# Eocene Rocks, Fossils, and Geologic History, Teton Range, Northwestern Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 932-B

*Prepared in cooperation with the National Park Service, the Geological Survey of Wyoming, and the Department of Geology of the University of Wyoming*

# Eocene Rocks, Fossils, and Geologic History, Teton Range, Northwestern Wyoming

*By* J. D. LOVE, ESTELLA B. LEOPOLD, *and* D. W. LOVE

GEOLOGY OF THE TETON–JACKSON HOLE REGION, NORTHWESTERN WYOMING

GEOLOGICAL SURVEY PROFESSIONAL PAPER 932–B

*Prepared in cooperation with the National Park Service, the Geological Survey of Wyoming, and the Department of Geology of the University of Wyoming*

*Remnants of Eocene rocks along the modern Teton Range date the final uplift and subsidence of the ancestral Teton-Targhee arch, and determine direction of Eocene drainage*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1978

**UNITED STATES DEPARTMENT OF THE INTERIOR**

**CECIL D. ANDRUS,** ***Secretary***

**GEOLOGICAL SURVEY**

**H. William Menard,** ***Director***

Library of Congress Cataloging in Publication Data
Love, John David, 1913
Eocene rocks, fossils, and geologic history, Teton Range, northwestern Wyoming.
(Geology of the Teton-Jackson Hole region, northwestern Wyoming) (Geological Survey Professional Paper 932-B)
Bibliography: p. 37
Supt. of Docs. no.: I 19.16:932-B
1. Geology, Stratigraphic—Eocene. 2. Paleontology—Eocene. 3. Geology—Teton Range. I. Leopold, Estella B., joint author. II. Love, D. W., joint author. III. United States. National Park Service. IV. Wyoming. Geological Survey. V. Wyoming. University. Dept. of Geology. VI. Title. VII. Series. VIII. Series: United States Geological Survey Professional Paper 932-B
QE692.2.L68 557.3'08s [551.7'8] 77-608133

---

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D. C. 20402
Stock Number 024-001-03123-0

# CONTENTS



# ILLUSTRATIONS

[Plates 1–4 follow "Index"; plate 5 is in pocket]



# TABLE

# EOCENE ROCKS, FOSSILS, AND GEOLOGIC HISTORY, TETON RANGE, NORTHWESTERN WYOMING

By J. D. LOVE, ESTELLA B. LEOPOLD, and D. W. LOVE


## ABSTRACT

The Hominy Peak Formation (new name), a sequence of mafic volcaniclastic sedimentary and igneous rocks as much as 610 meters (2,000 feet) thick, is exposed at the north end and on the west flank of the Teton Range, as well as along the south boundary of Yellowstone National Park. This formation overlaps Cambrian to Paleocene strata in the core of the Teton Range, and the entire section was subsequently deformed by post-Eocene tectonic movements. The Hominy Peak contains a pollen flora that correlates with middle Eocene floras associated with Bridger A–B vertebrate faunas at several sites in northwestern and southwestern Wyoming. K-Ar ages here and in adjacent areas are compatible with this age assignment. The Hominy Peak Formation and underlying Paleozoic rocks along the south boundary of Yellowstone National Park are intruded by the dacite porphyry of the Birch Hills, which has a late Eocene fission-track age of 40.5 ±2.6 million years.

The newly discovered relations of the Eocene rocks to older and younger strata provide a more complete insight into the tectonic history of the Teton Range. The ancestral uplift trended northwest and consisted of two parts — the low, broad Gros Ventre–Teton upwarp, bounded on its southwest flank by a thrust fault, and the much higher, larger Targhee uplift, at the northwest end. The dominant tectonic forces that created this uplift moved southwestward, directly opposite those in the thrust belt to the south. Yet to be determined are the subsurface limit to the northeast margin of the thrust belt under Teton Basin and whether the belt was overridden by the ancestral Teton block.

The Targhee uplift was eroded to its Precambrian core by mid-Late Cretaceous time and, for 35 million years, was the source of gold-bearing Precambrian quartzite conglomeratic debris to Upper Cretaceous, Paleocene, and Eocene strata in the Jackson Hole region. The Targhee uplift subsided into the Teton Basin–Snake River downwarp, probably shortly after middle Eocene time, and was never again a source of sediment. This subsidence, accompanied in places by normal faulting, also involved the ancestral Teton segment of the uplift. The structurally higher part of the Eocene northeast flank was rotated downward to the west so far that it became the present west flank of the modern Teton Range.

The structurally lower part of the Eocene northeast flank of the Teton Range was even more extensively modified during late Cenozoic time. Downwarps and normal faults, some with large displacements, developed along and east of the Eocene northeast flank, and these produced Jackson Hole. These north-trending grabens and horsts isolated the Gros Ventre segment of the ancestral Targhee–Teton–Gros Ventre uplift. The modern Teton Range arose in the last 9 million years; from part of a low northwest-trending anticlinal uplift it became a north-trending, west-tilted, asymmetric faultblock range with a precipitous east face.

The timing, magnitude, and other details of the tectonic history of the region are relevant to the renewed search for oil and gas in the Wyoming-Idaho thrust belt and to geothermal-energy evaluation. Two large artesian flows of hot water, one in Cambrian and the other in Pennsylvanian rocks, in the Cities Service oil test at moderately shallow depths in Teton Basin indicate a geothermal potential in the areas of late Cenozoic subsidence west of the present Teton Range.


# INTRODUCTION

## PURPOSE OF REPORT AND SUMMARY OF RESULTS AND CONCLUSIONS

The purpose of this report is (1) to present new data that help reconstruct the geologic history of the Teton uplift in Eocene time, (2) to summarize Pliocene and Pleistocene crustal modifications that disguise the Eocene events and that account for some of the unique and more conspicuous features of the uplift, and (3) to relate the timing, magnitude, and other details of the tectonic history of the region to the search for new oil and gas deposits and to evaluate the geothermal-energy potential. After a lapse of 70 years (since Veatch's report in 1907), 1975 discoveries of major amounts of oil and gas in the southern part of the thrust belt brought a suddenly renewed interest in the entire belt. In addition, exploration of the geothermal potential in part of Idaho, 15–23 km (50–75 mi) to the southwest, has prompted a reassessment of the geothermal potential of the area west of the present Teton Range, which is structurally a part of the ancestral Teton uplift.

The Paleocene and Cretaceous history of the Teton–Jackson Hole area and its relation to most of the gold occurrences in the region have been presented elsewhere (J. D. Love, 1973; Lindsey, 1972).

The chief results of this study are:

1. A geologic map (Christiansen and others, 1978) that shows for the first time the distribution of all known remnants of Eocene rocks along the west side and at the north end of the Teton Range.
2. Preliminary data on the geothermal potential of the Teton Basin west of the Teton Range. The Cities Service oil test drilled in 1974 in Teton Basin struck flowing artesian fresh water at a reported rate of 36,000 barrels per day, and a temperature of 48°C at a depth of 856 m (meters; 2,800 ft) in Pennsylvanian rocks. Another water flow, from Cambrian rocks, was reported between 1,615 and 1,646 m (5,300 and 5,400 ft) at a rate of 40,000 barrels per day, and at a temperature of 54°C. The combined flow was estimated at about 76,000 barrels ($14.6\times10^6$ L (liters)) of water per day. Total dissolved solids were less than 500 mg/L. The volume of artesian water and its temperature indicate that the part of the downwarped Teton Basin area athwart what in Eocene time was the crest of the ancestral Teton uplift has some geothermal-energy potential as well as considerable untapped and heretofore unrecognized ground-water resources.
3. Data that help evaluate the oil and gas potential of the northeast margin of the thrust belt. Most important to this evaluation is an understanding of the timing, nature, and magnitude of the Targhee–Teton–Gros Ventre tectonic forces that diametrically opposed the forces of the adjacent thrust belt. In parts of the thrust belt to the south and in many of the more conventional anticlines to the east, oil and gas accumulation apparently is directly related to the tectonic history, although rarely is the timing of the various structural events as well documented as in the Teton area. The surface, subsurface, and geophysical studies in progress may eventually determine within reasonable limits the northeast margin of the thrust belt under Teton Basin and whether the belt was overridden by the Teton block. The part of the Teton block under Teton Basin that was downwarped in late Cenozoic time has less oil and gas potential than that under and adjacent to the southwest margin of the block.
4. Recognition of the following geologic events:
   a. The Targhee–Teton–Gros Ventre uplift was, for 35 million years, a single continuous anticline. The Targhee part at the northwest end was the broadest and highest and was the first to be eroded to the Precambrian core. This unroofing to the Precambrian occurred at least as far back as middle Late Cretaceous (middle Niobrara) time. The Teton and Gros Ventre parts likewise had Precambrian cores, but they probably were not exposed until Eocene time. The highest part of the southwest flank of the Teton–Gros Ventre segment was bounded by a northeast-dipping thrust fault, the Cache Creek thrust. Along it the overriding mountain mass moved southwestward about 16 km (kilometers; 10 mi) and overrode youngest Paleocene strata. In contrast, the thrust sheets of the Idaho-Wyoming thrust belt, which were emplaced at a slightly earlier time and were peeled back by the Cache Creek thrust block, moved northeastward as much as 120 km (75 mi). None of the Wyoming part of the thrust-belt mountains has an exposed Precambrian core, and the southwestward-dipping thrust-belt fault surfaces are much flatter than the opposing fault surface under the Teton–Gros Ventre uplift.
   b. The first major volcanic activity in this area began in middle Eocene time, and at least 610 m (2,000 ft) of mafic debris was deposited by streams that flowed eastward, down the sides of several large localized vents.
   c. Large blocks of gold-bearing Precambrian quartzite, Paleozoic rocks, and fragments of andesite flows were carried eastward by mass gravity movements from the Targhee uplift to the west onto the somewhat lower flanks of the ancestral Teton uplift. These and associated finer grained deposits were the last to come from the Targhee uplift.
   d. The volcaniclastic rocks were deposited in a subtropical humid climate, are of middle Eocene age, and correlate with Bridger A–B vertebrate-bearing strata elsewhere in Wyoming.
   e. Probably shortly after middle Eocene time, the Targhee uplift subsided into what is now the Teton Basin–Snake River downwarp. As a result of this subsidence, accompanied in places by normal faulting, the structurally higher part of the northeast flank of the Teton uplift as it was in middle Eocene time was rotated downward to the west so far that it became the west flank of the modern Teton Range. The structurally lower part of the Eocene northeast flank of the Teton uplift was even more extensively modified

during late Cenozoic time. Downwarps and normal faults, some with displacement of several thousand meters, developed along and east of the Eocene northeast flank and, without deviation, continued southward across the ancestral Teton–Gros Ventre uplift and sundered the northern part of the thrust belt as well. These north-trending grabens and horsts isolated the Gros Ventre segment of the ancestral uplift and, along with the downwarping, were responsible for the development of Jackson Hole. The modern Teton Range arose in the last 9 million years; from part of a low northwest-trending anticlinal uplift it became a north-trending, west-tilted, asymmetric faultblock range with a precipitous east face.

f. The Teton Basin–Snake River downwarp and Jackson Hole both continued to sink, and the Teton Range continued to rise, through Pliocene, Pleistocene, and Holocene times.

## HISTORY OF INVESTIGATION

A sequence of mafic igneous and volcaniclastic sedimentary rocks, here named the Hominy Peak Formation, has long been recognized at the north end of the Teton Range (fig. 1), northwestern Wyoming (Hague and others, 1896). Recent geologic mapping delineates similar rocks high on the west flank of the Teton Range (fig. 2; Reed and Love, 1972). Figure 3 shows the regional setting of the Teton Range in relation to adjacent mountains, basins, and cultural features.

Rocks now assigned to the Hominy Peak Formation were first mapped by Hague, Weed, and Iddings (1896) as "late basic breccia" of "Neocene" age but were not described in detail. Amplified descriptions were given by Iddings and Weed (Hague, Iddings, and others, 1899, p. 161–162), but the basal part was presumed to be of Cretaceous age.

On the final atlas map accompanying the Yellowstone National Park monograph, Hague (1904) showed these rocks as "early basic breccia" of Miocene age. The lower part of the sequence was called "Colorado formation" of Cretaceous age.

Edmund (1951) did not differentiate the volcanic rocks on his map of the Teton Range but described the mafic sequence (Hominy Peak of this report) separately from the younger rhyolites. On the geologic map of Wyoming (J. D. Love and others, 1955) and the geologic map of Teton County (J. D. Love, 1956a), the Hominy Peak Formation was called "early basic breccia." Between 1956 and 1972, as a part of a regional mapping and stratigraphic investigation by the U.S. Geological Survey, all volcanic rocks and most sedimentary rocks in the area were studied, sampled, and analyzed for gold. In the preliminary report on this work the mafic sequence was called "Miocene(?) conglomerate" because of its similarity to the Colter Formation of Miocene age in Jackson Hole (Antweiler and Love, 1967). Later (D. W. Love, 1971), the section on Hominy Peak (type section of the Hominy Peak Formation of this report) was described, pollen samples were collected from several stratigraphic intervals, and the Eocene age of the rocks was established. Independent mapping and associated geological studies of the igneous part of our Hominy Peak Formation by D. W. Love in 1970 were used for a graduate thesis (D. W. Love, 1971).

## ACKNOWLEDGMENTS

We are grateful to R. S. Houston for petrographic studies of some thin sections and hand specimens of the volcanic rocks, and to U.S. Geological Survey colleagues J. L. Weitz and R. L. Christiansen for field and office help and criticism. J. C. Antweiler provided all gold analyses and independently collected many gold samples. D. A. Lindsey made size, composition, and orientation determinations of clasts in both the Hominy Peak Formation and the underlying Pinyon Conglomerate (Lindsey, 1972). R. A. Scott identified one fossil wood sample.

# EOCENE ROCKS

## HOMINY PEAK FORMATION

### NAME AND DEFINITION

All Eocene Rocks of the Teton Range are included in the Hominy Peak Formation (new name). It is named for Hominy Peak (fig. 4), on which a Forest Service lookout station was formerly located at VABM triangulation station 8362. (See Grassy Lake Reservoir topographic quadrangle map, 1956.) The type section is about 0.8 km (1/2 mi) south of the peak, on the southeast-facing escarpment of Hominy Ridge on the northwest margin of Conant Basin (figs. 5–7). The formation is a sequence of green, brown, and red volcaniclastic rocks and agglomerates that unconformably overlies the Pinyon Conglomerate (Paleocene and latest Cretaceous) and older rocks of various ages; near the type section the sequence is unconformably overlain by the rhyolitic Conant Creek Tuff (Pliocene; a new name in Christiansen and Love, 1977) and the rhyolitic Huckleberry Ridge Tuff (Pleistocene). The volcaniclastic rocks of the Hominy Peak Formation grade laterally into a vent facies of andesitic agglomerate, and andesite and basalt flows and dikes southwest of Conant Basin. This formation is here assigned to the Absaroka Volcanic Supergroup (Smedes and Prostka, 1972).

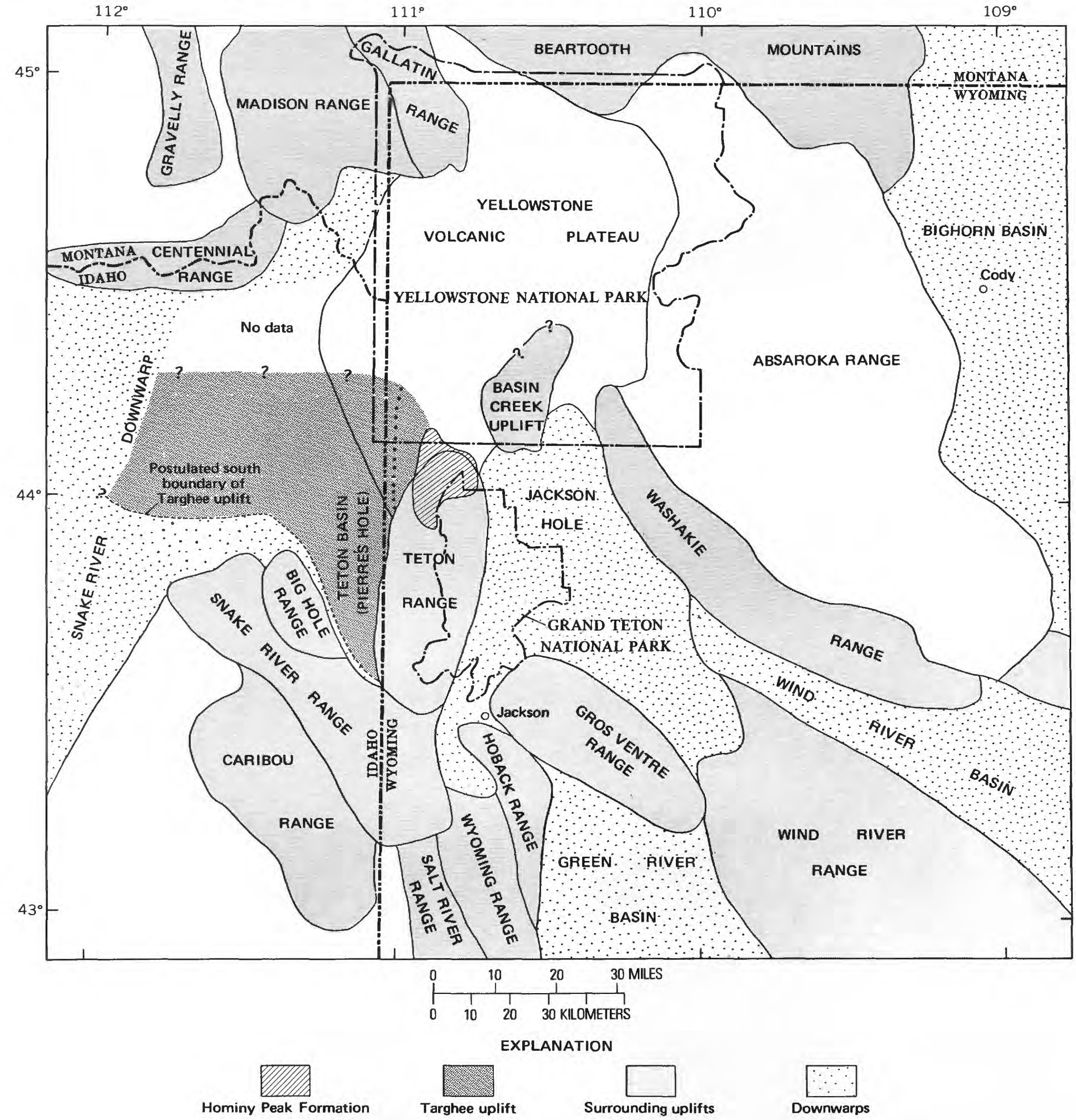



FIGURE 1. — Map showing relation of the area containing scattered outcrops of Hominy Peak Formation to Targhee uplift, surrounding uplifts, downwarps, the Yellowstone volcanic plateau, and the Absaroka Range. Line of large dots indicates approximate position of steep east flank of Targhee uplift during deposition of Hominy Peak Formation.

## DISTRIBUTION AND THICKNESS

The Hominy Peak Formation is known in two areas (fig. 2), one near the north end of the Teton Range, where the type section is, and the other 20 km (12½ mi) to the south, at the Grand Targhee Resort on the west flank of the Teton Range. In the northern area, outcrops of the Hominy Peak Formation are present as erosional remnants and in windows eroded through Pliocene and Pleistocene welded tuffs. These outcrops extend northward into southernmost Yellowstone National Park and about 11 km (7 mi) eastward to the east flank of the Teton Range. The longest continuous exposure and thickest section is in the vicinity of Hominy Peak, where about 610 m (2,000 ft) of strata was measured.

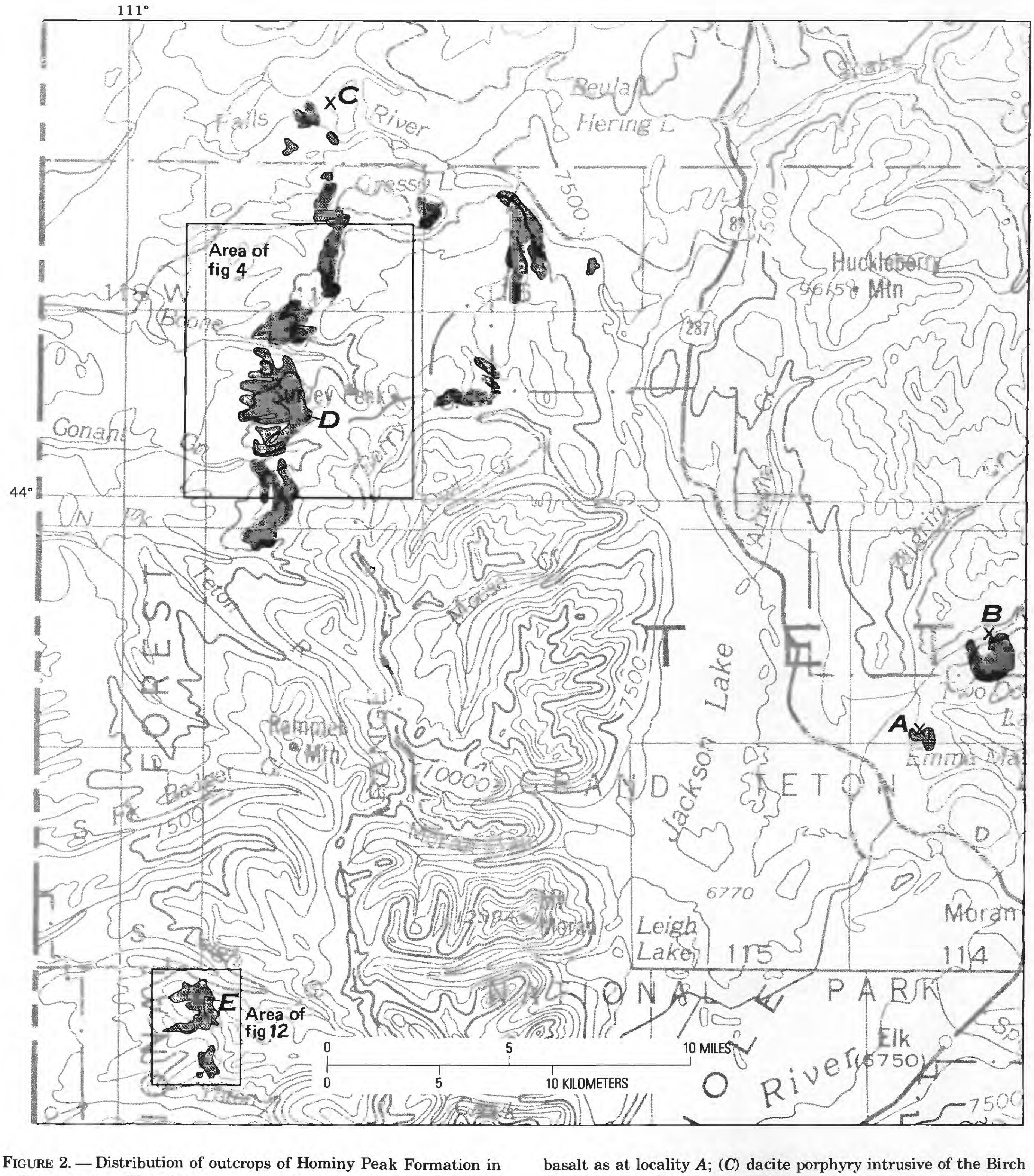
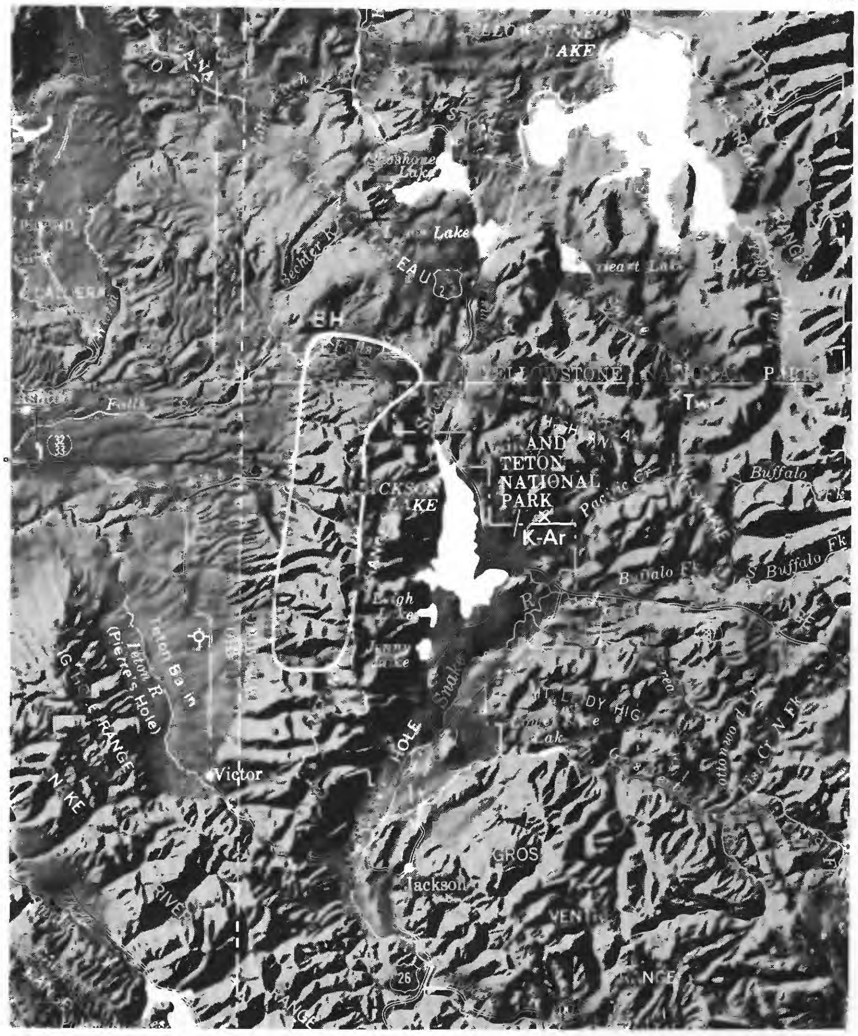



FIGURE 2. — Distribution of outcrops of Hominy Peak Formation in Teton region, Wyoming. Base from A. M. S. Driggs and Ashton quadrangles, 1:250,000, 1955. Indicated are (*A*) site of andesite and basalt intrusive with a K-Ar age of 48.6 ± 0.7 m.y.; (*B*) site of green tuff with a K-Ar age of 45.9 ± 0.5 m.y. overlying andesite and basalt as at locality *A*; (*C*) dacite porphyry intrusive of the Birch Hills with a fission track age of 40.5 ± 2.6 m.y.; (*D*) type section of Hominy Peak Formation and site of pollen collections; (*E*) Hominy Peak Formation at Grand Targhee Resort.

111° 110°

44°




0 10 20 30 40 MILES

0 10 20 30 40 KILOMETERS

## EXPLANATION

-◇- Site of Cities Service drill hole

×K-Ar Site of mafic andesite and basalt similar to Hominy Peak Formation, dated by K-Ar method as 48.6±0.7 m.y. (middle Eocene; for outline see fig. 2)

×Twr Site of White River Formation (lower Oligocene) fossil mammal collections with K-Ar age of 35.8±0.8 m.y.

×BH Dacite porphyry intrusive of the Birch Hills dated by fission track method as 40.5±2.6 m.y.

FIGURE 3. — Major geographic features and several fossil and radiometric sample localities discussed in text. Outlined area indicates general area containing exposures of Hominy Peak Formation.

Near the Grand Targhee Resort, the Hominy Peak Formation is about 61 m (200 ft) thick and is confined to Eocene valleys eroded in Paleozoic carbonate rocks and shales. No rocks overlie the Hominy Peak here.

In Jackson Hole, 32 km (20 mi) southeast of the type section (fig. 2, loc. *A* and just south of loc. *B*), several areas of brown and black andesite and basalt are similar to, and perhaps contemporaneous with, the igneous facies of the Hominy Peak Formation. These rocks are discussed later.

### LITHOLOGY

The original description of the rocks now called the Hominy Peak Formation (then called "late basic breccia") was given by Iddings and Weed (Hague, Iddings, and others, 1899, p. 161–162), as follows:

> The sedimentary area is bounded on the west by an accumulation of volcanic tuff-breccia that is exposed for a distance of 6 miles north and south, and again farther north in the neighborhood of Birch Hills. The actual extent of the breccia is unknown, since it is partially covered by rhyolite. * * * The rocks exhibit rude assorting, but are not bedded, the coarse agglomerates occurring with tuffs and fine breccias without order or arrangement. The material consists of basic andesites and basalts, some of which are absarokite and contain orthoclase as an essential constituent. Petrographically they are like the basaltic breccias of the Absaroka Range.
>
> The breccias are dark colored and often weather into fantastic towers, pinnacles, and cliffs, whose dark rich shades of red, brown, purple, and gray render them highly picturesque. The fragments are angular and subangular and often are several feet in diameter. * * * On the north side of Conant Creek, where the exposure is nearly 1,000 feet high, there are indications of rude bedding, dipping westward.
>
> The breccias were thrown upon the surface of deeply eroded and faulted sedimentary rocks, and undoubtedly were considerably eroded themselves before being buried beneath the rhyolite * * *.

The following description of the type section is a modern account of the sedimentary facies of the Hominy Peak Formation. Figures 5–8 illustrate characteristic exposures, outcrop appearance, and details of significant lithologic features.

#### *Type section of the Hominy Peak Formation*

[The type section of the Hominy Peak Formation is 0.8 km (1/2 mi) south of Hominy Peak, on the southeast-facing southern part of Hominy Ridge overlooking Conant Basin, SE1/4 sec. 16 and northern part of sec. 21, T. 47 N., R. 117 W., Grassy Lake Reservoir quadrangle, Teton County, Wyo. The upper part of the section is well exposed, but the basal part is seen only in sporadic outcrops. Major intervals were checked from elevations on the topographic maps and dips measured in the field. Thin units were measured with Brunton compass and steel tape. The section was studied, described, and sampled by J. D. Love in 1957, 1966, 1967, and 1970. A complete section of the Conant Creek Tuff is presented elsewhere (Christiansen and Love, 1977)]

| *Unit and description* | *Thickness (Feet)* | *(Meters)* |
|---|---|---|
| Conant Creek Tuff (Pliocene; basal part only): | | |
| 9. Ash-flow tuff, white, nonwelded, glassy; crudely sorted but not obviously bedded; friable, porous, coarse grained; consists of angular, curved, and wishbone-shaped clear shards and sparse chunks of fibrous pumice less than 1 cm (0.4 in.) across in a clayey matrix of weathered volcanic dust; contains sparse granules of obsidian, and phenocrysts less than 1 mm (0.03 in.) mainly of quartz, sanidine, and plagioclase .................. | 2.0 | 0.6 |
| Angular unconformity. Conant Creek Tuff has a regional strike of about N. 15° E.; regional dip ranges from 6° to 9° W. Some variability of dip may result from differential compaction plus depositional dip on a surface of some relief. The underlying Hominy Peak Formation strikes N. 10° E. and dips 20°–25° W. Few locally meaningful bedding surfaces occur in the Hominy Peak Formation, so the attitude was determined by three-point method and is only approximate. | | |
| Hominy Peak Formation (Eocene): | | |
| 8. Volcanic conglomerate, red-brown to green, crudely stratified; interbedded with olive-drab to green coarse-grained tuff in irregular beds; lower part poorly exposed along line of section but well exposed on strike to the southwest; upper part finer grained than lower; angular blocks of red and black andesite and basalt as much as 91 cm (3 ft) in diameter common; one boulder of Madison Limestone 2.4 m (8 ft) in diameter; smaller boulders of Death Canyon Limestone Member of Gros Ventre Formation; unit not studied in detail. Upper part baked red along contact with Conant Creek Tuff. The Conant Creek Tuff laps eastward across this unit to within about 61 m (200 ft) of the base, but the upper part of the unit is exposed along the steep escarpment and ridgetop to the southwest, where it is contorted and slumped and is much coarser grained, possibly because of being closer to vent facies; thickness uncertain; estimated to be about ......... | 1,000 | 305 |

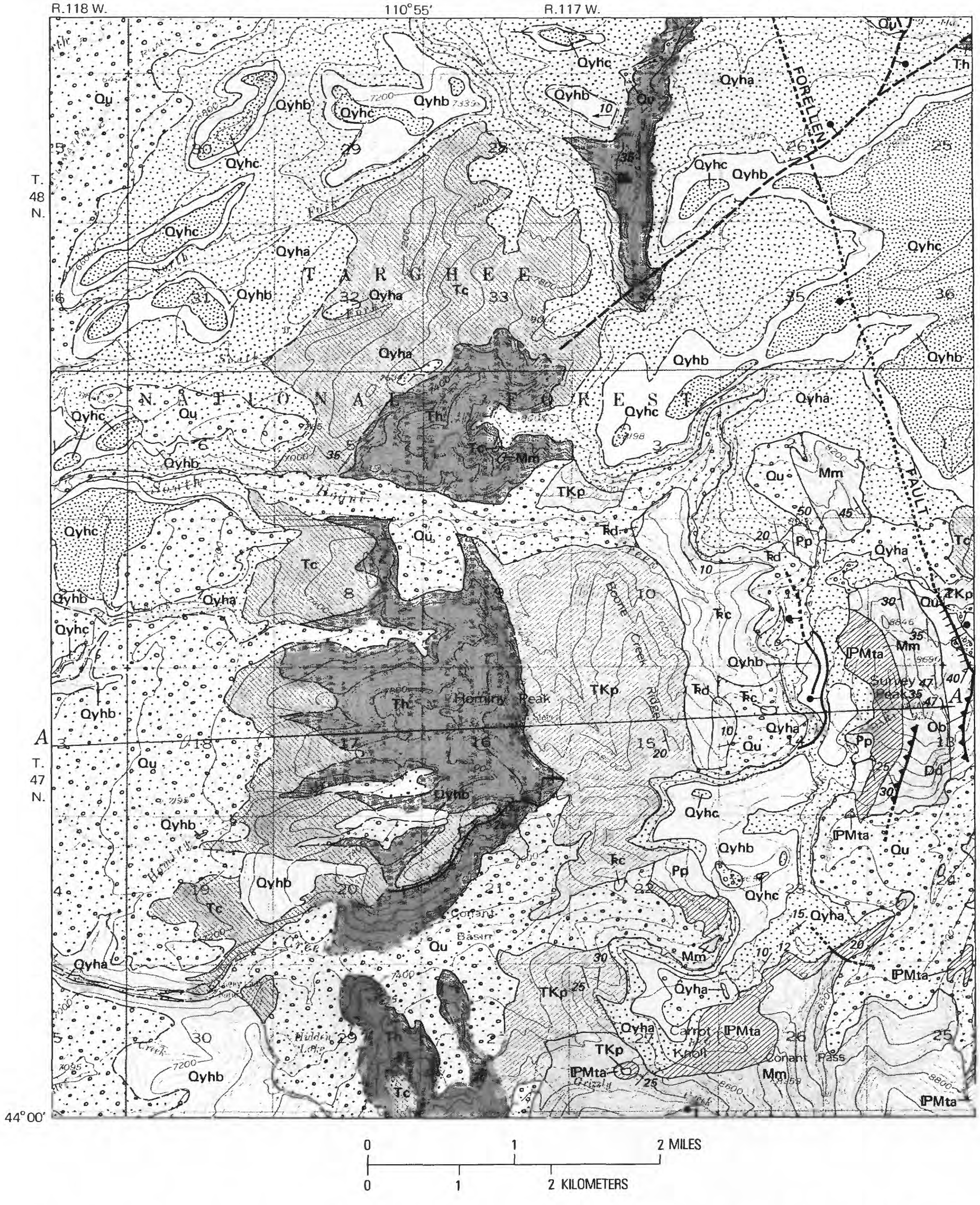



FIGURE 4. (above and right). — Geologic map of Hominy Peak Formation in the vicinity of the type section. Geology by R. L. Christiansen, H. R. Blank, Jr., J. D. Love, and J. C. Reed, Jr. (1978). Base from U.S. Geological Survey, Grassy Lake Reservoir, 1956. Heavy line with cross bars marks position of measured section. Small dots connect offset part of section.

## EXPLANATION

- Qu — Quaternary talus, colluvium, swamp deposits, alluvium, glacial debris, landslide debris, and slump block, undivided
- Quaternary Huckleberry Ridge Tuff
  - Qyhc — Unit C
  - Qyhb — Unit B
  - Qyha — Unit A
- Tc — Tertiary Conant Creek Tuff
- QThc — Huckleberry Ridge and Conant Creek Tuffs, undivided
- Th — Tertiary Hominy Peak Formation
- TKp — Paleocene and Upper Cretaceous Pinyon Conglomerate
- ℞c — Triassic Chugwater Formation
- ℞d — Triassic Dinwoody Formation
- Pp — Permian Phosphoria Formation
- PMta — Pennsylvanian and Mississippian Tensleep and Amsden Formations
- Mm — Mississippian Madison Limestone
- Dd — Devonian Darby Formation
- Ob — Ordovician Bighorn Dolomite

Contact — Dashed where approximately located

Normal fault — Dashed where approximately located; dotted where concealed or inferred. Bar and ball on downthrown side

Thrust fault — Dotted where concealed. Sawteeth on upper plate

25 Strike and dip of bedding

10 Generalized dip without strike

High-angle fault on which, at least locally, movement has been reversed—Bar and ball on presently downthrown side; hachures on originally downthrown side; dotted where concealed

Measured section—Dotted line connects offset part of section

| *Unit and description* | *Thickness (Feet)* | *(Meters)* |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 7. Claystone, chocolate-brown to purplish-gray; thinly bedded in part; blocky; weathers to a puffy bentonitic surface; top and bottom gradational, but unit has moderate lateral continuity (figs. 5–7); slumped in part, so thickness is only approximate; seven pollen samples collected at 30-cm (1-ft) intervals from a 152-cm (5 ft) section of finest grained blocky noncalcareous claystone in middle part of unit (table 1; sample D5459 is at top): | | |
| D5459–F. Claystone, brownish-gray, moderately soft; contains sparse fragments of carbonized plants. | | |
| D5459–E. Claystone, pale-lavender, moderately soft; contains abundant finely fragmented carbonized plant remains. | | |
| D5459–D. Claystone, light-pinkish-gray, hard, conchoidally fractured, brittle; contains many carbonized plant fragments. | | |
| D4617–C. Claystone, pale-tannish-gray, moderately soft; contains abundant carbonized plant fragments. Pollen collection D5459–B is from base. | | |
| D4271 (= D4617–B). Claystone, pale-olive-drab, soft; plant fragments larger and better preserved than in overlying beds; small fractured rush stems. Pollen collection D4271–C is from approximately this horizon. | | |
| D4617–A. Claystone, pale-brown, soft; crumbles into conchoidally shaped husks; contains abundant carbonized plant fragments. | | |
| Approximate thickness of unit 7 . . | 15 | 4.6 |
| 6. A remarkable unit of many rock types, none of which has much lateral continuity; consists principally of conglomerate composed of large and small red and black mafic clasts and masses of volcanic rocks and Paleozoic gray carbonate rocks embedded in a green and gray coarse tuff matrix. A black and dark-brown hard pinnacle-forming volcanic conglomerate and breccia 15–23 m(50–75 ft) thick is 15 m (50 ft) below top along line of section; softer beds form red and green badlands exposures along the Hominy access road north of line of section. On Hominy Ridge, upper part of unit contains several | | |


FIGURE 5. — Oblique aerial view southwest showing regional setting of type section of Hominy Peak Formation. Indicated are (*A*) Hominy Peak at the apex of Hominy Ridge; (*B*) type section of Hominy Peak Formation; (*C*) other exposures of Hominy Peak Formation; (*D*) Conant Creek Canyon in the Huckleberry Ridge Tuff of Yellowstone Group; (*E*) Snake River downwarp with Quaternary deposits at surface, over site of former Targhee uplift; (*F*) Pinyon Conglomerate on Boone Creek Ridge; (*G*) Huckleberry Ridge Tuff; (*H*) steeply dipping Paleozoic rocks on northwest flank of Teton Range; (*I*) South Boone Creek; (*J*) northern part of Survey Peak; (*K*) Triassic rocks. Photograph by J. D. Love, October 1, 1965.

| *Unit and description* | *Thickness (Feet)* | *(Meters)* |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 6. Many rock types — Continued masses of igneous rock more than 30 m (100 ft) long. One of these, a black basaltic porphyry with green glassy phenocrysts, was collected for a K-Ar age determination. A second mass, located on the highest part of Hominy Ridge, is a black hornblende porphyry that weathers red brown and contains abundant green euhedral hornblende crystals as much as 1 cm (3/8 in.) in diameter in a black groundmass. A third mass, 30.5 m (100 ft) northeast of Hominy Peak VABM 8362 is a lavender-brown breccia of andesite fragments of various sizes in a finely crushed matrix of the same rock. Thin sections of representative rocks in this unit were studied by R. S. | | |


FIGURE 6. — View northwest from west edge of Carrot Knoll toward type section of Hominy Peak Formation. Indicated are (*A*) hill 8373 capped by rhyolitic Conant Creek Tuff; (*B′*–*B*) units 3–8 in measured section of Hominy Peak Formation; (*C*) claystone containing Eocene pollen in unit 7; (*D*) white marker tuff comprising basal unit of Hominy Peak Formation; (*E*) cliff of west-dipping Pinyon Conglomerate in foreground; (*F*) Hominy Peak. Photograph by J. D. Love, August 11, 1965.

| *Unit and description* | *Thickness (Feet)* | *Thickness (Meters)* |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 6. Many rock types — Continued Houston, who reported as follows (written commun., 1960): | | |
| Wyo–710: Crystal-lithic tuff containing orthopyroxene, clinopyroxene, oxyhornblende, and plagioclase crystals; lithic fragments of pyroxene andesite(?). | | |
| Wyo–711: Porphyritic pyroxene andesite, approximately 50 percent phenocrysts of pyroxene and plagioclase, in a fine-grained groundmass of plagioclase, pyroxene, magnetite, and oxyhornblende. | | |
| Wyo–712: Highly vesicular porphyritic basalt composed of plagioclase, orthopyroxene, clinopyroxene, magnetite, and oxyhornblende. Vesicles contain chalcedony and zeolites(?). | | |
| Masses of Paleozoic rock, chiefly Madison Limestone and Cambrian limestones, are common in several parts of the unit. A zone about 152 m (500 ft) northwest of the Hominy-Berry Creek road, along top of | | |

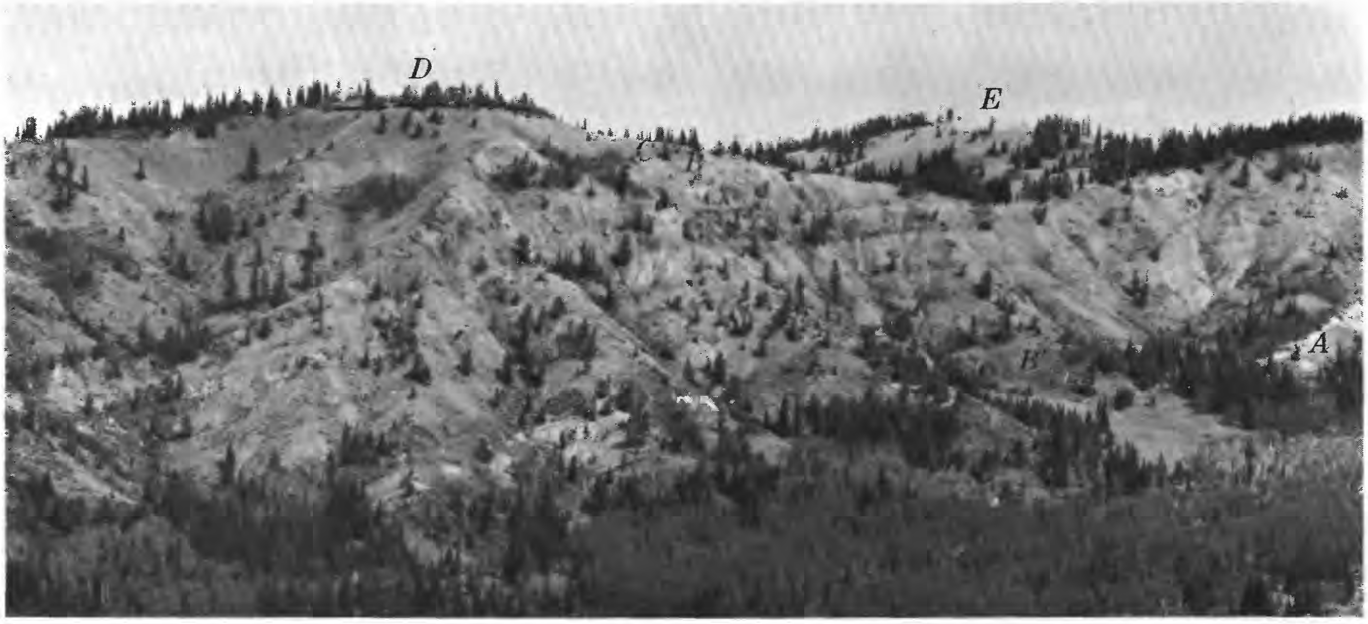



FIGURE 7. — View north across Conant Basin toward type section of Hominy Peak Formation. Indicated are (*A*) white marker tuff comprising basal unit; (*B'*—*B*) layered volcaniclastic rocks in units 3–6; (*C*) horizon of claystone containing Eocene pollen in unit 7; (*D*) rhyolitic Conant Creek Tuff unconformably overlapping Hominy Peak Formation; (*E*) Hominy Peak. Photograph by J. D. Love, September 2, 1970.

| *Unit and description* | *Thickness (Feet)* | *(Meters)* |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 6. Many rock types — Continued Hominy Ridge, contains many masses of Madison Limestone (the largest block being 10×3.05×3.05 m, or 33×10×10 ft) embedded in volcanic conglomerate. The limestone is somewhat brecciated and is cut by veinlets of chalcedony and celadonite(?) but contains well-preserved silicified corals and brachiopods. Near this block is a 3×5 m (10×15 ft) lens, a primary deposit, of blocky-weathering soft structureless plastic silty bentonitic claystone, pale greenish tan in color, with sporadic sand grains, glass shards, and irregular white and yellow clay inclusions. A semiquantitative spectrographic analysis (lab. No. D129990) shows no unusual amounts of any recognizable elements. Fossil wood is common throughout unit 6 and is especially abundant in the upper part where several logs 3 m (10 ft) long and 0.3 m (1 ft) in diameter were sampled. R. A. Scott reported (written commun., May 31, 1974) that | | |

| *Unit and description* | *Thickness (Feet)* | *(Meters)* |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 6. Many rock types — Continued one silicified specimen is of unidentifiable dicotyledonous wood. The absence of conspicuous growth rings indicates that it grew under conditions lacking marked seasonality. Two pollen samples were collected near the top of unit 6 along the line of section. Pollen sample D4617–G (table 1) was collected from a dark-brown siltstone that weathers white and is hard and noncalcareous and contains contorted mats of plant debris, chiefly rushes. Pollen sample D4617-H was collected from a noncalcareous hard black siltstone containing contorted mats of poorly preserved megascopically unidentifiable plant debris. Thickness of unit 6 was determined only approximately because of lack of continuity of lithologies ........ | 300± | 92± |
| 5. Volcanic conglomerate and conglomeratic tuff, laterally and vertically variable, olive-drab to dull greenish- and pinkish-gray, poorly cemented; cropping out | | |

FIGURE 8. — Gold-bearing quartzite-boulder conglomerate in unit 3 of Hominy Peak Formation. Imbrication of roundstones (top ledge) shows that current moved southeastward (toward camera). Note high degree of rounding, abundant pressure scars (light-colored mottled patches on boulders), and crude stratification. This is the only boulder conglomerate in the type section that is composed almost entirely of quartzite clasts; its lateral extent and variation in thickness have not been determined. Photograph by J. D. Love, August 14, 1967.

| Unit and description | Thickness (Feet) | Thickness (Meters) |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 5. Volcanic conglomerate and conglomeratic tuff — Continued on bare steep slopes; many Precambrian(?) quartzite roundstones, some as much as 61 cm (2 ft) in diameter, but commonly much smaller, associated with andesite and basalt roundstones of the same size range, are contained in a drab blocky tuff and volcanic sandstone matrix; at base is a chocolate-brown very fine grained claystone with plant fragments (pollen sample D 4271–B, table 1) | 115 | 35 |
| 4. Volcanic conglomerate, dark-gray; with angular basalt fragments as much as 2.4 m (8 ft) in diameter; some large angular masses of agglomerate; many highly rounded boulders of basalt and red and brown andesite; boulders near base are more rounded; large masses of basalt and andesite agglomerate from upper part have slid down outcrop face and now rest on lower part; abundant green celadonite(?) and chalcedony in middle, along with much more common clayey and drab tuff matrix; some carbonized and silicified wood at several horizons | 160 | 48.8 |
| 3. Conglomerate of Precambrian quartzite roundstones, rusty to greenish-brown; has considerable lateral continuity; chiefly cobbles, but some boulders of quartzite are as much as 122 cm (4 ft) in diameter, many with conspicuous green staining; some boulders of granite, gneiss, pyroxenite, and Tertiary volcanic rocks. Of 26 gold samples taken from this unit, 21 have previously been reported (Antweiler and Love, 1967, table 5). Gold is present in all samples, but flakes are small and values low (10–290 ppb). A 30-cm (1 ft) interval of carbonaceous ferruginous sandstone 61 cm (2 ft) below top of unit and 122 cm (4 ft) above base of rusty drab sandstone has broad plant stems but no leaves; pollen sample D4271–A (table 1) is from this 30-cm (1 ft) interval. Pebble | | |

| Unit and description | Thickness (Feet) | Thickness (Meters) |
|---|---|---|
| Hominy Peak Formation — Continued | | |
| 3. Conglomerate of Precambrian quartzite roundstones — Continued composition and orientation studies by D. A. Lindsey were made in part of the unit shown in figure 8. His imbrication measurements (written commun., 1970) show a paleocurrent direction of S. 54° E. | 115 | 35 |
| 2. Marker tuff, light-greenish-gray; weathers white; forms conspicuous light-colored outcrops on north and south sides of Conant Basin (fig. 7); most of sequence is coarse grained with angular clear glassy grains and pink and black grains most abundant; pebbly in part, especially in the upper half, with rounded pebbles as much as 10 cm (4 in.) in diameter, but commonly smaller, consisting of gray chert, quartzite, and sandstone and red, black, and gray mafic volcanic rocks; abundant biotite flakes, some of which are euhedral; greener part of unit has slightly bentonitic matrix. Samples from highly biotitic greenish-gray sandstone at top of unit, 47 m (150 ft) below top, 48.8 m (160 ft) below top, and 76 m (250 ft) below top show small amounts (28 ppb) of gold. Thin section Wyo–709 of representative lithology is a lithic crystal tuff, about one-third plagioclase, volcanic quartz, microcline, brown biotite, amphibole, and sphene, one-third rhyolite and other volcanic rock types, and one-third carbonate matrix. Sample L70–165 from biotite-rich middle part of unit has a K-Ar age of 72 m.y., which means that the biotite is contaminated, probably with some Precambrian biotite (J. D. Obradovich, written commun., Nov. 1974). Crossbedding measurements by D. A. Lindsey from middle part of unit show current to have flowed S. 22° W. (written commun., 1971) | 300 | 91 |
| Thickness of type section of Hominy Peak Formation, about | 2,007 | 612 |

Angular unconformity. Exposures are so poor and continuity of bedding planes so

| Unit and description | Thickness (Feet) | Thickness (Meters) |
|---|---|---|
| Angular unconformity — Continued uncertain in the underlying Pinyon Conglomerate that regional relations are the only clue as to the magnitude of the unconformity. The Pinyon Conglomerate apparently has a 5°–10° steeper dip to the west than does the Hominy Peak Formation and the strike of the Pinyon is 5°–10° more easterly. The contact between the two formations is sharp, but exposures do not permit any observations on amount and nature of contact relief. | | |
| Pinyon Conglomerate (Paleocene and uppermost Cretaceous): | | |
| 1. Conglomerate, light-tan; weathers rusty-brown in part; so poorly cemented that the formation crops out as fluted slopes with a few hard ledges; roundstones are predominantly gray and pink quartzite, commonly pebble to cobble size; a few roundstones are 1 m in diameter and reach a known maximum of 137×122×76+cm (4.5×4×2.5+ ft); the largest boulder of any kind observed in place is a red quartz pebble conglomerate and sandstone, the exposed part of which is 239×158×30 cm (8×5×1 ft) present in the lower part of the formation; matrix of Pinyon Conglomerate is angular rusty-brown sandstone; quartzite pebbles have a polish on unweathered surfaces, are highly fractured and incompletely recemented; roundstone composition and orientation measurements made in lower part of formation by Lindsey (1972). Imbrication measurements indicate paleocurrent directions ranging from S. 30° E. to S. 58° E. Gold samples were taken (and average 96 ppb) in lower and upper parts; thickness of formation computed from regional outcrop data and topographic map as approximately ................ | 1,900 | 579 |
| Angular unconformity. Chugwater Formation (Triassic; not measured). | | |

Among the most intriguing features of the Hominy Peak Formation in the northern area of outcrop are many large masses of Paleozoic carbonate rocks, two masses of Cretaceous conglomeratic sandstone, and several types of volcanic rocks, all interbedded with the volcaniclastic sedimentary sequence. The masses of sandstone and conglomerate are 1,890 m (6,200 ft) southeast of Hidden Lake (south of the area shown in fig. 2), where the Hominy Peak Formation overlaps Cambrian rocks. The masses are 7.6–10.6 m (25–35 ft) in diameter and are composed of rusty-tan to dark-gray conglomeratic sandstone and pebble conglomerate. Their lithology is unique in this region. A detailed section of the lower mass follows, with unit 1 being the oldest.

| Unit and description | Thickness (Feet) | Thickness (Meters) |
|---|---|---|
| 3. Sandstone, gray, pebbly; interbedded with granule conglomerate; pebbles are highly rounded, and some are polished on freshly exposed surfaces; composed chiefly of black and gray chert; embedded in a coarse-grained sandstone matrix of chert and quartz grains ..... | 5 | 1.52 |
| 2. Claystone, pebbly siltstone, and clayey sandstone, green to purple, mottled; claystone is plastic, waxy, very fine grained; disaggregates in water; appears to be bentonitic; two samples from middle, checked for pollen, are barren ................... | 4 | 1.2 |
| 1. Sandstone, gray, pebbly, coarse-grained, crossbedded; right side up, but dipping 60° NE. ........ | 10 | 3.05 |
| Total thickness measured | 19 | 5.77 |

The upper mass crops out as a 7.62-m (25-ft) cliff of gray pebble conglomerate with slickensided surfaces. Pebbles are highly rounded, some are polished, and the largest are 8 cm (3 in.) in diameter. Black and gray chert, such as is common in the Madison Limestone, is the dominant rock type in both blocks. Some roundstones of tan chert contain abundant sponge spicules; the rock is identical to some layers in the Phosphoria Formation in Jackson Hole. Less common rock types in the upper block are red chert, gray sandstone, and hard siliceous green and gray shale. Granules of phosphorite and pebbles of gray granite are sparse. Some layers have a white dense hard limestone matrix. No pebbles of volcanic rock were seen and very few of quartzite. If volcanic debris occurs in the matrix (other than possibly the waxy claystone), it is minor. Because these rock types are not present in the Pinyon Conglomerate, which crops out 2.41 km (1.5 mi) to the northeast (fig. 4), it is suspected that the strata may be of pre-Pinyon Cretaceous age, possibly a near-source facies of the Harebell or Mesaverde Formation.

No attempt was made to determine which of the Paleozoic masses is largest, but one mass of Madison Limestone on the north side of South Boone Creek (fig. 4), is 36.6 m (120 ft) long in a north-south dimension, 9.1 m (30 ft) thick, and 15.2 m (50 ft) wide. Bedding planes are nearly horizontal in the limestone. The rock is not metamorphosed and is only moderately fractured. Crinoid stems and other fossil fragments appear megascopically to be unaltered. At the base of the mass is a rock flour of limestone that has been recemented but includes little or no volcanic rock and does not appear to be metamorphosed along the glide plane. Other large blocks of Madison Limestone and volcanic rocks are exposed in unit 6 of the type section.

There may be multiple origins for these large blocks of pre-Tertiary rocks. Rouse (1937) and Parsons (1967) interpreted blocks of Paleozoic rocks to have been stripped off outcrops by advancing breccia flows, or to have been raised hundreds of feet within breccia-filled vents. Both processes may account for some of the older Paleozoic and Precambrian blocks in the Hominy Peak. Others, such as the Cretaceous masses, may simply have slid off the highlands to the west along with volcanic debris. Still others may have been carried upward to the surface in volcanic vents and then may have slid off the sides of the volcanoes in lahars.

Perhaps some of the blocks of Paleozoic rocks in the Hominy Peak Formation might have slid westward from the Teton Range, rather than eastward from the Targhee uplift, but the most compelling evidence against such a source is the association of Paleozoic rock masses with similar-size ones of volcanic origin. The core of the Teton Range is now largely exhumed (J. D. Love and others, 1972), and no source vents of sufficient size and with lithology comparable to that of the igneous masses in the Hominy Peak are presently exposed.

The vents southeast of the Teton Range (fig. 2, locs. *A, B*) are 24 km (15 mi) away, and the nearest ones to the east and northeast are 32–64 km (20–40 mi) away. Any slide blocks from these vents would have had to travel across a rough terrain of Cretaceous and Paleocene rocks unless it was completely covered by volcanic rocks that have since been removed. There is no evidence that the slide debris of Cretaceous and Paleocene rocks east of the Teton Range has been incorporated in the Hominy Peak; therefore, a nearby western source for the volcanic slide block seems logical.

A paleogeologic map depicting the beginning of Hominy Peak deposition must account for the presence of the Upper Cretaceous conglomeratic sequence and other smaller blocks and fragments of Mesozoic and older rocks in the same area. Inasmuch as the Cretaceous rocks could not have come from the north, south, or east, they must have come from a syncline to the west, between the area now comprising the present west flank of the Teton Range and the Targhee uplift. A similar syncline, but with Triassic rocks in the center, is present on South Boone Creek (fig. 4). The synclinal source would have had to be deep enough to contain a complete Paleozoic and Mesozoic section including the Mesaverde Formation (a total of about 4,570 m, or 15,000 ft). The central part of this postulated syncline must then have been uplifted enough for the conglomerate and sandstone to have slid to their present location. If the trend of the postulated syncline were parallel to other Laramide trends in and along the ancestral Targhee-Teton uplift, it would be northwest and, therefore, might not intersect (and is not shown on) the cross section (fig. 17). More geophysical work and drilling possibly could determine the location and magnitude of the syncline. It is near the area where the igneous facies of the Hominy Peak Formation reaches its maximum exposed development, west of the present Teton Range. Similarly, absarokites in the Absaroka region are commonly found along structural sags on foreland highs.

The northeasternmost exposures of the Hominy Peak Formation are east of the Paleozoic core of the Teton Range, approximately 9.6 km (6 mi) northeast of Survey Peak (fig. 2), where several hundred feet of strata is exposed. The sequence is predominantly mafic breccias and conglomerates of red and black basalt and andesite fragments as much as 91 cm (3 ft) in diameter, but averaging 3–5 cm (1–2 in.). The matrix is green, pink, and gray coarse-grained mafic crystal tuff. Rhyolite clasts are sparse. Some coarse-grained drab volcanic sandstones are interbedded with the conglomerates. A few thin light-gray hard blocky tuff lenses are present, some of which can be traced for 15 m (50 ft). Most exposures contain stumps of fossil wood and many wood chips. The beds are cut by small intrusive bodies of red and black mafic igneous rocks that are unconformably overlapped by Huckleberry Ridge Tuff. At this locality, the Hominy Peak has been folded and tilted eastward, and an angular unconformity of about 25° separates it from the Huckleberry Ridge Tuff.

In the southern part of the area shown in figure 4, at the site of the 20° dip symbol about 61 m (200 ft) of the basal white marker unit is exposed in a conspicuous east-facing landslide scar. The strata at this locality were referred to by Iddings and Weed (Hague, Iddings, and others, 1899, p. 161) as "presumably of Cretaceous age" and shown on the Yellowstone National Park atlas map (Hague, 1904) as "Colorado formation" of Cretaceous age. No detailed section was measured here during our investigations, but spot samples show the general lithology, as follows:

| Unit | Stratigraphic interval below top | |
|---|---|---|
| | *(Feet)* | *(Meters)* |
| Sandstone, brown, coarse-grained, soft | 10 | 3.05 |
| Sandstone, bright-green, coarse-grained; about 152 cm (5 ft) thick, grading upward and downward to brown sandstone | 30 | 9.15 |
| Tuff, light-gray, coarse-grained, pebbly; contains euhedral biotite flakes and clear plagioclase crystals | (1) | (1) |
| Sandstone, gray, fine-grained, even-bedded, biotitic; has continuity across exposure face and was used for dip and strike determination | (1) | (1) |
| Claystone, gray, blocky, 152 cm (5 ft) thick | 160 | 48.8 |
| Tuff, gray, coarse-grained, hard, pebbly | 180 | 54.9 |

[1] Interval data lost.

About 0.4 km (1/4 mi) southwest of this white scar, along a high spur, in the overlying brown volcaniclastic sequence, are jumbled angular blocks of red and white very coarse grained quartzite, 1.52–3 m (5–10 ft) in diameter, with contorted layering. The lithology of this quartzite differs from any of the Paleozoic strata of this area, including the Flathead Sandstone; thus, the blocks probably were derived from Precambrian metasedimentary rocks in the Targhee uplift to the west. The Flathead Sandstone is less dense and quartzitic, lacks contorted bedding, and is of a different shade of red.

Boulders of gray very fine grained quartzite 91–152 cm (3–5 ft) in diameter, with a leach rind 2– 5 cm (0.8–2 in.) thick, are common in the lower middle part of the Hominy Peak Formation on the north side of South Boone Creek. They resemble the Precambrian quartzite boulders in the Pinyon Conglomerate but are not as intensely fractured. Many of them have been spalled for artifact material by prehistoric Indians.

The igneous facies of the Hominy Peak Formation is most widespread and best exposed south of Conant Creek (fig. 4). Figure 9 compares the appearance of the igneous and sedimentary facies. The igneous facies is chiefly dark-red-brown and dull-green andesite flow breccia interlayered with andesite flows and cut by andesite dikes. The largest exposed vent complex is southwest of Conant Basin where volcanic rocks intertongue laterally with reworked waterlaid volcaniclastic strata. The general appearance of the igneous facies is shown in figures 10 and 11. Most of the rock debris consists of jumbled angular fragments of andesite tightly cemented into a breccia. Many blocks are more than 1 m (3 ft) in diameter. Thin sections show the rock fragments to be chiefly pyroxene andesite composed of augite, pigeonite, and labradorite or andesine. The volume and lack of sorting of this breccia are impressive, and the outcrops form massive cliffs and multicolored spires.

Small inclusions of brecciated pink deeply leached pyroxene andesite from an unknown source are sparse but widely scattered. Greenish-black and red dikes cut breccia and agglomerate; most are of porphyritic pyroxene andesite. Large (as much as 2 cm or 0.8 in.) dark-green augite crystals are common. Some dikes are highly contorted, possibly as a result of deformation of the enclosing blocks of breccia; these blocks may have slid in from the Targhee uplift to the west. All dikes are mineralogically similar to the breccias and lava flows. None cut Paleozoic strata in the Teton Range.

Both the igneous and sedimentary facies of the Hominy Peak Formation are cut by numerous north-trending quartz and chalcedony veins. At least two varieties of zeolites are present and bright-green celadonite(?) is abundant and conspicuous.

Andesitic breccias in the Absaroka volcanic field (fig. 3), 60 km (37.3 mi) to the east-northeast, similar to those in the igneous facies of the Hominy Peak Formation, have been described by Smedes and Prostka (1972), Prostka (1973), Rouse (1937), and Parsons (1967, 1969). Parsons (1969) presented criteria for recognizing various heterolithologic, unsorted andesite breccias in the Absaroka region. In 1967 he postulated phreatic eruptions, underground and surface autobrecciation, and subsequent breccia flows, massive lahars, and combinations of these processes and events. He thought that underground brecciation could result from rock bursts or block caving into partly empty vent chambers and contended that the breccia subsequently may have been intruded into the wallrock along with fresh magma or may have been extruded as breccia flows. In the poorly exposed area north of North Bitch Creek (fig. 2), the igneous facies is more massive and contains more dikes than other parts of the Hominy Peak Formation, which suggests that the facies was emplaced from the west.

Breccia intrusives and flows, and lahars, make up the bulk of the volcanic debris south and southwest of Conant Basin. Evidence for lahars is suggested by contorted layering, intensely deformed dikes that seem to have no local roots, and unsorted agglomeratic breccia.

The tendency of modern slopes on the Hominy Peak to slide, and the plasticity of the tuffs when wet show how easily the material could originally have moved under humid climatic conditions. The climate at the time of deposition of the Hominy Peak Formation was wet and warm.

FIGURE 9. — View west toward head of Conant Creek canyon, showing two facies of the Hominy Peak Formation. At left is an igneous facies consisting of mafic flows, breccias, and intrusive masses. At right is a sedimentary facies consisting of distinctly bedded volcaniclastic rocks. Photograph by D. W. Love, July 1971.

The few available chemical analyses from the northern area of the Hominy Peak Formation[1] show 2 percent or more $K_2O$. The contaminated sample of biotite run unsuccessfully for K-Ar age from the basal marker tuff in the type section contained 5.66 percent K (J. D. Obradovich, written commun., 1975), but this analysis may include a small amount of older biotite. Sanidine rims on the labradorite phenocrysts and in the groundmass likewise indicate a high $K_2O$ content.

In the southern area of the Hominy Peak Formation, north and south of the Grand Targhee Resort (figs. 2, 12), erosional remnants of waterlaid tuffaceous sedimentary and volcaniclastic rocks were deposited on mountainous topography cut into the Darby Formation and Madison Limestone (Reed and Love, 1972). Because of topographic relief and poor exposures (fig 13), the maximum thickness of the remnants is undetermined, but about 61 m (200 ft) seems reasonable.

The basal conglomerate at the locality of figure 14 (loc. U in fig. 13) is a tightly cemented sequence 3–6.1 m (10–20 ft) thick, composed of a jumble of angular boulders as much as 122 cm (4 ft) in diameter, unsized and unsorted. Rock fragments are chiefly of Tensleep Sandstone and Madison Limestone embedded in a red limestone cement. Farther north the basal conglomerate contains boulders of granite and volcanic rocks. Inasmuch as no such rocks are exposed in or near the area, the drainage pattern during deposition of the Hominy Peak Formation must have been very different from the present system; streams probably flowed south along the strike valleys eroded in the Darby Formation and Madison Limestone.

Streams transported abundant subrounded boulders of dense hard fine-grained basalt averaging 61–91 cm

[1] Most samples collected for this study were destroyed by fire.

FIGURE 10. — Vent facies of Hominy Peak Formation, southwest side of Conant Basin. The contorted layering in the middle is probably the result of local deformation of partly solidified andesite within the vent. For detail, see figure 11; for contrast in appearance with clastic facies of Hominy Peak Formation to the north, see figure 9. Photograph by D. W. Love, July 1970.

(2–3 ft) in diameter to the Targhee area (loc. bb, fig. 13). The source of these boulders probably was the Conant Basin volcanic centers 19 km (12 mi) to the north (figs. 2, 10).

The boulder facies grades southward into poorly cemented volcanic-pebble conglomerate in which about 75 percent of the fragments are red, brown, green, black, and gray basalt and pyroxene andesite. Average size of the clasts is less than 2.6 cm (1 in.) at the locality halfway between bb and GT (fig. 13), although the deposit contains boulders 30 cm (12 in.) in diameter. The matrix is red and gray bentonitic claystone and tuff. In the northernmost exposures (figs. 12, 13), soft red and purple blocky bentonitic tuff occurs at one or more horizons.

Sparse granite, gneiss, quartz pegmatite, and Paleozoic rock fragments were observed. A few boulders of gray graphic granite, similar to the very distinctive graphic granite in the Precambrian of the Rammel Mountain area 11 km (7 mi) north-northeast, add credence to the interpretation that the Hominy Peak strata in the Grand Targhee area were deposited by southward-flowing streams that drained what is now the northwestern flank of the Teton Range.

A very different conglomerate facies apparently underlies the basalt-boulder facies at locality ls (fig. 13). This facies consists almost entirely of angular blocks of Madison Limestone that crop out in a linear ridge superficially resembling a morainal deposit. Pit studies at the best exposures suggest (but do not prove) that the limestone facies dips under the basalt-boulder facies and that it likewise has a bentonitic claystone matrix. It might be a locally derived Eocene landslide deposit.

A unique feature of many Madison Limestone fragments in the basal conglomerate north and south of

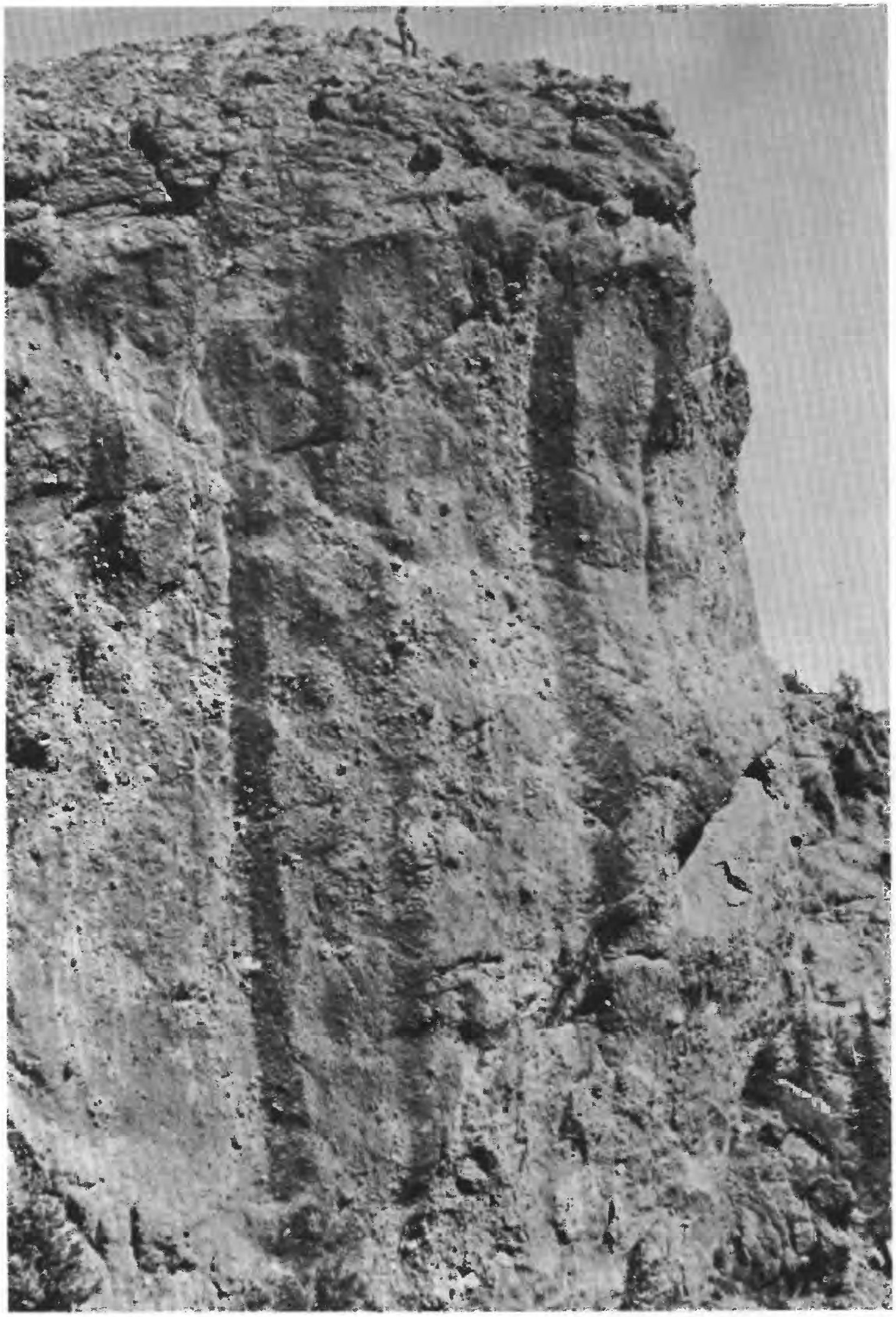


FIGURE 11. — Massively layered, poorly sorted andesitic breccia in vent facies of Hominy Peak Formation, southwest side of Conant Basin. Dark vertical stripes are water stains. Man at top shows scale. Photograph by D. W. Love, July, 1970.

Grand Targhee Resort is that they have become deeply weathered siliceous husks from which much of the limestone within has been dissolved. Figure 15 shows such a boulder. Many pebbles are leached to hollow siliceous shells. The siliceous coating is typically bluish white with what looks like a weathered phosphatic "bloom," but colorimetric analyses of four samples show less than 0.08 percent $P_2O_5$ (report 72DG–209, G. D. Shipley, analyst, Nov. 6, 1972). Spectrographic analyses of these samples show no anomalously high amounts of any element.

Although gold is a minor constituent of the Hominy Peak Formation, it has received considerable attention. Regional studies (Antweiler and Love, 1967; J. D. Love, 1973) show that the chief source was the Precambrian quartzite terrain in the Targhee uplift and that streams carried the gold eastward, both in the boulders and in the matrix fractions. The gold is coarser grained and has a less ragged appearance in the Hominy Peak Formation (fig. 16) and in the underlying Pinyon Conglomerate of this area than in the Pinyon and older conglomerates farther east in Jackson Hole (J. C. Antweiler, written commun., 1975). These attributes of the gold are consistent with its proximity to the postulated source area. Detailed studies of the composition of the gold and its stratigraphic and geographic distribution are being completed by J. C. Antweiler.

The following comparative data prepared by J. C. Antweiler show the progressive changes in size, weight, and percentage of actual gold within a particle, with distance from South Boone Creek, which is the closest locality to the original source. All the gold, as nearly as can be determined, came from the Targhee uplift, although perhaps from several parts of it. This may account for some of the variation in actual gold content within a particle.

| | South Boone Creek | Pacific Creek[1] | Cottonwood Creek[2] |
|---|---|---|---|
| Median particle weight (micrograms) | 23.5 | 13.3 | 9.3 |
| Weight of single particle 125 micrometers in diameter (average) | 13.3 | 10.7 | 10.0 |
| Percentage of gold in particles greater than 100 micrometers in diameter | 99.5 | 62.6 | 59.7 |

[1] 40 km (25 mi) southeast of South Boone Creek; placer gold from mixed source, Harebell Formation and Pinyon Conglomerate.
[2] 72 km (45 mi) southeast of South Boone Creek; placer gold from Pinyon Conglomerate.

Gold distribution in the Hominy Peak Formation follows a consistent pattern. The highest gold values are associated with quartzite conglomerate rather than with volcanic debris. Within the quartzite conglomerate (unit 3 in type section), the highest gold values are in the most ferruginous beds. Fifteen samples of quartzite conglomerate matrix from this unit ranged in gold content from 10 to 290 ppb and averaged 67 ppb.[2] Six samples of quartzite pebbles ranged in gold content from 10 to 110 ppb and averaged 51 ppb. Two samples of volcanic pebbles in the same unit averaged 15 ppb gold. Five samples from the basal marker tuff (unit 2 in measured section) averaged 28 ppb gold. Six samples from this same unit in the 61-m (200 ft) exposure described above in the southern part of the area of figure 2, averaged 15 ppb gold and 33 ppb mercury. In comparison, 29 samples from the matrix of the Pinyon Conglomerate in unit 1 of the measured section averaged 96 ppb gold, and the quartzite pebbles averaged 65 ppb gold.

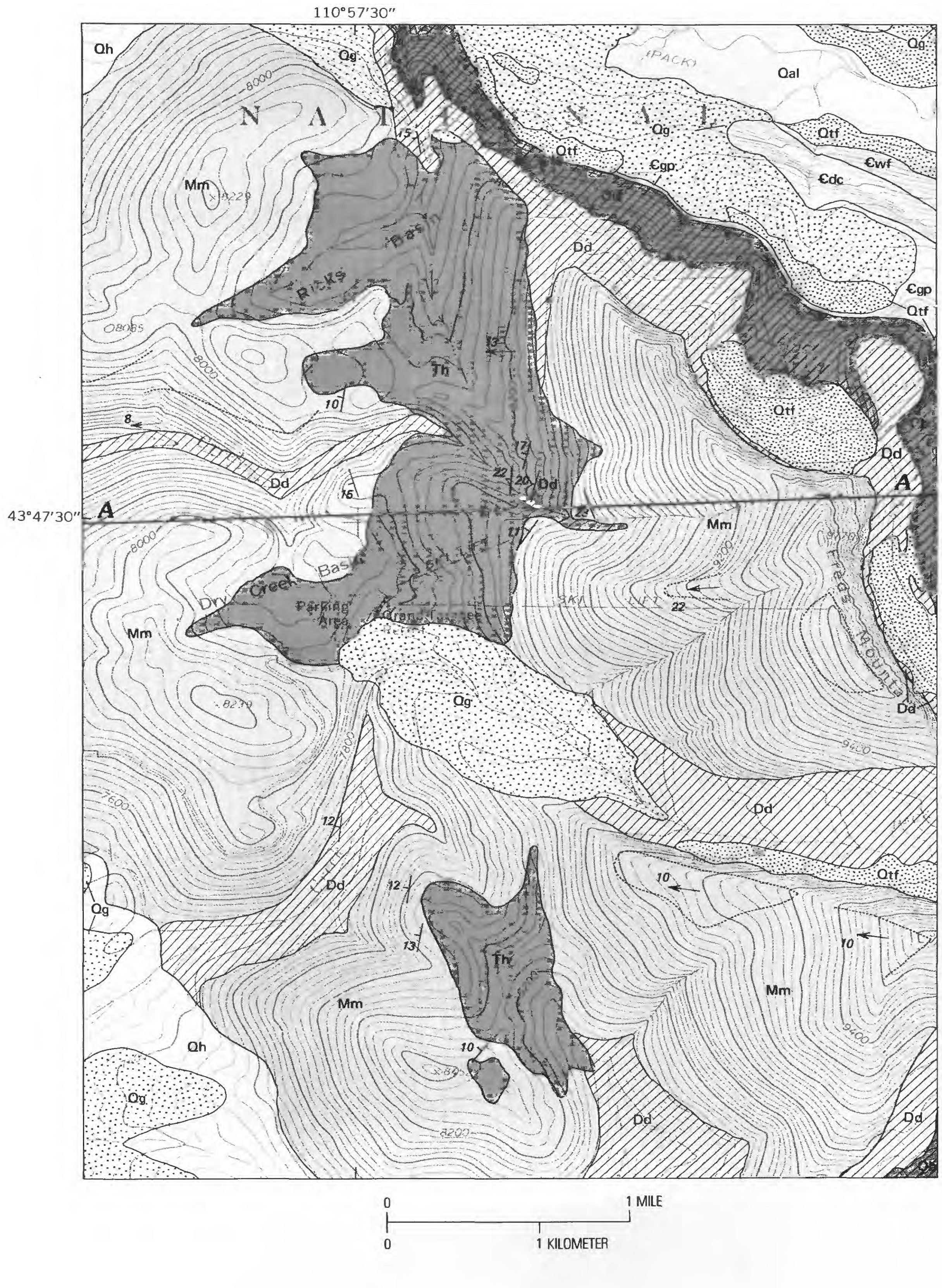
### STRATIGRAPHIC AND STRUCTURAL RELATIONS

The Hominy Peak Formation unconformably overlies rocks ranging in age from Cambrian to Paleocene on the east and west sides of the Paleozoic core at the north end of the Teton Range. The Conant Creek (Pliocene) and Huckleberry Ridge (Pleistocene) Tuffs unconformably overlap parts of all exposures of the Hominy Peak in this area. No rocks overlap the Hominy Peak in the southern area, and the record between Eocene and Pliocene is missing.

The present topographic position and attitudes of the Hominy Peak Formation are somewhat anomalous with respect to the Teton Range and the Teton Basin to the west. For example, in both areas of outcrop the Hominy Peak Formation overlaps the present-day west flank of the Teton Range. However, when the strata are rotated to their original position at the time of deposition, it becomes apparent that the modern west flank of the Teton Range was the east flank in Eocene time and that the structural axis of the Targhee–Teton–Gros Ventre uplift (J. D. Love, 1973) lay to the west under what is now Teton Basin (figs. 17, 18).

At the north end of the present Teton Range, the previously mentioned slide masses of Paleozoic and other rocks as much as 36.6 m (120 ft) in diameter are incorporated in the very coarse grained facies of the Hominy Peak Formation. It is postulated that the slope gradient eastward during deposition of this nonplastic facies of the Hominy Peak may have been as much as 122 m/1.6 km (400 ft/mi) (but actually could have been less). In order to attain the steep gradient, section *B* of figure 17 must be rotated to the position shown therein. The eastern margin of the Targhee uplift, on the basis of these assumptions, would have sagged at least 1,830 m

[2] 100 parts per billion at $140 per ounce is approximately 40 cents per ton.


110°57'30"
43°47'30"
A
A
Qh
Qg
Qal
Qtf
Ꞓgp
Ꞓdc
Ꞓwf
Mm
Th
Dd
Ricks Basin
Dry Creek Basin
Parking Area
SKI LIFT
Freds Mountain
8000
9400
7600
0
1 MILE
0
1 KILOMETER

(6,000 ft) after Hominy Peak deposition and 1,128 m (3,700 ft) after emplacement of the Huckleberry Ridge Tuff 1.9 million years ago. If the gradient was actually much less, the estimate of the amount of sagging would have to be proportionately reduced. The fine-grained claystones in unit 7 of the type section are not helpful in determining the depositional gradient for the formation as a whole, as they have only local extent and represent 4.6 m (15 ft) out of 611 m (2,000 ft) of strata. The claystones probably were deposited during a brief interval of time in a very localized body of water, perhaps a slide pond.

A similar reconstruction is possible in the Grand Targhee Resort area (fig. 19), using the Cities Service Oil Co., Hansen A–1 drill hole in the SW1/4NE1/4 sec. 9, T. 5 N., R. 45 E., 9 km (5.6 mi) west-northwest of the village of Alta (fig. 2) at the location shown in figure 3. This drill hole is in the middle of Teton Basin and went from upper Cenozoic white tuff and claystone directly into Permian rocks at a depth of about 730 m (2,400 ft). The drill hole bottomed in Precambrian rocks, and a core from 2,559 to 2,561 m (8,395 to 8,402 ft) recovered 70 cm (28 in.) of gray coarsely crystalline granite gneiss similar to the layered gneiss and migmatite in the Teton Range, described by Reed and Zartman (1973). No evidence of the Hominy Peak Formation was found in drill cuttings. Our interpretation is that this drill hole is on the southwest flank of the ancestral Targhee–Teton–Gros Ventre arch as it existed at the time the Hominy Peak Formation was deposited and that this formation did not extend to the crest of the range. After deposition of the Hominy Peak Formation, the crest of the arch transected by the line of the section in figure 19 apparently sagged at least 2,440 m (8,000 ft). As much as 610 m (2,000 ft) of this sagging may have occurred after emplacement of the Huckleberry Ridge Tuff 1.9 million years ago.

### AGE AND CORRELATION

The Hominy Peak Formation is considered to be part of the Absaroka Volcanic Supergroup (Smedes and Prostka, 1972). Direct lithologic correlation with groups or individual formations within this supergroup in and adjacent to southeastern Yellowstone National Park is not possible because a 24-km (15-mi) gap exists between that area and the easternmost exposures of the Hominy Peak Formation in the Teton area, and the rocks in each of these areas came from different local sources.

◀ FIGURE 12.—Geologic map of Grand Targhee Resort area, showing relations of Hominy Peak Formation (Th) to other rock units, including Wolsey Shale and Flathead Sandstone (Cambrian, Ꞓwf), Death Canyon Limestone Member of Gros Ventre Formation (Cambrian, Ꞓdc); Gallatin Limestone and Park Shale (Ꞓgp); Bighorn Dolomite (Ordovician, Ob); Darby Formation (Devonian, Dd); Madison Limestone (Mississippian, Mm); Huckleberry Ridge Tuff (Pleistocene, Qh); and the Quaternary unconsolidated units: alluvium (Qal), talus, rockfall, and fan debris (Qtf), and glacial debris (Qg). Location of cross sections shown in figure 18 is indicated as *A–A′*. Base from U.S. Geological Survey Granite Basin, 1968. Geology by J. C. Reed, Jr., and J. D. Love (1972). Strike and dip shown by conventional symbol; numbered arrow indicates general direction of dip without commitment as to strike. Dotted outlines are linear features conspicuous on aerial photographs.

Two samples for K-Ar age determination were collected from the type section of the Hominy Peak Formation: a white biotite-rich tuff from the basal white marker tuff (unit 2 in the type section) and a black basaltic porphyry from unit 6. Biotite separated from the tuff yielded an age of about 72 m.y., which indicates contamination from an older, probably Precambrian, source (J. D. Obradovich, written commun., 1975). A whole-rock K-Ar age determination of the basaltic porphyry is pending.

Pollen from several units in the type section (table 1) indicates a middle Eocene age for the Hominy Peak Formation. Horizons of collections are as follows:

| | |
|---|---|
| Unit 7 | USGS Paleobot. loc. D4617, samples A, B, and C; D5459, samples B, D, E, and F; and D4271 — C. |
| Unit 6 | USGS Paleobot. loc. D4617, samples G and H. |
| Unit 5 | USGS Paleobot. loc. D4271 — B. |
| Unit 3 | USGS Paleobot. loc. D4271 — A. |

Samples were cleaned with a scrub brush, macerated, and 25 grams was treated with HCl, cold HF for 3 hours, Schulze's solution for 3 minutes, KOH for one-half minute, and was subjected to heavy liquid flotation with $ZnBr_2$ adjusted to a specific gravity of 2.0. Organic residues thus obtained were bleached briefly with $NaClO_2$, washed, and mounted in AYAF (or, small samples, glycerine jelly).

Table 1 lists the forms identified. Key forms within the assemblages are shown on plates 1–4.

The Hominy Peak pollen flora is certainly of middle Eocene age. This conclusion is based on its similarity with the Kisinger Lakes flora (Leopold, in MacGinitie, 1974, p. 49), which "is distinctive not only because it is rich in species and families, but because it includes a wide range of tropical and warm temperate groups and a few marker fossils characteristic of Bridgerian (middle Eocene) strata. The pollen flora is widespread over about 30,000 square miles of western and central Wyoming." Key forms common to both the Kisinger Lakes flora and that in the Hominy Peak Formation include *Platycarya, Pistillipollenites mcgregorii, Trema,* cf. *Platanus, Cedrela* or *Melia,* Aceraceae, Bombacaceae?, *Triumfetta-Luehea,* cf. *Schoutenia, Ilex,*

TABLE 1. — *Pollen collections from the type section of the Hominy Peak Formation*

[X, presence of spore or pollen type in the sample, queried where identification uncertain; leaders (. . .) spore or pollen type not found]

| Unit No. | 3 | 5 | 6 | | 7 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| USGS Paleobot. Loc. No. | D4271 | D4271 | D4617 | D4617 | D4617 | D4271 (=D4617 -B) | D5459 | D4617 | D5459 | D5459 | D5459 |
| Sample No. | A | B | G | H | A | C | B | C | D | E | F |
| **Gymnospermae** | | | | | | | | | | | |
| *Abies* | × | ... | ... | ... | ... | ... | × | ... | ... | ... | × |
| Gynkaletes | ... | ... | ... | ... | ... | ... | × | ... | × | ... | ... |
| cf. *Keeteleria* | ... | × | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| *Picea* | × | ... | ... | ... | × | × | × | ... | × | × | ... |
| *Pinus* | × | × | × | × | × | × | × | × | × | × | × |
| *Sequoiapollenites* | ... | ... | ... | ... | ... | ... | ... | ... | × | ... | ... |
| *Taxodiaceaepollenites hiatus* | × | × | ... | ... | × | × | × | × | × | × | × |
| *Tsuga* | × | ... | ... | ... | × | ... | ... | ... | ... | ... | ... |
| **Dicotyledons** | | | | | | | | | | | |
| Aceraceae | ... | ... | ... | × | × | ... | ... | ... | ... | ... | ... |
| *Alangium* | ... | ... | × | ... | ... | ×? | ... | ... | ... | ... | ... |
| *Alnus* | ... | × | × | ... | × | × | × | × | × | × | ... |
| *Betula* type | × | × | ... | ... | ... | ... | ... | ... | × | × | ... |
| *Betulaepollenites plicatus* | ... | ... | × | ... | × | ... | ... | ... | ... | ... | × |
| Bombacaceae? | ... | ... | ... | × | × | ... | × | ... | × | ... | ... |
| *Carya* | × | × | × | × | × | × | × | × | × | × | × |
| *Cedrela* or *Melia* | ... | ... | ... | ... | × | ... | ... | ... | ... | ... | ... |
| cf. *Cuphea* | ... | ... | ... | ... | ... | × | ... | ... | ... | × | ... |
| *Eucommia* | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | × |
| *Ilex* | ... | ... | ... | ... | × | ... | ... | ... | ... | ... | ... |
| Juglandaceae; *Oreomunnea* type | ... | ... | ... | ... | ... | ... | × | ... | ... | × | ... |
| *Luehea Triumfetta* | × | × | × | ... | × | × | × | × | × | × | × |
| cf. *Morus* | ... | × | ... | ... | ... | × | ... | ... | ... | ... | ... |
| cf. *Nyssa* | ... | ... | ... | ... | ... | ... | × | ... | ... | × | ... |
| *Ostrya-Carpinus* type | ... | ... | ... | × | ... | ... | ... | ... | ... | ... | ... |
| *Pistillipollenites mcgregorii* | ... | ... | ... | × | × | × | × | × | × | ... | ... |
| cf. *Platanus* | ... | × | ... | ... | × | × | × | ... | ... | × | ... |
| *Platycarya* | ... | ... | ... | ... | ... | × | ... | ... | × ? | ... | ... |
| *Pterocarya* | × | ... | ... | × | × | ... | ... | ... | × | ... | ... |
| cf. *Schoutenia* | ... | ... | ... | × | ... | ... | ... | ... | ... | ... | ... |
| Sterculiaceae? | × | ... | ... | ... | ... | ... | × | ... | × | × | ... |
| *Tilia*? | ... | × | × | ... | × | × | ... | ... | × | ... | × |
| *Trema* | ... | ... | ... | ... | ... | × | ... | ... | ... | ... | ... |
| Ulmaceae, *Ulmus-Zelkova* type | ... | × | ... | ... | × | × | ... | ... | × | × | × |
| Ulmaceae, *Parasporia* type | ... | ... | ... | ... | ... | ... | × | ... | × | ... | × |
| **Monocotyledons** | | | | | | | | | | | |
| Ammonaceae, cf. *Annona* | ... | ... | ... | ... | ... | ... | ... | ... | ... | × | ... |
| Gramineae? | ... | ... | ... | ... | ... | ... | ... | ... | × | ... | ... |
| cf. *Pandanus* | ... | ... | ... | ... | ... | × | ... | ... | ... | ... | ... |
| **Ferns and fern allies** | | | | | | | | | | | |
| *Anemia* | × | ... | ... | ... | ... | ... | ... | ... | × | ... | ... |
| *Corrugatisporites* | ... | ... | ... | ... | ... | ... | × | ... | × | × | ... |
| cf. *Lastrea* | ... | ... | ... | ... | ... | ... | ... | ... | ... | × | ... |
| *Lycopodium* | × | ... | ... | ... | × | × | × | × | × | ... | ... |
| *Lygodium* cf. *kaulfussi* | × | ... | ×? | ... | ×? | ... | ... | ... | × | × | ... |
| *Osmunda* | ... | ... | ... | ... | ... | ... | ... | ... | × | ... | ... |
| cf. *Pteris* | ... | ... | ... | ... | ... | ... | ... | ... | ... | × | ... |
| *Selaginella* cf. *densa* | × | ... | ... | ... | ... | ... | ... | ... | ... | ... | × |

*Selaginella* cf. *densa,* and *Alangium.* The range of *Platycarya* in the Rocky Mountain region is from near the base of the Eocene through approximately early middle Eocene. *Pistillipollenites* in this region ranges from late Paleocene through early middle Eocene and is particularly abundant at the Tipperary locality of the

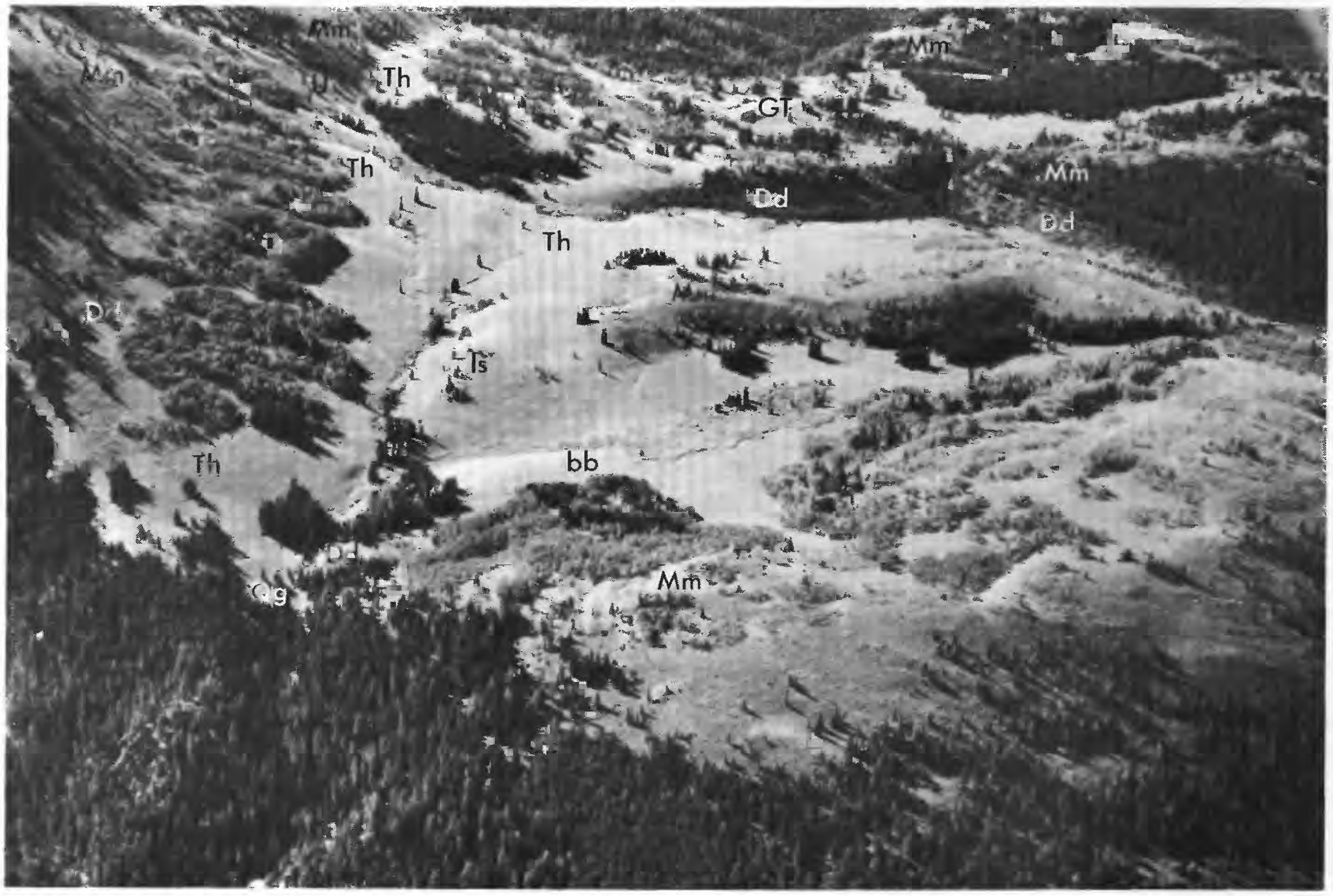



FIGURE 13.—Air oblique view south along west flank of Teton Range, showing area of Hominy Peak Formation near the Grand Targhee Resort. Indicated are sparsely vegetated outcrops of the Hominy Peak Formation (Th); Madison Limestone (Mm); Darby Formation (Dd); glacial debris (Qg); site of unconformity between Hominy Peak and Darby Formations shown in figure 14 (U); Grand Targhee Resort (GT); basalt boulder concentration in Hominy Peak Formation (bb); limestone conglomerate facies (ls). Photograph by W. B. Hall, T. H. Walsh, and J. D. Love, September 6, 1971.

Aycross Formation (Leopold and MacGinitie, 1972). This locality is 14 km (9 mi) southeast of section 14 in plate 5. In the somewhat younger beds of Bridgerian provincial age of Wood and others (1941) at the Kisinger Lakes floral locality (plate 5, section 7) this form becomes very rare. *Platanus*-type and *Cedrela-Melia* are known to range from Eocene through Oligocene strata, and are usually very rare.

Aceraceae types are notably varied in the Kisinger Lakes floral beds and in the uppermost strata of the Wind River Formation and are merely present at the Hominy Peak site. Bombacaceae? types are known from at least early middle Eocene strata at Kisinger Lakes, upward in time and stratigraphy through strata containing the Green River flora probably of younger middle Eocene age (MacGinitie, 1969) but are absent in beds of late Eocene age (Uintan provincial age of Wood and others, 1941). *Triumfetta-Luehea* and cf. *Schoutenia* as we know them are so far recorded only in the youngest strata of the Wind River Formation (of late early Eocene age) and in middle Eocene rocks, and are absent in Uintan or upper Eocene strata. ***Ilex*** and ***Alangium*** pollens in Wyoming are so far known only from middle Eocene beds. ***Selaginella*** cf. ***densa*** is a type rare in the middle Eocene, but it is recorded in Oligocene (in the Florissant Lake Beds) and is common in Neogene strata of the region.

Certain forms or groups that are characteristic of middle Eocene strata (as at Kisinger Lakes) are either absent or only tentatively identified in the Hominy Peak section. One such type includes the unusual spores of ***Lygodium*** cf. ***L. kaulfussi,*** which we identified at Kisinger Lakes by extracting sporangia from compression leaf fossils. Similar spores are present in the Hominy Peak strata, but they are smaller and do not have such pronounced wall thickenings. Another type is the Leguminoseae, which is moderately diverse at Kisinger Lakes but appears to be absent in the Hominy

FIGURE 14. — Unconformity between Hominy Peak and Darby Formations 275 m (900 ft) northeast of the Grand Targhee Resort. Strike is about north-south on both formations; the Hominy Peak dips 20° W., whereas the underlying Darby dips 7° W. Photograph by J. D. Love, September 17, 1971.

Peak assemblage. On the other hand, pollen of the Pinaceae is rare in most samples from the Kisinger Lakes flora and Green River strata of Bridgerian age but is common to dominant (about 60 percent of the pollen and spore tallies) in the Hominy Peak samples. It is possible that facies differences are responsible for such patterns.

Like the Kisinger Lakes and other middle Eocene floras, the Hominy Peak pollen assemblage includes a number of tropical or subtropical groups (Schizaeaceae cf. *Anemia, Alangium, Trema, Triumfetta-Luehea*), as well as warm temperate types (*Platycarya, Pterocarya, Cedrela* or *Melia*). The Hominy Peak flora represents what Leopold and MacGinitie (1972) have recognized as Phase III in their broad subdivision of the Rocky Mountain Eocene; the climate of this phase was described by MacGinitie (1974) as tropical or near tropical with a pronounced winter dry season. The climate was either frostless or, possibly, had rare light frosts. He inferred that the present semideciduous flora of southwestern Mexico, the bosque tropical subdeciduo, is the nearest living floristic group to the Kisinger Lakes flora. Figures 20 and 21 show this flora and terrain in western Mexico. It is thought by MacGinitie (written commun., 1976) that these views are analogous to the scene in northwestern Wyoming at the time of deposition of the Kisinger Lakes flora. Because such a frost-free climate with even temperatures is not conceivable at the present elevation of Kisinger Lakes site (2,804 m, or 9,200 ft), and, for other reasons, he concluded that the terrain lay from 1,219 to 2,438 m (4,000 to 8,000 ft) lower than now during the middle Eocene.

The middle Eocene (Bridgerian) flora of the Kisinger Lakes type with which we are dealing here has a succinct geographic range. It has not yet been found outside western and central Wyoming but ranges from just

FIGURE 15. — Characteristically deeply corroded boulder of Madison Limestone 61 cm (2 ft) in diameter in the Hominy Peak Formation near Grand Targhee Resort. Resistant surface is partly silicified and has a bluish-white, slightly phosphatic coating. Photograph by J. D. Love, September 17, 1971.

south of the town of Green River (where we have recently found an occurrence associated with a Bridger A vertebrate fauna collected by R. M. West), north to the northwest edge of the Wind River Basin, westward to the Teton Range, and southeastward to the southern margin of the Wind River Basin. Most of the localities of its occurrence are based on pollen data and are shown on a map by MacGinitie (1974, fig. 7), although when that work was published, neither the Hominy Peak nor the newly discovered locality near Green River, mentioned previously, was known.

On the basis of the correlation by pollen analysis, the Hominy Peak Formation is equivalent to the Aycross Formation (type area, pl. 5, section 13), part of the Wagon Bed Formation (unit 3 of Van Houten, 1964), the strata at the Kisinger Lakes leaf locality (called Tepee Trail Formation by Rohrer, in MacGinitie, 1974; for alternative correlations, see this report, pl. 5, section 7), and the upper part of the Wilkins Peak or lower part of the Laney Members of the Green River Formation in southwestern Wyoming.

The age determination that is geographically nearest to the type section of the Hominy Peak Formation is from the dacite intrusive of the Birch Hills (pl. 5, section 1), which cuts through and deforms the Hominy Peak. Apatite from the dacite has a fission-track age of 40.5±2.6 m.y. (L. L. Love and others, 1976). The intrusive relations indicate that the Hominy Peak must be older than 40.5 m.y.

A K-Ar age of biotite from the type area of the Aycross Formation (pl. 5, section 13; unpub. type section measured by J. D. Love in 1972) 70.7 m (232 ft) above the horizon of the Kisinger Lakes flora is 49.2±0.5 m.y. (J. D. Obradovich, written commun., 1975). Middle Eocene (Bridgerian) vertebrate fossils are present both above and below the strata with this

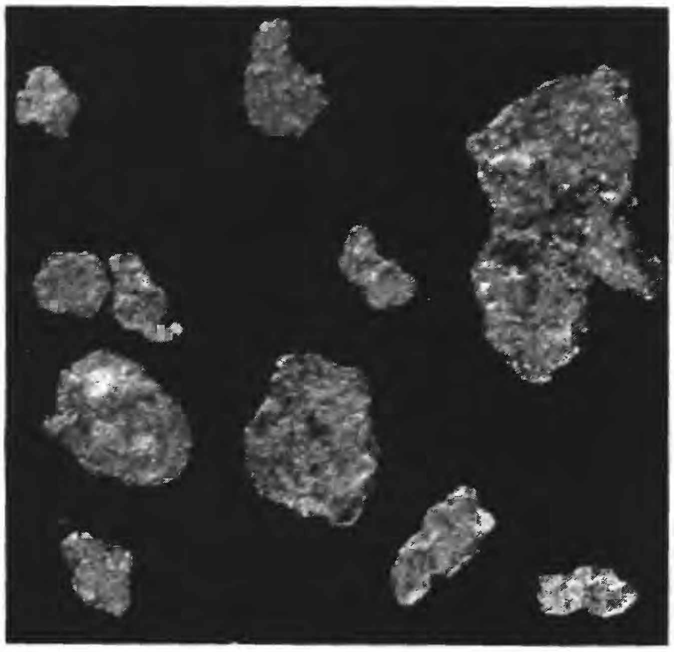


FIGURE 16. — Gold from quartzite conglomerate in the Hominy Peak Formation on South Boone Creek. Photograph by J. C. Antweiler, × 50.

age. The relations of the Kisinger Lakes flora to K-Ar ages elsewhere in this general area are shown in sections 7 and 9, plate 5. From these data it is apparent that in the K-Ar time scale, the Kisinger Lakes flora is about 49–49.5 m.y. old. In the fossil mammal time scale, it would be about Bridger A–B.

These K-Ar and fossil mammal time scales are reasonably compatible with the 48.8–49.1 m.y. ages (R. L. Mauger, written commun., 1974) obtained from tuff beds such as the Big Island tuff, an informal term of Mannion and Jefferson (1962; tuff No. 3 of Culbertson, 1961) in the upper part of the Wilkins Peak Member of the Green River Formation in the Green River Basin, about 273 km (170 mi) south-southeast of the type Hominy Peak Formation. The relation of these tuff beds to the newly discovered locality in the Green River Formation containing the Kisinger Lakes flora in this part of the Green River Basin has not been determined. About 96.5 km (60 mi) north-northeast, however, at the Big Sandy Bend locality (Leopold, in MacGinitie, 1974, p. 51), the Kisinger Lakes flora directly overlies a Bridger B fossil mammal bed (West, 1969, p. 87–88).

Along the southern margin of the Wind River Basin, Evernden, Savage, Curtis, and James (1964, sample KA–1021) obtained a K-Ar age of 49 m.y. from unit 1 of the Wagon Bed Formation (Van Houten, 1964) at a slightly lower horizon than the Kisinger Lakes flora (in unit 3) reported by Leopold and MacGinitie (1972).

Several other sites of K-Ar ages, not already described in connection with the Kisinger Lakes flora, in the Jackson Hole-southern Absaroka area are shown on plate 5. At locality *A* (fig. 2; pl. 5, section 3) a K-Ar age of 48.6±0.7 m.y. was obtained (J. D. Obradovich, written commun., 1975) from basalt in a large vent associated with a mafic andesite complex similar in appearance and mineralogic composition to the Hominy Peak Formation. At locality *B* (fig. 2; pl. 5, section 3), a greenish-white biotite tuff and claystone that overlies the basalt and mafic andesite sequence has a K-Ar age of 45.9±0.5 m.y. (J. D. Obradovich, written commun., 1975). This tuff, in turn, is overlain by white tuffaceous claystones containing early Oligocene fossil mammals (Sutton and Black, 1972).

In the Togwotee Pass area (pl. 5, section 4) the Eocene sequence has, at its base, variegated bentonitic tuffs (J. D. Love, 1947, section 6) containing vertebrate fossils more indicative of late Wasatchian provincial age of Wood and others (1941) than early Bridgerian provincial age, possibly of the same age as those in the basal beds of the type Aycross Formation (pl. 5, section 13; McKenna, 1972, p. 91). The variegated strata are overlain (pl. 5, section 5) by green tuffs and claystones that weather into badlands at Togwotee Pass. These contain an abundant fossil mammal assemblage of Bridger A–B age (McKenna, 1972, p. 92). About 70 m (230 ft) below the mammal horizon, in a roadcut along U.S. Highway 26–287, a greenish-gray tuff yielded a K-Ar age of 47.8±1.3 m.y. (J. D. Obradovich, in Smedes and Prostka, 1972, fig. 8). This sequence at Togwotee Pass is called Tepee Trail by Smedes and Prostka (1972) and by Rohrer (in MacGinitie, 1974), but, as is shown on plate 5, the combined evidence of K-Ar ages, pollen, vertebrate fossils, and lithology suggests that it is more likely correlative entirely or in large part with the Aycross Formation and should not be called Tepee Trail.

The Tepee Trail Formation at its type section (pl. 5, section 12) unconformably overlies the Aycross Formation, is lithologically very different from the Aycross and contains a large and unusual fossil mammal assemblage of late Eocene (Uintan) age (McKenna, 1972; also, written commun., 1975).

The Langford Formation (Smedes and Prostka, 1972) in and south of Yellowstone National Park has several features similar to those in the Hominy Peak, such as general lithologic composition (although the Langford may be more felsic), abundant fossil wood, and large masses of Precambrian and Paleozoic rocks. Fossil wood and blocks of pre-Tertiary rocks, however, are present in other parts of the Absaroka Volcanic Supergroup. Two whole-rock K-Ar ages from basalt unconformably overlying the Langford on Pinyon Peak (J. D. Love, 1974), 40 km (25 mi) east of Hominy Peak and 8.8 km ($5^1/_2$ mi) east of the area shown in figure 2,

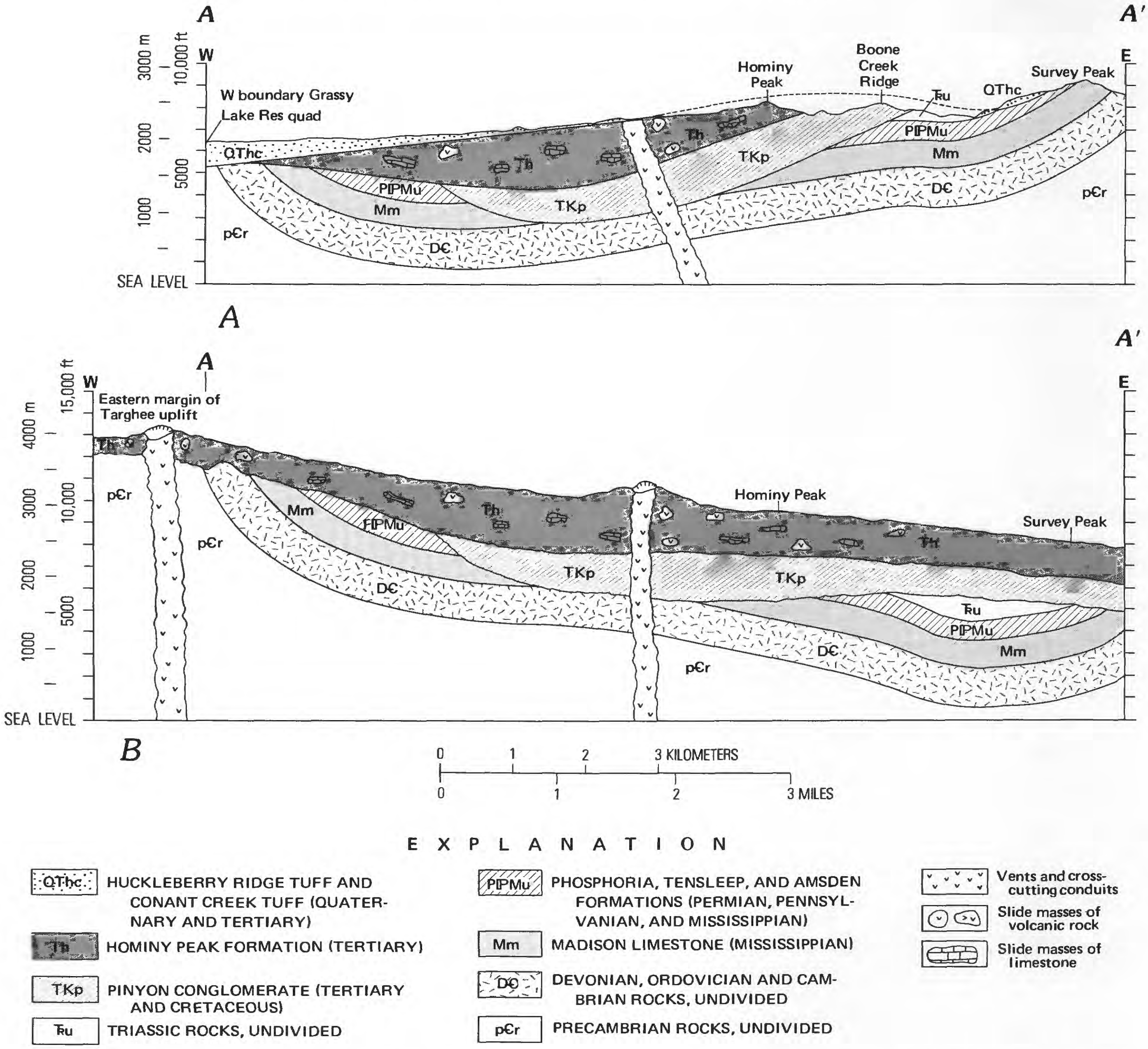



FIGURE 17.—Structure sections (without vertical exaggeration) along line *A–A'* in figure 4. Alluvial deposits are too thin to indicate. Section *A*, Relations of rocks and topography as they are now. Section *B*, Reconstruction of interpreted relations during a late stage of deposition of the Hominy Peak Formation in middle Eocene time; section is extended westward to include the hypothetical east margin of the Targhee uplift. Section *B* is arbitrarily rotated so that, in the eastern half, the slope gradient during the deposition of the Hominy Peak Formation is eastward about 122 m/1.6 km (400 ft/mi); this gradient is more than sufficient to move slide masses 45 m (150 ft) in diameter. On the basis of this interpretation, the eastern margin of the Targhee uplift would have sagged at least 1,830 m (6,000 ft) after Hominy Peak deposition and 1,128 m (3,700 ft) after emplacement of the Huckleberry Ridge Tuff. Units indicated are Huckleberry Ridge Tuff and Conant Creek Tuff (QThc), Hominy Peak Formation (Th), Pinyon Conglomerate (TKp), Triassic rocks (Ꞧu), Phosphoria, Tensleep, and Amsden Formations (PIPMu), Madison Limestone (Mm), Devonian, Ordovician, and Cambrian rocks (DO), and Precambrian rocks (pЄr). Locations and size of vents and cross-cutting conduits that supplied volcanic debris to the Hominy Peak Formation are diagrammatic, as are slide masses of volcanic rock and limestone within the Hominy Peak Formation.

average 49.4±1.0 m.y. (M. C. McKenna, written commun., 1970). Thus, the basalt would be comparable in age to the Aycross Formation at its type area, to the White Pass bentonite, an informal term (pl. 5, section

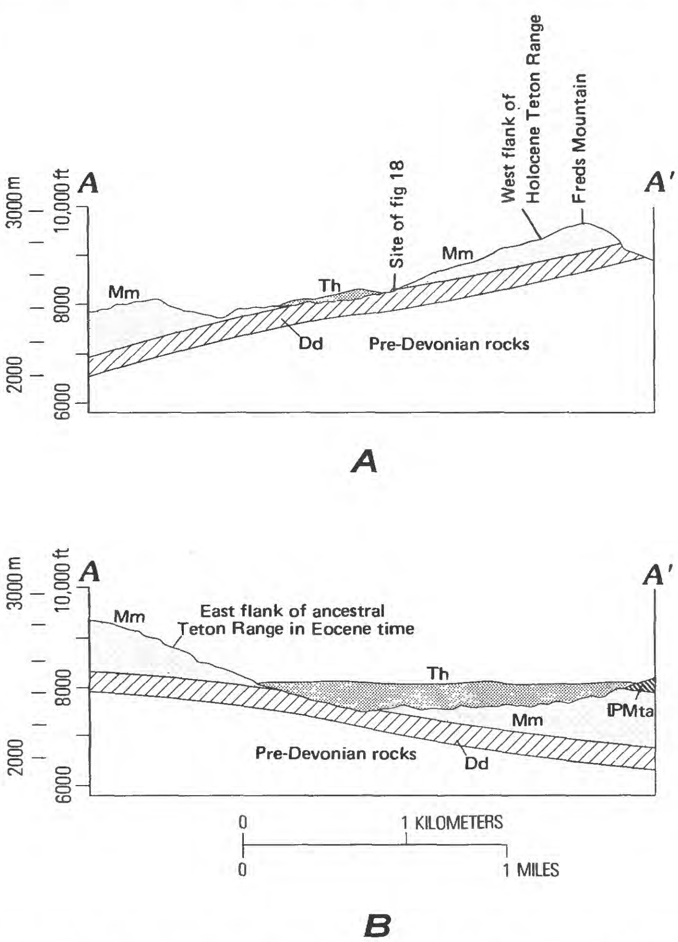



FIGURE 18.—Cross sections of rocks in the Grand Targhee Resort area. Section *A*, Present positions of rocks. Section *B*, Hypothetical position of rocks in middle Eocene time, determined by rotating section *A* 20°, until the Hominy Peak Formation (Th) is horizontal in an east-west plane, as it was believed to have been in middle Eocene time. No depositional dip is allowed for because the cross section is at approximately right angles to the stream carrying Hominy Peak debris southward along a strike valley cut in part in soft rocks of the Darby Formation (Dd). No vertical exaggeration is in either section. Other rock units: Tensleep Sandstone and Amsden Formation (Pennsylvanian and Mississippian, (IPMta); Madison Limestone (Mississippian, Mm).

9), to the lithologically similar basalt and andesite on Pilgrim Creek (pl. 5, section 3), and, on the basis of correlation of the Kisinger Lakes flora between sections 2 and 13 (pl. 5), to the Hominy Peak Formation.

No K-Ar ages are available for the Langford, but, assuming that it is not much older than the basalt on Pinyon Peak, 49.4 m.y. would come close to the time brackets of samples from units overlying and underlying the Langford in Yellowstone National Park and adjacent areas. In the park, the overlying Two Ocean Formation has an age of 47.9±1.3 m.y. and the underlying Pacific Creek Tuff Member of the Trout Peak Trachyandesite has an age of 48.0±1.3 m.y. (Smedes and Prostka, 1972, fig. 8).

Iddings (Hague, Iddings, and others, 1899, p. 338) assigned some of the rocks in the Conant Basin area to "transitional varieties between absarokite and basalts rich in olivine and augite." He indicated that the clouded labradorite laths are rimmed with clear orthoclase. Both augite and olivine with poikilitic glass inclusions are present. Iddings recognized the loose association of absarokite, shoshonite, banakite, and basalt and indicated that they were probably genetically related. Joplin (1965) proposed a shoshonite series similar to the tholeiite series, but Nicholls and Carmichael (1969) argued against such a series because none of the rocks in the series can be derived from each other through differentiation, and because many of the rocks in the shoshonite group resemble cumulates.

The rocks of the Conant Basin area are texturally identical to some of the absarokites, shoshonites, and banakites illustrated by Prostka (1973). He pointed out that the textures of these rocks in the Absaroka area show that the large, partially resorbed and corroded phenocrysts of olivine, pyroxene, and plagioclase are not in equilibrium with the groundmass, and probably are xenocrysts. He suggested that the shoshonite suite was derived by contaminating a syenitic magma with mafic-ultramafic layered cumulates.

### TECTONIC IMPLICATIONS

Because of the loss of samples for chemical and petrographic analysis, the following discussion of the Hominy Peak Formation as related to the Absaroka Volcanic Supergroup must be considered as very preliminary.

Iddings and later workers pointed out that one of the unusual attributes of absarokites, shoshonites, and banakites is the high $K_2O$ content. Peterman, Doe, and Prostka (1970) and Lipman, Prostka, and Christiansen (1972) indicated that the rocks in the Absaroka volcanic field include calc-alkalic andesites and related rocks and a volumetrically much smaller amount of shoshonites and alkalic rocks, which have almost twice as much $K_2O$. As indicated by Lipman, Prostka, and Christiansen (1972), Dickinson and Hatherton (1967) argued that the $K_2O$ content of similar andesitic rocks along continental margins and island arcs is directly related to the depth of the Benioff zone beneath the volcanic centers, the highest $K_2O$ content being farthest from the present trenches, and above the deepest parts of the Benioff zone.

Chadwick (1970) showed two zones of volcanic centers in the Absarokas, with the northeast zone higher in $K_2O$ than the southwest zone. Lipman, Prostka, and

Christiansen (1972), applying Dickinson and Hatherton's correlation between $K_2O$ content and Benioff zones, hypothesized that the Absaroka volcanic field is the surface expression of an Eocene Benioff zone, truncated by rapid movement of the North American plate over a trench. Lipman, Prostka, and Christiansen (1972) also hypothesized that the Eocene volcanics in the Challis region of Idaho are evidence for a second, shallow imbricate Benioff zone west of the Absaroka zone. Peterman, Doe, and Prostka (1970) indicated that the U/Pb ratios in rocks of the Absaroka area suggested that the Eocene rocks were derived from the upper mantle or lower crust by partial melting and that they retained an imprint of the loss of U relative to Pb from regional metamorphism about 2.8 billion years ago. If this interpretation is correct, it would imply that the parent rocks for the andesites were part of the North American plate rather than from the unrelated rocks in or beneath the Benioff zone.

Peterman, Doe, and Prostka (1970), however, indicated that these rocks could have been contaminated. Contamination is supported petrographically (Prostka, 1973) and by chemical analyses (L. L. Love and others, 1976). They showed that rocks of the Absaroka Volcanic Supergroup are not similar to typical andesitic island arcs in terms of spatial and temporal sequences of eruptive types. In modern island arcs, high-potassium rocks are among the youngest rocks to be erupted and occur toward the continental interior.

Although the bulk of the high-potassium rocks of the Absaroka Supergroup are in Chadwick's (1970) eastern belt, occurrences of absarokites, shoshonites and banakites are scattered throughout the western belt (L. L. Love and others, 1976) and high-potassium rocks may dominate the Hominy Peak Formation. The eastern belt, which includes the higher potassium rocks of the Sunlight Group (Smedes and Prostka, 1972) is not the youngest material to be erupted. It is stratigraphically between the Washburn Group and the Thorofare Creek Group which have lower $K_2O$ values (Smedes and Prostka, 1972).

From stratigraphic relations and from available radiometric ages, the trend of volcanism in the Absaroka volcanic field moved progressively from northwest to southeast (L. L. Love and others, 1976), and the youngest rocks are not potassium rich. The distribution of high-potassium rocks and the age trend oblique to the continent suggest that the island arc-Benioff zone model is not a good analogy for generating the Absaroka volcanic pile.

Several authors have divided the Absaroka volcanic field into subprovinces (Larsen, 1940; Rubel, 1971; Smedes and Prostka, 1972; L. L. Love and others, 1976). The Hominy Peak Formation should probably be considered as being within a subprovince; other subprovinces may occur to the northwest. All these would have to be studied in greater detail for a better understanding of the temporal and spatial relations necessary to produce a well-founded petrogenetic restoration. Perhaps high-potassium rocks in the Absaroka field are associated with a special kind of structural framework such as structural sags on foreland uplifts.

From this summary and from related data depicted on plate 5, it is apparent that, in a time span between 49 and 43 m.y. ago, and in an east-west distance of less than 161 km (100 mi), a series of distinctive faunal, floral, and lithologic units aggregating more than 1,525 m (5,000 ft) in thickness was deposited during periods of intense and varied volcanism in middle and late Eocene time. Plate 5 focuses attention on the complex relations of the predominantly nontuffaceous, generally variegated lower Eocene Wind River Formation and the entirely tuffaceous middle Eocene Aycross Formation, which is highly variegated in the eastern sections (12, 13, 14), but is green at section 5. Both facies are contemporaneous with the only slightly variegated Hominy Peak Formation, but they are derived from more easterly sources. All facies, however, contain the Kisinger Lakes flora. Plate 5 also shows, in sections 10, 11, and 12, the magnitude of sedimentation in 5 m.y. of late Eocene time — nearly 1,220 m (4,000 ft). During this late Eocene interval, the green nonvariegated Tepee Trail Formation and the gray Wiggins Formation were deposited and then were cut by major intrusive bodies, such as the dacite intrusive porphyry of the Birch Hills (discussed in the next section). Problems of the late Eocene age and correlation of the Wiggins Formation have been discussed elsewhere (J. D. Love and others, 1976).

## DACITE INTRUSIVE PORPHYRY OF THE BIRCH HILLS

The regional geologic setting of the intrusive of the Birch Hills is shown in geologic mapping of the Grassy Lake Reservoir quadrangle (Christiansen and others, 1978). Three localities of intrusive porphyry are present within 1.6 km (1 mi) of each other, and the rocks are lithologically similar. The two largest bodies are in contact with highly deformed Paleozoic rocks but the small middle one, 213 m (700 ft) south of the main intrusive, is intruded into or through the Hominy Peak. All three outcrops of the dacite porphyry are considered to have been emplaced by the same intrusive event, which is younger than the Hominy Peak Formation.

The largest porphyry intrusive is about 3.22 km (2 mi) long and 1.6 km (1 mi) wide and contains large and small euhedral phenocrysts of light-gray plagioclase

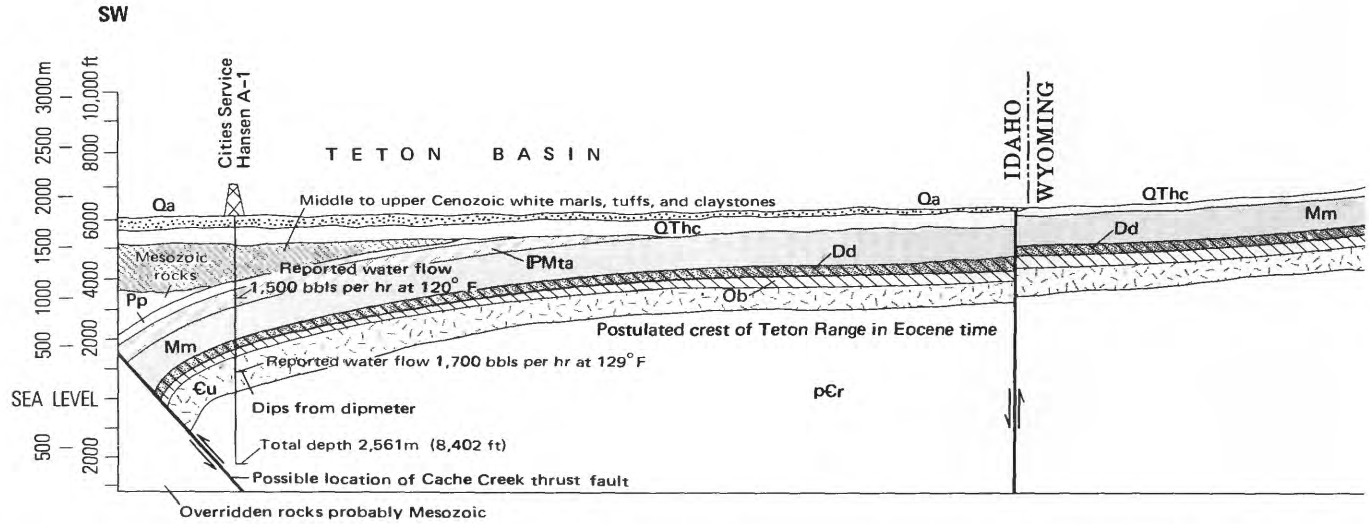



FIGURE 19 (above and right). — Interpretive section from the Holocene west flank of the Teton Range southwestward to the Cities Service drill hole in Teton Basin. Units indicated are Quaternary alluvium (Qa); Huckleberry Ridge Tuff and possible Conant Creek Tuff (QThc); Hominy Peak Formation (Th); unnamed sequence of middle to upper Cenozoic white marls, tuffs, and claystones; Phosphoria Formation (Pp); Tensleep Sandstone and Amsden Formation (PMta); Madison Limestone (Mm); Darby Formation (Dd); Bighorn Dolomite (Ob); Cambrian rocks undivided (Cu); and Precambrian rocks (pCr). No structural control is available in the 8-km (5 mi) area between the Wyoming-Idaho State line and the Cities Service well, and the structure may be more complex than is shown. If the interpretation is correct, the crest of the ancestral Teton Range, as it was in Eocene time, sagged at least 2,440 m (8,000 ft) after deposition of the Hominy Peak Formation and 610 m (2,000 ft) after emplacement of the Huckleberry Ridge Tuff 1.9 million years ago.

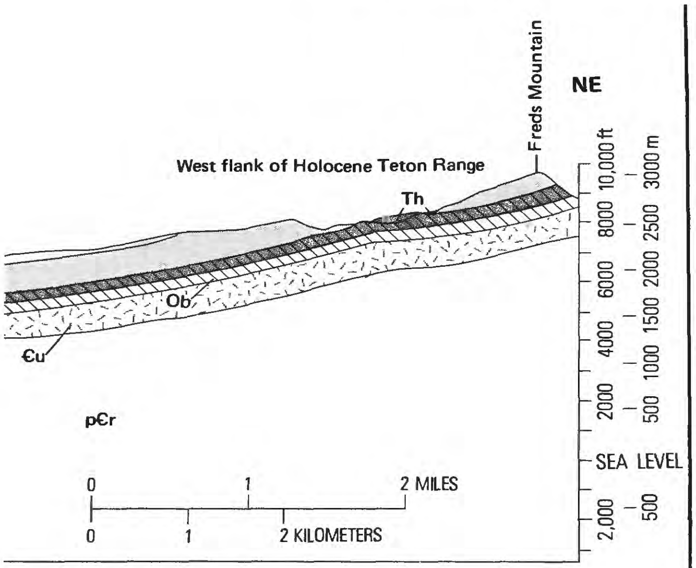
($An_{25}$), red-brown biotite, and ovoid phenocrysts of quartz. The groundmass is plagioclase ($An_{18}$–$An_{31}$), sanidine, and quartz. Apatite in the dacite has a fission-track age of 40.5±2.6 m.y. (L. L. Love and others, 1976). Thus, the intrusive is younger than the stratigraphically youngest part of the Wiggins Formation (43.1 m.y.; J. D. Obradovich, written commun., 1972) in section 10 of plate 5 but is older than the K-Ar age of 35.8 m.y. (J. D. Obradovich, written commun., 1972) associated with lower Oligocene fossil mammals in the White River Formation at Emerald Lake (fig. 3; J. D. Love and others, 1976).

## EOCENE GEOLOGIC HISTORY

The distribution of remnants of the Pinyon Conglomerate indicates that renewed uplift and extensive erosion of the north-trending prong of the Teton–Gros Ventre uplift as it was in Late Cretaceous time occurred after deposition of the Paleocene part of the Pinyon Conglomerate. This prong extended northward into Yellowstone National Park (J. D. Love and others, 1972). As a result of this renewed uplift, all of the Pinyon Conglomerate was removed from the northern end of the Teton Range as it existed in middle Eocene time, but remnants were preserved on both east and west flanks. An east-trending valley about 6.4 km (4 mi) wide was cut through rugged terrain between what is now Survey Peak and the south boundary of Yellowstone National Park.

The source of the quartzite that is the major constituent of the Pinyon Conglomerate was the Targhee uplift, a major mountainous upwarp believed to have been a northwest extension of, and continuous with, the ancestral Teton uplift. The Targhee segment subsided and was buried after deposition of the Hominy Peak Formation (J. D. Love and others, 1972; J. D. Love, 1973, fig. 2).

The first volcanic sediments, comprising the basal marker tuff in the Hominy Peak Formation of the Teton Range, were in part airfall debris that was reworked by eastward- or southeastward-flowing streams. This relatively quiet period was followed either by rise of the eastern part of the Targhee uplift and (or) by increase in precipitation. The result was tor-




rential deposition of huge quartzite boulders by eastward- and southeastward-flowing streams. Most of these boulders are completely rounded (that is, have not been fractured and subsequently partly rounded) and, therefore, are thought to have originated in the Precambrian terrain of the Targhee uplift. Boulder size in the Pinyon averages much smaller, although there are exceptions. (See J. D. Love, 1973, fig. 23.) Had the boulders in the Hominy Peak been reworked from the Pinyon, many of them (because of the secondarily induced brittle characteristic of the quartzite), would have been broken, and fragments then would have been rerounded before deposition in the Hominy Peak. Subrounded fragments, however, are not abundant. A comparison was made with quartzite conglomerates known to have been reworked in the Colter and Teewinot Formations (Miocene) of Jackson Hole. Quartzite clasts in the Colter and Teewinot are dull, have few percussion scars preserved, and exhibit a larger percentage of subrounded fragments than well-rounded ones with the original shape preserved. The reworked quartzite conglomerates contain a much lower amount of gold.

Soon after deposition of the quartzite conglomerate, major volcanic activity began along the east margin of the Targhee uplift. Several vents formed in the Hominy Peak area. Violent eruptions from these vents provided abundant basaltic and andesitic rock fragments that subsequently moved eastward as avalanches and debris flows down the sides of the volcanoes as well as down the east flank of the Targhee uplift, into the Hominy Peak area. Fragments of sedimentary rocks as much as 36.6 m (120 ft) in length were torn loose by the eruptions and earth tremors and were incorporated into the debris flows. Because these fragments do not appear to have been altered or intruded by igneous rocks, they probably came from outcrops rather than from the walls of the conduits. Some of them are shown diagramatically in figure 17.

The Grand Targhee Resort area has no local sources for the volcanic conglomerates, and the stratigraphic record in the Cities Service drill hole to the west (fig. 19) indicates no volcanic source in that direction. When the west component of dip in the Hominy Peak Formation is rotated to horizontal (fig. 18*B*), we see that here, too, the west flank of the Teton Range was the east flank of the ancestral Targhee-Teton uplift, as it was in Eocene time. Figure 19 illustrates that the crest of the Eocene uplift was about 12.8 km (8 mi) west of the Grand Targhee Resort area. We postulate that a powerful river, flowing southward along a strike valley cut into soft Devonian shales, brought in the volcanic sediments from centers near Conant Basin. The river had to transport abundant basalt boulders 61–91 cm (2–3 ft) in diameter a distance of at least 19 km (12 mi).

The only dated event involving the Teton uplift between middle Eocene and Pliocene time is the intrusion of the dacite porphyry in the Birch Hills inside the south boundary of Yellowstone National Park. The fission-track age of 40.5 m.y. places the intrusion in the late Eocene. The emplacement was accompanied by considerable deformation and alteration of the adjacent Paleozoic rocks and deformation of the Hominy Peak Formation. Either at the time of intrusion or later, the north prong of the Teton uplift that extends into Yellowstone National Park (J. D. Love and others, 1972) was uplifted once again, just as it was in Eocene time. As a result of this rise and, possibly, of the contemporaneous foundering of the Targhee uplift to the west and Jackson Hole to the east, several hundred or perhaps a thousand meters of the Hominy Peak Formation was stripped off the higher parts of the Teton arch before deposition of the Pliocene Conant Creek Tuff (Christiansen and Love, 1977). The timing of this event has not been documented, but Jackson Hole was sinking in early Miocene time, and probably Teton Basin was, too, at least late in the Miocene. Perhaps if diatoms and other fossils were to be recovered from cuttings of the white tuff and marlstone above Paleozoic rocks in the Cities Service oil test well in Teton Basin (fig. 19), this timing would be confirmed or refuted.

FIGURE 20. — General view of flora and terrain northeast of San Blas, Nayarit, Mexico, lat 22°N., long 105°30′ about 8 km (5 mi) east of the Pacific coast at an elevation of about 600 m (2,000 ft). This flora, climate, and terrain are considered by H. D. MacGinitie (written commun., 1976) to be generally comparable to the Kisinger Lakes floral assemblage, climate, and terrain at section 7 (pl. 5) in middle Eocene time. Vegetation is in the lower part of the semideciduous forest, and also in the upper edge of the Palmar, the palm forest with abundant large nut palms, ***Orbignya guacuyule***. The characteristic trees of this zone are ***Brosimum***, ***Guarea***, species of giant ***Ficus***, ***Ceiba***, ***Dendropanax***, ***Cecropia***, ***Castilla***, ***Enterolobium*** (and other legumes), ***Cordia***, ***Trophis***, ***Bursera***, ***Cedrela***. A striking feature of this forest is the variety and abundance of legumes. Annual precipitation is about 150 cm (59 in.) with dry season from November until April. Photograph by E. B. Leopold, January 22, 1974.

## SUMMARY OF POST-EOCENE GEOLOGIC HISTORY

Much of the Eocene geologic record in the Teton region has been fragmented or lost because of later geologic events. Events of each younger epoch obliterate or modify the older record (the "law of obliteration"), so the reconstruction summarized here has many gaps and uncertainties.

All the sedimentary record (if there ever was one) of Oligocene, Miocene, and most of Pliocene time on the Teton Range has been destroyed by erosion or has been buried, but, in Jackson Hole and Teton Basin, enough remnants are preserved to reconstruct the geologic history. (See events enumerated in J. D. Love and others, 1972.) The nearest upper Eocene sedimentary rocks to the Teton Range are tiny remnants, about 30.5 m (100 ft) thick, of green and white soft biotitic claystone and tuff along East Fork Pilgrim Creek, on plate 5, section 3. Biotite in the tuff has a K-Ar age of 45.9 m.y. These remnants are overlain by about 30.5 m (100 ft) of white soft fine-grained claystone (White River Formation) containing Oligocene vertebrate fossils (Sutton and Black, 1972). This claystone, in turn, is overlain by 2,135 m (7,000 ft) of Miocene light-gray tuff, sandstone, and volcanic conglomerate (Colter Formation; J. D. Love, 1956b). Farther south, the Colter is overlain by the Teewinot Formation, 1,830 m (6,000 ft) thick (J. D. Love, 1956b), consisting of white tuff, limestone, and claystone. The Teewinot was formerly assigned a middle Pliocene age on the basis of vertebrate fossils and a K-Ar age of 9 m.y., but in the European and marine time scale, this age would now be considered late Miocene (Berggren, 1972; Gill and McDougall, 1973, Berggren and Van Couvering, 1974, p. 59). The Miocene-Pliocene boundary is put at about 5 m.y.

At least 3,962 m (13,000 ft) of post-Eocene strata remains in Jackson Hole. On the west of the modern Teton Range, at least 730 m (2,400 ft) of Quaternary alluvium and middle and upper Cenozoic tuff, marl, and claystone remains in Teton Basin.

A comparison of sections *A* and *B* (fig. 20) and the record of conglomerate deposition in Jackson Hole from middle Late Cretaceous time to middle Eocene (J. D. Love, 1973) shows that the Targhee uplift, after having provided enormous volumes of distinctive coarse clastic gold-bearing quartzite debris to Jackson Hole for 35 million years, finally subsided 1,830 m (6,000 ft) or more after deposition of the Hominy Peak Formation. The absence of first-generation quartzite conglomerates in post-Eocene rocks of Jackson Hole indicates that the uplift subsided shortly after middle Eocene time and that it never again was a source of quartzite debris to sediments east of the Teton Range.

The differential foundering of parts of the Targhee–Teton–Gros Ventre uplift is related to volcanism in the Yellowstone-Absaroka volcanic area. It seems more than coincidence that the Targhee part of the uplift foundered, that the Teton and Gros Ventre segments broke apart shortly after the beginning of major volcanism in the region, and that the continued sagging and downfaulting of Jackson Hole and Teton Basin in late Cenozoic time is concomitant with adjacent late Cenozoic volcanism.

The northwest-trending Targhee–Teton–Gros Ventre uplift, which was a positive area for 35 million years, broke up along north-trending faults and downwarps in middle to late Cenozoic time. One segment of this older uplift — the present Teton Range — is still rising, at first as a barely recognizable new mountain range, now as a precipitous, partial horst which trends north at an angle of 55° to the original northwest trend. This new uplift is flanked on both sides by major downwarps and downfaulted blocks whose floors were once near the crest of the original uplift. The modern Teton Range continues to be restless. The many Quaternary events have been enumerated elsewhere (J. D. Love and others, 1972).

Although as yet imperfectly known, the amounts and times of post-Eocene downwarping and downfaulting are interpreted to be as follows:

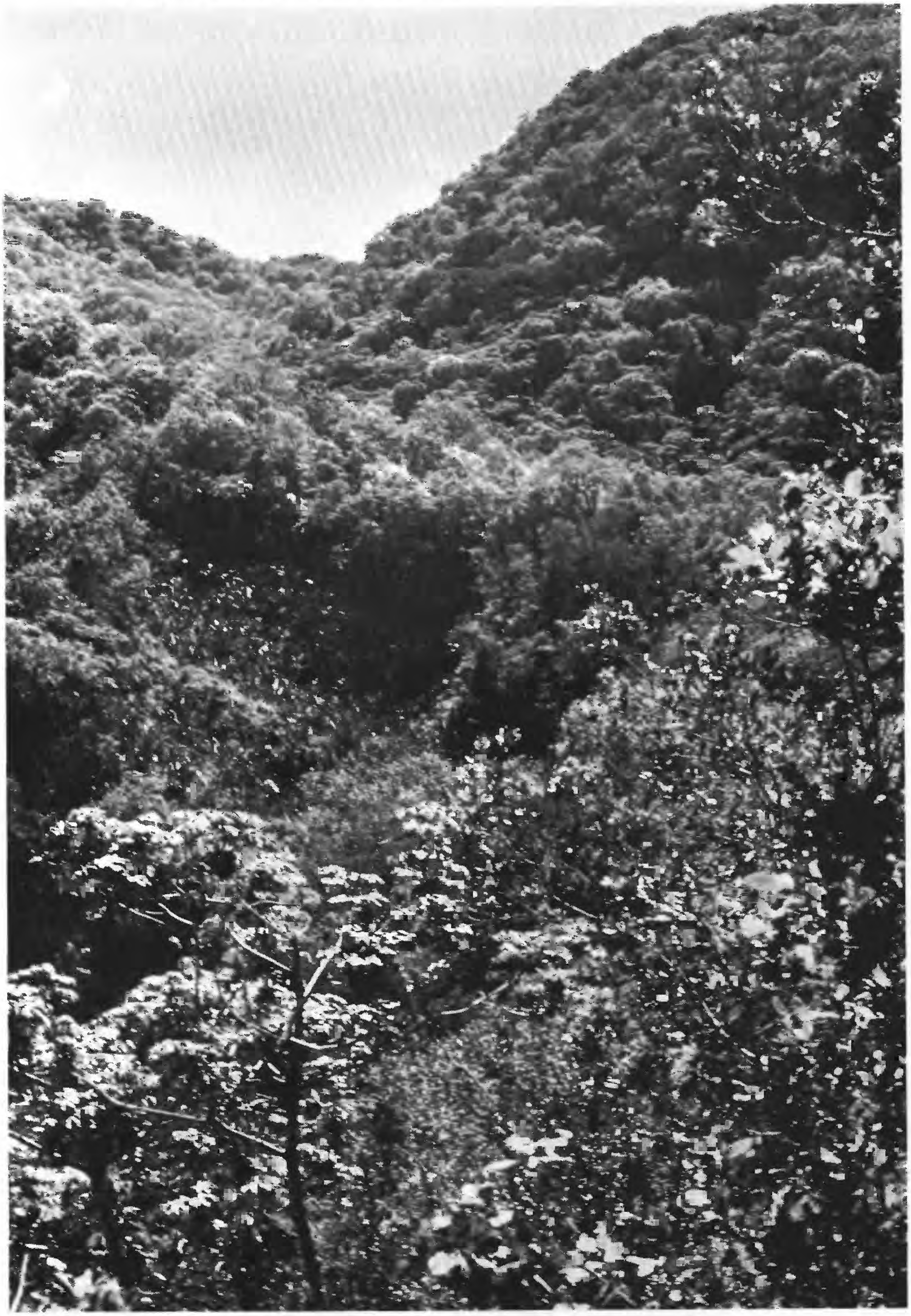
| | |
|---|---|
| West side of Teton Range, north end: | Post-Hominy Peak Formation (1,830 m, or 6,000 ft). |
| | Post-Huckleberry Ridge Tuff (1.9 m.y.) (1,130 m, or 3,700 ft). |
| West side of Teton Range, south end: | Post-Hominy Peak Formation (2,440 m, or 8,000 ft). |
| | Post-Huckleberry Ridge Tuff (1.9 m.y.) (760 m, or 2,500 ft). |
| East side of Teton Range: | Post-Hominy Peak Formation (7,620–9,150 m, or 25,000–30,000 ft). |
| | Post-Huckleberry Ridge Tuff (1.9 m.y.) (More than 1,500 m, or 5,000 ft). |

## OIL AND GAS AND GEOTHERMAL-ENERGY POTENTIAL

An understanding of Eocene and later tectonic history of the Teton uplift is necessary to make an adequate evaluation of the oil and gas and geothermal-energy potential of, and under, the uplift and of areas southwest in the adjacent northeastern part of the thrust belt. Veatch (1907) recognized the oil and gas potential of the thrust-belt rocks in southwestern Wyoming, but comparatively little attention was paid to it for nearly 70 years that followed. Then in 1975 a large producing well was drilled in one of the thrust sheets at Pineview, Utah. Following this, another major discovery was drilled in 1976 in southwestern Wyoming in a different thrust sheet. These discoveries stimulated intense exploration and reevaluation of the entire thrust belt by many oil companies.

The Cities Service dry hole in Teton Basin, completed in 1974, along with our own studies in the adjacent areas, provided data useful in a regional assessment. Figure 19 shows a highly generalized interpretation of the structure and indicates that the downwarped part of the Teton block under Teton Basin has only moderate oil and gas potential. These data, supplemented by studies in adjacent areas, however, indicate the possibility of oil and gas under, and southwest of, the margin of the block, in the northeastern part of the thrust belt.

The Cities Service oil test also made a significant contribution to the knowledge of the ground-water potential of the region. It is the only deep test drilled, as of



1976, in the major part of the Teton Basin. It encountered flowing artesian fresh water at a reported rate of 36,000 barrels per day, with a temperature of 49°C at a depth of 856 m (2,800 ft) in Pennsylvanian rocks. Another water flow was reported to occur between the depths of 1,615 and 1,646 m (5,300 and 5,400 ft) at a rate of 40,000 barrels per day, at a temperature of 54°C in Cambrian rocks. The combined flow was estimated at about 76,000 barrels ($14.6 \times 10^6$ liters, or 3,800,000 gallons) per day of water with total dissolved solids of less than 500 mg/L. This indicates that the downwarped Teton Basin area athwart the Eocene crest of the ancestral Teton Range has some geothermal-energy potential as well as considerable untapped and heretofore unrecognized ground-water resources.

## REFERENCES


Antweiler, J. C., and Love, J. D., 1967, Gold-bearing sedimentary rocks in northwestern Wyoming — a preliminary report: U.S. Geol. Survey Circ. 541, 12 p.

Berggren, W. A., 1972, A Cenozoic time-scale — some implications for regional geology and paleobiogeography: Lethaia, v. 5, no. 2, p. 195–215.

Berggren, W. A., and Van Couvering, J. A., 1974, the Late Neogene — Biostratigraphy, geochronology, and paleoclimatology of the last 15 million years in marine and continental sequences: Palaeogeography, Palaeoclimatology, and Palaeoecology, v. 16, no. 1/2, 216 p.

Chadwick, R. A., 1970, Belts of eruptive centers in the Absaroka-Gallatin volcanic province, Wyoming-Montana: Geol. Soc. America Bull., v. 81, no. 1, p. 267–274.

Christiansen, R. L., Blank, H. R., Love, J. D., and Reed, J. C., Jr., 1978, Geologic map of the Grassy Lake Reservoir quadrangle, Teton County, Wyoming: U.S. Geol. Survey Geologic Quadrangle map GQ-1459. (In press).

Christiansen, R. L., and Love, J. D., 1977, The Pliocene Conant Creek Tuff in the northern part of the Teton Range and Jackson Hole, Wyoming: U.S. Geol. Survey Bull. 1435–C, 9p.


◀ FIGURE 21. — Flora and terrain at twice as high an elevation (about 1,200 m or 4,000 ft) as that in fig. 20, in the upper part of the Bosque Tropical Subdeciduo (Rzedowski and McVaugh, 1966, p. 15–22), State of Nayarit, western Mexico. Site is along the road between Jalcocotan and Tepic, about 65 km (40 mi) east of the Pacific coast of Mexico, lat 21°30′ N., long 105° W. This flora, climate, and terrain are considered by H. D. MacGinitie (written commun., 1976) to be generally comparable to the more mountainous areas of the Kisinger Lakes flora in middle Eocene time. Oak-pine forest covers the ridge tops and the subdeciduous forest occupies the slopes and valleys. In the cool canyons is the Bosque Mesofila de Montana with *Carpinus, Salix, Celtis, Clethra, Ilex, Prunus, Persea, Phoebe, Meliosma,* and other temperate climate trees and shrubs. Elsewhere, the area is occupied by a complex tropical forest with abundant legumes. Characteristic trees are *Croton draco, Conostegia, Enterolobium, Cochlospermum, Oreopanax, Belottia, Luehea, Brosimum, Mirandaceltis, Cordia, Dendropanax, Guarea, Ficus, Orbignya, Bixa, Bursera, Ceiba, Cupania, Bumelia, Pithecelobium,* and other legumes. (See Pennington and Sarukhan, 1968, p. 20–21.) Photograph by H. D. MacGinitie, January 1974.


Culbertson, W. C., 1961, Stratigraphy of the Wilkins Peak Member of the Green River Formation, Firehole Basin quadrangle, Wyoming, *in* Geological Survey research 1961: U.S. Geol. Survey Prof. Paper 424–D, p. D170–D173.

Dickinson, W. R., and Hatherton, Trevor, 1967, Andesitic volcanism and seismicity around the Pacific: Science, v. 157, no. 3790, p. 801–803.

Edmund, R. W., 1951, Structural geology and physiography of the northern end of the Teton Range, Wyoming: Augustana Library Pubs. no. 23, 81 p.

Evernden, J. F., Savage, D. E., Curtis, G. H., and James, G. T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Am. Jour. Sci., v. 262, no. 2, p. 145–198.

Gill, J. B., and McDougall, Ian, 1973, Biostratigraphic and geological significance of Miocene-Pliocene volcanism in Fiji: Nature, v. 241, no. 5386, p. 176–180.

Hague, Arnold, 1904, Atlas to accompany U.S. Geological Survey Monograph 32 on the Geology of Yellowstone National Park: U.S. Geol. Survey.

Hague, Arnold, Iddings, J. P., and others, 1899, Geology of the Yellowstone National Park: U.S. Geol. Survey Mon. 32, pt. 2, 893 p.

Hague, Arnold, Weed, W. H., and Iddings, J. P., 1896, Yellowstone National Park, Wyoming: U.S. Geol. Survey Atlas, Folio 30, 6 p.

Joplin, G. A., 1965, The problem of the potash-rich basaltic rocks: Mineralogist Mag. v. 34, no. 268, p. 266–275.

Keefer, W. R., 1957, Geology of the Du Noir area, Fremont County, Wyoming: U.S. Geol. Survey Prof. Paper 294–E, p. 155–221.

Larsen, E. S., 1940, The petrographic province of central Montana: Geol. Soc. America Bull., v. 51, no. 6, p. 887–948.

Leopold, E. B., and MacGinitie, H. D., 1972, Development and affinities of Tertiary floras in the Rocky Mountains, *in* A. Graham, ed., Floristics and paleofloristics of Asia and Eastern North America: Amsterdam, Netherlands, Elsevier Publishing Co., p. 147–200.

Lindsey, D. A., 1972, Sedimentary petrology and paleocurrents of the Harebell Formation, Pinyon Conglomerate, and associated coarse clastic deposits, northwestern Wyoming: U.S. Geol. Survey Prof. Paper 734–B, 68 p.

Lipman, P. W., Prostka, H. J., and Christiansen, R. L., 1972, Cenozoic volcanism and plate-tectonic evolution of the Western United States; Part I, Early and Middle Cenozoic, *in* A discussion on volcanism and the structure of the Earth: Royal Soc. London Philos. Trans., ser. A, v. 271, no. 1213, p. 217–248.

Love, D. W., 1971, Geology of the Rammel Mountain area, Teton County, Wyoming: New Mexico Univ. M.S. thesis, 124 p.

Love, J. D., 1939, Geology along the southern margin of the Absaroka Range, Wyoming: Geol. Soc. America Spec. Paper 20, 134 p.

——— 1947, Tertiary stratigraphy of the Jackson Hole area, northwestern Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Chart 27.

——— 1956a, Geologic map of Teton County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook, 11th Ann. Field Conf., 1956: Map in pocket.

——— 1956b, New geologic formation names in Jackson Hole, Teton County, northwestern Wyoming: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 8, p. 1899–1914.

——— 1973, Harebell Formation (Upper Cretaceous) and Pinyon Conglomerate (uppermost Cretaceous and Paleocene), northwestern Wyoming: U.S. Geol. Survey Prof. Paper 734–A, 54 p.

——— 1974, Preliminary geologic map of south half of Mount Hancock quadrangle, Teton County, Wyoming: U.S. Geol. Survey Open-File Rept. 74–127.

Love, J. D., McKenna, M. C., and Dawson, M. R., 1976, Eocene, Oligocene, and Miocene rocks and vertebrate fossils at the Emerald Lake locality, 3 miles south of Yellowstone National Park, Wyoming: U.S. Geol. Survey Prof. Paper 932–A, 28 p.

Love, J. D., Reed, J. C. Jr., Christiansen, R. L., and Stacy, J. R., 1972, Geologic block diagram and structural history of the Teton region, Wyoming and Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I–730.

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

Love, L. L., Kudo, A. M., and Love, D. W., 1976, Dacites of Bunsen Peak, the Birch Hills, and the Washakie Needles, northwestern Wyoming, and their relationship to the Absaroka volcanic field, Wyoming-Montana: Geol. Soc. America Bull v. 87, no. 10, p. 1455–1462.

MacGinitie, H. D., 1969, The Eocene Green River flora of northwestern Colorado and northeastern Utah: California Univ. Pubs. Geol. Sci., v. 83, 203 p.

——— 1974, An early middle Eocene flora from the Yellowstone-Absaroka volcanic province, northwestern Wind River Basin, Wyoming: California Univ. Pubs. Geol. Sci., v. 108, 103 p.

Mannion, L. E., and Jefferson, G. L., 1962, An outline of the geology of the Wyoming trona deposits: San Francisco, Calif., Pacific Southwest Mineral Industry Conf., Am. Inst. Mining Engineers, pages unknown.

McKenna, M. C., 1972, Vertebrate paleontology of the Togwotee Pass area, northwestern Wyoming, *in* R. M. West, coordinator, Field Conference on Tertiary biostratigraphy of southern and western Wyoming: mimeographed guidebook, p. 80–101.

Nicholls, J., and Carmichael, I. S. E., 1969, A commentary on the absarokite-shoshonite-banakite series of Wyoming, U.S.A.: Schweizer, Mineralog u. Petrog. Mitt., v. 49, no. 1, p. 47–64.

Parsons, W. H., 1967, Manner of emplacement of pyroclastic andesite breccias: Bull. Volcanology, v. 30, p. 177–187.

———, 1969, Criteria for the recognition of volcanic breccias, *in* Igneous and metamorphic geology — A volume in honor of Arie Poldervaart: Geol. Soc. America Mem. 115, p. 263–304.

Pennington, T. D., and Sarukhan, J., 1968, Arboles tropicales de Mexico: Oxford Univ., Commonwealth Forestry Institute, pages unknown.

Peterman, Z. E., Doe, B. R., and Prostka, H. J., 1970, Lead and strontium isotopes in rocks of the Absaroka volcanic field, Wyoming: Contr. Mineralogy and Petrology, v. 27, no. 2, p. 121–130.

Prostka, H. J., 1973, Hybrid origin of the absarokite–shoshonite–-banakite series, Absaroka volcanic field, Wyoming: Geol. Soc. America Bull., v. 84, no. 2, p. 697–702.

Reed, J. C. Jr., and Love, J. D., 1972, Preliminary geologic map of the Granite Basin quadrangle, Teton County, Wyoming: U.S. Geol. Survey open-file report.

Reed, J. C., Jr., and Zartman, R. E., 1973, Geochronology of Precambrian rocks of the Teton Range, Wyoming: Geol. Soc. America Bull., v. 84, no. 2, p. 561–582.

Rohrer, W. L., 1974, Stratigraphy and stratigraphic relations of the fossil floras, *in* H. D. MacGinitie, An early middle Eocene flora from the Yellowstone-Absaroka volcanic province, northwestern Wind River Basin, Wyoming: California Univ. Pubs. Geol. Sci., v. 108, p. 10–18.

Rohrer, W. L., and Obradovich, J. D., 1969, Age and stratigraphic relations of the Tepee Trail and Wiggins Formations, northwestern Wyoming, *in* Geological Survey research 1969: U.S. Geol. Survey Prof. Paper 650–B, p. B57–B62.

Rouse, J. T., 1937, Genesis and structural relationships of the Absaroka volcanic rocks, Wyoming: Geol. Soc. America Bull., v. 48, no. 9, p. 1257–1296.

Rubel, D. N., 1971, Independence Volcano — A major Eocene eruptive center, northern Absaroka volcanic province; Geol. Soc. America Bull., v. 82, no. 9, p. 2437–2494.

Rzedowski, J., and McVaugh, Rogers, 1966, La vegetacion de Nueva Galicia: Michigan Univ. Herbarium Contr., v. 9, no. 1, p. 1–223.

Smedes, H. W., and Prostka, H. J., 1972, Stratigraphic framework of the Absaroka Volcanic Supergroup in the Yellowstone National Park region: U.S. Geol. Survey Prof. Paper 729–C, 33 p.

Sutton, J. F., and Black, C. C., 1972, Oligocene and Miocene deposits of Jackson Hole, Wyoming, *in* R. M. West, coordinator, Field conference on Tertiary biostratigraphy of southern and western Wyoming: mimeographed guidebook, p. 73–79.

Van Houten, F. B., 1964, Tertiary geology of the Beaver Rim area, Fremont and Natrona Counties, Wyoming: U.S. Geol. Survey Bull. 1164, 99 p. [1965].

Veatch, A. C., 1907, Geography and geology of a portion of southwestern Wyoming, with special reference to oil and gas: U.S. Geol. Survey Prof. Paper 56, 178 p.

West, R. M., 1969, Geology and vertebrate paleontology of the northeastern Green River Basin, Wyoming, *in* Symposium on Tertiary rocks of Wyoming — Wyoming Geol. Assoc. Guidebook, 21st Ann. Field Conf., 1969: Casper, Wyo., Petroleum Inf., p. 77–92.

Wood, H. E., and others, 1941, Nomenclature and correlation of the North American continental Tertiary: Geol. Soc. America Bull., v. 52, no. 1, p. 1–48.

# INDEX

[Page numbers of major references are in italic]

# PLATES 1–4

Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Photographic Library, Box 25046, Federal Center, Denver, Colorado 80225.

# PLATE 1

[D-numbers are U.S. Geological Survey paleobotany locality numbers. Following are stage-coordinate numbers for the U.S. Geological Survey Zeiss photomicroscope, serial number 46,995]

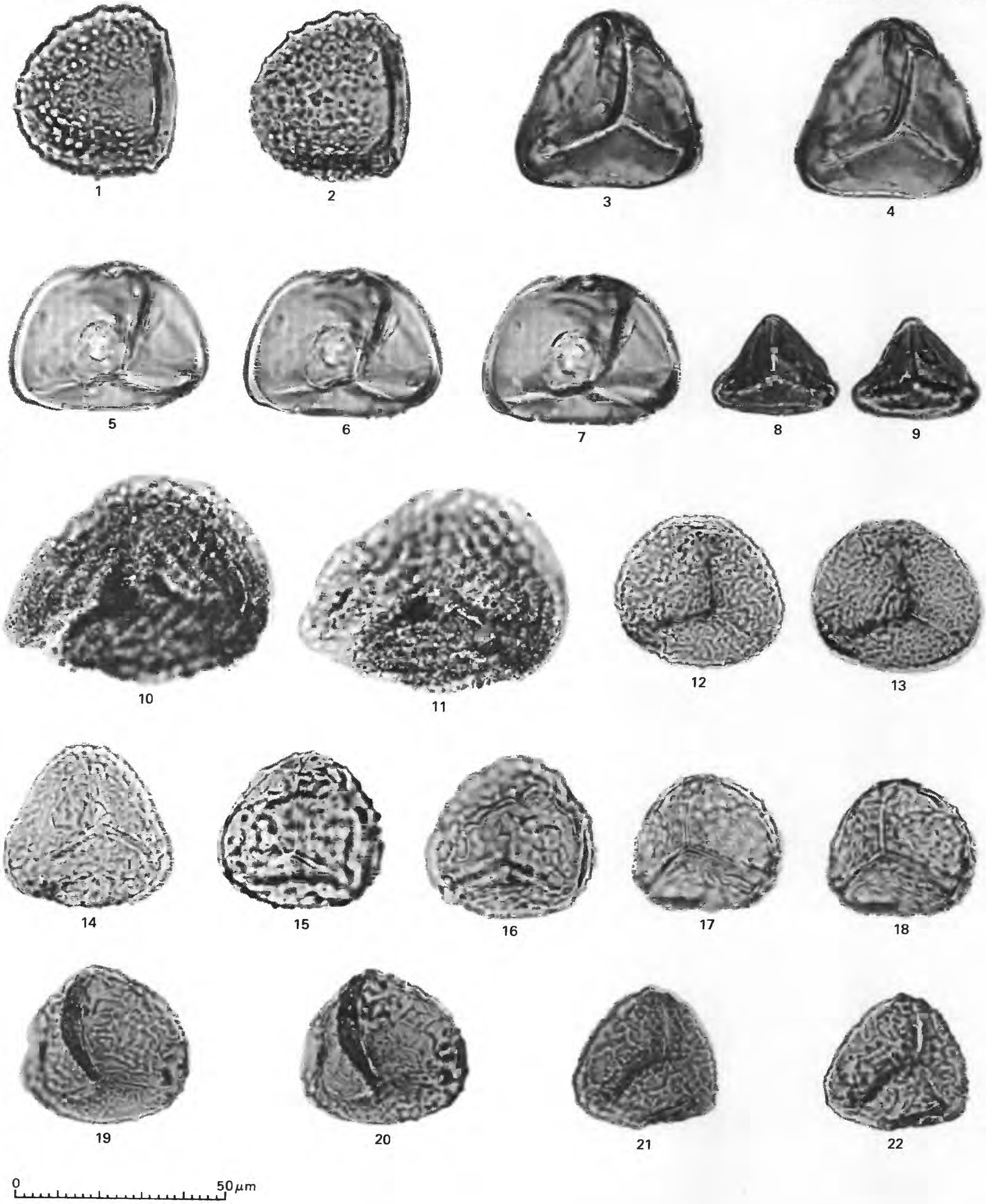
Spores characteristic of the Kisinger Lakes floral zone.

1,2. Monolete spores, Polypodiaceae or Aspidiaceae types.
D4617G(1), 115.5 × 15.2.

3–9. Trilete spores, undetermined.
D4617G(1), 104.5 × 12.4.
D4617G(1), 108.4 × 17.9.
D4617G(1), 110.6 × 5.1.

10, 11. *Cicatricosisporites*
D4271A(1), 96.0 × 2.5.

12–22. cf. Lycopodiaceae.
D4617A(2), 103.7 × 15.5.
D4617A(1), 85.0 × 6.0
D4617A(2), 15.6 × 95.5.
D4617A(1), 94.4 × 7.0.
D4617C(2), 98.2 × 7.9.
D4617A(1), 103.9 × 9.2.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
0
50 μm

## PLATE 2

[D-numbers are U.S. Geological Survey paleobotany locality numbers. Following are stage-coordinate numbers for the U.S. Geological Survey Zeiss photomicroscope, serial number 46,995]

Pollen characteristic of the Kisinger Lakes floral zone.

1, 2. ***Pinus*** (Pinaceae).
D4271A(1), 88.3 × 4.2.

3, 4. cf. Taxodiaceae.
D4617A(1), 109.0 × 5.1.

5–12. ***Tricolpites*** (cf. ***Platanus***).
D4617A(2), 111.9 × 19.5.
D4617A(2), 97.7 × 17.5.
D4617A(2), 110.8 × 20.4.
D4617E(1), 77.5 × 18.6.

13, 14. ***Ilex*** (Aquifoliaceae).
D4617A(1), 96.4 × 14.7.

15, 16. Tricolpate pollen, undetermined.
D4271C(1), 98.1 × 17.0.

17, 18. Monoporate pollen, undetermined.
D4617A(2), 87.2 × 19.0.

19–21. Betuloid triporate pollen.
D4617C(2), 98.2 × 9.2.
D4617C(2), 111.8 × 21.5.

22–26. ***Carya*** (Juglandaceae).
D4617C(2), 113.7 × 14.8.
D4271B(1), 16.7 × 89.0.

27–30. Triporate pollen, undetermined.
D4617A(2), 19.9 × 114.0.
D4617A(1), 113.4 × 6.9.

31, 32. ***Trema*** (Ulmaceae).
D4721C(2), 97.7 × 17.1.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
0
50μm

# PLATE 3

[D-numbers are U.S. Geological Survey paleobotany locality numbers. Following are stage-coordinate numbers for the U.S. Geological Survey Zeiss photomicroscope, serial number 46,995]

Pollen characteristic of the Kisinger Lakes floral zone.

1, 2. ***Pistillipollenites mcgregorii***
D4617H(1), 94.3 × 17.8.

3, 4. ***Carya,*** four pored (Juglandaceae).
D4617A(2), 18.2 × 91.8.

5, 6. ***Pterocarya*** (Juglandaceae).
D4271A(1), 94.8 × 21.3.

7, 8. cf. ***Trachelospermum*** (Apocynaceae).
D4617C(2), 104.0 × 12.3.

9, 10. cf. ***Castanea*** or ***Castanopsis.*** (Fagaceae).
D4617H(1), 97.5 × 11.3.

11–15. Tricolpate pollen, undetermined.
D4271C(1), 80.5 × 15.0.
D4617A(1), 86.0 × 13.3.

16, 17. cf. ***Luehea*** (Tiliaceae).
D4271C(1), 88.1 × 21.9.

18–21. ***Triumfetta*** (Tiliaceae).
D4617A(1), 76.5 × 9.1.
D4617A(2), 11.7 × 81.5.

22. cf. Tiliaceae.
D4617C(2), 111.1 × 6.0

23–27. ***Acer*** cf. ***palmatum*** (Aceraceae).
D4617A(2), 105.5 × 5.5.
D4617A(1), 112.9 × 14.6.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
0
50 μm

## PLATE 4

[D-numbers are U.S. Geological Survey paleobotany locality numbers. Following are stage-coordinate numbers for the U.S. Geological Survey Zeiss photomicroscope, serial number 46,995]

Pollen characteristic of the Kisinger Lakes floral zone.

1, 2. ***Alangium*** cf. ***barghoornianum*** (Alangiaceae).
D4617H(1), 95.7 × 19.5.

3, 4. ***Alangium*** (Alangiaceae).
D4617G(1), 95.5 × 5.0.

5, 6. Cornaceae?
D4617A(2), 112.3 × 14.2.

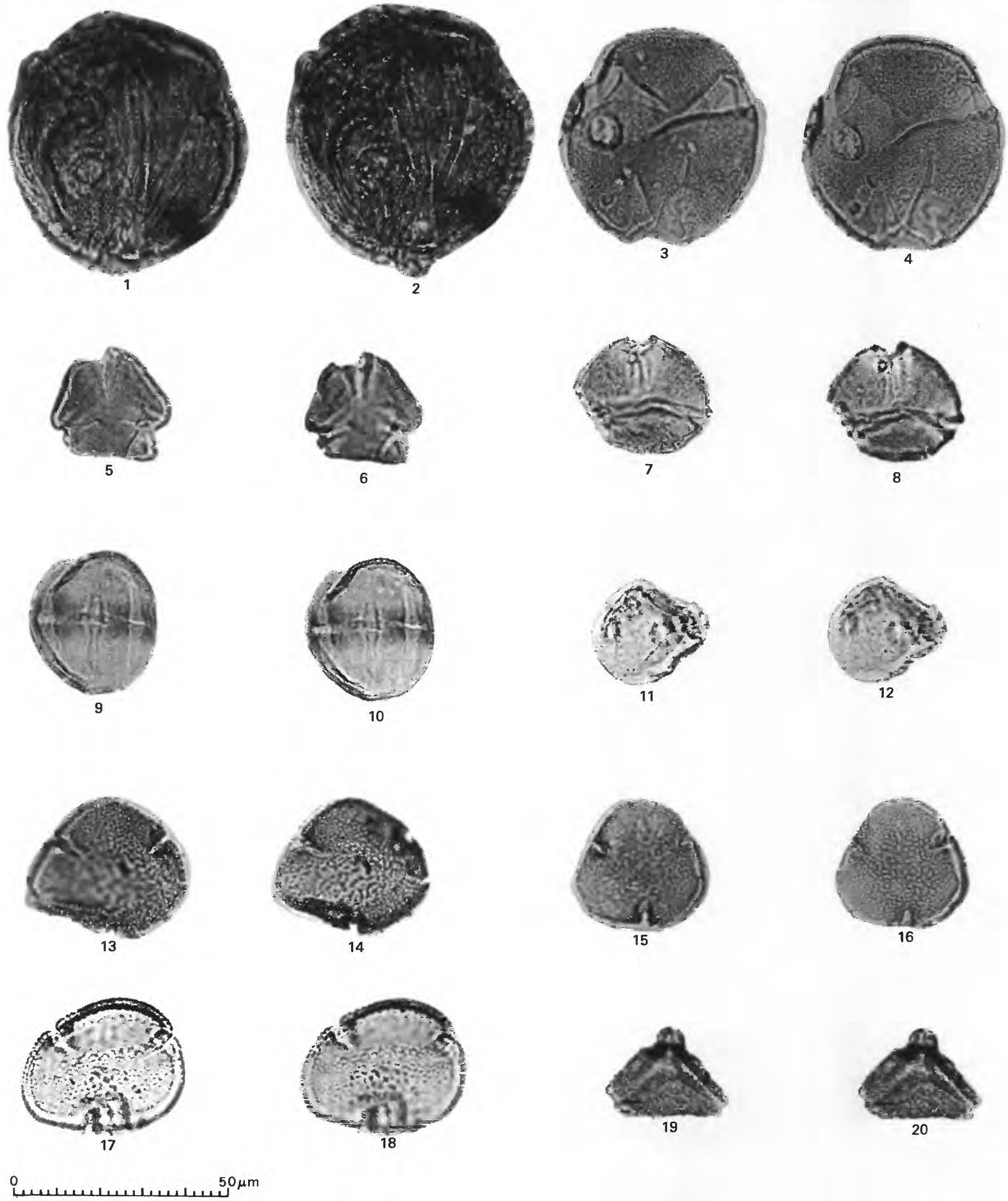
7–10. Tricolpate pollen undetermined.
D4617A(2), 83.7 × 5.9.
D4617A(2), 85.6 × 6.9.

11, 12. Brevicolporate pollen, undetermined.
D4617H(1), 112.5 × 21.9.

13, 14. cf. ***Bombax*** (Bombacaceae).
D4617H(1), 92.2 × 16.3.

15–18. Bombacaceae?
D4617A(2), 113.5 × 16.0.
D4271B(1), 16.7 × 89.0.

19, 20. Syncolporate pollen of Myrtaceae-Sapindaceae type.
D4617H(1), 95.7 × 19.5.




☆ U.S. Government Printing Office: 1978-677-026/13