

SUBMERGED SHORELINES OF JACKSON LAKE, WYOMING: DO THEY
EXIST AND DEFINE POSTGLACIAL DEFORMATION ON THE TETON FAULT

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Objectives

The Teton fault is one of the most active normal faults in the world, as attested by the precipitous high front of the Teton Range. After deglaciation of northern Jackson Hole about 15,000 years ago (Porter and others, 1983), offset on the Teton fault southwest of Jackson Lake has totaled 19-24 m (60-80 feet) (Gilbert and others, 1983). In less than the last 9 million years, offset on the Teton fault has totaled from 7,500 to 9,000 meters (Love and Reed, 1971).

Figure 1 shows how downdropping on the Teton fault results in tilting of Jackson Hole towards the fault. Submerged paleoshorelines of Jackson Lake may record this downdropping and tilt because the level of Jackson Lake is controlled by both the fortuitous position of the lake outlet and the immediate downstream course of the Snake River (Figure 1). The outlet of Jackson Lake is 12 km east of the fault and from there the Snake River has a very low gradient to a bedrock threshold 6 km further east. Thus the level of Jackson Lake is controlled by the bed of the river east of the hinge line of tilting (Figure 1). The postglacial history of movement on the Teton fault may thus be recorded by paleoshorelines submerged below the level of the pre-dam lake.

If paleoshorelines can be recognized and the lake outlet has been tectonically and erosionally offset, such paleoshorelines can be interpreted to define the age and size of offsets and associated earthquakes on the Teton fault during the last 15,000 years. Study of the subaerial part of the fault (Gilbert and others, 1982) has not permitted field definition of the amount of offset during individual faulting events. Consequently, the size and recurrence interval of associated earthquakes has not been determined based on the actual history and character of the Teton fault. In addition, if the exact geometry of tilting of submerged shorelines with distance from the Teton fault can be determined, this data can be used in the same manner as that used by Stein and Barrientos (1985) for the Borah Peak earthquake to model the dip and curvature of the Teton fault. Thus, the number, spacing, and bending of paleoshorelines may define the history of offsets and associated earthquakes on the Teton fault and the subsurface geometry of the fault plane. Such information is of value to interpret the Teton landscape to Park visitors, to the design of engineering structures in the region, and to understanding of ongoing Basin and Range

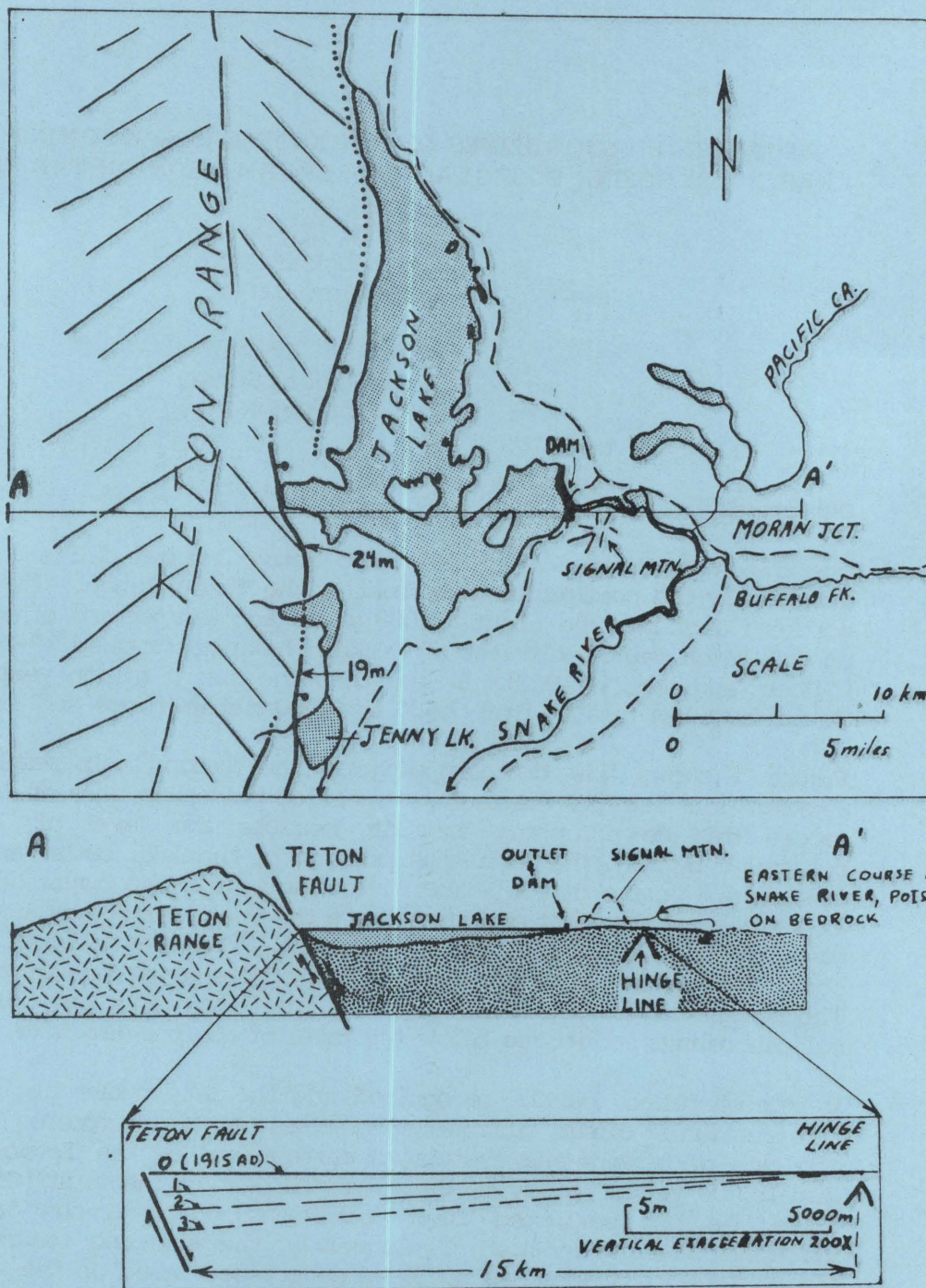


Figure 1. Top- Sketch map showing position of the Teton Fault relative to Jackson Lake and to the outlet-to-Moran Junction reach of the Snake River.
 Middle- Cross section showing position of Jackson Lake between Teton Fault and "hinge line".
 Bottom- Idealized diagram showing progressive deformation of shorelines (level lines), after 1, 2, and 3 offsets on the Teton fault.

tectonism.

Methods

If submerged paleoshorelines are present, they should be readily recognized by their continuous, almost horizontal character. Side scan sonar has proved a good method to image submerged paleoshorelines in Jackson Lake. Shore parallel traverses clearly show such shorelines, but do not permit definition of their depth. After some experimentation, we found the best technique was by boat traverses in a zig-zag pattern, coming into the shore at about a 45 degree angle to water depths as shallow as possible (about 2 meters), making a 90 degree turn and proceeding offshore at about 45 degrees. From such a zigzag pattern, as a paleoshoreline is observed on the side scan sonar record to go directly beneath the boat, its depth and sediment mantle can be determined from the fathometer and seismic reflection sonar.

For the geophysical traverses, the UW-NPS Research Ship Pelican (a 19-foot MonArk metal boat with electric generator and power winch) was snugly outfitted with a Geopulse reflection sonar, a Klein side scan sonar, a Raytheon fathometer, and a MiniRanger Falcon microwave navigation system. The ship and equipment was operated by 3-4 people. For the gravity coring work, most of this equipment was removed and a 200 lb gravity corer operated from the winch using 4-inch PVC pipe for coring. Locations of the traverses and core sites was by MiniRanger navigational system as well as by plotting on topographic maps, particularly where traverses went within a few meters of shore and the MiniRanger micro-wave transmission was blocked by intervening hills or trees.

Increasingly older paleoshorelines are expected to be mantled with a greater amount of unconsolidated lacustrine sediment. Piston cores were taken in given depths of water above suspected paleoshorelines to obtain samples of the lake sediment mantling the shorelines. Unfortunately cores either hit cobbles not mantled by lake sediment (Brown's Point) or did not penetrate through the lake sediments into the paleoshoreline deposits (Spaulding Bay and Moran Bay). Ten cores were obtained ranging in length from 0.5 to 1.8 meters. They appear to contain enough organic material for carbon-14 dating if the appropriate interval from just above the paleoshoreline could be sampled.

To our knowledge, the paleoshoreline method employed here is a new one for the definition of a fault history. This method might be applied to other areas where a lake is adjacent to an active fault, and the outlet of the lake is well away from the fault.

Results

In July, 11 days were spent on Jackson Lake aboard the UW-NPS Research Ship Pelican doing sonar traverses and coring. Nearly all the time was spent nearshore in the southern part of the lake. About 360 km of data were obtained. Ten cores with lengths between 0.5 and 1.8 meters were obtained of lake sediments, but did not penetrate through lake sediments into the underlying

paleoshoreline deposits.

Duplication and distribution of the records was completed by December, but the data has not been worked up yet. Figure 2 shows side scan records of submerged paleoshorelines at Brown's Point on the east side of Spaulding Bay (the original records are much better than this reduced copy of a copy). On the side scan sonar, the low-gradient part of a shoreline shows as light bands and the risers between shorelines shows as dark bands. The survey was made with 5 m of water above the pre-dam shoreline and the pre-dam shoreline is about the second shoreline in from the left in Figure 2. Below the pre-dam shoreline, about 8-10 paleoshorelines are recognizable and extend to a depth of about 10 m below the pre-dam shoreline. This site is about 6.5 km from the Teton fault where downdropping might be about half that adjacent to Teton fault, assuming the same deformation pattern as shown by Stein and Barrientos (1985), for the 1983 Borah Peak earthquake.

Other underwater features also suggest tectonic submergence has occurred. One of the most interesting is a sloping bench of glacial outwash that heads at a recessional ice-marginal position between Elk Island and Deadman Point and descends eastward to below the pre-dam outlet of Jackson Lake. After this outwash surface formed about 15,000 years ago (Porter and others, 1983), it apparently was tectonically submerged by downdropping on the Teton fault. This submergence of this once subaerial plain between Elk Island and Deadman Point joined together two previously separate parts of Jackson Lake.

In the Moran Bay area, different levels of deltaic progradation are apparent, the youngest and highest formed by streams at the time the dam was built. Deeper, older levels of deltaic progradation are apparent and represent older lake levels (paleoshorelines) that have been tectonically submerged.

In conclusion, about 8-10 paleoshorelines are present and represent a comparable number of major earthquakes on the Teton fault. The amount of downdropping for many of the events was about one meter 6.5 km east of the fault; downdropping at the fault may be about twice this amount. Glacial outwash and prograded deltas also have been submerged by downdropping on the Teton fault.

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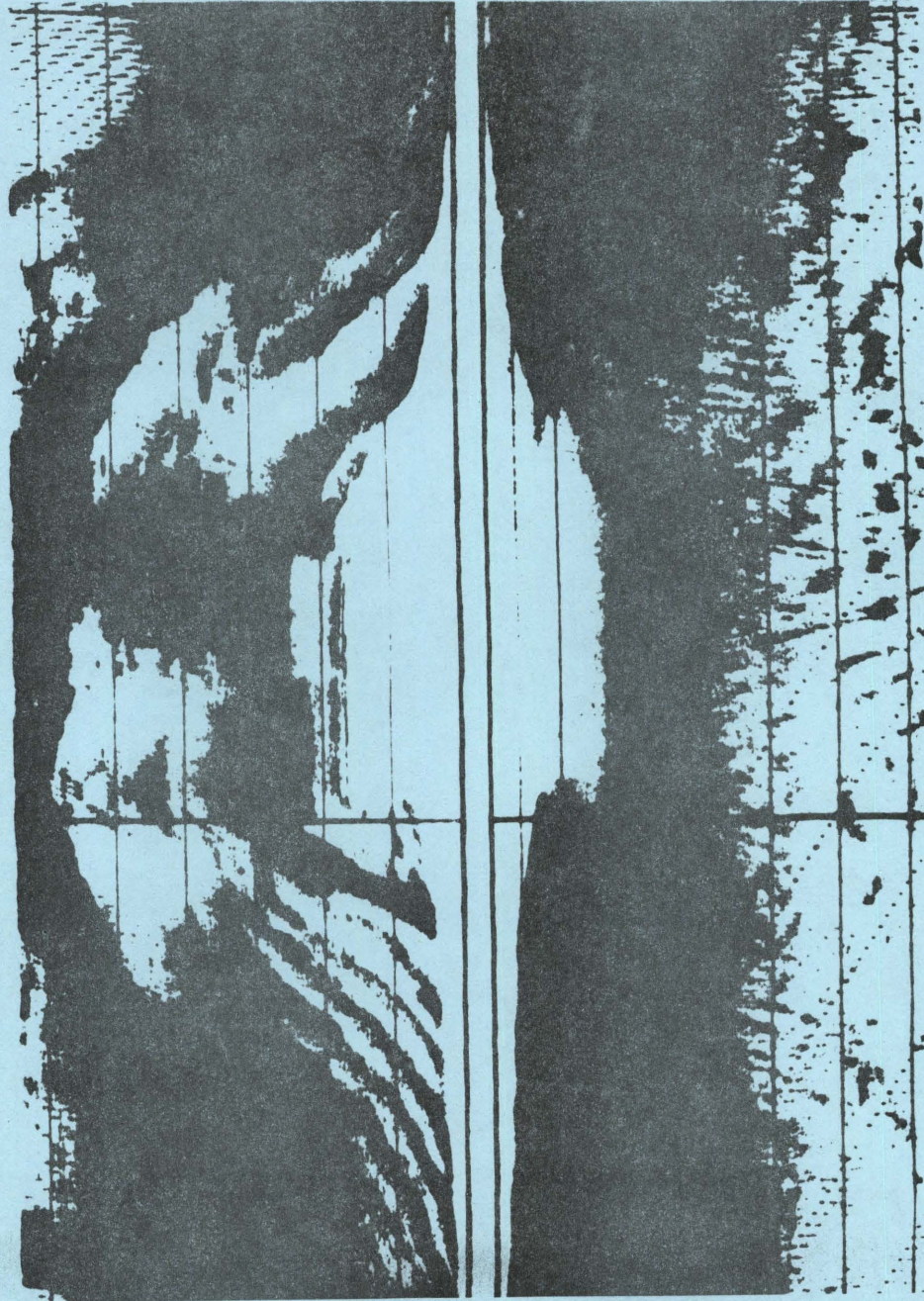


Figure 2. Side scan sonar record of submerged paleoshorelines at the northeastern margin of Spaulding Bay, Jackson Lake Wyoming. Shorelines are shown by the stripes. The light areas represent nearly horizontal shorelines, the dark bands represent the risers between shorelines. The original record is much better than this reduced copy of a copy of a copy. The reservoir shore is to the left. As the boat moved away from the shore (bottom), the water became deeper and the paleoshorelines moved from right to left under the boat (middle). The boat then turned towards shore and the shorelines moved from left to right beneath the boat. Paleoshorelines deeper than about the shallowest two are older than the pre-dam shoreline of Jackson Lake.

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