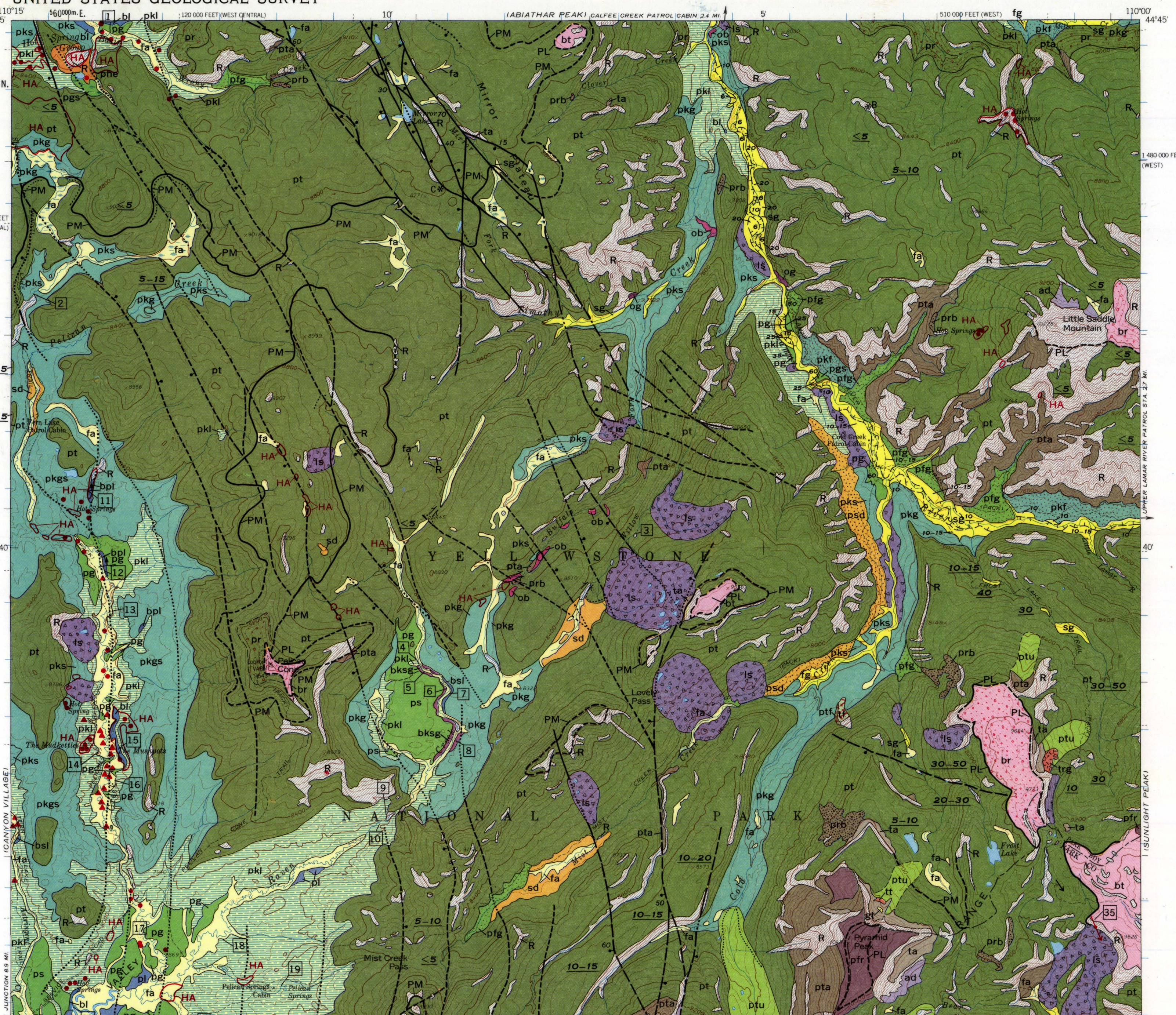


Base from U.S. Geological Survey, 1959
10,000-foot grid based on Wyoming coordinate system, west and west central zones
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

SCALE 1:62 500

CONTOUR INTERVAL 80 FEET
DOTTED LINES REPRESENT 40-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Geology mapped in 1967

QUADRANGLE LOCATION

DESCRIPTION OF UNITS

NEOGLACIATION

GLACIAL DEPOSITS

gt, tt — Till—Gray to buff, unsorted, unsized, angular fragments of local volcanic rocks in silty matrix. Forms small end moraines 5-20 feet high below headwalls of a few sheltered cirques; mostly near Cathedral Peak and Pyramid Peak. Moraines of the Gannett Peak Stade (gt) lie close to cirque headwalls, are unweathered, bear little or no vegetation. Moraines of the Temple Lake Stade (tt) lie a few hundred feet downslope from Gannett Peak moraines, are very slightly weathered, grass covered and locally forested, and locally overlap Pinedale Till.

trg — Rock glacier—Tongue of coarse rubble, with finer interstitial material below surface, in small cirque northeast of Frost Lake. Overlaps Pinedale Till and is overlapped by modern talus.

ALLUVIAL DEPOSITS

fa — Fine-grained humic alluvium—Light-brown to gray silt, fine sand, coarse sand, and pebbles; includes some decayed plant material. Overlies flood-plain deposits of stream gravel (sg), Pinedale lake silt (pl), or Pinedale Till (pt). As much as several feet thick.

sg — Stream gravel—Light-gray to grayish-brown pebble to boulder gravel of volcanic rocks in sandy matrix; underlies flood plains and low terraces of modern streams; commonly less than 10 feet thick.

fg — Fan gravel—Alluvial fan deposits at valley mouths; grades from bouldery gravel near fan heads to silty sand at distal edges; a few feet to about 50 feet thick.

COLLUVIAL DEPOSITS

co — Fine-grained colluvium (in stratigraphic sections 20 and 32 only)—Buff to grayish brown, silty to sandy, structureless, friable. Not mapped, but occurs widely at surface over terrace gravels and lake deposits; probably slope wash; could be partly eolian. Colluvium is 2-4 feet thick.

ta — Talus deposit—Angular to rounded rock fragments with sandy to silty matrix at depth; underlies slopes below cliffs, mostly east of crest of Absaroka Mountains. Much less extensive than Pinedale talus deposits (pta). Accumulating at present; lacks soil or vegetative cover, except for lichens. A few feet to 40 feet thick.

tf — Talus flow deposit—Lobate downslope extension of talus, 5-20 feet high, local crude imbricate fabric; lacks soil or vegetation cover.

fr — Frost rubble—Thin mantle of coarse, angular, or irregularly rounded rock fragments lacking matrix. Occurs along high ridges north and south of Jones Creek. Bears a thin humic azonal soil but appears seasonally active in places.

ad — Avalanche debris—Unsorted angular fragments and irregularly rounded boulders and cobbles in sandy matrix. Forms cones and fans below steep gullies along valley walls, mostly along Jones Creek and Crow Creek. Characterized by irregular bedding and by channels bordered by mudflow levees. Deposits a few feet to 50 feet thick. Commonly accumulate during snowmelt and torrential runoff.

sd — Solifluction deposit—Buff unsorted angular to subrounded stones in coarse to fine sandy silt matrix. Forms lobes and terraces 10-20 feet high on valley floors of Mist Creek and Willow Creek. Deposit derived from Pinedale Till on valley walls by solifluction.

ls — Landslide deposit—Lobate mass consisting of slump blocks and stony silty to sandy debris on valley slopes and floors downslope from headwall along ridge crest. Most occur where Eocene volcanic conglomerates overlie weak tuffaceous units; some are controlled in part by normal faults. Deposits ⅛-1½ square miles in area and as much as 200 feet thick. Individual slump blocks several hundred feet long. Deposit southeast of Frost Lake is relatively recent.

PINEDALE GLACIATION

GLACIAL DEPOSITS

ptu — Till—Angular to subangular stones of local volcanic rocks in grayish-brown to gray sandy to silty matrix; unsorted, unsized, and unconsolidated. Forms hummocky end moraines, 10-40 feet high, 1-3 miles downvalley from north- to northeast-facing cirques near Cathedral, Pyramid, and Silvertip Peaks. Moderately weathered; forested.

pt — Till—Grayish-brown to gray, stony sandy silt; unsorted, loose to compact; stones round to angular, a few faceted and striated, mostly local volcanic rocks. A single erratic of gneissic granite was found about a mile southeast of Mirror Lake. Deposits commonly 5-30 feet thick; form smooth to locally hummocky slopes. Upper limit of middle stade marked by local lateral moraines and by zones of thick hummocky till on steep slopes or in valley reentrants. Small recessional moraines in saddle separating Lamar River and Pelican Valley drainages.

pr — Rubble veneer—Thin mantle (0-5 ft) of locally derived rubble on glaciated uplands and valley walls; product of both glacial and weathering processes.

ICE-CONTACT DEPOSITS

pks, pkg, pksg, pkgs, pkf — Kame deposits—Light-gray to brownish-gray, poorly sorted, crudely bedded sand (pks), gravel (pkg), sandy gravel (pksg), gravelly sand (pkgs), and fan gravel (pkf); range in thickness from a few feet to 70 feet; deposited by streams in contact with glacial ice; mostly unconsolidated, but locally well cemented by silica; characterized by great variation in texture, sorting, and stratification, by postdepositional slumping, by crevasse-filling ridges, and by local enclosed depressions; form irregular terraces along valleys of Pelican Creek, Raven Creek, Cold Creek, and Lamar River.

LACUSTRINE DEPOSITS

pkl, pksl — Ice-dammed lake deposits—Silt (pkl) and sand (pksl) deposited in ice-dammed lakes along Raven Creek, upper Pelican Creek, and Pelican Valley. Silt is gray to bluish gray, moderately compact, massive to thinly laminated, locally varved; weathers buff to tan, or rusty brown where poorly drained; contains a few striated stones, and, in upper basin of Raven Creek, films of organic material on laminae. Sand is buff to tan, well sorted, medium grained; lies mainly in southeast part of Pelican Valley. Deposits are commonly 20-100 feet thick, are characterized by steep ice-contact slopes and landforms, and occur in topographic situations in which lakes could only have been dammed by ice.

pl — Lake sediments—Buff to tan silt and sand; unconsolidated to moderately consolidated; massive to thin bedded, 5-40 feet thick. Deposited in arm of ancestral Yellowstone Lake in Pelican Valley 110 feet above present Yellowstone Lake.

ALLUVIAL DEPOSITS

ps, pg, pgs — Stream sand and gravel—Sand (ps), gravel (pg), and gravelly sand (pgs). Form thin sheets mostly less than a foot thick over lake deposits in Pelican Valley. In the basin of Raven Creek the sand is 15 feet thick, and along Wrong Creek and Lamar River the gravel forms fill terraces 20-40 feet above the stream.

pfg — Fan gravel—Light-brown to brown; sand to boulders, mainly of volcanic rocks; forms steep alluvial fans at gully mouths along Lamar River. Deposits are 50 feet thick or more and have been incised 20-40 feet by modern streams.

COLLUVIAL DEPOSITS

pta — Talus deposit—Angular to subrounded blocky rubble, mostly andesite, on steep slopes below cliffs. Occurs mainly along crest of Absaroka Range, along valleys to east, and in valleys draining Little Saddle Mountain. Deposits are as much as 60 feet thick, inactive; many support vegetation. They are much more extensive than Neoglacial talus deposits.

ptf — Talus flow deposit—Similar to Neoglacial talus flow deposit, but inactive and forested. A single deposit borders Neoglacial talus flow near junction of Mist Creek and Cold Creek.

pfr — Frost rubble—Similar to Neoglacial frost rubble, but is inactive; contains considerable matrix, supports azonal soil, and is commonly grass covered.

prb — Block rubble—Irregular mantle of blocks, 6 inches to 3 feet long, lacking matrix, derived by frost-sorting from landslide debris and talus; occurs on slopes north and east of Pyramid Peak and north of Giant Castle Mountains. Rubble is 3-10 feet thick.

psd — Solifluction deposit—Buff to brown stony sandy silt, unsorted, nonbedded; forms irregular lobes 5-15 feet high. Deposits locally cut by channels and overlapped by levees of modern alpine mudflows; overlie kame gravel (pkg) on west sides of Cold Creek and Lamar River valleys.

phe — Hydrothermal explosion deposit—In southwest part of quadrangle, consists of massive compact yellowish to brownish clay-silt containing angular pebble- to boulder-sized fragments of silica-cemented gravel, sand, and laminated silt from underlying deposits. Formed by subaqueous hydrothermal explosion at Turbid Lake (Canyon Village quadrangle), 50-200 feet thick. In northwest part of quadrangle, consists of hydrothermally altered blocks and fragments of Eocene andesite conglomerate in a similarly altered gray to buff sand, silt, and clay matrix. Deposit forms ridge around west side of a vent in undisturbed Eocene conglomerate, much altered by still active hydrothermal springs. Probably formed by a subaqueous hydrothermal explosion when a lake lay in area during recession of Pinedale ice.

ig — Interglacial alluvial gravel (in stratigraphic sections 17, 20, 29, 32, and 33 only)—Rusty, manganese-stained, weakly cemented alluvial gravel and gravelly sand; round to subrounded pebbles and cobbles of rhyolite, andesite, and minor basalt, with some flattish subrounded to subangular pebbles of silica-cemented sand and silt. Matrix mainly angular quartz, feldspar, and obsidian sand. Gravel is 3-12 feet thick.

BULL LAKE GLACIATION

GLACIAL DEPOSITS

bt — Till—Brownish-gray to gray stony sandy silt, loose to compact, unsorted and unsized; stones subangular to subrounded, composed dominantly of locally derived andesite and basalt; deposits weathered to depth of 3 feet in places. Slopes covered by the till are commonly smooth, locally dissected; depressions mostly filled with colluvium. Deposits mainly on shoulders of ridges north of Crow Creek and Jones Creek, on uplands east of Frost Lake, and on Mirror Plateau. Till is 5-30 feet thick.

br — Rubble veneer—Thin mantle (0-5 ft) of locally derived rubble on glaciated uplands north of Frost Lake and east of Little Saddle Mountain above upper limit of Pinedale ice. In part glacial, in part the product of rock weathering.

ICE-CONTACT DEPOSITS

bksg — Kame sandy gravel—Gray to buff, poorly sorted, irregularly bedded, silica-cemented sandy gravel in upper basin of Raven Creek. Abrupt changes in texture, channel-and-fill crossbedding, and slump structure. Cobbles and pebbles mostly andesite and rhyolite. Disconformably underlies well-sorted Pinedale sand (ps) or kame gravel (pkg) in stratigraphic sections 5 and 8.

LACUSTRINE DEPOSITS

bl, bsl — Lake sediments—Bluish-gray, compact, massive to laminated clayey silt (bl) with local thin layers of fine sand. Crops out below Pinedale lacustrine deposits (pkl), till (pt), and interglacial gravel (ig) in Pelican Valley (stratigraphic sections 20, 21, 28, 29, 30, and 31). Along upper Pelican Creek deposits are silty sand (bsl) mostly much altered by hydrothermal activity, locally varicolored, and cemented by silica. At stratigraphic sections 11 and 12 an interstadial conglomerate (big) separates them from underlying pumiceous lake beds (bpl) of probable early Bull Lake age. In upper basin of Raven Creek deposits (bsl) consist of compact, grayish-green, massive to evenly bedded, well-sorted, medium- to fine-grained sand and lie beneath Pinedale sand (ps) and kame gravel (pkg) (stratigraphic sections 6 and 7). Deposits are 20-30 feet thick.

bpl — Lacustrine pumiceous sand—Light-bluish-gray to light-brown, well-sorted, evenly bedded, fine- to medium-grained pumiceous sand. Lower part of unit contains rounded to subangular pumice chunks and shards and a few pebbles of rhyolite and andesite. It is also deltaic with dips 15°-25° N. Overlies a silica-cemented pumiceous sandy rhyolite pebble gravel. Crops out in three places along upper sector of Pelican Creek (stratigraphic sections 11 and 12) and in Pelican Valley (stratigraphic section 32). Locally altered by hydrothermal activity; total unit as much as 70 feet thick; lower, deltaic part about 20 feet thick. Probably of early Bull Lake age.

ALLUVIAL DEPOSITS

big — Interstadial alluvial gravel (in stratigraphic sections 11, 12, and 32 only)—Yellowish-tan to brown, thin-bedded, silica-cemented coarse sand and sandy pebble layers. Pebbles subangular to rounded; most are ½ to 2 inches in diameter, some as much as 6 inches; mostly rhyolite, some andesite, minor basalt; some pellets and angular fragments of randomly oriented pale-green claystone or sedimentation breccias. Some thin claystone layers. Sand mainly of angular quartz, feldspar, and rhyolite alteration products. Separates overlying younger Bull Lake lacustrine deposits (bl, bsl) from older Bull Lake lacustrine pumiceous sand (bpl). Gravel is 2-18 feet thick.

oe — Old alluvial gravel (in stratigraphic section 12 only)—Grayish-brown, silica-cemented; pebbles of fresh and altered rhyolite; rounded, ¼-2 inches in diameter; some angular silicified greenish-gray silty clay pellets and fragments; sandy matrix composed of angular quartz and feldspar, altered rhyolite, and some pumice. Local rusty stain. Stream crossbedding. About 5 feet thick. Probably of early Bull Lake age

COLLUVIAL DEPOSITS

Frost rubble—Coarse angular frost-riven blocks developed on basalt on summit 1 mile southwest of Cathedral Peak above upper limit of Bull Lake Glaciation. Deposit is 2-8 feet thick. May have been partly reactivated in Pinedale time.

PRE-BULL LAKE DEPOSITS

og — Gravel associated with Osprey Basalt - Yellowish - brown, poorly sorted, crudely to well bedded boulder and cobble conglomerate with local pebble and sand lenses; moderately cemented. Clasts mainly of andesite, basalt, and some Yellowstone Tuff. Crops out along Lamar River at mouth of Willow Creek and along Timothy Creek near confluence of Buffalo Fork. More than 100 feet thick.

ob — Osprey Basalt-Medium-gray, dense to fine-grained basalt; crops out along Lamar River at north edge of quadrangle, along Timothy Creek about 2 miles above its mouth, and extensively along the upper reaches of Buffalo Fork. About 20 feet thick.

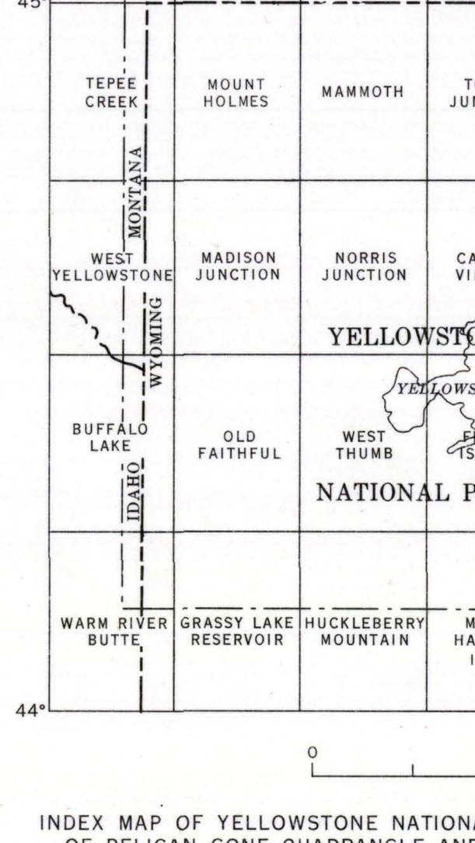
BEDROCK

R — Undifferentiated bedrock—(The following is based on unpublished data supplied by H. W. Smedes and H. J. Prostka, written commun., 1969.) Mainly Eocene volcanic rocks of Absaroka volcanic field and lesser areas of Yellowstone Tuff of Pleistocene age. The Eocene rocks dip gently south to southwest; in northern part of the quadrangle (Little Saddle Mountain and eastern part of Mirror Plateau) and on uplands in east-central part of quadrangle they are mainly andesite breccias and flows overlain by basaltic flows. On western part of Mirror Plateau, Pelican Cone, and the high ridges of Absaroka Range in the south part of the quadrangle the Eocene rocks include light-colored volcanic conglomerates, chiefly andesitic, and underlying lava flows. Giant Castle Mountain, Silvertip Peak, and Cody Peak in southeast corner of quadrangle are capped by Eocene andesite flows. Yellowstone Tuff unconformably overlies rocks of the Absaroka volcanic field on the west side of Mirror Plateau, on uplands southwest and northeast of Lamar River, southwest of Jones Pass, and on the bench north of Jones Creek.

STRATIGRAPHIC SECTIONS

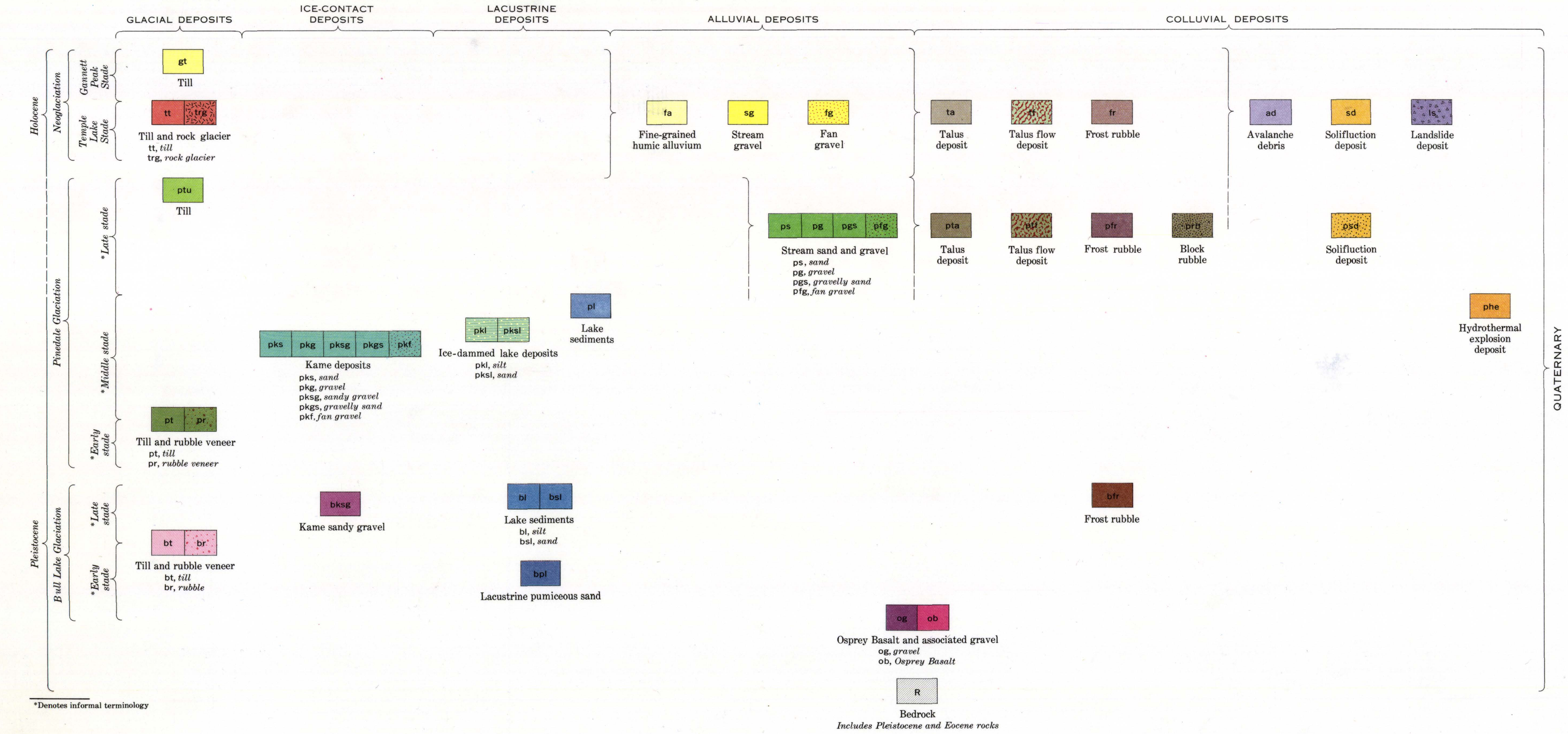
Units shown in descending order; numbers (where shown) represent thickness, in feet. Sections demonstrate distribution and stratigraphic relations of significant units vertically exposed and thus too small to be shown on the map

1. fa/sg/bsl
2. pks/pt
3. 10 pt/45 bt
4. pg/pkl
5. ps/bksg/bt
6. 25 ps/30 bsl
7. 5 pkg/48pksl/31bsl
8. pkg/bksg
9. pkl/pt
10. pkl/bl
11. pt/bl/big/bpl
12. 2 pt/7 bsl/18 big/70 bpl/3 eg
13. pkl/pkg
14. 6 pg/15 pkl/10 bsl
15. 40-50 pkl/40-50 bsl(?)/10-15 bpl(?) (section hydrothermally altered)
16. 15-25 pkl/20-30 bsl
17. 0.5 pg/10 pksl/12 ig
18. 2 fa/5 sg/12 bsl
19. pkl/bsl
20. 3 co/8-15 pkl/3-4 ig/30 bl
21. 35 pkl/10 pt/22 bl
22. pkl/pksl
23. pg/pksl
24. pkl/pt
25. pksl/pt
26. pksg/pt
27. 4 ps/10 pkl
28. 12 pkl/32 bl
29. 10 pkl/10 ig/20 bl
30. 4 pkl/3 ig/5 bl
31. 12 pkl/30 bl/22 bsl/20 bl
32. 2 co/22 pksl/8 ig/15 bsl/2 big/10 bpl
33. 10 pt/3 ig/20 bl
34. 10 pt/20 bl
35. 20 bl/2 bt



INDEX MAP OF YELLOWSTONE NATIONAL PARK SHOWING LOCATION OF PELICAN CONE QUADRANGLE AND PUBLISHED MISCELLANEOUS GEOLOGIC INVESTIGATIONS MAPS

EXPLANATION



Contact, approximately located
Dashed where inferred

Fault having Quaternary movement
Solid where map unit is offset; dashed where map unit is probably offset but mantled by unmapped local colluvium; short dashes where topographically expressed but mantled by map unit; dotted where inferred and concealed. Bar and ball on downthrown side. Numbers indicate offset of map unit in feet

Strike and direction of dip of deltaic sediments

Upper limit of Bull Lake ice, approximately located

Upper limit of early Pinedale ice, approximately located
Dashed where inferred

Upper limit of middle Pinedale ice, approximately located
Dashed where inferred

Direction of Pinedale ice movement
Shown by glacial streaming or molding feature

Bull Lake Pinedale
Glacial striations

Pinedale outwash channel
Showing direction of flow

End moraine
Composed of till or gravel

Stream-terrace scarps
Numbers indicate height, in feet, above stream

Location and number of stratigraphic section

Estimated thickness of surficial deposits, in feet
<5 indicates deposit less than 5 feet thick

Location and kind of erratic
C, *granitic gneiss*
B, *basalt*

Veneer of Pinedale erratics overlying older sedimentary unit

HYDROTHERMAL FEATURES

Active sinter spring

Warm spring

Area of hydrothermal alteration and hot-spring deposits

SURFICIAL GEOLOGIC HISTORY

INTRODUCTION

The Pelican Cone quadrangle is located northeast of Yellowstone Lake in Yellowstone National Park and in adjacent parts of Shoshone National Forest. The quadrangle is drained by Pelican Creek, which flows southwest across a broad grassy basin into Yellowstone Lake; by Lamar River, which flows northwest through a deep troughlike valley to the Yellowstone River; and by Crow Creek and Jones Creek, which flow east through deep U-shaped canyons into the North Fork of the Shoshone River.

The serrate crest of the Absaroka Range forms a divide across the southeast part of the quadrangle. From it, just east of Mount Chittenden, a more subdued divide extends northward to the Mirror Plateau. Local relief in the eastern part of the quadrangle is from 1,000 to 3,000 feet, and in the western part from 500 to 1,000 feet.

PLEISTOCENE GLACIATION

Great icecaps covered most of Yellowstone Park during at least three glaciations in Pleistocene time. From oldest to youngest these are called the pre-Bull Lake, Bull Lake, and Pinedale.

PRE-BULL LAKE GLACIATION OR BULL LAKE GLACIATION

No glacial deposits of the pre-Bull Lake glaciation have been recognized in the Pelican Cone quadrangle but outcrops of deeply weathered, poorly cemented cobble gravel (gravel associated with Osprey Basalt, og) along the Lamar River at the mouth of Willow Creek, and along Timothy Creek near the confluence of Buffalo Fork, are of pre-Bull Lake age. The gravel is of the same age as the Osprey Basalt (ob) with which it is intimately interlayered in the Tower Falls quadrangle.

BULL LAKE GLACIATION

Glacial deposits of the Bull Lake Glaciation consist of till (bt) and glacial rubble (br) that lie above the upper limit of Pinedale Glaciation on Mirror Plateau, Little Saddle Mountain, Pelican Cone, the ridge northeast of Lovely Pass, uplands north and east of Frost Lake, and broad benches on the north slopes of the valleys of Jones Creek and Crow Creek. The distribution and altitudes of these deposits show that an icecap covered almost all of the quadrangle in Bull Lake time and that it was more extensive than the subsequent Pinedale icecap. On the benches north of Jones and Crow Creeks the till has a mature but distinctly morainal topography, and is more deeply weathered than Pinedale Till. Bull Lake Till crops out beneath Pinedale Till and associated kame deposits at stratigraphic sections 3 and 5.

From evidence in other areas it is known that the Bull Lake Glaciation consisted of an early stade and a late stade. Though no till of the early stade was positively identified in this quadrangle, the presence of a lake in the Yellowstone Lake Basin during glacial recession in the latter part of the early stade and during the subsequent interstade, before the glacial advance of the late stade, is suggested by deposits of lacustral pumiceous silty sand and gravel (bpl) in Pelican Valley and along the northern sector of Pelican Creek. At stratigraphic sections 11, 12, 15, and 32 the pumiceous sand is characterized by deltaic foreset beds dipping 15°-25° N. The pumice is mixed with other materials and was probably reworked from older deposits by a lake that at one time extended up Pelican Creek to an altitude of at least 8,160 feet. The lowest outcrop of the pumiceous sand in this quadrangle is at 7,840 feet in Pelican Valley (stratigraphic section 32). The deposits are separated from lake silts of the late stade by an interstadial gravel (big) in stratigraphic sections 11, 12, and 32.

Little is known about the recession of the icecap in late Bull Lake time. The distribution and character of silica-cemented kame gravel (bksg) beneath Pinedale deposits in the upper basin of Raven Creek (stratigraphic sections 5 and 8) suggest that the Bull Lake ice stagnated at altitudes as high as 8,300 feet. At lower altitudes, deposits of lacustral silt and sand of late Bull Lake age underlie hills capped by Pinedale Till or by a veneer of Pinedale erratics in the area south of Pelican Creek near the west margin of the quadrangle and at stratigraphic sections 11, 12, and 34. The silts also disconformably underlie a post-Bull Lake and pre-Pinedale alluvial gravel at stratigraphic sections 20, 19, 30, 32, and 33 in Pelican Valley. The distribution and altitude range of the lacustrine deposits suggest that an ice-marginal lake opened gradually in Pelican Valley and its tributaries as the late Bull Lake ice receded to successively lower altitudes.

PINEDALE GLACIATION

Two ice masses covered most of the quadrangle during the Pinedale Glaciation. The larger and older was an icecap that developed in the Yellowstone Lake Basin to a maximum thickness of about 2,200 feet in this quadrangle. It overrode all but the highest peaks of the Absaroka Range to the east, reshaping many of them into huge roches moutonnees. The upper limit of the ice near Mount Chittenden was at about 10,000 feet altitude. This ice flowed eastward down the canyons of Jones Creek and Crow Creek and down the North Fork of Shoshone River to about 1½ miles north of Pahaska Tepee in the Sunlight Peak quadrangle. North of Mount Chittenden, the ice overtopped the divide between Pelican Valley and the Lamar River, rising to 9,500 feet altitude on Pelican Cone, and lay in contact with a smaller ice mass in the Lamar River drainage along a line trending northwest from Pyramid Peak to Mirror Lake.

The Lamar ice mass rose to 9,400 feet altitude on the uplands north of Frost Lake, and part of it flowed southeast through a pass east of Frost Lake to join ice flowing down Bear Creek from a local center of accumulation south of Pyramid Peak. To the north, the Lamar ice mass rose to 9,600 feet altitude on Little Saddle Mountain, and overtopped the Mirror Plateau at about 9,120 feet. In the valley of the Lamar River it was as much as 2,200 feet thick.

After the maximum advance of Pinedale Glaciation, which is called the early stade, the ice receded an unknown distance, and then built up again to a second stand, about 300 feet below the first maximum. This stand, which was in places a series of closely related stands, is correlated with the middle stade of Pinedale Glaciation. It is marked by lateral moraines, by areas of thick hummocky till along steep slopes and, in valley reentrants, by ice-marginal inwash deposits, and by drainage outlets leading away from stagnant ice depressions in the till. The limits of the middle stade are most clearly delineated in the northwest quarter of the quadrangle.

Following readvance of the middle stade, downwasting of ice first exposed the crest of the Absaroka Range and then the divide that separated the icecap in Yellowstone Lake Basin from ice in the Lamar River drainage. For a short time, melt waters flowed through some of the saddles in this divide. Saddles at the head of Cold Creek and at Mist Creek Pass were the first to be exposed, but there is little evidence of fluvial erosion or deposition in them.

Kame gravels were deposited along Cold Creek against ice that receded downvalley from 8,200 feet altitude near the headwaters to 7,600 feet near the Lamar River.

The saddle at the head of Willow Creek contains a recessional end moraine convex to the south, suggesting drainage to the south, at least temporarily. Recessional end moraines in the headwaters of Raven Creek, however, are convex to the north. Kame gravels enclosing a stagnant ice depression in the headwaters of Buffalo Fork were deposited against ice that receded down Buffalo Fork from an altitude of 7,750 feet nearly to its confluence with the Lamar River.

The southwest side of the Lamar River valley is bordered almost continuously by terraces of laminated silt deposited in a lake dammed by ice that receded northward downstream. These lacustrine silts extend from an altitude of 7,600 feet near the mouth of Cold Creek to 7,520 feet at the narrows above the mouth of Buffalo Fork, and from about 7,240 feet at the mouth of Buffalo Fork to 7,200 feet at the north edge of the quadrangle. The receding ice that dammed the lake was about 400 feet high when at the mouth of Cold Creek but was only about 160 feet high when at the north edge of the quadrangle. No lake deposits were found along the Lamar River valley upstream from the mouth of Cold Creek.

Stagnation and downwasting of the Yellowstone Lake basin icecap in the drainage of Pelican Creek are recorded by kame terrace deposits and by ice-dammed lake sediments deposited in the earliest waters ancestral to Yellowstone Lake itself. The upper basin of Raven Creek is enclosed by fluvial ice-contact gravels (pkg) to altitudes as high as 8,400 feet. As the ice receded into the narrows below the basin an ice-dammed lake opened up, and lake silts (pkl) were deposited at 8,240 feet altitude, or approximately 600 feet above present Yellowstone Lake. Subsequently as the ice downwasted into Pelican Valley, the lake receded from the basin of Raven Creek and alluvial gravel covered the lake beds to a depth of about 25 feet.

The lake next opened in the northeastern part of Pelican Valley where ice-dammed lake silt (pkl) occurs as high as 8,240 feet altitude. In the southeastern part of Pelican Valley, streams deposited kame gravel between ice and the valley slopes from 8,320 to 8,080 feet. Opening of an ice-marginal lake at 8,080 feet is recorded by deposits of ice-dammed lake sand (pksl) from 8,080 feet to 8,000 feet and by ice-dammed lake silt (pkl) at lower altitudes. In the basin of Pelican Creek, north of Pelican Valley, streams deposited gravelly sand (pkgs) around stagnant ice from 8,320 feet to 8,080 feet but, as the ice receded southward, an ice-marginal lake opened gradually from north to south. This event is recorded by lake silt (pkl) as high as 8,160 feet altitude at the north end of the basin, but only to 8,080 feet at the south end. A similar history is also recorded in the valley of Astringent Creek, where fluvial ice-contact sandy gravel (pkgs) occurs from 8,400 to 8,080 feet, and lake sediments (pkl) at lower altitudes.

After the lake had opened in the eastern end of Pelican Valley and its tributaries, it gradually enlarged westward at successively lower levels as the damming ice receded to the southwest. Thick silts (pkl) deposited in the lake at this time fill the valley floor, and overlap Pinedale kame deposits (pkgs) and Pinedale glacial rubble (pr) mantling older Bull Lake lake sediments (bl). The lake level at the west edge of the quadrangle at this time was at 8,000 feet altitude, or 270 feet above present Yellowstone Lake. The subsequent history of lowering of the lake can be inferred from the distribution of its deposits in the Canyon Village quadrangle, adjacent to the west.

Thin deposits of alluvial gravel (pg) or sand (ps) overlap the lake deposits at the mouths of tributaries to Pelican Creek. Some are graded to lake and marsh deposits (pl) 10-15 feet above the creek, and represent a final phase of the lake in Pelican Valley. Others are graded to terraces 20-30 feet above Pelican Creek that extend through Pelican Valley to the west.

In the northwest corner of the quadrangle an ice-dammed lake formed in the headwaters of Wrong Creek. Laminated lake silt (pkl), locally much altered by hydrothermal activity, is widespread in Hot Springs Basin up to about 8,400 feet altitude. It also occurs in the valley of Wrong Creek, in the upper sector of which it merges with Pinedale delta and alluvial fan gravel (pfg). The lake opened gradually as the ice front receded northwest down Wrong Creek. The lake silt (pkl) overlies older compact dense laminated lake silt (bl) of probable Bull Lake age and is locally overlain by Neoglacial stream gravel (sg).

Late Pinedale readvance.—Following stagnation and disappearance of ice at the end of middle Pinedale time, valley glaciers readvanced from cirques in the Absaroka Range during a cool interval called the late stade of Pinedale Glaciation. Sixteen such glaciers formed in this quadrangle, all in east- or north-facing cirques. The glaciers were ½-2½ miles long, mostly ½-1 mile wide. The longest formed in the valley northeast of Cathedral Peak and overrode older Pinedale kame gravel (pkg) deposits along Cold Creek. The average lower limit of these glaciers throughout the Absaroka Range was 8,560 feet altitude. Some of them built prominent end moraines, 30-60 feet high. The till (ptu) is commonly more stony and the stones are more angular than in older Pinedale Till (pt). The headwalls of cirques occupied by these glaciers are fresh and sharp, in marked contrast to the rounded crests and smoothed headwalls of older Pinedale cirques, many of which were overridden by the Pinedale icecap. Talus in the cirques is also fresher than that in the older Pinedale cirques.

Pinedale frost riving and solifluction.—During wasting of the Pinedale icecap and in late Pinedale time frost riving of the freshly exposed cliffs of cirques and steep valley slopes in the Absaroka Range, in particular the south slopes of Little Saddle Mountain, produced talus deposits (pta). Most are thin sheets of frost-fractured detritus, but some include glacial rubble washed or slumped from steep slopes. South-facing slopes tend to have greater accumulations than north-facing slopes. Locally, the lower parts of talus have flowed forward to produce lobate talus flow deposits (ptf) with arcuate frontal ridges.

On high gently sloping uplands above the limit of Pinedale ice, such as those east of Cathedral Peak and south of Pyramid Peak, widespread coarse- to fine-grained angular to subangular frost rubble (pfr) formed essentially in situ. These deposits, now stable, bear a brown podzolic soil 12-15 inches thick that supports a thick grassy tundra vegetation. Block rubble deposits (prb), composed of angular blocks 6 inches to 3 feet in diameter, formed locally on steep slopes, such as east of Cold Creek, where blocks riven from bedrock have moved irregularly downslope across underlying surficial deposits.

Solifluction deposits (psd) produced by slow downslope flowage of saturated mantle form broadly lobate constructional terraces around the margins of upland basins, such as the upper section of Willow Creek. Most are derived from till. Small unmapped solifluction deposits are widespread throughout the quadrangle.

Pinedale alluviation and erosion.— Little alluviation, other than ice-contact fluvial deposition, took place in Pinedale time. Thin alluvial fan and terrace deposits (pg), mostly of late Pinedale age, lie 15-25 feet above the streams in Pelican Valley and its tributaries. Along the Lamar River the alluvial gravel is 30 feet to more than 70 feet thick, and successive episodes of late Pinedale deposition and erosion have formed terraces 25-60 feet above the river. Alluvial fans (pfg) along valley sides at mouths of tributaries have been incised 25 feet or more by modern streams.

Maximum stream erosion occurred in late Pinedale time. It is greatest in the valley of the Lamar River, along tributaries to Pelican Creek such as Raven Creek, and in the valleys of Crow Creek and Jones Creek where it is from 30-60 feet.

Pinedale hydrothermal explosion activity.—A hydrothermal explosion deposit (phe) lies between Sedge Creek and Bear Creek along the west edge of the quadrangle. It is part of a larger mass that surrounds Turbid Lake just to the west, in the Canyon Village quadrangle. The explosion is inferred to have taken place under water. The explosion debris overlies an organic layer dated at 8,310±300 years B. P. (sample W-1944; Meyer Rubin, written commun., 1967). Another and probably older Pinedale hydrothermal explosion deposit occurs in Hot Springs Basin.

NEOGLACIATION

During the altithermal interval following recession of the late Pinedale valley glaciers, cirques were empty and slopes were relatively stable. Subsequently, during the Neoglaciation, small glaciers less than half a mile long formed in three cirques in the Absaroka Range. Two small moraines were built in the cirque on the north face of Pyramid Peak and in the high east-facing shelflike cirque southwest of Cathedral Peak. A single moraine formed in the east-facing cirque 1 mile southwest of Cathedral Peak. The outer moraines (tt), including the single moraine, are 20-30 feet high and are mostly grass covered and support a few trees; they represent the Temple Lake Stade of Neoglaciation. The inner moraines (gt) are similar, but fresher, and support only a local sparse grassy vegetation; they represent the Gannett Peak Stade of Neoglaciation.

NEOGLACIAL FROST RIVING AND SOLIFLUCTION

Frost riving and solifluction in Neoglacial time were far less widespread than in Pinedale time. Talus (ta) is mainly restricted to areas beneath cirque headwalls and south-facing cliffs along ridge crests above Jones Creek and Crow Creek. The deposits locally grade into cirque avalanche debris (ad). Frost rubble (fr) formed and is locally forming today along the crests of the Absaroka Range, but is not so widespread as it is south of the quadrangle. A few block rills and sorted circles were noted east of Cathedral Peak. Small active solifluction lobes and terraces (sd) are present in areas such as the upper basin of Raven Creek and the Lamar Valley where ground water, perched on lake silt, saturates the overlying mantle. Peat deposits as much as 6 feet thick occur in some solifluction lobes and terraces in the upper basin of Raven Creek.

NEOGLACIAL ALLUVIATION AND EROSION

Since late Pinedale time, 5-15 feet of gravel (sg) has been deposited along Pelican Valley and its tributaries. Most of this gravel is mantled by 1-4 feet of fine-grained humic alluvium (fa). In the Lamar River valley, alternating erosion and deposition have formed a sequence of gravel terraces less than 25 feet above the river. East of the Absaroka crest, avalanche processes have gullied the steep slopes and deposited extensive avalanche debris (ad) on the valley floors. Throughout the quadrangle, fine-grained humic alluvium (fa) has formed in depressions in Pinedale Till, in upland basins, along Pinedale meltwater channels, and on many flood plains.

LANDSLIDES

A number of large landslides (ls) have occurred where lava flows or mudflow breccias of the Absaroka volcanic field overlie tuffaceous units that become saturated and fail on steep slopes. Some of the landslide deposits contain huge masses of rock that have collapsed as a unit from the headwall. Such deposits occur on both sides of the ridge crossed by Lovely Pass, where they are in part controlled by normal faults, and on the north slope of the valley of Bear Creek, east of Pyramid Peak. Others occur west of Pelican Creek, and north of Pelican Cone. Many small slides have occurred in the lake beds (pkl) underlying the southwest side of Lamar River valley. Most of the landslides are in part seasonally active. Some—for example that on Bear Creek—appear to have originated in Neoglacial time, others in Pinedale time. Part of the large slide at the head of Willow Creek may have flowed onto stagnant ice.

QUATERNARY NORMAL FAULTING

A southeast-trending belt of normal faults that offset Quaternary deposits extends from the northwestern part of the quadrangle south across the south-central part. Individual faults are from 3/10 to 6 miles long and near-vertical, and have throws that range from 10 to at least 100 feet. The arcuate pattern of the faults in the northwestern part suggests a relation to a caldera that lies just west of the quadrangle. These faults delineate at least two complex grabens. The faults to the south, however, appear to be related to a zone of en echelon faulting that extends south of Yellowstone Lake, up the valley of the Yellowstone River.

Movement on the faults occurred at different times during the late Quaternary. Some faults are overlapped by Pinedale Till, some offset Pinedale Till, and some offset Holocene alluvium. The scarps of some of the latter are so fresh, and their relation to ponds and drainage changes are so delicate that their most recent movement may possibly be related to the Hebgen Lake earthquake of August 17, 1959. However, along some faults stratigraphic throw exceeds topographic throw, which suggests that movement was recurrent and that it may have begun before late Quaternary time.

HYDROTHERMAL ALTERATION

Major areas of hydrothermal alteration occur along Pelican Creek and in the Hot Springs Basin Group along Wrong Creek; minor areas lie along East Entrance Road, along faults northeast of Pelican Cone, and west and north of Little Saddle Mountain. With the exception of minor travertine deposits in Pelican Creek, the alteration is acidic, produced by sulfur-laden gas and water. Both bedrock and surficial deposits are commonly altered to light-colored clay or to a crumbly aggregate that supports little or no vegetation. Surficial deposits, particularly those of Bull Lake age, are locally cemented by silica.

SURFICIAL GEOLOGIC MAP OF THE PELICAN CONE QUADRANGLE, YELLOWSTONE NATIONAL PARK AND ADJOINING AREA, WYOMING

By
Gerald M. Richmond and H. A. Waldrop

1972

Wyoming (Pelican Cone quad.). Surficial. 1:62,500. 1972.
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