Geological Society of America Bulletin

Late Quaternary History of the Snake River in the American Falls Region, Idaho

DONALD E TRIMBLE and WILFRED J CARR

Geological Society of America Bulletin 1961;72;1739-1748
doi: 10.1130/0016-7606(1961)72[1739:LQHOTS]2.0.CO;2

DONALD E. TRIMBLE
WILFRED J. CARR } *U. S. Geological Survey, Federal Center, Denver 25, Colo.*

Late Quaternary History of the Snake River in the American Falls Region, Idaho

Abstract: While mapping the American Falls region, we found evidence that contributes to the middle Pleistocene to Recent history of the Snake River, and indirectly to the history of overflow of Lake Bonneville. Middle Pleistocene to recent rocks in the valley are mainly lacustrine and fluvial silts and clays, with some sand, gravel, basalt, and a few thin tuff beds. The formation of terraces can be correlated with events both up- and downstream.

The Snake River was at least once, and possibly twice, dammed and diverted by eruptions of basalt, resulting in the formation of lakes and deposition of lacustrine beds. A rather flat-lying, thin, but persistent gravel at the base of one lake bed formation may represent a glacial period, possibly Illinoian, during which the Snake River had a large volume.

Overflow of water from Lake Bonneville into the Snake River system, by way of the Marsh Creek-Portneuf valley, laid down a deltaic-fluvial deposit here named the Michaud Gravel. At this time the Snake River, greatly augmented by Lake Bonneville overflow, began to cut channels through and around a lava dam. Terraces between Aberdeen, American Falls, and Pocatello were formed during the existence of the lake in which the Michaud Gravel was deposited and by fluvial processes after drainage of the lake. At one stage in the downcutting, bars of huge basalt boulders were built across the mouths of abandoned spillways.

Radiocarbon dating and geologic evidence from the area between Preston and Soda Springs, Idaho, suggest that basalt flows diverted the Bear River into Lake Bonneville, perhaps causing it to overflow. This diversion probably occurred about 33,000 years ago. This dating accords with events in the American Falls region.

CONTENTS

INTRODUCTION

Detailed geologic mapping of the American Falls and Rockland 15-minute quadrangles, Idaho, and reconnaissance of the Yale and Michaud 15-minute quadrangles and adjacent areas by the U. S. Geological Survey (Fig. 1) has revealed previously undescribed events in the history of the Snake River valley and the relation of these events to the spillover of Lake Bonneville at Red Rock Gap. In the American Falls region the late Quaternary history can be closely related to the local stratigraphy.

Robert C. Bright contributed valuable evidence from the Preston, Idaho, area.

The area is in southeastern Idaho (Fig. 1) along the Snake River valley from Pocatello southwestward to the mouth of the Raft River. The Snake River valley in this region consists of (1) a relatively flat wide upstream area around the American Falls Reservoir in which the Snake River has a low gradient, (2) a

Geological Society of America Bulletin, v. 72, p. 1739–1748, 2 figs., 1 pl., December 1961

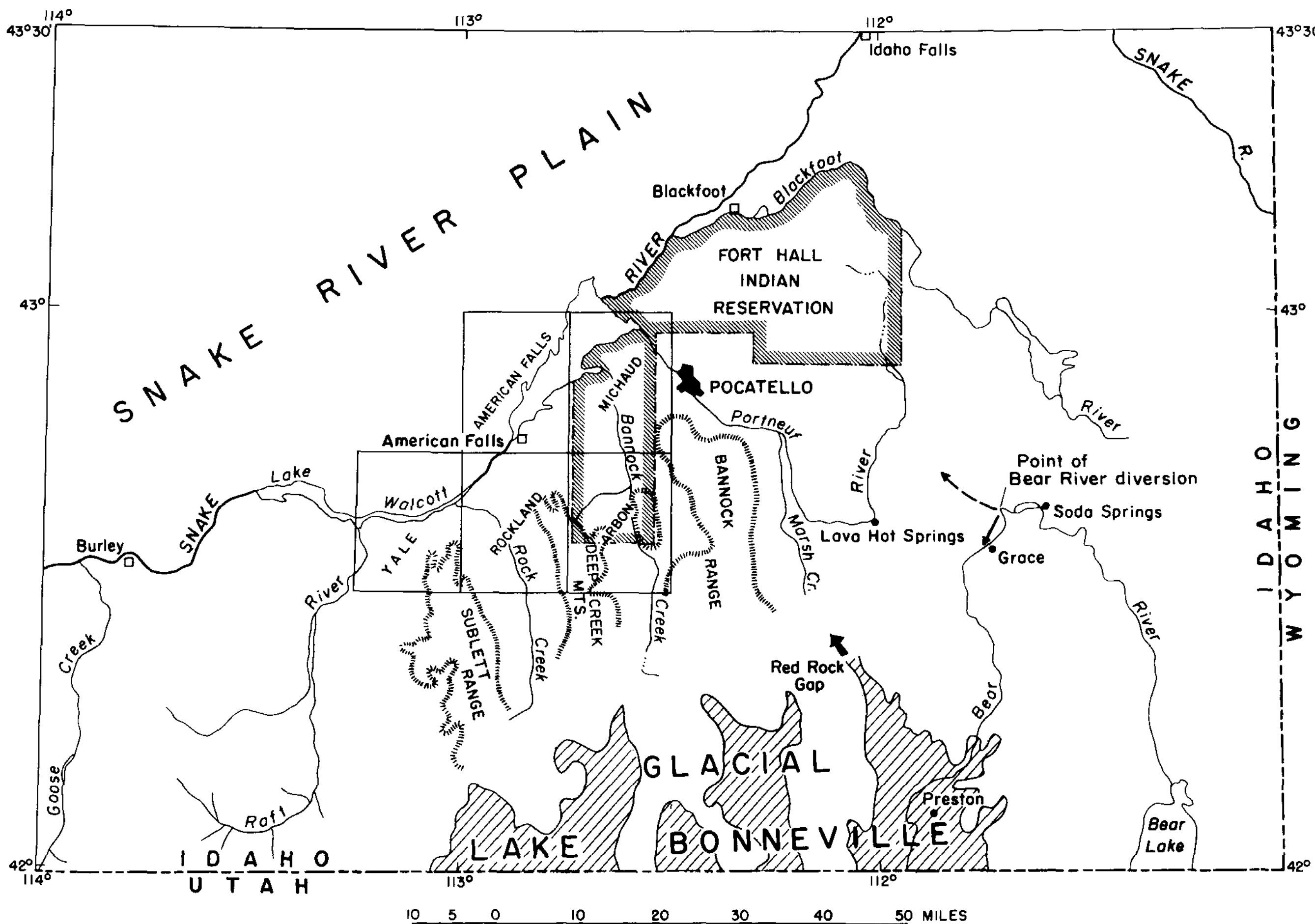


Figure 1. Index map of southeastern Idaho showing the American Falls region, its relation to glacial Lake Bonneville, and other geographic features

middle area below American Falls, where the river has a gradient of 7 feet per mile, and through which it has carved a canyon 50 to 150 feet deep, partly in Recent time, and (3) a downstream area below Massacre Rocks, now occupied by Lake Walcott and impounded by Minidoka Dam, where the gradient is low, but where part of the channel passes through a shallow canyon, cut mainly in late Pleistocene time. The upstream area is underlain by soft sediments with some intercalated basalt on the northwest side of the valley. The middle part of the valley is cut mainly in older basaltic and rhyolitic rocks, and the lower part is cut along the boundary between basalt and weakly consolidated sedimentary deposits.

G. K. Gilbert (1890) was the first to report in detail upon the Quaternary history of the Bonneville basin, but he did not study the Snake River valley itself. He recognized (p. 60) the point of spillover of Lake Bonneville at Red Rock Pass and its significance in relation to lake stages. He also recognized three important high Lake Bonneville stages, the oldest of which he called the "Intermediate stage" (p. 135–154) because its deposits lie between the Bonneville and Provo levels in elevation. The Provo is the youngest of the three stages. Part of the deposits of Gilbert's "Intermediate stage" were later named the Alpine Formation by Hunt and others (1953, p. 17).

The first important geologic study of the Snake River Plains was by Russell (1902). Mansfield, during his study of the Fort Hall Indian Reservation, made the first detailed geologic map (1920, Pl. III) in the American Falls region. He did not examine the deposits of the Snake River valley in detail but did recognize three erosion cycles, the younger two of which are partly equivalent to fluvial terraces mapped by the writers. Later Mansfield (1927, p. 15–20) proposed a more complex series of erosion cycles for southeastern Idaho.

Stearns and others (1938) made the only previous comprehensive geologic study of the eastern Snake River valley, but much of the report concerns ground-water resources of the region. They named most of the Tertiary formations and noted (p. 89) that, "essentially all the [alluvial] material [along the Snake River] was laid down either in impounded waters behind lava dams, or as fans at the toes of these dams." They emphasized the role of springs along the Snake River as agents of erosion but failed to recognize the importance and timing of Lake Bonneville spillover in the late Pleistocene history of the Snake River valley. More recently Stearns and Isotoff (1956) mapped the Massacre Rocks-Eagle Rock area. Poulsen, Nelson, and Poulsen (1943) studied the soils of part of the area and named several terraces.

Modern contributions to the study of Lake Bonneville have been numerous, and much discussion of the chronology and stratigraphy of the various lake stages has been published (Bissell, 1952; Richmond and others, 1952; Williams, 1952; Hunt and others, 1953; Marsell and Jones, 1955; Eardley and others, 1957; Feth and Rubin, 1957; Broecker and Orr, 1958). These papers indicate many problems and lack of agreement on the chronology of Lake Bonneville, much of which stems from differences in radiocarbon age determinations on marl and tufa from the lake.

The importance of the Lake Bonneville spillover in the late Quaternary history of the Snake River valley was first noted by H. A. Powers and H. E. Malde in the western Snake River Plain. They interpreted boulder bars and abandoned cataracts as caused by torrential waters added to the river by Lake Bonneville spillover (Malde, 1960).

STRATIGRAPHY

Rocks exposed along the Snake River include rhyolitic and welded tuff of Pliocene age; basalt and basaltic tuff of probable early Pleistocene age; clay, silt, sand, and gravel of middle to late Pleistocene age, mostly lacustrine and fluvial; basalt of middle to late Pleistocene age; and alluvium and dune sand of Recent age.

The oldest rocks prominently exposed in the Snake River canyon are the Pliocene Neeley Lake Beds (Stearns and others, 1938, p. 43) and the Walcott Tuff of Stearns (Stearns and Isotoff, 1956, p. 23). These two conformable formations crop out mainly along the south side of the Snake River from American Falls southwestward to Rock Creek. The Neeley consists of about 100 feet of poorly bedded light-tan to orange-brown fine- to coarse-grained rhyolitic tuff, with lenses of pebbles and pumice fragments. The overlying Walcott is about 15 to 75 feet thick and consists of a lower white bedded tuff unit and an upper welded obsidian tuff unit.

Unconformably above the Walcott Tuff, and having about the same distribution, is an unnamed unit, 10 to 100 feet thick, of probable early Pleistocene age, consisting of basaltic tuff with rhyolitic pyroclastic debris, overlain unconformably by basalt. Stearns *et al.* (1938, p. 47) included this formation in the Massacre Volcanics, of which the basalt is a part.

The next youngest formation, and the oldest with which this paper is directly concerned, is named the Raft Formation. This unit formerly was called the Raft Lake Beds (Stearns and others, 1938, p. 48). The name is changed because much of the unit, as indicated by Stearns and others (p. 40, 50) and as observed by us, appears to be fluviatile rather than lacustrine, although much of the formation probably did accumulate in a lake. The Raft Formation includes part of what Stearns *et al.* (p. 69) called the American Falls Lake Beds. The lower part of his American Falls consisted of beds older than the basalt that dammed the Snake River and created the lake in which the American Falls Lake Beds were deposited. Thus, in the bluffs on the Snake River opposite Neeley, we assign to the Raft approximately the lower two-thirds of the exposed beds. The Raft Formation is exposed at scattered places along both sides of the Snake River below American Falls, but chiefly in the bluffs opposite Neeley and below Rock Creek on the south side of the river (Pl. 1). The Raft is mainly light-colored poorly bedded to nearly massive silt in the upper part and tan and gray clay, silt, and fine sand in the lower part. It contains a few gravel lenses, many irregular nodules and persistent layers of calcium carbonate, and a few local layers of basaltic and rhyolitic tuff. The Raft ranges from a few feet to more than 200 feet thick. Originally considered Pliocene(?) by Stearns and others (1938, p. 48), it is now known to be Pleistocene on the basis of mollusk collections.

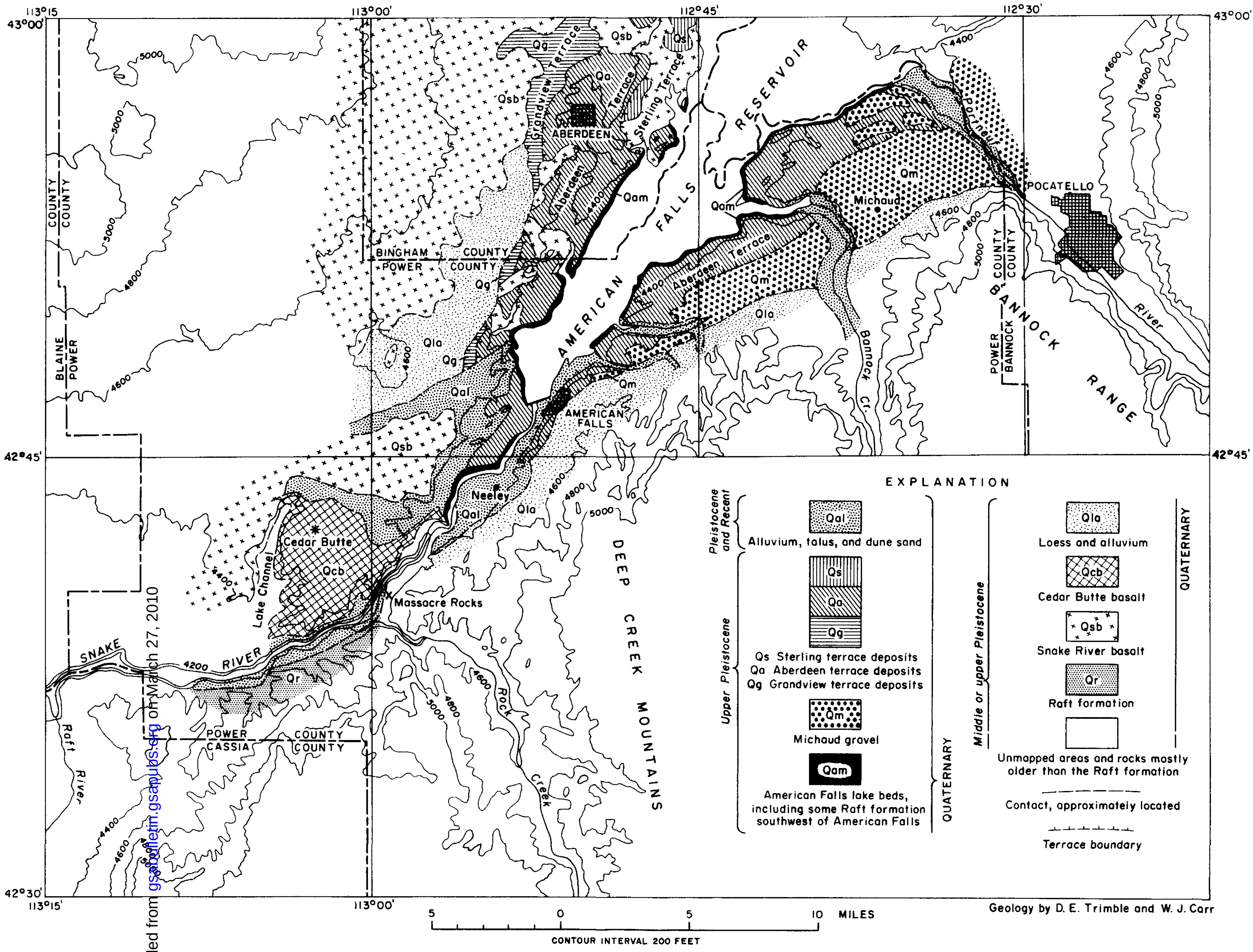
Above the Raft, but possibly intertonguing with it, is a widespread group of nearly contemporaneous basalt flows from several vents northwest of the Snake River. These flows are restricted to the northwest side of the Snake River valley. They contain conspicuous olivine crystals, much magnetite, and glass in the groundmass, and are normally vesicular and fresh looking. These basalts are part of what has been mapped as Snake River Basalt (Ross and Forrester, 1947) and "undifferentiated basalt" (Stearns and others, 1938, Pl. 4).

Cedar Butte Basalt (Stearns and others, 1938, p. 69), which is younger than most of the Snake River Basalt except for flows of Recent age outside the area, occurs in an area about 8 or 10 miles long by 4 or 5 miles wide, almost entirely west of the present Snake River canyon. It probably overlies the Raft Formation in most places, but exposures of this contact are poor. The Cedar Butte issued from vents about 11 miles southwest of American Falls. Over most of the area it is a single flow about 25 to 75 feet thick but locally it consists of at least two olivine basalt flows totaling 200 feet.

The American Falls Lake Beds, which were deposited immediately after emplacement of the Cedar Butte Basalt, overlie the Snake River Basalt or the Raft Formation, where the basalt is absent. The lower part of the American Falls Lake Beds of Stearns and others (1938, p. 69) is now included in the Raft Formation. The lake beds are exposed along the northwest side of the Snake River from a point 1 mile northeast of Eagle Rock to the upper end of the American Falls Reservoir. They are 40–80 feet thick and consist of light-colored bedded silt, sand, clay, and one persistent layer of blocky white diatomaceous clay. A layer of peat occurs near the top of the formation 5 miles northwest of Pocatello. At the base of the formation a thin, discontinuous but persistent layer of gravel is included, although this gravel is probably not related to the lake beds.

Above the American Falls Lake Beds are deltaic sand and gravel deposits, and several terrace deposits of silt, sand, and gravel, all mainly north and east of American Falls. The deltaic sand and gravel, which marks an important event in the Pleistocene history, is named the Michaud Gravel. The type locality is in gravel pits on the south side of the Union Pacific Railroad at Michaud, Idaho, about 8 miles west of Pocatello. The Michaud is composed of sand and gravel that contains boulders as much as 8 feet in diameter at Pocatello, but the size diminishes rather abruptly westward to small cobbles at Michaud, and to a sand with a few small pebbles northeast of American Falls. The pebbles are mainly quartzite of Paleozoic age, but limestone and volcanic rocks are also present. The Michaud is about 5 to 50 feet thick.

Three terraces are distinguished between American Falls and Aberdeen (Pl. 1) (from oldest to youngest): the Grandview, Aberdeen, and Sterling terraces, named by Poulsen, Nelson, and Poulsen (1943, p. 5). The terraces are covered by 5 to 25 feet of light-colored alluvium of sand, silt, and clay, and, on the Sterling and Aberdeen terraces, local gravel. These deposits are delineated mainly by topographic position; the Grandview lies be-



SKETCH MAP OF THE AMERICAN FALLS REGION, IDAHO, SHOWING DISTRIBUTION OF LATE QUATERNARY ROCKS

tween altitudes of about 4430 and 4460 feet, the Aberdeen between 4390 and 4430 feet, and the Sterling between 4360 and 4390 feet.

The Aberdeen terrace is cut partly on Michaud Gravel and is therefore younger than the Michaud.

Latest Pleistocene and Recent deposits in the area consist of alluvium, dune sand, and talus. Most of the older alluvium is reworked from, and is lithologically indistinguishable from parts of the Michaud Gravel and Aberdeen terrace deposits. It is distributed from nearly present river level up to about 4460 feet in altitude, mainly southwest of American Falls. Sand dunes of Recent age occur in a large northeast-trending belt paralleling the Snake River along its north side. The dunes are locally active, and most trend northeasterly. Recent alluvium is restricted to a few gravel bars along the Snake River and some fine-grained sediments in the American Falls Reservoir area.

GEOLOGIC HISTORY

Deposition of the Raft Formation and Overlying Gravel

In middle or late Pleistocene time the Raft Formation was deposited, largely in a lake formed by damming of the river channel by basalt flows, possibly immediately west of the Raft River. Lake beds in the Raft require damming to an altitude of about 4400 feet. A persistent zone of marlstone occurs at an altitude or about 4280 feet and rises eastward to 4350 feet, representing a westerly dip of about 10 feet per mile. This dip may be due to regional tilting. On the margins of the depositional basin of the Raft Formation southwest of Rock Creek, local gravelly and sandy beds were laid down, generally above 4400 feet. A few beds of basaltic tuff and rhyolitic tuff in the Raft indicate that volcanic eruptions continued but were much less voluminous.

After deposition of the Raft Formation, through drainage was re-established, and a very gentle valley with its axis nearly in the present position of the Snake River formed in the Raft. Local base level was about 4320 feet, and the gradient of the ancestral Snake River was probably less than 1 foot per mile. Wells about 3 and 6 miles northwest of American Falls encountered the top of the Raft at about 4340 and 4350 feet, respectively, indicating a slope of about 5 feet per mile on the sides of the valley.

A mixture of rhyolitic and basaltic ash and a thin but widely persistent pebbly sand and gravel were deposited on this very gentle slope. Most of the pebbles are less than 1 inch in diameter, and many are from distant sources. It is difficult to explain the transportation of this gravel in such a gentle valley. Most of the pebbles could not come from the Deep Creek Mountains to the south, nor is any local older gravel known from which they could have been derived. A constriction of channel or considerable increase in volume and velocity of the river, seems to be probable. The Snake River Basalt, some of which probably was erupted about this time, could have reduced the width of the valley from about 5 to 1.5 miles in the American Falls area. This, however, would have been insufficient to account for the increase in velocity of the river, so we conclude that temporarily the Snake carried much more than normal volume. At least 80 per cent of the pebbles in this deposit are pink Brigham Quartzite of Cambrian age, which could have been derived only from the three major drainages at the east side of the area—Bannock Creek, the Portneuf River, and Ross Fork Creek. Very few basalt pebbles are present in the gravel. Presumably a substantial portion of the water responsible for moving this gravel came down these streams.

The gravel overlying the Raft Formation has yielded bones of birds, mammoths, horses, camels, bison, and other animals, as well as fresh-water clams and snails, and land snails. Skulls of the giant bison, *Bison* (*Gigantobison*) *latifrons* (Harlan), were described by Hopkins (1951, p. 192–197). These specimens came from the gravel below the American Falls Lake Beds and above the Raft Formation, at the east edge of the American Falls Reservoir. Hibbard (1955, p. 221) believes that *Bison latifrons* is no older than Illinoian age. However, Schultz and Frankforter (1946, p. 8) consider the giant bison to be Kansan and Yarmouth. From the same gravel at another locality we collected bones of mammoth or mastodon, genus indeterminable, *Equus* sp., *Camelops* sp., and *Bison* sp. These were identified by G. E. Lewis, C. B. Schultz, and L. G. Tanner (Written communication, 1958), who suggested an age between late Kansan and middle Illinoian and compared the association of mammoth, horse, and camel to a similar association in the Sappa Formation of Nebraska, of Yarmouth age (Schultz and Tanner, 1957, p. 64, 66, 70, 74). The Sappa is latest Kansan or early Yarmouth

(Condra and others, 1950, p. 22; Frye and others, 1948, p. 520).

D. W. Taylor believes that mollusks from the underlying Raft Formation are middle or probably late Pleistocene (Written communication, 1959). The following species from the Raft and the overlying gravel identified by Taylor, suggest a cool wet environment.

	Raft Formation	Gravel at base of American Falls Lake Beds
Fresh-water clams		
Sphaerium striatinum (Lamarck)	×	×
Pisidium compressum Prime	×	×
Fresh-water snails		
Valvata humeralis (Say)	×	×
V. utahensis Call	×	×
Lithoglyphus fuscus (Haldeman)	..	×
Stagnicola caperata (Say)	×	?
S. palustris (Müller)	..	×
S. traskii (Tryon)	×	..
S. sp. a	×	..
S. sp. b	×	..
Gyraulus circumstriatus (Tryon)	..	×
G. parvus (Say)	×	×
Carinifex newberryi (Lea)	..	×
Helisoma anceps (Menke)	..	×
Promenetus exacuous (Say)	..	×
P. umbilicatellus (Cockerell)	..	×
Ferissia indet.	..	×
Physa indet.	..	×
Land snails		
Pupilla muscorum (Linnaeus)	..	×
P. indet.	×	..
Vertigo gouldi (Binney)	..	×
Vallonia cyclophorella (Sterki)	×	×
cf. *Succinea*	×	×
Discus cronkhitei (Newcomb)	..	×
D. shimeki cockerelli Pilsbry	×	..
D. indet.	×	..
Retinella indet.	..	×
Hawaiia minuscula (Binney)	..	×
Zonitoides arboreus (Say)	..	×
Oreohelix strigosa depressa (Cockerell)	×	..

Most of the above mollusks also occur in the overlying American Falls Lake Beds, which Taylor (written communication, 1959) believes are late Pleistocene.

The gravel is almost certainly late Kansan or early Wisconsin. We believe that the increased stream velocity, indicated by the ability to move gravel on a very gentle slope, and the cool moist climate suggested by the fossils imply a glacial rather than an interglacial environment of deposition. When the age of *Bison latifrons* has been determined, the gravel can be dated with more confidence.

Damming of the Snake River and Deposition of the American Falls Lake Beds

After deposition of the gravel above the Raft Formation and extrusion of Snake River Basalt, eruptions from Cedar Butte and associated vents 11 miles southwest of American Falls filled at least 8 miles of the Snake River valley with basalt and dammed the river (Fig. 2). The Cedar Butte Basalt abutted the Snake River Basalt on the north and the Walcott Tuff and Massacre Volcanics on the south, forming a large dam. The upper surface of the dam sloped gently upstream from an altitude of more than 4450 feet near the vents to about 4370 feet at the upstream edge. Water was impounded in a lake that extended upstream about 40 miles nearly to Blackfoot. The maximum altitude of its surface was about 4450 feet, the approximate minimum altitude of the Cedar Butte Basalt dam at its northern and southern margins and the altitude of the base of the highest wave-cut scarp marginal to the American Falls lake. Overflow poured around the margins of the dam through two major spillways, one discharging in about the present position of Lake Channel, the other along the present Snake River channel.

The American Falls Lake Beds were deposited in this lake and accumulated to an altitude of about 4400 feet. On the west side of the lake they were deposited on the fringes of Snake River Basalt. Elsewhere they rested mainly on the Raft Formation and the gravel deposit. At first mostly fine sand and silt were deposited in the lake, except eastward from the mouth of Bannock Creek where Bannock Creek and the Portneuf River built deltas of crossbedded sand. Conditions then changed, and 5 to 15 feet of white, blocky, very diatomaceous clay was deposited throughout the lake basin. In the eastern end of the lake, the clay was laid down on an undulating surface cut by streams in the deltaic deposits.

Overflow of Lake Bonneville

When the American Falls lake had become two-thirds filled with sediments, glacial Lake Bonneville overflowed through Red Rock Gap about 50 miles southeast of Pocatello. The water descended northward by way of Marsh Creek and the Portneuf River valleys, entered the shallow American Falls lake near Pocatello, and deposited the Michaud Gravel on the lake beds. As waters entered the lake much of the tremendous energy of this flood abated, and huge well-rounded boulders as much as 8 feet in diameter were deposited at Pocatello. Pebbles and cobbles were carried some distance into the lake.

the site of a receding falls approximately along the present Snake River channel and was cut mainly along the southern margin of the Cedar Butte Basalt. As the heads of the two channels receded upstream, the altitude of the head of the southern channel became lower more

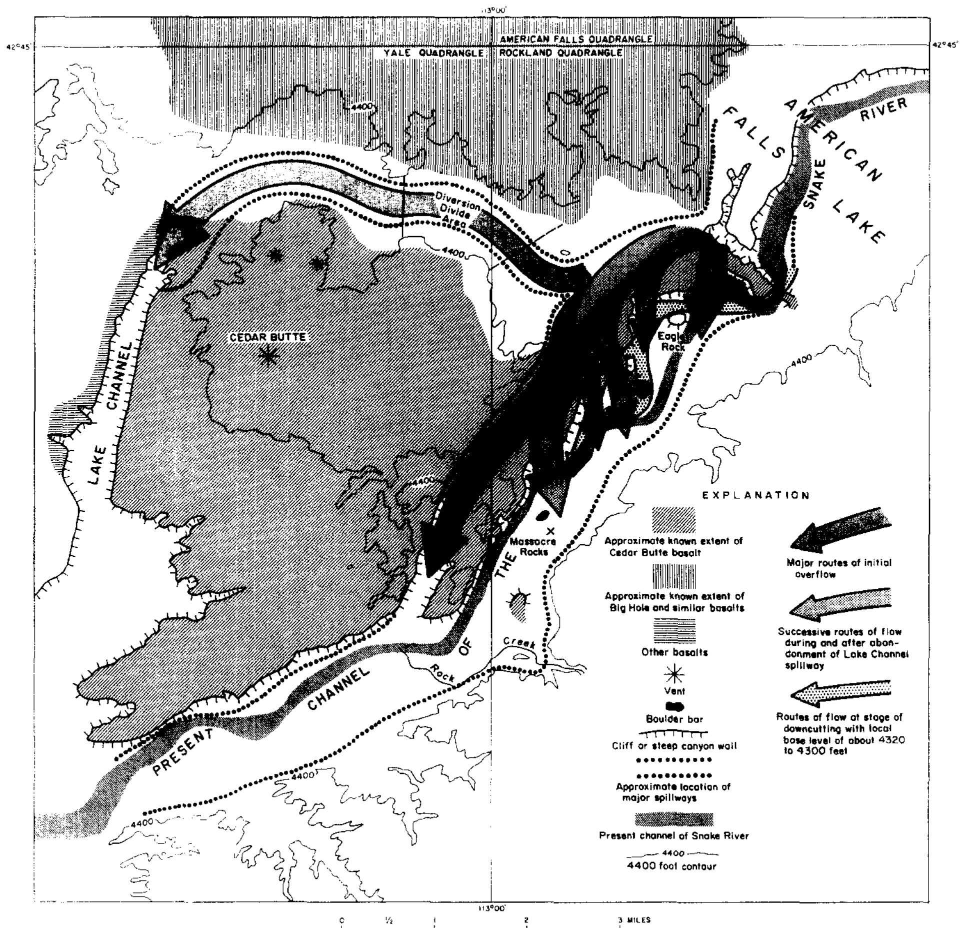


Figure 2. Map of area of spillover of American Falls lake showing Cedar Butte Basalt dam and routes of Lake Bonneville-Snake River flow

The tremendous volume of Lake Bonneville overflow added to the Snake River drainage, greatly increased the discharge from the American Falls lake, and accelerated the cutting of the two major spillways (Fig. 2) around the Cedar Butte Basalt dam. Headward cutting of the northern spillway resulted in a falls at the head of a basalt-rimmed canyon, now called Lake Channel. The southern spillway was also

rapidly than the northern stream could erode its course, so that, when the head of the southern channel fell to an altitude of about 4400 feet, all the water was diverted into the southern spillway.

Just before this diversion a persistent scarp was cut at an altitude of about 4420 feet on beds marginal to the American Falls Lake Beds and on the Michaud Gravel. This scarp marks the front of the Grandview terrace and the back of the Aberdeen terrace. Pebbles of Paleozoic rocks on the floor of the abandoned channel indicate fluvial conditions upstream. Sand and some gravel were deposited on the fore part of the present Aberdeen terrace. The lack of coarse material suggests cessation of initial outflow of Lake Bonneville at this time.

When the Lake Channel spillway was abandoned, the falls in the other channel was probably between Massacre Rocks and Eagle Rock (Fig. 2), about 2 or 3 miles downstream from the eastern margin of the Cedar Butte Basalt. Marginal spillways were successively cut and abandoned as the falls in the main channel receded upstream across a gradually lower surface of the Cedar Butte Basalt. The base level of cutting downstream from the falls was about 4320 feet or about 120 feet above present river level.

The fluvial Sterling terrace, with a back at an altitude of about 4380 feet, was cut at this time. It probably was graded temporarily to the Cedar Butte Basalt dam near its eastern margin, or possibly to the basalt at American Falls.

When the river finally breached the dam about a mile northeast of Eagle Rock, rapid downcutting occurred upstream in the soft sediments. Bars of huge, locally derived basalt boulders (mainly Cedar Butte Basalt), some as much as 20 feet in diameter, were built across the mouths of abandoned spillways between Eagle Rock and Massacre Rocks. Some of these bars may have been formed by water occupying the marginal spillway. Others, however, cannot be explained so simply, and their location suggests that they may have been emplaced in part because of the confinement of a large volume of overflow waters from Lake Bonneville to a narrower channel at and below the former dam with resulting increased velocity and competency of the stream.

Return of Normal Snake River Flow

Overflow of Lake Bonneville ceased, and in latest Pleistocene and Recent time the river lowered its channel about 100 feet in the Eagle Rock area. In upstream areas it has reworked downward the gravels that once belonged to the Michaud Gravel and Aberdeen terrace deposits. More recently, the river has deposited a little gravel as bars in the channel. Some of the reworked gravel, however, may be intermediate in age between the Aberdeen terrace deposits and Recent alluvium, possibly correlating with the Sterling terrace deposits upstream. One deposit of older alluvium is the gravel at the east end of the American Falls Dam, from which Gazin (1935) collected a large and varied vertebrate fauna from an undetermined part of the Pleistocene. This fauna includes musk ox, considered indicative of glacial periods; the deposit probably is Wisconsin.

Upstream in the American Falls Reservoir area, alluvium, now mostly inundated by the reservoir, was deposited in the valley. Currently active longitudinal sand dunes have developed along the northwest side of the valley. Construction of the American Falls Dam has resulted in accumulation of fine sediments in the reservoir.

CHRONOLOGY OF EVENTS IN RELATION TO SPILLOVER OF LAKE BONNEVILLE

Three features of the area that seem to require abnormally large volumes of water, probably from Lake Bonneville, are (1) large boulders in the Michaud Gravel at Pocatello; (2) the northern and southern channelways around the Cedar Butte Basalt dam, which apparently were occupied simultaneously; and (3) the boulder bars in the Snake River canyon.

The Michaud Gravel is older than 30,000 years, as indicated by a radiocarbon date of 29,700 ± 1000 years B.P. (Rubin and Alexander, 1960, sample W-731) for shells from the deposits of the Aberdeen terrace, which is younger than the Michaud Gravel.

The effects of Lake Bonneville spillover seen at American Falls are probably related to drainage changes in the Bear River studied by R. C. Bright. The age of shells from high shore-line deposits of a former lake near Thatcher, Idaho, has been determined as 32,500 ± 1000 years B.P. (Rubin and Alexander, 1960, sample W-704). This Thatcher Lake was formed by diversion of the Bear River, and the lake spilled into the Bonneville basin. Bright has suggested that this diversion of Bear River into the Bonneville basin may have caused overflow at Red Rock Pass (Rubin and Alexander, 1960). On the basis of the inferred history at American Falls the Michaud Gravel is not much older than the Aberdeen terrace, and could be the same age as the diversion of the Bear River.

Bright (written communication, 1961) has also recognized in the Thatcher area a shore line of the Bonneville stage of Lake Bonneville, which is much younger than the shore lines of the earlier Thatcher lake. The deposits of the older lake were excavated nearly to the level of the present valley floor before the Bonneville stage deposits were superimposed. This lowering of base level requires that a divide between Thatcher and Preston, Idaho, be cut down about 700 feet, mostly through quartzite. The Bonneville stage deposits in the Thatcher area have not yet been dated, but they are obviously much younger than the older Thatcher Lake. The Michaud Gravel, therefore, which probably is contemporaneous at least in part with the older lake, is considerably older than the Bonneville stage.

The channels around the Cedar Butte Basalt dam were almost certainly cut by water of the same stage of spillover that deposited the Michaud Gravel. The boulder bars, too, might possibly be attributed to this stage. It is conceivable, therefore, that all the features of this area that indicate a large volume of water were formed during a single episode of overflow of Lake Bonneville older than Bonneville stage.

The fineness of the Aberdeen and subsequent Sterling terrace deposits, however, suggests an abatement of the Lake Bonneville outflow before the Cedar Butte Basalt dam was breached. If the boulder bars were formed after breaching of the lava dam they probably were emplaced by outflow waters of the Bonneville stage of spillover. If, however, they were emplaced during an earlier spill, then no record of spillover waters of the Bonneville stage has been recognized in this area.

REFERENCES CITED

Bissell, H. J., 1952, Stratigraphy of Lake Bonneville and associated Quaternary deposits in Utah Valley (Abstract): Geol. Soc. America Bull., v. 63, p. 1358

Broecker, W. S., and Orr, P. C., 1958, Radiocarbon chronology of Lake Lahontan and Lake Bonneville: Geol. Soc. America Bull., v. 69, p. 1009–1032

Condra, G. E., Reed, E. C., and Gordon, E. D., 1950, Correlation of the Pleistocene deposits of Nebraska: Neb. Geol. Survey Bull. 15A, p. 22

Eardley, A. J., Gvosdetsky, Vasyl, and Marsell, R. E., 1957, Hydrology of Lake Bonneville and sediments and soils of its basin: Geol. Soc. America Bull., v. 68, p. 1141–1201

Feth, J. H., and Rubin, Meyer, 1957, Radiocarbon dating of wave-formed tufas from the Bonneville basin (Abstract): Geol. Soc. America Bull., v. 68, p. 1827

Frye, J. C., Swineford, Ada, and Leonard, A. B., 1948, Correlation, Pleistocene of Great Plains with glacial section: Jour. Geology, v. 56, p. 520

Gazin, C. L., 1935, Annotated list of Pleistocene mammalia from American Falls, Idaho: Washington Acad. Sci. Jour., v. 25, p. 297–307

Gilbert, G. K., 1890, Lake Bonneville: U. S. Geol. Survey Mon. 1, 438 p.

Hibbard, C. W., 1955, The Jinglebob interglacial (Sangamon?) fauna from Kansas and its climatic significance: Mich. Univ. Mus. Paleontology Contr., v. 12, no. 10, p. 221

Hopkins, Marie L., 1951, *Bison* (*Gigantobison*) *latifrons* and *Bison* (*Simobison*) *alleni* in southeastern Idaho: Jour. Mammalogy, v. 32, p. 192–197

Hunt, C. B., Varnes, H. D., and Thomas, H. E., 1953, Lake Bonneville: Geology of northern Utah Valley, Utah: U. S. Geol. Survey Prof. Paper 257-A, 99 p.

Malde, H. E., 1960, Evidence in the Snake River Plain, Idaho, of a catastrophic flood from Pleistocene Lake Bonneville: U. S. Geol. Survey Prof. Paper 400-B, p. 295–297

Mansfield, G. R., 1920, Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho: U. S. Geol. Survey Bull. 713, 152 p.

—— 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152, 409 p.

Marsell, R. E., and Jones, D. J., 1955, Pleistocene history of lower Jordan Valley, Utah: Utah Geol. Soc. Guidebook to Geology of Utah, no. 10, p. 113–120

Poulsen, E. N., Nelson, L. B., and Poulsen, A. E., 1943, Soil Survey of the Blackfoot-Aberdeen area, Idaho: U. S. Dept. Agriculture Bur. of Plant Industry, ser. 1937, no. 6, 111 p.

Richmond, G. M., Morrison, R. B., and Bissell, H. J., 1952, Correlation of the late Quaternary deposits of the La Sal Mountains, Utah, and of Lakes Bonneville and Lahontan by means of interglacial soils (Abstract): Geol. Soc. America Bull., v. 63, p. 1368–1369

Ross, C. P., and Forrester, J. D., 1947, Geologic map of the State of Idaho: U. S. Geol. Survey

Rubin, Meyer, and Alexander, Corrinne, 1960, U. S. Geological Survey radiocarbon dates, V: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 129–185

Russell, I. C., 1902, Geology and water resources of the Snake River Plains of Idaho: U. S. Geol. Survey Bull. 199, 192 p.

Schultz, C. B., and Frankforter, W. D., 1946, The geologic history of the bison in the Great Plains (a preliminary report): Neb. Univ. State Mus. Bull. (Contr. Div. Paleont.), v. 3, no. 1, p. 1–10

Schultz, C. B., and Tanner, L. G., 1957, Medial Pleistocene fossil vertebrate localities in Nebraska: Neb. Univ. State Mus. Bull., v. 4, no. 4, p. 59–81

Stearns, H. T., and Isotoff, Andrei, 1956, Stratigraphic sequence in the Eagle Rock volcanic area near American Falls, Idaho: Geol. Soc. America Bull., v. 67, p. 19–34

Stearns, H. T., Crandall, Lynn, and Steward, W. D., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho: U. S. Geol. Survey Water-Supply Paper 774, 268 p.

Williams, J. S., 1952, Red Rock Pass, outlet of Lake Bonneville (Abstract): Geol. Soc. America Bull., v. 63, p. 1375

Manuscript Received by the Secretary of the Society, November 25, 1960
Publication Authorized by the Director, U. S. Geological Survey