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THE GEOLOGY AND VERTEBRATE PALEONTOLOGY OF UPPER EOCENE STRATA IN THE NORTHEASTERN PART OF THE WIND RIVER BASIN, WYOMING

PART 1. GEOLOGY

(WITH 1 PLATE)

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PART 1. GEOLOGY[2]

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(With 1 Plate)

INTRODUCTION

GENERAL SETTING OF THE AREA

The northeastern part of the Wind River Basin described in this report includes the lower lands of the basin and parts of the bordering mountain ranges, which are the eastern part of the Owl Creek Mountains and the southern end of the Big Horn Mountains in Hot Springs, Fremont, and Natrona Counties, Wyoming (figs. 1 and 2). Lost Cabin and Lysite are the only towns within the area. Lysite is a station on the Chicago, Burlington, and Quincy Railroad and is about 8 miles north of Moneta, a town on U. S. Highway 20.

The Owl Creek and Big Horn Mountains are folded and faulted mountain ranges arranged in echelon and made up of pre-Cambrian and Paleozoic rocks with minor amounts of Mesozoic rocks along the outer flanks. The bordering part of the Wind River Basin is underlain by Tertiary strata of both early and late Eocene age. The younger Eocene strata consist of resedimented andesitic volcanic rocks and form a narrow belt adjacent to the mountains, and in part within them. These volcanic-rich strata are separated from the Wind River

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[1] Part 2 of this paper, "The Mammalian Fauna of the Badwater Area," by C. Lewis Gazin, appeared in Smithsonian Misc. Coll., vol. 131, No. 8, Oct. 30, 1956.

[2] Publication authorized by the Director, U. S. Geological Survey.

formation of early Eocene age on the south by a normal fault of large displacement.

The Wind River formation is a thick clastic one composed of the debris eroded from the Owl Creek and Big Horn Mountains during at least the later part of their structural deformation and growth. The Wind River formation is exceedingly coarse grained in the area of its outcrop closest to the mountains and finer grained away from the mountains. The strata of younger Eocene age are conspicuously different in appearance and composition, consisting of andesitic volcanic material derived from the volcanic centers in the Absaroka Range 70 miles to the west-northwest. Although some of the volcanic material probably was carried to the northeastern part of the Wind River Basin by streams, much of the material may have been transported aerially. The rocks include relatively little material eroded from the Owl Creek and Big Horn Mountains, which had their present form and very nearly their present topography at the time the rocks of middle(?) and late Eocene age were deposited.

HISTORY OF INVESTIGATION

The geology of the northeastern part of the Wind River Basin (fig. 1) has long been of interest because of the large faunas of vertebrate fossils that have been found in the Eocene strata there. J. L. Wortman, collecting in 1880 for E. D. Cope (Osborn, 1929, p. 160), appears to have been the first collector to enter the northeastern part of the basin. During the following years, classic collections were made from the Wind River formation in exposures along Cottonwood Creek and in a broad area east of Lost Cabin, and along Alkali Creek, just south of the map area shown in figure 2. These collections later provided the basis for the faunal definition of the latter part of early Eocene time. No fossils of younger Eocene age were found in early investigations although the younger strata are markedly different in lithology from the Wind River formation. Granger saw some of the strata now known to be of late [3] and probably middle(?) Eocene age and considered them to be a lower part of the Wind River sequence that is exposed on Cottonwood Creek (Sinclair and Granger, 1911, p. 105). The large fault that separates these two units was not recognized.

Granger's mention of the "dull-colored, deeply disintegrated clays

[3] As used by the U. S. Geological Survey, late Eocene is equivalent to the Uintan age of most vertebrate paleontologists. The next younger age, Duchesnean, is classified by the Survey as Eocene or Oligocene.

with some feldspathic sandstone and much gypsum" is the only recognition of the younger Eocene rocks until Wood, Seton, and Hares (1936) announced the discovery of fossil mammals of late Eocene age from a locality on Badwater Creek (loc. 3, fig. 2). Love (1939, p. 78) compared the strata here with the Tepee Trail formation of late Eocene age in the Absaroka Range, where the formation consists of flows, breccias, and tuffs. Wood, Seton, and Hares recog-

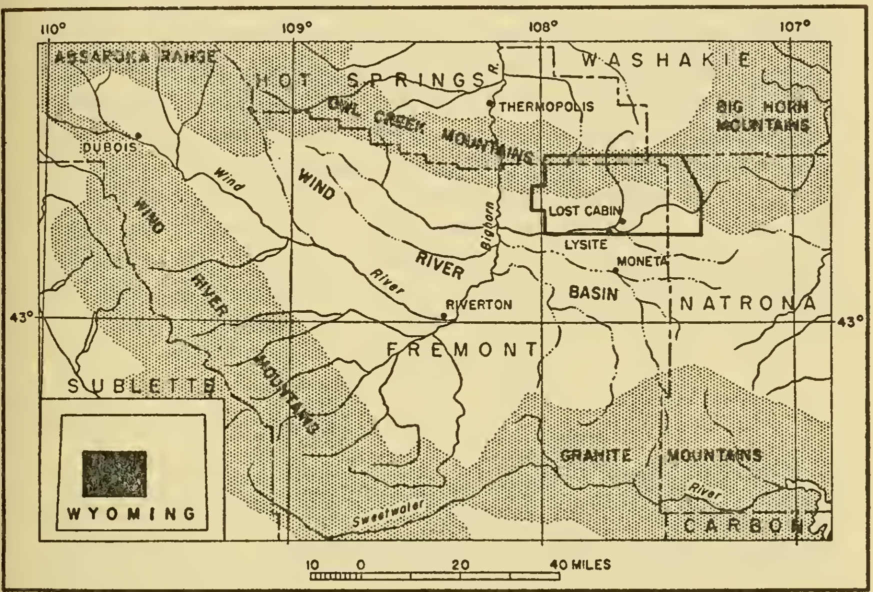


FIG. 1.—Sketch map showing location of area discussed in this report.

nized the fault that separates the strata of middle(?) and late Eocene age on the north from the Wind River formation on the south. In 1944, investigations of the geology of the area were begun by the U. S. Geological Survey to establish the structural relations between the Wind River Basin and the bordering Owl Creek and Big Horn Mountains and to map the geology of the area (Tourtelot, 1946, 1948, 1953).[4] Considerable emphasis was placed in these investigations on the Tertiary stratigraphy as a basis for interpreting the geologic history of the area. The fauna described by C. L. Gazin in Part 2 of this report was discovered during this work. The fauna was enlarged by collections made by A. E. Wood (1949) and by C. L. Gazin and Franklin Pearce in 1946 and 1953.

[4] Data from these publications are included in this report without direct citation, for the most part.

ACKNOWLEDGMENTS

I am deeply grateful to J. D. Love for guidance and inspiration during the field investigations, which were carried out under his supervision. His knowledge of deposits of Tertiary age in Wyoming and the geology of that State, freely shared, enabled me to place concepts developed from observations in the northeastern part of the Wind River Basin within the framework of the regional geologic history. G. Edward Lewis aided greatly during the fieldwork by supplying prompt identifications of fossil vertebrates submitted to him for study and by participating in many helpful discussions of stratigraphic problems. The enthusiasm and constant encouragement of Dr. Gazin have aided much in the preparation of this report. E. B. Wasson assisted in the fieldwork in 1945 and R. A. Christman in 1947; both were able and pleasant field companions. I am indebted also to the residents of the area for many helpful courtesies. Particular mention should be made of Mr. and Mrs. R. W. Spratt, Mr. and Mrs. Frank Rate, and Mrs. William Twidale and the late Mr. Twidale.

STRATIGRAPHY

THE WIND RIVER FORMATION

The Wind River formation is divided into the Lysite and Lost Cabin members, each of which consists of two facies. The members are differentiated on the basis of the composition of roundstones in the conglomerate beds and the colors of the fine-grained beds. The two members have been distinguished only in the area east of the west line of R. 91 W. In other areas, such as the remainder of the Wind River Basin, the Big Horn Basin, and elsewhere, the two names are used only to identify faunal zones, the younger of which, the Lost Cabin, is characterized by *Lambdotherium* (Sinclair and Granger, 1911; Van Houten, 1945).

The Lysite member, the oldest part of the Wind River formation exposed in the northeastern part of the Wind River Basin, consists of orange-red and yellowish-gray variegated siltstone with beds of tan to brown fine-grained to conglomeratic sandstone and some boulder conglomerate. The boulder conglomerate is exposed near the center of T. 39 N., R. 89 W., in the northwest part of Cedar Ridge. Rock pieces as large as 2 feet in diameter are common, and exceptional pieces are as much as 10 feet in maximum diameter. Conglomeratic sandstone along Cottonwood Creek, near the fault that separates the Wind River formation from the strata of middle(?)

and late Eocene age, grades southward along the scarp into orange-red fine-grained rocks. These, in turn, grade southward into gray siltstone and claystone associated with thin carbonaceous beds and sandstone in channels. The boulder conglomerate and conglomeratic sandstone contain pieces of sandstone, limestone, and dolomite derived by erosion from Paleozoic rocks. Fragments of Mesozoic rocks are included in the Lysite member along Lysite Creek in T. 39 N., R. 90 W., and sec. 9, T. 39 N., R. 89 W.

The Lost Cabin member of the Wind River formation consists chiefly of violet-red, purple, and gray variegated siltstone and claystone with beds of gray to brown fine-grained to conglomeratic sandstone and boulder conglomerate. The boulder conglomerate makes up the main mass of Cedar Ridge in the southeastern part of T. 39 N., R. 89 W. The average size of the rock pieces in the conglomerate is about 1 foot, but pieces as large as 6 feet in diameter are locally present. The boulder conglomerate grades southward into finer grained rocks, and claystone and siltstone become prominent in the sequence as the conglomeratic beds disappear. Channels filled with sandstone are a conspicuous feature of the fine-grained facies of the member. The boulder conglomerate is made up almost entirely of granite, gneiss, and other igneous and metamorphic rocks eroded from the Big Horn Mountains.

The two members of the Wind River formation could not be separated west of R. 91 W., but boulder conglomerate similar to that in Cedar Ridge forms prominent hills just south of the Cedar Ridge fault in T. 39 N., R. 92 W., and also grades southward into finer grained rocks.

Together, the composition and other characteristics of the Lysite and Lost Cabin members of the Wind River formation indicate a tectonically active mountain front shedding debris into the adjacent basin. The coarseness of the boulder conglomerate suggests that depositional slopes may have been steep. The Paleozoic and Mesozoic materials in the Lysite member and the Pre-Cambrian material in the overlying Lost Cabin indicate the progressive nature of the deformation undergone by the mountains and their contemporaneous erosion.

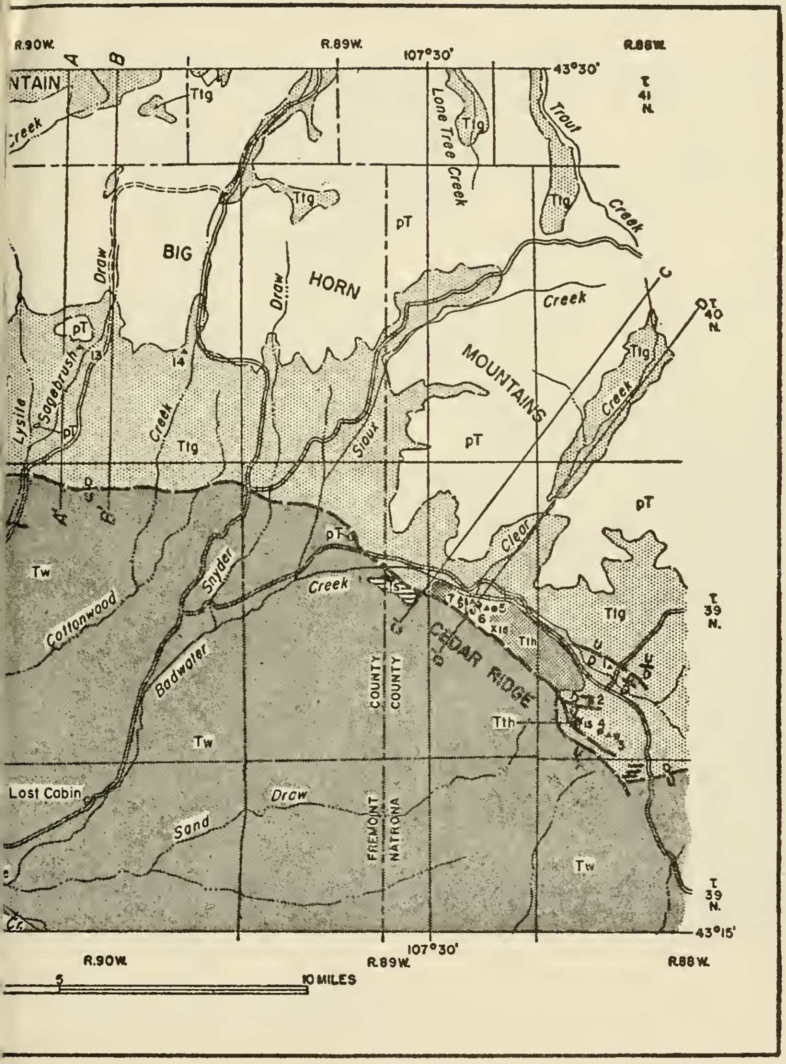
THE TEPEE TRAIL FORMATION

In the Absaroka Range, about 70 miles west-northwest of the northeastern part of the Wind River Basin, Love applied the formation name "Tepee Trail" to a thick sequence of volcanic sedimentary rocks that also include volcanic breccias, tuffs, and some flows. The formation was named for a local trail near the East Fork River about 18 miles northeast of Dubois (Love, 1939, pp. 73-79). The Tepee Trail formation was provisionally assigned a late Eocene age on the basis of a small number of vertebrate fossils and the position of the formation above strata of middle Eocene age and beneath strata assigned an Oligocene age. Love commented (1939, p. 78) on the similarity in composition and age between the Tepee Trail formation and the strata in the northeastern part of the Wind River Basin of middle(?) and late Eocene age.

Masursky (1952) traced the Tepee Trail formation of Love eastward along the north side of the Owl Creek Mountains to a point in T. 43 N., R. 100 W., Hot Springs County. Tourtelot and Thompson (1948) mapped the andesitic sequence of middle(?) and late Eocene age westward along the northern margin of the Wind River Basin to a point in T. 6 N., R. 4 E., which is about 30 miles southeast of the easternmost area of the Tepee Trail formation of Love mapped by Masursky. The andesitic sequence is correlated with the Tepee Trail formation of Love on the basis of lithologic and compositional similarity, and age; the name "Tepee Trail" is here applied to the andesitic sequence in the northeastern part of the Wind River Basin.

The Tepee Trail formation in the northeastern part of the Wind River Basin forms a belt of outcrop along the south side of the Owl Creek and Big Horn Mountains. The south boundary of the belt is relatively straight and is everywhere marked in the area shown in figure 2 by a normal fault along which the Tepee Trail formation has been dropped down against the Wind River formation. The north boundary of the belt of outcrop is highly sinuous, reflecting the overlap of the Tepee Trail on the rough topography of the pre-Tertiary rocks of the mountains. Isolated masses of strata rich in volcanic material and assigned to the Tepee Trail formation occupy the upper part of stream basins on both the south and north sides of the mountains. Examples are upper Clear Creek in T. 40 N., R. 88 W. (fig. 2), and the basins of Trout, Lone Tree, and Nowood Creeks on the north side of the Big Horn Mountains, and West Bridger and smaller creeks to the west on the north side of the Owl Creek Mountains. Lysite Mountain is a plateau-like remnant of the Tepee Trail formation in which the strata lap southward on and across both the Big Horn and Owl Creek Mountains and extend into the Wind River Basin. The Tepee Trail strata of Lysite Mountain form a sharp escarpment facing north into the Big Horn Basin about 8 miles north of the north edge of the area shown in figure 2.

The maximum thickness of the Tepee Trail formation is not readily



R.90W.
R.89W.
107°30'
R.88W.
43°30'
T. 41 N.
NTAIN
Tig
Creek
Lone Tree Creek
Trout Creek
BIG
HORN
MOUNTAINS
Draw
pT
Creek
T. 40 N.
Sagebrush
Lysite
Sioux
Clear
Creek
Tth
T. 39 N.
Tw
Cottonwood
Snyder
Badwater
CEDAR RIDGE
COUNTY
COUNTY
FREMONT
NATRONA
Lost Cabin
Draw
Sand
T. 39 N.
43°15'
R.90W.
R.89W.
107°30'
R.88W.
5
10 MILES

on.

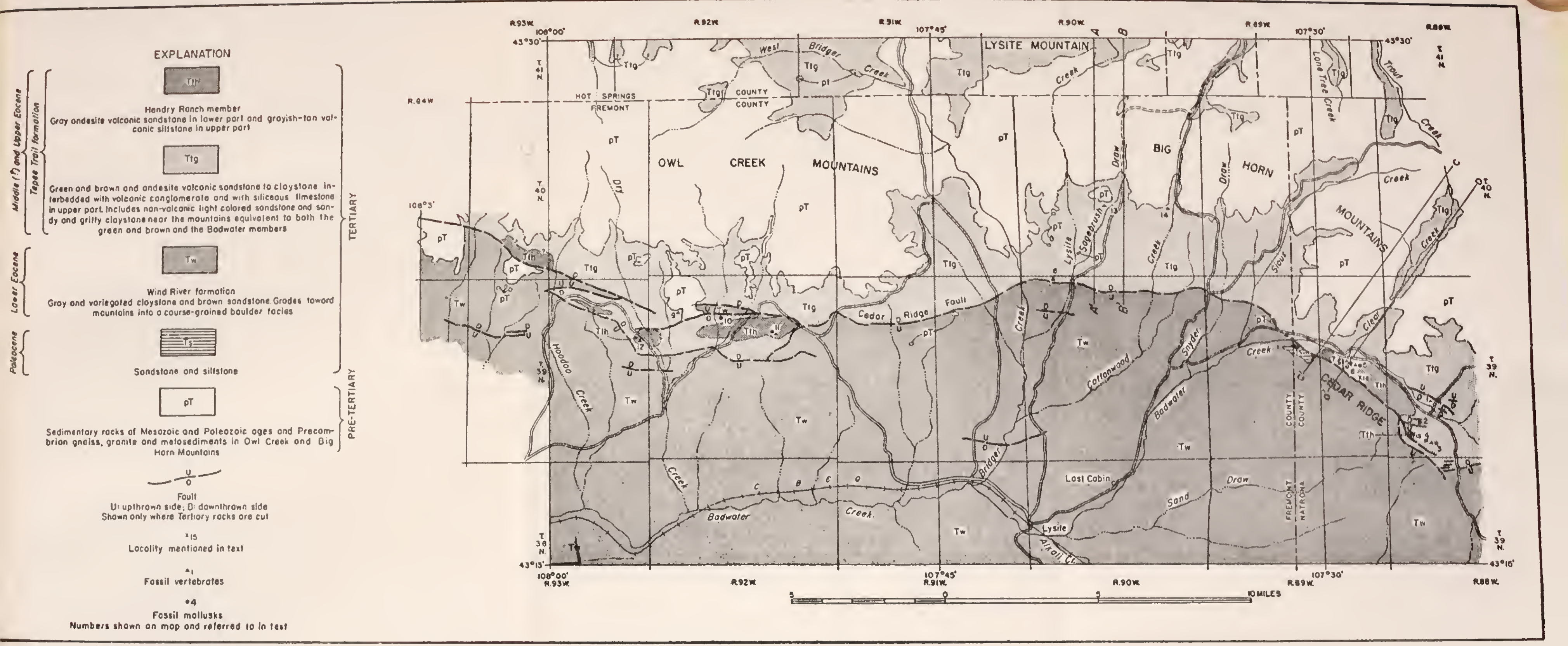


Fig. 2.—Geologic map of northeastern Wind River Basin showing distribution of Tepee Trail formation.

determinable because of its overlap on the topography of the mountains and because the base of the formation is not exposed within the area of figure 2. The top of the formation is everywhere an erosional surface. A composite section of the formation, pieced together from exposures between Cedar Ridge and Badwater Creek in T. 39 N., R. 89 W., indicates the presence of about 700 feet of strata assigned to the Tepee Trail formation (fig. 5). Correlations between the sections are made somewhat uncertain by discontinuous exposures and by minor faulting. On the north face of Lysite Mountain, about 520 feet of Tepee Trail strata are present. As much as 150 feet of the Tepee Trail is exposed in a continuous section at only a few places on the south side of the mountain ranges. The Tepee Trail formation consists of a sequence of green, brown, and gray strata rich in volcanic material of andesitic composition.[5] The sequence can be divided into lower and upper members in exposures south of the mountain front, and an essentially nonvolcanic facies equivalent to both members directly adjacent to the mountains or in some reentrants within them (fig. 3). The lower member consists chiefly of green and brown rocks ranging in texture from conglomerate to claystone with some limestone. The upper member consists chiefly of gray and greenish-gray fine-grained strata overlain by tan siltstone. The nonvolcanic facies is made up of white and light-gray pebbly claystone and mudstone and is referred to as the white clastic facies.

Green and brown member.—The most characteristic lithologic features of the green and brown member of the Tepee Trail formation are bedded sedimentary rocks rich in volcanic material and zones of conglomerate containing roundstones of hard andesite and hard tuff(?) embedded in a coarse-grained matrix of similar volcanic material. The colors are independent of the lithology, in large part, and at some places the green color seems to be a secondary feature, the nature and origin of which have not been studied. Along Badwater Creek (southwestern part of T. 39 N., R. 88 W.) and along Dry Creek (sec. 8, T. 39 N., R. 92 W.), light-colored siliceous freshwater limestone is prominent in the upper part of the member. Just east of Snyder Draw (sec. 29, T. 40 N., R. 89 W.) is a small out-

[5] In previous reports on this area, the Tepee Trail rocks have been called "tuffs." Actually, the final depositing agent of nearly all the rocks was running water and the aerial transport of the volcanic material to the area, necessary for the use of the pyroclastic rock name "tuff" (Wentworth and Williams, 1932; see also Hay, 1952), can only be inferred. Although many of the strata are clearly resedimented tuffs that have been transported only a short distance by water, use of the terms proposed by Wentworth and Williams for water-laid volcanic material is more accurate and is followed in this report.

crop of fresh-water limestone interbedded with coarse-grained volcanic sandstone. The beds of limestone contain some fine-grained volcanic material, and at most places are highly siliceous with large irregular masses of gray to green chalcedony and chert that has replaced the limestone. Small well-defined nodules of black chalcedony are common. The limestone is abundantly fossiliferous in localized areas; gastropods are commonest, pelecypods and vertebrate remains

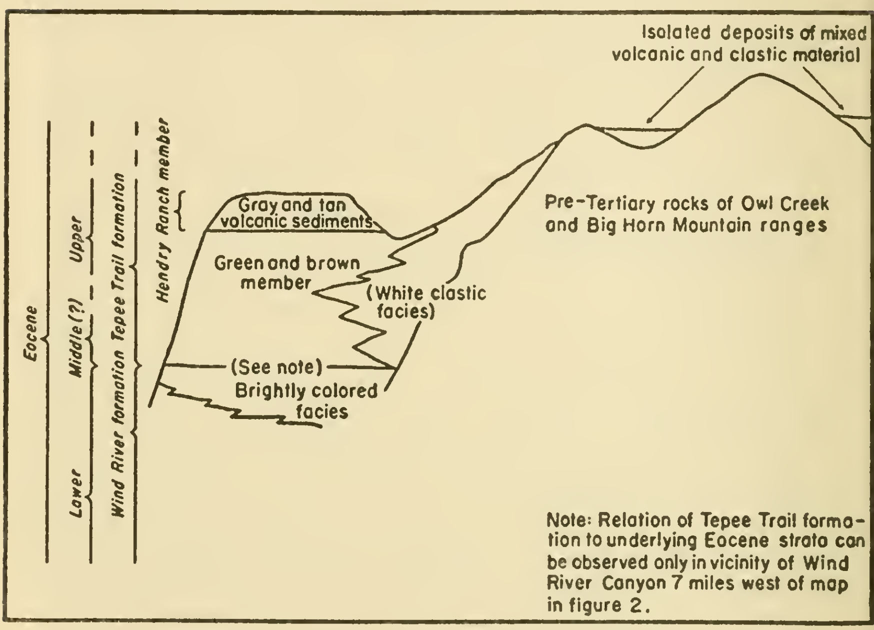


FIG. 3.—Diagrammatic cross section showing relations of facies of Tepee Trail formation.

being less abundant. Prop roots of palms, replaced by bluish-black chalcedony, are abundant and conspicuous in the limestone. On Badwater Creek, the siliceous limestone apparently passes laterally to the northwest into bright emerald-green volcanic sandstone.

The volcanic rocks in the Absaroka centers are mostly andesitic, although basaltic breccias and tuffs are present (Love, 1939, p. 76). The detrital volcanic rocks in the northeastern part of the Wind River Basin are similar in composition to the Absaroka rocks. Labradorite, as determined by measurement of extinction angles, is the commonest plagioclase, although one thin section contained bytownite. Biotite and euhedral hornblende are abundant; hypersthene and pigeonite are common. Shards of somewhat altered glass are abundant in some of the finer grained rocks. The minerals occur mostly as anhedral to euhedral crystals and the rocks would be classified as crystal tuffs, for the most part, except for their deposition in running water. Lithic fragments are common in most rocks, however, and are the major constituent in some. The lithic fragments are subrounded and are most abundant in association with strata that contain roundstones of volcanic rock.

The green and brown member is fairly uniform in its gross lithologic characteristics, being readily recognizable by its colors alone at most places. On the north side of Badwater Creek (loc. 1 and vicinity, fig. 2), the rocks consist of light-gray to grayish-brown hard ledgy fine-grained limy andesitic volcanic sandstone and siltstone somewhat different in gross appearance from most beds in the Tepee Trail. A fragmentary tooth identified as *Amynodon?,* characteristic of the Tepee Trail of this area, suggests that this sequence is only a locally different facies of the Tepee Trail formation.

The abrupt lithologic changes, on a bed-by-bed basis, that characterize the green and brown member of the Tepee Trail are shown by two sections in adjacent parts of secs. 22 and 27, T. 40 N., R. 90 W. (fig. 4), near the mouth of Sagebrush Draw. Green colors are striking in the rocks at the exposures in sec. 27 but are entirely missing in the section only about half a mile to the north. Both sections have more yellow and gray colors than is common along the south end of the Big Horn Mountains. The only feature that appears to be common to the two sections is a conglomerate zone 40 to 50 feet below the base of the gravel that caps the pediment surface below which the two sections are exposed. The conglomerate zone, however, is not continuous between the two sections.

Gypsum and crystalline selenite are abundant on the weathered surface of these exposures. Selenite also forms on the weathered surface of Tepee Trail strata in other parts of the area but is particularly conspicuous here. The siltstone and claystone have no obvious pyrite content and the origin of the selenite is not known. It is possible that these outcrops are the "deeply disintegrated clays . . . and much gypsum" mentioned by Granger (Sinclair and Granger, 1911, p. 105).

At several places, rocks of the green and brown member contain abnormally large amounts of selenium, as much as 187 parts per million being found in one bed in sec. 3, T. 39 N., R. 91 W., Fremont County (Beath, Hagner, and Gilbert, 1946, p. 11). At this place, the rocks are red, white, ocher, green, and brown, and range from coarse grained to fine grained. The red colors are anomalous in the

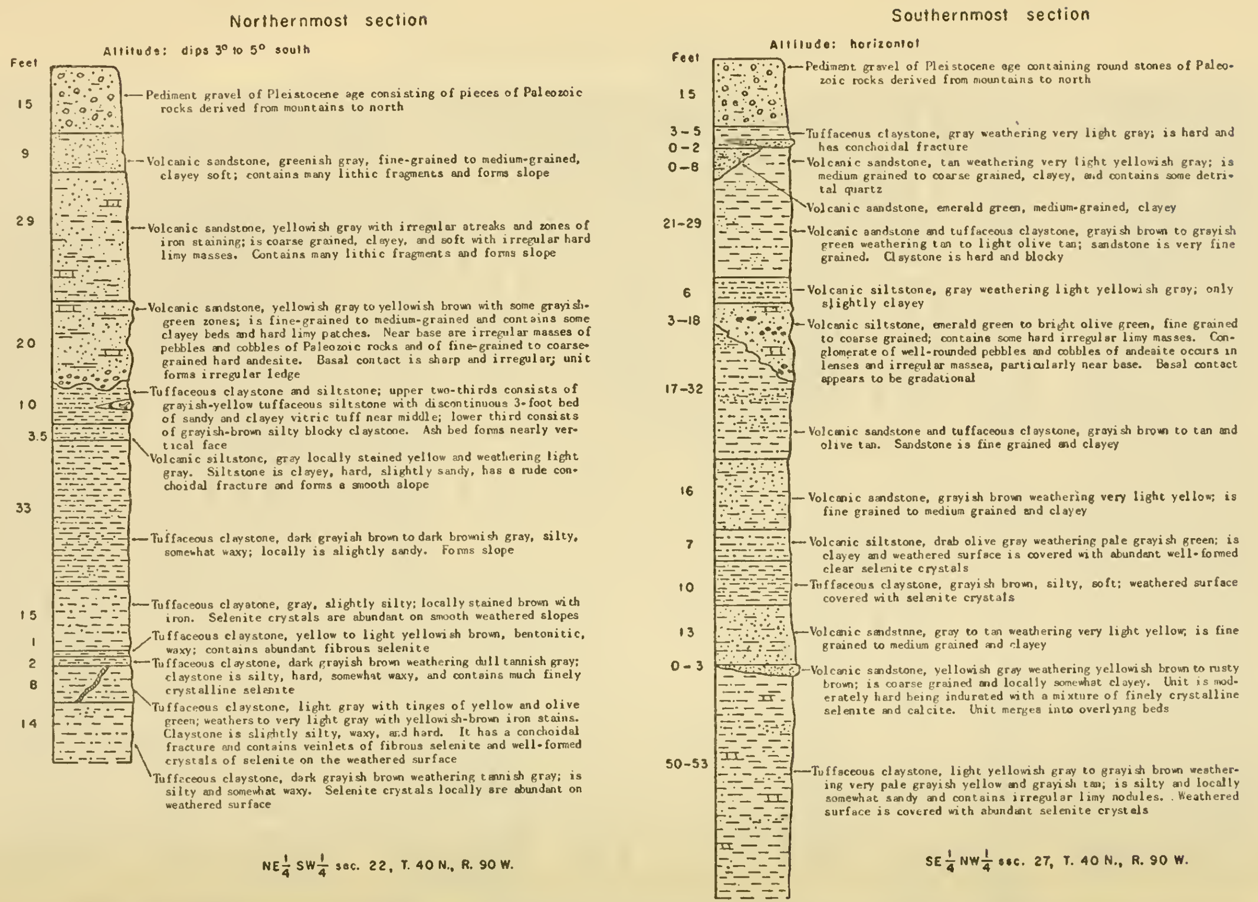


FIG. 4.—Sections of green and brown member of Tepee Trail formation near mouth of Sagebrush Draw.

member and are found in a fan-shaped area having its apex in a strike valley eroded in the Amsden formation of Pennsylvanian age on the north flank of the Owl Creek Mountains. The red color presumably is derived from the Amsden formation, which contains red fine-grained rocks. Selenium-bearing vegetation on the green and brown member is detectable by its odor, particularly in the spring or after a shower of rain, in sec. 24, T. 40 N., R. 90 W., and at several places along the south flank of the Owl Creek Mountains in the northwestern part of T. 39 N., R. 91 W., and the northeastern part of T. 39 N., R. 92 W. The selenium content of the rocks is thought to be related to their volcanic constituents (Beath, Hagner, and Gilbert, 1946). Uranium minerals have been found in the green and brown member at a few places (Love, 1954).

Hendry Ranch member.—The green and brown member is overlain by gray and greenish-gray claystone and siltstone and tan siltstone rich in volcanic material in five areas along the northern margin of the Wind River Basin. The easternmost, and largest, area lies between the Cedar Ridge fault and Badwater Creek in T. 39 N., Rs. 88 and 89 W., Natrona County. The other four are in Tps. 39 and 40 N., Rs. 92 and 93 W., Fremont County, in the western part of the map in figure 2. In each of these areas, the gray and greenish-gray unit and tan siltstone form the youngest part of the Eocene section. The new name "Hendry Ranch member" is applied to this sequence. The name is derived from Hendry Ranch in the NE¼SE¼ sec. 14, T. 39 N., R. 89 W., Natrona County, as shown on the topographic map of the Badwater quadrangle. Good but discontinuous exposures of the Hendry Ranch member are found south of the ranch and to the southeast along Badwater Creek; from them was collected the largest part of the late Eocene fauna described by Gazin (1956) in Part 2. The type section (fig. 5) of the Hendry Ranch member is a composite one including three localities, all in Natrona County: locality 15 (fig. 2), NE¼ sec. 31, T. 39 N., R. 88 W., which includes the contact of the Hendry Ranch member with the fresh-water limestone of the underlying green and brown member of the Tepee Trail formation; locality 7 (fig. 2), SW¼ sec. 14, T. 39 N., R. 89 W., which displays typical exposures of fossiliferous gray and greenish-gray rocks; and locality 16 (fig. 2), NE¼ sec. 23, T. 39 N., R. 89 W., which contains the tan siltstone that makes up the upper part of the Hendry Ranch member. The maximum preserved thickness of the Hendry Ranch member is about 550 feet, based on measurements in localities 7 and 16 above.

The lower part of the Hendry Ranch member of the Tepee Trail

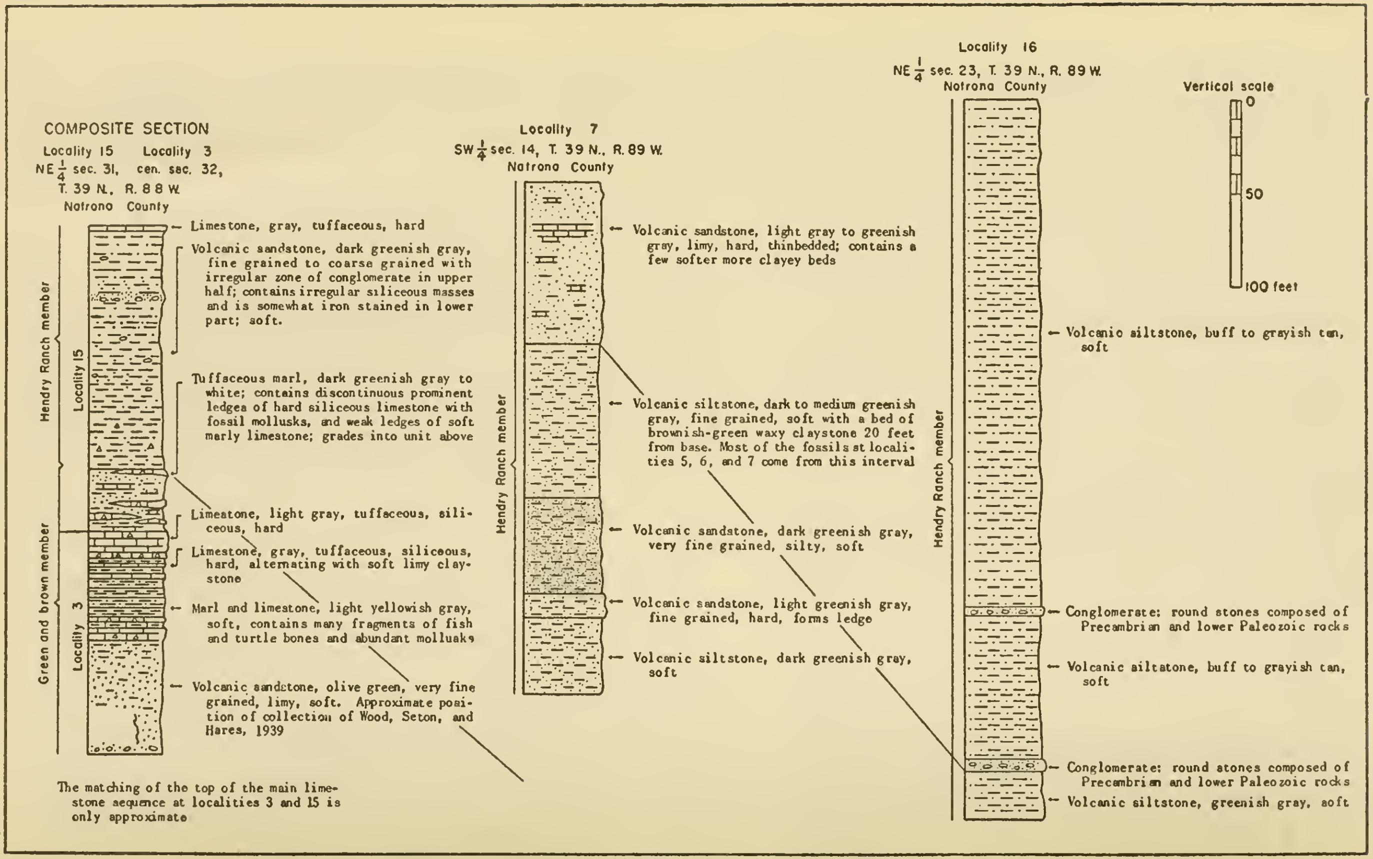


FIG. 5.—Stratigraphic sections of Hendry Ranch member of Tepee Trail formation.

Fossiliferous strata of Hendry Ranch member of Tepee Trail formation. Upper, locality 7 (see figs. 2 and 3), part of the type section of the Hendry Ranch member. Lower, locality 6, about half a mile east of locality 7. The ledge near the bottom of the sequence marks the same horizon at both localities. The first fossils from the Hendry Ranch member were found at these localities. (See table 1 for list of fossils.)

formation is made up of gray and greenish-gray andesitic volcanic sedimentary rocks and the upper part is tan volcanic siltstone. The greenish-gray unit has a maximum thickness of about 200 feet and the siltstone unit has a maximum thickness of about 350 feet. Single exposures of the lower unit do not reveal more than about 150 feet of strata. The siltstone unit is the youngest part of the sequence and its top is an erosional surface; the original thickness of the siltstone cannot be determined.

The Hendry Ranch member is consistent in its major lithologic characteristics and is easily recognizable wherever seen, even in areas of only partial exposure. The member is confined to isolated areas of outcrop, and no facies changes were detected.

The greenish-gray volcanic claystone and siltstone weathers to smooth badland slopes at most places. In general, the rocks in the greenish-gray unit are finer grained than the rocks in the underlying green and brown member. Irregular ledges of harder and more limy siltstone and sandstone are present in some exposures and one such ledge is particularly prominent at localities 6 and 7 (pl. 1). Thin beds of gray to black waxy claystone are present in the upper part of the same exposures. Crystals of selenite are abundant on the surface of most outcrops. Local lenses of fine-grained chert and quartz pebble conglomerate are interbedded with the tuffs.

The volcanic material in the rocks corresponds in composition to an andesite. The plagioclase feldspar is andesine, instead of labradorite as in the green and brown member of the Tepee Trail formation. Not enough petrographic work has been done on the Tepee Trail to evaluate the significance of the apparent difference in feldspars in the two members. Light-tan to greenish-brown biotite and hornblende are abundant and a few delicate shards of altered glass are present in most thin sections.

At many places the rocks weather to a nodular surface very similar to the "nodular zones" of the Oligocene sequences in Nebraska and South Dakota. Some of such nodular zones have been interpreted as parts of paleosol complexes by Schultz, Tanner, and Harvey (1955). The nodular zones in the lower part of the Hendry Ranch member contain *Glypterpes*, cf. *G. veternus*, a large land snail, and also clay- and calcite-filled borings similar to the fossil larval chambers of insects described by Brown (1934, 1935), apparently indicating subaerial conditions during deposition of the rocks. The nodules have yielded most of the fragmentary fossil vertebrates found in the Hendry Ranch member, a type of occurrence typical of the paleosol complexes reported by Schultz, Tanner, and Harvey (1955).

The tan volcanic siltstone unit of the Hendry Ranch member was found only along Badwater Creek north of Cedar Ridge and in a small area just north of locality 11 (sec. 10, T. 39 N., R. 92 W.). The siltstone is soft and forms poorly exposed slopes in contrast to the lower member, which forms badlands areas. The siltstone ranges in color from grayish tan to pale greenish gray, and gray; it is somewhat limy throughout, poorly bedded, and irregularly jointed. At most places, two beds of white limy vitric tuff as much as 3 feet thick are present in the lower part of the sequence. The vitric tuff beds are highly lenticular and are missing at locality 16 (figs. 2 and 5). The siltstone unit contains much admixed volcanic material, however, particularly in its lower part. Lenses of bright-green volcanic-rich sandstone are present at some places. At locality 7 (figs. 2 and 5), medium-grained to coarse-grained volcanic sandstone at the base of the siltstone unit lies on greenish-gray claystone and siltstone.

Lenses of conglomerate and coarse-grained sandstone made up of pieces of Pre-Cambrian and Cambrian rocks as much as 1 foot in diameter are common in the lower part of the siltstone unit and in the upper part of the greenish-gray unit. In some places, fragments of light-grayish-green siltstone from the lower unit are included in lenses of intraformational conglomerate in the lower part of the siltstone unit.

The change from greenish-gray rocks below to tan siltstone above takes place within a few feet, but no consistent criteria were found for separating the two units along their contact. The most usable contact for field mapping is where the material in which the conglomerate lenses are included changes from the gray claystone and siltstone of the lower unit to the tan siltstone of the upper unit. Where conglomerate or coarse-grained material is not present, this change occurs about at the base of a bed of white vitric tuff. However, in local areas, there is prominent channeling at the contact. This channeling may account in part for the thinning of the underlying lower greenish-gray unit from place to place.

The white clastic facies.—The white clastic facies (fig. 3) consists chiefly of material eroded from the Owl Creek and Big Horn Mountains and deposited directly adjacent to the mountains or in reentrants within them. Volcanic material is mixed in different amounts with the derived clastics but the essential characteristic of the rocks of the white clastic facies is the general absence of volcanic material compared to the rest of the Tepee Trail formation. The white clastic facies is particularly well developed along the south side of the Owl Creek Mountains and is conspicuous in the area embraced by the forks of Dry Creek (Tps. 39 and 40 N., Rs. 92 and 93 W.). The facies is prominent also between the westernmost fork of Dry Creek and Hoodoo Creek. In the Dry Creek drainage, the facies consists of very light-gray to white pebbly and sandy claystone and very clayey sandstone. The rather uniform admixture of sand and pebbles gives the claystone a somewhat cementlike appearance. Although some of the sandstone beds show sorting and bedding, in general, the facies shows an absence of sorting during its deposition. Pebbles of quartz and feldspar and abundant sand grains are scattered through the claystone like raisins in a pudding. The very poor sorting and general lack of bedding is suggestive of mudflows but no other evidence of this kind of deposition was recognized. Most of the clay beds in this sequence weather to a soft puffy surface and the clay in such beds probably is bentonitic. Some of the light-colored claystone is hard and only slightly plastic when wet. The forks of Dry Creek drain an area in the Owl Creek Mountains made up chiefly of pink to brown granite and the feldspars in these rocks could have yielded kaolinitic weathering products during Tepee Trail time. Such claystone may be kaolinitic but no mineralogical study was made.

East of Hoodoo Creek, the facies is yellow to brown and contains several distinctive dull-red beds. Cobbles of granite and dark-colored gneiss, phyllite, and schist are abundant. The generally more somber color of these exposures and lack of the white claystone characteristic of the Dry Creek area is believed to be related to the dark-colored gneiss, schist, and phyllite in the area drained by Hoodoo Creek. The lateral gradation of the clastic material eroded from the mountains into the green and brown volcanic sediments of the Tepee Trail is well displayed along the sides of pediment benches in the area between Hoodoo Creek and the west fork of Dry Creek.

The white clastic facies is typically developed along Lysite Creek (T. 40 N., R. 90 W.) and was derived chiefly from Paleozoic rocks. Red colors are common in the facies near where it overlaps Pennsylvanian and Permian rocks in the mountains. This is particularly noticeable in the reentrant in the Big Horn Mountain front in T. 39 N., R. 88 W., north of locality 1 (fig. 2).

The equivalence of outcrops of the white clastic facies and the Hendry Ranch member of the Tepee Trail formation can only be inferred. The Hendry Ranch member is found only in areas isolated from the Tepee Trail strata adjacent to the mountains. At the same time, the equivalence of material of the white clastic facies and the Hendry Ranch member is believed certain because material of the white clastic facies is found in the mountains at altitudes much above the outcrops of the Hendry Ranch member. Some part of the intermixed volcanic and clastic material in the Clear Creek Basin (fig. 6), for example, undoubtedly is equivalent to at least part of the Hendry Ranch member.

Age.—The age of the Tepee Trail formation in the northeastern part of the Wind River Basin is considered to be middle(?) and late Eocene. The Hendry Ranch member has yielded a fauna that is late

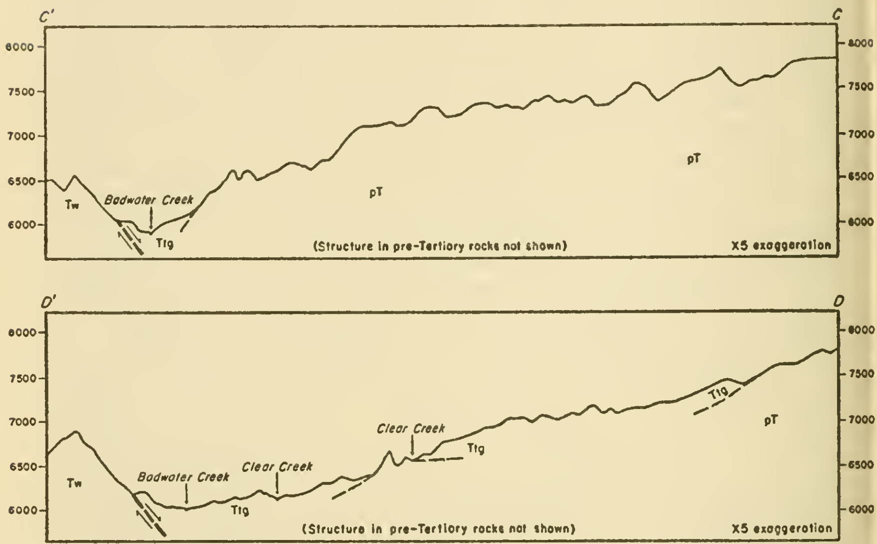


FIG. 6.—Cross sections along Clear Creek Valley (D'-D) and along ridge parallel to and 1 mile northwest of Clear Creek (C'-C) showing Tepee Trail formation filling valley.

Eocene in age and suggests equivalence with an upper Uintan stage according to Gazin (see Part 2). The green and brown member has not yielded many or very well preserved fossils but those that are known, according to Gazin, also are late Eocene in age. Locality lists of vertebrate and invertebrate fossils from the Tepee Trail formation in the northeastern part of the Wind River Basin are shown in table 1. Tentative assignment of a possible middle Eocene age to the lower part of the Tepee Trail formation is based upon the absence of recognizable rock sequences yielding middle Eocene fossils in the northeastern part of the Wind River Basin and upon the relation of the Tepee Trail formation to underlying rocks in adjacent areas.

The type Tepee Trail formation in the Absaroka Range lies unconformably upon the Aycross formation, the type area of which has yielded middle Eocene fossils (Love, 1939, p. 70). In exposures on

TABLE 1.—*Upper Eocene fossils from northeastern Wind River Basin, Wyoming*

Map number	Location	Formation or member	Fossils
1	29-39N-88W, SWNE	Tepee Trail	*Amynodon?* sp.
2	29-39N-88W, SWSW	Tepee Trail	*Lymnaea similis, L. vetusta, Lymnaea* sp., *Physa* cf. P. *bridgerensis, Physa* cf. *P. pleromatis, Australorbis spectabilis, Vertigo arenula* [1]
3	32-39N-88W, NWSE	Tepee Trail	*Amynodon advenus*, brontotheriid indet., crocodilian, *Australorbis spectabilis, Lymnaea* sp.[2]
4	32-39N-88W, SENW	Tepee Trail	*Goniobasis ternera, Lymnaea similis, Australorbis* cf. *A. spectabilis, Unio haydeni, Unio* sp.[1]
5	13-39N-89W, SWSW	Hendry Ranch	Carnivora indet., *Miacis* cf. *M. robustus, Limnocyon?* sp., *Epihippus* cf. *gracilis, Desmatotherium woodi, Dilophodon* cf. *D. leotanus, Epitriplopus?* sp., *Pentacemylus?* sp., *Protoreodon pearcei, P. petersoni, Leptotragulus* cf. *medius*, Leptoreodon? sp., *Peratherium* sp., *Glypterpes* cf. *G. veternus, Rapamys?* sp., large paramyid, smaller paramyid, *Sciuravus dubins, Protadjidaumo* sp., rodent indet., *Mytonolagus wyomingensis* [3]
6	14-39N-89W, SESE	Hendry Ranch	*Epitrilopus?* sp., *Hyopsodus* cf. *H. uintensis, Protoreodon petersoni, Diplobunops* cf. *D. matthewi, Dilophodon* cf. *D. leotanus, Leptotragulus* cf. *L. medius, Glypterpes* sp., *Physa* sp.
7	14-39N-89W, SWSE	Hendry Ranch	*Epihippus* cf. *parvus, Dilophodon* cf. *leotanus, Desmatotherium woodi, Apriculus praeteritus, Malaquiferus tourteloti, Protoreodon pearcei?*, leptomerycid.
8	6-39N-90W, NENE	Tepee Trail	*Palaeosyops?* sp.
9	7-39N-92W, NENE	Tepee Trail	*Hyrachyus*(?) sp.
10	9-39N-92W, NWSW	Tepee Trail	*Lymnaea similis, Lymnaea* sp., *Physa* sp., *Australorbis spectabilis, Vertigo arenula* [1]
11	10-39N-92W, SESE	Hendry Ranch	*Malaquiferus tourteloti, Eomoropus anarsius,*[4] *Glypterpes* cf. *G. veternus*
12	13-39N-93W, NWNE	Hendry Ranch	*Sciuravus?* sp.
13	21-40N-90W, SWSE	Tepee Trail	Titanothere
14	23-40N-90W, SWSE	Tepee Trail	Titanothere

[1] Yen, 1948, 1949.
[2] Wood, H. E., 2d, Seton, and Hares, 1936.
[3] Wood, A. E., 1949.
[4] Fieldwork by Gazin in 1956 has shown this specimen to be from SE¼SE¼ sec. 9, T.39N., R.92W.

the north face of Lysite Mountain, Tepee Trail strata lie with apparent conformity on lake beds of Green River type about 220 feet thick (Tourtelot, 1946). These lake beds are identical in type to those in the Tatman formation in the central part of the Big Horn Basin to the north. The relations between the Tatman formation and the lake beds and the overlying strata of the Tepee Trail formation of Lysite Mountain actually are indeterminable, but the available data suggest that middle Eocene time may well be represented in the lower part of the Tepee Trail.

The top of the lake beds at Lysite Mountain is at an altitude of about 6,400 feet. On Tatman Mountain, 70 miles northwest of Lysite Mountain, the Tatman formation is about 700 feet thick (Van Houten, 1944, p. 194) and the uppermost beds preserved are at an altitude of about 6,200 feet. At Squaw Buttes, 55 miles northwest of Lysite Mountain, the Tatman formation is about 800 feet thick (Van Houten, 1944, p. 192), and the uppermost beds preserved are at an altitude of about 5,900 feet. Although the present altitude of the Tatman formation is in part the result of post-Tatman structural movements (Van Houten, 1944), the essential uniformity of altitude of the youngest lake beds in the three areas mentioned makes it possible to interpret them as parts of a single episode of lake deposition. The Tatman formation is considered to be early Eocene in age in the central part of the Big Horn Basin (R. L. Hay, personal communication, 1956), but the lake beds on Lysite Mountain could be either early or middle Eocene in age, or both. Even if the lake beds on Lysite Mountain should be considered to be middle Eocene in age, there is no line of evidence to suggest that all of middle Eocene time is represented there. The continuation of lake deposition from early to middle Eocene time in southwestern Wyoming and Utah is well known. Dane (1954) has shown that parts of the ancient Green River Lake persisted even into late Eocene time.

Somewhat similar age relations of the lower part of the Tepee Trail formation can be deduced from the sequence in the Boysen area (Tourtelot and Thompson, 1948), just west of the area shown in figure 2. In the Boysen area, near Wind River Canyon, the Tepee Trail formation rests with apparent conformity on a brightly colored sequence continuous with the lower part of the Wind River formation. The brightly colored sequence was considered by Tourtelot and Thompson to be a part of the Wind River formation that might be of early middle Eocene age. This leaves most of the middle Eocene to be accounted for, and, provisionally, it is here considered to be represented in the lower part of the Tepee Trail formation of the northeastern part of the Wind River Basin. The Tepee Trail formation in the northeastern part of the Wind River Basin thus may include rocks of the same age as the upper part of the Aycross formation in the northwestern part of the Wind River Basin.

Van Houten (1950, 1954, 1955) has described a formation of both middle and late Eocene age, rich in volcanic material, along the southern margin of the Wind River Basin. This formation includes material from both the Absaroka volcanic center and the Rattlesnake Hills, a volcanic field of middle and late Eocene age in southern Natrona County. The middle Eocene part of this sequence is not separable from the late Eocene part of the sequence on a lithologic basis.

STRUCTURE

The Tepee Trail strata of the northeastern part of the Wind River Basin are moderately deformed. The most prominent structural feature involving the Tepee Trail formation is the Cedar Ridge fault, which everywhere within the area of figure 2 forms the southern boundary of the Tepee Trail outcrop area. Most of the structural features within the outcrop area of the Tepee Trail are related to this fault, the displacement of which is indeterminable. A minimum displacement of about 1,000 feet, however, is indicated for that part of the fault in T. 39 N., R. 89 W. Here, a total of about 500 feet of Tepee Trail strata is exposed near the fault, and the top of these beds is about 500 feet below the top of Cedar Ridge which is made up of Wind River boulder beds. This is the largest displacement that can be demonstrated but the actual displacement on the fault may be much larger.

In the Dry Creek drainage, the Cedar Ridge fault divides into several branches that enclose grabens in which Tepee Trail strata are found, and horsts made up of boulder beds assigned to the Wind River formation. Some parts of the faults in this area cut pre-Tertiary rocks.

The Tepee Trail strata exposed along the north side of Cedar Ridge probably are cut by many normal faults of small displacement and extent. Only a few of these could be mapped and shown on figure 2. Most of the minor faults join the trace of the Cedar Ridge fault at large angles. Similar minor faults, essentially normal to the Cedar Ridge fault, probably cut Tepee Trail strata at other places along the Cedar Ridge fault but they could not be recognized. All are believed to be the result of adjustments in the relatively downward-moving block as the major faulting took place.

Near the mountains, the Tepee Trail strata dip at low angles away from the mountains. Some part of this angle of dip may represent original depositional slope; the rest is the result of the southward tilting of the mountain block in response to the movement on the Cedar Ridge fault. Near the Cedar Ridge fault, the strata dip northward at many places, the strata having been dragged upward by movement along the major fault.

The age of the Cedar Ridge fault and associated structures cannot be placed more closely than post-late Eocene. It seems likely, however, that the Cedar Ridge fault is as young as Pliocene, to conform with the pattern of normal faulting that resulted from epeirogenic uplift of the Rocky Mountain region, as pointed out by Love (1939, p. 114).

SEDIMENTATIONAL HISTORY

The sedimentational interpretation of the Eocene strata in the northeastern part of the Wind River Basin can contribute to the reconstruction of the geologic history of the Wyoming basins, which has been reviewed by Van Houten (1952). This history, briefly stated, applies chiefly to the Wind River and Big Horn Basins and is one of mountain and basin formation in late Cretaceous and early Tertiary time, with the rising mountains shedding much debris into the basins by early Eocene time. Much of the present mountain topography had been shaped by the end of early Eocene time, which seems also to mark the end of differential movement between the mountain ranges and the basins until much later in Tertiary time. From middle Eocene time through at least some part of Miocene time, and perhaps into the Pliocene, the basins were progressively filled, chiefly with volcanic material from the Absaroka-Yellowstone volcanic region. As the basins were filled the mountain ranges were buried, and eventually a broad constructional plain resulted from which are inherited many of the features of the present drainage system.

The process of basin filling was essentially continuous but it was interrupted locally from time to time (Love, 1952). During Paleocene and early Eocene time, the surfaces of deposition in the basins were not far above sea level, the increasing amount of sediments in the basins being accommodated by differential movements between the mountains and the basins. From middle Eocene time on, the surfaces of deposition were gradually raised higher and higher, in part because the sediments accumulated without basin sinking and perhaps in part because of progressive epeirogenic uplift. Epeirogenic uplift had its major pulsation, or reached its culmination, probably in Pliocene time, as pointed out by Love (1939). It is believed that faulting, represented by the Cedar Ridge fault, and others mentioned by Love, by which the relations between mountain ranges and basins were again changed, took place at this time.

The sedimentational history of Eocene rocks in the northeastern part of the Wind River Basin can now be discussed against this background. The rocks of the Tepee Trail formation present two interesting sedimentational problems. One is the mode of transport of such large volumes of volcanic material. The other is the conditions that permitted the accumulation of volcanic material directly adjacent to a rugged topography in the pre-Tertiary rocks and prevented the erosion of them and the incorporation of the debris with the volcanic material.

Discussion of these problems necessarily is speculative in large part. Perhaps a somewhat imaginative reconstruction of events and conditions will stimulate the gathering of data bearing on such problems.

The Wind River formation in the northeastern part of the Wind River Basin represents a complex of depositional conditions. Extremely coarse debris was shed by the mountains into the basin, as evidenced by the boulder conglomerate in Cedar Ridge and in the western part of the area included in figure 2. These conglomerate masses did not extend far into the basin, however, and at the time they were accumulating near the mountains red-banded fine-grained sediments were being deposited no more than 4 or 5 miles to the south. Apparently these were derived from the uplands, large areas of which were covered with red residual soil according to Van Houten (1948). The manner of deposition of the conglomerate has not been studied. The great size of some of the boulders suggests that mudflows may have been important in moving the coarse material out of the mountains. Mudflow structures were not recognized in the conglomerate, though, perhaps because they had been obscured by reworking of the mudflow masses by streams.

In the Boysen area, west of that shown in figure 2, the mountain debris, none as coarse as that in the northeastern part of the Wind River Basin, was moved southeast from the mountain front by relatively short tributaries to a generally eastward-flowing master drainage system (Tourtelot and Thompson, 1948). The locus of successive levels of the master drainage system seems to lie about along the south margin of figure 2. The depositional pattern of the numerous channel sandstones that mark the locus of the drainageway does not change as the eastern border of the Wind River Basin is approached, and it is concluded that the basin was open to the east during at least the later part of early Eocene time.

Conditions of deposition of the Tepee Trail formation were quite different. First, the bulk of the sediment being deposited was derived from the volcanic centers in the Absaroka-Yellowstone region. Second, very little material was being eroded from the mountain ranges in contrast to the vast amount of debris that had been shed by them during early Eocene time. There is little or no evidence of any marked general climatic change, although the local climate probably was somewhat modified by the seemingly great volcanic activity no more than 70 miles or so to the west.

The well-developed bedding and rounded pebbles, cobbles, and grains of volcanic material indicate that the final agent acting on most of the material in the Tepee Trail formation was running water. Pond or quiet-water environments certainly existed, as is indicated by the fresh-water limestone and beds of claystone, but these seem to be minor in the environment as a whole. It is possible that the pebbles and cobbles of volcanic material were carried from their source to the northeastern part of the Wind River Basin entirely by streams. The presence of cobbles, however, seems to imply streams of great carrying power. Other evidence for such streams, such as channeling and relatively thick accumulations of conglomerate, are largely lacking. Also, it is difficult to imagine streams with such carrying power having courses essentially parallel to the mountain fronts and as close to them as the distribution of cobbles would indicate.

At present, the volcanic breccia, tuff, and minor intrusive rocks of the Tepee Trail formation in the Absaroka Range form steep escarpments above the Wind River Basin on the south and the Big Horn Basin on the east. These erosional escarpments clearly have little relation to the possible former extent of the materials into the Wind River and Big Horn Basins. Squaw Buttes, in the southwestern part of the Big Horn Basin, is an isolated remnant of the Early Basic Breccia (Van Houten, 1944). Although the pieces of the rock have been somewhat rounded, and the mass should be called a volcanic conglomerate (R. L. Hay, personal communication, 1956), the rock is similar in appearance and physical characteristics to the breccias of the Absaroka Range. Squaw Buttes thus appears to be a remnant of volcanic material in the deposition of which running water was not the dominant agent. Probably masses of volcanic material once extended much farther into the Wind River and Big Horn Basins than they do now. Anderson (1933) has described volcanic mudflows that traveled much farther than the present distance between Squaw Buttes and the Absaroka Range, and on slopes that were similar to those that must have existed in the Big Horn Basin. The interpretation that formerly much more extensive volcanic mudflow masses were present in both the Wind River and Big Horn Basins is believed to be reasonable and helps explain the presence of volcanic cobbles in the northeastern part of the Wind River Basin.

The volcanic cobbles have a somewhat peculiar distribution along the south side of the Big Horn Mountains. The northernmost sec-

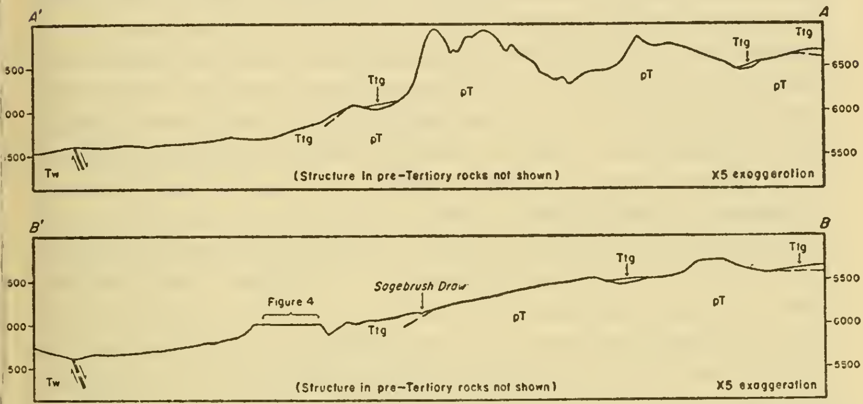


FIG. 7.—Cross sections along Sagebrush Draw (B′-B) and along ridge parallel to and 1 mile west of Sagebrush Draw (A′-A) showing position of Tepee Trail formation on north flank of Big Horn Mountains and in valley on south flank of mountains.

tion of figure 4 illustrates this distribution. The rocks shown in the section are exposed at the mouth of Sagebrush Draw where that stream leaves a canyon as much as 500 feet deep in the pre-Tertiary rocks and has its course on the Tepee Trail formation. A cross section through this canyon and a parallel section through the ridge a mile west of the canyon is shown in figure 7. At the north end of the section, strata of the Tepee Trail formation from the main mass of Lysite Mountain almost enter the upper part of the canyon. A remnant of Tepee Trail strata is preserved within the canyon, and Tepee Trail strata extend into the lower part of the canyon from its mouth. The strata in the northernmost section of figure 4 are very nearly within the mouth of the canyon, being less than half a mile distant from pre-Tertiary rocks both to the east and to the west. Volcanic conglomerate is moderately abundant in a unit about 50 feet below the top of the Tepee Trail strata exposed there but, curiously, is present in somewhat larger amounts than similar-sized material derived from the pre-Tertiary rocks. It is difficult to imagine how the volcanic material could have been placed almost within the canyon mouth by streams flowing eastward or northeastward in the Wind River Basin, even though a source for the volcanic material might have been a mudflow 50 or even 20 miles away. A similar topographic setting for Tepee Trail deposition is shown in figure 6, a cross section along Clear Creek, and a contrasting section along the ridge a mile west of the creek.

In considering this anomalous distribution of volcanic conglomerate, it should be recalled that both the Wind River Basin and the Big Horn Basin to the north were being filled at about the same time. Inasmuch as the Wind River Basin is believed to have been open to the east, and the Big Horn Basin was either closed or open to the north, there is no reason for the two basins to have filled at the same rate. Quite the contrary seems much more reasonable, in fact, when it is considered that volcanic material could enter the Wind River Basin chiefly through a relatively narrow passage at the northwest end of the basin. The middle and late Eocene volcanic material had access to the Big Horn Basin, obviously, all along the west side of the basin, 70 miles or so long. It seems logical to believe, therefore, that the Big Horn Basin was filled to the lowest topographic point between the Owl Creek and Big Horn Mountains at a time when the floor of the Wind River Basin on the south side of the mountains was still several hundred feet below this point. The lowest point between the ranges probably is concealed by the Tepee Trail strata along Bridger Creek (T. 41 N., R. 91 W.). As successively higher low points in the mountains were reached, such as the upper part of Sagebrush Draw, material would flood down the canyons to the south. Some downcutting of the canyons probably took place at this time and soon erosion into the Big Horn Basin fill permitted volcanic cobbles to move down the canyons and be deposited in their mouths.

The white clastic facies of the Tepee Trail formation clearly represents erosion of the mountains during Tepee Trail time. At very few places, however, do the rocks of the white clastic facies indicate as much vigorous sedimentational activity as suggested by the coarse volcanic sediments in the Tepee Trail. The general lack of sorting and possible mudflow deposition of some of the white clastic facies have been mentioned. The white kaolinitic appearance of some parts of the white clastic facies, particularly adjacent to areas underlain by granite, may be the result of leaching of iron from the early Eocene residual soils that were suggested by Van Houten (1948). Further investigation of this possibility would be interesting.

Although the white clastic facies and scattered fragments of pre-Tertiary rocks in the Tepee Trail formation, such as those at the mouth of Sagebrush Draw, indicate some erosion of the uplands of pre-Tertiary rocks, the amount of such materials seems anomalously small. This is particularly evident where the Tepee Trail formation was deposited at the foot of relatively steep canyons such as shown in figures 6 and 7. Whatever may have been the actual amount of material eroded from the pre-Tertiary rocks of the mountains in Tepee Trail time, it seems obvious that such locally derived material was considerably diluted and may have been masked by the larger amount of volcanic material.

A further possible explanation related to the mode of transport of the volcanic material also seems attractive. Hypothetical mud-flows, of which possibly Squaw Buttes is the only remnant, have been suggested as an agent in the transport of cobbles of volcanic rock to the northeastern part of the Wind River Basin in addition to possible stream transport of such materials from the Absaroka source. Mud-flows of such magnitude seemingly would be most likely to occur during long-continued volcanic activity in the Absaroka-Yellowstone region. It is easy to believe that large amounts of relatively fine-grained ejecta would have been carried aerially to the east. The presence of glass shards in most rocks and abundant euhedral crystals of feldspar in some of the resedimented crystal tuffs point to such a condition. If this truly pyroclastic material was transported aerially to the northeastern part of the Wind River Basin and deposited on the slopes in large enough amounts, the streams would have been choked with such debris and incapable of eroding the pre-Tertiary rocks. The pyroclastic material would have moved down the slopes either by rill wash or various kinds of mass movement. The streams at the bottoms of the slopes were short, draining only the south sides of the Big Horn and Owl Creek Moutains, and their capacities would be overloaded by relatively small amounts of pyroclastic debris. Hence, except for canyons that may have been delivering material from the Big Horn Basin into the Wind River Basin, little pre-Tertiary material could be expected to be incorporated in the Tepee Trail formation even though it was deposited at the foot of well-developed highlands.

The upper unit of the Hendry Ranch member reflects a rather large change in depositional conditions. Vitreous volcanic ash became really conspicuous for the first time in strata assigned to the Tepee Trail. In addition, erosion of the pre-Tertiary rocks seems to have become more effective, judging from the conglomerate made up of

Pre-Cambrian and Cambrian rocks in the lower part of the unit. Evidently, the rocks of later Paleozoic age now fringing the south side of the Big Horn Mountains for 3 or 4 miles both northwest and southeast of Clear Creek had been covered by older Tepee Trail strata, leaving only the Pre-Cambrian and Cambrian rocks of the highlands along the upper reaches of Clear Creek available for erosion.

REFERENCES

Anderson, C. A.

1933. The Tuscan formation of northern California, with a discussion concerning the origin of volcanic breccias. Univ. California Publ., Bull. Dept. Geol. Sci., vol. 23, pp. 215-276.

Beath, O. A.; Hagner, A. F.; and Gilbert, C. S.

1946. Some rocks and soils of high selenium content. Geol. Surv. Wyoming Bull. 36, pp. 1-23.

Brown, R. W.

1934. *Celliforma spirifir,* the fossil larval chambers of mining bees. Journ. Washington Acad. Sci., vol. 24, pp. 532-539.

1935. Further notes on fossil larval chambers of mining bees. Journ. Washington Acad. Sci., vol. 25, pp. 526-528.

Dane, C. H.

1954. Stratigraphy and facies relationships of upper part of Green River formation and lower part of Uinta formation in Duchesne, Uintah, and Wasatch Counties, Utah. Bull. Amer. Assoc. Petrol. Geol., vol. 36, pp. 402-425.

Gazin, C. Lewis.

1956. The geology and vertebrate paleontology of upper Eocene strata in the northeastern part of the Wind River Basin, Wyoming. Part 2: The mammalian fauna of the Badwater area. Smithsonian Misc. Coll., vol. 131, No. 8, 35 pp., 1 fig., 3 pls.

Hay, R. L.

1952. The terminology of fine-grained detrital volcanic rocks. Journ. Sedimentary Petrol., vol. 22, No. 2, pp. 119-120.

Love, J. D.

1939. Geology along the southern margin of the Absaroka Range, Wyoming. Geol. Soc. Amer. Spec. Pap. No. 20, pp. 1-134.

1952. Preliminary report on the uranium deposits in the Pumpkin Buttes area, Powder River Basin, Wyoming. U. S. Geol. Surv. Circ. 176, pp. 1-37.

1954. Reconnaissance for uranium in the United States, Wyoming. U. S. Geol. Surv. Trace Elem. Invest. Rep. 440, issued by U. S. Atomic Energy Commission, Techn. Inf. Serv., Oak Ridge, Tenn., pp. 175-180.

Masursky, Harold.

1952. Geology of the western Owl Creek Mountains (map). Guide Book, 7th Ann. Field Conf., Wyoming Geol. Assoc.

Osborn, H. F.

1929. The titanotheres of ancient Wyoming, Dakota, and Nebraska. U. S. Geol. Surv. Monogr. 55, vol. 2, pp. 1-953.

SCHULTZ, C. B.; TANNER, L. G.; and HARVEY, CYRIL.
1955. Paleosols of the Oligocene of Nebraska. Bull. Univ. Nebraska State Mus., vol. 4, No. 1, pp. 1-15.
SINCLAIR, S. J., and GRANGER, WALTER.
1911. Eocene and Oligocene of the Wind River and Big Horn Basins. Bull. Amer. Mus. Nat. Hist., vol. 30, art. 7, pp. 83-117.
TOURTELOT, H. A.
1946. Tertiary stratigraphy in the northeastern part of the Wind River Basin, Wyoming. U. S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 22.
1948. Tertiary rocks in the northeastern part of the Wind River Basin, Wyoming. Guide Book, 3rd Ann. Field Conf., Soc. Vert. Paleont., pp. 53-67. Also published in 1948 under same title in Guide Book 3rd Ann. Field Conf., Wyoming Geol. Assoc., pp. 112-124.
1953. Geology of the Badwater area, central Wyoming. U. S. Geol. Surv. Oil and Gas Invest., Map OM 124.
TOURTELOT, H. A., and THOMPSON, R. M.
1948. Geology of the Boysen area, central Wyoming. U. S. Geol. Surv. Oil and Gas Invest. Map PM 91.
VAN HOUTEN, F. B.
1944. Stratigraphy of the Willwood and Tatman formations in northwestern Wyoming. Bull. Geol. Soc. Amer., vol. 55, pp. 165-210.
1945. Review of latest Paleocene and early Eocene mammalian faunas. Journ. Paleont., vol. 19, pp. 421-461.
1948. Origin of red-banded early Cenozoic deposits in Rocky Mountain region. Bull. Amer. Assoc. Petrol. Geol., vol. 32, pp. 2083-2126.
1950. Geology of the western part of Beaver Divide area, Fremont County, Wyoming. U. S. Geol. Surv. Oil and Gas Invest. Map OM 113.
1952. Sedimentary record of Cenozoic orogenic and erosional events. Guide Book 7th Ann. Field Conf., Wyoming Geol. Assoc., pp. 74-79.
1954. Geology of the Long Creek-Beaver Divide area, Fremont County, Wyoming. U. S. Geol. Surv. Oil and Gas Invest. Map OM 140.
1955. Volcanic-rich middle and upper Eocene sedimentary rocks northwest of Rattlesnake Hills, central Wyoming. U. S. Geol. Surv. Prof. Pap. 274-A, pp. 1-14.
WENTWORTH, C. K., and WILLIAMS, HOWEL.
1932. The classification and terminology of the pyroclastic rocks. Nat. Res. Counc. Bull. 89, Rep. Comm. Sedimentation 1930-32, pp. 19-53.
WOOD, A. E.
1949. Small mammals from the uppermost Eocene (Duchesnean) near Badwater, Wyoming. Journ. Paleont., vol. 23, No. 5, pp. 556-565.
WOOD, H. E., 2D.; SETON, HENRY; and HARES, C. J.
1936. New data on the Eocene of the Wind River Basin, Wyoming (abstract). Proc. Geol. Soc. Amer. 1935, pp. 394-395.
YEN, TENG-CHIEN.
1948. Eocene fresh-water mollusca from Wyoming. Journ. Paleont., vol. 22, pp. 636-638.
1949. Corrections of fossil localities. Journ. Paleont., vol. 23, p. 329.