International Limnogeology Congress (ILIC6), Reno USA, special issue on new limnogeological research focused on Holocene lake systems

Scott W. Starratt · Michael R. Rosen

Received: 24 August 2017 / Accepted: 30 September 2017 / Published online: 27 October 2017
© Springer Science+Business Media B.V. (outside the USA) 2017

The 6th International Limnogeology Congress (ILIC6) of the International Association of Limnogeology (IAL) was held in Reno, Nevada, USA 15–19 June, 2015. The successful congress brought together a wide variety of academic, government, and industry participants from 20 countries and six continents. The highpoint of the four-day meeting were eight keynote addresses highlighting cutting-edge research in paleolimnology and limnogeology. These addresses were often the focal point of discussions throughout the congress. Among the topics covered in the more than 140 poster presentations included the use of biological proxies to identify paleoenvironmental change due to natural variability and human impact, the evolution of mineral formation in saline lakes, sedimentation deposition processes in Mesoproterozoic lakes, the role of groundwater in lacustrine hydrology, and organic and inorganic contaminant histories in modern lakes. The abstract volume and field trip guide for the meeting is available at Rosen et al. (2015) and Rosen (2015), respectively.

This special issue concentrates on Holocene lakes depositional processes, and is the one of two special issues. A concurrent special issue will focus on pre-Holocene studies that contribute to our knowledge of ancient lakes.

Nine papers comprise this special issue. One is focused on the early and middle Holocene, three are focused on the period since the Medieval Climate Anomaly, and five are focused on processes in modern lakes and how an understanding of those processes can be applied to ancient lake systems. The first paper (Ye et al. 2017) evaluates the early and middle Holocene (11.50–4.17 cal ka BP) record of the East Asian monsoon and its influence on the Neolithic culture of Zhejiang Province in southern China. Using several proxies including grain size, the chemical alteration index, Mg/Sr and major oxide ratios, and pollen concentrations Ye et al. identified four distinct climatic intervals; (1) a warm period between 11.50 and 8.77 cal ka BP, (2) an interval between 8.77 and 7.99 cal ka BP that was cooler and drier at the beginning and gradually became warmer and wetter towards the end, gradually leading into, (3) the Holocene Climate Optimum between 7.99 and 5.68 cal ka BP, (4) followed by a period of stepwise temperature decline between 5.68 and 4.17 cal ka BP.

Johnson et al. (2017) used changes in the diatom flora and sediment geochemistry in Fallen Leaf Lake, located in the Lake Tahoe Basin (California and Nevada), to assess climate variability over the past

S. W. Starratt (✉)
US Geological Survey, 345 Middlefield Road,
Menlo Park, CA 94025, USA
e-mail: sstarrat@usgs.gov

M. R. Rosen
US Geological Survey, 2730 N. Deer Run Rd,
Carson City, NV 89701, USA

1200 years. The authors show that Fallen Leaf Lake was sensitive to climatic cooling during the Little Ice Age and to the human activities that began to influence the basin in the mid-19th century, however they found little evidence of anthropogenic N deposition. Four diatom zones were identified; (1) Pre-Little Ice Age Zone, (2) Little Ice Age Zone which expressed cooler conditions characterized by *Stephanodiscus alpinus* and *Aulacoseira subarctica*, (3) Transitional Zone identified by an increase in the *Lindavia rossii-ocellata* group and *Discostella stelligera* and decreased *Pseudostaurosira brevistriata* suggesting warming and human influence, and (4) Anthropogenic Zone with a rapid increase in mesotrophic taxa. The Anthropogenic Zone is also characterized by geochemical indicators of coal burning and smelting activities.

Montes de Oca et al. (2017) uses chironomids and sedimentary pigments (chlorophyll derivatives and carotenoids) to evaluate the effect of changing climate conditions, the deposition of ash from local volcanic sources, and human activities on two remote lakes in northern Patagonia. The authors demonstrated the impact of ash deposition on chironomid assemblages over the past 200 years using a chronology established by ^{210}Pb and tephra layers deposited during historic eruptions. In addition to local natural factors, climatic change and human activities have also influenced the chironomid assemblages over the past ~ 50 years. These changes were also accompanied by changes in the amount of organic matter deposited in the lake and variations in the sedimentary pigment ratio.

The development of irrigation systems to transport water from the Amu Darya (Khorezm Province, Uzbekistan) in the early and mid-twentieth century to support of large-scale production of cotton both reduced the amount of water entering the Aral Sea and may have resulted in the formation of the more than 400 shallow lakes in the region. Rosen et al. (2017) investigated the history of 12 of these lakes using organic carbon content, and pollen concentration and abundance. Most of the lakes investigated are less than 150 years old. The data show that between 70 and 50 years ago most of the lakes changed from saline conditions with low levels of organic carbon and pollen concentration to freshwater conditions with high organic carbon content and abundant freshwater plant pollen. Pesticide profiles (DDT and its degradation products and γ -HCH) show that peak

concentrations (1950–1990) are associated with peak pesticide use during the Soviet era. This timing suggests that most of the lakes would not exist without irrigation input from the Amu Darya.

Nutz et al. (2017) introduce a new end-member in an alternative, sedimentologically based lake classification system. This category is referred to as the wind-driven water body (WWB). Wind-induced lake-scale circulation and wave-related depositional processes result in the construction of beach ridges, spits, or cusped spits and the shoreline, and sediment drift, shelf progradation, and erosional surfaces in the deeper, offshore environment. This physiography is expressed by the I_{WWB} index, a ratio of the maximum representative fetch relative to mean basin depth. It is suggested that an I_{WWB} index value greater than three favors the evolution of a lake as a WWB.

Qinghai Lake, the largest modern lake in China, is used to study the types of and depositional mechanisms that form modern beach bars (Zhang et al. 2017). The important factors controlling beach bar development are wave length and height, lakeshore terrain, and available sediment supply. Using modern coastal dynamic theory, beach bars were divided into two categories; (1) breaking bars that develop near the breaking zone where water depth is a function of wave height and length, and (2) surf bars that develop in the surf zone, where surf water depth equals breaking wave height. Wind waves play an important role in the location and development of beach bars in Qinghai Lake. This research increases our understanding of beach bar sandstone units which are an important oil and gas reservoir in China.

Shan et al. (2017) review the sedimentary characteristics and genesis of a sandy, topset-dominated braided river delta from Huangqihai Lake. Ground penetrating radar, trenching, and grain size analysis were used to identify ten lithofacies types. The delta contains four distinct architectural elements, including channel fill, compound bar, sand sheet, and river mouth bar. This type of topset-dominated delta forms with a gentle slope (0.2°), in young (~ 25 years) and shallow (< 10 m) environments where arid conditions and human influence results in a low sediment supply.

Regardless of the ionic composition, saline lakes that support a thin veneer of microbial mats can modify the chemical behavior of evaporitic sediment and promote the formation of carbonates and sulfates from Ca-poor waters with high Mg/Ca ratios

(Cabestrero and Sanz-Montero 2017). The authors studied six lakes in two evaporitic endorheic drainage systems in central Spain. One group of lakes consists of highly alkaline, brackish to saline lakes containing a high concentration of chloride with carbonate dominant over sulfate, and a second group of mesosaline to hypersaline lakes in which sulfate is the dominant anion. Mineral assemblages contain several phases that indicate a mixed carbonate-sulfate precipitation pathway in brackish to saline lakes and a sulfate-dominated pathway in mesosaline to hypersaline lakes. Geochemical changes in the environment surrounding the microorganisms favor the nucleation of hydrated Mg-carbonates, calcite, and dolomite. The microbial mats provide nucleation sites for gypsum and the bubbles produced by metabolic activities favor the formation of hydrated Mg-sulfates. Modern evaporitic microbial environments are important analogs for understanding brine evolution and mineral precipitation pathways in shallow water settings that have existed since the Archean on Earth and perhaps on Mars.

Schuster and Nutz (2017) evaluate modern processes in Lake Turkana and paleolake deposits in the Turkana Basin, and demonstrate that the identification of lacustrine paleoshorelines from typical clastic landforms and deposits is the key to accurately reconstructing the spatial variability of lakes over time and to the recognition of transgressive–regressive cycles. Classic models of clastic sediment deposition in rift valley lakes emphasize transportation by rivers. These sediments are distributed by fan-deltas and/or deltas into a water body of varying depth, where reworking is limited in the littoral zone and episodic in deeper water. Evidence for wave-dominated forms is present in modern Lake Turkana, where it includes prominent, active littoral landforms. Raised beach ridges and spits provide evidence for similar conditions during the Holocene (African Humid Period) climate-driven highstand of Megalake Turkana, and its subsequent forced regression. Typical nearshore sedimentary facies and stratigraphic architectures associated with paleolake Turkana were identified in Pliocene and Pleistocene deposits in the Turkana Basin. This study shows that wave action is an important agent for the erosion, transport, and deposition of clastic sediment at the basin-wide scale in lakes and should be incorporated into depositional models developed for lacustrine systems.

Since its founding by Elizabeth Gierlowski-Kordecz and a handful of other limnogeologists in 1993, the IAL was led by Beth until her untimely death in May 2016. A tribute to Beth and her significant body of work can be found at: <http://link.springer.com/article/10.1007/s10933-016-9915-1> and <http://ial.strikingly.com/>. As ILIC6 was Beth's last ILIC meeting, it is fitting that we devote space to acknowledge Beth's contribution to ILIC and IAL, and her role as a friend and colleague. Without Beth the IAL, ILIC, and the Limnogeology Division of the Geological Society of America would not exist. Beth convinced the scientific community that lake-focused research organizations are important, and will continue to be important into the future. She was more than just a colleague to many of us, as she was also a great friend, mentor, and a steadfast promoter of limnogeology as a discipline. Beth is sorely missed, but the solid foundation that she established for the limnogeology field will live on. We dedicate both of these Special Issues of the Journal of Paleolimnology to Beth's memory and to her science.

The next ILIC meeting (ILIC7) will take place as a joint conference with the International Paleolimnology Association (IPA) in Stockholm, Sweden, 18–21 June 2018. The ILIC7 is a year earlier than the past four-year cycle in order to coincide with the regular triennial IPA conference. More information will be available at the IAL (www.ial.strikingly.com) and IPA (<http://paleolim.org/>) websites and the conference webpage (<http://ipa-ial.geo.su.se>) or tweet @IPA_IAL_2018 in the near future.

The editors would like to thank Tina Triplett, Executive Director of the Nevada Water Resources Association, and her team for their dedication in making sure all aspects of the Sixth International Limnogeology Congress ran as smoothly as possible. We would also like to thank the ILIC6 organizing committee and the many sponsors of the meeting for contributing to the scientific and financial success of the Congress. And lastly, we would like to thank the many individuals who took the time to improve the manuscripts that comprise this volume.

References

- Cabestrero O, Sanz-Montero ME (2017) Brine evolution in two inland evaporative environments: influence of microbial

- mats in mineral precipitation. *J Paleolimnol*, 1–19. doi:[10.1007/s10933-016-9908-0](https://doi.org/10.1007/s10933-016-9908-0)
- Johnson BE, Noble PJ, Heyvaert AC, Chandra S, Karlin R (2017) Anthropogenic and climatic influences on the diatom flora within the Fallen Leaf Lake watershed, Lake Tahoe Basin, California over the last millennium. *J Paleolimnol*. doi:[10.1007/s10933-017-9961-3](https://doi.org/10.1007/s10933-017-9961-3)
- Montes de Oca F, Motta L, Plastani MS, Laprida C, Lami A, Massafiero J (2017) Reconstructing recent environmental changes using non-biting midges (Diptera: Chironomidae) in two high mountain lakes from northern Patagonia, Argentina. *J Paleolimnol*, 1–13. doi:[10.1007/s10933-017-9957-z](https://doi.org/10.1007/s10933-017-9957-z)
- Nutz A, Schuster M, Ghiennie J-F, Roquin C, Bouchette F (2017) Wind-driven waterbodies: a new category of lake within an alternative sedimentologically-based lake classification. *J Paleolimnol*, 1–11. doi:[10.1007/s10933-016-9894-2](https://doi.org/10.1007/s10933-016-9894-2)
- Rosen MR, compiler (2015) Sixth International Limnogeology Congress—Field Trip Guidebook, Reno, Nevada, June 15–19, 2015: U.S. Geological Survey Open-File Report 2015, 1108, p 100. <http://dx.doi.org/10.3133/ofr20151108>
- Rosen MR, Cohen A, Kirby M, Gierlowski-Kordesch E, Starratt S, Valero Garcés BL, Varekamp J, eds. (2015) Sixth International Limnogeology Congress—Abstract Volume, Reno, Nevada, June 15–19, 2015: U.S. Geological Survey Open-File Report 2015–1092, p 244. <http://dx.doi.org/10.3133/ofr20151092>
- Rosen MR, Crootof A, Reidy L, Saito L, Nishonov B, Scott JA (2017) Determining the origin of shallow lakes in the Khorezm Province, Uzbekistan, and the history of pesticide use around these lakes. *J Paleolimnol*, 1–19. doi:[10.1007/s10933-016-9914-2](https://doi.org/10.1007/s10933-016-9914-2)
- Schuster M, Nutz A (2017) Lacustrine wave-dominated clastic shorelines: modern to ancient littoral landforms and deposits from the Lake Turkana Basin (East African Rift System, Kenya). *J Paleolimnol*, 1–23. doi:[10.1007/s10933-017-9960-4](https://doi.org/10.1007/s10933-017-9960-4)
- Shan X, Li S, Li S, Yu X, Wan L, Jin L, Wang R (2017) Sedimentology of a topset-dominated, braided river delta of Huangqihai Lake, north China: implications for formation mechanisms. *J Paleolimnol*, 1–17. doi:[10.1007/s10933-016-9929-8](https://doi.org/10.1007/s10933-016-9929-8)
- Ye W, Chen Q, Zhu L, Li F, Wang T, Cheng L, Zhang Y (2017) Early mid-Holocene climate oscillations recorded in the Beihuqiao Core, Yuhang, Zhejiang Province, China. *J Paleolimnol*, 1–16. doi:[10.1007/s10933-017-9959-x](https://doi.org/10.1007/s10933-017-9959-x)
- Zhang Y, Hu C, Wang M, Ma M, Wang X, Jiang Z (2017) A quantitative sedimentary model for the modern lacustrine beach bar (Qinghai Lake, Northwest China). *J Paleolimnol*, 1–18. doi:[10.1007/s10933-016-9930-2](https://doi.org/10.1007/s10933-016-9930-2)