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Pyramid Lake and Winnemucca Lake (dry lake bed on right), Nevada

(Credit: Google Earth)





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From the Editor

Michelle Goman

Rohnert Park, CA

Welcome to the Fall 2015 edition of the Limnogeology Newsletter!

This edition of the Newsletter begins with a message from our division chair Joop Varekamp. It contains a list of sessions for the upcoming 126th Annual GSA Meeting in Baltimore, and other informational items including:

- Details of the 2015 ILIC meeting to be held at Reno/Tahoe, Nevada
- The Kerry Kelts Award Winner
- Research findings from the 2014 Kelts Award Winners

Don't forget to send me your news items!

Michelle (goman@sonoma.edu)

Message from the Chair

Dear Limnogeologists

The ILIC6 conference has come and gone and was very successful. We had 160 attendees, a wealth of papers presented and star keynote speakers. The fieldtrips were great as well. I went on the Pyramid Lake field trip and enjoyed both the scenery, the tufa mounds, and our interactions with the Native American guides. Then field season was upon us, and more cores and water samples were collected by many of us.

This past summer we made some progress with our plans to reorganize the Limnogeology website, but hope to make further progress in November. Any inputs from the membership are more than welcome. We probably will move it to the *Connected Community* area of the GSA website, but more of that in the near future.



Coring at 100 m depth at
Paulina Lake, Newberry Oregon
(Photo credit: Joop Varekamp)

And now we are looking ahead at the GSA meeting where we have many Limnogeology sponsored sessions (see page 25-28). The Limnogeology Division is also sponsoring a lunch event in memory of and celebrating the work and person of Andrew Hill, who passed away in September 2015. Andrew Hill was a paleoanthropologist who was well known in lake circles through his fieldwork in Africa. His friends and colleagues will honor him during this special event in the lunch break between the morning and afternoon sessions of T195 on Monday November 2 in room 324 (Baltimore Convention Center).

Please join us at our business meeting at the Baltimore GSA on Tuesday November 3 from 6-8 PM in room BCC 307. We do this with our friends and colleagues from the Sedimentology Division and the Society for Sedimentary Geology – the Seds&Suds and Lims&Limes event. We will provide food and drinks, make sure to bring your own amazing lake topic to discuss, while the sed folks are looking for the most baffling sedimentary feature. Our annual awards will be presented at the business meeting. This year we received again many deserving applications for the Kerry Kelts Award and our 2015 Kelts Awardee is Ann Morey Ross (Oregon State University).

This year Andy Cohen is the Israel Russell Awardee in Limnogeology. His extensive lake studies in Africa, his popular textbook, and his mentorship for many students as well as service to the profession make him a deserving medalist.

I look forward to seeing you in Baltimore.....

Joop Varekamp

Limnogeology Division Chair

LIMNOGEOLOGY T-SHIRT DESIGN CONTEST!

Have you ever wanted to be a clothing designer? The Limnogeology Division is holding a contest for a new T-shirt design. Please send your design ideas to division secretary, Michelle Goman, by April 15th 2016. The winning design will debut on the catwalks of the GSA 2016 Denver meeting.

~*~

KERRY KELTS 2014 AWARDEES RESEARCH UPDATES

Investigating a late Miocene – early Pliocene marine incursion (southern Bouse Formation) into the southwestern United States using $\delta^{18}\text{O}$ values in inorganic and biologic carbonates: implications for the evolution of the lower Colorado River corridor, AZ-CA.

Jordon Bright

(THE University of Arizona; Department of Geosciences)

2014 Kerry Kelts Research Award Co-Winner

INTRODUCTION

Ever since John Wesley Powell's historic journey through the Grand Canyon in 1869, the Colorado River has become an iconic symbol of the American Southwest. The Colorado River is the largest river in the southwestern United States to reach the ocean. It flows over 2300 km from its headwaters in the Rocky Mountains in Colorado to the Gulf of California, draining nearly 250,000 square kilometers of watershed. The evolution of the modern Colorado River is more fascinating than even Powell could have imagined. Prior to about 15 Ma, the ancestral Colorado River flowed to an unknown location somewhere to the north or northeast of the Rockies (e.g., Cather et al., 2012). Between 15 and 6 Ma, extension and subsidence in the Basin and Range Province and the opening of the early Gulf of California caused wholesale reorganization of the watersheds in the southwestern U.S. (Potochnik and Faulds 1998; Potochnik, 2001; Cather et al., 2012; Dickinson, 2015). By about 6 Ma, the ancestral Colorado River had reversed its course and began winding its way to the southwest (e.g., Pederson, 2008), crossing a tectonically chaotic landscape of plateaus, canyons, basins, and mountain ranges before finally reaching the early Gulf of California at about 5 Ma (Dorsey et al., 2007, 2011). The course of the modern Colorado River now cuts through the high topography of the Kaibab Uplift and slashes across the northern flank of the Colorado Plateau, working its way through the iconic Grand Canyon in the process. Along its lower

reaches, the Colorado River traverses four previously topographically closed basins of the Basin and Range Province. Thus, the evolution of the modern Colorado River is the common thread that ties together much of our understanding about the late Cenozoic tectonic and geomorphic evolution of the southwestern U.S. (e.g., Blackwelder, 1934).

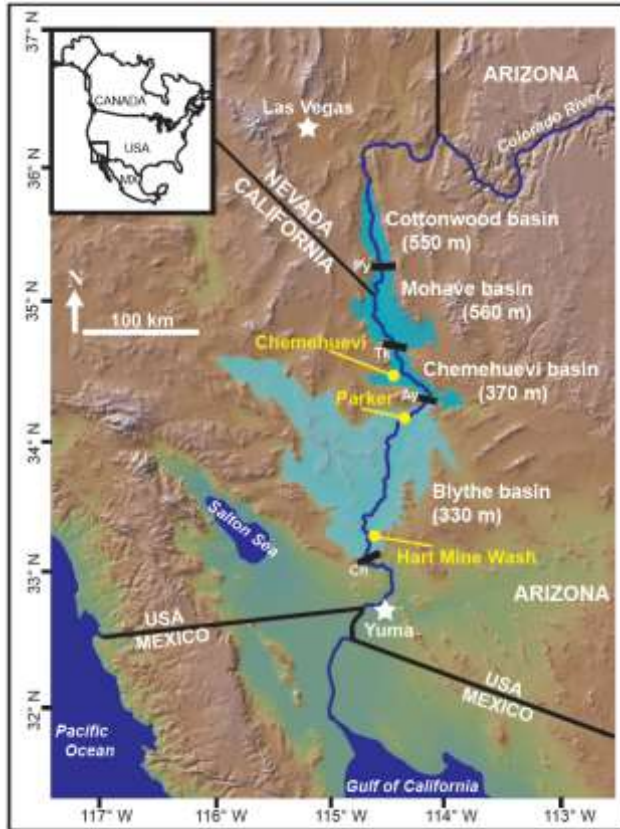


Figure 1. Map of southwestern U.S. and northwestern Mexico. Blythe basin (lightest blue) contains outcrops of the contested southern Bouse Formation. Three basins to the north (darker teal) contain outcrops of the lacustrine northern Bouse Formation. Maximum elevation of Bouse Formation outcrops are shown in brackets. Py – Pyramid paleodam, Tk – Topock paleodam, Ay – Aubrey paleodam, Ch – Chocolate Mt. paleodam. Base map from GeoMapApp (Ryan et al., 2009).

An enigmatic series of ~ 5 Ma carbonate and siliciclastic deposits that are discontinuously exposed along nearly 250 km of the lower Colorado River between Las Vegas, NV, and Yuma, AZ, (Fig. 1) preserve a record of the events that happened before the ancestral Colorado River became fully integrated with the early Gulf of California. This suite of sediments has been named the Bouse Formation (Meztger, 1968). Since the early 1900's, the origin of the Bouse Formation has been the focus of considerable debate. Early workers found fossil clams, barnacles, and foraminifers in the southernmost exposures of the Bouse Formation, in what is now Blythe basin (hereafter “southern Bouse Formation”) (Fig. 1). Initial interpretations accounted for the marine fossil assemblage by suggesting that the southern Bouse

Formation was deposited in a northern extension or estuary of the early Gulf of California (Fig. 2A,B); an interpretation favored by some workers to the present day (Ross, 1923; Brown, 1923; Noble, 1931, Wilson, 1931; Smith, 1970; McDougall, 2008; McDougall and Miranda Martinez, 2014). Hamilton (1960) was the first to propose an alternative interpretation favoring a saline lake origin (Fig. 2C). Blair and Armstrong (1979) later suggested that the unfossiliferous Bouse Formation north of Blythe basin (hereafter “northern Bouse Formation”) should also be included in the marine transgression model in order to accommodate similar marls and limestones that are exposed as far north as the Las Vegas, NV, area. Over the past 20 years, the debate over the origin of the northern Bouse Formation

has largely been settled. A number of studies focusing on paleontology, geomorphology, and on both stable isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) values and strontium isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$) in carbonates collectively suggest that the northern Bouse Formation was deposited in a series of southward cascading, fresh to mildly brackish lakes that were fed by the ancestral Colorado River (Fig. 1) as it was drawn south towards the early Gulf of California from the Las Vegas area (Spencer and Patchett, 1997; Poulson and John, 2003; House et al., 2008; McDougall, 2008; Roskowski et al., 2010; Pearthree and House, 2014; Crossey et al., 2015) (Fig. 1). The origin of the southern Bouse Formation and its marine fauna is still unresolved and intensely debated (e.g., Spencer et al., 2013; McDougall and Miranda Martinez, 2014).

Southern Bouse Formation carbonates have $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values and $^{87}\text{Sr}/^{86}\text{Sr}$ ratios that overlap those of the northern Bouse Formation (Spencer and Patchett, 1997; Poulson and John, 2003, Crossey et al., 2015), permitting a similar ancestral Colorado River-fed lake origin (Fig. 2C). The presence of obligate marine planktic foraminifers and a diverse benthic foraminifer assemblage (McDougall, 2008; McDougall and Miranda Martinez, 2014), a variety of marine/estuarine diatoms (Miller et al., 2014), and abundant remains of barnacles (Zullo and Buising, 1989) provide strong arguments favoring a marine (Fig. 2A) or estuarine (Fig. 2B) origin (e.g., Smith, 1970). Conclusive geochemical evidence for a marine origin, such as marine $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, has not been found (Spencer and Patchett, 1997; Roskowski et al., 2010; Crossey et al., 2015). The strontium dynamics of the ~ 5 Ma lower Colorado River corridor, and Blythe basin in particular, are surprisingly complex (Crossey et al., 2015). Groundwater with high strontium concentrations and continental $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were present in the area just before the southern Bouse Formation was deposited. A small contribution of this groundwater could produce the continental $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the southern Bouse Formation even if 25-75% of the water in Blythe basin was seawater (Crossey et al., 2015). The proximity of Blythe basin to ~ 5 Ma seawater is not contested. For instance, Miocene marine rocks underlie proposed Bouse Formation sediments in wells near Yuma, AZ, (Fig. 1) just 60 km south of Blythe basin (Olmstead et al., 1973; McDougall, 2008). Whether or not seawater from the early Gulf of California extended into Blythe basin is unclear and is the focus of this investigation.

SIGNIFICANCE

The significance of a marine or lacustrine interpretation for the southern Bouse Formation is centered on two key topics; the regional post-Miocene tectonic history of the

lower Colorado River corridor and the adjacent Colorado Plateau, and the biogeographic implications of a diverse marine assemblage in what may be a continental lake setting.

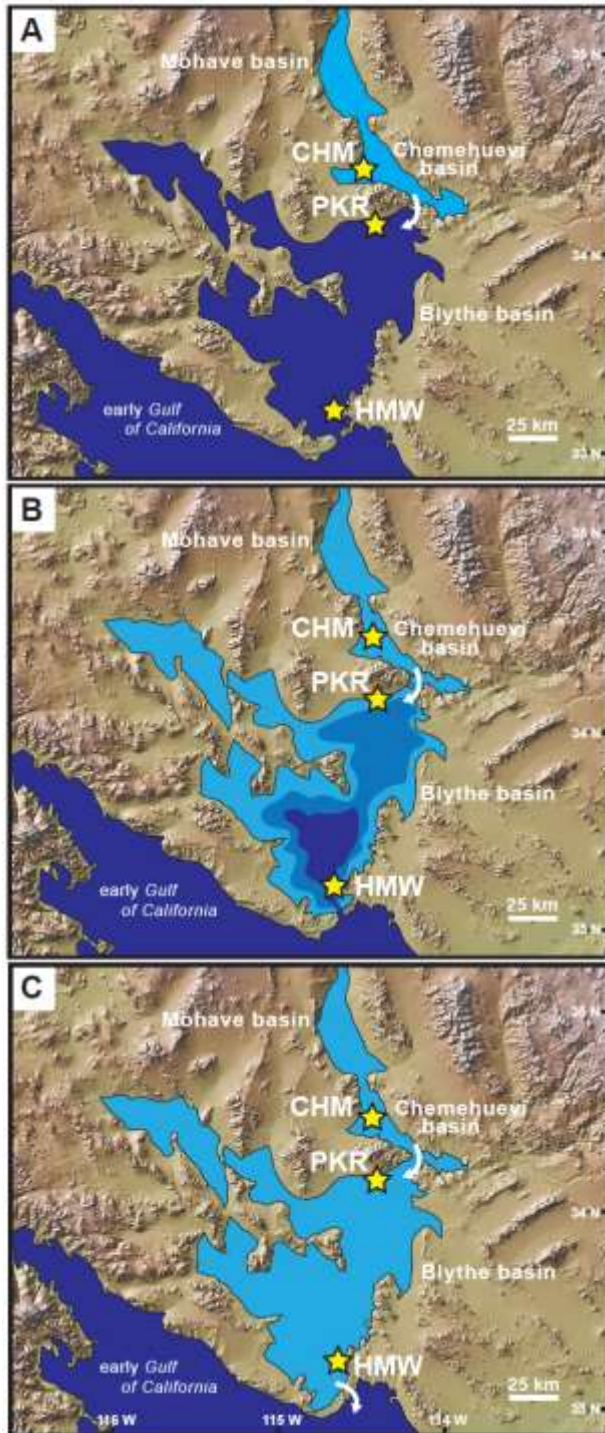


Figure 2. Conceptual images of (2A) a marine origin, (2B) an estuarine origin, and (2C) a lacustrine origin for the southern Bouse Formation in Blythe basin. Topography south of Blythe basin has been flooded to 330 masl to mimic possible late Miocene paleo-sea level scenarios. CHM – Chemehuevi, PKR – Parker, HMW – Hart Mine Wash. Base map from GeoMappApp (Ryan et al., 2009).

likely candidate for a lacustrine analogue would be modern and Holocene sediments from the land-locked Salton Sea (Fig. 1), which contain a nearly equally impressive array of benthic

Outcrops of the southern Bouse Formation are found as high as 330 masl (Pearthree and House, 2014) (Fig. 1). If the southern Bouse Formation was deposited at sea level as either a marine or estuarine deposit, then this categorically requires 330 m of post-Miocene uplift, which has larger implications for the rate and timing of uplift of the neighboring Colorado Plateau (Lucchitta, 1979). If the southern Bouse Formation is lacustrine, then the elevation of the outcrops simply reflects water level within a closed basin and any tectonic implications are lost (Spencer and Patchett, 1997).

The variety of marine fossils, and specifically the obligate marine planktic foraminifers, in the southern Bouse Formation is intriguing and easily accounted for by a marine or estuarine interpretation. Conversely, marine mollusks, benthic foraminifers, and more rarely barnacles, have been documented in lakes (Anadón, 1992). The diversity of marine fossils in the southern Bouse Formation, however, is probably unparalleled in any known lake. The most

foraminifers, marine-estuarine diatoms, barnacles, and other marine-estuarine organisms (Arnal, 1958; Whistler, 1995; Detwiler et al., 2002; Lange and Tiffany, 2002). However, the Salton Sea, and to our knowledge all other saline lake ecosystems, extant and fossil, lack uncontested occurrences of planktic foraminifers. If the southern Bouse Formation is lacustrine, then it would dramatically change our perception about the diversity of marine organisms that are capable of colonizing lakes. This in turn could be applied to other controversial marine-lacustrine debates, for example, the debate over potential Cenozoic marine incursions into the interior of South America (e.g., Vonhof et al., 1998; Boonstra et al., 2015).

RATIONALE AND METHODS

I sampled 3 Bouse Formation outcrops that were strategically located along a north-south transect (Fig. 1). One outcrop was of lacustrine northern Bouse Formation in Chemehuevi basin (Fig. 1). The remaining two outcrops were of southern Bouse Formation located at Parker, AZ, and near Hart Mine Wash, AZ. The outcrop at Parker, AZ, is located near where the ancestral Colorado River would have entered Blythe basin (Fig. 1). The outcrops at Hart Mine Wash are located near the southern margin of Blythe basin (Fig. 1), far from any major river input, and would have been near the mouth of the proposed Bouse estuary (Fig. 2B). This sampling strategy allows me to document the $\delta^{18}\text{O}$ values in micrite and ostracode calcite from an uncontested lacustrine environment in Chemehuevi basin, and then compare those results to the $\delta^{18}\text{O}$ values in micrite and ostracode calcite from the contested southern Bouse Formation exposed at Parker and at Hart Mine Wash. If the southern Bouse Formation is marine (Fig. 2A), then the micrite and ostracode $\delta^{18}\text{O}$ values from Parker and Hart Mine Wash should be similar to each other and should have $\delta^{18}\text{O}$ values characteristic of marine carbonates. If marine, the results from both southern Bouse Formation outcrops should be strikingly different from the results from the lacustrine northern Bouse Formation. Similarly, if the southern Bouse Formation is estuarine (Fig. 2B), then the micrite and ostracode $\delta^{18}\text{O}$ values should show a clear transition from lacustrine conditions in Chemehuevi basin, to mildly saline conditions at the head of the Bouse estuary near Parker, to nearly marine conditions near the mouth of the Bouse estuary near Hart Mine Wash (Fig. 2B). Specifically, the salinity and $\delta^{18}\text{O}$ value of water in an estuary are positively correlated (e.g., Ingram, 1996). If the southern Bouse Formation is estuarine, then there should be a noticeable

increase in micrite and ostracode $\delta^{18}\text{O}$ values from the head of the estuary at Parker to the mouth of the estuary near Hart Mine Wash (Fig. 2B).

Bouse Formation sediments were disaggregated and sieved over 45 μm screens. Microfauna in the $> 120 \mu\text{m}$ fraction were identified and counted. A portion of the $< 45\mu\text{m}$ sediment fraction (micrite) was retained, dried at 40°C , and analyzed for its $\delta^{18}\text{O}$ values ($\delta^{18}\text{O}_{\text{MIC}}$). Valves from two genera of ostracodes (*Cyprideis* – marginal marine; *Candona* – continental) were also analyzed for their $\delta^{18}\text{O}$ values ($\delta^{18}\text{O}_{\text{CYP}}$, $\delta^{18}\text{O}_{\text{CAN}}$, respectively). All $\delta^{18}\text{O}$ values were generated using an automated KIEL-III carbonate preparation device attached to a Finnegan MAT 252 gas-ratio mass spectrometer and the University of Arizona. The stable isotope results are reported in standard delta (δ) notation where: $\delta\text{‰} = [(\text{R}_{\text{sample}}/\text{R}_{\text{std}})-1] \times 10^3$; and R = ratio of $^{18}\text{O}:^{16}\text{O}$. R_{std} refers to the standard Vienna Pee Dee belemnite (VPDB).

PRELIMINARY RESULTS

The $\delta^{18}\text{O}_{\text{MIC}}$ value ($-7 \pm 1\text{‰}$; Fig. 3) from roughly the lower one third of the lacustrine Chemehuevi section (Figs. 1 and 2) is expectedly non-marine. In contrast, the $\delta^{18}\text{O}_{\text{CAN}}$ value ($-1 \pm 1\text{‰}$; Fig. 3) from the base of the Chemehuevi section is surprisingly high. A $\delta^{18}\text{O}_{\text{CAN}}$ value this close to 0‰ could be interpreted as “marine-like”. *Candona* spp. are continental ostracodes and do not live in seawater, however, so a marine origin is highly unlikely. A lacustrine origin for the high $\delta^{18}\text{O}_{\text{CAN}}$ value is supported by equally high $\delta^{18}\text{O}_{\text{CAN}}$ values from the fully lacustrine Lake Bonneville sequence in Utah. (J. Oviatt, pers. comm.). The offset between the $\delta^{18}\text{O}_{\text{MIC}}$ and $\delta^{18}\text{O}_{\text{CAN}}$ values can be accounted for by various combinations of a $+2\text{‰}$ vital effect in $\delta^{18}\text{O}_{\text{CAN}}$ values (von Grafenstein et al., 1999), a temperature contrast between the epilimnion where the micrite formed and the benthos where the *Candona* valves were calcified ($\sim +0.24\text{‰}$ per 1°C cooling; e.g., Leng and Marshall, 2004), and perhaps mild seasonal isotopic stratification between the epilimnion and benthos. The much lower $\delta^{18}\text{O}_{\text{MIC}}$ value ($-14 \pm 1\text{‰}$; Fig. 3) from the upper two thirds of the Chemehuevi section suggest open-basin or nearly fluvial conditions prevailed when those sediments were deposited. Valve fragments of *Candona* sp. from the upper Chemehuevi section have recently been submitted for $\delta^{18}\text{O}$ analysis, but the results are not available at this time. I interpret the transition from a moderate $\delta^{18}\text{O}_{\text{MIC}}$ value to a much lower $\delta^{18}\text{O}_{\text{MIC}}$ value to represent the initial closed-basin filling of Chemehuevi basin with over-spilling and evaporatively ^{18}O -enriched water sourced

from the much larger Mohave basin to the north (Fig. 1), followed by a transition to a through-flowing, open basin configuration as Chemehuevi basin filled and finally over-spilled. This interpretation is consistent with the “fill- and-spill” lacustrine model for northern Bouse Formation (e.g., House et al., 2008; Pearthree and House, 2014).

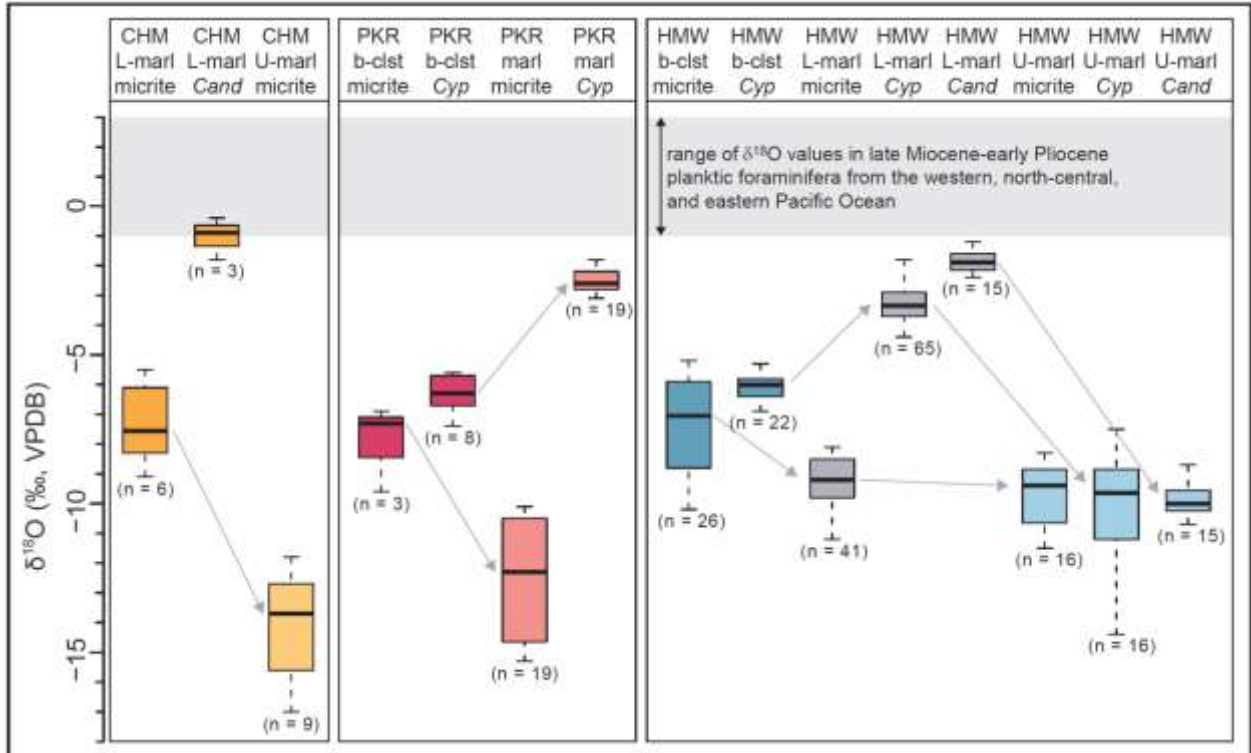


Figure 3. Boxplots of $\delta^{18}\text{O}$ values from micrite and ostracode calcite from the northern Bouse Formation at Chemehuevi (CHM), and the southern Bouse Formation at Parker (PKR) and at Hart Mine Wash (HMW). L-marl – lower marl, U-marl – upper marl, b-clst – bioclastic, *Cyp* – *Cyprideis* (marginal marine ostracode), *Cand* – *Candona* (continental ostracode), thick black horizontal line – median, colored boxes – interquartile range, whiskers – minimum and maximum values. Outliers ($n = 9$) are excluded for clarity.

The southern Bouse Formation sediments at both Parker and Hart Mine Wash consist of a basal bioclastic limestone horizon overlain by several meters of soft marl. I interpret the bioclastic limestone as being deposited in a near-shore environment whereas the marl was deposited in deeper, quieter water. At Hart Mine Wash, I designated the lowest ~90% of the marl sediments as “lower marl” and the uppermost ~10% of the marl sediments as “upper marl”. The $\delta^{18}\text{O}_{\text{MIC}}$ and $\delta^{18}\text{O}_{\text{CYP}}$ values from the bioclastic sediments at both Parker and Hart Mine Wash are surprisingly similar, and are much lower than what is expected from a marine environment (Fig. 3). The $\delta^{18}\text{O}_{\text{MIC}}$ values in the marl at Parker and in the lower marl at Hart Mine Wash are also moderately similar, and again are much lower than would be expected if the micrite was formed in seawater (Fig. 3). The $\delta^{18}\text{O}_{\text{MIC}}$ values from both southern Bouse Formation marls are consistently lower than the $\delta^{18}\text{O}_{\text{MIC}}$ values in the respective underlying bioclastic horizons (Fig. 3). The $\delta^{18}\text{O}_{\text{CYP}}$ values from the marls at Parker are similar to both

the $\delta^{18}\text{O}_{\text{CYP}}$ and $\delta^{18}\text{O}_{\text{CAN}}$ values from the lower marl at Hart Mine Wash, and all three values are surprisingly similar to the $\delta^{18}\text{O}_{\text{CAN}}$ values from the northern Bouse Formation at Chemehuevi (Fig. 3). The $\delta^{18}\text{O}_{\text{MIC}}$ values from the upper marl at Hart Mine Wash are similar to the $\delta^{18}\text{O}_{\text{MIC}}$ values from the lower marl there (Fig. 3), but the $\delta^{18}\text{O}_{\text{CYP}}$ and $\delta^{18}\text{O}_{\text{CAN}}$ values in the upper marl decrease by about 7‰ to 10‰ (Fig. 3). The details of this transition are currently under review and cannot be discussed here, but this large decrease in ostracode $\delta^{18}\text{O}$ values has significant implications for my paleoenvironmental interpretation of the sedimentary sequence at Hart Mine Wash. One key observation, however, is the similarity in $\delta^{18}\text{O}_{\text{MIC}}$, $\delta^{18}\text{O}_{\text{CYP}}$, and $\delta^{18}\text{O}_{\text{CAN}}$ values at Parker and at Hart Mine Wash to the $\delta^{18}\text{O}_{\text{MIC}}$ and $\delta^{18}\text{O}_{\text{CAN}}$ values from the lacustrine northern Bouse Formation in Chemehuevi basin (Fig. 3).

And finally, the stratigraphic structure of the $\delta^{18}\text{O}_{\text{MIC}}$ values from the lacustrine northern Bouse Formation is replicated at both Parker and in the lowest sediments at Hart Mine Wash (Fig. 3). Note that the basal sediments at each of the three sections contain micrite with moderate $\delta^{18}\text{O}_{\text{MIC}}$ values that are then overlain by marls with lower $\delta^{18}\text{O}_{\text{MIC}}$ values (Fig. 3). And note that the near-shore, bioclastic sediments at Parker and Hart Mine Wash contain ostracodes with moderate $\delta^{18}\text{O}_{\text{OST}}$ values but that the overlying deeper water marls at both locations contain ostracodes with much higher $\delta^{18}\text{O}_{\text{OST}}$ values (Fig. 3). The up section change in $\delta^{18}\text{O}_{\text{OST}}$ values is the opposite of what is observed for the $\delta^{18}\text{O}_{\text{MIC}}$ values (Fig. 3). Collectively, these similarities suggest that the southern Bouse Formation at Parker and at Hart Mine Wash is lacustrine in origin.

In summary, there is no appreciable difference in the $\delta^{18}\text{O}_{\text{MIC}}$ or ostracode $\delta^{18}\text{O}$ values from the lacustrine northern Bouse Formation in Chemehuevi basin and from the contested southern Bouse Formation at Parker and Hart Mine Wash, and the $\delta^{18}\text{O}_{\text{MIC}}$ values from the southern Bouse Formation are too low to represent marine conditions; a marine interpretation for the southern Bouse Formation seems untenable. There is no appreciable difference in the $\delta^{18}\text{O}_{\text{MIC}}$ or ostracode $\delta^{18}\text{O}$ values from the two southern Bouse Formation exposures at Parker and Hart Mine Wash; an estuarine interpretation seems untenable. I argue that the similarity in the $\delta^{18}\text{O}_{\text{MIC}}$ and ostracode $\delta^{18}\text{O}$ values, coupled with the similarities in the isotopic stratigraphy, at all three Bouse Formation outcrops strongly argues against a marine or estuarine interpretation for the southern Bouse Formation. Collectively, these new results favor a lacustrine origin for the southern Bouse Formation.

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Lipid-based immuno-magnetic capture and isolation of environmental microorganisms

Cindy Frickle, University of Minnesota Department of Earth Sciences

2014 Kerry Kelts Research Award Co-Winner

Introduction

The aim of my research is to attack one of the leading problems in microbiology, one that will have a significant impact on understandings of geosphere-biosphere interactions, including paleoclimate and climate change. An estimated 98% of microbes in the environment have yet to be isolated—meaning researchers have been unable to grow these species in pure culture, which is necessary for rigorous study and understanding of an organism. Addition of a nutrient source to any environmental sample typically results in growth of microbial “weeds” rather than the slow-growing, geochemically significant species that are endemic to widespread oligotrophic zones. I am developing a method to enable physical separation of targeted microbial groups, based on physiology. This has various implications in geology, from understanding the microorganisms that are important in biogeochemical cycles to enabling climate tracking.

Significance

A specific type of membrane lipid found in thermophilic archaea is responsible for the ability to survive at boiling temperatures near hydrothermal vents. Predictable “folding” patterns create variants of the lipid, Crenarchaeol, that correspond directly to the environmental temperature. This adaptation is widely used by the Archaeal phylum, Thaumarchaeota, found throughout lacustrine and marine water columns. The GDGT (glycerol diether glycerol tetraether) paleoclimate proxy, TEX₈₆, involves measuring well-preserved fossils of these archaeal lipids in sediments and calculating paleotemperature based on the relative amounts of Crenarchaeol variants in a sample. A study found that archaea throughout the marine water column yielded lipids that matched the measured temperatures near the traps, but strangely, the sedimentary record captured only the sea surface temperature (Wuchter et al, 2006). There was somehow preferential preservation of near-surface lipid composition, despite ubiquitous Archaea throughout the water column. More recent genetic analysis suggests that these species express lipids differently based on the depth in which they reside (Villanueva et al, 2014). Isolation of these cells would enable rigorous experimentation that could explain

how the signal is being distorted and determine whether or not this widely used climate-tracking proxy is accurate.

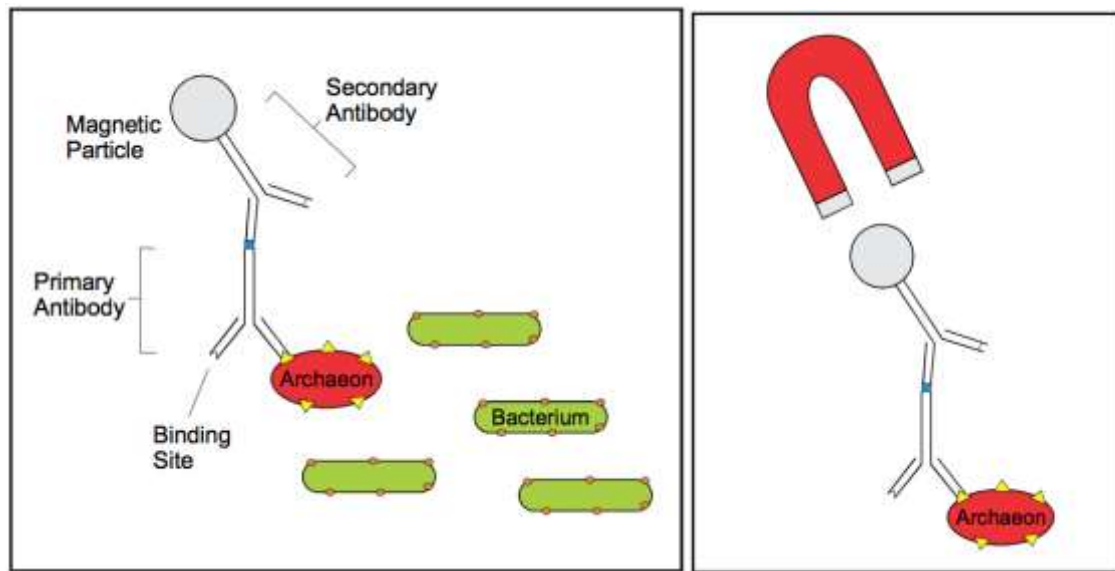


Figure 1. Y-shaped antibody proteins specific to archaeal membrane components allow physical, magnetic separation of targeted species from others in a mixed culture.

In our proof of concept study, we are targeting the organic molecule squalene, found in outer membrane lipids of certain archaea. We are developing a new method in which we can physically partition bacteria from archaea, enriching a sample for only the targeted archaea. This is achieved by attaching magnetic antibodies to squalene membrane molecules and passing a mixed sample of live cells through a magnetized separation chamber. Growth and isolation of the targeted organism follows by decreasing or even eliminating various unwanted species.

Results

Specificity

Preliminary experiments involved testing the primary antibody for specificity to archaeal squalene. A fluorophore was bound to the primary antibody to allow visual confirmation of binding to cells in pure culture. Archaeal cells appeared to bind with squalene antibodies at a 1:40 antibody dilution (Figure 2a). Bacterial cells did not appear to bind at this concentration (Figure 2b).

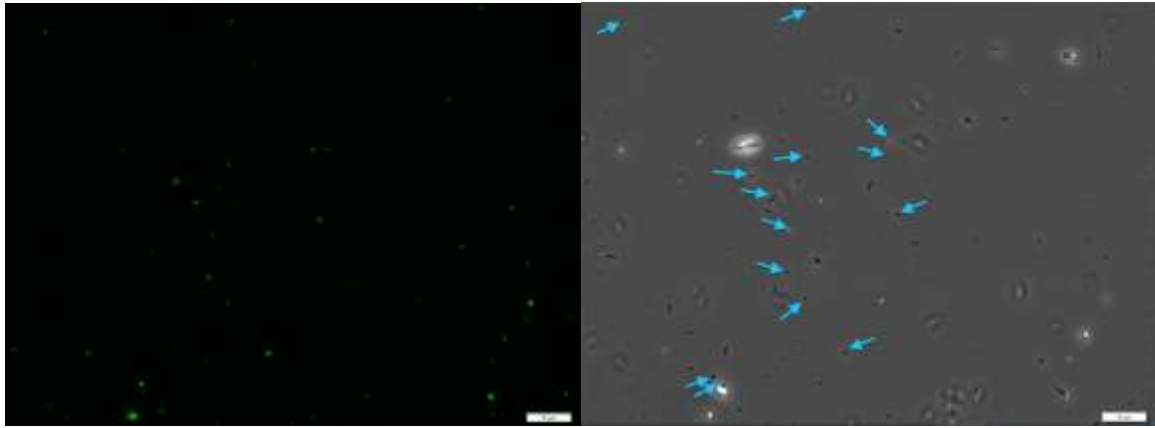


Figure 2a. Immunofluorescence test of antibody specificity: Epifluorescent (left) and phase contrast (right) images of *Halobacterium* cells tagged with SQE#14 primary antibody (1:40) and secondary FITC fluorophore (1:1000). Arrows point to antibody-bound objects. Scale bar=10 μ m.

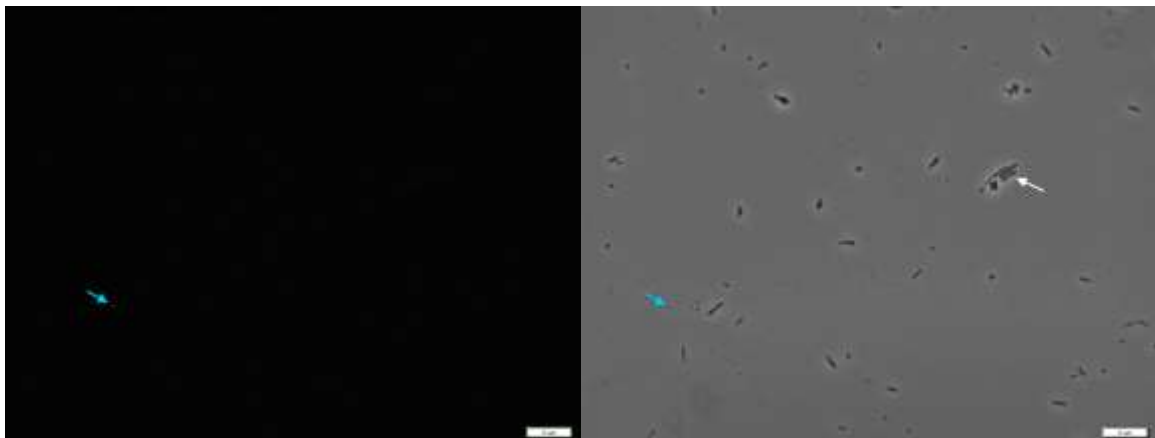


Figure 2b. Immunofluorescence test of antibody specificity: Epifluorescent (left) and phase contrast (right) images of *Salinibacter* cells treated with SQE#14 primary antibody and secondary FITC fluorophore. Blue arrow points to brightest spot on epifluorescence image. White arrow points to a cluster of cells. No fluorescence is visible in the region of the cell cluster. Scale bar=10 μ m.

Viability

Dense cultures of the archaeal strain were grown from antibody-bound cell isolates, indicating that cell viability could be maintained.

Separation Efficiency

Quantitative polymerase chain reaction (qPCR) was used to quantify efficiency of separation by comparing cell counts of each type before and after the antibody separation procedure (Figure 3). It was determined that a large proportion of cells was lost during the rinse steps,

particularly archaea. Additionally, the magnetized sample did not appear to be preferentially enriched in archaeal cells.

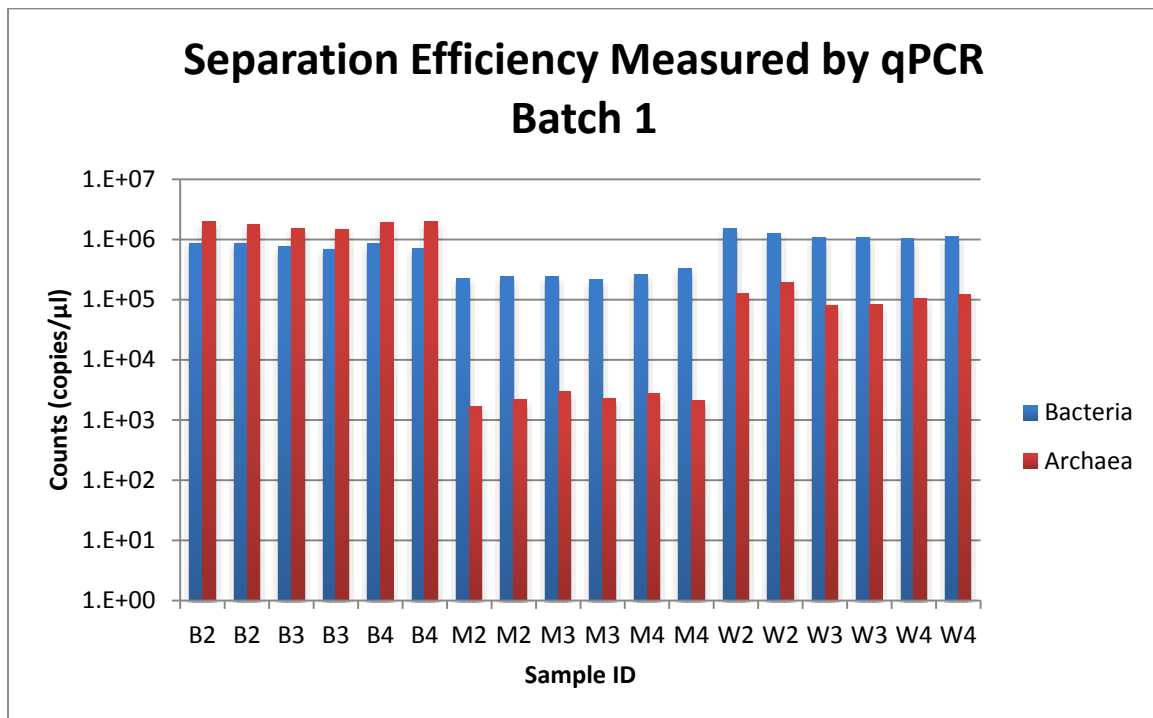


Figure 3a. Duplicate samples from triplicate separations were compared. Before sample (B) quantities surprisingly did not equal the sum of magnetized (M) and washed out (W) samples.

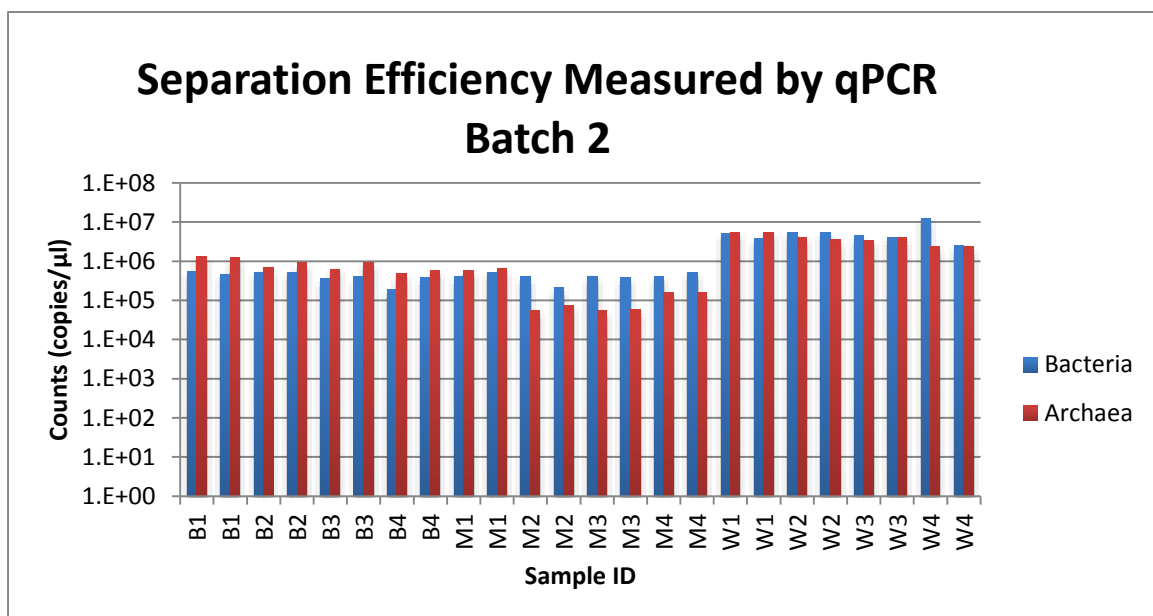


Figure 3b. Following optimization of procedure steps to better retain cells, a second, quadruple separation experiment was analyzed using qPCR for cell counts.

Cell loss

Various steps in the separation procedure were optimized for better archaeal cell retention. Still, we suspect that clustering of cells throughout the experiment is affecting the overall results. This was supported by visual evidence of cell clumping (Figure 4) and qPCR performed on aspirated wash solutions that would otherwise be discarded (Figure 5).

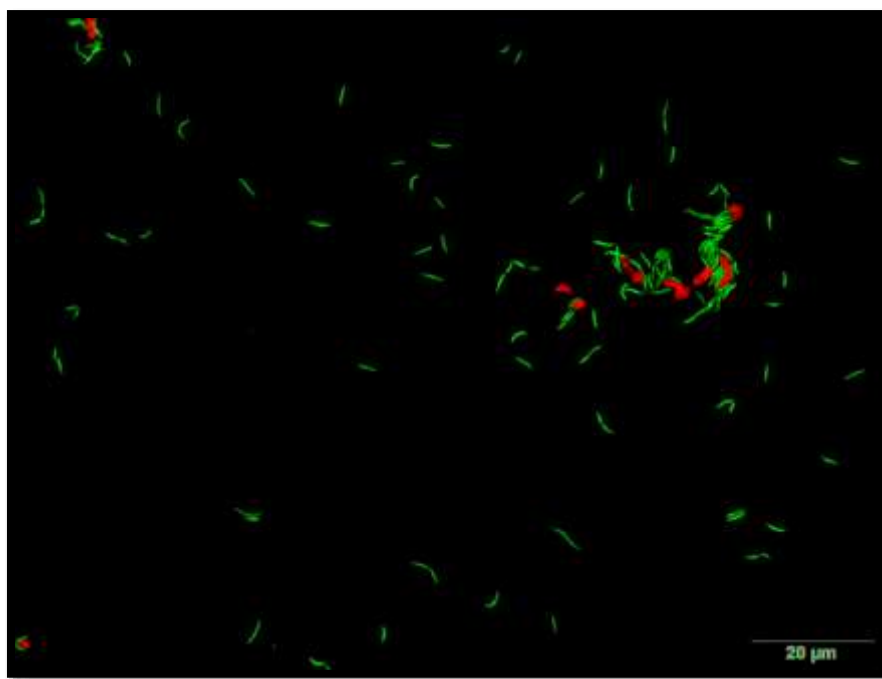


Figure 4. Fluorescent in-situ hybridization (FISH) image of a Wash fraction sample, with FITC-labeled bacteria (green) and TXred-labeled Archaea images overlaid. Bacterial cells are found both free-floating and clustered, while archaeal cells are mostly associated with cell clusters.

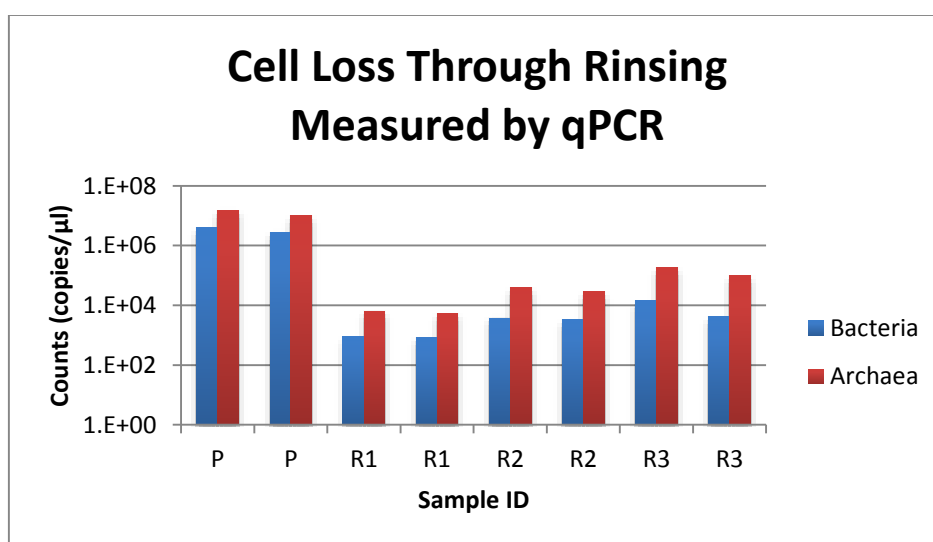


Figure 5. Quantification of cell loss during separation procedure by clade: Duplicate qPCR results of cell quantities before treatment and cluster filtering (P-samples), followed by

samples of each rinse supernatant. R1 = acetic acid, R2 = ddH₂O, R3 = phosphate buffered saline (PBS).

Conclusion

In summary, squalene antibodies tested positive for specificity to the archaeal membrane component and we have found that viable cells can be obtained after performing this procedure; however, we have encountered challenges to successfully separating the two cell types, most likely due to cell clustering during media wash steps. Also, we experienced preferential loss of the targeted cells. Future work will aim to overcome these obstacles by utilizing different growth methods, varying media, and/or an alternative magnetic separation chamber.

Acknowledgements

I would like to thank the Geological Society of America Limnogeology Division for the Kerry Kelts Award. This award not only gave funds to continue research, but also instilled confidence in my work, which was greatly appreciated when results didn't come back the way I had expected! Thanks to my labmates Beverly Flood, Dan Jones, Ben Harrison, and Elizabeth Ricci for help at the bench, and to Karen Lloyd and her group at University of Tennessee, Knoxville, for performing qPCR. This work was also supported by the University of Minnesota Department of Earth Sciences Zoltai Graduate Fellowship and Kerry Kelts Memorial Travel Award.

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2015 KERRY KELTS AWARD

The 2015 Kerry Kelts Student Research Awardee is:

Ann Elisabeth Morey (Oregon State University) with a project on
“Earthquake triggered deposits in Squaw Lake, Oregon”.

Ann will be presented with her award at the annual Division Business Meeting on
November 3rd.

Congratulations to Ann!

The Kerry Kelts Award Committee considered 7 proposals for 2015. We continue to receive generous donor support and will make an award of \$1000. We would like to acknowledge the following limnogeologists for their generous donations to the Kerry Kelts award this past year.

Kevin M. Bohacs
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Elizabeth H. Gierlowski-Kordesch
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James M. Russell
Lora Stevens
Minze Stuiver
William J. Ullman
David L. Warburton
Herman B. Zimmerman

Thanks to all the students who submitted proposals, and good luck as you continue your research in Limnology, Paleolimnology, and Limnogeology.

2015 Israel C. Russell Award



The Israel C. Russell Award is awarded for major achievements in Limnogeology through contributions in research, teaching and service.

The 2015 Israel C. Russell Award winner is Andrew Cohen (University of Arizona). The award will be presented to Andrew at the annual Division Business Meeting on November 3rd. We hope to see you there!



The Sixth International Limnogeology Congress (ILIC6) was held in Reno, Nevada, from June 15–19, 2015. The ILIC meetings have been held every 4 years since the first meeting in 1995 and were subsequently convened in Brest, France (1999), Tucson, Arizona, USA (2003), Barcelona, Spain (2007), and Konstanz, Germany (2011). The Congress in Reno, USA marks the second time the Congress has been held in the United States and more

than 165 scientists from every part of the world participated. About one-half of the participants were from North America, together with scientists from Europe, South America, Asia, Africa, Australia, and New Zealand. The format of the Reno Congress followed the format originated at the Tucson Congress (ILIC3), which is unusual for scientific meetings. Nine keynote speakers spread throughout the Congress gave 1-hour talks, with the rest of the time available for viewing posters that were presented by the bulk of the participants. Keynote presentations were diverse and showed the breadth of research that is being done in lake systems worldwide. The abstracts of the keynote speakers and about 140 poster

presentations are included in a US Geological Survey Open File Report: <http://pubs.usgs.gov/of/2015/1092/pdf/ofr2015-1092.pdf>. These posters covered a variety of limnologic, paleolimnologic, and limnogeologic topics including contaminant histories of lakes, the role of groundwater in lake processes, the formation of minerals in lake sediments, terminal lakes, how lakes reveal climate changes and paleohydrologic processes, the impact of volcanic emissions on lakes, as well as the biologic and chemical evolution of lake systems.

The ILIC6 also included a half-day workshop on using the Bacon age-dating modeling software. The workshop was run by Amy Myrbo and Susan Zimmerman, and was attended by more than 15 participants, many of whom were students. The workshop provided hands-on practice for new and beginning users of the Bacon age-depth modeling software and related tools. Attendees created age-depth models using their own data, with support and advice from Amy and Susan.

Students were a big part of the Congress, with more than 25 students attending. Several students received scholarships to help pay for registration and travel costs and were sponsored by the International Association of Sedimentologists, the University of Kentucky, Northern Arizona University, Queen's University, Canada, and the National Autonomous University of Mexico.

The Congress included a mid-Congress half-day field trip to Lake Tahoe, led by Sudeep Chandra and Alan Heyvaert that illustrated the limnogeologic history of the lake. The participants also learned about the current water resource issues that involve keeping the lake clean, providing potable water to inhabitants, and keeping invasive species out of the lake. A one-day post-Congress field trip to Pyramid Lake, Nevada, led by Brian Wadsworth of the Pyramid Lake Paiute Tribe and Alan Heyvaert also was held to discuss water management, cultural, and limnogeological aspects of the lake. The Congress also included two overnight pre- and post-Congress field trips. The pre-Congress field trip examined outcrops and lake sequences of closed-basin lakes in the Eocene Green River Formation in Wyoming, led by Michael Smith and Jennifer Scott. The post-Congress field trip to Pleistocene deposits and modern lakes in the Great Basin of North America (led by Susan Zimmerman, Ken Adams, and Michael Rosen), provided participants with a glimpse at a wide variety of lakes in the Western United States. The field trip guides for these trips and two field trips that didn't have enough participants to run are available at <http://pubs.usgs.gov/of/2015/1092>.



Lake Tahoe with ILIC6 field participants in the foreground (Credit: Melanie Leng)



Although smaller than some ILIC meetings, the Congress was still a success both scientifically and financially. Participants were able find time to have long discussions about the science they are interested in and also enjoy interesting in-depth talks from experienced and up and coming experts in limnogeology and paleolimnology. The meeting would not have taken place without the help of the Organizing committee who provided guidance and support as well as finding sponsors for the meeting. The ILIC6 sponsors are listed below as one final thank you for their support of the Congress. The next Congress will be in 3 years and will be held in Sweden jointly with the International Paleolimnology Association. I hope to see you there!

ILIC6 Organizing Committee Chair
Michael Rosen

The list of sponsors for ILIC6 in alphabetical order include:

Cox Analytical Services
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Rhizosphere Research Products
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IN THE EXHIBIT HALL!*



Sessions Sponsored by Limnogeology Division at the 127th GSA at Baltimore

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DIVISION SPONSORED SESSIONS:

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<u>T70. Digital Technology in Real and Virtual Geoscience Experiences I</u> Declan De Paor, Steven J. Whitmeyer, Callan Bentley	<i>Sunday, 1 November 2015: 8:00 AM-12:00 PM Room 339 (Baltimore Convention Center)</i>
<u>T70. Digital Technology in Real and Virtual Geoscience Experiences II</u> Declan De Paor, Steven J. Whitmeyer, Callan Bentley	<i>Sunday, 1 November 2015: 1:30 PM-5:30 PM Room 339 (Baltimore Convention Center)</i>
<u>T70. Digital Technology in Real and Virtual Geoscience Experiences (Posters)</u> Authors will be present from 3:30 to 5:30 PM.	<i>Sunday, 1 November 2015: 9:00 AM-5:30 PM Exhibit Hall (Baltimore Convention Center)</i>

<p><u>T55. Investigating Coastal Environments: A Tribute to Derald G. Smith</u></p> <p>Harry M. Jol</p>	<p><i>Monday, 2 November 2015: 8:00 AM-12:00 PM</i></p> <p><i>Room 336 (Baltimore Convention Center)</i></p>
<p><u>T55. Investigating Coastal Environments: A Tribute to Derald G. Smith</u> (Posters)</p> <p>Authors will be present from 4:30 to 6:30 PM.</p>	<p><i>Tuesday, 3 November 2015: 9:00 AM-6:30 PM</i></p> <p><i>Exhibit Hall (Baltimore Convention Center)</i></p>
<p><u>T195. Paleoenvironmental Reconstruction of Hominin Sites: New Methods, New Data, and New Insights I</u></p> <p>Cynthia M. Liutkus-Pierce, Gail M. Ashley, Andrew S. Cohen</p>	<p><i>Monday, 2 November 2015: 8:00 AM-12:00 PM</i></p> <p><i>Room 324 (Baltimore Convention Center)</i></p>
<p><u>T195. Paleoenvironmental Reconstruction of Hominin Sites: New Methods, New Data, and New Insights II</u></p> <p>Cynthia M. Liutkus-Pierce, Gail M. Ashley, Andrew S. Cohen</p>	<p><i>Monday, 2 November 2015: 1:30 PM-5:30 PM</i></p> <p><i>Room 324 (Baltimore Convention Center)</i></p>
<p><u>T195. Paleoenvironmental Reconstruction of Hominin Sites: New Methods, New Data, and New Insights</u> (Posters)</p> <p>Authors will be present from 4:30 to 6:30 PM.</p>	<p><i>Monday, 2 November 2015: 9:00 AM-6:30 PM</i></p> <p><i>Exhibit Hall (Baltimore Convention Center)</i></p>

<p><u><i>T35. Honoring the Diverse Career of Dr. W. Berry Lyons: Geochemistry from Polar Deserts to Tropical Watersheds</i></u></p> <p>Sarah K. Fortner, Carolyn B. Dowling, Karen Johannesson, Klaus Neumann, Carmen A. Nezat</p>	<p><i>Tuesday, 3 November 2015: 8:00 AM-12:00 PM</i></p> <p><i>Room 342 (Baltimore Convention Center)</i></p>
<p><u><i>T125. Lakes of the World</i></u></p> <p>Scott W. Starratt, Johan C. Varekamp</p>	<p><i>Wednesday, 4 November 2015: 1:30 PM-5:30 PM</i></p> <p><i>Room 347/348 (Baltimore Convention Center)</i></p>
<p><u><i>T125. Lakes of the World (Posters)</i></u></p> <p>Scott W. Starratt, Johan C. Varekamp</p> <p>Authors will be present from 4:30 to 6:30 PM.</p>	<p><i>Wednesday, 4 November 2015: 9:00 AM-6:30 PM</i></p> <p><i>Exhibit Hall (Baltimore Convention Center)</i></p>
<p><u><i>T190. Paleoecological Patterns, Ecological Processes, Modeled Scenarios: Crossing Temporal Scales to Understand an Uncertain Future</i></u></p> <p>Miriam C. Jones, Simon Goring, Debra A. Willard</p>	<p><i>Tuesday, 3 November 2015: 8:00 AM-12:00 PM</i></p> <p><i>Room 314 (Baltimore Convention Center)</i></p>
<p><u><i>T190. Paleoecological Patterns, Ecological Processes, Modeled Scenarios: Crossing Temporal Scales to Understand an Uncertain Future (Posters)</i></u></p> <p>Authors will be present from 4:30 to 6:30 PM.</p>	<p><i>Wednesday, 4 November 2015: 9:00 AM-6:30 PM</i></p> <p><i>Exhibit Hall (Baltimore Convention Center)</i></p>

TOPICAL AND DISCIPLINE SESSIONS:

<u><i>T192. Lawrence A. Hardie Commemorative Session I</i></u> Tim K. Lowenstein, Robert V. Demicco, Linda Hinnov	<i>Tuesday, 3 November 2015: 8:00 AM-12:00 PM</i> <i>Room 319/320 (Baltimore Convention Center)</i>
<u><i>T192. Lawrence A. Hardie Commemorative Session II</i></u> Tim K. Lowenstein, Robert V. Demicco, Linda Hinnov	<i>Tuesday, 3 November 2015: 1:30 PM-5:30 PM</i> <i>Room 319/320 (Baltimore Convention Center)</i>
<u>Limnogeology (Posters)</u> Authors will be present from 4:30 to 6:30 PM.	<i>Wednesday, 4 November 2015: 9:00 AM-6:30 PM</i> <i>Exhibit Hall (Baltimore Convention Center)</i>

GSA Limnogeology Division Annual Business Meeting

Tuesday, 3rd November 2015: 6:00 PM-8:00 PM

Room 307 (Baltimore Convention Center)

Joint Annual Business Meeting and Awards Reception of GSA Sedimentary Geology Division, GSA Limnogeology Division and Society for Sedimentary Geology (SEPM): Free Food and Cash Bar.

~*~

In the past year, we've received notice of the passing of the following
of our colleagues:

John Costain
Blair Jones
James Vine

Upcoming Meetings

Geological Society of America (GSA) Annual Convention

2015 Baltimore, Maryland: 1–4 November

2016 Denver, Colorado, 25–28 September

2016 GSA Section Meetings

Cordilleran Section

Ontario, California

4–6 April 2016

Rocky Mountain Section

Moscow, Idaho

18–20 May 2016

North-Central Section

Champaign, Illinois

18–19 April 2016

South-Central Section

Baton Rouge, Louisiana

21–22 March 2016

Northeastern Section

Albany, New York

21–23 March 2016

Southeastern Section

Columbia, South Carolina

31 March–1 April 2016

Association of American Geographers (AAG) Annual Meeting

March 29th-April 2nd San Francisco, California

<http://www.aag.org/cs/annualmeeting>

Numerous sessions organized by the Paleoenvironmental Change Specialty Group.

Limnogeologists encouraged to participate! For more information please contact Limnogeology division secretary Michelle Goman. Abstract Deadline October 29th.

World Lakes Conference (WLC16)

The **16th World Lakes Conference (WLC16)** The Sixteenth World Lake Conference (WLC16)

November 7-11th 2016 in Bali, Indonesia.

<http://www.ilec.or.jp/en/wlc/new/?p=2864>

American Society of Limnology and Oceanography (ASLO)

Santa Fe, New Mexico for the 2016 Summer Meeting, to be held 5-10 June 2016

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<http://aslo.org/meetings/sessions/index.php>

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To get the latest information on other Limnogeology meetings and workshops...

David Warburton, Webmaster

If you have any news, photos, articles, upcoming conferences and recent publications, you would like to share with the division, please submit it to Michelle Goman at goman@sonoma.edu



Panorama of Pyramid Lake with Anaho Island.
(Photo credit: Michelle Goman)



Participants of the ILIC6 Pyramid Lake Fieldtrip
(Photo Credit: Michael Rosen)