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Featured Faculty Research

Sedimental Journeys

Tectonic and Climatic Record of Eocene Lake Gosiute

Alan Carroll

Large ancient lakes are ideally suited to record interactions between rising orogenic topography and the atmosphere, due to their ability to capture the physical and chemical products of weathering of the surrounding landscape. Unlike marine sediments, lake deposits can provide highly resolved local records of these interactions. Also, the preservation of significant thicknesses of lacustrine strata provides an important perspective on vertical crustal movements that are associated with the creation of closed drainage basins. Finally, lake deposits are of major economic significance for resources such as oil shale, oil, trona, and borates.

Despite their importance, lacustrine sedimentary basins are much less well-known than their marine counterparts. For the past several years my students and I have been working on the Eocene Green River Formation in Wyoming, with the goal of understanding the overall stratigraphic evolution of the basin and its relationship to regional tectonics and climate. This ongoing work has taken several forms. First, we are using detailed field and subsurface studies to develop new sequence stratigraphic models for lacustrine facies. In contrast to marine systems, sediment supply in lacustrine basins is intimately linked to changes in lake level, and in many cases is also linked to the uplift of sills relative to subsidence of the basin floor. For example, work by PhD student Jeff Pietras suggests that renewed uplift of the Wind River Range may have diverted a major river system away from the greater Green River basin, causing Lake Gosiute to both shrink and become sediment starved (Figure 1). Climatically-induced drops in lake level are also associated with decreases in sediment supply, which means that lowstand deposits are often poorly developed.

We are also conducting the first systematic study of strontium isotopes in a pre-Quaternary lake system, in collaboration with Prof. Clark Johnson and Brian Beard of the UW Radiogenic Isotopes Laboratory. Jeff Pietras, PhD student Meredith Rhodes, and MS student Brooke Swanson together are compiling a $^{87}Sr/^{86}Sr$ curve for Eocene Lake Gosiute based on analysis of carbonate phases, analogous to the marine strontium curve. These data will provide a critical linkage between lacustrine sedimentation and the weathering of the surrounding drainage basin, by helping to reconstruct past patterns of riverine and groundwater inflow. So far we

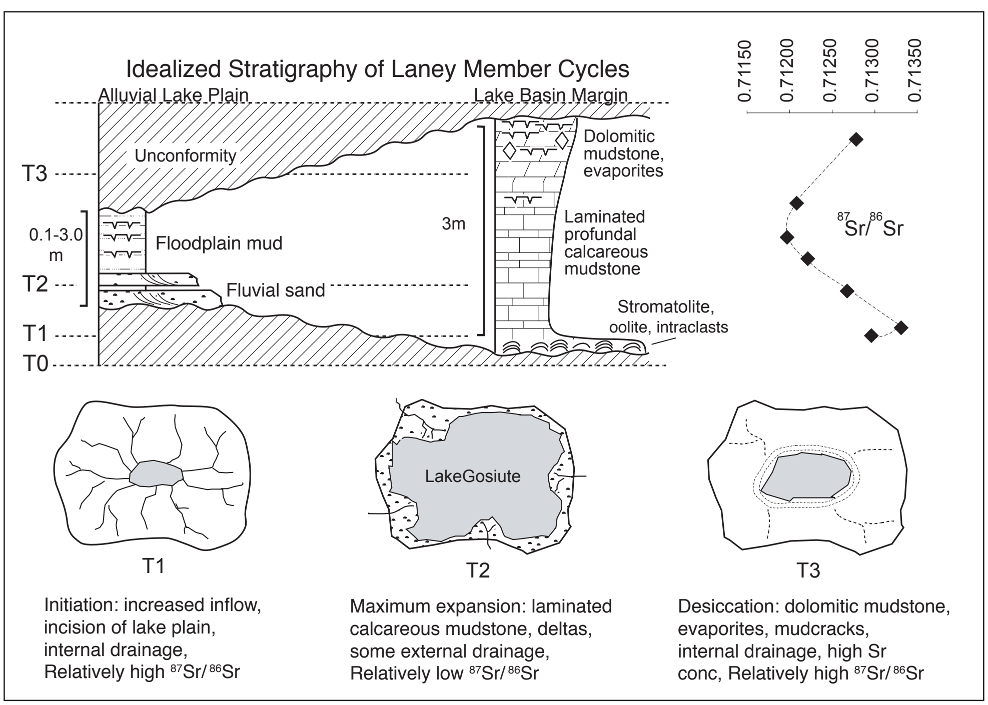

Fig. 1. Schematic representation of the impact of renewed uplift of the Wind River Range on Lake Gosiute (Pietras et al, in review)

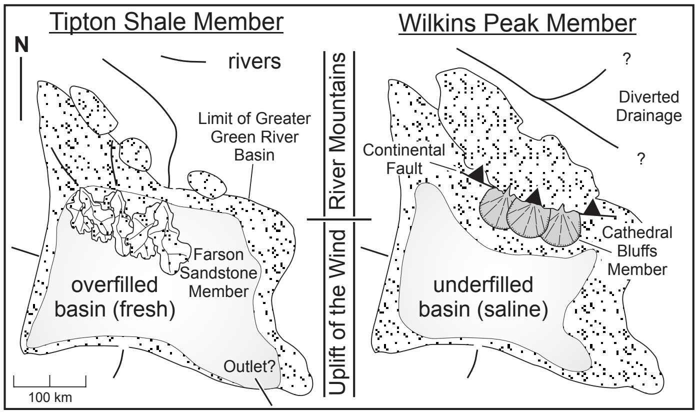

Fig. 2. Cartoon showing $^{87}Sr/^{86}Sr$ variation within one lake cycle of the Laney Member (Rhodes et al., 2002).

have documented large shifts in lakewater $^{87}Sr/^{86}Sr$, depending on whether the lake was being fed primarily from Laramide uplifts bounding the basin (relatively high $^{87}Sr/^{86}Sr$) or from a combination of these sources and regional drainage from the Absaroka volcanic field to the north (relatively low $^{87}Sr/^{86}Sr$). Meredith Rhodes' work on the Laney Member has shown that these changes can occur at the scale of individual lake expansion-desiccation cycles, reflecting increased regional drainage during lake highstands (Figure 2).

Repetitive lacustrine facies associations such as depicted in Figure 2 are often interpreted as evidence for Milankovitch-scale orbital forcing of sedimentation, and many studies focus on using such "cycles" to derive information about past climate changes. However, chronostatigraphic control in lake deposits is characteristically poor, and independent tests for the presence of precession or other cycles are virtually unknown. In fact it is common for the cycles themselves to be used as the basis for a timescale, with obvious potential for circular reasoning. Recent MS and current PhD student Mike Smith is currently colllaborating with Prof. Brad Singer and the UW Rare Gas Geochronology Laboratory to use $^{40}Ar/^{39}Ar$ dating of tuffs interbedded in the Green River Formation to create a high-resolution chronostatigraphic framework. So far we have dated 6 tuffs to resolutions approaching ±100 ka (2s error), more than an order of magnitude better than previous studies. Interval ages provided by Mike's data, combined with Jeff Pietras' detailed stratigraphic work, have allowed us to directly measure the apparent average duration of lake cycles in the Wilkins Peak Member. What we have found is that apparent cycle duration varies greatly depending on position within the basin. Near the basin margin relatively few cycles are preserved, and their apparent durations are calculated to be approximately 50 Ka. About twice as many cycles are preserved within the same tuff-bounded interval closer to the basin center, giving an apparently duration of 25 ka, close to that for precession. However, paleosols and other indicators of missing time are present even at the basin center, suggesting that true cycle duration may actually be shorter than precession-scale. An important implication of these findings is that it may be impossible to identify a chronostratigraphically complete facies succession anywhere within an evaporative lake basin.

In the future we will continue toward our goal of building an integrated model for the Eocene evolution of the greater Green River basin. We are also collaborating with MS student Selena Mederos and Prof. Basil Tikoff to help link this history with the Laramide tectonic evolution of the region. Financial support for our work has been provided by Conoco, Texaco, the National Science Foundation, the Donors of the Petroleum Research Fund of the American Chemical Society, and by the Graduate School of the University of Wisconsin-Madison.

References

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