

Paleolimnology: the history and evolution of lake systems.

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Paleolimnology: The History and Evolution of Lake Systems

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This book is a great feat because lake science covers such a wide range of disciplines that a vast array of knowledge is needed to hit all the bases. Cohen has hit a home run in covering topics such as the physics, chemistry, and biology of modern lakes, the geomorphology, sedimentology, and chemistry of Holocene to Pleistocene lakes, the faunal archives of the Quaternary, and the paleontology of fossil lakes. The breadth of knowledge contained within one book cover is impressive and I tip my...

First Page Preview

Paleolimnology: The History and Evolution of Lake Systems, Andrew S. Cohen, 2003, Oxford University Press, New York, 500 p. (Hardcover, \$85.00) ISBN: 0-19-513353-6.

This book is a great feat because lake science covers such a wide range of disciplines that a vast array of knowledge is needed to hit all the bases. Cohen has hit a home run in covering topics such as the physics, chemistry, and biology of modern lakes, the geomorphology, sedimentology, and chemistry of Holocene to Pleistocene lakes, the faunal archives of the Quaternary, and the paleontology of fossil lakes. The breadth of knowledge contained within one book cover is impressive and I tip my hat to the author for his great efforts to cover many aspects of lake science. This book is an amazing accomplishment.

Paleolimnology is a term, however, that has many different shades of meaning depending on one's experience, analytical tools, interests, and point of view. The first overview on paleolimnology in the United States was a book chapter by Bradley (1963) within the tome *Limnology in North America*, which summarized the study of what he called extinct lakes—lakes without water. W. H. Bradley, who published extensively on the Eocene Green River Formation in the earlier part of the 20th century (e.g., Bradley, 1929), clearly wanted to contrast lakes from deep time (pre-Pleistocene) with three Pleistocene lakes. In doing so, he recognized the need to observe and describe lakes throughout the Phanerozoic to gain knowledge of the entire spectrum of possible lake types. Bradley, however, cited only 58 references while summarizing information on ten lakes ranging in age from Permian through Pleistocene in the U.S.A. Along similar lines, Feth (1964) published an exhaustive review on ancient lake deposits in the U.S.A. (mostly from the western half, Precambrian to Pleistocene in age), citing 319 publications that listed 240 stratigraphic units containing lake-deposited sediments. In contrast, Reeves' (1968) book *Introduction to Paleolimnology* mostly highlighted lake science as it applied to modern and Pleistocene lakes. Topics included their mode of origin, chemical and physical aspects of water and sediment, as well as their paleoclimatic records within sedimentary archives, citing 530 references. Clearly, the perspective of lake studies was already diverging in the 1960s, using the modern study of lakes and rivers (limnology) to analyze either the sedimentary archives within extant/ancient lake basins (Plio-Pleistocene to Holocene in age; *sensu* Rossiter and Kawanabe, 2000) or extinct/fossil lake basins (pre-Pliocene in age). Although both authors drew examples from both categories of lake basins, the different viewpoints based on geologic age are notable. Most of these differences arose from the different analytical techniques needed to investigate rocks versus unconsolidated sediments (wet or dry).

The immense increase of knowledge on all aspects of lakes over the past thirty years is evident in Cohen's book on paleolimnology. He uses 2014 references with a more global flavor to bring across the high points in the study of lake systems, including modes of lake formation, physics and chemistry of lake waters and sediments, sedimentology of lake archives, biology and paleoecology of lake systems, as well as the description and interpretation of lake records for paleoclimatic analyses from modern and ancient lakes. More importantly, for the first time ever, there is an overview devoted exclusively to the evolution of lacustrine ecosystems through the Phanerozoic using information from both trace and body fossils (see studies on trace fossils in continental systems; e.g., Buatois and Mángano, 1994; Buatois et al., 1998; Miller and LaBandeira, 2002; Miller et al., 2002). Cohen also summarizes and constrains issues such as origin, dispersal, diversity, and evolution of organisms in lake environments isolated from the world's oceans. This is a logical extension of work on terrestrial to freshwater ecosystems, such as Gray (1988) and Behrensmeier et al. (1992).

With only 500 pages of text, it is clear Cohen could not include everything about lakes. His perspective on the definition of paleolimnology is similar to that of Reeves; Cohen wishes to present data needed to understand the ancient lake-basin systems (modern to Plio-Pleistocene in age) that he studies in East Africa. A summary of the contents of the chapters follows.

The introductory chapter discusses the value of lake sediments as archives of Earth history. The emphasis here is on the general techniques of data collection in an extant lake basin, including sediment coring, seismic and sonar surveys, as well as sampling and analysis of lake-terrace outcrops for lake-level changes through time. The next topic is a discussion of time and event resolution in the interpretation of sediment cores, especially the use of the hydroclimate filter, defined as the modification effects of the physical parameters of a water body on the resultant sedimentary record. Variable environmental factors across the depth range of a lake, from external to internal factors, can influence the sedimentary record in different ways. Examples from modern to Pleistocene lakes are given with only a quick paragraph about the lake cycles of the Triassic Lockatong Formation of the Newark basin in the eastern U.S.

The second chapter is a good summary on the geologic evolution of lake basins—streamlining the work of Hutchinson (1957) and others, especially discussing the different types of tectonic basins with some examples of fossil basins, including rift, foreland, pull-apart, and cratonic settings, as well as lake basins in continental collisions. Table 2.1 includes many basin types as well as possible temporal and spatial scales of their lake deposits—a nice touch. Glacial lakes, fluvial lakes, coastal lakes, volcanic lakes, deflation lakes, karstic lakes, dammed lakes, meteorite-crater lakes, and human-made lake examples are all present.

The next two chapters are short summaries on physical and chemical limnology pertinent to the study of ancient lakes. They are quite dense, but all the information necessary to understand paleolakes is there and summarized very succinctly. Topics include lakes zones, stratification types, and mixing through heat, wind, and currents in the physical chapter, and oxygen, carbon, ions, salinity, nutrients (such as nitrogen, phosphorus, and silica), and stable isotopes in the chemical chapter.

The first half of the next chapter on biologic limnology is an overview of the major groups of fauna and flora in lakes today, including bryozoans and foraminifera (although nothing on freshwater jellyfish!). The pictures of the different organisms are extremely helpful, matching Latin names to real animals and plants. The second half of the chapter deals with the abiotic and biotic factors that control species distribution. The abiotic factors are discussed with many examples and include light, temperature, dissolved oxygen, pH, salinity, nutrients, water turbulence, substrate, and habitat heterogeneity. The biotic factors, such as competition and predation, are only discussed generally. Lastly, Cohen deals with the conditions controlling species diversity through time and space, such as habitat area and longevity, lake history, and colonization patterns.

The sixth chapter covers chronology techniques since age control is critical for sediment-core analysis—in order to determine age, rates of processes and fluxes, and correlation of spatial data. Table 6.1 summarizes isotopic techniques in geochronometry (with references) for unconsolidated lake sediments. Also summarized are fission track dating, luminescence dating, amino acid racemization, correlation techniques, and magnetic properties of sediments and rocks. A short and non-exhaustive section devoted to biostratigraphy of pre-Quaternary (and post-Paleozoic) lake deposits ends the chapter.

Chapter seven is dedicated to the origin and physical characteristics of the sedimentary record of lakes, drawing mainly from modern to Pleistocene examples, though some pre-Pleistocene rocks are described. The major factors controlling sedimentation (e.g., watershed geology and climate, hydrology, and organic productivity) are discussed. Table 7.1 summarizes most of the possible environments to be found associated with lakes—including information on lithology, sedimentary structures, stratigraphic architecture, typical fossils, and time resolution of deposits. A very short section on sequence stratigraphy in lake basins is present as well as a discussion of depositional processes and possible vertical sequences in lake deltas, coastal deposits, carbonates, sublacustrine fans, and hemipelagic and pelagic sediments, such as laminites and varves.

Chapter 8 extends the ideas of the seventh chapter into examples of lake facies within specific types of lake basins and lake types, such as rift lakes, foreland-basin lakes, glacial lakes, crater lakes, and saline lakes and playas. Examples range from the modern to the Paleozoic, with many cross-sections and vertical sequences for illustration.

The ninth chapter deals with geochemical archival data gleaned

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