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Acoustic stratigraphy of Bear Lake, Utah–Idaho—Late Quaternary sedimentation patterns in a simple half-graben

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Abstract

A 277-km network of high-resolution seismic-reflection profiles, supplemented with a sidescan-sonar mosaic of the lake floor, was collected in Bear Lake, Utah–Idaho, in order to explore the sedimentary framework of the lake's paleoclimate record. The acoustic stratigraphy is tied to a 120 m deep, continuously cored drill hole in the lake. Based on the age model for the drill core, the oldest continuously mapped acoustic reflector in the data set has an age of about 100 ka, although older sediments were locally imaged.

The acoustic stratigraphy of the sediments below the lake indicates that the basin developed primarily as a simple half-graben, with a steep normal-fault margin on the east and a flexural margin on the west. As expected for a basin controlled by a listric master fault, seismic reflections steepen and diverge toward the fault, bounding eastward-thickening sediment wedges. Secondary normal faults west of the master fault were imaged beneath the lake and many of these faults show progressively increasing offset with depth and age. Several faults cut the youngest sediments in the lake as well as the modern lake floor. The relative simplicity of the sedimentary sequence is interrupted in the northwestern part of the basin by a unit that is interpreted as a large (4×10 km) paleodelta of the Bear River. The delta overlies a horizon with an age of about 97 ka, outcrops at the lake floor and is onlapped by much of the uppermost sequence of lake sediments. A feature interpreted as a wave-cut bench occurs in many places on the western side of the lake. The base of this bench occurs at a depth (22–24 m) similar to that (20–25 m) of the distal surface of the paleodelta.

Pinch-outs of sedimentary units are common in relatively shallow water on the gentle western margin of the basin and little Holocene sediment has accumulated in water depths of less than 30 m. On the steep eastern margin of the basin, sediments commonly onlap the hanging wall of the East Bear Lake Fault. However, no major erosional or depositional features suggestive of shoreline processes were observed on acoustic profiles in water deeper than about 20–25 m.

Keywords: Bear Lake; Seismic-reflection profiles; Graben; Faulting; Sedimentation

1. Introduction

Lacustrine sediments in rift basins have considerable scientific and economic importance, and acoustic methods (seismic-reflection and sidescan-sonar data) are some of the primary tools for studying rift-basin sedimentation and structure. Acoustic-stratigraphic studies of modern rift-basin lakes have mostly been conducted in large lakes within complex rift systems such as the East African Rift (e.g., Johnson et al., 1987; Lezzar et al., 1996; Scholz et al., 1993) and the Baikal Rift (e.g., Colman et al., 2003; Moore et al., 1997; Scholz and Hutchinson, 2000). These rift systems typically com-

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prise multiple complex basins separated by structurally complicated accommodation zones. In contrast, Bear Lake in Utah and Idaho (Fig. 1) is situated within a relatively small, single half-graben. The lake thus affords an opportunity to study rift-basin sedimentation in arguably its simplest configuration.

The Bear Lake Basin (Fig. 1) is located at the southern end of the larger Bear Lake Valley, extending northward near the northeastern margin of the basin and range province, at its boundary with the Colorado Plateau. The Bear River Range, to the west of the lake, is mostly underlain by Paleozoic carbonate rocks, in which a karst drainage is well developed, presumably contributing large amounts of groundwater to the lake. To the east of the lake is the Bear Lake Plateau, mostly underlain by Tertiary continental rocks.

The long-term tectonic history of the area is complex, beginning with Laramide foreland thrusting, followed by a reversal of stress with the development of extensional Basin and Range structures. Major studies of the bedrock and surficial geology of the area include Williams and others (1962), Kaliser (1972) and Dixon

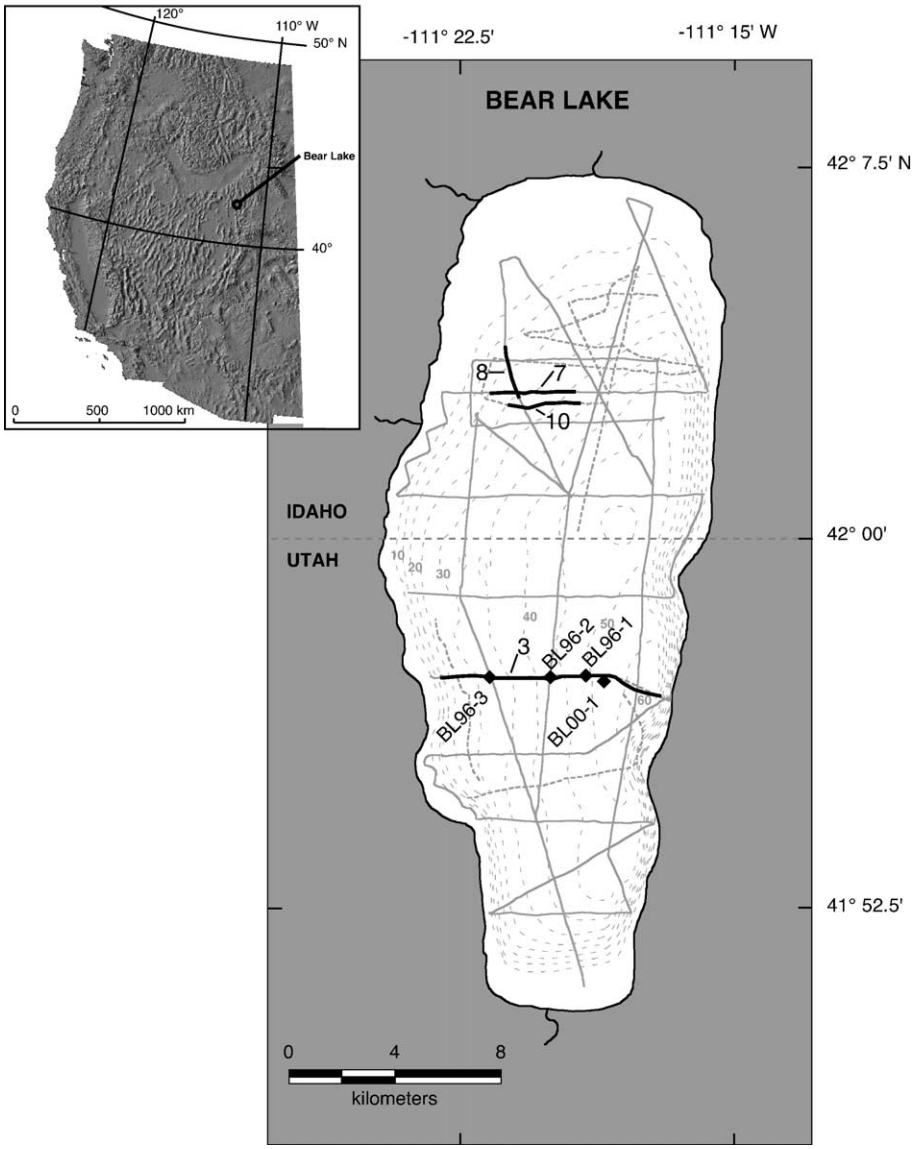

Fig. 1. Map of Bear Lake showing location of acoustic-reflection profiles. Bathymetric contour interval 5 m, beginning with 10 m. Heavy lines with numbers show the location of profiles illustrated in the figures corresponding to the numbered labels. Diamonds indicate core locations, from east to west, BL00-1, and BL96-1, -2 and -3. Inset: western United States location map for Bear Lake.