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Glacial Terraces along the Snake River in Eastern Idaho and in Wyoming

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THIS PAPER describes the river terraces that are prominent features in Swan Valley, Idaho, and were in Grand Valley before it was submerged by the Palisades Reservoir. The terraces reveal several stages in the excavation of the valley floors in the later part of Pleistocene time.

The ages of the terraces can be determined because they can be traced up the Snake River into Jackson Hole, Wyoming, and related to the glacial events there, which in turn have been correlated with the standard glacial sequence elsewhere in the Rocky Mountains. The ages of the terraces have more than geologic interest, for they bear on the time of development of the thick loess soils of southeastern Idaho, and also can help to date archaeological findings in the region. The highest terrace is probably earlier than man's arrival in North America, but man was present when the lower and younger terraces were formed.

The Terrace System

The profiles of the terraces that can be distinguished along the upper Snake River (Figure 1) are shown on Figure 2. The terraces have not been traced below Swan Valley, where they become obscure in the narrow canyon the Snake River has cut across a plateau underlain by volcanic rocks.

The long profile of the Snake River, used as a base of reference, was plotted from 5-foot contours of a river survey from Pine Creek, Idaho, to Horse Creek, Wyoming, in the southern part of Jackson Hole. Contours from topographic sheets were used to extend the river profile northward through Jackson Hole to Jackson Lake. Distances along the river are in miles from Pine Creek.

Elevations of terraces less than about 50 feet above river level were measured by hand levelling. Elevations of higher terraces were measured by aneroid barometer, with occasional checks by levelling. All measure

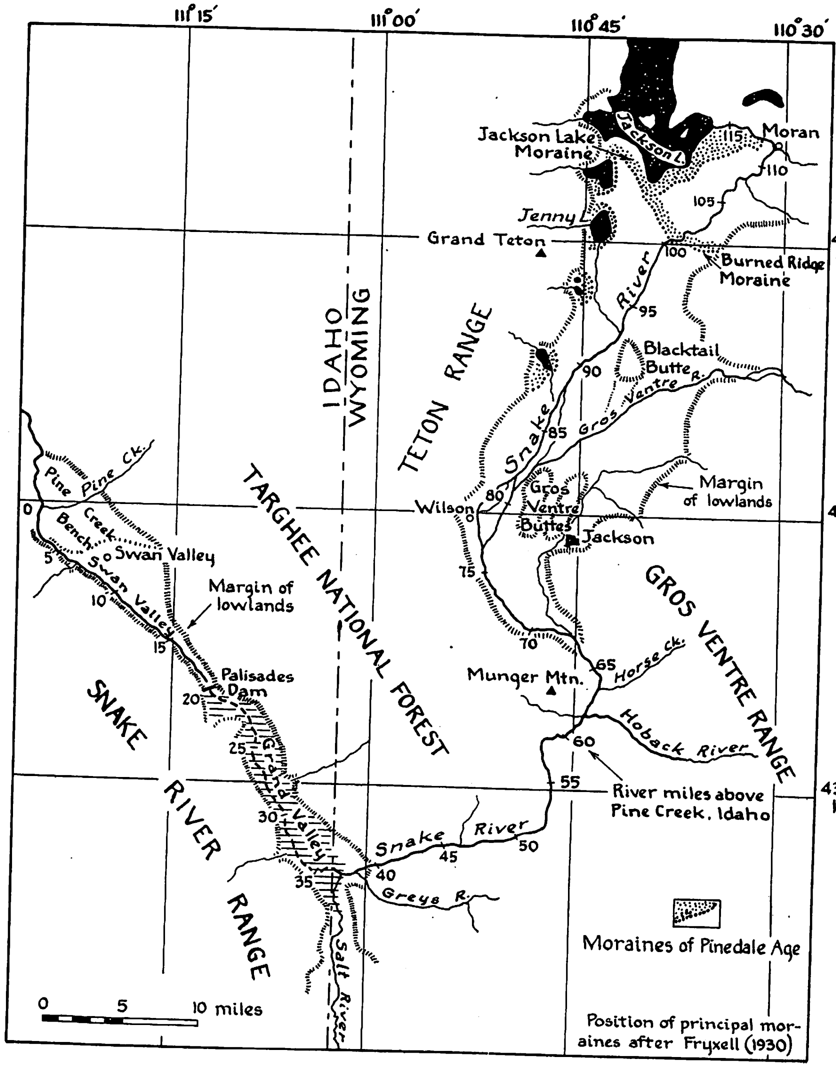

Figure 1. Map of the upper Snake River, Idaho-Wyoming.

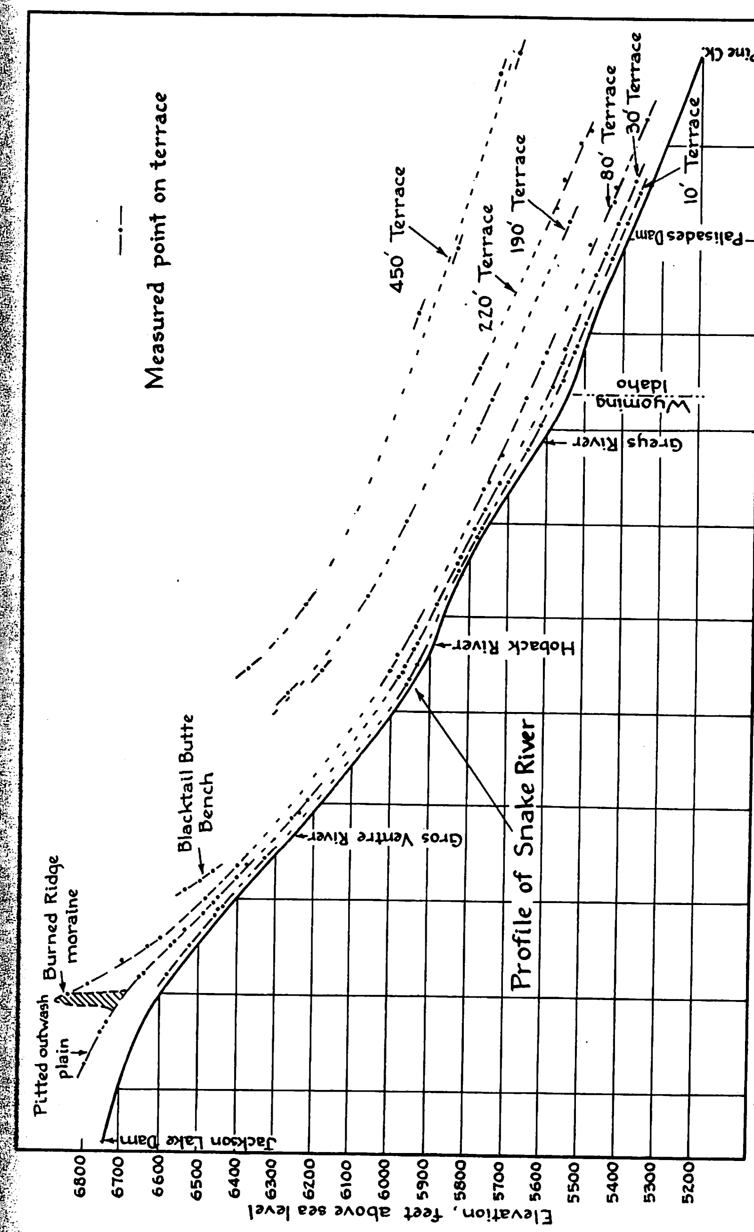

Figure 2. Profiles of glacial terraces along the upper Snake River, Idaho-Wyoming.

ments were made from the level of the river in the late summer of 1949. Stream level fluctuates very little during summer when the flow of the river is controlled at the dam at Jackson Lake.

The terraces are referred to by their approximate elevation above the Snake River at the Idaho-Wyoming border, rather than by names which might imply correlation with a sequence of glacial events that is still subject to controversy. Probable correlations with the glacial sequence in Jackson Hole and other parts of the Rocky Mountains are discussed after the terraces have been described.

450-Foot Terrace

The remnants of the highest terrace found in the Grand Valley and the upper parts of the Swan Valley are a few small benches underlain by cobbly gravel. The gravel is usually seen as float on slopes below the benches rather than in outcrops, because a heavy mantle of loess and colluvium covers the benches.

A profile drawn through the few available points suggests a terrace of gentler gradient than that of the Snake River at present. The profile rises from 450 feet above river level at the head of Grand Valley to about 500 feet above river level at the northern end of Swan Valley. Perhaps this old surface was graded to the Pine Creek Bench, which is the remnant of a pediment at the northern end of Swan Valley. The pediment was eroded across a valley-filling assemblage of volcanics and sediments of Tertiary age. Tens of feet of loess mantle the Pine Creek Bench and generally obscure the relations, but the bedrock surface, overlain by some gravel, appears to be about 500 feet above river level.

No traces of this high terrace were found along the Snake River canyon above Grand Valley. A small gravel bench about 365 feet above river level occurs at mile 60, in a wide part of the valley upriver from the canyon and south of Jackson Hole. The profile has been extended through this point, though such a correlation is of course weak.

The considerable age of this terrace is shown by the high elevation above river level, by the few and scanty remnants, and by the weathered condition of the cobbles and boulders. Cobbles of granitic rocks are oxidized and crumbly and the quartzites somewhat roughened.

220-Foot Terrace

Many well-preserved remnants of a terrace about 220 feet above the Snake River occur along the margins of the Swan and Grand Valleys. The cobbly gravels are several tens of feet thick in most exposures and testify to a good deal of alluvial filling of the valley. The cobbles and boulders are up to a foot in diameter and composed of the common rocks of the drainage, such as sandstone, quartzite, limestone, and granitic types. The limestones are corroded and pitted and the granitic rocks somewhat oxidized.

This terrace bears a cover of 10 or more feet of loess. A pine forest thrives on the thick loess soil, whereas only grass and sagebrush grow on the almost bare gravel of much younger terraces.

No traces of this terrace were found through the Snake River Canyon. Above the canyon, at mile 58, there is a prominent bench formed by a remnant of the terrace that has been preserved downriver from a large rock spur. This bench is a mile long and a third of a mile wide, big enough to be dry-farmed. The upper surface of the gravel is here about 215 feet above river level. About 35 feet of loess and silty overwash from the walls of the valley lie on the gravel so that the top of the bench is about 250 feet above river level.

The profile of this terrace has been prolonged upriver (Figure 2) through several prominent benches in the southernmost part of Jackson Hole, between river miles 65 and 70. These benches are morainal forms rather than true alluvial terraces, formed near an ice terminus at which the terrace probably headed.

190-Foot Terrace

In Grand Valley and the lower part of the Snake River Canyon there are a few small gravel-capped benches at heights of about 190 feet above river level. As much as 3 feet of loess covers the gravel. Only one or two points below Grand Valley could be assigned to a terrace at this height. No traces of the terrace were found more than a mile above the junction of Greys River and the Snake River. The weak expression of this terrace suggests a minor episode of alluviation and valley widening.

Blacktail Butte Bench

A prominent bench formed by alluvial gravel extends southward of Blacktail Butte in Jackson Hole for about 2 miles. Several to many feet of loess cover the gravel. No traces of a correlative surface have been identified elsewhere. This patch of outwash gravel provides evidence for an episode of alluviation somewhat later than those in which the gravels of the 190-foot and 220-foot terraces were spread, yet considerably older than those in which the gravels of the prominent younger terraces were spread.

80-Foot Terrace

An alluvial terrace about 80 feet above the Snake River forms a large part of the floor of Swan Valley and the submerged floor of Grand Valley. This terrace is a young topographic form. Channels and bars showing relief up to 7 feet appear plainly because no more than a foot of loess occurs upon the gravel in most places. The edge of this terrace above the next lower terrace seems almost as fresh as when the river first trimmed it; there are very few gullies because little runoff occurs on the surface of the permeable gravel.

The gravel of this terrace is notably coarse and contains boulders as much as 2 feet long. Little weathering has occurred, except that the granitic rocks have lost the polish they received during stream transportation.

The terrace is easy to trace up the canyon of the Snake River. In some places the elevation of the top of the terrace gravel is hard to fix because of overlying alluvial-fan gravel.

The terrace is wide enough to provide much agricultural land, even in the southern part of Jackson Hole. It is largely eroded away through a distance of about 15 miles in the central and widest part of Jackson Hole.

Near Blacktail Butte the terrace becomes prominent and begins to rise higher above river level. The terrace ends against the outer edge of the Burned Ridge moraine at a height of 220 feet above the river. Clearly the terrace represents the gravel outwash from the ice front that formed the Burned Ridge moraine.

30-Foot Terrace

The terrace about 30 feet above the level of the Snake River at the Idaho-Wyoming border is much narrower than the 80-foot terrace but can be traced easily through Swan and Grand Valleys, the Snake River Canyon, and to the northern end of Jackson Hole.

The gravel of the 30-foot terrace resembles that of the 80-foot terrace. However, the loess on the 30-foot terrace in most places is so thin that it does not hide the cobbles and boulders.

This terrace begins to increase in height above the level of the Snake River a few miles south of the Burned Ridge moraine. Gaining elevation steadily, it crosses the moraine through the gap the Snake River has cut. The terrace reaches a maximum height of about 110 feet where it merges with a pitted outwash plain south of the Jackson Lake moraine that encloses the southern end of Jackson Lake. The 30-foot terrace can also be traced to the outer margins of the piedmont moraines on the east side of the Teton Range, for example the horseshoe moraine that encloses Jenny Lake.

10-Foot Terrace

A terrace at most places 8-12 feet above river level occurs persistentl along the Snake River. This is a graded alluvial surface indicating a forme stream profile distinctly above the present one. For example, the profil of the terrace is smoother through the Snake River canyon than the profil of the river, which is marked by rapids and steps where the river is cuttin down across resistant strata. This youngest terrace has not been relate to any glacial moraine in Jackson Hole. Nevertheless it probably originate during some late-glacial episode which caused streams to become heavil loaded.

Terraces and Glacial Chronolog

The deep terraced valleys of this region reveal a long history of dowr cutting, interrupted by episodes when streams spread alluvium and raise their beds. The downcutting reflects the great uplifts of Pleistocene time The sheets of gravel that form the 80- and 30-foot terraces are valley train built out from ice fronts marked by prominent moraines, and the othe gravel terraces probably originated in the same way.

In this study an attempt has been made to relate the terraces to th glacial sequence that Fryxell (1930) described for Jackson Hole. Fryxel recognized deposits of the Pinedale, Bull Lake, and Buffalo glaciations tha Blackwelder (1915) had originally named from his regional studies. Thi sequence remains the standard for the northern Rocky Mountains, althoug somewhat modified due to later studies.

The 450-foot terrace appears to be earlier than the Bull Lake glaciatior It is so much higher than the 220-foot terrace, which is believed to be c Bull Lake age, that it cannot even be referred to the first of the two advance or stades of the Bull Lake glaciation that have been revealed by the studie of Moss (1951) in the Wind River Mountains and Williams (1961) i Stanley Basin east of the Sawtooth Mountains of Idaho. The 450-foc terrace should be referred to pre-Bull Lake time rather than to the Buffal glaciation, because it is now recognized as an oversimplification to refer al pre-Bull Lake glacial deposits to a Buffalo stage. For example, Richmon (1962) has found evidence of three pre-Bull Lake tills in the Wind Rive Mountains in Wyoming.

The 450-foot terrace is to be considered pre-Wisconsin in age, becaus the Bull Lake glaciation is believed to be of early Wisconsin age. Perhap the terrace and the glacial advance it represents may be correlative with th Illinoian glaciation of the classic sequence in the east-central United State

The 220-foot terrace is considered to be of Bull Lake age. Ice of Bu

Lake age advanced to the southern end of Jackson Hole, where the remnants of Bull Lake moraines form benches on both sides of the Snake River. Till with associated sand and gravel forms benches 240 feet above river level on the east side of the river. A bench with rolling morainic topography about 350 feet above river level fringes the northeastern side of Munger Mountain, west of the river, and lower morainic benches occur farther north. Bull Lake moraine in this region bears a cover of loess many feet thick; this characteristically thick loess serves to distinguish topographic forms of Bull Lake age from those of Pinedale age which rarely have more than a foot of loess upon them.

The weakly developed terrace at a height of 190 feet and the Blacktail Butte Bench are referred to the Bull Lake glaciation because of the thick cover of loess upon them, and also because of their height above terraces of Pinedale age. The Blacktail Butte bench signifies a readvance late in the stage, because it is so far north of the southern limits of Bull Lake ice.

The Bull Lake glaciation is now correlated with the early advances of ice of the Wisconsin stage in the midcontinent, which Flint (1957) believes to have occurred 20,000 to 30,000 years before the present. No reliable dates in years for Bull Lake deposits in this area have yet been obtained. Material from a silt 500 feet above drainage level in the northern part of Jackson Hole gave a radiocarbon date of 27,000 ± 800 years (Love and de la Montagne, 1956: 176); perhaps the silt was deposited near the margins of the Bull Lake ice, but the relations are not definitely known.

The 80-foot and the 30-foot terraces are believed to be of Pinedale age and correlative with the two Pinedale stades that Moss (1951) distinguished in the Wind River Mountains, from evidence of moraines and associated terraces.

The interpretation just offered conflicts with that of Fryxell (1930), who believed that the Burned Ridge moraine and the terrace that stems from it are of Bull Lake age. Here the question arises: is the 80-foot terrace sufficiently older than the 30-foot terrace—of unquestioned Pinedale age—to be assigned to the previous, Bull Lake stage? As stated previously, the 80-foot terrace and the Burned Ridge moraine lack certain features that generally typify topographic forms of Bull Lake age. The moraine of undisputed Bull Lake age in the central and southern parts of Jackson Hole is smoothed by mass wasting and has many feet of covering loess. The Burned Ridge moraine bears scarcely any loess and is very young-looking topographically, for example the ice-contact face on the inner side of the moraine seems almost as steep and sharp as when formed.

A feature of late Pinedale age such as the 30-foot terrace probably is at least 9,000 years old. Gastropod shells from marly deposits in depressions on the Jackson Lake moraine—at which the 30-foot terrace heads—gave a radiocarbon date of 8,800 ± 250 years and 9,580 ± 250 years (Love and de la Montagne, 1956: 172). The 80-foot or Pinedale 1 terrace is probably not more than a few thousand years older, for it is almost as fresh-looking as the 30-foot terrace and has less than a foot of loess upon it.

The 10-foot terrace appears to be considerably younger than the Pinedale glaciation. Probably it correlates with the Temple Lake glaciation that Moss (1951) recognized in the Wind River Mountains. Climate warmed up after the Pinedale glaciation and glaciers disappeared from the Rocky Mountains in the postglacial optimum or Hypsithermal between 7,500 and 4,000 years before the present. Later, glaciers were reborn in the higher parts of the mountains due to cooling in the Little Ice Age of Matthes (1942), or Neoglacial. Two advances in Neoglacial time are recognized. The first is the Temple Lake glaciation, shown by moraines that are at fairly high elevations but normally bear some vegetation. The second is a minor advance in historic time, shown by bare morainic debris generally within the glacial cirques. The 10-foot terrace is somewhat less than 4,000 years old if related to the Temple Lake glaciation. The latest or historical advance was a relatively slight one, and stream regimens were not sufficiently changed to produce a stream terrace.

Summary

Alluvial terraces in the Swan and Grand Valleys of eastern Idaho have been dated by tracing them up the Snake River and relating them with glacial features of known age in Jackson Hole, Wyoming.

The highest terrace recognized is about 450 feet above the level of the Snake River at the Idaho-Wyoming border. It is older than the Bull Lake stage of glaciation and therefore of pre-Wisconsin age.

A terrace about 220 feet above the Snake River heads at the southern end of Jackson Hole. It apparently dates from the Bull Lake glaciation, which is considered to be of early Wisconsin age. A weakly developed terrace 190 feet above river level and a large patch of outwash gravel south of Blacktail Butte in Jackson Hole record two minor advances of ice later in Bull Lake time. The alluvial surfaces of Bull Lake age have a capping of many feet of loess.

The two terraces which are about 80 and 30 feet above the Snake River at the Idaho-Wyoming border begin at young moraines in the northern part

of Jackson Hole. The moraines and terraces represent two advances of ice during the Pinedale glaciation of late Wisconsin age. They may date from the interval 11,000 to 9,000 years before the present. Less than a foot of loess occurs on surfaces of Pinedale age.

A terrace 8-12 feet above river level probably correlates with the minor Temple Lake glaciation which occurred after the postglacial optimum of climate, less than 4,000 years before the present.

Alluvial surfaces with several to many feet of loess upon them in this region are of Bull Lake (early Wisconsin) age, or older. Surfaces with a few inches to a foot of loess will generally be of Pinedale (late Wisconsin) age.

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The Toxicity of Beta vulgaris Fruits as an Inhibitor of Germination of Grass Fruits and as an Autotoxin

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Although the presence of germination-inhibiting substance(s) in the fruits of *Beta vulgaris* (sugar beet) has been recognized for about 20 years, the ecological significance of the inhibitor is not resolved. This study is an attempt to assess the importance of the toxin as an autotoxin in the germination of sugar beet, and as an inhibitor of germination of several grass species, *Agropyron cristatum, Agropyron dasystachyum, Agropyron spicatum, Alopecurus arundinaceus, Festuca arundinacea, Poa bulbosa,* and *Triticum aestivum.* The supervision of this study by Dr. R. Daubenmire of Washington State University is gratefully acknowledged.

Fröschel (1939a, 1939b, 1940) with aqueous extracts of sugar beet fruits demonstrated inhibition of germination in 28 species belonging to 14 families. In greenhouse studies, it was shown that *Melandrium* and rye did not develop when planted with sugar beet in soil (Fröschel and Funke, 1941).

The toxic material has been variously ascribed to ammonia (Stout and Tolman, 1941a and 1941b; Rehm, 1953), excessively high osmotic pressure due to inorganic salts (Duym *et al.,* 1947; Rehm, 1953), unsaturated yellow oil (DeKock *et al.,* 1953), organic acids (Massart, 1957), soluble oxalates (Duym *et al.,* 1947; Miyamoto, 1957), and to unidentified volatile substances (Duym *et al.,* 1947; Fröschel, 1955). Copper, zinc, and lead, as well as gums and tannins, are not present in quantities large enough for an appreciable degree of toxicity (Stout and Tolman, 1941b); auxins are probably not involved (Duym *et al.,* 1947).

Light promotes inhibition (Duym *et al.,* 1947; Evenari, 1949; Fröschel, 1940), but high temperatures (Duym *et al.,* 1947; Stout and Tolman, 1941b) and high pH (Stout and Tolman 1941b) have no effect.

Tolman and Stout (1940) have suggested that the soil adsorbs the toxic material, which is in harmony with their results that germination is more rapid in soil than on filter paper. After filtration of sugar beet fruit extract