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A GUIDE TO THE GEOLOGY OF SHOSHONE NATIONAL FOREST, WYOMING

by

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CONTENTS

TABLES

Plate

Figures*

*The photographs, Figures 1-16, appear at the end of the text as xerox copies. Photographic prints are available from the Geological Survey of Wyoming for an additional charge.

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INTRODUCTION

Shoshone National forest, the first National Forest established in the United States, covers part of three major mountain ranges in northwest Wyoming. These include, in order of diminishing areal extent, (1) the Absaroka Mountains, (2) the Wind River Range, and (3) the Beartooth Mountains. Elevations within these areas vary from 4,600 to 13, 785 feet above sea level. From a geologic and scenic aspect, it is doubtful that the Shoshone is surpassed by any National Forest.

It can be observed **(Plate 1)** that the bulk of the rock types and their ages represent two periods of geologic time, the Precambrian and the Tertiary. The oldest rocks are Precambrian granites, gneisses, schists, and other rocks that form the cores of the Wind River and Beartooth ranges. These rocks are widely exposed in the Washakie Division and more limited exposures occur in the extreme northern and southern parts of the Yellowstone division.

The rocks with the most extensive areal distribution are the Tertiary volcanics that underlie most of the Yellowstone division. These include intrusive bodies of andesite, basalt, dacite, granodiorite,

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and phyolite, as well as andesite flows, andesite breccias, basalt flow, volcanic sandstones, and volcanic conglomerates that have a layered appearance.

Rocks of more limited areal extent include, sandstones, shales, and limestones of Paleozoic, Mesozoic, and Tertiary ages **(Table 1)** that crop out in the northern and southern parts of the Yellowstone division and along the northeast flank of the Washakie division. The sedimentary rocks of Paleozoic and Mesozoic age are highly folded and faulted, reflecting the mountain-building movements of the Laramide Orogeny, which began during Late Cretaceous time.

During Pleistocene time, most, if not all of the Shoshone National Forest was covered by glacial ice. These glaciers sculptured the mountains into the forms observed today.

GENERAL GEOLOGY OF SHOSHONE NATIONAL FOREST

Northwest Wyoming

Precambrian rocks, exposed in the cores of the Beartooth Mountains and Wind River Range, are composed of great thicknesses of sedimentary rocks, which were folded, metamorphosed, and intruded by large bodies of granitic and other igneous rocks. This period of time, which is not too well documented from the geological standpoint, covered many millions of years. After these events, the old mountains were eroded away, and, by the beginning of Paleozoic time, the land surface was reduced to a peneplane.

Table 1. Generalized Time-Rock Table for Shoshone National Forest Area

Era	Period	Epoch	Duration (millions of years)	Representative Rock Units	Representative Rock Types	Fossils
Cenozoic	Quaternary	Recent		Alluvium	Variety of different types	
		Pleistocene	1	Glacial deposits		
	Tertiary	Pliocene	12	See Table 2	Variety of volcanic rocks	plants, bones, teeth, petrified wood
		Miocene	12			
		Oligocene	11			
		Eocene	22	Wind R.-Willwood fms., etc.	sandstone, shale, coal, etc.	
		Paleocene	5	Ft. Union fm.	same as above	
Mesozoic	Cretaceous		72	Lance	sandstone, shale, coal	bones, plants
				Meeteetse Mesaverde		plants
				Cody	shale, bentonite	oyster shells, cephalopods
				Frontier	shale, sandstone	
				Mowry	shale,	fish scales
				Thermopolis	shale, sandstone	fish teeth
				Cloverly	shale, sandstone, conglomerate	plants, teeth
	Jurassic		46	Morrison	sandstone, shale	Dinosaur bones
				Sundance	sandstone, shale limestone	cephalopods, oyster shells
				Gypsum Spring	gypsum, shale	
	Triassic		49	Nugget	sandstone	
				Chugwater	red shale, etc.	reptiles
				Dinwoody	shale, sandstone	oyster shells
Paleozoic	Permian		50	Phosphoria	limestone, shale sandstone, phosphate rock, etc.	lamp shells, snails shark teeth
	Pennsylvanian		30	Tensleep	sandstone	lamp shells amphibian tracks
				Amsden	sandstone, shale, limestone, etc.	lamp shells sea lilies
	Mississippian		35	Madison	limestone, cavernous in places	lamp shells corals, sea lilies
	Devonian		60	Three Forks *	limestone, shale	
				Jefferson*-Darby	limestone	fish fragments
				Beartooth Butte*	red sandstone	plants, fish
	Silurian		20	absent		
	Ordovician		75	Bighorn	dolomite	horn corals, sea lilies, lamp shells, snails, cephalopods
	Cambrian		100	Gallatin #	limestone, shale	trilobites, lamp shells
				Gros Ventre #	sandstone, shale	trilobites, lamp shells
				Flathead	sandstone	worm tubes
Proterozoic Archeozoic	Precambrian time				granite, gneiss schist, etc.	algae

Present geologic knowledge indicates that the age of the earth is approximately five billion years. The oldest known rocks within the Shoshone National Forest are about 2.7 billion years.

* These terms are used in the Clarks Fork area.

In the Clarks Fork area, the Pilgrim limestone is part of the Gallatin Group; while the Meagher limestone is part of the Gros Ventre Group.

Seas of the Cambrian Period (oldest period of the Paleozoic) entered Wyoming from the west and deposited sandstones, shales, and some limestone. By the end of Cambrian time, the seas had completely withdrawn and Wyoming remained emergent through much of Ordovician time. Late in Ordovician time, the State was again submerged, and in this sea was deposited the Bighorn Dolomite. In the Bighorn Mountains, this formation contains the earliest record of fish remains in the State.

The seas may have covered northwest Wyoming during the Silurian Period, but if so, these sediments must have been completely eroded away before late Devonian time, since these rocks have not been recognized in the northwest part of the State. Late in Devonian time, a sea covered northwestern Wyoming and in it were deposited dolomite, red shale, and some sandstone.

Early in Mississippian time, most of the State was covered by a sea in which was deposited the Madison Limestone.

During the first half of the Pennsylvanian Period, marine red shale, cherty limestone, and sandstone were deposited. During the last half of Pennsylvanian and the early part of Permian time, the area now covered by Shoshone National Forest, was emergent. During Middle Permian time, the Phosphoria sea entered Wyoming from the west and dolomite, chert, limestone, sandstone, and phosphate rock were deposited in it.

No folding occurred at the end of the Paleozoic era, since Mesozoic rocks rest directly upon Paleozoic rocks with no angular discordance. The Triassic sea invaded Wyoming from the west, and marine shale, sandstone, and dolomite were laid down. With the termination of normal marine conditions, the red shales of the Chugwater Formation were laid down in a depositional environment not well understood. The Nugget Sandstone was deposited at the close of Triassic time.

During Jurassic time, gypsum, sandstone, limestone, and variegated shales were deposited under a wide variety of marine and continental conditions.

In Cretaceous time, the sea oscillated back and forth and in it were deposited shale and sandstone. Coal was deposited in swamps on the coastal plains. A period of intense crustal disturbance began during Late Cretaceous time.

By early Cenozoic time, the mountains and basins of northwest Wyoming were well outlined. As the mountains continued to grow, they were subjected to erosion, which caused the deposition of Tertiary sedimentary rocks in the basins. Shortly after, extensive volcanism occurred, and this has continued up to relatively recent times. In Pleistocene times, mountain glaciation eroded the mountains into the forms that are observed today.

Wind River Range

The Wind River Range is a northwest-trending, thrust-faulted anticline that is about 40 miles wide and about 150 miles long. The core of the range is composed dominantly of Precambrian granites, granodiorites, and gneisses, with more limited distribution of schists and other metamorphic rocks cropping out at the south end. Sedimentary rocks exposed on the northeast flank range in age from Cambrian to Late Cretaceous. Although highly folded and faulted in places, these rocks have a regional northwest trend and dip moderately to the northeast. Rocks ranging in age from Eocene to Pleistocene overlap the older formations.

Apart from its scenic attraction, the Wind River area is of significant geologic interest, since it is considered the type locality of glacial stages for the entire Rocky Mountain area. Three glacial stages are generally recognized:

Stage	Age	Extent
Pinedale	Wisconsin* (youngest)	Least
Bull Lake	Wisconsin	
Buffalo	pre-Wisconsin (oldest)	Greatest

The Buffalo glaciation, the most extensive and widespread of the Quaternary glaciations, was several thousand feet thick in many places and covered an area of more than 5,000 square miles in the Wind River, Yellowstone and Absaroka regions.

The Bull Lake glaciation, about 80 miles long by 16 to 20 miles wide, occupied an area of about 1,500 square miles. The ice was more than 3,000 feet thick in the canyons and between 1,000 and 1,800 feet thick on the Fremont (Summit) erosion surface. The peaks above 11,000 feet projected through the Bull Lake ice as nunataks, and tongues of this ice sheet extended 5 to 15 miles down canyon to the east slope of the Wind River Range.

*The youngest of the four Pleistocene glacial ages which are: Nebraskan, Kansan, Illinoian, and Wisconsin.

The Pinedale glaciation, about 60 miles long by 12 - 15 miles wide, covered an area of nearly 800 square miles. This glacial ice, which occurred at an elevation of about 10,500 feet, had a thickness of 800 to 1,000 feet.

Absaroka Mountains

The Absaroka Mountains is a broadly dissected plateau of dominantly horizontal to gently inclined volcanic rocks that have been greatly eroded and deeply entrenched by a series of canyons varying between 2,000 to 5,000 feet in depth. This area, which is often designated the Absaroka volcanic field, is bounded on the north by the Beartooth Range, where the volcanic rocks abut the Precambrian rocks, on the east by the Bighorn Basin, on the south by the eroded margin of volcanic rocks, and on the west by the younger eruptions of rhyolite and basalt in Yellowstone National Park. At one time, the volcanic rocks undoubtedly extended farther to the east into and probably across the Bighorn Basin.

Major volcanic activity began in Eocene time and continued into the Miocene. Minor volcanism continued until Pleistocene time. As many as six different volcanic units were first recognized and mapped in the Absarokas. These have been grouped under two major epochs of volcanism described as the Early and Late series of volcanic breccias and basalt flows. Lately, however, it has been necessary to revise the terminology because the northern half is dominantly underlain by actual igneous rocks, while the southern half is dominantly underlain by sedimentary rocks of volcanic composition (**Table 2**). These are some exceptions in the southern part where actual igneous flows and breccias are present in local areas; however these can be observed grading into volcanic sandstones and conglomerates.

The volcanic rocks vary in thickness from several hundred feet at the edge of the field to as much as 6,500 feet in the center or interior. Some observers feel that by adding the maximum thicknesses of each unit, the total over-all thickness of volcanic rocks would range between 11,000 to 13,000 feet!

During the time required for the deposition of these volcanic rocks, volcanism was spasmodic. There were periods of erosion and local folding and faulting. As a result, much of the actual igneous rock became reworked by streams and mudflows (landslides) and was deposited as the volcanic sandstones and conglomerates that are seen today. There were several sources for these igneous rocks. The basalt flows originated by molten magma rising up through local fissures (cracks in the earth) and flowing out on the surface of the ground. Many of the presently exposed igneous intrusive bodies (**Plate 1**) were the sites of old volcanic vents. Ancient volcanoes in the Yellowstone and northern Absaroka areas probably provided much of the pyroclastic material that was later reworked and redeposited.

The prevolcanic history of the Absaroka area undoubtedly was characteristic of that of northwestern Wyoming. The prevolcanic relief has been judged to be in the order of several thousand feet,

Table 2. Generalized Correlation of Volcanic Rock Units, Absaroka Mountains

Age	Southern Absaroka Area	Central and South-Central Absaroka Area	Northern Absaroka Area
Oligocene	Wiggins formation	Wiggins formation	Late Basic Breccia
			Late Acid Breccia
?			?
Eocene	Tepee Trail formation	Blue Point conglomerate	Blue Point conglomerate
		Early Basalt flows	Early Basalt flows
		Pitchfork Formation	Early Basic Breccia
	Aycross formation		Early Acid Breccia *
	Wind River formation #	Willwood-Tatman fm. #	Willwood formation #

* Also called Cathedral Cliffs formation.

\# Non-volcanic rocks.

based on the exposures along the Clarks Fork River (see No. 5, Hunter Peak area). However, recent studies in this area indicate that gravity faults have affected sedimentary rocks of lower Paleozoic age as well as the earliest volcanic rocks of Middle Eocene age. Therefore, in this area, the tremendous prevolcanic relief may be more apparent than real.

At least two stages of glaciation occurred in the Absaroka area, but these evidently were not as widespread nor as intense as those in the Wind River area. This assumption is based on the lack of moraines and other physiographic features, particularly in the southern part of the Absaroka area.

Beartooth Mountains

The Beartooth Mountains, located in northwestern Wyoming and south-central Montana, is a northwest trending uplifted block of Precambrian rocks that is about 80 miles long and about 40 miles wide. The Clarks Fork of the Yellowstone River is considered to be the approximate boundary between the Absaroka and Beartooth Mountains.

The core of the Beartooth Mountains is dominantly granitic gneiss and schist that has been intruded by black colored dikes. These rocks are well exposed on the high, glaciated plateau, which is traversed by the Red Lodge - Cooke City Highway. On the east flank of the range, the highly faulted Paleozoic and Mesozoic sedimentary rocks have a general north-south trend with a very steep easterly dip. On the south and southwest, the Paleozoic sedimentary rocks wrap around the Precambrian rocks of the Beartooth to such an extent that the trend is now in a northwest direction. These rocks, although complexly faulted, dip southwesterly under the Eocene volcanic rocks of the Absaroka Range.

Three stages of Pleistocene glaciation have been provisionally recognized in the Beartooth Range; however, these have not received any detailed study in the Shoshone National Forest area.

AREAS OF GEOLOGIC INTEREST

(Refer to **Plate 1**)

Clarks Fork - Sunlight Basin area

1. Beartooth Plateau. The Beartooth Plateau (**Figure 1**) is a high, rolling erosional surface that exposes mainly Precambrian granites and metamorphic rocks and a few remnants of lower Paleozoic rocks. Many Pleistocene glacial cirques and U-shaped valleys occur here, and these are often occupied by lakes and perennial snow and ice fields.

2. Bearthtooth Butte. Beartooth Butte is a remnant of lower Paleozoic sedimentary rocks resting on Precambrian rocks. The oldest known land plant fossils as well as ancient fish remains occur in these sedimentary rocks.

3. Pilot and Index Peaks (**Figure 2**). Pilot Peak, to the south, is a sharp glaciated horn that has been eroded from the flat-lying

flows of Early Basalt sheets. Index Peak is a breccia-filled vent. The lower part of the mountain mass is composed of the Early Basic Breccia, which rests on Paleozoic limestones.

4. Cooke City mining area. The Cooke City, or New Work mining district became active in the early 1870s, and has continued intermittently until the present time. The mineralization is composed of iron-copper-gold veins and lead-silver veins. Although most of the mineralization occurs in the Gallatin National Forest of Montana, some of the lead-silver mine workings (particularly on Republic Mountain) extend into the Shoshone National Forest of Wyoming.

5. Hunter Peak area. From the junction of the Red Lodge-Cooke City Highway and Sunlight Basin road southeastward, the road runs for the next 7 miles along the side of the Clarks Fork Valley, just below the Cambrian Pilgrim Limestone. Precambrian granite gneisses are exposed in the canyon and on the north side of the valley. The Pilgrim limestone crops out as a continuous shelf along the south side of the valley. The dark brown Early Basic Breccia unconformably overlies the Paleozoic formations. Since these breccias may lie on the Mississippian Madison Limestone or as low as the Cambrian Pilgrim Limestone, the pre-volcanic relief (erosional surface) was about 1,500 feet.

Hunter Peak proper is composed of the Bighorn, Threeforks, Jeferson, and Madison formations of Paleozoic age. Actually, Hunter Peak is one of the Heart Mountain (detachment or thrust) fault blocks. The trace of this fault extends from silver gate through the Clarks Fork-Dead Indian Hill area to Heart Mountain, distance of approximately 50 miles.

6. Hurricane Mesa. Hurricane Mesa is a high, dissected plateau-like surface, that is underlain chiefly by volcanic rocks of the Early Basic Breccia. Emplaced in the center of the Mesa is a large ring-dike complex. This circular volcanic feature undoubtedly represents one of the source areas of the Early Basic Breccia.

7. Cathedral Cliffs. Cathedral Cliffs is a precipitous north-facing cliff that rises 2,500 feet above the valley floor. The lower part of the cliffs is composed of light colored sedimentary rocks of Cambrian, Ordovician, Devonian, and Mississippian ages. Irregularly overlying the Mississippian Madison Limestone is the Eocene volcanic Cathedral Cliffs Formation which, in turn, is unconformably overlain by the dark-colored Early Basic Breccia. The Cathedral Cliffs Formation is overlain by a light colored block of Madison Limestone, which is a remnant of the Reef Creek detachment fault. The Heart Mountain fault cuts the lower Paleozoic rocks at the base of the cliffs. The dark vertical lines in the Madison Limestone are igneous dikes.

8. Sugarloaf Mountain. Sugarloaf Mountain is another exposure of the Heart Mountain detachment or thrust fault. Here, the steeply dipping Bighorn Dolomite of Ordovician age rests on the flat-lying Cambrian Pilgrim Limestone.

9. Dilworth fault zone. On the north side of the Clarks Fork valley, the Precambrian rocks of the Beartooth Mountains have been elevated between 2,000 and 3,000 feet along the Dilworth fault zone. Several U-shaped glacial valleys have been eroded in the Precambrian rocks.

10. Antelope Mesa. Antelope Mesa is a flat table-like butte that is capped by the Pilgrim Limestone. From Antelope Mesa to Dead Indian Creek, the road runs on Cambrian rocks. Both the Meagher and Pilgrim Limestones form prominent ledges, while above these are the "disturbed" Ordovician, Devonian, and Mississippian rocks that are involved in the Heart Mountain fault. Between Russell and Dead Indian Creeks, there are several small uranium deposits in the Cambrian Flathead Sandstone.

11. Dead Indian Hill. From Dead Indian Creek to the top of Dead Indian Hill, the switch-back road crosses sedimentary rocks ranging in age from Cambrian to Pennsylvanian. The top of the hill is capped by the Pennsylvanian Tensleep Sandstone, which is a remnant of the Heart Mountain fault. From the top of Dead Indian Hill eastward to the Shoshone National Forest boundary, the road runs alternately on redbeds of the Triassic Chugwater Formation, limestone of the Permian Phosphoria Formation, and the massive Tensleep Sandstone. The long dip slope east of the Forest boundary is underlain by the Phosphoria Formation.

Westward from Dead Indian Hill (**Figure 3**), is one of the most spectacular scenic and geologic views that can be seen in any national forest. From here, one can observe the Precambrian crystalline rocks of the Beartooth Plateau and Dead Indian Creek, which are overlain by highly faulted Paleozoic rocks. In the Sunlight Basin area, these rocks are unconformably overlain by dark colored volcanic rocks of the Early Basic Breccia, which, in turn, have been intruded by numerous igneous dikes and plugs. The Sunlight glacier can be seen in the distance.

12. Sunlight Basin. A mile-long, rather smooth, terminal glacial moraine fills Sunlight Basin between White Mountain and the mouth of Elk Creek. This moraine dammed Sunlight valley and the resultant lake formed the present flat-bottomed Sunlight Basin. This lake was short lived, since no shoreline terrace remnants can be observed. Some of the pebbles in the moraine are of Precambrian rock fragments, and it is believed that this moraine was deposited by a glacier moving upstream from the Clarks Fork valley. No Precambrian rocks crop out farther up Sunlight Creek.

13. White Mountain. White Mountain (**Figure 4**), on the north side of and at the lower east end of Sunlight Basin, is a brown colored volcanic neck that has intruded the light colored upper Paleozoic limestones. The numerous irregular dikes and the neck provided the heat that caused these limestones to be changed into marble. Because of the numerous flows and breccias of igneous rock adjacent to this neck, it is believed that during Eocene time this was a volcano that had built up a cone approximately the size of Vesuvius in Italy.

14. Windy Mountain. Windy Mountain is a major breccia-filled volcanic vent, which has been intruded by a swarm of parallel dikes that are oriented in a north-south direction.

15. Sulfur deposits. Between White Mountain and the sulfur camp, the road runs across an exposure of Madison Limestone that also underlies Little Bald Ridge.

Several surficial sulfur deposits occur near Sulfur Lake and Sunlight Creek. The two largest deposits occur on the slope northwest of the lake, which is located on the northwest side of the road. Four other deposits, which can be seen from the road, occur on the southeast side of Sunlight Creek. The sulfur cements surficial debris and also encrusts fractures in bleached volcanic rocks of the Early Basic Breccia. The largest deposit is slightly more than 2 acres in size; however, most of the deposits are less than one-half acre in size. These deposits have been known for more than 60 years and various attempts have been made to exploit them.

16. Sunlight Mineralized area. The mineralization in Sunlight Basin occurs in the glacial cirque basins and on the ridges at the headwaters of various branches of Sunlight and Sulphur Creeks and the North Fork of the Shoshone River. These deposits are associated with an intrusive and volcanic center, which consists of a small igneous stock, several plugs, hundreds of radially arranged dikes, and a few cone sheets all intruding the Early Basic Breccia.

Iron, copper, lead, gold, and silver minerals occur in small irregular veins in fault zones and along dike contacts in the volcanic rocks. The mineralization was first discovered in about 1893, and numerous unsuccessful attempts have been made since then to develop the deposits. There are a number of underground workings in the area, but most of these are considered unsafe for entry. The total production of ore from this area probably did not exceed 30 or 40 tons.

17. Sunlight Glacier. The Sunlight Glacier is one of a few small glaciers that exist today in the Sunlight area. It is about a mile long and about one-half mile wide and lies at the foot of Sunlight Peak in a large composite cirque basin at the head of Sulphur Creek. The other three or four glaciers in the area are small cliff glaciers plastered on the walls of northeast-facing cirques. These are remnants of the last glaciation in the Sunlight area and were responsible for the final sculpturing of the high mountain topography that can be seen today.

North Fork-South Fork Shoshone River area

18. North Fork area. The highway leading west to Yellowstone National Park follows the scenic glaciated canyon that has been eroded in the Early Basic Breccia. The brown rocks include lava flows, breccias, volcanic conglomerates, and tuffs. These have been eroded into various pinnacles and hoodoos that have been given such names as Elephant Head Rock, Henry Fork Rock, Hanging Rock,

between Blackwater and Cabin Creeks. The bridge, estimated to be about 40 feet wide at the base, 80 feet wide near the top, and about 150 to 200 feet high, occurs in the lower part of the Late Basic Breccia.

22. Eagle Creek mineralized area. The Eagle Creek mineralized area is located on the northwest edge of the "Meadows", about 12 miles upstream from the junction of Eagle Creek with the North Fork of the Shoshone River. The mine workings here consist of a 725-foot tunnel, a caved shaft, and several prospect pits. These were driven to intersect gold-bearing veins that occur in the Late Basic Breccia associated with a small intrusive igneous body. No gold can be observed in the mineralized rock specimens; however, traces of pyrite (fools gold) and lead, zinc, and copper minerals occur on the tunnel dump and in veins within the tunnel. No mining is being carried on at the present time; however, two gold shipments were reportedly made from the area sometime during the 1930s.

The "Meadows" is an interesting valley from a geological standpoint, since none of the other stream valleys in the area have the same configuration. It is a glaciated valley approximately 2 miles long and 0.5 mile wide. Since it has a flat floor, it may have been a short-lived lake that was dammed by a moraine or landslide at the east end. Placer gold has been reported from the alluvial deposits here and on Crouch Creek, located about 2 miles to the north.

Chimney Rock, Holy City, and Palisades. Many dark colored dikes of varying thicknesses and orientations can be seen cropping out on both sides of the highway and intruding (cutting across) the Early Basic Breccia. One of these dikes is called the Chinese Wall.

Overlying the Early Basic Breccia are the dark colored Early Basalt flows. These usually crop out in a series of high vertical cliffs. Thin remnants of the Late Basic Breccia overly the Early Basalt flows and cap many of the higher mountain peaks. The Late Basic Breccia is similar in color and composition to the Early Basic Breccia.

19. Sweetwater Creek sulfur deposit. The sulfur deposits are located about 2 miles north of the junction of Sweetwater Creek with the North Fork of the Shoshone River. The deposit probably does not exceed 20 acres in size. The sulfur cements surface debris. These recent deposits are the result of decomposition of hydrogen-sulfide gas which issues from crevices in the reddish brown andesite breccias.

20. Sweetwater Creek oil spring. The oil spring lies on the west bank of Sweetwater Creek within 100 yards of the largest sulfur deposit. The oil probably rose through fractures in volcanic rocks (of the Early Basic Breccia), which intersect the older oil-bearing sedimentary rocks at depth.

21. Blackwater Natural Bridge. A slender arch forms a spectacular natural bridge that has been eroded in a narrow, serrated ridge

23. South Fork Valley. The South Fork valley is geologically similar to the North Fork valley, except that it is wider. The oldest rocks exposed within the National Forest boundary are the red and tan sandstones, shales, and conglomerates of the Eocene Willwood Formation. These rocks are overlain by the brown Pitchfork Formation (southern volcanic equivalent of Early Basic Breccia, **Table 2**), which, in turn, is overlain by the dark brown cliff-forming Early Basalt flows. The high ridges, peaks, and mesas are composed of volcanic rocks of the Wiggins - Late Basic Breccia sequence (**Table 2**).

A large glacial moraine, about 5 miles wide, is exposed along the South Fork valley, between the Ishawooa Guard Station and Ishawooa Creek. This probably represents the farthest advance of the glaciers in the northeast direction along the South Fork that occurred during Pleistocene times.

24. Deer Creek Natural Bridge. Deer Creek flows through a scenic natural bridge that is located in a deep gorge. This bridge, which is about 25 feet high, 15 feet wide near the top of the span, and 25 feet wide at the base of the span has been eroded in soft volcanic tuff of the Pitchfork Formation. It was formed by undercutting during the growth of an entrenched meander of Deer Creek.

25. Landslide area. A belt of landslide hills, about 4 miles long and 1 mile wide, is located opposite Valley, on the southeast side of

the river. It is believed that this landsliding occurred soon after the valley was brought to its present level by glaciation.

26. Box Canyon of the South Fork. A few miles above its junction with Cabin Creek, the South Fork flows through a narrow box canyon about 500 feet deep. The original U-shaped glacial canyon has been modified by the lower postglacial box canyon, as a result of the South Fork encountering a more resistant intrusive igneous rock. The rock types immediately above and below the box canyon are less resistant to stream erosion, and hence wider valleys are present.

27. Stinkingwater Mineralized area. The mineralized area is located near the confluence of Needle Creek with the South Fork of the Shoshone River. The mine workings here consist of several tunnels and prospect pits, some of which were reportedly financed by Buffalo Bill Cody during the early 1900s.

The mineralization lies in and adjacent to a large granodiorite stock that has intruded the Pitchfork-Early Basic Breccia, Early Basalt flows, and the Wiggins-Late Basic Breccia formations. Pyrite and molybdenum occur in a highly fractured and silicified zone in an area adjacent to Needle Creek and at the base of the southwest slope of Needle Mountain. Narrow veins containing pyrite, lead, silver, and copper crop out on Crater Mountain. Because of the presence of molybdenum, at least one major mining company has recently undertaken exploration in the area.

28. <u>Foster Reservoir fossil area</u>. Foster Reservoir is located at the western edge of a large landslide. The volcanic rocks cropping out on the near-vertical cliff, just west of the reservoir, include, in ascending order, the Pitchfork Formation, Early Basalt flows, and the Wiggins Formation. The landslide, of which Devils Tooth is a prominent feature, is composed largely of debris from the Pitchfork Formation. Many bone and teeth fragments are scattered on the surface, and these represent remains of such extinct Eocene animals as a tiny three-toed horse, an ancestral rhinoceros, a relative of the rhinoceros, and a tapir-like animal.

29. <u>Pickett Creek natural bridges</u>. Two small natural bridges occur on Burnt Fork of Pickett Creek. The largest of the two is located in SE1/4 sec. 16, T.49N., R.104W. This bridge, which is estimated to be about 100 feet wide and 100 feet high, occurs high on a narrow prong-like ridge composed of gray volcanic conglomerates and tuffs of the Wiggins Formation.

The smaller of the two bridges is located about one-half mile southeast of the larger one. It is rudely circular in appearance with an estimated diameter of about 8 feet. Geologically, it is similar to the larger bridge.

The Pickett and Blackwater natural bridges occur on narrow ridges that were eroded to their present configuration by stream action many thousands of years ago. The streams may have meandered in places and attacked the softer rocks, undermining them in places. Toward the later stages of erosion, melting snow and rain would drain down the outcrop or joints and attack the softer beds. Alternating freezing and thawing assisted the wedging-out fragments of rock until a hole was formed. By a continuation of the above processes, the hole would become enlarged to form a natural bridge.

30. Fourbear oil field. There are no producing oil fields within the Shoshone National Forest at the present time; however, the Fourbear field is the nearest and lies within 2 miles of the Forest boundary. Because of the close proximity of the Fourbear oil field and other geological factors, the portion of Shoshone National Forest that lies within the Greybull River-Cottonwood Creek area has undergone extensive seismic exploration for new oil fields. It is not unlikely that an oil field within the Forest boundary may be discovered sometime in the future.

The Fourbear field is an anticlinal structure that produces oil from the Paleozoic Phosphoria, Tensleep, Amsden, and Madison formations. These producing horizons lie between 2,800 to more than 4,000 feet below the land surface.

31. Greybull River-Jack Creek area. The road on the south side of the Greybull River that leads west from the Fourbear oil field to Jack Creek, crosses a large landslide **(Figure 5)** just west of the National Forest boundary. The narrow ridge, between the hummocky

topography of the landslide and Jack Creek proper, located just south of the road, is a large andesite dike, 2 miles or more in length, that has intruded the Pitchfork Formation.

Looking northwest from the landslide across the Greybull River, one can see, in ascending order, good outcrops of the red and tan colored sedimentary rocks of the Willwood Formation, the brownish rocks of the Pitchfork Formation, the dark brown cliff-forming Early Basalt flows, and the overlying volcanic conglomerates and tuffaceous sandstones of the Wiggins Formation.

32. Jack Creek anticline. The Jack Creek anticline is a structural feature that has folded the Pitchfork Formation, the Early Basalt flows, and the Wiggins Formation into a large dome whose axis trends approximately northeast. Several small igneous bodies have intruded the structure near the south end. In recent years, the area has been explored for petroleum possibilities.

33. Gold Reef area. The Gold Reef mineralized area, at the head of Jack Creek was reportedly discovered by an Indian chief by the name of Gard during the 1890s. The early miners built a wagon road up Kay Creek and over the Jack Creek divide for access to the area. Remnants of this early road are still visible.

Since it was believed that the area contained gold, two tunnels were driven to intersect vein-like outcrops. The longest tunnel, located on a west-facing talus slope at the foot of a cliff, has about 1,700 feet of workings. No visible mineralization is apparent on the dump or within the mine. The smaller tunnel, located about one-fourth mile south of the larger tunnel, is about 125 feet long and contains traces of pyrite and copper sulfide on the dump.

34. Francs Peak. Francs Peak (**Figure 6**), elevation 13,140 feet, is the highest mountain in the Absaroka Mountains. It is underlain by volcanic rocks of the Wiggins Formation. Southwest of Francs Peak, and exposed in Avalanche Creek, is a light colored circular-shaped rhyolite plug that has intruded and deformed the Wiggins Formation.

35. Bonne Creek petrified wood area. Beautiful specimens of opalized petrified wood occur just north of the Bonne Creek-North Cow Creek divide. Individual specimens vary from black, brown, orange, yellow, and gray. Fragments are fairly abundant; however, some logs can also be observed in the cliffs of the Wiggins Formation.

36. Mt. Burwell. Mt. Burwell is a concical-shaped peak located on the ridge-like divide between North Cow, Bonne, and Burwell Creeks. It probably represents a small volcanic vent, since it has a central intrusive core of andesite, while at the base are beds of light gray tuff and reddish brown scoria (vesicular igneous rock). A similar feature, but on a larger, more complex scale, can be seen on the south side of Cow Creek.

Wood River area

37. Brown Creek area. The Brown Creek area is composed dominantly of the brownish volcanic rocks of the Pitchfork Formation. These layered rocks have been folded, faulted, and intruded by several small spine-like plugs of basalt. A large landslide, about three-fourths of a square mile in area, lies east of the mouth of Brown Creek.

38. Blue Point. Blue Point, located on the road about one-half mile west of the Shoshone National Forest boundary, is the type locality for a group of rocks called the Blue Point conglomerate **(Table 2)**. This dark green volcanic conglomerate can be traced from Carter Mountain in the Greybull River area to Cottonwood Creek. In the Greybull river area the Blue Point conglomerate lies at the base of the Wiggins Formation and overlies the Early Basalt flows. Since the Early Basalt flows are absent in Wood River and areas to the south, the Blue Point conglomerate is used as a convenient marker bed to separate the Pitchfork Formation from the overlying Wiggins Formation. The Blue Point conglomerate crops out as a small cliff that drops abruptly for about 50 feet into Wood River. Just south of this point, on the south side of Wood River, can be seen a small landslide with a cliff-forming scar at its head.

39. Middle Fork fault. The Middle Fork of Wood River roughly follows the trace of a large fault that extends into the Deer Creek

drainage. Where formerly the Blue Point conglomerate was seen to crop out on the road (as described above), it is now exposed on the ridge between Deer Creek and Dick Creek and high on the south-facing slopes between Deer and Jojo Creeks. This indicates that this portion of the Blue Point conglomerate (as well as the Pitchfork and Wiggins Formations) have been uplifted approximately 1,300 feet.

Looking west, from the mouth of Middle Fork (**Figure 7**) one can see the glaciated U-shaped valley of Wood River. The Pitchfork Formation crops out on the rounded slopes on both sides of the river, while the overlying darker brown cliffs are the massive volcanic conglomerates of the Wiggins Formation (**Figure 7**).

40. Jojo Creek area. South of the mouth of Jojo Creek is a large area of landslide and glacial debris. Above this can be seen an excellent cross sectional view of a funnel-shaped intrusive body of andesite (**Figure 8**). Andesite is a very common igneous rock that occurs both as flows and intrusive bodies in the upper Wood River area. It is usually a green rock that is mottled with light gray feldspar crystals. Another similar body of andesite underlies Standard Peak on the ridge between South Fork and Middle Fork of Wood River.

The hummocky topography just upstream from the mouth of Jojo Creek is a small glacial moraine.

41. Kirwin mineralized area. Mineralization was discovered in the Kirwin area during the 1890s. Early miners in the area drove

approximately 7,500 feet of mine workings, but most of these today are caved or unsafe for entry (**Figure 9**). The Galena Ridge tunnel, near the mouths of Galena and Canyon Creeks, is the most extensive of these workings and is 2,327 feet long. The rocks exposed in the area consist dominantly of andesite flows and breccias of the Wiggins Formation. These have been intruded by three plug-like bodies and many dikes.

Although this area is locally famous for gold, it has more significance because of the presence of molybdenum. The mineralization is of two types: (1) pyrite-molybdenum-copper veins in altered rock on Bald Mountain, and (2) lead-silver veins in the Brown Mountain-Canyon Creek area. Although there has been little recorded production from the Kirwin area, the district has been explored in recent years by both mining and petroleum companies.

42. Wood River-Caldwell Creek divide. Exposed on the Wood River-Caldwell Creek divide is a large body of light gray rhyolite that forms a mountain peak approximately 12,00 feet in elevation. This intrusive body of rhyolite is unusual, in that it has uplifted a large block of Paleozoic sedimentary rocks (**Figure 10**) that is approximately 1,500 feet thick and occupies an area of about one square mile. The exposure is of considerable interest, since the Paleozoic rocks here are at an extremely high elevation (about 12,000 feet) while the nearest exposures of other Paleozoic rocks are about eight miles to the southwest and several thousand feet lower in elevation. South of the rhyolite, the Wiggins Formation has been deformed and dips steeply to the south.

Cottonwood-Owl Creek Area

43. Cottonwood Creek Natural Bridge. A small, partially caved natural bridge occurs near the head of Cottonwood Creek. This was formed by Cottonwood Creek undercutting a nonresistant bed of volcanic conglomerate of the Wiggins Formation.

44. Sugarloaf Mountain. Sugarloaf Mountain (**Figure 11**) is a rectangular-shaped peak 9,912 feet high that occurs on the divide between Sugarloaf Creek (tributary to Cottonwood Creek) and the North Fork of Owl Creek. Sugarloaf and the small horn-shaped peak to the northwest are both bodies of a mottled red and light gray igneous rock that has intruded the light gray volcanic conglomerates of the Wiggins Formation. Evidently, Sugarloaf was the source of the lava flow that underlies Squaw Teat Butte (located southeast of Sugarloaf), since both rock types are similar in appearance.

45. Washakie Needles. Washakie Needles (**Figure 12**), located on the ridge between Rock Creek and the South Fork of Owl Creek, and Dome Mountain to the northwest are both part of a dacite plug that has intruded the Wiggins Formation. The dacite, which crops out in an area one and one-half miles long by one-half mile wide, is a coarse-grained, light colored igneous rock that is mottled by black mica and hornblende.

46. Castle and Steamboat Rocks. Castle and Steamboat Rocks, located on the ridge between East Fork River and Bear Creek, are erosional remnants of the Wiggins Formation. Excellent exposures of white to gray beds of tuff and volcanic conglomerates with intercalated beds of red andesite can be seen here.

47. Wiggins Peak. Wiggins Peak, elevation 12,160 feet, is located on the ridge between Bear and Caldwell Creeks. The rocks, which are lava flows and breccias of many different shades of color, are the youngest volcanics in this area and are called the Caldwell Canyon volcanics. These rest unconformably on the Wiggins Formation. Several miles to the north of Wiggins Peak, and on the west slope of the Black Canyon of Caldwell Creek, are two additional patches of strawberry-colored breccias that may be related to the Caldwell Canyon volcanics.

48. Frontier Creek Petrified Forest. Upright petrified trees of many varieties and sizes occur in the Wiggins Formation along the walls of Frontier Creek canyon (**Figure 13**). Many of these are comparable in size to the largest of those reported in Yellowstone National Park. In addition, beautiful silicified pine cones, seed clusters, fruits, and twigs occur in areas adjacent to the trees. Since this area has been extensively vandalized, no collecting of specimens is permitted.

49. Crescent Mountain. Crescent Mountain, situated a few miles northwest of Shoshone Pass, is an eroded volcanic cone of black basalt

and red scoria on the Continental Divide. This cone, which rests on the Wiggins Formation, may be of Pleistocene age.

50. Du Noir Glacier. The Du Noir Glacier, located at the head of one of the tributaries to East Fork of the Du Noir River, is a relic glacier that is now a small perennial snow and ice field.

51. Brooks Lake and Pinnacle Buttes. Brooks Lake, east of Togwotee Pass, is dammed by a small terminal moraine that is located at the end of a pre-Bull Lake (glacial stage) glacial groove. Pinnacle Buttes, located east of Brooks Lake, is an excellent exposure of horizontally bedded, light gray, volcanic conglomerates and tuffs of the Wiggins Formation.

The greenish rocks cropping out at Togwotee Pass are volcanic conglomerates and tuffs of the upper Eocene Tepee Trail Formation.

52. Ramshorn Peak. Ramshorn Peak, which can be seen northeast of the Dubois-Togwotee Pass highway, is another good scenic-geologic view of the light colored volcanic conglomerates and tuffs of the Wiggins Formation. The rounded hills below the Ramshorn are composed of the volcanic sediments of the Tepee Trail Formation.

53. Lava Mountain. Lava Mountain, which occurs on the Continental Divide south of Togwotee Pass, is a rounded reddish knob with cliffs on the north and east sides. The knob is a cinder cone of scoria and volcanic ash; however, the cliffs are composed of basalt that has been glaciated.

Southeastward, from Lava Mountain to Warm Springs Creek, is a large area of Tertiary strata of volcanic composition. These rocks overlap Precambrian crystalline and Paleozoic sedimentary rocks, which compose the northwestern end of a large asymmetric anticlinal fold that formed the Wind River Range. Although the Paleozoics form moderate to steep dip slopes to the northeast, they are highly faulted in places with displacements as much as 3,000 feet. Gold- and monozite- (thorium-rare earth mineral) bearing gravels occur along Warm Springs Creek. The gold was reportedly mined at one time at Clark's placer mine near the tie camp. Several occurrences of uranium have been reported from Precambrian rocks in nearby areas.

54. Whiskey Mountain. Whiskey Mountain, elevation 11,095 feet, is underlain by the Cambrian Flathead Formation. Uranium occurs in cavernous, silicified rocks of Cambrian(?) age in this area. To the west are glaciated Precambrian rocks composed dominantly of coarsely crystalline pink granite. The granite grades into gneisses and schists further west. A good section of sedimentary rocks, ranging in age from Cambrian to Tertiary, crops out east of Whiskey Mountain. The more resistant of these rock types form northeast dipping hogbacks. The Amsden Formation of Pennsylvanian age contains local concentrations of hematite (iron oxide) near the Whiskey Peak area. These deposits have been explored by the U.S. Bureau of Mines on Red Creek.

Looking south-southest from Whiskey Mountain, one can see tundra developed on the Cambrian Gros Ventre Formation. In the background is the gently sloping Fremont erosional surface.

55. Dinwoody Glaciers. The term Dinwoody glaciers (**Figure 14**) refers to a group of glaciers that occur east of the axial crest of the Wind River Range in the Gannett Peak area. The South Dinwoody is the longest glacier in the area.

There are at least 60 permanent ice fields and glaciers in the higher parts of the Wind River Range, and most of these occur on the east side. All of these recent glaciers are confined to cirques at an elevation of 10,000 feet or more. Many of the streams and lakes in this section of the Wind River Range occupy large glacial U-shaped troughs, and many large morainal deposits occur east of this part of the National Forest. These facts indicate that the original, or earlier, glaciers had a much greater areal extent.

56. Gannett Peak. Gannett Peak (**Figure 15**), elevation 13,785 feet, is the highest mountain peak in Wyoming. It is underlain by Precambrian granite gneisses and schists that grade westward into coarse-grained granites. Gannett Peak, and all of the other peaks of the Wind River Range that occur above 11,000 feet, projected through the original ice sheets as nunataks.

Lander area

57. Lizard Head Peak. Lizard Head Peak, elevation 12,842, is another nunatak that is composed of gray, coarsely crystalline granite,

almost entirely surrounded by glacial valleys. Rocks cropping out to the north (**Figure 16**) and east to Shoshone Lake are largely composed of the same gray coarse-grained granite that has been extensively glaciated.

58. Sinks area. The Sinks, located about one and one-half miles east of the Forest boundary along the Middle Fork of the Popo Agie River, is named for an area where the river disappears into a cavern below the gray flaggy limestone that marks the top of the Mississippian Madison Limestone.

About one-third mile east of the National Forest boundary, along the Middle Fork of the Popo Agie River, is a terminal moraine. A lateral moraine occurs near the University of Missouri's Camp Branson (a geology field camp).

59. Fossil Hill area. The switchback road beyond Camp Branson traverses red and brown sandstone, green and red shale, and limestone of Cambrian age. The formations exposed here are respectively, Flathead Sandstone, Gros Ventre Formation, and Gallatin Limestone. Fossil Hill, east of the road, is underlain by the Ordovician Bighorn Dolomite and capped by a remnant of the Madison Limestone.

Frye Lake marks the contact of the Cambrian Flathead Sandstone with the Precambrian crystalline rocks. From here, almost to State Highway 28, the road traverses Precambrian granitic rocks that have been intruded by dark colored diabase (igneous rock) dikes that trend across the country for miles. These dikes contain inclusions of granite.

60. Granite Peak area. Granite Peak, and areas to the east and north, are composed of Precambrian granites and granodiorites that have been glaciated.

61. Atlantic City Iron Mine. The Atlantic City iron project operated by the Columbia-Geneva Steel Division of U.S. Steel Corporation, is located 8,300 feet above sea level and is the highest, large-scale open pit iron mine in the United States. Initial production of iron ore began in August, 1962. The operation, which is designed to produce 4,000 tons of iron agglomerates per operating day, is the only continuously active mine within Shoshone National Forest.

The iron, which occurs in the mineral magnetite, is concentrated in two different metamorphic rock units of Precambrian age. The approximate average iron content of the upper unit of rock is 32 percent, and this is upgraded to approximately 62 percent iron. This concentrate is then shipped by rail to the steel mill at Provo, Utah.

Adjacent to the iron deposits, in SE1/4 sec. 26, T.30N., R.100W., are small asbestos deposits, which occur in Precambrian metamorphic rocks. A small mill was built here in 1919 and some asbestos was produced before 1921.

62. Limestone Mountain. Limestone Mountain, located about one mile northwest of the National Forest boundary and State Highway 28, is underlain by the cliff-forming, fossiliferous Madison Limestone,

which dips about ten degrees northeast. Underlying the Madison here is the Ordovician Bighorn Dolomite, and the Cambrian Gallatin Limestone and Gros Ventre Formation.

63. Atlantic City-South Pass gold area. Although outside the boundary of the Shoshone National Forest, the Atlantic City-South Pass area is included in this guide because of its close proximity to the National Forest. Gold was reportedly first discovered in this area in the 1840s; the earliest on record in Wyoming. Most of the gold mined in Wyoming has been produced in this area from such underground mines as the Miners Delight, Carissa, and Duncan. Placer gold has been mined along Rock Creek. Some gold is still sporadically produced from this area; however, most of the production occurred between 1869 and 1874. Most of the gold occurs in Precambrian metamorphic rocks, in quartz veins associated with these rocks, and in alluvial (sand and gravel) deposits along streams.

BIBLIOGRAPHY*

Bayley, C., 1963, Precambrian iron deposits near Atlantic City: U.S. Geological Survey Bulletin 1142-C.

Blackwelder, Eliot, 1915, Post-Cretaceous history of the mountains of central western Wyoming: Journal of Geology, v. 33, p. 97-117.

Branson, E.B., and Branson, C.C., 1941, Geology of Wind River Mountains, Wyoming: American Association of Petroleum Geologists Bulletin, v. 25, p. 120-151.

Dunnewald, J.B., 1958, Geology of the Fish Lake Mountain area, Fremont County, Wyoming: M.A. thesis, University of Wyoming, Laramie.

Dunrud, C.R., 1962, Volcanic rocks of the Jack Creek area, southeastern Absaroka Range, Park County, Wyoming: M.S. thesis, University of Wyoming, Laramie.

Foose, R.M., and others, 1961, Structural geology of Beartooth Mountains, Montana and Wyoming: Geological Society of America Bulletin, v. 72, p. 1143-1172.

Gilliland, J.D., 1959, Geology of the Whiskey Mountain area, Fremont County, Wyoming: M.S. thesis, University of Wyoming, Laramie.

Hague, A., 1899, Absaroka Folio: U.S. Geological Survey Geological Atlas of the U.S., Folio no. 52, 7 p.

Hay, R.L., 1954, Structural relationships of tuff-breccia in Absaroka Range, Wyoming: Geological Society of America Bulletin, v. 65, p. 605-620.

Hay, R.L., 1956, Pitchfork Formation, detrital facies of Early Basic Breccia, Absaroka Range, Wyoming: American Association of Petroleum Geologists Bulletin, v. 40, p. 1863-1898.

Hewett, D.F., 1911, Sulphur deposits of Sunlight Basin, Wyoming: U.S. Geological Survey Bulletin 530, part 1, p. 350-362.

Hewett, D.F., 1912, The ore deposits of Kirwin, Wyoming: U.S. Geological Survey Bulletin 540, part 1, p. 121-132.

Hewett, D.F., 1912, Sulphur deposits in Park County, Wyoming: U.S. Geological Survey Bulletin 540, part 1, p. 477-480.

Howell, J.V., and others, 1957, Glossary of geology and related sciences: American Geological Institute, 325 p.

Keefer, W.R., 1957, Geology of the Du Noir area, Fremont County, Wyoming: U.S. Geological Survey Professional Paper 294-E, p. 155-220.

**Editor's note: The author listed bibliographic references here, but they do not appear as citations in the text.*

Krushensky, R.D., 1961, Volcanic features of the Hurricane Mesa area, Park County, Wyoming: Geological Society of American Special Paper 68, p. 214.

Love, J.D., 1939, Geology along the southern margin of the Absaroka Range, Wyoming: Geological Society of American, Special Paper 20, 134 p.

Love, J.D., 1955, A proposal to create the Frontier Creek National Monument: unpublished report, 8 p.

Love, J.D., de la Montagne, John, and Kinney, D.M., 1956, Road logs: Wyoming Geological Association 11th Annual Field Conference Guidebook, Jackson Hole, Wyoming.

Love, J.D., Weitz, J.L., and Hose, R.K., 1955, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000.

Lovering, T.S., 1929, The New World or Cooke City mining district: U.S. Geological Survey Bulletin 811-A, p. 1-87.

Masursky, Howard, 1952, Geology of the western Owl Creek Mountains: Wyoming Geological Association 7th Annual Field Conference Guidebook, scale .9 inch = 1 mile.

McKay, E.J., 1948, Geology of Red Canyon Creek area, Fremont County, Wyoming: M.S. thesis, University of Wyoming, Laramie.

Osterwald, F.W., and others, 1959, Mineral resources of Wyoming: Geological Survey of Wyoming Bulletin 50, 259 p.

Parker, R.B., 1962, Precambrian agmatites of the Wind River Range, Wyoming: University of Wyoming Contributions to Geology, v. 1, p. 13-19.

Parsons, W.H., 1937, The ore deposits of the Sunlight mining region, Park County, Wyoming: Economic Geology, v. 32, p. 832-854.

Parson, W.H., 1939, Volcanic centers in the Sunlight area, Park County, Wyoming: Journal of Geology, v. 47, p. 1-26.

Parson, W.H., 1939, Glacial geology of the Sunlight area, Park County, Wyoming: Journal of Geology, v. 46, p. 737-747.

Parson, W.H., 1958, Origin, age, and tectonic relationships of the volcanic rocks in the Absaroka-Yellowstone-Beartooth region, Wyoming-Montana: Billings Geological Society 9th Annual Field Conference Guidebook, p. 36-43.

Parsons, W.H., 1960, Origin of Tertiary volcanic breccias, Wyoming: International Geological Congress, XXI Session, Norden 1960, Part XIII, Copenhagen, p. 139-145.

Pierce, W.G., 1941, Heart Mountain and South Fork thrusts, Park County, Wyoming: American Association of Petroleum Geologists Bulletin, v. 25, p. 2021-2045.

Pierce, W.G., 1957, Heart Mountain and South Fork detachment thrusts of Wyoming: American Association of Petroleum Geologists Bulletin, v. 41, p. 591-626.

Pierce, W.G., 1960, The "break-away" point on the Heart Mountain detachment fault in northwestern Wyoming: U.S. Geological Survey Professional Paper 400-B, p. 236-237.

Pierce, W.G., 1963, The Cathedral Cliffs Formation, the Early Acid Breccia unit of Northwestern Wyoming: Geological Survey of America Bulletin, v. 74, p. 9-22.

Pierce, W.G., 1963, Reef Creek detachment fault, northwestern Wyoming: Geological Society of America Bulletin, v. 74, p. 1225-1236.

Poldervaart, A., and Bentley, R.D., 1958, Precambrian and later evolution of the Beartooth Mountains, Montana and Wyoming: Billings Geological Society 9th Annual Field Conference Guidebook, p. 7-15.

Richmond, G.M., 1962, Three Pre-Bull Lake tills in the Wind River Mountains, Wyoming: U.S. Geological Survey Professional Paper 450-D, p. 132-135.

Richmond, G.M., Glaciation of the Rocky Mountains: Quaternary of United States, v. 1: John Wiley and Sons, Inc., New York (in preparation).

Rouse, J.T., 1933, The structure, inclusions, and alteration of the Deer Creek intrusive, Wyoming: American Journal of Science, Fifth Series, v. 26, p. 139-146.

Rouse, J.T., 1934, The physiography and glacial geology of the Valley region, Park County, Wyoming: Journal of Geology, v. 42, p. 738-752.

Rouse, J.T., 1937, Genesis and structural relationships of the Absaroka volcanic rocks, Wyoming: Geological Society of America Bulletin, v. 48, p. 1257-1296.

Rouse, J.T., 1940, Structural and volcanic problems in the southern Absaroka Mountains, Wyoming: Geological Society of America Bulletin, v. 51, p. 1413-1428.

Rouse, J.T., 1947, The Absaroka volcanic field: University of Wyoming, Wyoming Geological Association, and Yellowstone-Bighorn Research Association Field Conference in the Bighorn Basin Guidebook, p. 165-172.

Spencer, A.C., 1916, The Atlantic gold district and the North Laramie Mountains, Fremont, Converse, and Albany Counties, Wyoming: U.S. Geological Survey Bulletin 626, p. 9-45.

Spencer, E.W., 1958, Structural trends in the Beartooth Mountains, Montana and Wyoming: Billings Geological Society 9th Annual Field Conference Guidebook, p. 16-23.

Wilson, W.H., 1963, Correlation of volcanic rock units in the Southern Absaroka Mountains, northwest Wyoming: University of Wyoming Contributions to Geology, v. 2, p. 13-20.

Wilson, W.H., 1964, The Kirwin mineralized area, Park County, Wyoming: Geological Survey of Wyoming Preliminary Report 2, 12 p.

Wise, D.U., 1958, The relationship of Precambrian and Laramide structures in the Southern Beartooth Mountains, Wyoming: Billings Geological Society 9th Annual Field Conference Guidebook, p. 24-30.

GLOSSARY OF TERMS

Alluvial - Refers to alluvium, or recent gravels, sands, and clays that have not been cemented together.

Altered rock - One that has undergone chemical and mineralogical changes since its original formation.

Anticline - Refers to a rock structure in which layered rocks dip in opposite directions like the roof of a house.

Cephalopod - A fossil characterized by a straight or spirally coiled shell which is divided into numerous interior chambers.

Crystalline - The term refers to the texture of igneous rocks with respect to the mineral crystals and their arrangement the regin; however, in this report it also refers to Precambrian igneous and metamorphic rocks.

Detachment fault - The more-or-less horizontal gravity sliding of rock formations over other rock formations. Could also be called a thrust fault, except that the mechanism producing the sliding is different.

Dike - A tabular-shaped body of igneous rock that cuts across (intrudes) the structure of adjacent rocks.

Erosion surface. A land surface shaped by the weathering action of streams, ice, rain, wind, etc.

Fault - A displacement of rocks in the earth's crust along a fracture(s).

Fissure - An extensive crack in the rocks.

Fold - A bend in layered rocks.

Formation - A group of sedimentary rocks that is used as a geological mapping unit and named after a geographic locality, i.e., Tensleep Sandstone, Thermopolis Shale, etc.

Igneous rocks - Rocks that were formed by the solidification of molten earth material (magma). There are two types: (1) intrusive, a type that has penetrated other rocks; and (2) extrusive, rocks that have, in a molten stage, flowed over other rocks on the surface of the earth and then solidified.

Metamorphic rock - These are rocks that are made up of other rocks, such as igneous or sedimentary, and later changed by solutions, heat, pressure (or all three) into a rock that has a different appearance or composition from the original rock.

Moraine - Rock debris deposited by direct glacial action.

Nunatak - A mountain peak that formerly projected through glacial ice.

Orogeny - Period of mountain building movements.

Peneplane - A land surface worn down by erosion to a flat or nearly featureless plane (plain).

Placer - Refers to a mineral deposit that has been weathered from a vein or other type of deposit and concentrated by gravity and water in the gravels and sands of stream and river channels.

Plug - An intrusive mass of solidified igneous rocks.

Prospect - Undeveloped mineral deposit.

Pyroclastic - Material explosively ejected from a volcanic vent.

Ring dike - A crudely circular dike with steep dip.

Sediment - A term applied to rock, organic, or other material deposited by streams, lakes, seas, wind, or ice.

Sedimentary rock - Rock formed by the accumulation of sediment.

Strata - Sedimentary beds or layers of sedimentary rock.

Sulfide - In this report, the term is applied to a mineral that is composed of sulfur and a metal (such as copper).

Talus - A sloping heap of rock fragments at the foot of a cliff.

Trilobite - A primitive crab-like animal characterized by a three-lobed body.

Tundra - A level of gently rolling treeless plain underlain by a black muck soil and a permanently frozen subsoil.

Tunnel - A general term for a horizontal mine opening. Actually, a tunnel has an opening at both ends, while an **adit** has only one opening. Tunnels, as used in this report, are more correctly defined as adits.

Variegated - Refers to rocks of alternating color (such as red and green).

Vein - A fracture (or crack) in the Earth's crust filled with mineral matter.

Weathering and erosion - Weathering is the mechanical breakdown of rocks, while erosion is the progressive removal of such particles by wind, water, etc.

Volcanic vent - An opening in the earth's crust, out of which volcanic materials were erupted to the surface.

ROCK DEFINITIONS

Andesite-dacite - Andesites are usually gray to green igneous rocks that are mottled by light and dark colored minerals. Major mineral components include feldspars, amphiboles, pyroxenes, and black mica. If quartz is present, the rock is called dacite.

Basalt - Basalt is a very dark colored, heavy, fine-grained extrusive (occasionally intrusive) igneous rock that is composed primarily of feldspar, pyroxene, with or without olivine.

Gneiss - A metamorphic rock similar to granite except that it is generally coarsely banded with light and dark colored minerals.

Granite-granodiorite - Light colored intrusive igneous rocks that are granular in appearance and contain quartz, feldspars, black mica and/or amphibole and pyroxene.

Rhyolite - Rhyolites are usually light colored, fine-grained igneous rocks, often containing visible crystals of quartz, feldspar, and black mica.

Schist - Schist is a crystalline rock with a finely laminated appearance. Most specimens are dark colored because of the abundance of black mica or amphibole.

Scoria - A fine-grained and porous igneous rock that is usually dark colored; however, the specimens referred to in this report are red.

Tuff - Volcanic ash fragments that are cemented or bonded together to form consolidated rock.

Volcanic breccia - Volcanic breccias, which occur as wither intrusive or extrusive igneous rocks, are composed of angular rock fragments (usually igneous) enclosed within a matrix of tuff or fine-grained igneous rock.

Volcanic conglomerate - Volcanic conglomerate is a cemented sedimentary rock containing rounded fragments (pebble size or larger) of volcanic rock enclosed within a finer-grained matrix of similar material.

Volcanic sandstone - Volcanic sandstone is a term applied to those rocks containing an abundance of rounded, water-worn grains of volcanic rock.

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The information presented in this report has been compiled from the listed bibliographic references as well as from the writer's field work. Much of the Wind River glacial data was based upon the unpublished notes of Gerald M. Richmons of the U.S. Geological Survey. R.S. Houston, Department of Geology, University of Wyoming; J.D. Love, U.S. Geological Survey; and H.D. Thomas, State Geologist of Wyoming; reviewed the manuscript and offered valuable criticisms.

Figure 3. View looking westward from Dead Indian Hill. Light colored Paleozoic rocks in foreground. Dark colored Early Basic Breccia in background. White Mountain in right center of photo. Sunlight glacier near skyline on left edge of photo.

Figure 2. Pilot (left) and Index Peaks.

Figure 1. Glaciated Precambrian rocks cropping out on the Beartooth Plateau. View near Beartooth Pass, looking north. Forest Service photo.

Figure 6. Francs Peak (right skyline), and volcanic rocks of the Wiggins formation from the upper Greybull River. View looking north.

Figure 5. Landslide (L), dike (d), Pitchfork formation (Tp), Early Basalt flows (ebf), and Wiggins formation (Twi), on the south side of the Greybull River just east of the mouth of Jack Creek.

Figure 4. White Mountain. Light colored rocks are metamorphosed Paleozoic limestones. Dark colored rock, between and above limestones, is the neck of an old volcano.

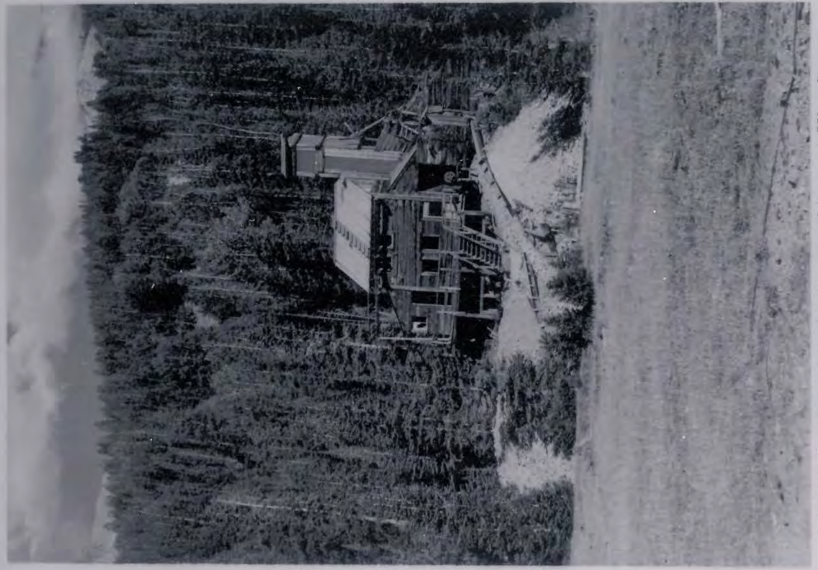


Figure 9. Abandoned mine workings at Kirwin.

Figure 8. Andesite funnel-shaped plug (A) and talus-landslide slope (L) on the south side of Wood River, south of the mouth of Jojo Creek. Arrow points to the intrusive contact between the funnel and the

Figure 7. View looking southwest, up Wood River. Rounded slopes in the foreground are underlain by the volcanic sandstones and conglomerates of the Pitchfork formation. Rugged slopes in the ... Wiggins

Figure 12. Washakie Needles. View looking northeastward from the South Fork of Owl Creek. Photo by J.D. Love.

Figure 11. Sugarloaf Mountain (right) and Squaw Teat Butte. View looking northwestward from Sugarloaf Creek (tributary to Cottonwood (Creek).

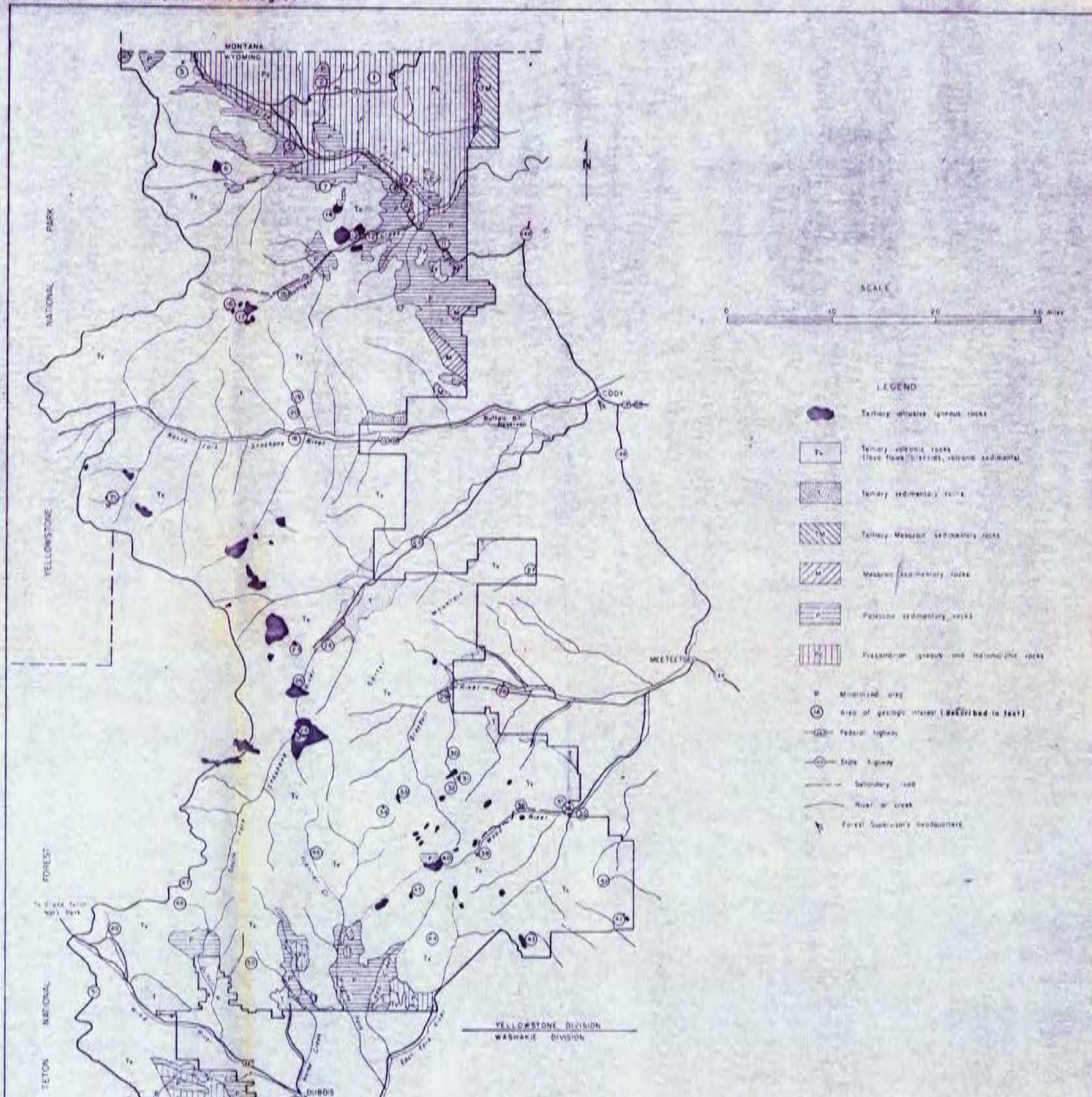
Figure 10. Paleozoic block (P) resting on a rhyolite plug (R) at the head of Wood River.

Figure 15. Gannett Peak and one of the Dinwoody glaciers. Forest Service photo.

Figure 14. Dinwoody glaciers. Forest Service photo.

Figure 13. Petrified tree enclosed within the volcanic conglomerates of the Wiggins formation on Frontier Creek. Photo by J. D. Love.

Figure 16. Glaciated Precambrian rocks of the Wind River Mountains. View looking southeastward near Graves Lake. Photo by R. B. Parker.



Modified from Love and others (1955),
Geologic Map of Wyoming

Generalized Geologic Map of the Shoshone National Forest

by

William H. Wilson

1963