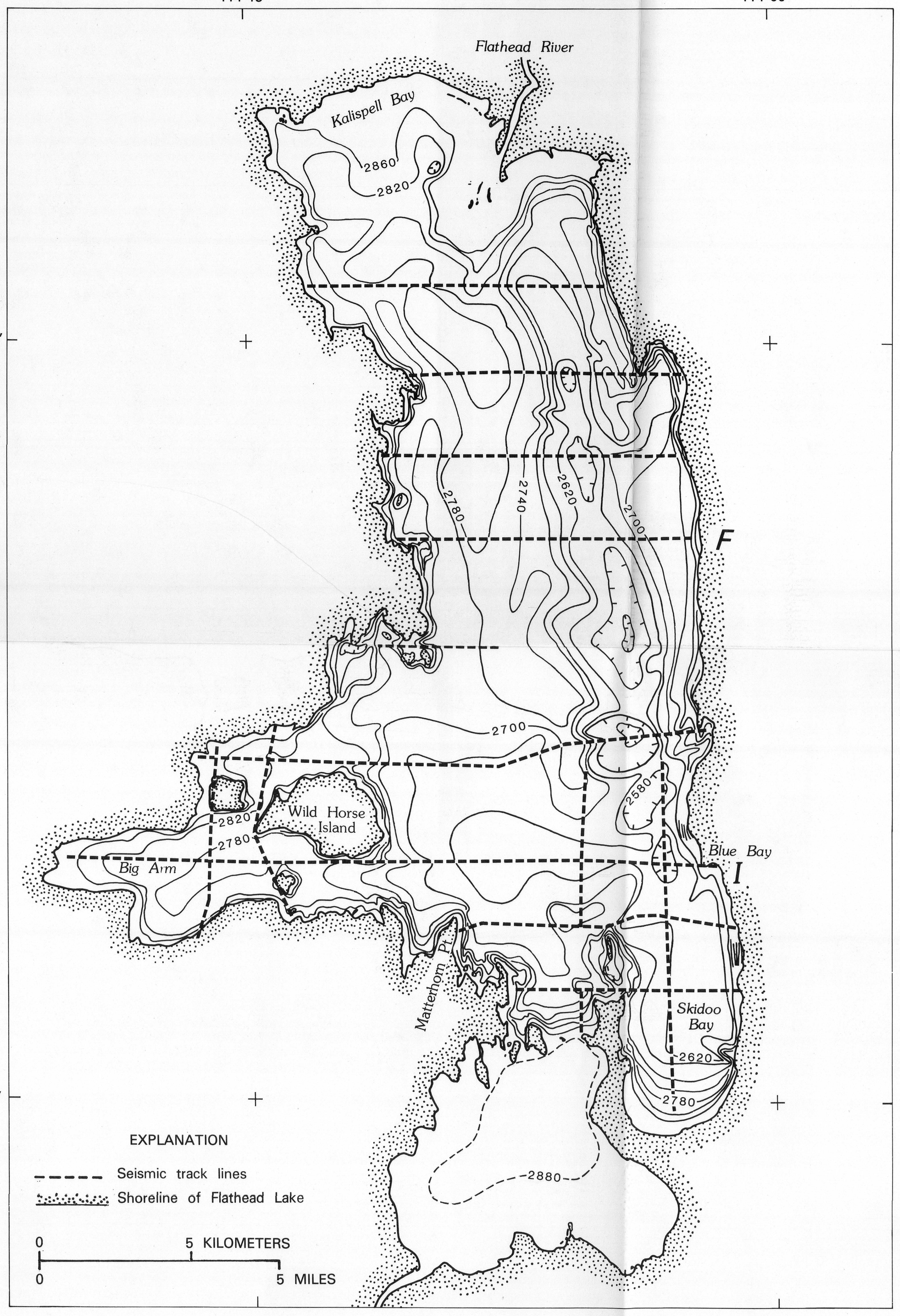

Figure 1. Bathymetric map (Kogan, 1980) with track lines of useable seismic reflection data. Contour interval 40 ft; datum mean sea level.

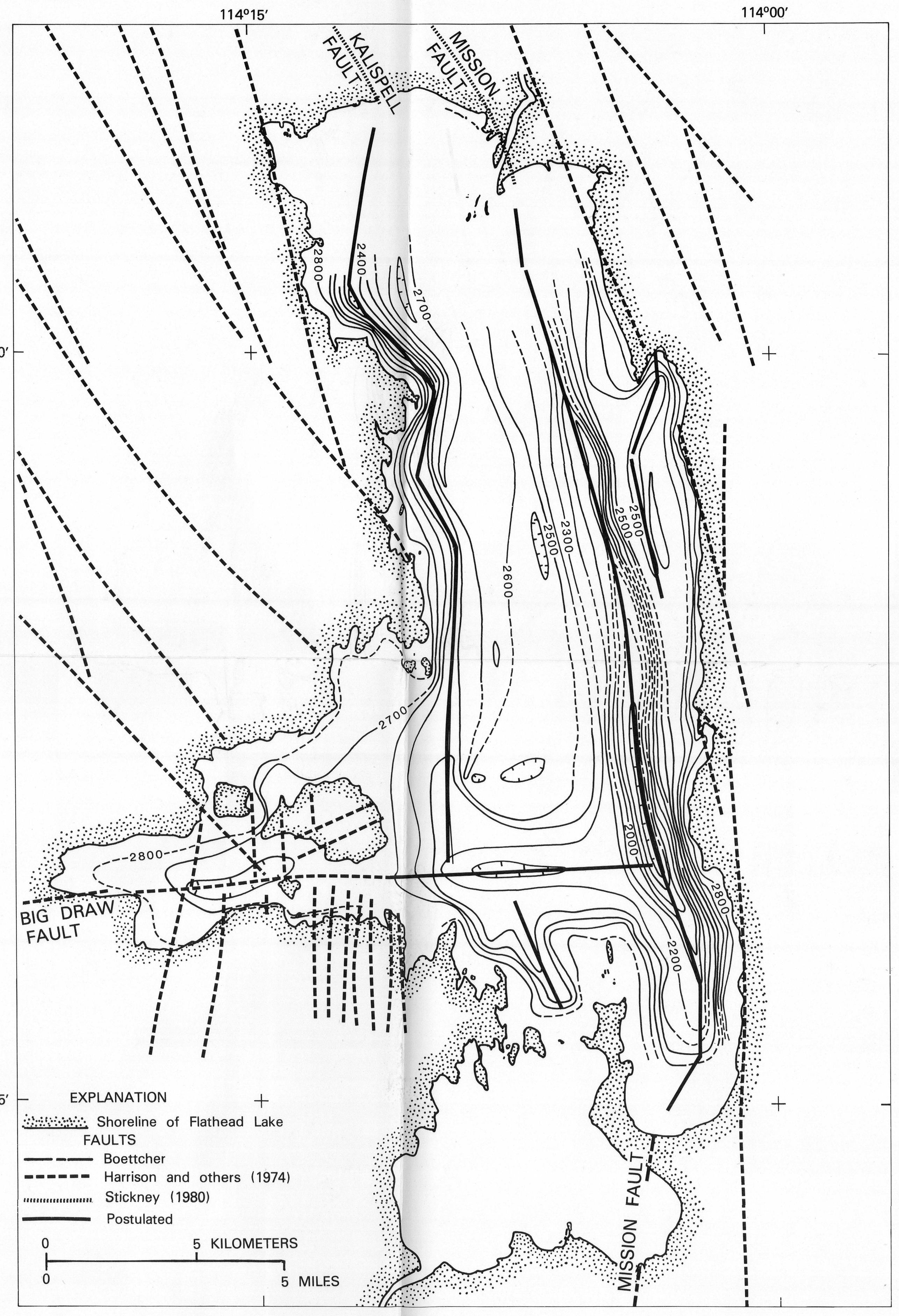

Figure 2. Bedrock elevation with previously mapped and postulated faults superimposed. Contour interval 100 ft; datum mean sea level.

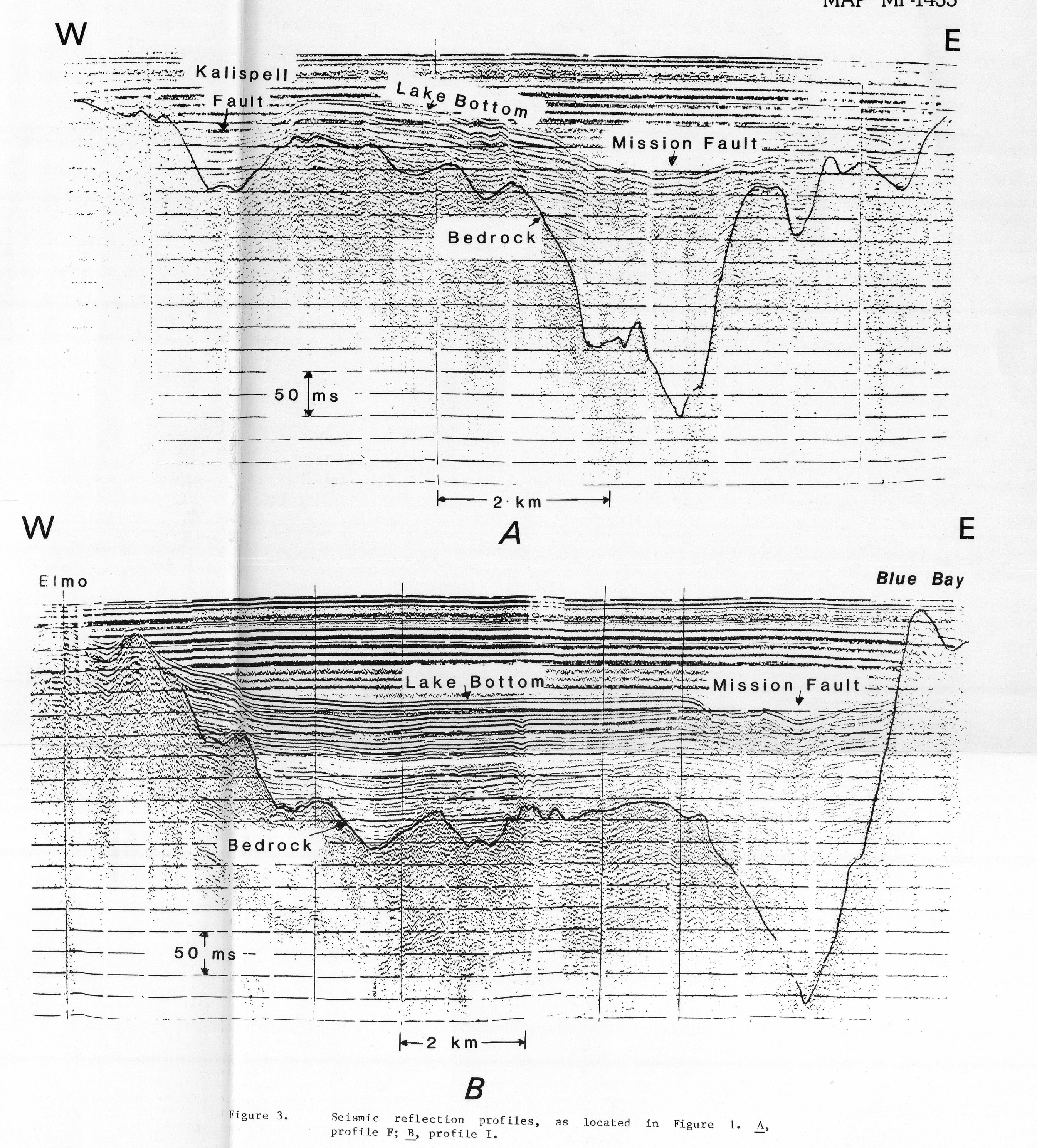

Figure 3. Seismic reflection profiles, as located in Figure 1. A, profile F; B, profile I.

DISCUSSION

A seismic reflection survey of Flathead Lake, Montana, was carried out in 1970 to study the geologic structure underlying the lake. Approximately 200 km of track lines were surveyed resulting in about 140 km of useable data (Fig. 1). A one cu. in. air gun was used as the energy source. Navigation was by a series of theodolite sitings of the boat from pairs of shore-based control points.

The quality of the seismic data is quite variable. In shallow water areas a strong water bottom multiple masks out any deeper reflections. In deeper water areas the data quality is good (Fig. 3) with penetration through the unconsolidated sediments to the bedrock surface.

A depth to bedrock map (Fig. 2) was constructed from the interpreted profiles (Figs. 4A and 4B) by measuring the time interval to the lake bottom and the time interval between the lake bottom and the basement surface. The water depth was determined by multiplying the water bottom two-way travel time by 2380 ft/sec (one half the velocity of seismic waves in fresh water of 4760 ft/sec, Press, 1966). The thickness of the unconsolidated sediments was determined by multiplying the basement surface minus lake bottom two-way time interval by 2800 ft/sec (one half the velocity of seismic waves in saturated glacial outwash; Press, 1966). The water depth and unconsolidated sediment thickness were added to obtain the depth-to-bedrock. This number was then subtracted from a lake level of 2892 ft to obtain the bedrock elevation which is contoured in Fig. 2.

Flathead lake varies in depth from more than 350 ft just offshore on the eastern side of the lake to a large area on the south which averages about 10 ft; on the north, in Kalispell Bay, the depth is 15-20 ft. This northern shallow water area is due to large deltas built by the Flathead River. The unconsolidated sediments range in thickness from 0 to 950 ft in the deep valley just west of Blue Bay (Profile I, Fig. 3B). The bedrock depth varies from exposures on the lake bottom to more than 1285 ft below lake level. The maximum bedrock relief is just west of Blue Bay (Profile I, Fig. 3B) where the bedrock drops approximately 1300 ft over a horizontal distance of 4000 ft (18° slope). At the north end of the lake there is an outcrop of stratified glacial outwash sediments resting on Precambrian Belt Series rocks. Apparently these sediments were deposited in Flathead Lake when it stood at a higher level, before the outlet breached its terminal moraine dam to the present depth of the cut (G. Crosby, written commun., 1981). This same sequence of glacial outwash sediments over Belt Series rocks is probably what is being seen in the seismic data in the lake. Also, since these sediments are tilted 20°, this implies that post Wisconsin faulting took place.

Three major bedrock valleys, two north-south and one east-west, can be identified in Figs. 2, 4A, and 4B. They can also be seen in the bathymetry (Fig. 1) but are not as pronounced.

The major valley is the north-south valley along the east side of the lake. At its deepest, this valley reaches an elevation of 1610 ft (about 1285 ft below lake level). Its northern extent cannot be determined but its northward trend is to the mouth of the Flathead River where it probably continues as the Mission Fault mapped on shore (Stickney, 1980). Southward its trend is to the southeastern end of Skidoo Bay where it also continues as the Mission Fault (Boettcher, 1980). This valley apparently represents the trace of the Mission Fault in the lake (LaPoint, 1973). The horizontally lying unconsolidated sediments in this valley are disrupted over the central fault zone, which implies that since the sediments were deposited, the fault has been active. Stickney (1980), from microearthquake studies, suggests that at least the northern end of the mission fault is presently active. Kogan (1980) estimated sedimentation rates in the lake from 1 cm/yr to 1 mm/yr and, from that and recent high resolution seismic data, he estimated possible major earthquake activity anywhere from 800 yrs to 10,000 yrs BP.

A smaller north-south valley, which probably also represents a fault trace, parallels the western shore of the lake. At its deepest, this valley reaches an elevation of less than 2300 ft (600 ft below lake level). The northern extent of this feature is obscured by multiples in the shallow water, but its trend is onshore near Somers on the western side of Kalispell Bay, and it may then continue as the Kalispell Fault (Stickney, 1980). The southern extension of this feature may terminate against the east-west fault that passes just south of Wild Horse Island. Since there is no evidence of faulting on the south shore at Matterhorn Point, which would be the southward extension of this postulated fault, it must terminate under the lake. The overlying unconsolidated sediments in this north-south valley show no disruption implying no motion on this feature of a magnitude great enough to disrupt the overlying flat-lying sediments.

The east-west fault, extends from the westernmost point of Big Arm, near Elmo, passing south of Wild Horse Island to the Mission Fault where it apparently terminates. The eastward extension of this fault would intersect Blue Bay; however, the faults mapped onshore in this area (Fig. 2) are all north-south, which implies that it terminates in the lake. This fault seems to represent the eastward trace of the Big Draw Fault (LaPoint, 1973, and Harrison and others, 1974). Again the overlying unconsolidated sediments in this valley show no disruptions. However, Witkind (1977) believes that this is an active fault.

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The original seismic survey, conducted in 1970, was a cooperative program conducted by the author, while he was at the University of Wisconsin - Milwaukee, and Gary W. Crosby, while he was at the University of Montana. The field program was carried out with the aid of several graduate students and technicians, from the University of Montana and the University of Wisconsin - Milwaukee. I'd like to particularly thank Ronald J. Friedel of the University of Wisconsin - Milwaukee for his technical support and Sid Prahl, who was at the University of Montana, for his data processing. I'd also like to thank Gary W. Crosby, Phillips Petroleum Co., for technically reviewing this report.

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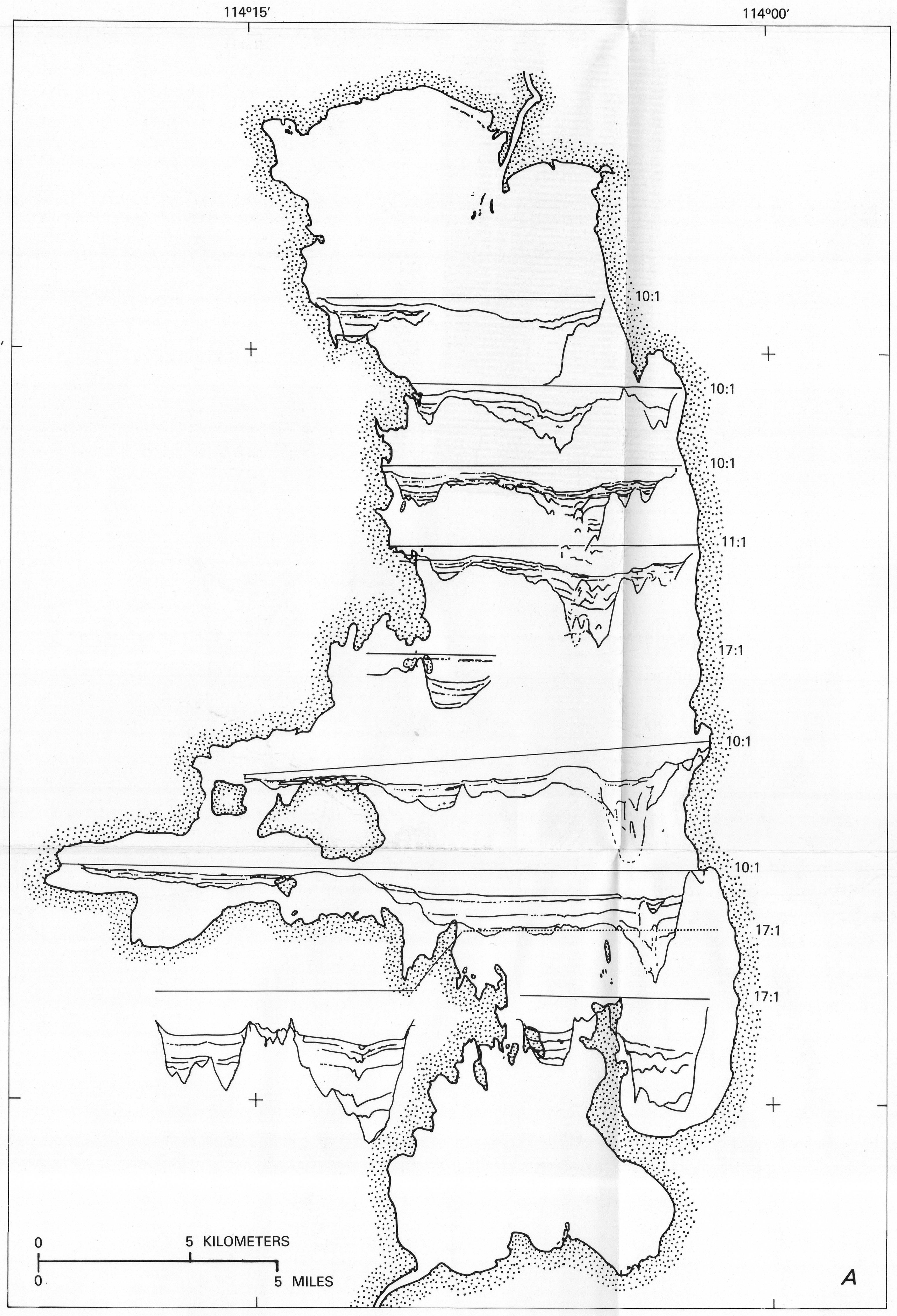
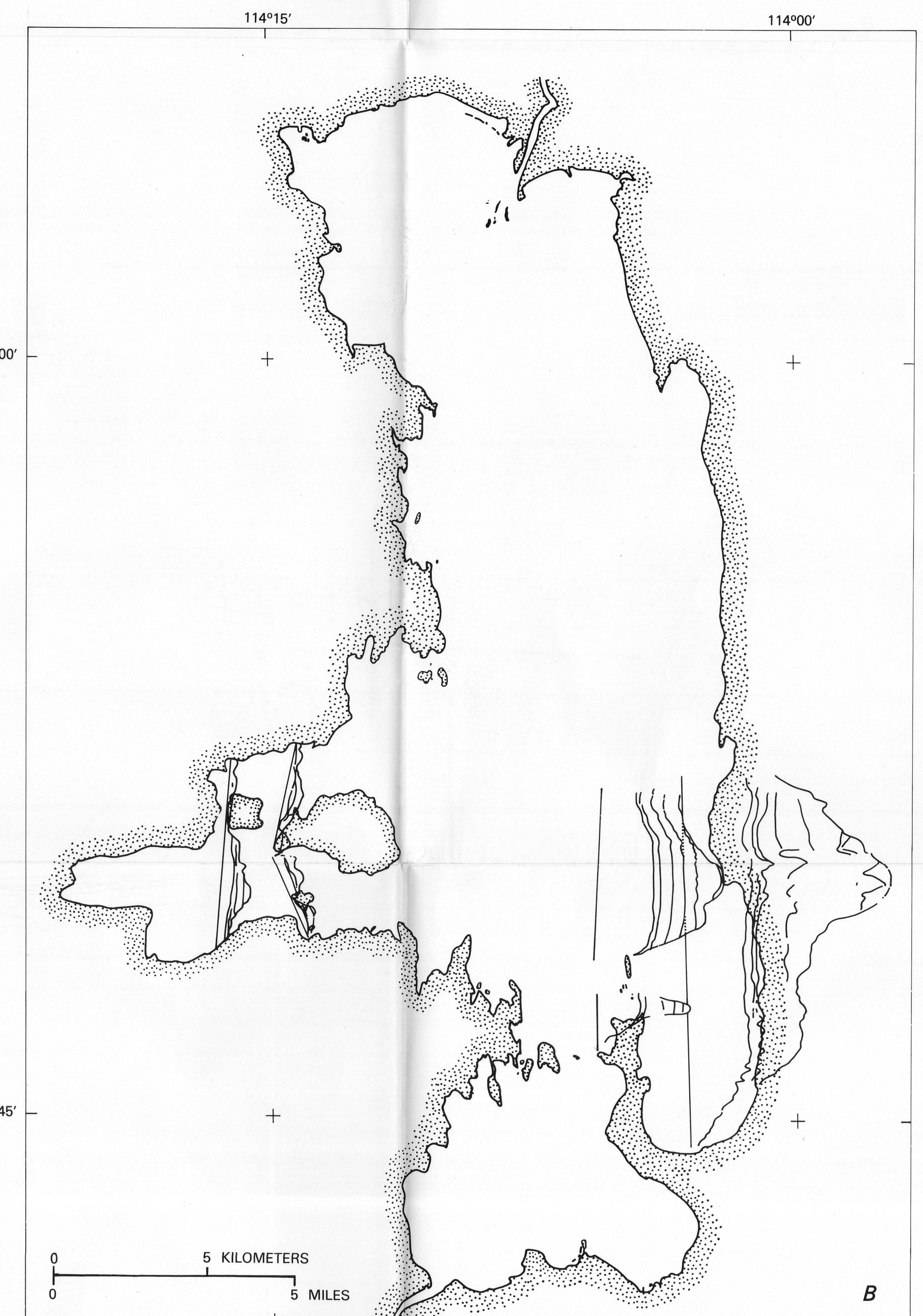
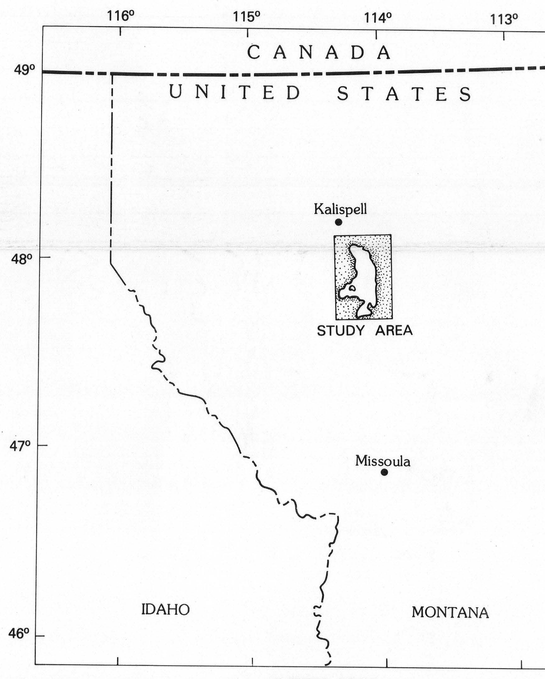




Base from U.S.Geological Survey, Kalispell, 1957-66, and Wallace, 1956-66; scale 1:250,000

Figure 4. Interpretations of seismic reflection profiles. The bottom line in each profile is the bedrock surface. Lines above the bottom are prominent reflectors in the material above bedrock. The profiles are positioned so that the water surface on each profile (straight line) corresponds with the location of the associated track line, as located in Fig. 1. A, east-west profiles. The vertical exaggeration varies from profile to profile ranging from 10:1 to 17:1. B, north-south profiles. The vertical exaggeration varies from profile to profile ranging from 5:1 to 20:1.



INDEX MAP

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1982

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