 level, there was another period of renewed downcutting and the No. 2 level was formed.

The No. 2 level is the one which is most extensive today along the present stream and is about 27 feet below the No. 3 level and about 13 feet above the No. 1 or present-day stream level (See Fig. 6). It is the level on which the Peaceful Valley Park headquarters are located. As noted previously, there is some doubt if this level can be distinguished from the No. 3 level. To the writer, it seems that this can be done but in a number of places, the No. 2 level has so regraded the No. 3 level that the two cannot be separated.

After the cutting of the No. 2 level, the stream again experienced a period of downcutting and the present stream level is the result. At the present time, it would appear that the stream is probably not downcutting extensively but instead is aggrading its channel.

How the Badlands Are Formed

The history of the Little Missouri has been outlined in the preceding part of this report. Now it would be well to consider just how the actual formation of these unusual scenic land forms took place.

First and most important to the formation of badlands is the action of water. This may seem unreasonable to the casual visitor who drives through the Park on a hot summer day with little or no water in sight anywhere. It must be remembered, however, that these erosional features were not formed in a day and that the erosive agencies have been at work for a long time. Furthermore, when the rain does come in this area, it frequently comes in the form of sudden showers and downpours which cause very rapid cutting in a short period of time.

In addition to the erosive work of short quick downpours of rain, the formation of the badlands is aided by the type of material being eroded. In the Paleocene rocks exposed in the Park area, it is found that poorly cemented sands, clays and siltstones are in the majority. These materials are easily eroded into gullys which can be seen on the sides of each of the buttes. This extensive gullying is the beginning of the badlands and therefore, each butte side shows the badlands in miniature.

Another factor in the formation of the badlands is the action of the burning lignite beds. The results of this burning can be seen through the Park by the great outcrops of the fused and burned rock which originally were shales, clays and sands overlying the lignite prior to its burning. These clinker beds are locally called "scoria." However, from the standpoint of erosion the most important thing that the burning lignite beds did was to open the ground above the lignite and break it up so that erosion was accelerated by these irregularities when the water did fall on the land.

The clinker also affects the land forms in that it is more resistant to erosion than some of the softer beds and therefore, where it caps, the buttes, the highest areas of the Park are frequently found. This relationship of the clinker beds to the topographically high areas can be seen everywhere in the Park.

Unusual Geologic Features of the Park

"Scoria" or Clinker

Certainly, the most noticeable and outstanding color in the Park is the red of some of the rocks. Invariably, these rocks are the ones about which there is the greatest question in the mind of the visitor. These beds are locally called "scoria" and are formed by the fusing and baking of sands and shales and clays when a bed of lignite immediately underlying them burns.

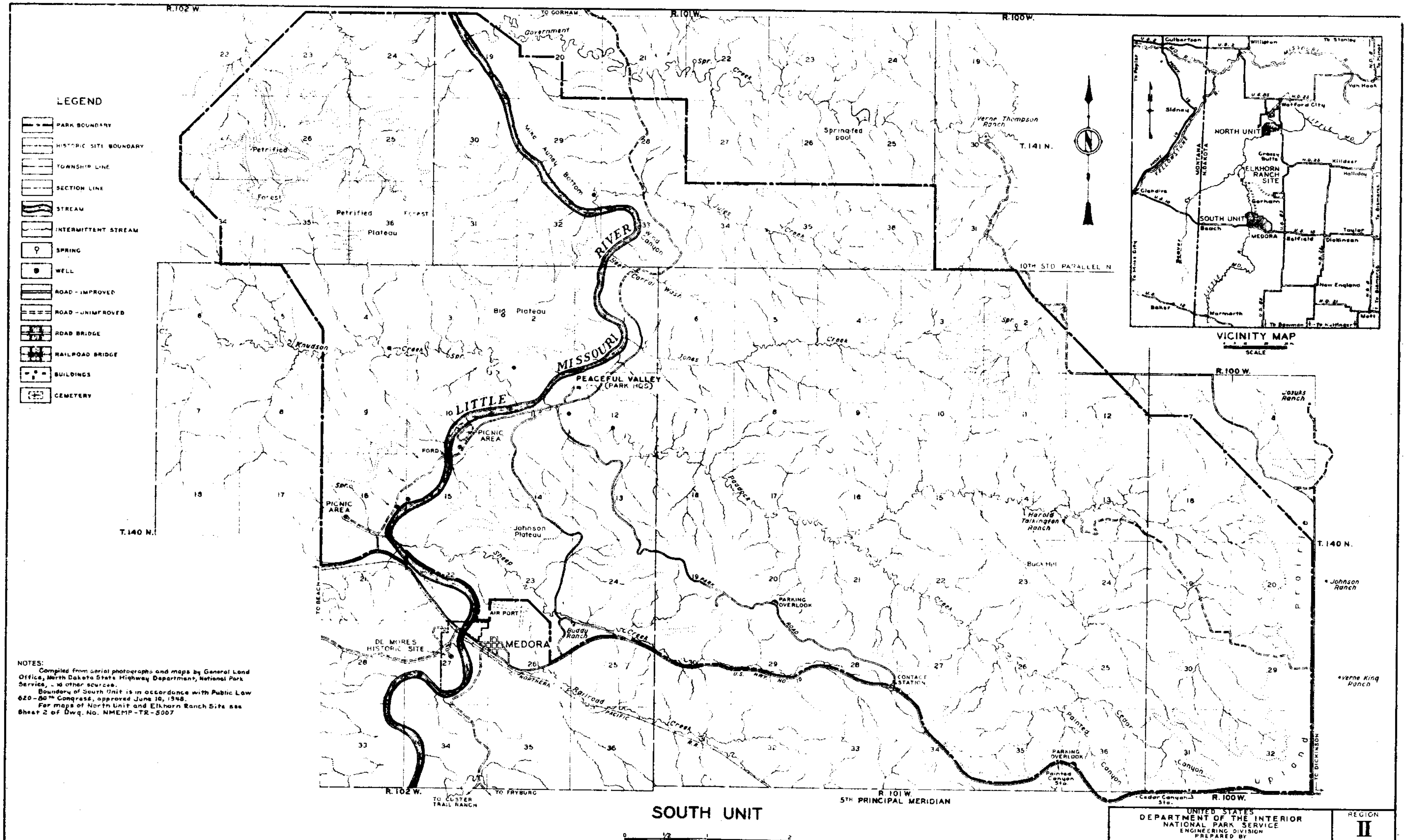
The term "scoria" is incorrectly used geologically speaking when used to describe rocks of this nature. Scoria when correctly used applies only to a dark-colored porous rock associated with basaltic lava flows from an active volcano. Thus, it is a term to be used only with igneous rocks. Inasmuch as all the rocks of the Park are of sedimentary origin, that is, laid down by water, the term should not be used here.

The correct term for this material is clinker. This material as noted previously was formed when the minerals composing them were altered chemically due to being heated to or above the fusing point. In some places, they melted and flowed like slag out of a blast furnace. It may be this flow structure plus the porous nature of some of the clinker which caused the early settlers to call this rock "scoria." It should be categorically stated that there are no igneous rocks native to the Park area and that volcanoes never existed in the badlands.

Clinker, due to its alteration by fire, does have some interesting features which show some resemblance to igneous rock. One is that in some places, it has melted enough to flow. Another feature is the columnar jointing which is found in some of the outcrops. This type of jointing can best be described as a series of cracks produced usually at or near right angle to the surface of greatest cooling. The end result is the production of numerous polygonal columns standing side by side on the outcrop. Usually, inasmuch as the greatest cooling surface was generally the surface of the ground and inasmuch as the rocks are nearly horizontal, the polygonal columns usually cut across the original bedding planes of the rock. The jointing is being called in this report pseudocolumnar jointing. Such jointing is a feature found usually only in igneous rocks. Such columnar jointing can be well seen in the lava flows interbedded with the gravels at Tower Falls on the Yellowstone River in Yellowstone National Park and in the igneous rocks exposed in the Devils Tower in the Devils Tower National Monument in Wyoming.

Petrified Trees

An item of great geologic interest in the Park is the presence of numerous petrified stumps in certain zones in the strata (See Fig. 7 & 8). The stumps do not occur in all the rocks but seem



NOTES:

Compiled from aerial photographs and maps by General Land Office, North Dakota State Highway Department, National Park Service, and other sources.

Boundary of South Unit is in accordance with Public Law 620-80th Congress, approved June 10, 1948.

For maps of North Unit and Elkhorn Ranch Site see Sheet 2 of Dwg. No. NMEMP-TR-5007

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
ENGINEERING DIVISION
PREPARED BY
REGIONAL
OFFICE

REGION II

SHEET 1 OF 2

TOPOGRAPHIC BASE MAP

PART OF THE MASTER PLAN

THEODORE ROOSEVELT NAT'L MEM. PARK

DRAWING NO. NMP TR-5007

DATE OCT. 1949

to be concentrated in zones where apparently they were originally more abundant than they were at other levels. Most frequntly, only the rootless stumps of the trees are found and seldom if ever are the roots with them. This may possibly be explained by the fact that the trees are representatives of a type of conifer known as *Sequoia*. The *Sequoia* and other conifers have a very shallow root system. Inasmuch as the roots were near the surface and were smaller and less durable than the stumps, they all decayed before petrifying. Similar reasons must also be given for the few trunks and branches although some of these are known. In one spot in the Park, a trunk measuring more than 40 feet in length was observed (See Fig. 9).

Interestingly enough, the petrification of the stumps is not in every place complete. On some of the stumps, it will be observed that the outside of the stump has been completely turned to stone while the inside of the stump is as yet not completely petrified and is still almost charcoal-like. The petrification probably takes place in something like the following fashion:

After the tree is buried, the water in the rock begins to percolate through it. This water does two things: first, it dissolves out with the help of bacterial action the softer cellulose material of the wood; secondly, the water carrying mineral matter in solution (in this case silica) deposits the mineral in the space left by the dissolving out of the plant tissue. This goes on so that the replacement is very gradual and is almost a molecule for molecule affair—a molecule of plant tissue being simultaneously replaced by a molecule of silica. In this way, the original cellular structure of the wood is preserved so that today the stumps in many cases look exactly like old wood stumps except for the fact that they are stone.

Sandstone concretions

There are in the Park many large and irregularly-shaped sandstone concretions which in many cases look almost like petrified logs and in some instances have probably been mistaken for them. These are not fossils because they have never been living material and they are entirely inorganic in origin.

The exact origin of these features is not known but probably they form in the sandstone beds where the sand is locally more permeable and allows the passage of underground water more freely. The underground water carries mineral matter in solution. This mineral matter may be either silica as mentioned in the case of the petrified stumps or calcium carbonate (lime). Whichever mineral it is makes little difference as it will be deposited ultimately in the pore spaces of the rock in these permeable zones. When the sand in these zones has been cemented with this mineral matter, the zones are more resistant to erosion and therefore, stand out on weathering. Thus, we have these unusual "log" and "ball" concretions present in numerous places in the Park. Frequently, they give rise to interesting erosional features in that the more resistant concretions cap less resistant sands and clays giving rise to unusual pillars and columns.

Road Log Through the Park

Going East Read Down	Going West Read Up	
0.0	10.9	Leave main highway on west end of Park area.
0.5	10.4	Old entrance to Park.
0.8	10.1	Sandstone concretions. Note holes made by wind abrasion. Bank swallows nest in these holes.
1.5	9.4	Sandstone concretions on west side of road. Clinker caps hills to the northeast.
1.6	9.3	Sandstone concretions. Close inspection shows excellent ripple mark cross bedding.
1.8	9.1	Edge of Johnson Plateau. Edge of the upper old valley which is the No. 4 level of this report.
2.5	8.4	Note clinker capping hills to the northeast.
2.9	8.0	Begin dropping off the Johnson Plateau.
3.7	7.2	Begin the No. 3 terrace level.
3.9	7.0	Edge of the No. 3 terrace level. Start the No. 2 terrace.

Going East Read Down	Going West Read Up	
3.95	6.95	Road to the south to the picnic area.
4.1	6.8	Road to the east, junction with road to Park Headquarters.
4.2	6.7	Inner edge of the No. 2 level.
4.5	6.4	Inner edge of the No. 3 level.
4.6	6.3	Impure lignite outcrop.
5.0	5.9	Lignitic shale in the road ditch. Badly broken plant fossils.
5.1	5.8	View to west over Little Missouri Valley.
5.2	5.7	White efflorescense on the rocks is probably calcium carbonate brought to the surface and deposited when the water evaporated.
5.4	5.5	Note clinker capping the hills to the north. Poor grade of lignite in road ditch on south side of road.
5.8	5.1	Massive sandstone concretions on the south side of road.
6.4	4.5	Good stand of badland cedar. Note clinker on hilltop to south.
6.5	4.4	Sandstone concretions to the south.
6.7	4.2	Clinker outcrop showing some of the unburned coal still present with ash at the top.
6.9	4.0	Note level to the north. This level is probably equivalent to the level of the Johnson Plateau and is probably part of the old upper stream surface (No. 4 Level). Note clinker to the north above the road.
7.0	3.9	Clinker outcrop to north. Note the excellent example of pseudocolumnar jointing.
7.1	3.8	Note sandstone concretions and how they cap erosion pillar to the south.

Going East Read Down	Going West Read Up	
7.2	3.7	Note extensive gullying on the sides of the buttes to the north.
7.7	3.2	Clinker to the north and south.
8.2	2.7	Road to south to observation point. Good stand of badland cedar.
8.3	2.6	Log-like sandstone concretions at road side to the north. Thin zone of these concretions runs to the east here for a short distance.
8.6	2.3	Excellent view to south. Highest level seen is probably the same as the Johnson Plateau (No. 4 level). The level below it is probably the No. 3 level. Fine examples here of gullying on the sides of the buttes. Note also the bedding of the bedrock strata.
8.7	2.2	Note dark gray and purple lignitic shales to the north.
8.75	2.15	Parking overlook. In the general view to the north and west the level immediately below upland surface is probably the No. 4 level. Note clinker below the overlook and in the distance.
9.0	1.9	Note the small bench held up by gray clay. Note *Sequoia* stumps to the north.
9.3	1.5	Note sandstone concretions to the north.
9.5	1.4	Good examples of gullying on both sides of road.
9.6	1.3	Small cave to the north on the side of a butte.
9.9	1.0	Fossil *Sequoia* stump zone of the north side of the road.
10.3	0.6	Clay-capped buttes on both sides of the road
10.4	0.5	Good examples of gullying action.
10.9	0.0	Checking station at the east end of the Park.