GREAT SALT LAKE AND THE BONNEVILLE BASIN: GEOLOGIC HISTORY AND ANTHROPOCENE ISSUES

Edited by Michael D. Vanden Berg, Richard L. Ford, Carie Frantz, Hugh Hurlow, Kellen Gunderson, and Genevieve Atwood

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Cover photo: Exposed Holocene microbialite mounds near Lakeside, western Great Salt Lake, Utah. Photo by Michael Vanden Berg

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LAND ACKNOWLEDGEMENT

We acknowledge that the watershed of Great Salt Lake and the Bonneville Salt Flats is the traditional and ancestral homeland of the Shoshone, Paiute, Goshute, and Ute peoples. The Utah Geological Association recognizes and respects these sovereign nations and their traditions, cultures, and histories. We, the editors and authors of this book, honor the enduring relationship that exists between Indigenous peoples and the lands we discuss in this volume, a history that spans over ten thousand years dating back to the Fremont and other ancestral peoples of the Great Basin. Utah's Indigenous peoples were the original stewards of the systems and landscapes that are the focus of this guide and were witnesses to many of the changes discussed in this volume. Today, descendants of the original stewards of these lands are critical partners in the work ahead to understand, preserve, and protect our natural world and geoheritage for generations to come.

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UGA-51	Great Salt Lake and the Bonneville Basin: Geologic History and Anthropocene Issues, edited by M.D. Vanden Berg, R.L. Ford, C. Frantz, H. Hurlow, K. Gunderson, and G. Atwood, 2024.

PRESIDENT'S MESSAGE

On behalf of the members of the Utah Geological Association (UGA), I invite you to engage with the cutting-edge science presented in this guidebook. The UGA is a non-profit, all-volunteer organization of geologists and other geoscientists who share a common interest in Utah's geology. The purpose of the UGA is to increase and disperse geological information to the scientific community and promote public awareness of the usefulness of geology in general. Publication of our guidebook series is one of the principal ways that we fulfill our mission, and we are very proud of UGA Publication 51, Great Salt Lake and the Bonneville Basin: Geologic History and Anthropocene Issues. We are also very excited to offer this guidebook as a free, open-source publication. This is an important "first" for our association and we hope this will promote the wide dissemination of the important and timely science presented in this volume.

As a geomorphologist and Quaternary geologist, I was aware of the basic geologic history of Pleistocene Lake Bonneville and its Holocene remnant, Great Salt Lake, even before my family and I moved to Salt Lake City in 1992. Shortly after my arrival I had the very good fortune to audit several of the late Don Currey's (1934-2004) graduate seminars on Lake Bonneville and the Great Basin at the University of Utah. I was also an early member of the advisory board of FRIENDS of Great Salt Lake during this time. During my 25-year career at Weber State University, I viewed and contemplated Great Salt Lake almost every evening during my homeward commute from Ogden to Salt Lake City. Thus, even though my research did not focus on this system, I was a student of the Lake and very much aware of its importance. Jump to 2022. As UGA's President-Elect, I was very pleased when the Governing Board agreed that our 2023/2024 guidebook should focus on this critical and threatened biogeochemical system. I am very grateful that Michael Vanden Berg (Utah Geological Survey) agreed to serve as lead editor. Michael recruited a dedicated and talented editorial team (Carie Frantz, Hugh Hurlow, Kellen Gunderson, and Genevieve Atwood), which in turn recruited authors engaged in current research and shepherded their manuscripts through the peer-review process in a timely fashion. Thank you all.

I would also like to thank the AAPG Rocky Mountain Section Foundation for their very generous grant to the UGA in support of Publication 51 and its associated fall field trip. UGA's 2023 field trip (October 20-21) to Great Salt Lake and the Bonneville Salt Flats, co-sponsored by the Utah Geological Survey (UGS), was a big success. Field trip leaders Michael Vanden Berg (UGS) and Jeremiah Bernau (Chevron) organized and executed an informative and enjoyable trip that shared the results of recent and ongoing research. Day 1 focused on biogeochemical processes operating in the south arm of Great Salt Lake, which the participants circumnavigated by driving across the railway causeway. This was an exciting first for many participants, including myself. Day 2 focused on the Bonneville Salt Flats, its hydrology, geochemistry, and management issues. The 29 participants, with 12 different affiliations, enjoyed great science and beautiful fall weather. Five university students participated and the RMS-AAPG grant enabled the UGA to offer them a substantial discount on their registration fee.

Great Salt Lake attained a new record-low water-surface elevation in November 2022 (see Rowland and Freeman, this volume, for details). The subsequent media coverage, legislative activity during the 2023 session, and local community response – along with UGA's efforts to produce Publication 51 – made 2023 "the year of the lake" for many of us. I give a final thank you to everyone who is working for a sustainable future for this vital ecosystem through science-based decisions.

With gratitude,
Richard L. ("Rick") Ford
2022-2023 UGA President

EDITORS' MESSAGE

What do you think about when someone mentions Great Salt Lake? Stinky, gross, crusty, wasteland, a place to visit once, but not to return—these are common perceptions, but did you know that Great Salt Lake:

- √ is an important stopover point in North American for millions of migratory birds;
- √ hosts the vast majority of wetland acreage in Utah;
- √ contains the world's largest accumulation of Holocene microbialites;
- √ is the only producer of magnesium metal in North America;
- √ is one of two places in the U.S. that produces lithium, a vital mineral for the transition to clean energy;
- √ contributes to the "Greatest Snow on Earth" in the form of lake effect snow;
- √ produces significant quantities of potash, which is a vital fertilizer needed to grow our food; and
- √ is the number one producer of brine shrimp cysts, which are used in aquaculture facilities worldwide.

Like most terminal saline lakes around the world, the public pays little attention when the lake is "behaving". During these times, scientists are quietly conducting their research, some outdoor enthusiasts are recreating on its waters and along the shores, and industry hums along business as usual. However, every so often the lake goes outside of "normal". When this happens, everyone stands up and takes notice. In the mid-1980s, the lake went outside of "normal" and reached very high levels, threating shoreline communities and infrastructure. Significant actions were taken to tame the high-water levels, including installing massive pumps on the west side to send water into the Bonneville desert. Through the 1990s and 2000s, the lake went back to a state of "behaving" and most people again overlooked our finicky neighbor.

The lake is once again behaving outside of "normal", this time with historic low lake levels. We think everyone can agree that low lake levels pose a risk to Utah citizens in the form of dust emissions, reduced snowpack, threatened wildlife, and impacts to industrial activity. It is in this environment of low lake level and increased attention that the Utah Geological Association proudly releases Publication 51. This new compilation of 14 timely research papers on Great Salt Lake and older Lake Bonneville will hopefully contribute to the new body of scientific work that can help inform those charged with managing this unique resource.

The editors greatly appreciate the authors for being willing to share their knowledge and write such informative papers. We would also like to thank Cheryl Wing, our fantastic and very patient graphic artist for formatting all the papers and other materials with care and attention to detail. In addition, acknowledgement goes to the American Association of Petroleum Geologists Rocky Mountain Section Foundation for providing funding for this book and the associated field trip. Finally, we would like to thank the UGA and all its many volunteers for all their hard work promoting the wonderful geology of Utah.

Michael Vanden Berg, Rick Ford, Carie Frantz, Hugh Hurlow, Kellen Gunderson, and Genevieve Atwood

UGA 51 Editors

DEDICATION

J. Wallace ("Wally") Gwynn, Ph.D.
(May 30, 1940 – July 15, 2021)

Utah Geological Association Publication 51 is dedicated to the career and memory of Dr. John Wallace Gwynn—Wally to his family, friends, and colleagues. Those who had the pleasure of working with Wally fondly remember his infectious smile and enthusiasm, coupled with a depth of knowledge and strong desire to help others.

Wally was born and raised in Salt Lake City, Utah, and attended the University of Utah, where he majored in mineralogy and geology. After completing his doctorate in 1970, Wally worked as a mineral exploration geologist for Phelps Dodge Corporation and as a research geologist for AMAX and Great Salt Lake Minerals. In 1975 Wally joined the Utah Geological Survey (UGS) as a saline-minerals geologist, a position he held for 34 years until his retirement in 2009. In retirement Wally worked as a private consultant on several potash projects in Utah.

Wally's Ph.D. dissertation focused on the tar-sand resources of Uintah and Grand counties, and he continued this work with the UGS. Wally also investigated and published reports on the oil-well brines of the Uinta and Paradox basins, subsurface brines of the Sevier Lake area, and low-temperature geothermal resources along the Wasatch Front. However, the bulk of Wally's UGS career was spent investigating and publishing on the brines and mineral resources of Great Salt Lake; he was the Survey's Great Salt Lake expert for more than 30 years and the author of numerous UGS publications about the Lake. In addition, Wally edited two major compilation volumes about Great Salt Lake during his UGS career: Great Salt Lake: A Scientific, Historical and Economic Overview (Utah Geological and Mineral Survey Bulletin 116, 1980) and Great Salt Lake: An Overview of Change (Utah Department of Natural Resources Special Publication, 2002).

Great Salt Lake was Wally's true scientific passion. He was dogged in his systematic collection of geochemical data, going out onto the lake month after month to document the chemistry and physical properties of the Lake's water layers. The lake data he collected during his UGS tenure is foundational and still in use today. During the 1980s high stand, he was called upon by the Department of Natural Resources to offer guidance with respect to the advisability and consequences of the West Desert pumping project. Wally was all about the data and very generous with his time and expertise, serving on numerous technical committees and responding to inquiries from state and federal agencies, industries, and the general public. Even in retirement Wally followed developments at the Lake. In his interactions, Wally was a kind, patient, and soft-spoken person, and in his work, he was a dedicated geoscientist and public servant.