

**A BEAR RIVER COMMISSION STAFF SUMMARY OF THE
USGS STUDIES OF BEAR LAKE AND ITS CATCHMENT**

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The Clinton administration determined it was important to learn from science what could be observed about climate change. One of the efforts suggested by the USGS was authorized. The plan was to look for a lake where long-term records could be obtained from the sediments in the lake bottom. After searching for the best lake, agreement was reached that Bear Lake would be the place to look.

Several millions of dollars were authorized to be spent and a large and impressive group of scientists were employed to conduct many studies. This team of scientists was led by Joseph G. Rosenbaum. Just for ease of reference, I will refer to the studies and team as a group as the "Rosenbaum studies or team."

In 1996 the first effort began with the acquiring of three cores from the bed of Bear Lake. More coring was to follow. These cores were sliced into many samples and sent to several experts and geologic laboratories. The project was authorized to use collected information to go back a few tens of thousands of years and study past climates. While the cores were being examined, other scientists looked for more clues in the landscape around Bear Lake.

It was quickly learned that the Rosenbaum team had hit the jackpot. They learned that in parts of the Bear Lake bed sedimentation had occurred at a very slow rate. This meant that a very short section of core could take one back a long period of time into the Lake's history. In fact, they determined that they had cores that took the sediment record back as much as 250,000 years. For the team this created a problem as the study was authorized to only look back a few tens of thousands of years, yet they had very valuable information that needed to be studied. They worked around this issue and, with time, several papers were prepared.

Reading early drafts of these papers led the Bear River Commission to conclude that it would be most important for the findings to be published and preserved. The Commission also came to the conclusion that all of the papers were very technical and written in such a way that most residents of the area would find the reports difficult to understand. With time, there were 18 papers prepared and 15 of them were published in 2009 by the Geological Society of America as that Society's "Special Paper 450."

The Commission searched for a way to have a qualified team write a summary report that could be easily read and understood. None of the technical authors stepped forward. With the approval of the USGS, the Commission worked with the Utah Geological Survey to have a desired publication prepared. This effort resulted in a UGS publication titled "Why is Bear Lake So Blue?" This brief booklet does use some facts from the Rosenbaum publications and it answers some intriguing questions, but it fell far short of the Commission's goal. As of this writing, the Commission's objective has not been reached.

There is a copy of all 18 papers in the Bear River Commission library and the Commission also has an electronic copy of all 18 papers. The following is this writer's attempt to identify at least some of the key findings of each report. The introductory report and the following 14 reports listed are found in the GSA paper. The last three were not published by the GSA.

REPORTS PREPARED BY THE USGS ON THE BEAR LAKE CATCHMENT

A. Introduction to Paleoenvironments of Bear Lake, Utah and Idaho, and its catchment.

Joseph G. Rosenbaum and Darrell S. Kaufman.

This brief paper is, as the title indicates, an introduction to the many studies. It describes the work done and some of the conclusions. It was not intended to be a summary of all the findings.

1. Climatic and limnologic setting of Bear Lake, Utah and Idaho. Walter E. Dean, et al.

This short paper describes the Lake as it is today. It discusses the water chemistry of the spring-fed Lake as it was before the diversion of the Bear River into the Lake and the change in chemistry when the River was diverted about 100 years ago into the Lake.

2. Geology and geomorphology of Bear Lake Valley and upper Bear River, Utah and Idaho.

Marith C. Reheis, et al.

The report describes the Lake as being in a fault-bounded valley. It tells of periods when the Lake was much higher than the present level. The Bear Lake Valley once filled to as far north as the Nounan Narrows, and the current Lake is a small remnant of the larger Lake with a drop in elevation of about 80 feet.

3. Late Quaternary sedimentary features of Bear Lake, Utah and Idaho. Joseph P. Smoot.

This report describes the clay, sands and gravels deposited (sediments) in and around the Lake over an extended period of time. It describes how changes in Lake chemistry also change minerals deposited. This gives an indication as to when the Lake was connected to the River.

4. Isotope and major-ion chemistry of groundwater in Bear Lake Valley, Utah and Idaho, with emphasis on the Bear River Range. Jordon Bright.

This investigation looks at the chemistry of the groundwater reaching the Lake. It also analyzes isotopes in the water. It is concluded that when the River is not flowing into the Lake, 99 percent of the dissolved minerals in the Lake come from streams and springs draining the Bear River Range to the west of the Lake; hence, very little water reaches the Lake from the Bear Lake Plateau to the east of the Lake.

5. Radiocarbon ages and age models for the past 30,000 years in Bear Lake, Utah and Idaho. Steven M. Colman, et al.

The report, using radiocarbon dating, looks at pollen, ostracods and carbon found in the Lake sediments as revealed by the core samples. This allows for the creation of age models over the last 30,000 years. The age model is referred to as the backbone in reconstructing past environments. Ostracods are very small bean-shaped animals, with some being just visible to the naked eye. Their forms have changed with time, which make them good guide fossils.

6. Allogenic sedimentary components of Bear Lake, Utah and Idaho. Joseph G. Rosenbaum, et al.

The study looks at the mineralogy, chemistry and magnetic properties of the sediments in the Lake found in the cores. It identifies carbon-rich deposits brought to the Lake by waters from the Bear River Range when the River did not flow into the Lake. It also describes quartz-rich layer deposits by the River into the Lake as the River drains from its headwaters in the Uinta Mountains. Iron-rich red layers are also identified as coming from the River during ice age glacial melt.

7. Endogenic carbonate sedimentation in Bear Lake, Utah and Idaho, over the last two glacial-interglacial cycles. Walter E. Dean.

This investigation looked at the carbon-rich sediments deposited over the last two periods between the last two glacial periods. It discusses sediments over the last 220,000 years. Looking more recent in time, it notes that chemistry started to change about 11,000 years ago, indicating a withdrawal of River waters from the Lake. The chemistry of minerals would infer that, for the most part, the River did not flow into the Lake from 7,000 years ago until man diverted the River into the Lake about 100 years ago. Most of the time, however, over the last 220,000 years, the River was connected to the Lake.

8. Ostracode endemism in Bear Lake, Utah and Idaho. Jordon Bright.

The author found that Bear Lake is one of few lakes worldwide with its own unique species of ostracods. These are called endemic species and there is a correlation with the endemic fish species found in Bear Lake. There is an implication that the environmental setting in the Lake has been somewhat stable for hundreds of thousands of years despite changing climates. This stability can be attributed to the stable flow of streams and groundwater from the Bear River Range to the west of the Lake.

9. A 19,000-year vegetation and climate record for Bear Lake, Utah and Idaho. Lisa A. Doner.

This study analyzes pollen found in the cores taken from the Lake. Glacial and non-glacial periods can be identified. Pollen is a good indicator of climate change. The pollen from the

cores indicated a warm and dry period from 12,000 to 7,500 years ago. Generally, the past 7,500 years have been more wet and cool.

10. *A 19,000-year record of hydrologic and climatic change inferred from diatoms from Bear Lake, Utah and Idaho.* Katrina A. Moser and James P. Kimball.

Diatoms are single-celled algae. Their growth in the Lake is changed as Lake levels change and as the Lake may be covered with ice. Diatoms can be used to track changes in sediments carried into the Lake. The study concludes that from 19,000 years ago to 14,000 years ago there is a good fossil diatom record, perhaps because of increased turbidity of water coming into the Lake from glacier-fed streams and ice cover. The record of the diatoms indicates that the Lake was tied to the River from 14,000 years ago to 7,600 years ago. There is a suggestion of drier conditions from 3,000 years ago to the present.

11. *The glacial/deglacial history of sedimentation in Bear Lake, Utah and Idaho.* Joseph G. Rosenbaum and Clifford W. Heil, Jr.

It is noted that the Bear River is the largest river in the Great Basin and, at times in the past, it has contributed to Bear Lake. The cores can be used to determine where the majority of the sediments in the Lake come from as the sediments from the River draining the Uinta Mountains are different from the sediments contributed to the Lake by local streams. The sedimentary record indicates glaciation, and it was found that, as to the Lake, maximum glaciation occurred as Lake Bonneville reached its greatest size about 20,000 years ago. Glacial sediments are also found in Bear Lake that predate the rise of Lake Bonneville. Drier conditions may have occurred at Bear Lake when Lake Bonneville was falling.

12. *Sedimentary constraints on late Quaternary lake-level fluctuations at Bear Lake, Utah and Idaho.* Joseph P. Smoot and Joseph G. Rosenbaum.

Evidence of the lake-level history of Bear Lake for the past 25,000 years is of three types. Shorelines carved into the land above the modern Lake level is one indicator, but is only preserved in some areas. Grain size in Lake cores is another indicator. Sedimentary texture is also a tool. A model was created to include all three indicators. Two maps were created, one showing grain size in the sediments of the Lake when the Lake was at maximum historical elevation, and the other when the Lake elevation was about 80 feet below the historic level. Using this approach, the elevation of the Lake can be determined at various times in the past. For example, the model shows that prior to 18,000 years ago, the Lake level was stable and near the modern level and probably overflowing. However, between 17,500 years ago and 15,500 years ago, the Lake was about 132 feet below the modern level. Several Lake levels higher than the modern Lake level are also indicated between 8,500 and 700 years ago.

13. *Paleomagnetism and environmental magnetism of GLAD800 sediment cores from Bear Lake, Utah and Idaho.* Clifford W. Heil, Jr., et al.

Ancient records of the earth's magnetism are also a tool. The authors divided the sedimentary sequence in Bear Lake into zones. As the Lake becomes more saline because of the reduction of fresh water inflow and/or increased evaporation, different minerals can form. For example, as the Lake becomes more saline, pyrite is formed. Magnetic features can be used to compare climate over large areas; however, the Bear Lake record only suggests feasible possibilities of this type of correlation between Bear Lake catchment and areas far removed.

14. *A quarter-million years of paleoenvironmental change at Bear Lake, Utah and Idaho.* Darrell S. Kaufman, et al.

Bear Lake was found to be one of the longest-lived lakes on the North American continent. The cores indicate a spring-fed alkaline lake where carbonate-bearing sediments have accumulated continuously. A continuous, almost 400-foot core contains evidence of hydrologic and environmental change over the last two glacial-interglacial cycles. Precipitation of carbon-rich minerals has been occurring and there are massive silty clay and marl deposits. The core indicates the influence of the River and Lake level changes. During most of the last quarter-million years, the River has been tributary to the Lake. The paper provides a figure that shows four maps of various lake levels and Lake and River relationship. One of these shows a small and isolated lake and another shows a much-expanded Bear Lake with its outlet far to the north near Nounan.

The following three papers were not published in the GSA Special paper 450, but may be found in the Commission's library.

15. *Unusual Holocene and late Pleistocene carbonate sedimentation in Bear Lake, Utah and Idaho, USA.* Walter Dean, et al.

"Bear Lake hydrology combined with evaporation created an unusual situation that produced large amounts of aragonite, but no evaporate minerals." This statement by the authors explains the reason for the writing of the paper. The salinity of the Lake increased about 11,000 years ago and aragonite became the dominant mineral accumulating in the bottom sediments. Lake forming aragonite is usually found in small saline lakes where salinity varies considerably; however, other evidence indicates that the chemistry of the Lake has remained fairly constant for a long period of time.

16. *A continuous 250,000 yr. record of oxygen and carbon isotopes in ostracode and bulk-sediment carbonate from Bear Lake, Utah-Idaho.* Jordan Bright, et al.

Oxygen and carbon isotopes were analyzed from the almost 400 foot long core and they indicated dramatic fluctuations in the Lake's hydrologic budget over the last 250,000 years. During most of the time, the Lake was fresher than the modern Lake. Brief intervals that are an exception to this finding can be identified in the isotope record in the core.

17. *Age model for a continuous, ca 250-ka Quaternary lacustrine record from Bear Lake, Utah-Idaho.* S. M. Colman, et al.

The sediments sampled by the almost 400 foot drill core from the Lake comprise one of the longest lake sediment sequences recovered from an existing lake and the age dates back beyond the age of radiocarbon dating. Using other information found in the core, an age dating model was created. This age model represents the best estimate of the chronology of deposition in Bear Lake and might be used to address paleoclimate questions, including the relationship of the Bear Lake area to other areas.