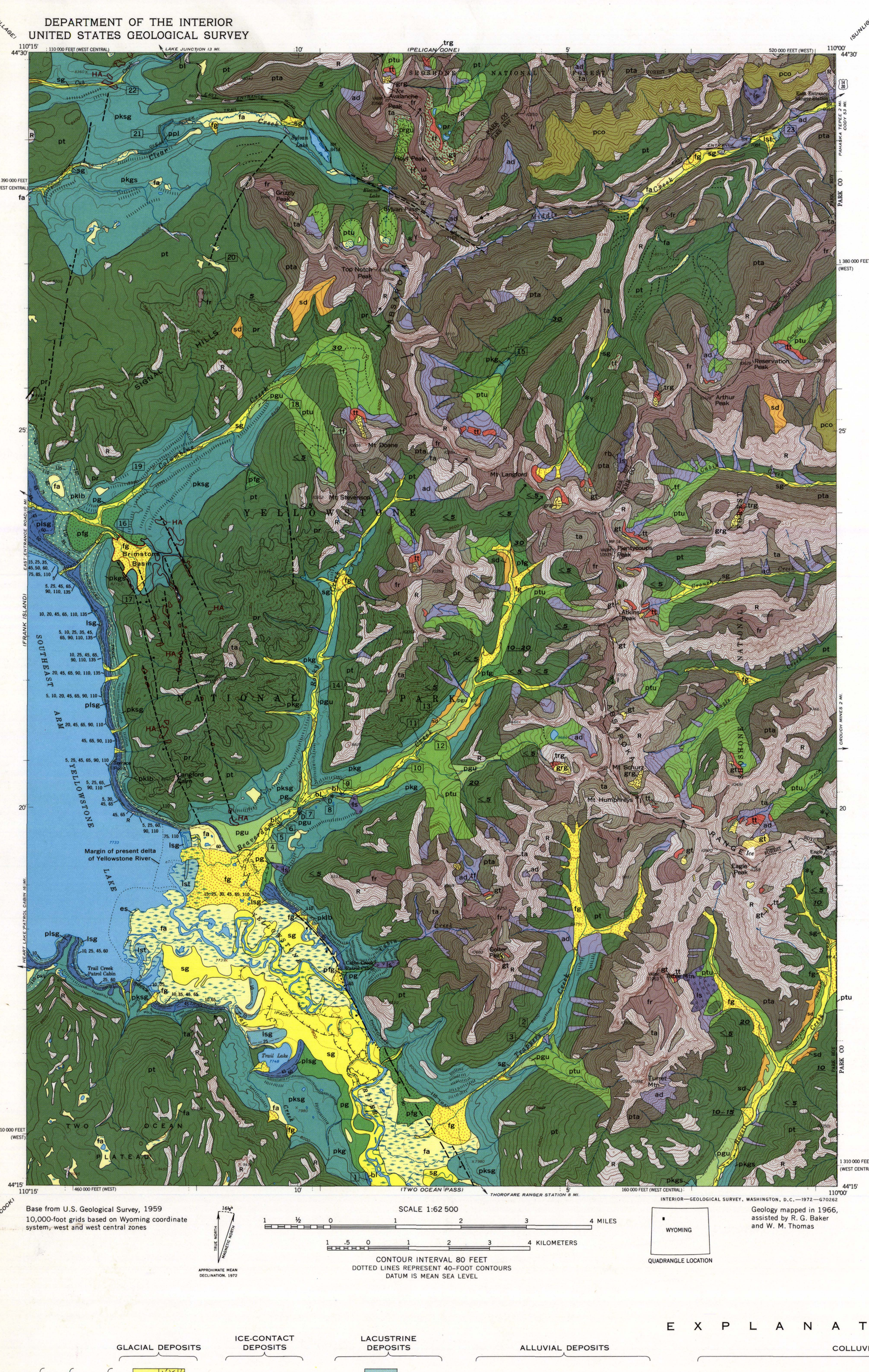
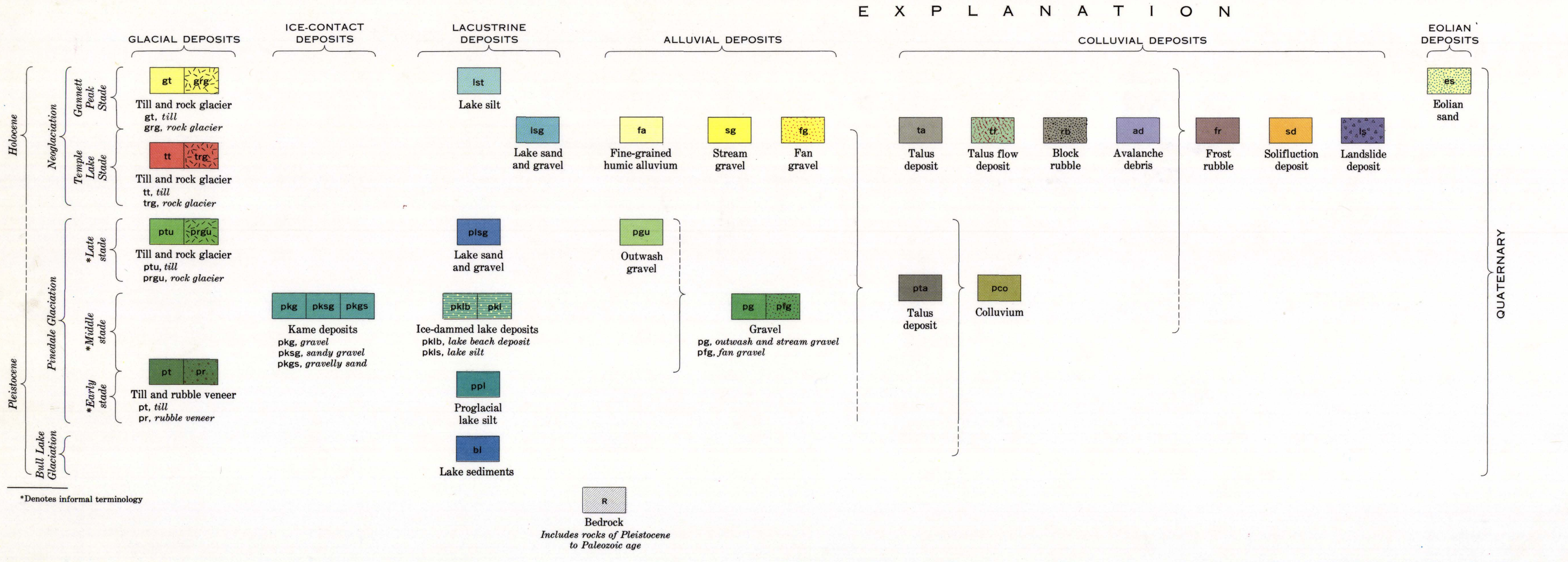
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY



EXPLANATION



DESCRIPTION OF UNITS

NEOGLACIATION

GLACIAL DEPOSITS

gt, tt — *Till*—Forms moraines in north- and east-facing cirques in Absaroka Range. Consists of angular to subangular fragments in fine-grained silty matrix; unsorted, nonstratified, buff to gray. Moraines of Gannett Peak Stade (gt) are fresh and bear little or no vegetation, except lichens. Moraines of Temple Lake Stade (tt) are very slightly weathered, grass covered, and locally forested, and commonly are partly covered by talus and avalanche debris from the cirque headwall.

grg, trg — *Rock glacier*—Glacier-shaped tongue of angular to subangular rock debris that heads against steep cirque headwall; composed mainly of dense intrusive rocks. Material at surface open textured; silty matrix at depth. Surface displays flow ridges and furrows arcuate downslope. Frontal slopes steep; commonly more than 50 feet high. Deposits of the Gannett Peak Stade (grg) are fresh and barren, and have active fronts. Deposits of the Temple Lake Stade (trg) are inactive and locally forested. Fragments at surface are slightly weathered, and interstitial voids are locally filled with humic debris.

LACUSTRINE DEPOSITS

lst — *Lake silt*—Humic silt at edge of modern Yellowstone delta, and at site of small Holocene lake dammed by avalanche debris near East Entrance (stratigraphic section 23). Similar to fine-grained humic alluvium (fa) but of lacustrine origin.

lsg — *Lake sand and gravel*—Gray to tan sand and gravel forming present and past beaches of Yellowstone Lake, up to and including the 25-foot shoreline. Deposits well sorted, commonly crossbedded. Gravel mostly well rounded. Some deposits lie on wave-cut benches cut in older ice-dammed lake deposits (pkl) or on rock; others form constructional features such as spits and bars that locally retain lagoons.

ALLUVIAL DEPOSITS

fa — *Fine-grained humic alluvium*—Silt, sand, and clay in a seasonally marshy environment. Underlies flood plain and delta of Yellowstone River, poorly drained meadows along streams, kettles, and old lagoons on kame or lake terraces, and small glacial depressions on uplands. In most areas deposition seasonally active. Charcoal in the lower part of a 5-foot section (stratigraphic section 20) of tan sandy silt, 1.3 miles southwest of Grizzly Peak, has a C^{14} age of 3,100±250 years (sample W-2003; Meyer Rubin, written commun., 1968).

sg — *Stream gravel*—Gravel with coarse sand matrix in stream beds and terraces less than 30 feet above Yellowstone River and larger creeks. Deposits include lenses of sand and finer grained material; they are gray to tan, well sorted, and well bedded. Gravel is well rounded, mostly less than 3 inches in diameter. In valley of Middle Creek, near East Entrance, sand and gravel fill over bedrock is more than 100 feet thick.

fg — *Fan gravel*—Alluvial fan gravel, tan to gray, subrounded to subangular, moderately sorted, and crudely bedded. Contains lenses of sand and silt. Boulders abundant at head of deposit which commonly grades upstream into avalanche debris in upper valleys and cirques. Distal sector of deposits commonly silty.

COLLUVIAL DEPOSITS

ta — *Talus deposit*—Angular to subangular rock fragments underlying steep slopes at base of cliffs. Interstices void at surface but filled with silty matrix at depth. Thickness 5-50 feet; deposits commonly accumulating above 9,000 feet altitude at present; unstable. Vegetation commonly absent except for lichens.

tf — *Talus flow deposit*—Material same as talus, but forms a lobate, arcuate ridge, 5-20 feet high, at toe of a talus; formed by downslope flow.

rb — *Block rubble*—Large angular blocks forming barren open rubble. Single deposit mapped on toe of landslide on west side of ridge separating south fork of Middle Creek from Cabin Creek.

ad — *Avalanche debris*—Rounded to angular debris in a muddy matrix forming fan-shaped or lobate deposits. Occurs below cliffs at base of avalanche chutes. Deposits unsorted to poorly sorted, crudely bedded, tan to gray, locally very bouldery. In places gradational headward into talus and downslope into fan gravel. Locally characterized by torrent and alpine mudflow levees. Includes debris transported by torrential runoff, mudflow, slushflow, and snow avalanche.

fr — *Frost rubble*—Thin mantle of angular to rounded clasts of andesite and, locally, basalt in silty matrix. Weathered from bedrock, moved slightly downslope and vertically mixed by frost action. Thin humic azonal soil. Commonly occurs on upland above timberline. Where formed from massive rock, material is angular, contains little matrix, and is sparsely vegetated; where formed from poorly consolidated conglomeratic bedrock, it is rounded to angular, contains abundant matrix, and is commonly covered with alpine turf. Though locally seasonally active, most deposits are stable, some since Pinedale time.

sd — *Solifluction deposit*—Buff coarse to fine stony sandy silt; unsorted and unsized. Forms lobes 15-20 feet high on lower valley walls of Beaverdam and Howell Creeks where saturation of lake silt under gravel in steep terrace fronts has caused flowage out over outwash gravel (pgu) of late stade of Pinedale Glaciation. On east side of Signal Hills, deposit is derived from glacial deposits and frost rubble.

ls — *Landslide deposit*—Lobate masses of rubble or gravel in a muddy matrix. Includes slumped colluvium and alluvium on high bench west of East Entrance, slumped bedrock at head of the south fork of Middle Creek, and slumped kame deposits east of the delta of the Yellowstone River.

EOLIAN DEPOSITS

es — *Eolian sand*—Brown fine sand forming dunes 10-15 feet high along modern shoreline at west edge of Yellowstone River delta. Massive to crossbedded; mostly stable; supports grass and a few trees; locally active in fresh blowout areas.

PINEDALE GLACIATION

GLACIAL DEPOSITS

ptu — *Till*—Subangular to subrounded rock fragments in gray-brown to gray, fine-grained silty matrix; unsorted, unsized, and nonstratified. Boulders as much as 1 foot in diameter common on surface. End moraines mark outer limit of late stade of Pinedale Glaciation, are commonly 10-40 feet high. On upper Beaverdam Creek (stratigraphic section 12) the till matrix is a dark, locally bedded stony silt, suggesting deposition in water. Along Columbine, Beaverdam, and Trappers Creeks, the till rests on kame deposits of middle Pinedale age. Moraines are commonly forested and covered with forest litter. Brown podzolic soil is weakly developed, and about 1.5 feet thick.

prgu — *Rock glacier*—A rock glacier of the late stade of Pinedale Glaciation about 0.75 mile long lies in the south-facing cirque between Avalanche and Hoyt Peaks in the northern part of the quadrangle. It displays large collapse features probably associated with melting of a former ice core. Its frontal slope is several hundred feet high. Deposit similar to Neoglacial rock glaciers, but surface is locally well forested and mantled by silty humic soil.

pt — *Till*—Subangular to subrounded andesite rock fragments in gray compact silty matrix; unsorted, unsized, and nonstratified; 0-10 feet thick on uplands and upper slopes, 10-15 feet thick on lower slopes. Local morainal form. Some stones striated and glacially shaped; most have same shape as stones in local bedrock. Deposits in part moved downslope by colluvial processes; contain nonglacial accretions of weathered bedrock. Brown podzolic soil on till is weakly developed and 1-1.5 feet thick. South of Middle Creek, in northeast corner of the quadrangle, well-defined moraines occur on bench 500-1,000 feet above local drainage. Well-defined moraines also border kame gravel deposits (pkg) near Sylvan Lake. Along upper Beaverdam Creek (stratigraphic section 13), Columbine Creek (stratigraphic section 18), and Clear Creek (stratigraphic section 21), the till consists of scattered stones, some striated, in a massive, blocky, locally bedded dark-gray silt that appears to have been deposited under water.

pr — *Rubble veneer*—Thin mantle (0-5 feet) of rubble in a silty matrix; mantles hills east of Yellowstone Lake. No striated stones found and no striations found on small outcrops included with deposits as mapped. However, the hills were covered by Pinedale ice to depths of at least several hundred feet, and much of the surficial debris was probably deposited by ice filling against slopes with no scouring action. Deposits probably moved downslope by solifluction and frost action during and after deglaciation.

ICE-CONTACT DEPOSITS

pkg, pksg, pkgs — *Kame deposits*—Buff to gray sand and gravel forming kame terraces with ice-contact frontal scarps and irregularly benched upper surfaces. Commonly between elevations of 8,480 and 7,840 feet (110-750 feet above Yellowstone Lake). Deposits are 20-100 feet thick, and are most extensive in valleys tributary to Yellowstone Lake. They are moderately well sorted, but abrupt vertical changes in grain size are common. Bedding is uneven and locally dips steeply in several directions over a small area. The sand is commonly coarse grained and subangular; the gravel commonly rounded and less than 6 inches in diameter. Some deposits include lenses of lake silt and sand. Locally they contain or are mantled by poorly sorted units such as mudflow debris, solifluction debris, and till. In the upper section of Rocky Creek lake silts, locally containing mollusk shells, occur at the upstream end of the kame terrace deposits.

LACUSTRINE DEPOSITS

plsg — *Lake sand and gravel*—Gray to tan sand and gravel forming beaches of former open-water levels of Yellowstone Lake 60-65 and 45 feet above present lake level. Crossbedded; well sorted; but with textural variation both vertically and horizontally. Some deposits lie on benches wave-cut in older ice-dammed lake deposits (pkl) or on rock. Others form constructural features such as spits and bars that locally retain lagoons, especially at the 60- to 65-foot former shoreline.

pklb — *Ice-dammed lake beach deposit*—Gravelly to sandy beach deposits and gray to buff lacustrine sand and gravel of ice-dammed lakes and ponds 240, 220, 180, 135, 110, 90, and 75 feet above Yellowstone Lake. Beach deposits, commonly 5-15 feet thick, lie on wave-cut platforms cut in ice-dammed lake sand and silt or on rock; locally forms only a veneer on rock.

pkl, pksl — *Ice-dammed lake silt and sand*—Light-tan to gray, massive to thinly laminated lake silt (pkl) deposited in embayments and lagoons of ice-dammed lake. Unit mapped 1.5 miles west of Trail Creek Patrol Cabin. Also occurs in stratigraphic sections 3, 6, 7, 8, 12, and 14 along Trappers Creek, Beaverdam Creek, and Rocky Creek. On Rocky Creek (stratigraphic section 14) humic silty clay in this unit yielded a radiocarbon age of 13,140±700 years (sample W-2037; Meyer Rubin, written commun., 1969). Gray to tan, massive to evenly bedded, well-sorted, medium-grained, ice-dammed lake sand (pksl), observed in stratigraphic sections 6, 7, 8, and 13 only.

ppl — *Proglacial lake silt*—Moderately compact greenish-gray to brown silt mapped along Clear Creek. Also noted in stratigraphic sections 2, 5, 9, and 21, beneath Pinedale Till. Commonly poorly exposed, but indicated by seepage zone at top of lake silt and by landsliding of overlying units. Along Clear Creek, deposit is more than 25 feet thick and consists of a lower well-bedded sandy unit and an upper massive silt unit. Ice-rafted pebbles, including obsidian, common in upper part; material grades upward into clayey Pinedale Till.

ppls — *Proglacial lake sand (in stratigraphic section 5 only)*—Light-gray medium-grained well-sorted thick-bedded massive friable to loose lake sand. Probably deposited in ice-dammed lake.

ALLUVIAL DEPOSITS

pgu — *Outwash gravel*—Coarse crudely sorted and weakly bedded outwash gravel underlying terraces that locally extend to moraines of late stade of Pinedale Glaciation. Thickness 20-40 feet. Deposits overlap or are entrenched into kame deposits of the middle stade along Howell, Trappers, Beaverdam, Rocky, and Columbine Creeks. At mouth of Beaverdam Creek, deposits are graded to beach deposits of 60- to 65-foot level of Yellowstone Lake.

pg — *Outwash and stream gravel*—Underlies meander-scarred terraces more than 25 feet above Yellowstone River near Trail Lake, and small terrace remnants along Beaverdam and Columbine Creeks. Lithology and texture similar to Neoglacial gravel. Probably mostly of late Pinedale age, but not physically connected with moraines of late stade.

pfg — *Fan gravel*—Similar to Neoglacial fan gravel, but incised 25-50 feet by streams. At head of Beaverdam Creek, associated with outwash and moraines of late Pinedale age. At mouth of Columbine Creek, similar to other alluvial fans but built into ice-dammed lake.

ppg — *Proglacial gravel (in stratigraphic sections 5 and 9 only)*—Gray to buff interlayered coarse cobble gravel and sand; weakly bedded to markedly stream crossbedded; local lenses of laminated lacustrine silt and massive well-sorted sand; 25-40 feet thick.

COLLUVIAL DEPOSITS

pta — *Talus deposit*—Similar to Neoglacial talus (ta), but inactive and mostly forested or grass covered; includes some frost rubble and colluvium on steep slopes. Occurs at lower elevations than Neoglacial talus and laterally beyond the limits of that talus in cirque basins. Especially abundant on steep rocky slopes of canyons east of crest of Absaroka Range.

pco — *Colluvium*—Colluvial mantle on moderate slopes above upper limit of Pinedale ice in northeast part of quadrangle. Consists of slabs and subrounded boulders in a tan silty matrix. Thickness 2-30 feet; commonly 10 feet. Mostly stable and supporting open forest vegetation.

BULL LAKE GLACIATION

GLACIAL DEPOSITS

bt — *Till (in stratigraphic sections 3 and 22 only)*—Gray compact stony sandy clay till.

LACUSTRINE DEPOSITS

bl — *Lake sediments*—Bluish-gray, weathering pinkish brown, compact dense thinly laminated silt, varved silt, or megavarved silt interspersed with beds of silt and fine sand. A few ice-rafted striated stones. Local beds of massive silt or fine sand, 6 inches to 2 feet thick. In stratigraphic section 8, the upper part of the lake sediment includes thin laminae of fine sand containing scouring rush (*Equisetum*) and small compressed branches or twig fragments; a log from this zone dated >42,000 years B.P. (sample W-2197; Meyer Rubin, written commun., 1968). Laminated beds along Beaverdam Creek dip 5° W. Top marked by erosion bench beneath overlying less-consolidated Pinedale deposits.

FLUVIATILE DEPOSITS

bg — *Gravel (in stratigraphic sections 2, 5, 7, 8, 17, 19, and 22 only)*—Gray coarse well-rounded to subrounded boulder to pebble gravel in sandy matrix; 30-50 feet thick. Stream crossbedding weakly to strongly developed; local slump structures; poorly sorted; thick bedded; may be of ice-contact origin.

BEDROCK

R — *Bedrock*—(The following is based on unpublished data supplied by H. W. Smedes and H. J. Prostka, oral commun., 1969.) Yellowstone Tuff of Pleistocene age underlies most of the lowlands in the Clear Creek-Cub Creek drainage and a minor area in the Columbine Creek drainage. The rest of the quadrangle is underlain by lower Tertiary rocks of the Absaroka volcanic field. The oldest unit crops out below an altitude of 8,500 feet in the northeast corner of the quadrangle, and consists of several basalt flows interbedded with conglomerates containing roundstones of andesite and basalt. Resting on this unit, and underlying most of the area of the quadrangle, are crudely bedded andesitic rocks of the vent facies of the Absaroka volcanic field and a lesser amount of well-bedded andesitic rocks of the alluvial facies of the Absaroka volcanic field. Plugs of rhyodacite, some half a mile or larger in diameter, surrounded by contact zones of hornfels, form many of the peaks along and near the divide that forms the eastern boundary of the Park. Abundant andesite dikes occur in the northern and northeastern third of the quadrangle. A body of granodiorite in the upper part of Clear Creek is largely covered by Yellowstone Tuff and Pinedale Till.

STRATIGRAPHIC SECTIONS

Units shown in descending order; numbers denote thickness, in feet.

1.	Yellowstone River	[illegible]
2.	Trappers Creek	[illegible]
3.	Trappers Creek	[illegible]
4.	Beaverdam Creek	[illegible]
5.	Beaverdam Creek	[illegible]
6.	Beaverdam Creek	[illegible]
7.	Beaverdam Creek	[illegible]
8.	Beaverdam Creek	[illegible]
9.	Beaverdam Creek	[illegible]
10.	Beaverdam Creek	[illegible]
11.	Beaverdam Creek	[illegible]
12.	Beaverdam Creek	[illegible]
13.	Beaverdam Creek	[illegible]
14.	Rocky Creek	[illegible]
15.	Middle Creek	[illegible]
16.	Alluvium Creek	[illegible]
17.	Brimstone Basin	[illegible]
18.	Columbine Creek	[illegible]
19.	Columbine Creek	[illegible]
20.	Signal Hills	[illegible]
21.	Clear Creek	[illegible]
22.	Cub Creek	[illegible]
23.	Middle Creek	[illegible]

[1] Volcanic ash.
[2] Gray silt of late Pinedale or younger age.
[3] Peat.
[4] Charcoal.
[5] Wood.

SURFICIAL GEOLOGIC HISTORY

INTRODUCTION

The Eagle Peak quadrangle is southeast of Yellowstone Lake in Yellowstone National Park and adjacent parts of Shoshone National Forest. The terrain comprises the southeastern shore of Yellowstone Lake (elev. 7,733 feet), including the delta of the Yellowstone River, and the Absaroka Range to the east. The Absaroka Range consists of a western zone of foothills dissected by broad valleys, a central high rugged glaciated crest cut by numerous cirques, and an eastern zone of deep U-shaped glaciated valleys separated by high cliffed ridges. The crest of the Absaroka Range attains altitudes between 10,000 and 11,350 feet. Individual peaks rise 2,500-3,000 feet above adjacent canyon floors.

PLEISTOCENE GLACIATION

During at least three Pleistocene glaciations (from oldest to youngest: pre-Bull Lake, Bull Lake, and Pinedale), great icecaps covered most of Yellowstone Park. In this quadrangle, no deposits or erosional features of the pre-Bull Lake glaciation have been found. Evidence of Bull Lake Glaciation is scanty but, together with that from other areas of the Park, indicates that Bull Lake Glaciation was somewhat more extensive than Pinedale Glaciation for which abundant evidence as to character and extent is preserved.

BULL LAKE GLACIATION

Bull Lake glacial deposits are limited to a few exposures (stratigraphic sections 3 and 22) where compact gray till is overlain by poorly sorted, irregularly bedded gravel of probable ice-contact origin, which in turn is overlain disconformably by till (pt) of Pinedale age and associated deposits. The extent of Bull Lake ice could not, therefore, be determined from observations in this quadrangle. At other exposures (stratigraphic sections 7, 8, and 19) gravel (bg) of Bull Lake age grades upward into compact blue-green lake silt, overlain disconformably by Pinedale deposits. At these and still other exposures (stratigraphic sections 5, 6, and 9) the lower part of the Bull Lake lake deposits is thickly varved to thinly laminated and contains striated stones, probably ice-rafted. Thus, the lake probably formed during recession of Bull Lake ice. However, the upper part of the lake deposits at some exposures (stratigraphic sections 1, 8, and 9) is not varved and contains wood fragments (stratigraphic section 8), interlayered thin mats of scouring rush (*Equisetum*), and carbon films of probable algal origin. These organic materials suggest that the lake existed during the interval between the Bull Lake and Pinedale Glaciations. Wood from stratigraphic section 8 has a radiocarbon age of >42,000 years (sample W-2197; Meyer Rubin, written commun., 1968).

East of the Continental Divide, the upper or more eastward part of some of the deposits mapped as Pinedale Till may be of Bull Lake age.

PINEDALE GLACIATION

Early in Pinedale time, valley glaciers descended from the high parts of the Absaroka Range southeast of the quadrangle and coalesced in the valley of the Yellowstone River into a single large glacier which flowed northwest into the basin of Yellowstone Lake. Here the ice formed a center for snow accumulation and enlarged gradually, encroaching into the valleys and over the foothills east of the lake until it ultimately overflowed the crest of the Absaroka Range at altitudes of 10,000-10,500 feet. Evidence for this is preserved in valleys east of the lake where thick deposits of proglacial gravel and lake silt, formed in ponds dammed by ice downstream, are overlain by clayey Pinedale Till derived from the lake basin and containing local erratics of light-gray coarse-grained diorite porphyry. This porphyry is not known in the drainage to the east and was probably derived from the headwaters of the Yellowstone River. In the upper sectors of the valleys, the till is of local origin, showing that descending valley glaciers met ice building up in the basin in the middle sectors of the valleys. Further evidence of buildup of the basin ice is found on the uplands east of the lake which are covered with a thin mantle of locally derived glacial rubble (pr) but lack grooves or striae indicative of downslope glacial scour. At the glacial maximum, the ice over the east side of the lake basin and in the valley of the Yellowstone River was at least 3,000 feet thick. Saddles, cirque headwalls, and some summits along the crest of the range have been scoured by ice flowing east across the divide, and thin deposits of till containing erratic fragments from the west occur on the divide and to the east where ice flowing across the divide merged with local glaciers. In Sylvan Pass, ice more than 1,000 feet thick flowed eastward into the drainage of Middle Creek. Though no terminal moraines were recognized in this valley, lateral moraine crests about 3.5 miles upstream from East Entrance, near altitude point 8570, slope upstream into the south fork of Middle Creek and show that the ice from Sylvan Pass flowed at a higher level than the ice in the valley of the south fork.

A recession from the outermost moraines of the early Pinedale maximum and a subsequent readvance in middle Pinedale time is suggested by a sequence of end moraines near the confluence of Middle Creek with its south fork, and in the valley north of Arthur Peak.

Stagnation of the Pinedale icecap.—At the end of middle Pinedale time, shrinking of the icecap gradually exposed first the crests and then the foothills of the Absaroka Range. Melt water temporarily drained across the rock floor of Sylvan Pass (now covered by about 70 feet of talus), about 740 feet above present Yellowstone Lake, and cut about 40 feet into bedrock along the drainage immediately to the east. Subsequently, the cap appears to have separated from local glaciers in the upper valleys. Kame terrace deposits of fluvioglacial gravel and interbedded local silt, built against an ice front receding downstream, occur as high as 8,480 feet altitude (750 feet above Yellowstone Lake) on Clear Creek, as high as 8,400 feet altitude (670 feet above Yellowstone Lake) on Columbine Creek, Beaverdam Creek, Cabin Creek, and Trappers Creek (locally 8,640 feet), and as high as 8,300 feet altitude (570 feet above Yellowstone Lake) on Howell Creek. The kame terraces extend downslope as low as 7,840 feet altitude (110 feet above Yellowstone Lake), indicating that the ice margin was lowered 460-660 feet during deposition. As many as six different terraces have been observed in places; most are discontinuous.

Along Rocky Creek, 350 feet above Yellowstone Lake, peaty ice-contact lake sediments (stratigraphic section 14) overlying kame sand and gravel deposited during middle Pinedale deglaciation has a radiocarbon age of 13,140±700 years B.P. (sample W-2037; Meyer Rubin, written commun., 1969).

Ice-dammed lake deposits of interbedded sand, gravel, and silt occur below the kame terraces at the canyon mouths and extend along the slopes of the foothills between canyons. The upper limit of these lake deposits ranges from 7,970 feet altitude (240 feet above Yellowstone Lake) to 7,840 feet (110 feet above the lake). These deposits indicate that ponded waters opened along the ice margin earlier in some places than in others. Lake beaches formed as the ice front lowered and ponded waters became more continuous along the ice margin. The beaches occur discontinuously at the following heights in feet above present lake level: 240, 220, 180, 135, 110, 90, and 75 to 80 (heights measured by hand level). The 110-foot level is the most continuously developed.

A lower terrace, 60-65 feet above the lake, is also extensively developed. The deposits of this terrace are characterized by large spits, bars, and enclosed lagoons (for example, north of Columbine Creek), that are indicative of strong longshore currents found only in a large and long-lived body of open water. This terrace is believed to represent the level at which the lake became free of ice.

Late Pinedale readvance.—A readvance of the glaciers from north- and northeast-facing cirques in the Absaroka Range occurred in late Pinedale time. Headwalls of cirques thus reoccupied were sharpened and steepened by the ice. End moraines (ptu) in the valleys show that the glaciers were 1-4 miles long. The average altitude of the end moraines is 8,560 feet. A single rock glacier, more than half a mile long, and having a steep front at least 200 feet high, lies in the cirque southeast of Avalanche Peak. The end moraines and their outwash gravel deposits (pgu) overlie or are entrenched into kame terrace deposits (pkg) of middle Pinedale age, for example, on Beaverdam Creek, Trappers Creek, Columbine Creek, and Howell Creek. Outwash from the moraines is graded to the beach deposit of the 60-foot lake level at the mouth of Beaverdam Creek, and indicates correlation of the advance with the younger deposits of this lake level.

Pinedale frost riving and solifluction.—As the Pinedale icecap wasted, frost-riving of freshly exposed cliffs formed extensive talus deposits (pta), now preserved beyond the limits of Neoglacial talus in cirques and along canyon walls. In many places the material is mixed with glacial debris washed or slumped from steep slopes. The deposits are more widespread on the slopes of the deep canyons east of the crest of the Absaroka Range than in the more open valleys to the west. Talus formation appears to have continued until after the recession of the late Pinedale glacial readvance. The deposits are now stable and forested. It is probable that some upland frost rubble deposits (fr), mapped as Neoglacial in age, include deposits of Pinedale age.

NEOGLACIATION

After recession of the late Pinedale valley glaciers, cirques were empty and slopes throughout the quadrangle were relatively stable during what is known as the Altithermal interval. Subsequently, during what is known as the Neoglaciation, small ice masses less than half a mile long formed below the north and northeast facing parts of many cirque headwalls, and deposited moraines or rock glaciers in the upper parts of the cirque basins. However, many cirques occupied by late Pinedale glaciers were not reoccupied or were only in part reoccupied in Neoglacial time.

The moraines of Neoglacial age commonly mark two advances. Till (tt) of the older advance, known as the Temple Lake Stade, underlies stable moraines or rock glaciers (trg) partly covered by vegetation. Their average altitude is 9,430 feet. Till (gt) of the younger advance, known as the Gannett Peak Stade, lies upslope from the older, and is characterized by fresh blocky moraines and rock glaciers whose average altitude is 9,760 feet. More Neoglacial moraines occur east of the range crest than west of it. Some cirques occupied by Temple Lake ice were not reoccupied in Gannett Peak time. During neither stade did the ice extend beyond the cirque lips, and in some instances it was restricted to the cirque headwalls. Very little cirque headwall modification was effected.

Two small glaciers occur east of the range crest—one on the north face of Eagle Peak, the other north of Avalanche Peak.

LOWERING OF YELLOWSTONE LAKE

Below the 60-foot lake terrace, whose deposits represent the oldest open-water stage of Yellowstone Lake, are at least seven successive lower lake terraces, represented by beach deposits, deltas, spits, bars, lagoons, and terraces cut on rock. They occur discontinuously around the lake at the following levels in feet above the lake: 45, 35, 25, 20, 15, 10, and 5. Those at 45, 25, and 10 feet are the most prominent. Although some deposits, such as the spits, bars and deltas in the vicinity of Columbine Creek, are entirely of depositional origin, and others are cut on bedrock, some are cut on Pinedale ice-dammed lake deposits (pkl) which extend beneath the terrace deposits to points below present lake level in several places. The stratigraphic relation of these terrace deposits to glacial deposits is unknown, except that they are younger than the maximum late Pinedale advance. Deposits (plsg) of the 45- and 35-foot terraces are thought to be of late Pinedale age; those of lower terraces (lsg) of altithermal or Neoglacial age. Lowering of the lake appears to have been controlled by erosion of the outlet.

NEOGLACIAL FROST ACTION, SOLIFLUCTION, AND AVALANCHE ACTIVITY

Frost-riving in Neoglacial time produced extensive deposits of talus below cirque headwalls and cliffed slopes, especially east of the Absaroka Range crest. These deposits are much less extensive than those of Pinedale age. They are gradational downslope into avalanche debris (ad), which also forms at the foot of cliffs where talus is lacking. Avalanche debris tends to be the product of transport by avalanche processes, debris avalanche, mudflow, nivation wash, and torrential floods rather than simply transport by gravity as is talus. Talus flow deposits (tf), which are ridges of debris resulting from the downslope flowage of the toe of a talus, occur in a few places, for example, west of Mount Doane and northeast of Hoyt Peak.

Frost rubble (fr) is widespread on the summit uplands. Some is locally active; some is of Pinedale age. A few deposits have formed *in situ*; many have moved downslope. Most are barren and of blocky to rubbly material.

Neoglacial solifluction deposits occur primarily in two settings. Some are in the form of lobes of debris with fronts as much as 20 feet high that have flowed from the valley walls out over outwash terrace deposits of late Pinedale age on the valley floor, for example, along Howell Creek and along the upper sector of Beaverdam Creek. These deposits are seasonally active during the spring and early summer. Other deposits, also seasonally active, form low terraces and lobes on gently sloping uplands, for example on Table Mountain, where small frost-sorted features such as sorted streams, sorted nets, and sorted circles are developed in frost rubble. A single block field (rb) is developed on the edge of a small landslide below cliffs along the divide between the southeast fork of Middle Creek and Cabin Creek. Landslide activity is not significant in the Eagle Peak quadrangle, though a few small deposits (ls) were observed.

HOLOCENE ALLUVIATION AND EROSION

Holocene alluviation is most extensive in the valley of the Yellowstone River, whose broad flat floor is overlain in many places by 10-15 feet of humic silty to sandy alluvium (fa), and is underlain to an unknown depth by sand and gravel (sg). The river is subject to strong floods during spring runoff and its flood channel is characterized by bars of bouldery gravel as much as 15 feet high. Bordering the flood plain are gravel terraces (sg) that merge downstream at and north of Trail Lake, with lake beaches of the 45-, 25-, and 10-foot levels of Yellowstone Lake. A measure of the rate of growth of the delta of the river is indicated by the distance of the present shoreline from older beach deposits: 45-foot beach, 3 miles, 25-foot beach, 2.5 miles, and 10-foot beach, 2 miles. The delta area north of the 10-foot shoreline is characterized by low sandy gravel levees bordered by broad areas of thick deposits of fine-grained humic muck (fa) deposited in former estuarine areas of the lake. Similar organic sediments extend only a few inches below the lake surface for more than a quarter of a mile offshore on the modern delta, through which the Yellowstone River flows in a channel at least 50 feet deep. Irregular dune ridges of fine sand (es) lie at the exposed edge of the delta. Most are stabilized by brush and a few trees, but some small areas are active.

Along streams other than the Yellowstone River, Holocene alluviation is characterized by narrow modern flood plains bordered locally, as on Beaverdam Creek, by local gravel terraces (sg) 5, 10, and 25 feet above the streams, and by alluvial fans (fg) both at drainage confluences and in the valley heads.

Just southwest of the East Entrance, modern debris avalanching onto the valley floor is indicated by piles of boulders overwhelming trees and by a C^{14} date of 550±250 years (sample W-2008; Meyer Rubin, written commun., 1968) from wood at the base of sediments (stratigraphic section 23) deposited in a local lake just upstream from a large debris avalanche fan.

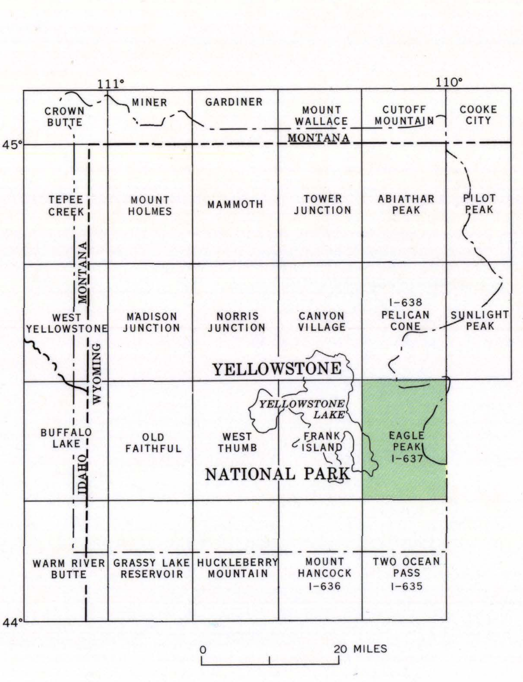
The extent of Holocene erosion is indicated by the depth to which the stream deposits (sg) of this age are entrenched below outwash deposits (pgu) of late Pinedale age. Along Columbine, Beaverdam, and Howell Creeks, this erosion amounts to from 30 to 80 feet. Cirque headwall areas unoccupied by ice since late Pinedale time are locally gullied as much as 10 feet, and those unoccupied since middle Pinedale time as much as 30 feet, especially on south-facing slopes. Channels at the heads of debris avalanche cones along valley walls are commonly 25-40 feet deep.

QUATERNARY FAULTS AND ACID ALTERATION

White unvegetated areas resulting from acid alteration of both bedrock and surficial deposits occur along a zone of late Quaternary faulting just east of Yellowstone Lake. This zone of faults is a northern extension of that along the eastern side of the valley of the Yellowstone River. Along it, between the delta of the river and Brimstone Basin, deposits of Pinedale Till and kame sediments are altered, the more porous units being altered the most. The modern alteration appears to be entirely an acid alteration resulting from upward percolation, primarily along fault zones, of hydrogen sulfide gas. Hot springs are lacking, and no warm areas have been detected on infrared imagery of the region. In Brimstone Basin, altered debris forms a white chip wash. Brimstone Basin is a graben bounded by and including normal faults. Pinedale Till and kame deposits are locally offset 5-20 feet by these faults.

North of Brimstone Basin, well-defined fault lineaments cut across Pinedale kame deposits and continue northward to Cub Creek, where altered areas and pools of cool acidic water occur.

In Sylvan Pass area, no evidence of alteration was noted along the faults shown. Although no offset of surficial deposits was observed, the freshness of the lineaments suggests Quaternary movements. Sylvan Pass is a fault zone, deeply notched by the overflow of ice and water from icecaps in the Yellowstone Lake Basin; displacement, probably mostly pre-Quaternary, is 200-240 feet, downthrown to the north (H. W. Smedes, written commun., 1969).



INDEX MAP OF YELLOWSTONE NATIONAL PARK SHOWING LOCATION OF EAGLE PEAK QUADRANGLE AND PUBLISHED MISCELLANEOUS GEOLOGIC INVESTIGATIONS MAPS

SURFICIAL GEOLOGIC MAP OF THE EAGLE PEAK QUADRANGLE, YELLOWSTONE NATIONAL PARK AND ADJOINING AREA, WYOMING

By
Gerald M. Richmond and Kenneth L. Pierce
1972

For sale by U.S. Geological Survey, price $1.00