# VARVED LAKE BEDS IN NORTHERN IDAHO AND NORTHEASTERN WASHINGTON

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*Abstract.*—Thick deposits of fine-grained sediment underlie the floors of the Purcell Trench, the Pend Oreille Valley and adjacent lowlands, and the Priest River valley in northern Idaho and northeastern Washington. The deposits formed in a late glacial lake while ice blocked the north-flowing stretch of the Pend Oreille River. Sheets of clay, distinctly varved in places, are interbedded with sheets of sand and silt. The sheets of sand and silt are interpreted as drainage varves that were deposited when the lake burst out past the ice dam at about 12- to 65-year intervals. The sheets of sand in the lowlands underlain by lake deposits provide small, but in most places adequate, water supplies for domestic and stock needs.

The principal lowlands of northern Idaho—the Pend Oreille Valley, the Purcell Trench, and the adjoining valleys (fig. 1)—are underlain by thick deposits of clay, silt, and fine-grained sand. The sediments accumulated in a lake that existed in late glacial time when ice dammed the stretch of the Pend Oreille Valley that extends northward into Canada.

## GLACIAL LAKE IN WHICH VARVED BEDS WERE DEPOSITED

The lake had a maximum shoreline altitude of a little less than 2,500 feet above sea level, as shown by patches of lake deposits on the margins of the lowlands. The lake overflowed southward through a col south of Newport, Wash., and also, at times, southward past Athol, Idaho, to the Rathdrum Prairie.

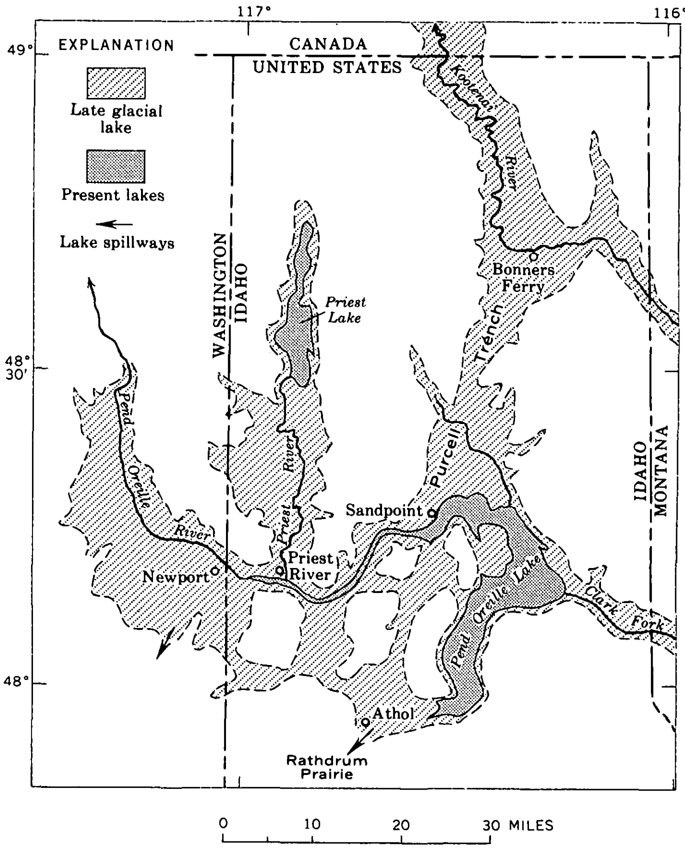


FIGURE 1.—Map showing extent of late glacial lake in the Pend Oreille and Priest River valleys and the Purcell Trench in northern Idaho and northeastern Washington.

This late glacial lake in the Purcell Trench and the Pend Oreille lowlands should not be confused with Lake Missoula, which was impounded in the Clark Fork drainage when ice several thousand feet thick occupied the Purcell Trench and extended at least to the southern end of Lake Pend Oreille. According to Alden (1953), Lake Missoula had a maximum water-level elevation of about 4,200 feet behind the ice dam in the gorge of Clark Fork and drained southward across the Rathdrum Prairie when the ice in the Purcell Trench thinned. The late glacial lake, which succeeded and was considerably smaller than Lake Missoula, disappeared when ice melted from the stretch of the Pend Oreille Valley that extends northward into Canada.

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## DESCRIPTION AND GEOLOGIC SIGNIFICANCE OF THE VARVED LAKE BEDS

### Purcell Trench and Pend Oreille Valley

Thick lake deposits occupy the Purcell Trench and associated valleys. The trench was deepened by ice that was several thousand feet thick and covered all but the higher parts of the bordering mountains, which rise almost 5,000 feet above the present valley floors. Below part of Pend Oreille Lake the bedrock is at least 1,140 feet (the depth of the lake at its deepest known place) below the present lake level. This suggests that the sediment thickness in this part of the Purcell Trench may be about 1,000 feet. Wells drilled many years ago in unsuccessful attempts to obtain ground-water supplies at Sandpoint, Idaho, are reported to have penetrated lake deposits only to depths of nearly a thousand feet, and a recent unsuccessful water well, 11 miles north of Sandpoint, was finished in silt and clay at 330 feet (Walker, 1964). Although the lake deposits are thinner in the Pend Oreille Valley, a well near the town of Priest River penetrated 317 feet of silt, clay, and fine-grained sand before being completed in a thin bed of water-bearing gravel.

Exposures in most of the lowlands show that the lake deposits consist of alternating beds of yellow to blue clay, tan silt, and fine-grained sand. Bedding planes are indistinct, and material in the beds is poorly sorted. The beds of sand may be several feet thick and occur at intervals of from 10 to 20 feet. Beds of clay and sand tend to be silty, and beds of silt contain a good deal of clay.

### Priest River valley

In the Priest River valley, however, the lake sediments consist of varved clay and beds of well-sorted silt and sand. Figure 2 shows a section of these beds along the highway about 3 miles north of the town of Priest River. A few minutes' work with a shovel exposes excellent glacial varves (fig. 3). Presumably, well-sorted deposits were formed at this location because the narrow arm of the lake in the Priest River valley was less disturbed by waves and currents than the wider parts of the lake in the Pend Oreille Valley and the Purcell Trench.

*Description of a representative section.*—The lake deposits of the Priest River valley are illustrated by a 28½-foot section (fig. 4) measured about 3 miles north of the town of Priest River.

Only 18 percent of this section is sand (table 1). That the rest is silt and clay shows that deposition occurred in relatively quiet water.

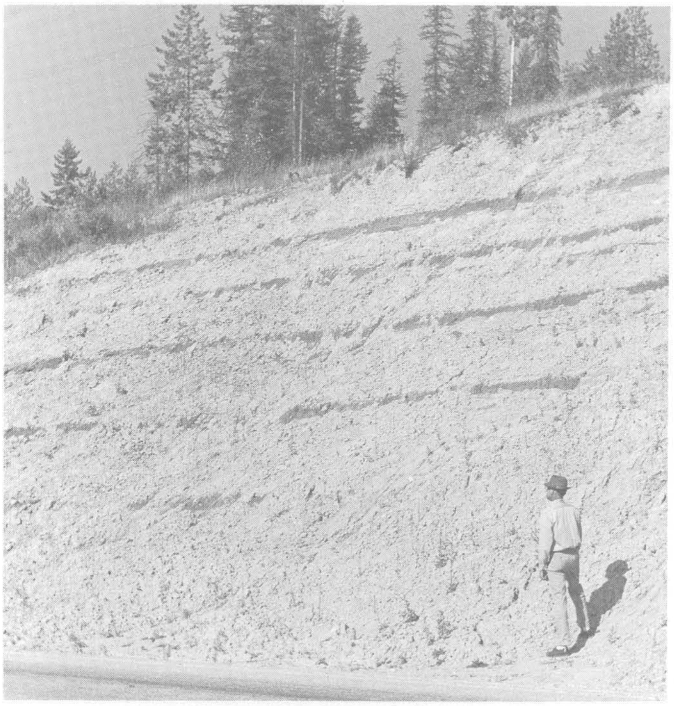

FIGURE 2.—Glacial-lake beds in the Priest River valley, 3 miles north of the town of Priest River, Idaho. The dark layers are wet beds of sand and the light layers are mainly varved clay coated with dry overwash.

FIGURE 3.—Typical varved clay in the southern part of the Priest River valley. About 14 years of deposits are represented in the photograph.

The varved clay indicates that the lake was ice covered in winter and open during part of the summer and was fed by melt water from an ice front. Also, the varved clay indicates a stable lake level, because currents produced by changing lake levels would interfere with the delicate sorting process necessary for the formation of varves.

At three places in the section, a foot or more of varves is so deformed by wrinkling that the varves cannot be counted or measured accurately. The deformation is more likely due to minor earth movements after the Priest River intrenched the deposits than to overriding by ice, for which there is no evidence. The varves are saturated with water and provide gliding planes for motion toward the center of the valley.

The varved clay accumulated at an average rate of a foot in about 16 years. The varves range in thickness from 0.3 to 3.1 inches and average about 0.8 inch, and they are slightly thinner toward the top of the section. Upward thinning of the varves can most logically be interpreted as indicating increasing distance to the local source of sediment—the ice front, which was shrinking northward in the Priest River valley.

The unvarved clay provides no clues as to the rate of deposition. Possibly it was deposited during periods when the ice cover was continuous from year to year and the only water entering the lake was from the base of the glacier. Such inflow would have carried in suspension the clay-sized products of glacial grinding. Many other glacial lakes contain some clay that lacks evidence of varving.

The beds of silt, generally less than a foot thick, are tan or light brown, and show thin laminations. They indicate currents strong enough to drift clay-sized particles elsewhere but too weak to move sand by traction.

The beds of sand range in thickness from 0.3 to 2 feet. The grains are mostly finer than 0.3 mm and are well sorted. Except for one thin bed that is cross-bedded, all the beds show thin horizontal laminae. The characteristics of the sand beds suggest sheetlike movement of water at velocities just strong enough to move small grains of sand.

*Repetition of clay-sand-silt-clay sequence in the representative section.*—A principal feature of the 28.5-foot section is the repetition, 4 times, of the following sequence: varved clay, a bed of sand, a bed of silt, then varved clay. The 4 distinct sand-silt couplets occupy about 7.5 feet of the 28.5-foot section.

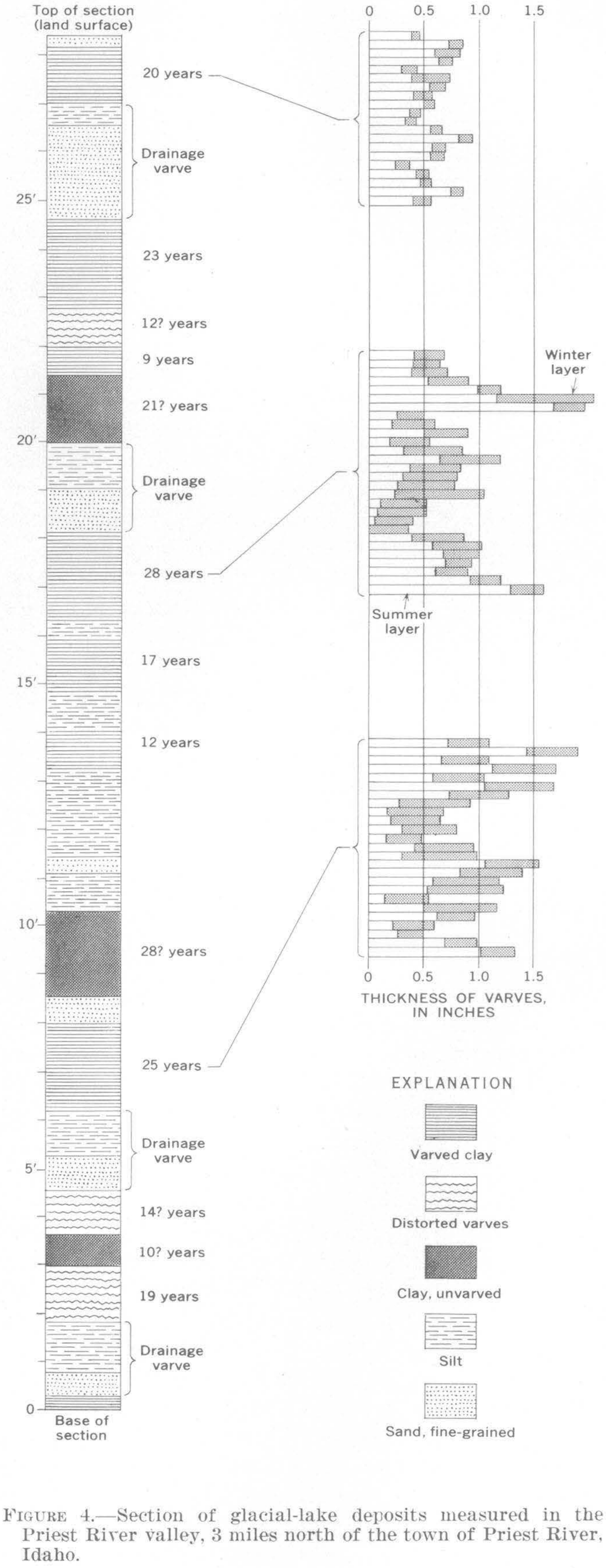


FIGURE 4.—Section of glacial-lake deposits measured in the Priest River valley, 3 miles north of the town of Priest River, Idaho.

TABLE 1.—*Summary of types of material found in representative section of lake deposits in the Priest River valley*

| Type of material | Total thickness (feet) | Percentage of section |
|---|---|---|
| Clay, varved | 12.4 | 43 |
| Clay, unvarved | 3.8 | 13 |
| Silt | 7.3 | 26 |
| Sand, fine-grained | 5.0 | 18 |
| Total | 28.5 | 100 |

The abrupt changes from varved clay to sand indicate the sudden development of currents strong enough to spread layers of sand where previously only silt and clay had been settling from still or very slowly moving water. The silt upon the sand shows a slackening of current. The varved clay upon the silt shows the reestablishment of still water in the lake. The most probable cause for such a sequence is that a gush of water suddenly escaped from the lake, thereby setting up currents throughout the lake, and that later, still water was reestablished. This train of events would have resulted from retreats and readvances of the ice that dammed the Pend Oreille Valley.

Probably the late glacial lake was dammed at this time by piedmont glaciers descending from the mountains on both sides of the stretch of the Pend Oreille Valley that runs northward into Canada, and not by a massive valley-filling lobe. Slight recession of whichever piedmont glacier dammed the lake would allow water to spill, and the ensuing flood would quickly widen the breach, as has happened, for example, during many historic outbreaks past ice dams in Iceland. The lake level then would stabilize against the next large mass of ice down the valley, and later it might rise to its original level if the upvalley tongue of ice advanced again.

The currents produced by release of large volumes of water would spread a sheet of sand over the floor of the lake. Then, after overflow ceased and currents died down the fine-grained material that had been stirred into suspension would settle out to form a bed of silt. Finally, varved clay would again accumulate.

According to this interpretation each sand-silt sequence constitutes a single varve. That outbursts of glacial lakes past ice dams and reestablishment of still water occur within single years is shown by historical records of outbursts of glacial lakes in the Alps, Himalayas, and Iceland. For example, the Mattmarksee in the Swiss Alps has broken out over its ice dam in 26 years since 1859 (Charlesworth, 1957, p. 453). In the Baltic area, unusually thick varves of coarse-textured materials have long been recognized as indicators of sudden drainage of glacial lakes. The thickness of the drainage varves in the Priest River valley, 1.5 to 2.4 feet (fig. 4), is not excessive; Pettijohn (1949, p. 468) states that megavarves may be several feet thick.

The section (fig. 4) also shows that at times the deposition of varved clay was interrupted and layers of silt a few inches to a foot thick were spread on the floor of the lake. Presumably such beds of silt indicate minor outbreaks that did not set up currents strong enough to spread a sheet of sand. If so, such beds of silt each represent a year.

The number of years between some of the outbursts can be determined by counting varves. The number of years between other outbursts may be estimated by assuming that varves which are too distorted to count accurately and unvarved clay accumulated at the same rate as the clay with countable varves. The results of such counting and estimates give the following chronology:

Drainage
  20 years
Drainage
  65? years, 44 years of varved clay, clay representing 21? years
Drainage
  28 years
Drainage, minor
  17 years
Drainage, minor
  12 years
Drainage
  28? years, clay
Drainage, minor
  25 years
Drainage
  43? years, 33 years of varved clay, clay representing 10? years
Drainage
  Varved clay, base of section

The intervals so determined and estimated between drainages range from 12 to about 65 years and average about 20 years. Presumably the drainages occurred in years of warmer-than-average weather, which caused glaciers to shrink.

### Weather and climate as indicated by the varved beds

Some fluctuations in weather are recorded in the varves. In general, varves thicker than average indicate warmer years when the ice-free season lasted longer and the lake received more melt water and sediment than usual. Also, winter layers will be comparatively thin compared to summer layers in years when the ice cover persisted a relatively short time. Plots of three sections of undeformed varves (fig. 4) show that the thicknesses of varves increase and decrease through irregular intervals. Although the lower two sections show a slight tendency for the proportions of summer-deposited sediment to increase toward the bounding drainage varves, the varves as a whole fail to show a distinct trend from warm to cool to warm again between years when drainage occurred. In other words, the varves do not consistently grow thinner above a drainage varve and then thicken upward toward the next overlying drainage varve, even though they seem to show some variations in yearly weather.

### Rate of accumulation of the varved lake beds

Estimates indicate that the 28.5-foot section of lake deposits measured in the Priest River valley accumulated in about 250 years, or at an overall rate of about a foot in 9 years. Sediment must have accumulated much faster in the wider parts of the lake in the Purcell Trench and Pend Oreille Valley. At a rate of only a foot in 9 years it would have taken 10,000 years for the accumulation of the 1,000 feet or more of lake deposits in parts of the Purcell Trench, which is probably considerably longer than the life of this late glacial lake. Because the main part of the lake received sediment from extensive areas of glacial drainage to the Purcell Trench in Canada and also from the basin of Clark Fork where the soft and easily eroded deposits of former Lake Missoula provided large amounts of silt and clay, it seems likely that the rate of sediment accumulation throughout most of the lake would have been much greater than in the Priest River Valley.

### Ground water in the varved lake beds

The sand beds in the lake deposits are the main source of ground water to domestic and stock wells in the area of the glacial lake. These beds also feed a number of small seep springs in the shallow valleys intrenched in the lake deposits of the valley floors. The yield of the beds of sand is very low, but ground-water supplies adequate for rural use are developed by boring wells about 3 feet in diameter and casing them with sections of culvert or similar pipe. Such wells store enough water to permit the pumping of several hundred gallons during a few daytime hours, and they fill again by seepage at rates of a gallon a minute or less during hours of no pumping.

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# GEOLOGICAL SURVEY RESEARCH 1967

## Chapter B

GEOLOGICAL SURVEY PROFESSIONAL PAPER 575–B

*Scientific notes and summaries of investigations in geology, hydrology, and related fields*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1967