THE GEOLOGICAL SURVEY OF WYOMING

S. H. KNIGHT, State Geologist

BULLETIN No. 27

GEOLOGY OF THE NORTHWEST PART OF THE RED DESERT, SWEETWATER AND FREMONT COUNTIES, WYOMING

BY

RAYMOND L. NACE

UNIVERSITY OF WYOMING
LARAMIE, WYOMING
MARCH, 1939

STATE OF WYOMING

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GEOLOGY OF THE NORTHWEST PART OF THE RED DESERT, SWEETWATER AND FREMONT COUNTIES, WYOMING

By Raymond L. Nace

INTRODUCTION

Location and Relations of the Area

The Red Desert is a loosely-defined area most of which is north of the Union Pacific Railroad and Lincoln Highway in the central and east parts of Sweetwater County, Wyoming. The part of the desert mapped by the writer, about 115 square miles in area, is approximately 50 miles northeast of Rock Springs, within Tps. 26-28 N.,

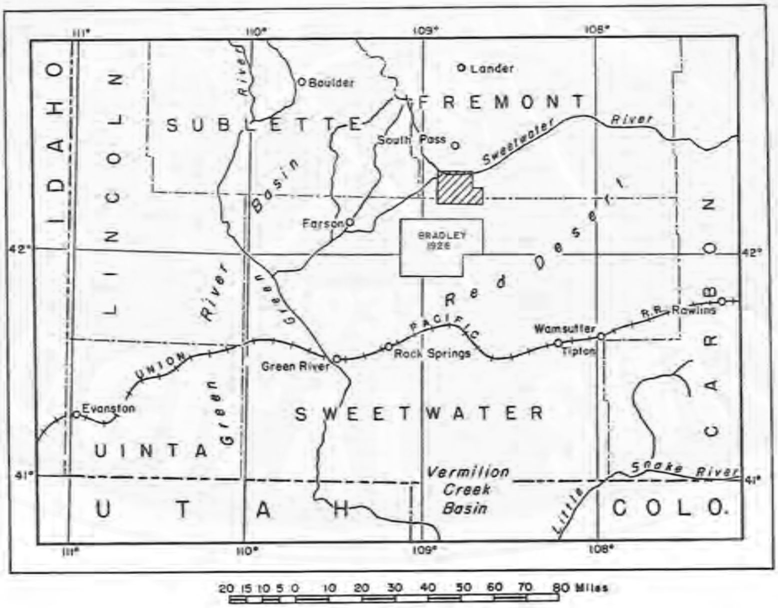

Fig. 1. Index map of southwest Wyoming

Rs. 99-101 W., in north-central Sweetwater and southwest Fremont counties. The mapped area centers around Oregon Buttes with its north boundary near the course of the Sweetwater River, about 7 miles south of the southeast termination of the Wind River Mountains (Fig. 1).

Purpose of the Survey

The geologic investigations upon which this report is based were undertaken for the Geological Survey of Wyoming with the purpose of obtaining data which would clarify the stratigraphic and structural relations of the Tertiary formations in the Red Desert region near the Wind River Mountains, where they have been little studied. The stratigraphy of the region was studied, detailed lithologic sections were prepared, a reconnaissance geologic map of part of the desert was made, and a small collection of fossils was obtained.

The text material is primarily concerned with the mapped area, but regional stratigraphy and correlations of southwest Wyoming are discussed insofar as they relate to formations exposed in the area of the map (Pl. 1).

Field Work

Field work was done during August and September, 1935. The location of points incident to mapping was determined by triangulation with a Brunton compass from known points, or by pace traverse on compass bearing from known points. Points on the map were checked with section corners wherever these could be found. T. 26 N., R. 101 W. was surveyed by the U. S. General Land Office in 1931. Corners established by this survey were marked with iron pipes and brass plates. According to the settings of these markers, T. 26 N. is offset about 30 feet eastward on T. 27 N. During the years 1882-1883 Tps. 25-28 N., Rs. 99-100 W. were surveyed. Markers of native stone were used. In many places the inscriptions on these have been obliterated by weathering. Thus it was not always possible to check points on the map against unmistakably identifiable corner markers.

Acknowledgments

The writer wishes to express appreciation to Dr. L. S. Russell, of the Geological Survey of Canada, for his identifications and analysis of invertebrate fossils collected in the desert. A single mammal tooth was identified by Dr. G. G. Simpson at the American Museum of Natural History. Thin sections of rock specimens and fossil algae were prepared by Dr. J. D. Love. Mr. Darby Hand and Mr. Jack Isberg rendered periods of valuable assistance in the field. Professor R. H. Beckwith and Dr. H. D. Thomas, of the University of Wyoming, have contributed valuable suggestions in the preparation of the manuscript. Professor Beckwith also contributed petrographic analyses of rock samples. To Professor S. H. Knight, Chairman of the Department of Geology at the University of Wyoming and Director of the Geological Survey of Wyoming, the writer is indebted for the opportunity to do the field work.

Earlier Geologic Investigations

The region in which the writer's area is situated was briefly described in general terms by Endlich (9, pp. 43-44, 110-114, 128-154) and Peale (22, pp. 524-526). Schultz (28, pp. 28, 31) and Bradley (4, pp. 123, 125) have briefly referred to the area. Generalized remarks on the geomorphology of the region have been made by Westgate and Branson (35, pp. 147-153). Hares and Cook (10, p. 78) have noted evidences of earth movements along the northwest margin of the Red Desert.

Geologic reports on the igneous and metamorphic rocks of the Atlantic City-South Pass gold mining district, a few miles north of the area, have been published by various authors (Knight, 17; Beeler, 2; Runner, 25; Spencer, 34). The Great Divide Basin, in the southeast part of the Red Desert, has been described by Smith (33).

Detailed descriptions or accurate geologic maps of the area have not been previously published. The 1925 edition of the U. S. Geological Survey Map of Wyoming shows the geology of the writer's mapped area essentially as described in the early reconnaissance reports of the Territorial surveys. The Federal map is at wide variance with subsequently acquired data and shows none of the structural features of the region. The north boundary of Bradley's map (4, p. 58) of northern Sweetwater County is 3¾ miles south of the south boundary of the writer's map (Fig. 1).

Geography

Surface Features

North of the Continental fault (Pl. 1) the surface of the area is chiefly well rounded hills and ridges, and rolling uplands, with a maximum relief of about 1,600 feet. The narrow, slightly incised[1], meandering course of the Sweetwater River, near the north boundary of the area, is characterized by graded reaches which locally give it the appearance of early maturity. South of the Continental fault the drainage area of Orégon Gulch Creek is topographically similar to the north area.

A conspicuous fault-block ridge of Eocene sediments trends east and somewhat south through the mapped area from the NW cor. sec. 18, T. 27 N., R. 101 W. through sec. 20, T. 27 N., R. 100 W., where it is terminated by Oregon Gulch. In the middle of sec. 15, T. 27 N., R. 100 W., the ridge is bisected by a fault-line stream valley. The steep north face of the Eocene ridge appears to be a true fault scarp in an advanced stage of dissection. The scarp is on the upthrown block, which is composed of less resistant sediments than those on the downthrown block. The backslope of the ridge is

[1]The term, incised meander, is here used in accordance with the conventions proposed by J. L. Rich (24, p. 470) to apply to stream valley meanders whose nature, whether intrenched or ingrown, has not been determined.

gentle, with average slopes of from 5 to 10 degrees. East of Oregon Gulch, where the continental fault is strongly flexed and complicated by minor oblique tear faults, the scarp is conspicuous only locally. In secs. 22-24, T. 27 N., R. 100 W., differential erosion has reduced the upthrown block and produced an incipient obsequent fault-line scarp. In the adjacent sec. 19, T. 27 N., R. 99 W., the fault-line scarp is rather conspicuous.

Faulted Oligocene sediments from broken uplands and sharp ridges in a narrow belt north of the Continental fault through secs. 22-24, T. 27 N., R. 100 W., and sec. 19, T. 27 N., R. 99 W.

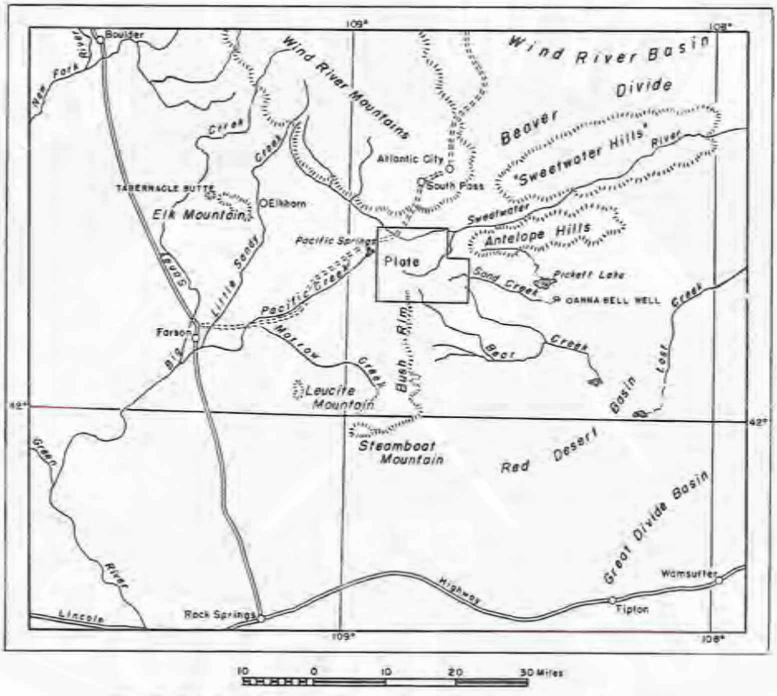

Fig. 2. Detailed index map of region adjacent to mapped area.

Continental Peak, variously known as "Emigrant Peak," "Centennial Peak" and "Yellow Butte," is a conspicuous landmark south of the east end of the mapped part of the Continental fault. The summit of the peak, near the center of sec. 35, T. 27 N., R. 100 W., is represented on the Hayden Survey topographic map with an elevation of 8,456 feet. The elevation of the base of the peak is about 7,000 feet at the lowest places. Long elevated tongues of horizontal sediments extend south and east from the peak, whose west base merges with the lowlands south of the Continental Divide scarp. Some distance east and southeast of the peak are badlands, locally known as "The Honeycombs."

Oregon Buttes ("Table Hills") occupy an area of about 4 square miles in the north-central part of T. 26 N., R. 101 W. The highest elevation is over 8,600 feet, on the north butte. Southward from the buttes a long narrow bridge of essentially horizontal strata, known as Bush Rim, extends to Steamboat Mountain, near the center of T. 23 N., R. 102 W., beyond the limits of the mapped area (Fig. 2). The east edge of the rim is a drainage divide which separates the interior drainage of the Red Desert on the east from the Pacific drainage on the west.

A southward-facing, irregular scarp, 150 to 300 feet high, which extends eastward from North Oregon Butte to Continental Peak, marks the north limit of the Red Desert in this area.

The central portion of the Red Desert is a basin of interior drainage. The Continental Divide branches to enclose the basin. The west branch of the divide passes over Oregon Buttes and southward along Bush Rim. The east branch extends eastward along the crest of the scarp mentioned above and passes out of the area northeast of Continental Peak.

DRAINAGE AND WATER SUPPLY

The north part of the area is drained eastward by the Sweetwater River. The central part of the area, north and east of the Continental Divide, is drained into the Sweetwater through Oregon Gulch and its tributaries. The west part of the area is drained westward by tributaries of Pacific Creek and Rock Cabin Creek. From between the branches of the Continental Divide, stream courses drain south and east into the interior of the desert, where they disappear.

The Sweetwater River is the only permanent stream in the area. Oregon Gulch is intermittent. Fresh water is available the year round from springs shown on the geologic map (Pl. 1) in the SE¼SE¼ sec. 15, and SE¼SE¼ sec. 35, T. 27 N., R. 101 W. West of the mapped area, in secs. 1 and 2, T. 27 N., R. 102 W., waters from the group of springs called Pacific Springs (Fig. 2) coalesce and constitute the headwaters of Pacific Creek.

CLIMATE AND VEGETATION

The climate of the area is semi-arid. Vegetation is chiefly sagebrush and prairie grasses. Cottonwoods, willows and aspens are restricted to minor areas along the Sweetwater River, a few sheltered hillsides, and near water seeps. Sparse growths of cottonwood and pine are present on the north and west slopes and top of north Oregon Butte.

CULTURE

A poorly graded dirt road from Farson to South Pass and Lander extends through the northwest corner of the area mapped. It is the only improved road in the region. The mapped area is traversed by numerous sheep wagon trails, of which those passable by automobile are shown on the geologic map. The unimproved road which extends northeast across the north part of the area was formerly the Oregon Trail of pioneer emigrants.

There are no towns within the area. Sheepherders' camps may usually be found at principal springs in the summer. The Blair and Hay ranch houses are occupied intermittently during the summer but are closed in winter.

Present productive occupations in the area are sheep and cattle grazing and wild horse trapping. Considerable placer gold prospecting has been carried on in various stream gravels, but results have not been of commercial magnitude.

STRATIGRAPHY

PRE-TERTIARY ROCKS

Inliers of pre-Cambrian igneous and metamorphic rocks, projecting through Tertiary cover near the Sweetwater River, are the only pre-Tertiary rocks exposed within the mapped area. In the stratigraphic classification here employed, therefore, rocks are classified as Tertiary and pre-Tertiary. Several types of igneous and metamorphic rocks comprise the pre-Tertiaries, but on the map the several types are not distinguished.

A typical exposure of the pre-Cambrian rocks is on the north bank of the Sweetwater River at the crossing of the Farson-South Pass road in sec. 28, T. 28 N., R. 101 W. The exposure (Fig. 3) consists of a narrow roof pendant of black and greenish-brown micaceous schist and gray granitoid injection gneiss, cut by younger dikes of pink quartz-microcline granite and pegmatite. The dikes are from 1 to 6 feet thick. The dikes and the foliation of the schists have an average strike of N. 60° W., and an average dip of 32° northward. This exposure extends from the vicinity of the bridge northwest along the sides of the river channel beyond the limits of the geologic map.

The 1925 edition of the U. S. Geological Survey Geologic Map of Wyoming represents the boundary of the main mass of the pre-Cambrian rocks of the Wind River Mountains extending southward two miles into T. 27 N., R. 101 W., and slightly more than a mile in T. 27 N., R. 100 W. The writer found only one small inlier of pre-Cambrian rock in T. 27 N., as shown on the Geologic map (Pl. 1), on the north boundary of sec. 4, T. 27 N., R. 100 W. Except for this small isolated mass the igneous and metamorphic rock outcrops are confined to the region farther north and west, near the Sweetwater River, where there are five small inliers of pre-Cambrian rock projecting from 2 to 30 feet above the level of surrounding Tertiary sediments. These outcrops are of comparatively small area and are surrounded by Tertiary cover. The southern limit of the principal outcrops of the pre-Cambrian core of the Wind River Mountains is actually from 5 to 7 miles farther north than is shown on the Federal survey map.

The tertiary cover between the pre-Cambrian inliers is of irregular thickness and is little more than a residual mantle in some places. Its mere presence is nevertheless of geomorphic importance.

GENERAL SECTION OF FORMATIONS EXPOSED IN NORTHWEST PART OF RED DESERT

Age	Formation	Member	Characteristics	Thickness (feet)
Recent		Alluvium	Silt, clay, loam, sand and gravel, all locally derived and locally variable.	Variable
Pleistocene (?)		Till (?)	Gravel, boulders and erratics, irregularly distributed as local residual veneer.	Variable
Oligocene	Chadron	"Upper" Chadron	Gray, grayish-buff, thick-bedded nodular well consolidated tuffaceous sandstone. Thin lenses of very pure white volcanic ash. Few thin beds of fresh-water limestone. Conglomeratic in lower part.	450?
		Beaver Divide Conglomorate	Gray to nearly black cross-bedded boulder and pebble conglomerate in matrix of coarse tuffaceous calcareous sandstone.	68±
	Disconformity			
Upper (?) Eocene	Continental Peak		Reddish-brown, gray and green fine- to medium-grained thin- to thick-bedded and massive, blocky and cross-bedded tuff and tuffaceous sandstone.	145-250
	Disconformity			
Middle Eocene	Bridger	"Upper" Bridger	Brown, gray and greenish thin- to thick-bedded and cross-bedded sandstone, and shale; calcareous at some horizons. Some thin beds of brown limestone. Thin beds of clay-pellet conglomerate and conglomeratic sandstone in lower part.	215-270
		Disconformity		
		"Lower" Bridger	Gray and brown thin- to thick-bedded sandstone; gray, brown and green mudstone, silt, clay and shale. Few thin beds of brown hard, brittle limestone.	455-495
	Intertongued Green River and "Wasatch"	Morrow Creek tongue	Buff shaly marl, green to brown clay and calcareous clay. Few thin beds of hard, brittle brown limestone.	20-32
		Cathedral Bluffs tongue	Varicolored gray, green, brown, tan, red and maroon clay, mudstone and arkosic grit. Thin lenticular beds of pebble conglomerate.	250±
		Tipton tongue	Yellow, brown and gray thin- to thick-bedded cross-bedded sandstone. Concretions abundant, especially in lower part.	167±
		Hiawatha beds	Varicolored red, gray, green, brown tan and maroon clay, mudstone and arkosic grit. Thin lenticular beds of pebble conglomerate.	?
Angular unconformity				
Pre-Cambrian			Metadiabase schist, injection gneiss, quartz-feldspar granite and pegmatite.	

Fig. 3. P

The olc
Hiawatha ı
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mapped are
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confused w
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(Paleocene
Divide Basi

formation now available is not adequate for such a revision,
prove advisable to revive and re-define King's name (16
356, 360-377), Vermilion Creek formation. The name, ı
doned as a supposed synonym of "Wasatch," was originally
typical beds in the Vermilion Creek Basin.

It is certain that designation of the Haiwatha beds and
Bluffs tongue as parts of the "Wasatch" is confusing a
graphically meaningless. No part of the Hiawatha-Cathed
sequence has ever been correlated with the type Wasatch on
other than inference. The writer's evidence shows that a
upper part of the Hiawatha beds is of lower Green
(middle (?) Eocene). The upper type Wasatch (Knight
may also be of lower Green River age, but that is also pure
The Cathedral Bluffs tongue, also partly of Green River
fossils of lower Bridger age.

Variable areal extent of the Green River members re
tuations in the expanse of the Eocene Green River lake.
Hiawatha and the Cathedral Bluffs beds are periphera
deposits whose area of deposition closed in on or recede
center of the lake basin as the lake shrank or expan
Cathedral Bluffs tongue represents a period of maxim
age of the lake and encroachment of the fluvial deposits.
mapped by the writer includes a part of what was the ma
lake during Tipton and Morrow Creek times.

The Bridger formation, originally named by Hayden (
from exposures in the southern part of the Green River
since been described by many authors. It includes both
lacustrine sediments and overlies the Green River formatio
out large areas in southwest Wyoming. Conventionally t
has been considered distinct in age from the Green R
writer believes that the lower part of the type Bridger i
Green River age and that in the centers of the sites of G
deposition, where the Green River reaches its maximum d
it is overlain by middle, not lower, Bridger.

The Bridger is stratigraphically succeeded by the Ui
tion in the Uinta Basin of Utah. The exact time interval
ed by the Uinta is not clear, although it is known to rep
or all of the upper Eocene. Occurrences of beds of Ui
Wyoming are sporadic. Certain beds in the Beaver Div
at the south and east edges of the Wind River Basin,
called Uinta. Tuffaceous beds in the Red Desert, to which
applies the name, Continental Peak formation, may be of

The Chadron member of the White River group (
typically developed in the Great Plains region, is believed
ent along the north edge of the Red Desert. A basal co
phase of the Chadron is here called the Beaver Divide c
member.

No post-Oligocene Tertiary beds are present in the mapped area or in the Red Desert. Thin remnants of tuffaceous conglomerate north of the north boundary of the area mapped have been reported by Bradley (7, p. 185) to bear a close petrographic resemblance to the Brown's Park formation (upper Miocene (?) in the Uinta Mountains. These beds were not mapped by the writer or studied in detail; it is certain, however, that they are distinct from, and young than, the Chadron formation.

EOCENE FORMATIONS

Hiawatha Beds

Beds assigned to the Hiawatha crop out in the mapped area in a small isolated patch in the SE¼SE¼ sec. 21, T. 27 N., R. 101 W. A measured section of the exposed part of these beds is represented in Section 1 of the tables of measured sections.

The lithology at the locality where the section in Table 1 was measured is essentially similar to that of the formation in the type locality in the Vermilion Creek Basin. Both the Cathedral Bluffs and Hiawatha consist essentially of varicolored clays, sandstones, arkosic grits and mudstones, conglomeratic sandstones, and pebble conglomerates. The chief difference from the type outcrops of the Hiawatha in the writer's measured section is the predominance of coarse clastics over clay and mudstone.

No Hiawatha outcrops other than that at which the above section was measured were identified in the writer's area. Hiawatha beds possibly are present in a narrow strip along the scarp of the Continental fault east of Oregon Gulch Creek. Rocks along the fault scarp are badly obscured by talus, residual mantle and drag-blocks of Oligocene strata. Moreover the upper Hiawatha beds can be distinguished from the lithologically identical Cathedral Bluffs only where the Tipton tongue of the Green River is also exposed. In the central and western parts of the Red Desert, and along the west flank of the Wind River Mountains there are exposures of beds, which, on the basis of lithology, cannot be distinguished as either Hiawatha or Cathedral Bluffs. The stratigraphy is further complicated by the fact that the Tipton itself is sandstone in this area, and closely resembles sandstone beds in both the Cathedral Bluffs and Hiawatha.

Tipton Tongue of the Green River Group

The Tipton tongue of the Green River group is represented in a sequence of tan, yellow, brown and gray sandstones exposed along the flanks of the monocline in secs. 19-22, T. 27 N., R. 101 W. A detailed section of these beds is shown in Section 1.

The Tipton tongue at its type locality, south of Tipton station in southwest Sweetwater County, and on the west side of the Rock Springs uplift, has been described by Schultz (28, p. 30) as "fissile shale, conglomerate, oolitic limestone, shale, clay and sandstone." Northward from the Rock Springs uplift, through the area mapped by Bradley (4, pl. 58), coarser clastic material enters into the composition of the Tipton tongue, though there is a persistent basal limestone. Bradley remarked (pp. 123-125):

> Above this remarkably persistent basal limestone there is a noticeable differentiation in the lithology of the Tipton tongue in different parts of the area. Southeast of a diagonal line drawn through secs. 1 and 31, T. 24 N., R. 102 W., the Tipton tongue consists of finely laminated shale, ostracode-bearing limestone, limestone, oolite, and alga reefs but no sandstone. Northwestward from that line sandstone becomes more and more abundant. Near the line the sandstone is usually limy, micaceous, very fine-grained, and in thin relatively persistent beds. Rarely this fine limy sandstone shows cross-bedding on a minute scale.

Although the Tipton tongue is not continuously exposed between Bradley's area and that of the writer, it seems fairly certain that the sandstone sequence in Section 1 belongs to the Tipton. Both the lithology and the stratigraphic position indicate this conclusion. The conspicuously micaceous character of the Tipton sandstones in both areas is especially indicative. If the identification is correct, the northward increase of sandiness, noted by Bradley, is complete in the writer's area, and the tongue is exclusively sandstone and pebble conglomerate. The absence of shale and limestone results from northward gradation of the more typical lacustrine limestone and shale in shoreline delta and channel sandstones along and near the former margin of the Tipton lake.

The average thickness of the Tipton tongue in the measured sections given by Bradley (4, pp. 129-130) is about 120 feet, with a minimum of 100 and a maximum of 179 feet. The thickness in the writer's area is 167 feet.

The only species of fossil found in the Tipton tongue of this area is the gastropod, *Viviparus paludinaeiformis* (?) (Hall), of which internal molds occur in great numbers in beds No. 13 and 14 (Section 1).

Cathedral Bluffs Tongue

The Cathedral Bluffs tongue is extensively exposed in the mapped area south of the Continental fault. Complete sections of the tongue could not be measured since the top and the base of the formation are both exposed in only one locality. In the southern parts of secs. 20 and 21, T. 27 N., R. 101 W. the basal Cathedral Bluffs beds appear at the surface in the southwest limb of a monocline (Pl. 1). In the north part of sec. 28 higher beds of the tongue are exposed in the lower part of a high bluff. The inclination of the beds carries them underground well north of this bluff, at angles over 25°. Beds in the bluff itself are horizontal, but there are no intervening exposures of measurable dips. Hence a complete section could not be accurately measured there. The lower beds differ in no important respect from higher beds in the tongue shown in sections measured at Oregon Buttes and Continental Peak (Sections 2 and 3). It was estimated in the field that in secs. 21 and 28, T. 27 N., R. 101 W., the thickness is not less than 250 feet, and is probably greater. Bradley (4, p. 125) said that south of this region, near the head of Alkali Brook, the tongue is about 200 feet thick, while farther south, at Steamboat Mountain, it is only about 100 feet thick. In some localities to the south and southwest the tongue thins and disappears altogether.

The Cathedral Bluffs tongue is composed of varicolored red, brownish-red, yellow, tan, olive drab, gray and light green beds of clay, mudstone, shale, arkosic grit, conglomeratic sandstone and pebble conglomerate. Most beds of conglomeratic sandstone and conglomerate are grayish or reddish-brown in color, one-half to 2 or 3 feet thick, and are usually lenticular. Greenish clays and mudstones are best developed at and near the top of the tongue. These commonly contain fragments of quartz and feldspar as much as 3-tenths of an inch in diameter. Many such beds contain an abundance of selenite and powdery, efflorescent calcite. The latter appears to have been concentrated at the land surface by upward capillary circulation and evaporation of water. In places the resulting soil mantle is loose and fluffy to a depth of 4 inches.

South and southwest of Continental Peak, outside the limits of the mapped area, the Cathedral Bluffs beds are eroded into typical badlands, locally known as the "Honeycombs." East of the area the north boundary of the beds extends from between Sand Creek and the Antelope Hills (Fig. 2) southeastward south of Picket Lake into the north part of the Red Desert Basin. From there they can be traced to their type locality, south of the Lincoln highway near Wamsutter. From the west boundary of the mapped area the Cathedral Bluffs beds were traced northwestward to the southwest flank of the Wind River Mountains in the neighborhood of the headwaters of Big and Little Sandy creeks and the west fork of the Sweetwater River. The beds there occupy a wide intermontane basin, 15 or 20 square miles in area, where they are shown on the U. S. Geological Survey Map of Wyoming as Wasatch. These so-called Wasatch beds are light-colored clays, sands, grits and boulder conglomerates which rest directly on the uneven surface of the pre-Cambrian rocks. Southwestward from the flank of the mountains, within a distance of about 6 miles, they grade laterally into finer sediments of typical Cathedral Bluffs type. At the crossing of the Elkhorn-Boulder road over Big Sandy Creek a thickness of about 100 feet of the beds is exposed in low bluffs along the creek. The exposures are continuous northwestward from there along the flank of the mountains to Boulder, beyond which they were not traced. A short distance south of Boulder, along the New Fork River, they are overlain by the northern extension of the Green River formation.

No diagnostic fossils of any kind were found in the Cathedral Bluffs beds in the area mapped. A few fossil algae, probably referable to *Chlorellopsis coloniata* Reis, are present as noted in bed No. 3, Section 3. About 6 miles east of the area, in the northwest part of T. 26 N., R. 98 W., 75 feet below the top of the Cathedral Bluffs, the incomplete crown of a single mammalian molar tooth was found. The tooth was referred by Dr. Simpson to *Trogosus* or *Tillotherium*, "probably the latter."

Morrow Creek Tongue of the Green River Group

The Morrow Creek member of the Green River group is represented by twenty to thirty-two feet of beds in the area mapped. The only readily identifiable exposures enclose the bases of Oregon Buttes and Continental Peak on their east, south and west sides. Questionably identifiable beds are present near the base of the scarp between the peak and the buttes. The Morrow Creek beds are here described as a tongue, and on the geologic map (Pl. 1) are included in the base of the "lower" Bridger.

Schultz (28, p. 24) stated that the Green River formation is traceable across the north end of the Rock Springs uplift into the Red Desert to a point about 20 miles southeast of the Antelope Hills. In this report, however, Schultz included the Cathedral Bluffs tongue in the Green River formation. Hence it is not certain that he actually traced true Green River beds, as now defined, to the locality mentioned.

The following passage from Bradley (4, p. 125) is worthy of note:

> The Laney shale member of the Green River formation thins northward from about 200 feet in sec. 31, T. 24 N., R. 104 W., to less than 50 feet, and finally by the introduction of more and more thin fingers of green clay it loses its lithologic identity and passes over in sec. 3, T. 25 N. R. 102 W., into the typical fluviatile deposits of the Cathedral Bluffs tongue of the Wasatch formation. Throughout the remainder of the area the Morrow Creek member of the Green River formation, which itself becomes sandy and thins northward from more than 300 feet to about 100 feet in Oregon Buttes, in sec. 12, T. 26 N., R. 101 W., rests directly upon the Cathedral Bluffs tongue.

The present writer independently mapped the lower boundary of the Morrow Creek member as the base of the Bridger through the middle of sec. 12, T. 26 N., R. 101 W. The contact of the base of this unit with the Cathedral Bluffs beds is easily identified, but the thickness of the Morrow Creek facies was found to be considerably less than that indicated in Bradley's statement.

The detailed section (Section 2) of sediments on the east flank of north Oregon Buttes shows about 20 feet of beds (No.'s 4 to 7) definitely of Morrow Creek type. A band of lacustrine shaly marl in this Morrow Creek facies is prominent in many parts of the area. The nature of subjacent and superjacent beds, as well as the thickness of the marl itself, is variable from place to place, as shown by comparison of equivalent beds in Sections 2 and 3. South and southeast of Continental Peak, where the marl is thickest, it is readily identifiable. The same is true south of Oregon Buttes and in a small outlier mapped as "lower" Bridger in the NW cor. sec. 31, T. 27 N., R. 101 W. Along the scarp between Oregon Buttes and Continental Peak, however, and in the bluffs in sec. 28, T. 27 N., R. 101 W., the Morrow Creek beds could not be identified with certainty. It was therefore considered impractical to attempt to distinguish it as a separate unit on a reconnaissance geologic map. In this report the beds are called a tongue because they are considerably thinner than in the regions south of the area mapped, and because they probably disappear completely farther north, leaving the Bridger resting directly on the Cathedral Bluffs (Fig. 5).

Fossils other than the alga, *Chlorellopsis coloniata* Reis, were not obtained from the Morrow Creek in this area.

Bridger Formation

For the purpose of this report the Bridger formation is divided into upper and lower parts, but the terms, "lower" and "upper," are not intended to indicate time relation to the typical Bridger formation in the Bridger Basin. They mean merely the lower and upper lithologic divisions of the Bridger formation as it is developed in the mapped area. The two parts are readily distinguishable and were mapped separately. Within the mapped area the upper Bridger has been removed everywhere except at Continental Peak and Oregon Buttes. Bridger beds are present in parts of the Red Desert east of Continental Peak and southwest of the mapped area. None of these exposures was examined in detail but they appear to belong to the "lower" Bridger.

"Lower" Bridger.—From the top of the Morrow Creek facies upward throughout the "lower" Bridger, the lithologic sequence is an alternation of somber-colored sandstones, siltstones, clays, mudstones, shales and limestones. Most of the limestones are finely crystalline, hard, brown or gray in color, and from 2 inches to 1 foot in thickness. Some of them are partly silicified. Many contain innumerable ostracodes. Algal structures also are common at several horizons. Most of the limestone beds are sharply defined, but the contacts of other rock types are gradational in many cases. The majority of the clastic deposits are poorly sorted and not highly lithified. Many are ferruginous. The presence of mica flakes in various sandstone beds indicates short distance of travel from their original source. The lithology of the "lower" Bridger is shown in detail in Sections 2 and 3. At Oregon Buttes it is nearly 500 feet thick; at Continental Peak the thickness is about 455 feet. The difference in thickness of the "lower" Bridger in the two sections is probably due to the disconformity at its top, or to minor disconformities within the unit.

In addition to the invertebrates listed on page 20, ostracodes occur in great abundance in many beds throughout the lower part of the Bridger formation. Algal remains are also numerous at various horizons. Examined in thin section the algae appear to be identical with specimens of *Chlorellopsis coloniata* Reis, described from the Green River formation by Bradley (5). Numerous specimens of gar-pike scales, cf. *Lepidosteus,* and bone fragments of *Crocodilus* sp., chiefly from the appendicular skeleton, were found in an outlier of bed No. 35, Section 2, near the center of sec. 34, T. 27 N., R. 101 W., and in an underlying lenticular bed of bluish-gray arkosic grit. A bed above number 35 in this outlier yielded a badly crushed and distorted but nearly complete turtle carapace.

INVERTEBRATE FOSSILS FROM THE "LOWER" BRIDGER[1]

GASTROPODA

Viviparus paludinaeiformis (?) (Hall).	Oregon Buttes; Section 2, bed No. 35. Continental Peak; Section 3, Bed No.'s 40, 42.
Viviparus wyomingensis (?) (Meek)...	Continental Peak; Section 3, bed No. 40.
Physa bridgerensis (?) (Meek).......	
Goniobasis tenera (Hall)............	
Planorbis spectabilis Meek............	
Vertigo arenula (White)............	
Gonyodiscus (?) sp..................	
Pupillid, undet......................	Continental Peak; Section 3, bed No. 42.
Viviparid or land snail, undet.........	Oregon Buttes; Section 2, bed No. 35.

PELECYPODA

Elliptio haydeni (Meek).............	Oregon Butte; Section 2, bed No. 35. Also in outlier of same bed near center of sec. 34, T. 27 N., R. 101 W.
Lampsilis (?) sp.	

Several horizons in the "lower" Bridger yielded plant remains, but almost all of them are too fragmentary and fragile to be collected. A single specimen of *Equisetum* (?) was obtained. Petrified wood is abundant in several localities in the middle and upper portion of the "lower" Bridger, as in Section 2, bed No.'s 23 and 42, and Section 3, bed No. 29. Along the north boundary of sec. 34, T. 27 N., R. 101 W., in the upper part of the "lower" Bridger, there are many fragments of petrified wood scattered on the ground surface, and several petrified tree-trunks are still standing, thickly encrusted with algal deposits. At a somewhat lower level, in the southwest corner of sec. 34, within a few feet of the corner marker, there is an incomplete petrified tree, lying prone on the ground surface, with a measured length of over 60 feet. One-half mile northeast of this cornerstone is another petrified fallen tree 50 feet long.

[1]All invertebrate fossils in the list, except **Physa bridgerensis**, were identified by Dr. L. S. Russell.

"Upper" Bridger.—The "upper" Bridger consists predominantly of sandstone and shale. Some of the sandstones are calcareous and there are a few thin beds of limestone. Cross-bedding is common in the sandstones. The base of the "upper" Bridger is marked by the presence of clay pellets which occur in limestones, cross-bedded sandstones and conglomeratic sandstones. The clay pellets in the "upper" Bridger are megascopically identical with clays and mudstones in the subjacent upper part of the "lower" Bridger, from which they were obviously derived. Most of the clay pellets are less than one-half inch wide. Associated fragments of quartz and feldspar are uniformly smaller. The base of the "upper" Bridger is less clearly defined at Continental Peak than at Oregon Buttes. At Continental Peak the clay-pellet conglomerates, if present, are so badly obscured by talus and small land-slips that they were not found.

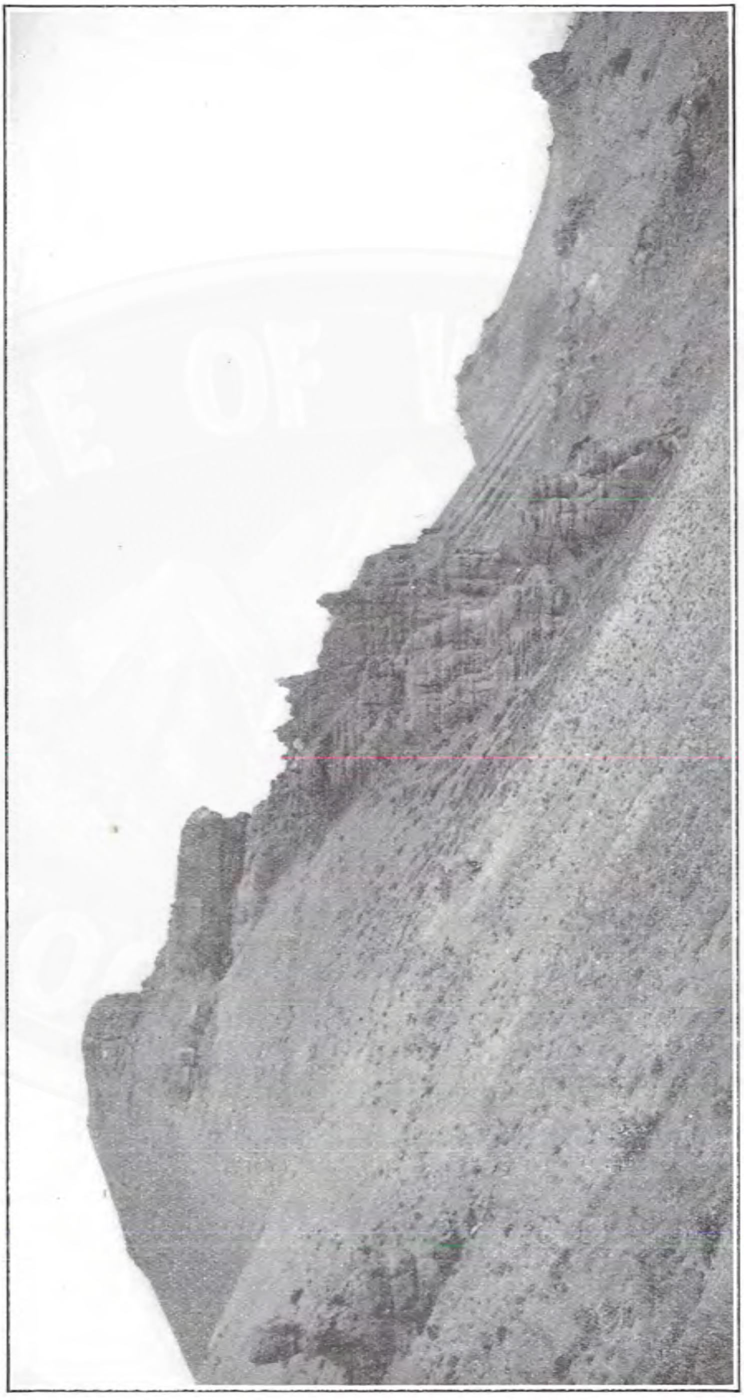
A convenient reference horizon for the determination of the base of the "upper" Bridger is bed No. 35, Oregon Butte section (Section 2), which is the same as bed No. 40, Continental Peak section (Section 3), in the "lower" Bridger. This thin, highly fossiliferous horizon in the "lower" Bridger is somewhat variable in stratigraphic distance from the top, due to the disconformity above, but it is usually within 80 or 90 feet of the top. The magnitude of the disconformity was not determined. Regional study, which would be necessary properly to evaluate it, was not possible because of limited exposures.

The "upper" Bridger beds of the area mapped have yielded the single fossil gastropod *Goniobasis tenera* (Hall), from beds No. 39, 42 and 48, Section 2. Abundant scales, teeth and spines of fish occur in the lower part of the "upper" Bridger at Continental Peak. Near the middle of the unit there are also incomplete specimens of small fossil fish in beds of calcareous shaly mudstone. Seventy-five feet above the base of the "upper" Bridger a badly weathered unidentifiable mammal vertebra was found.

Concerning the assemblage of fossil molluscs from the Bridger formation as a whole, Dr. Russell said (personal communication) that "The collection as a whole is predominantly aquatic in environment. Only the three species designated respectively, *Gonyodiscus?* sp., *Vertigo arenula*, and *Pupillid* undetermined, are certainly terrestrial".

Continental Peak Formation

At Oregon Buttes and Continental Peak the "upper" Bridger is disconformably overlain by a sequence of reddish-brown, gray and green sandstone, ash and ashy sandstone beds. These range from very fine- to medium-grained in texture; a few of the beds are thin-bedded; others are thick-bedded and blocky; some of the thicker sequences show typical stream-channel cross-lamination. The thickest succession of these beds is at Continental Peak, where the section represented in Section 4 was measured.



Type section of Continental Peak formation. Near center of sec. 35, T. 27 N., R. 100 W., Fremont County, Wyoming

The name, Continental Peak formation, is hereby proposed for these beds. The type section (Section 4) is 250 feet thick and was measured on the west side of Continental Peak near the center of sec. 35, T. 27 N., R. 101 W., Fremont County, Wyoming. A photograph of the type section is shown in Plate 2. A section of the Continental Peak formation, less complete than the type section, was measured on the east side of north Oregon Butte, as shown in Section 5.

Samples of representative ash and ashy beds from the Continental Peak formation were prepared for petrographic study in the following manner: Specimens were crushed in a porcelain mortar and passed through a set of screens. The fragments which passed through the screen of 100 meshes to the inch but remained in the 150-mesh screen were retained and treated with hydrochloric acid. The material was allowed to remain in the acid until heating and addition of fresh acid no longer produced effervescence. The samples were then washed, filtered and dried. After drying they were again shaken in the 150-mesh screen to remove smaller fragments released by the chemical treatment. The fragments were then examined under a petrographic microscope. The following petrographic descriptions of samples were made by Prof. R. H. Beckwith.

SAMPLES FROM THE TYPE SECTION

Bed No. 1.

Volcanic ash of intermediate composition. Fragments. Consists predominantly of glass, with hornblende, biotite and a soda-lime feldspar present in abundance. Glass fragments are partly devitrified. Small quantities of carbonate cementing material are present. Uniformly pale green in color.

Bed No. 3 (from a greenish-buff argillaceous layer).

Volcanic ash. Fragments. Most of the material is an isotropic volcanic glass. Disseminated through the glass are fine crystals of some mineral showing first order gray and yellow interference colors. This mineral was probably formed by devitrifaction of the glass. Refractive index of the glass is between 1.510 and 1.515.

Bed No. 4 (lower part).

Dacitic volcanic ash. Fragments. Most of the material is an isotropic volcanic glass. Disseminated through the glass are fine crystals of some mineral showing first order gray and yellow interference colors. This mineral was probably formed by devitrifaction of the glass. Refractive index of the glass is between 1.510 and 1.515. There are also a few fragments of quartz and green biotite, green hornblende and oligoclase. Some fragments of glass contain needles of green hornblende and laths of feldspar, indicating a porphyritic structure.

Bed No. 4 (upper part).

Volcanic ash. Fragments. Some of the material is isotropic, indicating that the original material was a glass. Most of the material now consists of a finely disseminated mineral probably resulting from the devitrifaction of the glass, which shows first order gray and yellow interference colors. Refractive index of the glass is between 1.515 and 1.525.

Bed No. 6 (lower part).

Volcanic ash of intermediate composition. Fragments. Consists predominantly of glass fragments, with an abundance of hornblende, biotite and a soda-lime feldspar present. Feldspars are extraordinarily fresh; the hornblende is partly chloritized. Principle cementing material present is a carbonate, probably calcite.

Bed No. 6 (19 feet above base; from a zone in which occur irregularly distributed spherical masses 1-3 inches in diameter, of soft, crumbly, coarse, almost pure, white volcanic ash.).

Volcanic ash. Fragments. Composition similar to that of the enclosing beds. The ash masses contain hexagonal phenocrysts of biotite embedded in the glass fragments. These white ash masses may have a source or transportation history different than the enclosing ash beds, or they may be small volcanic lapilli.

Bed No. 6 (upper part).

Essentially volcanic ash. Fragments. Composition essentially the same as that of the lower ashes, but a few rounded quartz grains are present. The quartz grains may have come from a different source than the main mass of the ash.

Sample from Continental Peak formation northeast of Pickett Lake.

Dacitic volcanic ash, with ostracodes. Thin section. This section consists predominantly of isotropic glass, which is partly devitrified. Some extensive areas have been completely replaced by carbonate material. The glassy material shows, in ordinary light, an excellent shard structure. The glass contains broken fragments of quartz, green and brown hornblende, and oligoclase.

The measured section and the petrographic data compiled by Professor Beckwith indicate that the major part of the materials which comprise the Continental Peak formation are of volcanic origin. Much of the ash has been worked over by wind and streams, with the addition of varying amounts of ordinary clastic material derived from older rocks to the north. The formation is even more ashy in composition to the east and southeast near Pickett Lake and Lost Creek. Possible sources of the ash in the Continental Peak formation are indicated in the following statement by Professor Beckwith:

> The volcanic ash must have been transported a long distance. The nearest known area of volcanic flows is approximately 25 miles to the south in the Leucite Hills on the north flank of the Rock Springs dome. It is very improbable that the ash came from that locality, inasmuch as the volcanic rocks of the Leucite Hills are low in silica and high in potash, and the predominant minerals present are phlogopite, leucite and sanidine. The feldspars of the Continental Peak formation belong to the soda-lime series and are characteristic of dacites and andesites. The nearest known dacites and andesites form the volcanic plugs of the Rattlesnake Hills nearly 100 miles to the northeast. Other more distant possible sources are to the south in Colorado and to the north in the Yellowstone Park region.

Within the area mapped the only extensive exposures of the Continental Peak formation are those which encircle Continental Peak and Oregon Buttes. About 1½ miles northeast of the type section three small slice-blocks of the formation are present along the Continental fault. Northeastward from the Continental fault the formation apparently thins and disappears underground against the flank of the Wind River Mountains, as shown in structure section A-A[1] (Pl. 1). The underground thinning and disappearance of the formation is inferred from the fact that along the Sweetwater River the Chadron formation rests directly on pre-Cambrian rocks.

Northwest of Pacific Springs in Elk Mountain and Tabernacle Butte (Fig. 2) the Continental Peak formation is exposed in faulted outcrops. The lower beds are more coarsely sandy than any beds in the type section. At Elk Mountain the lower beds are dark-green to light-brown and gray mudstones and coarse poorly sorted sandstone, with some fine re-worked ash in the matrix. Spheroidal epigenetic concretions are abundant. Normal faulting and subsequent landslips along the fault scarp at Elk Mountain have confused the succession of lithologies, which was not studied in detail. The sandstones and mudstones are overlain by about 400 feet of well consolidated thick- to thin-bedded, cross-bedded gray sandy clay, white, gray and tan sandy volcanic ash, and cross-bedded ashy sandstone. About 30 feet of thick-bedded and roughly cross-bedded gray cobble conglomerate caps Elk Mountain. The conglomerate is composed of angular and subangular fragments of quartz, white feldspar, granite, schist and syenite in a matrix of coarse ashy sandstone. Appreciable amounts of carbonate cement are present. Regional dips of from 4 to 5 degrees were measured on the conglomerate.

Exposures of the Continental Peak formation were found in the Red Desert several miles east of Pickett Lake and along the course of Lost Creek. The formation there resembles the ash and ashy sandstones at Elk Mountain. Near Pickett Lake several zones, 2-10 inches thick, are highly silicified.

Fossils are rare in the Continental Peak formation in most localities. The gastropod, *Viviparus wyomingensis Meek* occurs sparingly in the type section, where it was found only in Bed No. 1 (Section 4). The same species is very numerous in the outcrops east of Pickett Lake, but rare in the Lost Creek region. Numerous ostracodes of species distinct from the Bridger and Green River formations types, an unidentified species of alga, and turtle bones occur in several localities.

At Lost Creek there are several beds, 2-4 feet thick, of pebble conglomerate and coarse arkosic conglomeratic sandstone similar in appearance to the conglomerates at Elk Mountain, but finer in texture. Dips of 7-10 degrees were measured at Lost Creek and near Pickett Lake.

Stratigraphic Relations and Correlation of Eocene Formations

The intertonguing relations of the "Wasatch" and Green River formations in Sweetwater County, Wyoming and Moffat County, Colorado, have been discussed in detail by Sears and Bradley (30), and by Bradley (4). A generalization of these relations, modified after Bradley (4, Pl. 59), is represented diagrammatically in Fig. 4.

The age of these "Wasatch" beds has been considered the same as that of the type Wasatch, near Evanston, Wyoming. Nightingale (19, p. 1023), said that the Hiawatha is "of lower Wasatch age," and that the Cathedral Bluffs is "of upper Wasatch age." The type Wasatch has been subdivided (bottom to top) into the Almy, Fowkes and Knight formations. The writer (18, pp. 146-151) has inferred that the Almy and Fowkes are correlative with some part of the Fort Union (Paleocene), chiefly on grounds of stratigraphic position and general probability. Definite paleontologic evidence of their age has not been produced. Their position unconformably below the upper lower Eocene Knight member indicates their age as Paleocene, lower lower Eocene or both. The 4,000-foot thickness of the Haiwatha and its stratigraphic position below the Green River establish a reasonable inference that part or all of the Hiawatha corresponds to part or all of the type Wasatch. So long as the age of the lower Wasatch is undetermined, however, it is meaningless to say that the Hiawatha beds are "of lower Wasatch age." Since "Wasatch" has no definite time meaning the term should be avoided in correlations. Lithologic similarity is not a safe correlation criterion, for sediments of Wasatch type rise and fall across significant time-boundaries.

The Cathedral Bluffs tongue has been said to be "of upper Wasatch age." The upper type Wasatch (Knight member) contains upper lower Eocene index vertebrates. The Cathedral Bluffs tongue, on the other hand, interfingers with the lower Green River, which most authorities consider middle Eocene. In the summer of 1938 the writer found that in some localities in southwest Wyoming the Knight interfingers with the Green River formation. He concluded that either the lower Green River is not middle Eocene, or the upper Knight crosses the boundary between the middle and lower Eocene. Further complications are introduced in the problem by the finding of an incomplete molar tooth of the lower Bridger mammal, *Tillotherium*(?), in the northwest part of the Red Desert in Cathedral Bluffs beds. The tooth was identified by Dr. G. G. Simpson, of the American Museum of Natural History, who made the following statement concerning it (personal communication):

> . . . it is too fragmentary for really exact identification, but it does give a good line on age which may be welcome.
>
> The genus seems to be either *Trogosus* or *Tillotherium*, probably the latter. Except for its slightly larger size and minute details undoubtedly highly variable, it can be matched quite closely by the right M^3 of specimens from the Upper Huerfano and the Lower Bridger. To the best of

> my knowledge, nothing like it has ever been found in the "Wasatch" or Wind River, where the group is represented by the structurally somewhat distinct and invariably much smaller *Esthonyx*.
>
> Without attempting too close a correlation on such fragmentary evidence, I should say that the beds from which this tooth came are with sufficient probability to be considered Middle, and not Lower, Eocene. . . . of course there is an outside chance that a forerunner of *Tillotherium*, never before discovered, appeared in the late Lower Eocene, but it would take very strong evidence to controvert the apparent evidence of this tooth. It indicates Middle Eocene about as strongly as a single broken tooth possibly could.

The horizon from which the tillothere(?) tooth came is about 75 feet below the top of the exposures of the Cathedral Bluffs tongue in the locality where the tooth was found (NW cor. T. 26 N., R. 98 W.).

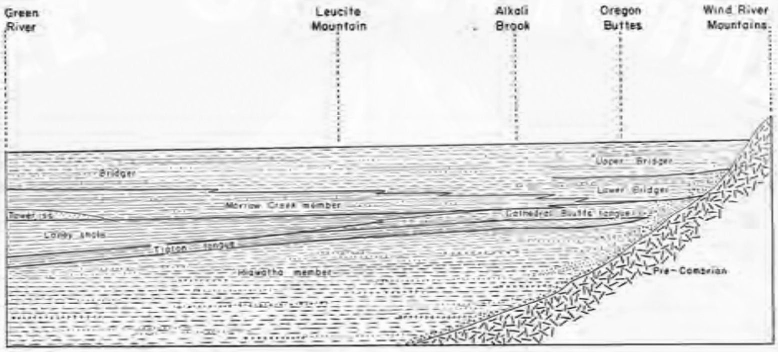


Fig. 5. Physical relations of Eocene formations at the end of Bridger (middle Eocene) time.

It was ascertained in the field that the tooth could not possibly have been derived from the Bridger formation by transportation. If the tooth correctly indicates middle Eocene (lower Bridger) age, the Cathedral Bluffs beds in the writer's area are separated from the type upper Wasatch by a wide time gap. Thus Nightingale's inference that the Cathedral Bluffs beds are "of upper Wasatch age" is not confirmed by the only guide fossil recorded from the Cathedral Bluffs beds.

The least drastic conclusion which can be drawn is that the details of the whole time classification of the Eocene rocks of southwest Wyoming are now in question. It is not necessary to interpose the possibility that the mammal tooth may represent a hitherto undiscovered forerunner of *Tillotherium*. The tooth could well belong to a known type, and occur in beds deposited during the known time range of that type. Detailed sections measured in the area of the writer's map show a strictly conformable sequence in which the base of the Bridger is separated from the top of the Cathedral Bluffs by only 20-32 feet of the Morrow Creek tongue. Northward, where the Morrow Creek tongue pinches out underground, the Bridger is doubtless in conformable contact with the Cathedral Bluffs (Fig. 5). The writer's interpretation of the relations of the Oregon Buttes and Continental

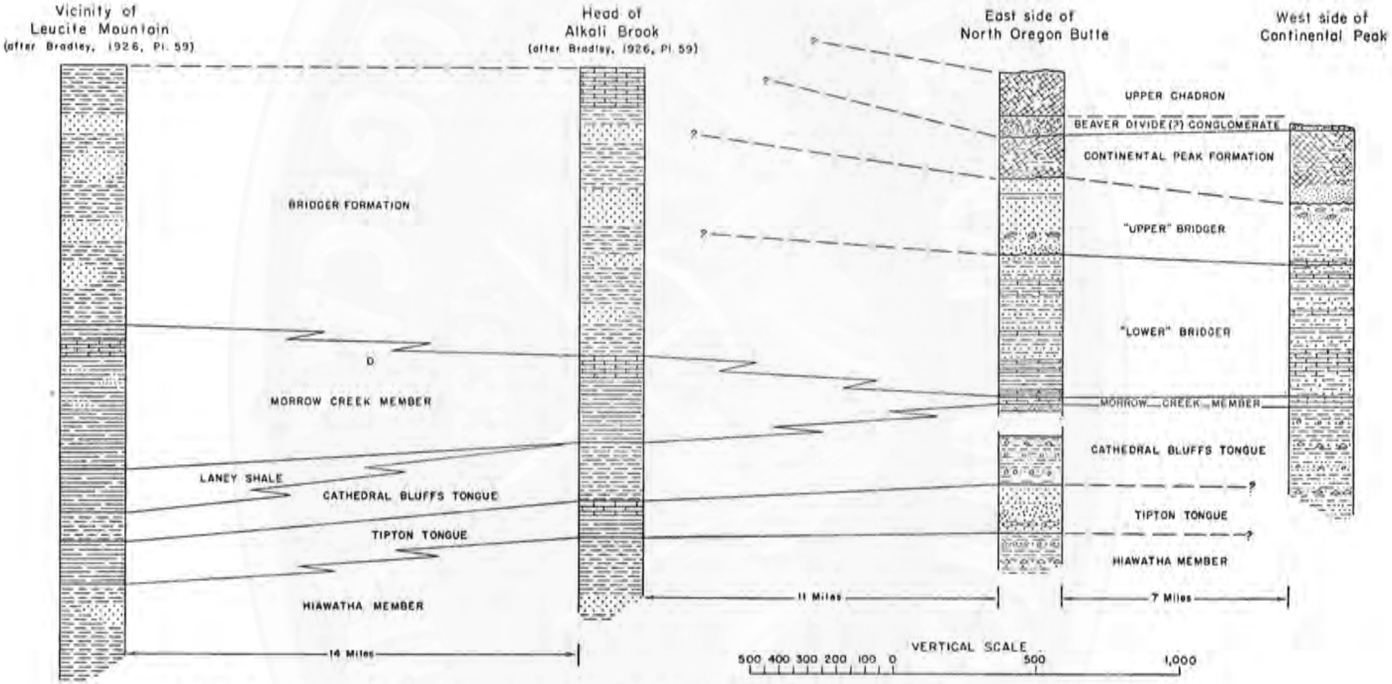


Fig. 6. Correlation of Tertiary sections in north-central Sweetwater County and southwest Fremont County, Wyoming.

Peak sections to Bradley's sections at Alkali Brook and Leucite Mountain is illustrated in Fig. 6. In drafting Fig's. 5 and 6 the center of the Morrow Creek was used as a horizontal datum plane. The relations obtained appear more normal than in Bradley's restoration (Fig. 4), in which the Tipton tongue was used as a datum plane. From the relations showns in Fig's. 5 and 6 the writer deduces the following series of events:

1. The Green River lake began its history on a surface formed by Hiawatha beds whose surface sloped gently southward away from the Wind River Mountains.

2. Early in Green River time the Tipton lake encroached toward the Wind River Mountains reaching almost to their southeast end, between the present course of the Sweetwater River and the surface trace of the Continental fault. As sediments beneath the spreading Tipton lake accumulated, the peripheral subaerial Hiawatha deposits continued to accumulate, but their area of deposition was progressively restricted.

3. Following maximum extension, the Tipton lake shrank, its shoreline retreating southward toward Rock Springs. The surface of the Tipton tongue was thus exposed to streams depositing the encroaching Cathedral Bluffs beds, identical in lithology with the previously accumulated Hiawatha.

4. Maximum shrinkage of the Tipton lake and encroachment of the Cathedral Bluffs beds was followed by a second expansion of the lake, now in the Laney stage. Laney deposits overlapped the Cathedral Bluffs beds, whose area of deposition was becoming restricted.

5. The lake passed from the Laney to the Morrow Creek stage while northward encroachment of lacustrine sediments was still in progress.

6. During middle Morrow Creek time the lake reached a second extreme of northward extension, again reaching nearly to the flank of the Wind River Mountains. Before the Morrow Creek lake reached its maximum expansion northward, *Bridger time had begun.* On the southwest side of the Green River Basin, in the type locality of the Bridger formation, fluvial sediments of Bridger lithology began to accumulate. Meanwhile, *beds of typical Cathedral Bluffs lithology were still being deposited at the southeast end of the Wind River Mountains.* This lithology was entirely an expression of the nature of the source rocks of the sediments, not of the time of deposition.

7. Early in Bridger time beds of typical Bridger lithology began to accumulate at the southeast end of the Wind River Mountains along the margins of the Morrow Creek lake. As their area of deposition increased, the Bridger deposits encroached on the lake, filling its basin from the margin and pushing its shore southward.

8. Eventually the lake basin was entirely filled by its own Morrow Creek sediments and by encroaching Bridger deposits.

9. Following disappearance of the lake, Bridger sediments were spread over the whole area formerly occupied by the Green River lakes. During the spread of Bridger sediments, small local lakes were present from time to time throughout the area; these were either cut-off remnants of the Morrow Creek lake, or local lakes occupying irregularities on the surface of the Bridger formation. Beneath these temporary lakes the remains of ostracodes, algae and fish were entombed as the depressions filled.

If the above interpretation is correct, the Bridger beds which rest on the Morrow Creek formation near the center of the former Green River lake are younger than those which overly the Morrow Creek at the margins of the former basin.

The opinion that the upper Green River formation in Sweetwater County is of lower Bridger age seems not to have been stated by previous authors, although Bradley (6, p. 21), in his study of Green River microfossils and oil shale, found indications of analogous relations in the eastern part of the Uinta Basin, Utah. Concerning the significance of fossils found there in the Bridger Bradley said:

> It is somewhat puzzling that the vertebrate fossils found near the base of the sandstone series indicate middle or late Bridger time. This suggests that, as there appears to have been no significant break in sedimentation between the Green River and Bridger formations, the uppermost portion of the Green River formation is perhaps of Bridger age. In other words, if the boundary between the Green River and Bridger formations were to be determined wholly by the vertebrate fossils it apparently should be placed at some indefinite horizon below the present lithologic boundary. According to this definition of the boundary, lakes seem to have persisted longer in the Uinta Basin than in the Green River Basin of Wyoming, where all of the Bridger epoch is represented by fluviatile deposits.

It does not seem necessary longer to believe that lakes persisted longer in the Uinta Basin than in the Green River Basin. While "all of the Bridger epoch is represented in fluviatile deposits in Wyoming," it does not follow that none of the Bridger epoch is represented by lacustrine (Green River) deposits in some localities. Much confusion has arisen from the traditional viewpoint that the lacustrine Green River formation accumulated during a distinct time interval which is not represented in the Green River Basin by fluvial beds. Obviously, however, the peripheries of the lake were sites of deposition of fluvial beds contemporaneous with the lacustrine sediments. Three conclusions therefore follow: (1) all of Green River time is somewhere represented by fluvial deposits; (2) in some localities beds of "Wasatch" lithology pass conformably upward into beds of Bridger lithology, with no intervening lacustrine beds; (3) the Green River group does not represent an Eocene time interval distinct from the upper "Wasatch" and lower Bridger.

Correlation of the Continental Peak formation is likewise difficult. The only certainly identified fossil from this formation is the gastropod, *Viviparus wyomingensis*. The range of the species has not been definitely established, but referred specimens have been recorded from beds as old as lower Eocene and as young as lower Oligocene. The formation is believed to correlate with either the upper type Bridger or with the Uinta formation. Petrographic descriptions of rock specimens from both the Bridger and Uinta have been published by several authors (Sinclair, 31, 32; Johannsen, 15; Howard, 14), and the widespread presence of dacitic and glassy tuffs in both formations is now well-known. Neither unit, however, has distinctive petrographic characters which could be safely used for correlation with outcrops elsewhere. Professor Beckwith's descriptions of microscopic fragments from the Continental Peak formation compare equally well with descriptions of specimens from both the Uinta and Bridger. Some Continental Peak hand specimens agree best megascopically with greenish tuffs and tuffaceous sandstones described by Johannsen (15, p. 22) from the Bridger formation. Vertebrate fossils, however, are still the only reliable guides, and identifiable remains have not yet been found in the Continental Peak formation. It is believed that application of either name, Bridger or Uinta, to these beds might lead to further confusion of terminology with an already long synonymy. The name, Continental Peak formation, is therefore used as a tentative designation pending discovery of paleontologic data.

OLIGOCENE FORMATIONS

Chadron Formation

The Chadron formation of the White River group is represented in the mapped area by a sequence of conglomeratic and ashy sandstones which crop out in the upper parts of Oregon Buttes and Continental Peak and in most of the area north of the Continental fault. A detailed section of the formation at Oregon Buttes is shown in Section 6. The thickness in this section is obviously not the maximum for the formation in this region. Detailed sections were not measured elsewhere because there were no other strategic exposures of basal beds. The probable minimum thickness is about 500 feet.

Nomenclature.—Hayden (12, p. 29), in an early description of the "Sweetwater Plateau" of central Wyoming, applied the name, "Sweetwater group," to beds present at the surface. Endlich (9, pp. 3-158), who later described the same region, adopted Hayden's terminology and noted the presence of the "Sweetwater group" throughout the "plateau" region from the Beaver Divide, at the southern rim of the Wind River Basin, into the Continental Peak-Oregon Buttes area. The name, "Sweetwater group," has long since been abandoned and the beds assigned to the White River group, because of the presence of titanothere remains.

The lower portion of the White River group along the Beaver Divide has been shown to belong to the Chadron member. The base of the Chadron member in that locality is a thick conglomerate for which Bauer (1, pp. 678-680) has proposed the name, "Sweetwater member." Part of his description is here quoted:

> Unconformably on the Uinta formation, from the head of Sand Draw southwestward to the south end of the Wind River Range, is a boulder bed whose thickness varies from a few feet to 150 feet. For the most part the material is unstratified and poorly sorted. It ranges from sand grains to ten- or twelve-foot boulders.
>
> * * * * * * *
>
> Above the boulder beds, or Sweetwater member, along the Sweetwater rim are consolidated gravel and sand beds of fluviatile origin.
>
> The boulder beds described above are believed to be the initial stage in the development of the White River Group. Granger found a skull of Titanotherium in these beds, near Wagonbed Springs.

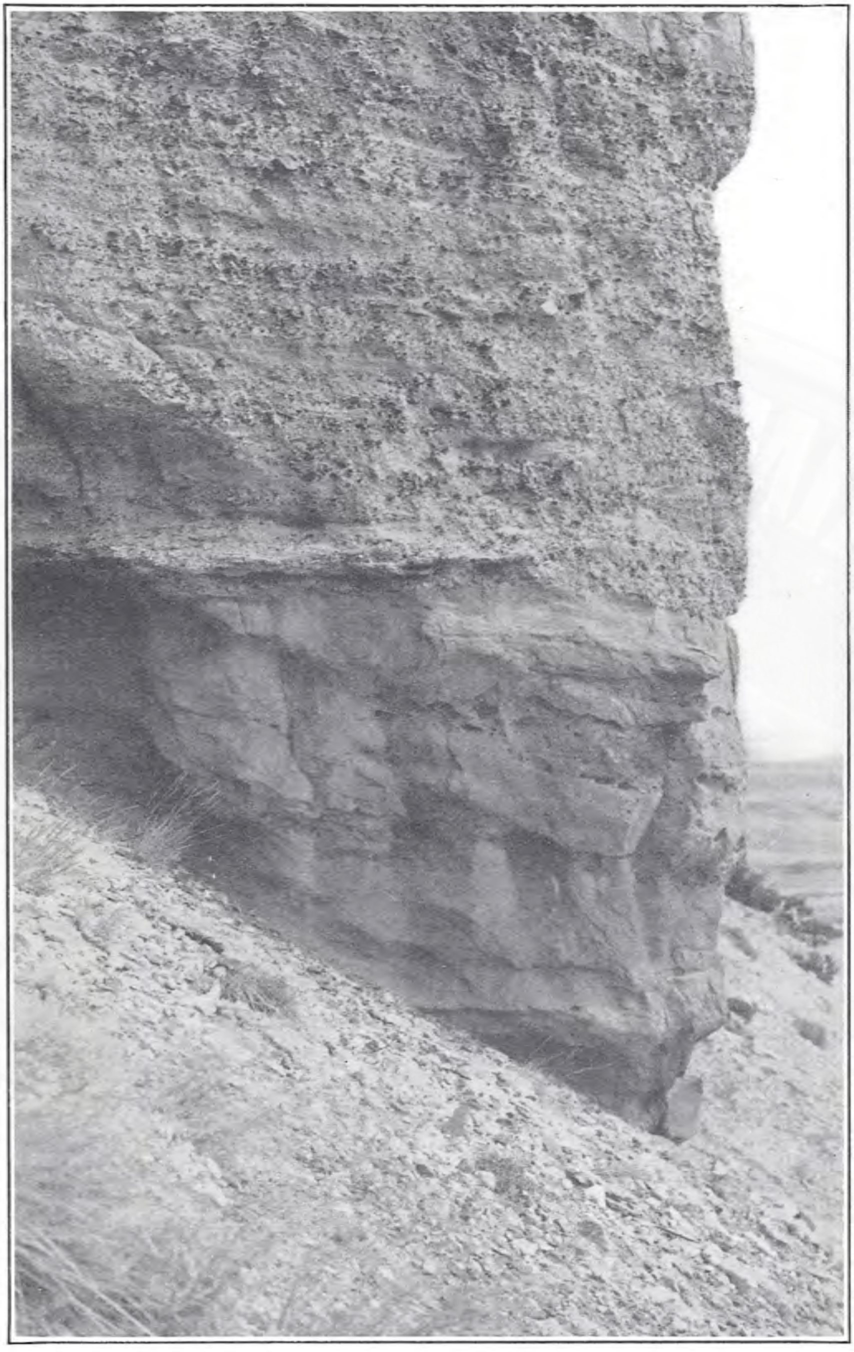
The name, Sweetwater, was unfortunately not available for use as a stratigraphic name. It was first used, as indicated above, by Hayden and Endlich in application to the whole of the White River group in the "Sweetwater Plateau." The name was therefore already in the synonymy of the White River group at the time Bauer applied it to the basal conglomerate of the Chadron. An inquiry, directed to the U. S. Geological Survey Committee on Stratigraphic Names, was referred by the committee for reply to Dr. W. H. Bradley, who made the following statement (personal communication):

> The Geologic Names Committee informs me that your opinion concerning the name *Sweetwater* accords with the code of rules for stratigraphic nomenclature published in the Bulletin of the Geological Society of America, vol. 44, pp. 423-459, which states that a name, once abandoned, is no longer available for any use other than that of restoring the original usage. Moreover, they inform me, your case is strengthened by the fact that the name *Sweetwater* has also been used for a dolomite of Permian age in Texas.

The proposal of a new name is therefore in order. The writer proposes that the basal conglomerate of the Chadron formation in the Beaver Divide region be known as the *Beaver Divide conglomerate member of the Chadron formation.*

Beaver Divide conglomerate member.—A sequence of conglomerates and ashy sandstones in the writer's area is exposed north of the Continental fault and in the upper parts of Oregon Buttes and Continental Peak. These beds were described by Endlich (9, pp. 110-112) as continuous with similar beds in the Beaver Divide region. The writer has traced them from the mapped area into outcrops in the southern portion of the "Sweetwater Plateau" which are continuous with those in the Beaver Divide. At Oregon Buttes the conglomerate is in the base of the Chadron, disconformably overlying the Continental Peak formation (Pl. 3). There is little doubt that this is the Beaver Divide conglomerate.

Within the mapped area the Beaver Divide conglomerate is best exposed on the east side of North Oregon Butte in the west part of sec.



Disconformable contact of the Beaver Divide conglomerate (above) and the Continental Peak formation. Oregon Buttes, SW¼NW¼ sec. 2, T. 26 N., R. 101 W.

2, T. 26 N., R. 101 W., where it is 68 feet thick (Section 6). The base of the member is a boulder conglomerate of angular and subangular fragments of igneous and metamorphic rock and nodules of buff and white ash and sandstone, in a matrix of sandstone and ashy sandstone. A large amount of carbonate cement is present. Conglomerate boulders range up to 1 foot in diameter, but the majority are less than 0.5 feet. Upward the conglomerate becomes less coarse, ranging through cobble and pebble sizes to coarse conglomeratic ashy sandstone. The matrix of the conglomerate comprises from 50 to 75 per cent of the rock, which is rudely cross-bedded. The conglomerate is well consolidated and resistant, forming vertical cliffs in some places. Its resistance is largely due to the carbonate cement, which is but little affected by mechanical weathering agents.

Material from the matrix of a representative sample of the conglomerate was prepared for microscopic examination. Professor Beckwith gives the following petrographic description:

> Section 6, Bed No. 1 (middle part of bed).
> *Conglomerate consists of black schist pebbles in a matrix of dacitic volcanic ash.* Fragments. The material for microscopic examination was prepared from the matrix. The predominant material is partially devitrified volcanic glass. Some of the glass fragments contain phenocrysts of quartz, green hornblende, and feldspar. There are also large simple fragments of quartz, green hornblende and oligoclase.

A conspicuous character of the Beaver Divide conglomerate in this region is the predominance of black and dark-colored basic and ultrabasic igneous and metamorphic rock fragments in the large size ranges. Almost all the boulders and most of the cobbles are of these types. Acid igneous rock fragments are confined chiefly to the small size ranges. Many weathered hill-tops capped by the conglomerate appear almost black from a distance, due to a residual mantle of the dark-colored fragments.

The thickness of the conglomerate is variable. The 68-foot section at Oregon Buttes is the thickest observed by the writer. Contact of the conglomerate with the overlying "upper" Chadron is gradational in some localities.

The conglomerate is widely distributed and was useful in mapping. It also aided determination of the amount of slip along the Continental fault, and it clarified the structural relations of beds throughout the north half of the mapped area. There are many small outcrops of the conglomerate adjacent to the north side of the fault. It is exposed south of the Continental fault only in narrow outcrops on Oregon Buttes and Continental Peak. In and near the narrow, shallow valley of the Sweetwater River there are extensive exposures. Northward from the writer's north boundary the conglomerate thins and pinches out between the pre-Cambrian basement and the "upper" Chadron. Northwestward from the mapped area there are discontinuous outcrops for several miles along the flank of the Wind River Mountains. Eastward for at least 10 miles there are extensive outcrops in the Antelope and "Sweetwater" hills.

"Upper" Chadron.—The term, "upper," is here used in a positional sense only. The "upper" Chadron consists chiefly of gray or grayish-buff nodular ashy sandstones. The best exposures are at Oregon Buttes where, however, there appears to be less ash mixed with the sandstones than in outcrops north of the Continental fault. Most of the beds north of the fault, however, are higher in the succession than those at Oregon Buttes. Samples of the "upper" Chadron beds were examined under the microscope by Professor Beckwith, who reports as follows:

Section 6, Bed No. 2 (lower part).

Conglomeratic sandstone, consisting of pebbles of quartz, feldspar and black metamorphic rock in a matrix of volcanic ash. Fragments. Approximately 50 per cent of the fragments in the matrix are partially devitrified glass. One fragment of glass containing an oligoclase phenocryst was observed. Simple grains of quartz, orthoclase and microcline are abundant. Oligoclase showing zonary banding, green hornblende, brown biotite, epidote and tourmaline occur in smaller amounts.

The sedimentary material was partially derived from a terrane of plutonic igneous and metamorphic rocks and partially from volcanic eruptives. The quartz and potash feldspar were probably derived from a potash granite. The zonary banding of the oligoclase and the occurrence of one crystal of oligoclase as a phenocryst embedded in partially devitrified glass indicate that the ashy material is probably of dacitic composition.

Section 6, Bed No. 3 (ash lens).

Fine-grained volcanic ash. Fragments. The material consists almost entirely of partially devitrified volcanic glass. The glass has undergone only slight devitrifaction. Most of the material in the glass grains is isotropic. Several glass fragments contain phenocrysts of feldspar which is weathered so that the composition of the feldspar cannot be determined. There are very few simple fragments of quartz.

"Upper" Chadron; from thin buff bed near center of sec. 8, T. 27 N., R. 101 W.

Sandstone with volcanic ash matrix. Thin-section. Almost all of the rock is partially devitrified glass with well-defined shard structure. Small irregular areas have been replaced by carbonate material. There are a very few fragments of quartz and oligoclase.

Table 6, Bed No. 4.

Sandstone with volcanic ash matrix. Fragments. The crushed fragments were prepared from the coarser part of the hand specimen. The predominant material is partially devitrified glass. Simple fragments of quartz, zonary-banded oligoclase, orthoclase and microcline are fairly abundant. Green hornblende is present in small amounts. Many of the fragments of quartz and feldspar and the hornblende fragments are rounded, indicating that they were transported as mineral fragments which were not embedded in a glass during transportation. It is probable that some of the material is of volcanic origin and that part was derived from a potash-granite terrane.

The "upper" Chadron is present in most of the area north of the Continental fault. Northwest of the mapped area there are continuous exposures for several miles and the formation thins out and disappears by overlap on the underlying pre-Camprian rocks. East and northeast of the mapped area the "upper" Chadron is continuous with Chadron beds in the "Sweetwater Plateau."

MEASURED SECTIONS OF TERTIARY FORMATIONS

1. Section of Hiawatha beds and Tipton tongue; SE¼SE¼ sec. 21, T. 27 N., R. 101 W., Fremont County, Wyoming.

		Feet
	Present land surface	
	TIPTON TONGUE	
23.	Sandstone, yellow hard coarse conglomeratic	1.0
22.	Sandstone, brown to yellow medium-grained thin-bedded	9.0
21.	Sandstone, brown to yellow, fine-grained platy	1.0
20.	Sandstone, grayish-green and yellow fine- to medium-grained thin-bedded	4.0
19.	Sandstone, gray and yellow coarse poorly sorted. Lower half thick-bedded; upper half cross-bedded. Weathers pitted. Several thin bands of platy sandstone 0.5 to 1 ft. thick, and a few thinner lentils of coarse hard calcite-cemented biotitic sandstone. Between 25 and 35 feet above base are numerous epigenetic siliceous concretions	39.5
18.	Pebble conglomerate, gray and yellow. Subangular fragments in sandstone matrix	0.5
17.	Muscovitic sandstone, gray medium-grained thin-bedded	4.0
16.	Limonitic sandstone, gray and brown medium-grained platy. Weathers rusty	2.5
15.	Muscovitic sandstone, gray friable medium-grained cross-bedded. Few limonitic zones 1± ft. thick. Muscovite flakes as much as 0.4 in. wide	66.0
14.	Limonitic micaceous sandstone, yellow friable medium-grained thin-bedded. Weathers grayish-brown, tan, and reddish. Abundant internal molds of *Viviparus paludinaeiformis?* 0.5 ft. above base	2.5
13.	Ferruginous micaceous sandstone, yellowish-brown fine-grained well-sorted thin-bedded. Ellipsoid epigenetic concretions throughout up to 3 ft. in diameter. Concretions of very hard, brittle finely crystalline sandy calcite around irregular nuclei of coarsely crystalline calcite. Upper 4 feet of bed composed mostly of these concretions in which *Viviparus paludinaeiformis?* is abundant	30.0
12.	Limonitic argillaceous sandstone, yellow, brown and tan medium- to coarse-grained poorly sorted	7.0
	Total, Tipton Tongue	167.0
	HIAWATHA BEDS	
11.	Arkosic sandstone, yellow coarse-grained poorly sorted thick-bedded. Grades upward into medium-grained greenish-gray sandstone	8.0
10.	Conglomeratic sandstone, gray and brown. Rounded and subangular fragments up to 0.1 ft. in diameter in matrix of coarse argillaceous sandstone	1.5
9.	Sandstone, bluish-gray coarse, poorly sorted with small hard concretions 0.1-0.2 ft. in diameter	1.5
8.	Clay, variegated yellow, tan, brown, red, maroon and gray. Sandy in places	30.0
7.	Micaceous arkosic pebble conglomerate, yellow	7.0
6.	Conglomeratic sandstone, gray and brown. Rounded and subangular fragments up to 0.1 ft. in diameter. Lenticular	0.0-0.5

5.	Clay, sandy clay and flaky shale, variegated tan, brown, maroon, red, purple and greenish-yellow	14.0
4.	Pebble conglomerate, greenish-tan lenticular. Angular and subangular fragments in matrix of coarse sandstone. Weathers reddish-brown	0.0-1.0
3.	Arkosic mudstone, bluish-gray. Feldspar fragments up to 0.3 in. in diameter	12.0
2.	Conglomeratic sandstone, greenish-brown hard rudely cross-bedded. Pebbles up to 0.2 ft. in diameter. Weathers brownish-green	5.0
1.	Arenaceous arkosic clay, variegated yellow, brown, red and greenish-blue	85.0
	Total, Hiawatha Beds	164.0-165.5

Base not exposed

2. Section of Cathedral Bluffs, Morrow Creek and Bridger beds; east side of north Oregon Butte, W½ sec. 2, T. 26 N., R. 101 W., Sweetwater County Wyoming.

CONTINENTAL PEAK FORMATION — Feet

Disconformity; relief of 1-5ft.

BRIDGER FORMATION

"Upper" Bridger

		Feet
55.	Sandstone, light-gray friable fine-grained thin- to thick-bedded and blocky. Thickness variable	1.0-6.0
54.	Sandstone, gray and tan hard fine-grained thin-bedded	1.0
53.	Sandstone, blue-gray fine-grained nodular thin-bedded to massive	34.0
52.	Arenaceous limestone, grayish-brown fissile. Abundant plant fragments, ostracodes, and fish scales and vertebrae	1.0
51.	Arenaceous limonitic shale, light-brown, soft	0.8
50.	Shale, gray and brown hard, brittle	2.0
49.	Calcareous, arenaceous shale, gray hard, brittle	2.0
48.	Very calcareous sandstone, gray and brown fine-grained. *Goniobasis tenera* var. *carteri* and ostracodes comprise over half the rock	0.3
47.	Calcareous sandstone, gray fine-grained well-sorted thin-bedded	0.8
46.	Sandstone, gray, brown and tan coarse to medium-grained thin-bedded to massive and blocky. Upper part argillaceous	102.0
45.	Ferruginous sandstone, gray, yellowish and brown medium-grained poorly sorted blocky. Some argillite near middle. Lower portion roughly cross-bedded with a few small clay-pellets	40.5
44.	Limonitic biotitic sandstone, brown friable coarse-grained poorly sorted. Thin-bedded at base with gastropods. Upper part conglomeratic with green clay-pellets ranging from pin-head size to 0.5 in. wide. Few poorly preserved plant remains near top	10.0
43.	Biotitic sandstone, gray hard coarse-grained poorly sorted thin-bedded. Clay pellets present but less numerous and larger than in bed No. 41	1.0
42.	Clay-pellet conglomerate. Green clay and shale pellets in loosely consolidated coarse gray sandstone matrix. *Goniobasis tenera* abundant	1.0

41. Biotitic ferruginous sandstone, gray to brown hard coarse poorly sorted. Clay pellets up to 0.5 in. in diameter. Gastropods, poorly preserved	1.0
40. Limonitic sandstone, yellow friable coarse to medium-grained poorly sorted to well-sorted thin-bedded. Irregularly streaked with flaky green shale near base. Few large epigenetic concretions and small pockets of limonite	5.0
39. Conglomeratic sandstone, gray coarse poorly sorted. Lenticular. Irregularly interbedded with green, gray and brown shale, and dense, hard brown argillite. *Goniobasis tenera* abundant	0.0-2.0
38. Ferruginous sandstone, brown medium-grained massive. Pocketed with powdery hematite and limonite	26.0
37. Sandstone, gray coarse poorly sorted cross-bedded. Clay pellets numerous	30.0
Total, "Upper" Bridger	259.4-266.4

Disconformity

"Lower" Bridger

36. Alternating medium-grained gray and brown sandstones, gray arenaceous argillites, and flaky gray, green and brown shales in beds from 5 to 15 ft. thick	90.5
35. Sandstone, gray fine-grained poorly sorted irregularly bedded. Thickness irregular. Irregular calcareous and argillaceous zones. Weathers rusty brown. Abundance of *Goniobasis tenera* and *Viviparus paludinaeiformis?* One specimen of a distinct viviparid or land snail. Few shells of *Elliptio haydeni*, chelonian and crocodile bones and lepidosteid fish scales	1.0-2.0
34. Sandstone banded brown yellow and gray thick- to thin-bedded. Shaly in places. Silicified wood abundant	34.0
33. Arenaceous limestone, gray and brown thin-bedded. Ostracodes abundant	1.0
32. Arenaceous limestone, brown finely crystalline thin-bedded	1.0
31. Calcareous sandstone, tan loosely consolidated fine-grained. Ostracodes abundant	0.5
30. Arenaceous shale, green	0.1
29. Ferruginous shaly sandstone, gray	0.5
28. Arenaceous shale, gray. Abundant ostracodes and a few poorly preserved leaves	1.0
27. Limestone, banded black and brown dense, hard finely crystalline thin-bedded. Algal limestone in places. Few thin silicified layers. Ostracodes abundant	2.0
26. Alternating coarse to medium-grained massive to thin-bedded tan, yellow and brown ferruginous sandstones, and greenish-gray siltstone and mudstone, in beds from 5 to 10 ft. thick	89.0
25. Sandstone, gray friable fine-grained well-sorted thin-bedded	45.5
24. Limestone, brown porous. Ostracodes and *Chlorellopsis coloniata* abundant	1.5
23. Arenaceous limestone, light-brown hard thin-bedded. Weathers dark brown	1.5
22. Sandstone, tan	3.0
21. Shale, gray and greenish-brown	8.5
20. Argillaceous siltstone, banded pink, tan, brown and purplish-gray hard, brittle thin-bedded	4.0

19.	Alternating beds of poorly consolidated yellow micaceous argillaceous sandstone, hard yellow and brown siltstone, green and brown arenaceous clay, and hard gray and brown muscovitic mudstone in beds 5 to 15 ft. thick	85.0
18.	Micaceous sandstone, gray and medium-grained poorly consolidated platy	1.0
17.	Biotitic siltstone and mudstone, gray and brown hard	26.0
16.	Limestone, light-brown finely crystalline thin-bedded	1.0
15.	Limestone, buff hard. Ostracodes abundant	1.0
14.	Calcareous shale and clay, brown, gray and green	53.5
13.	Micaceous clay and sandstone, brown loosely consolidated	15.5
12.	Sandstone, green hard fine-grained. *Chlorellopsis coloniata* and a few ostracodes	0.5
11.	Limestone, brown hard, brittle finely crystalline. Irregularly silicified. Ostracodes abundant	0.5
10.	Siltstone, gray, grades upward into arenaceous green clay	11.0
9.	Limestone, buff hard, brittle finely crystalline. Shaly partings. Few ostracodes	4.0
8.	Arenaceous clay, brown, tan and green	13.0
	Total, "Lower" Bridger	496.1-497.1
	Total, Bridger formation	755.5-763.5

MORROW CREEK TONGUE

7.	Shale, brown soft flaky	7.0
6.	Silicified algal limestone, brown dense hard thin-bedded	1.5
5.	Calcareous clay and shaly marl, buff. Algal balls *(Chlorellopsis coloniata)* abundant	8.0
4.	Limestone, brown hard, brittle thin-bedded. Some shaly limestone. Brown calcareous clay partings	3.0
	Total, Morrow Creek Tongue	19.5

CATHEDRAL BLUFFS TONGUE

3.	Arkosic grit, brown and tan, grading up into green, gray, and light-brown clay, and brown sandy clay	17.5
2.	Arkosic pebble conglomerate. Angular fragments up to 0.5 in. in diameter in a coarse sandstone matrix	4.0
1.	Clays and grits, variegated, red, blue, gray, tan, yellow, brown and green	?

Base not exposed

3. Section of upper Cathedral Bluffs, Morrow Creek and Bridger; west side of Continental Peak, E½ sec. 34 and W½ sec. 35, T. 26 N., R. 100 W., Fremont County, Wyoming.

CONTINENTAL PEAK FORMATION

Disconformity; local relief of 1 ft.

BRIDGER FORMATION		Feet
"Upper" Bridger		
56.	Alternation of beds of fine-grained nodular thin-bedded brownish-yellow ferruginous sandstone, 1 to 3 ft. thick, and irregularly thin-bedded light-brown arenaceous ashy mudstone 0.3 to 0.8 ft. thick. Sandstones contain ellipsoid brown and gray epigenetic concretions 0.5 to 3 ft. thick	26.0

55. Ferruginous sandstone, brownish-yellow fine-grained thin-bedded. Some beds indistinctly cross-laminated. Discoidal brown epigenetic concretions 1 to 30 ft. wide and 0.1 to 0.4 ft. thick..	23.0
54. Sandstone, gray and light-brown fine-grained nodular massive. Weathers reddish-brown and light red. Upper 60 ft. badly obscured by talus	77.0
53. Sequence obscured by thick talus and small landslides. Apparently gray and light-brown clays, argillites and sandstones.....	60.0
52. Sandstone and shale, gray, brown and greenish. Few ostracodes in upper 3 ft.	28.5
51. Arenaceous limestone, brown and buff hard thin-bedded with clay-galls. Abundant ostracodes and scales, teeth and fin-spines of fish. Few small gastropods	0.5
Total, "Upper" Bridger	215.0
Disconformity	
"Lower" Bridger	
50. Arenaceous shale, mudstone and siltstone, gray, brown and green. Few thin hard calcareous zones with ostracodes	24.5
49. Limestone, gray and brown, with ostracodes. Silicified in places..	3.0
48. Micaceous sandstone, yellowish-brown fine-grained to coarse poorly sorted	18.0
47. Shaly sandstone, gray	10.0
46. Arenaceous shale, gray and brown	4.0
45. Arenaceous shale, gray and brown. Weathers rusty brown......	0.5
44. Ferruginous sandstone, brown fine-grained massive. Grades upward into massive light-brown mudstone	15.0
43. Siltstone, grayish-brown with thin bands of arenaceous shale[a]....	10.0
42. Calcareous arenaceous shale, gray. Composition variable. Few poorly preserved leaves. *Viviparus paludinaeiformis*? and *Physa bridgerensis*? present. Also undetermined pupillid, lepidosteid fish scales, bone fragments and silicified wood. Ostracodes abundant	8.0
41. Shale and argillite, pinkish-brown, tan and gray. Abundant leaf fragments. Ostracodes rare	1.0
40. Sandstone, gray and brown coarse irregularly bedded. Highly calcareous and shaly in places. Weathers rusty. Ostracodes, fish scales and vertebrae present. Gastropods abundant: *Goniobasis, Viviparus paludinaeiformis?, V. wyomingensis?, Planorbis spectabilis, Vertigo arenula,* and *Gonyodiscus?* sp........	4.0
39. Shale greenish-brown and gray. Grades upward into medium-grained blocky yellow clay and sandstone	38.0
38. Calcareous arenaceous shale, gray and brown hard platy. Alternates with thin bands of flaky gray calcareous shale.........	3.0
37. Arenaceous shale, gray and brown flaky to fissile	1.0
36. Shaly limestone, gray and brown. Ostracodes	0.5
35. Limestone, gray, brown and black. Some layers silicified. Ostracodes abundant	0.5
34. Calcareous shale, gray and brown. Ostracodes	0.4
33. Limestone, gray and brown hard thin-bedded. Ostracodes.......	1.0
32. Shaly limestone, gray and brown soft. Some layers incompletely silicified. Ostracodes	0.5

a—Talus slopes of beds 43 to 48 are littered with fish bones and scales, chelonian dermal plates, crocodile teeth and silicified gastropod shells.

31.	Limestone, buff hard finely crystalline thin-bedded. Ostracodes...	1.0
30.	Sandstone, gray and brown thin-bedded. Ostracodes...........	1.0
29.	Sandstone and clay, greenish and brown thin-bedded. Small nodular epigenetic concretions..................................	5.0
28.	Limestone, light brown hard, with numerous small solution cavities. Laterally grades into fine-grained calcareous sandstone containing numerous hard epigenetic concretions 0.2 to 0.4 ft. in diameter. Irregular contact with underlying bed............	0.5-1.0
Minor disconformity		
27.	Clay and sandy clay, brown and gray. At base is a band 1 to 2 ft. thick of sandstone and mudstone intermixed without conformity to bedding planes	53.0
Minor disconformity		
26.	Arenaceous clay, brown	3.0
25.	Ferruginous sandstone, gray coarse well-sorted.................	6.0
24.	Clay and sandstone, brown, tan and gray poorly consolidated....	9.5
23.	Sequence obscured by talus. Apparently an alternation of gray and tan shales. Petrified wood..............................	36.0
22.	Limestone, light-buff soft	0.5
21.	Shale, gray, brown and greenish-brown soft.....................	22.5
20.	Clay, grayish-brown. Some silicified algal limestone at top......	6.5
19.	Shale, brown and tan soft......................................	23.0
18.	Shale, gray and soft...	2.5
17.	Sandstone, gray friable medium-grained well-sorted............	1.5
16.	Arenaceous clay, brown and greenish-tan	25.0
15.	Shale and clay, greenish	10.0
14.	Calcareous shale, greenish-brown	17.0
13.	Clay and shale, greenish-brown	2.0
12.	Limestone and calcareous clay, buff. Ostracodes................	1.5
11.	Limonitic calcareous shale, brown "papery"....................	8.0
10.	Limestone and imbedded calcareous argillaceous algal balls. Some secondary crystalline calcite seams	0.8
9.	Calcareous shale, green	2.0
8.	Ferruginous calcareous shale, brown "papery"..................	15.0
7.	Arenaceous seleniferous clay and shale, green and brown........	60.0
	Total, "Lower" Bridger	455.7-456.2
	Total, Bridger formation	670.7-671.2

MORROW CREEK TONGUE

6.	Limestone, brown, tan and light-gray. Ostracodes and partly silicified algal balls	3.0
5.	Calcareous shale, brownish-gray. White along parting planes. Ostracodes abundant. Thin silicified algae reef 15 ft. above base. Algal balls higher up	22.5
4.	Clay and shale, well consolidated. Greenish at base, grading upward into gray shale with limonitic seams and joints. Secondary crystalline calcite abundant throughout. Partly silicified algal balls at top	6.5
	Total, Morrow Creek Tongue..........................	32.0

CATHEDRAL BLUFFS TONGUE

3. Arenaceous clay, greenish-gray somewhat fissile. Upper half of bed contains much intermixed powdery calcite. Top contains an aggregate of tubular somewhat tapering structures up to 0.8 ft. in diameter and 10 ft. in length, horizontally embedded in the clay. Tubes consist of a central tubular hole, 0.5 in. to 0.1 ft. in diameter, surrounded by a shell of silicified wood 0.1 to 0.2 ft. thick, and an outer shell of algal incrustations, 0.2 to 0.4 ft. thick	45.0
2. Limonitic arkosic grit, yellow coarse. Finer grained at top......	5.0
1. Alternating variegated bands of red, brownish-red, yellow, olive-drab and light-green arkosic grits, clays, sandy shales and shale, in beds 0.5 to 5 ft. thick. Degree of consolidation varies from bed to bed. Some of clays fairly well-consolidated. Several bands, 0.1 to 0.2 ft. thick, of ferruginous conglomeratic sandstone. One band, 0.5 to 1.5 ft. thick of pebble conglomerate. Abundant selenite crystals in upper 1.5 ft............	74.0
Total, Cathedral Bluffs tongue........	124.0

Base not exposed

4. Section of Continental Peak formation and Beaver Divide conglomerate on northwest side of Continental Peak in the SE¼NW¼ sec. 35, T. 27 N., R 100 W.

BEAVER DIVIDE CONGLOMERATE	Feet
7. Boulder conglomerate. Angular and subangular boulders and cobbles of basic and ultra-basic igneous and metamorphic rock in a matrix of fine-grained gray calcareous ashy sandstone....	15
Total, Beaver Divide Conglomerate	15
Disconformity	
CONTINENTAL PEAK FORMATION	
6. Sandy volcanic ash, yellowish-gray well consolidated, slightly friable coarse. Cliff-forming. Upward becomes hard, fine-grained and thick-bedded. Weathers muddy yellow and pitted; forms irregular knobs and ledges. In zone 35-50 feet above base are three layers, 1 to 1.5 ft. thick, of bright light-green ashy shale	87
5. Arkosic sandstone, reddish-brown to grayish-black coarse-grained cross-bedded. Few clay pellets present up to 0.5 in. in diameter. Contains nodules and flattened concretions of very hard fine-grained quartzitic sandstone	12
Disconformity	
4. Ashy sandstone, mottled red and greenish-gray fine-grained nodular........	26
3. Alternating beds, 1 to 8 ft. thick, of thick-bedded gray and red sandstone, and thick-bedded light-greenish-buff argillaceous ash, sandstones contain nodular and discoidal concretions up to 2 ft. thick, of very hard, dense yellowish-brown quartzitic sandstone	113
2. Micaceous sandstone, red fine-grained thick-bedded. Becomes grayish, nodular and ashy in upper part	5
1. Volcanic ash, light-green, rather coarse thick-bedded. Small amount of calcite cement present. *Viviparus wyomingensis* Meek and turtle bones........	7
Total, Continental Peak formation........	251

Disconformity, relief of 1 ft.

BRIDGER FORMATION

5. Section of Continental Peak formation; east side of north Oregon Butte, west-central part of sec. 2, T. 26 N., R. 101 W.

	Feet
BEAVER DIVIDE CONGLOMERATE	
Disconformity	
CONTINENTAL PEAK FORMATION	
3. Alternating thick beds of fine-grained gray sandstone and gray to greenish ashy sandstone. Upward the alternation of beds becomes indistinct and the rock is a medium-grained massive yellowish-brown sandstone, ashy in some layers	85
2. Ferruginous sandstone, yellow medium-grained cross-bedded	31
1. Basal part ferruginous sandstone, yellow coarse moderately well-sorted friable cross-bedded, with clay-pellets. 4 ft. above base grades into medium-grained friable cross-bedded yellow sandstone. Cross-bedding absent in upper portion, where rock grades into blocky gray ashy mudstone. Basal zone of bed is essentially a clay-pellet conglomerate, with clay-pellets apparently derived from the "upper" Bridger. Clay-pellets are absent 4 feet above the base. Middle portion contains nodular concretions	29
Total, Continental Peak formation	145
Disconformity; relief of 5 feet.	
BRIDGER FORMATION	

6. Section of Chadron formation; east side of North Oregon Butte, west-central part of sec. 2, T. 26 N., R. 101 W.

	Feet
Present land surface	
CHADRON FORMATION	
"Upper" Chadron	
4. Sandy volcanic ash, grayish-buff fine-grained nodular thick-bedded. Nodules 0.1 to 0.5 ft. in diameter. Weathers into rough-faced cliffs and irregular ledges	110
3. Volcanic ash, pure white very fine-grained; low specific gravity. Lenticular	0-5
2. Sandy, very calcareous volcanic ash, grayish-buff well consolidated. Somewhat conglomeratic. Apparently a mixture of re-worked volcanic ash and medium-grained, poorly sorted sandstone. Small fragments of hornblende and biotite are numerous. In the lower 15 feet of this bed there are two lenses, 0.1 to 0.2 ft. thick, of dense, hard brown fresh-water limestone	35
Total, "Upper" Chadron	145-150
Beaver Divide conglomerate member	
1. Boulder, cobble and pebble conglomerate. General color gray. Angular and subangular fragments of schist, quartz, pink and white feldspar, porphyritic granite, gneiss, and derived nodules of buff and white volcanic ash and ashy sandstone, in a matrix of coarse ashy, highly calcareous sandstone. Conglomerate fragments range up to 1ft. in diameter. Coarsest near base, grading upward into conglomeratic sandstone. Change to base of "upper" Chadron rather abrupt	68
Total, Beaver Divide Conglomerate	68
Total Chadron formation	213-218
Disconformity	
CONTINENTAL PEAK FORMATION	

MIOCENE(?) ROCKS

No post-Oligocene Tertiary sediments are present in the mapped area. North of the area there are younger Tertiary sediments, similar to the Chadron in general appearance. The following petrographic description, prepared by Professor Beckwith, shows, however, that these beds are quite distinct from the Chadron:

Arkosic conglomerate with volcanic ash matrix.

Fragments. Less than half of the fragments in the matrix are devitrified glass. Devitrifaction has gone almost to completion. Very little isotropic material remains. Most of the glass has altered to a fine flaky mineral showing first order gray and yellow interference colors. A few devitrified glass grains contain lath-shapped feldspar phenocrysts. Minerals present as simple grains are quartz, orthoclase, microcline, oligoclase and green hornblende. The feldspars have been extensively sericitized. Several compound grains consisting of quartz and hornblende, and orthoclase and green hornblende, were observed. A number of the larger mineral grains are rounded, probably as a result of transportation as simple grains.

Different materials in the rock came from different sources. Some of the quartz and potash feldspar probably were derived from a granitic terrane. The occurrence of hornblende intergrown with large crystals of quartz and orthoclase suggests that at least part of the hornblende was derived from a potash granite. The high degree of devitrifaction of the glass may indicate that the ashy material was derived from an older sedimentary ash succession and was subjected to weathering during a second cycle of erosion and deposition.

It is postulated that these sediments were deposited as a mixture of debris derived from the igneous and metamorphic rocks of the Wind River Mountains and the Chadron formation. Conspicuous megascopic differences from the conglomeratic part of the Chadron are the absence of large fragments of dark-colored metamorphic and igneous rock, the low degree of lithification, the arkosic character, and the absence of well-defined bedding. These beds apparently are the same as those shown as "Tertiary Pliocene and Miocene undivided" on the 1925 edition of the U. S. Geological Survey Map of Wyoming. The writer found no evidence of their age other than that they overlie the Chadron.

QUATERNARY SEDIMENTS

Most of the Quaternary sediments in the mapped area are locally derived alluvium which in many places is difficult to distinguish from the formations from which it was derived. South of the Continental fault along Oregon Gulch the alluvium is a mixture of reworked "lower" Bridger and Cathedral Bluffs. North of the fault the alluvium is distintegrated and transported Chadron, from which the finer material has been sorted out. Analogous similarities to local rock outcrops pertain elsewhere in the area except in the immediate channel of the Sweetwater River. There the alluvium, present in sandbars and floodplain scrolls, is coarse sand and grit composed principally of angular quartz and feldspar grains, with subsidiary mica. Locally in the channel of the river there are residual accumulations of boulders from the Beaver Divide conglomerate.

Certain deposits in the area may be of glacial origin. The backslope of the fault-ridge from sec. 18, T. 27 N., R. 101 W., eastward through sec. 19, T. 27 N., R. 100 W., is littered with igneous cobbles and boulders up to 3 feet in diameter. These are obviously not weathered residuum from the Cathedral Bluffs beds, for it contains no conglomerates with boulders of comparable size. The boulders may be residual from a former sheet of glacial or fluvio-glacial material. Thick deposits of till and boulder clay are present in many places along the southwest flank of the Wind River Mountains. These may once have extended southeastward over the mapped area.

STRUCTURE

General Statement

Earth movements within the area mapped and adjacent regions are expressed in monoclinal folding, normal faulting, and irregular twisting and warping. The most conspicuous structural feature of the region is the normal fault which extends across the entire mapped area from the SW cor, sec. 7, T. 27 N., R. 101 W., to the SE cor. sec. 18, T. 27 N., R. 99 W. To this fault the name, *Continental fault,* is applied for convenience of description. Another important structural feature is the monocline which extends from the SE cor. sec. 21, T. 27 N., R. 101 W., to the SW cor. sec. 18.

Continental Fault

The Continental fault is a normal fault, as shown in the structure section A-A[1] (Pl. 3). The fault dips northward at about 68° near the northwest corner of sec. 16, T. 27 N., R. 101 W., the only place found where the dip could be measured. Displacement along the fault cannot be accurately determined.

The structure section shows all sedimentary rock units except the Tipton tongue and Hiawatha beds with constant thickness. Actually these units probably do not maintain constant thickness northward. Underground each unit probably thins northward toward the mountains. No data are available, however, on the amount or rate of thinning, and any assumptions as to these would introduce complications which would not clarify general conceptions. The slope of the pre-Cambrian surface is entirely conjectural. The location of the edge of the Tipton Tongue is not known. The Hiawatha is shown thickening at the expense of the Tipton.

The structure section, thus drawn, shows a displacement of 1,975 feet along the fault plane. The throw is 1,830 feet. A general check on the magnitude of the throw can be made from data on the topographic map of the Hayden Survey. The base of the Beaver Divide conglomerate on Oregon Buttes is at an elevation of about 8,600 feet, while north of the fault the base is at about 7,600 feet. Assuming that the base of the conglomerate was originally horizontal, the north block has been dropped 1,000 feet. The beds in the block immediately south of the fault, however, have been uplifted by a monoclinal fold approximately 450 feet higher than their level beneath Oregon Buttes. Addition of this figure would increase the total vertical movement to 1,450 feet. The two figures, 1,450 and 1,830 feet, may be taken as the minimum and maximum values for throw of the fault.

The surface trace of the Continental fault is strongly bent at several places, most conspicuously in sec. 24, T. 27 N., R. 100 W., and sec. 19, T. 27 N., R. 99 W. These bends are actually in the fault plane, not merely apparent bends produced by shifting of the surface trace of the fault over inequalities of topography. In most places the bending is opposite in direction to that which would be produced by topography.

In the eastern part of the area the Continental fault is subparallel to other subsidiary faults which bound minor slices and probably join the main fault underground. Numerous transverse and oblique faults cross the main fault in the same area. The majority of the transverse faults occur where the main fault trace is convex southward.

Minor Faults

The small, doubtfully identified transverse fault in Oregon Gulch, trending NE across the boundary between secs. 20 and 21, T. 27 N., R. 100 W., may be considerably longer than shown on the map. There are some indications that it may extend southwest along Oregon Gulch to the neighborhood of the Blair house. Definite evidence of its presence or absence along that part of the gulch is lacking, due to the writer's inability to recognize the exact parts of the Cathedral Bluffs beds which crop out north and south of the gulch.

The long transverse fault shown extending from sec. 3 southward to sec. 28, T. 27 N., R. 101 W., could not be located closer than fifty feet, except in the adjacent corners of sec.'s 21, 22, 27, 28, and the north part of sec. 15. North of the SW cor. sec. 7 the presence of the fault is doubtful. If present there the displacement is very small.

Regional Relations of Faults

The Continental fault extends northwest beyond the limits of the mapped area at least as far as the northeast face of Elk Mountain. From the east boundary the fault extends eastward at least 13 miles. Extensive tilting of the Continental Peak formation in the region southeast of Pickett Lake as far as Lost Creek indicates that the Continental fault may extend into the central part of the Red Desert.

Fault movement occurred after deposition of the lower Oligocene Chadron formation, the youngest beds which the fault offsets. Closer dating by available evidence is not possible. Known data may be summed up as follows: The Continental fault is a normal fault with a down-throw on the north of nearly 2,000 feet. The fault has a known length of nearly 50 miles and may be considerably longer. Fault movement occurred in post-Oligocene time. The fault is a regional structural feature of the first magnitude.

Folds and Warps

Folding was intense but strictly local in the monocline shown on the geologic map in the east-central part of the mapped area. The highest dip measured was 59°, on Tipton beds in the SE¼SE¼ sec. 21, T. 27 N., R. 101 W. In the north limb of the monocline the beds dip generally southward at angles of from 1 to 5 degrees. On the south limb the beds also dip southward, but flatten to a horizontal attitude within a distance of one-fourth of a mile. On the east the monocline terminates against a transverse fault which brings Tipton in contact with "lower" Bridger. Westward the monocline dies out near the west boundary of T. 27 N. Westward from that line the Cathedral Bluffs beds are simply tilted, with southward dips.

Near the north boundary of sec. 18, T. 27 N., R. 101 W., there is a small local syncline. Throughout the mapped area beds have been intensely crumpled and dragged in a narrow zone adjacent to the Continental fault. North of the fault, near the east boundary of the map, dips as high as 62° were measured in the Chadron. Throughout the area north of the fault there are local minor warps, but no definite system of folds was recognized.

All the folding and warping within the mapped area was probably associated with movement along the continental fault, since strata are folded only near the fault and involve beds as young as those cut by the fault. The fault trends roughly parallel to the flanks of the Wind River Mountains and the "Sweetwater Mountains" and the block toward the mountains is downthrown. The significance of this fact has yet to be determined.

GEOMORPHOLOGY

The mapped area is a sub-maturely dissected region of moderately coarse-textured topography. It consists essentially of low, rolling foothills in the borderland between the rough topography of the Wind River Mountains and the monotonous "swell and swale" topography of the Red Desert. The Red Desert proper is a part of the intermontane plateau region known to geomorphologists as the Wyoming Basin.

The Sweetwater River is a rejuvenated stream which, since rejuvenation has incised its course and reached a stage of late youth within the mapped area. The gradient is about 20 feet per mile. Locally meanders are well developed and floodplain scrolls are conspicuous. The stream is in the process of superposition onto the pre-Cambrian rocks from mantling Oligocene and Miocene(?) rocks. Locally the process of superposition is complete, most conspicuously near the headwaters of the river (Fig. 2) which flow entirely on pre-Cambrian rocks. The course of the river is incised below an old erosion surface along the flank of the mountain to a depth of from 200 to 300 feet.

Westgate and Branson (35) have described four "peneplane" surfaces in and adjacent to the Wind River Mountains. Bradley (7), however, in a recent study of the geomorphology of the Uinta Mountains, has applied the pediment concept to the interpretation of extensive erosion surfaces developed there. His objections to the peneplane theory are based primarily on (1) the strong regional slope of the surfaces, (2) the presence of a gravel sheet on the surfaces, in contrast to the deeply weathered soil mantle characteristic of peneplanes, (3) the fact that the gravel sheets rest on bare, fresh bedrock. Bradley has postulated that the so-called peneplanes of the Wind River Mountains are likewise pediments and may correlate with those in the Uinta Mountains. Insofar as the writers observations extend, they support Bradley's opinion concerning the surfaces in the Wind River Mountains.

"Peneplane" surface No. 4 of Westgate and Branson (35, pp. 147-148), said to be best developed in the neighborhood of Atlantic City at an elevation of about 8,500 feet, they considered to be probably represented on the summit surfaces of Oregon Buttes. They were unaware of the intervening Continental fault. Surfaces cannot be correlated across this fault until the time of movement in relation to the erosion cycles can be determined. The writer believes that known data is inadequate for reconstruction of the erosional history of the region.

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